TANK-AUTOMOTIVE RESEARCH AND DEVELOPMENT TEST RESUMES

VOLUME VI
SCOUT CARS through TESTS, SPECIAL, MISCELLANEOUS

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ORDNANCE TANK-AUTOMOTIVE COMMAND

Center Line, Michigan

APRIL 1957

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PREFACE

This publication is intended for Ordnance and contractor personnel who desire summarized information on Ordnance research and development test reports written in the last 25 years.

The objectives of the publication are to reveal trends in Ordnance test development, to provide newly assigned technical personnel with an additional source of orientation, and to prevent costly and time-consuming duplication of previous effort. It presents valuable test information in quick-reference form, enabling engineering personnel to grasp quickly the accomplishments and results of the numerous tank-automotive tests.

The publication comprises 12 volumes. Volumes I through X contain resumes of unclassified test reports arranged alphabetically by subject. Resumes of classified reports are contained in Volume XI. Volume XII is a complete index of all test reports summarized in the publication.

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VOLUME VI

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Section 33
SCOUT CARS

SUMMARY

This summary covers resumes of 19 engineering reports written on the endurance and performance testing of reconnaissance or scout cars for the period from 1937 to 1944. Eleven of the reports are concerned with the scout car M3A1, while the remainder are on miscellaneous scout cars. Testing was conducted at Camp Mackall, Detroit Arsenal, Aberdeen and General Motors Proving Grounds. Test scout cars are described in the following sections and their relative merits briefly discussed.

1/4-TON, 4x4, SCOUT CAR (CROSLEY PUP) (1943)

The Crosley 1/4-ton, 4x4, scout car Model CT-3 was powered by a 2-cylinder, 13-1/2 hp engine. The vehicle was equipped with a 3-speed transmission, 2-speed transfer case, mechanical brakes, and quarter-elliptical springs. One report, covering general operating characteristics, stated that this vehicle was unsatisfactory for replacing or supplementing standard 1/4-ton, 4x4 vehicles. The list of deficiencies included limited load carrying capacity and mobility, and insufficient power and speed.

ALLIS-CHALMERS FULL TRACKLAYING RECONNAISSANCE VEHICLE V-40 (1942)

The Allis-Chalmers reconnaissance vehicle V-40 was full-tracked and powered by a 4-cylinder, 50 hp engine. This vehicle weighed 4200 pounds and seated four men, including the driver. Though found unsatisfactory due to poor slope climbing, fording ability, and mechanical failures, the V-40 was considered worthy of further development.

SCOUT CARS T25, T25E1, T25E2, AND T25E3 (1943)

Standard Willys-Overland, 4x4, 1/4-ton trucks were covered with 1/4-inch armor plate in an effort to convert these vehicles into scout cars. The standard, basic 1/4-ton truck, when used for reconnaissance, was overloaded by 240 pounds. With the addition of armor, the T25 car was overloaded by 785 pounds; the T25E1 was overloaded by 1005 pounds; the T25E2 was overloaded by 1250 pounds; and the T25E3 was overloaded by 1265 pounds. Since the basic frame, chassis, and power plant could not accommodate the additional armor weight, termination of development was recommended.

PILOT SCOUT CAR M2A1 (1937)

The scout car M2A1 consisted of a commercial 4x4 truck chassis with a special steel body and continuous gun track around the body interior. This vehicle weighed 7640 pounds and was powered by a Hercules JXD, 6-cylinder, 95 hp engine. Performance of this vehicle was considered excellent and approval was recommended.

COMMAND RECONNAISSANCE CARS (1943-1944)

In 1943, six bodies fabricated almost entirely from wood and one all steel body were tested on 4x4 reconnaissance cars ("Jeeps"). The chassis components of the test vehicles were poor and failed more frequently than the bodies.

A report written in 1944 covered five different tests of a 2383-pound, 60 bhp Willys-Overland (Jeep). No conclusions were made in this report, but reference was made to the individual reports.

SCOUT CAR M3A1 (1939 to 1944)

The pilot model scout car M3A1, tested in 1939, consisted of a specially designed commercial 4x4 chassis on which an armored open top body was mounted. Power was supplied by a 110 hp, 6-cylinder, liquid-cooled Hercules gasoline engine. Space was provided for a crew of eight, including the driver. This vehicle performed satisfactorily and was recommended, with modifications, for adoption as standard.

In 1941, three M3A1 scout cars were tested, two with diesel engines and one with a gasoline engine. One diesel was a Buda-Lanova Model 6-OT-317 and the other, a Hercules, Model DJXD, while the gasoline engine was a Hercules 6-cylinder, Model JXD. The diesel powered vehicles were considered acceptable for scout car use and were superior to the gasoline vehicle in economy, fire hazard features, and freedom from vapor lock, and were about equal in performance. Additional tests were recommended.

Other tests of this vehicle included an unsuccessful attempt to modify it to 37mm gun motor carriage M3A1E3, and an unsuccessful application of roof armor on gun motor carriage M3A1E2. The remainder of the tests were devoted to development tests with emphasis on air cleaner and brake development.

REPORT RESUMES

SUBJECT: Scout Cars Airborne 147
TITLE: Test of Scout Car, 1/4-Ton, 4x4 (Crosley Pup)

IDENTIFICATION: Project No. 147
DATE OF REPORT: 2 November 1943
ORIGIN: Headquarters Airborne Command, Army

TANK AUTOMOTIVE TEST RESUMES

Ground Forces, Camp Mackall, North Carolina
PURPOSE: To determine the suitability of 1/4-ton, 4x4 scout cars (Crosley Pup) for use in airborne operations
METHOD: Tests were conducted on the vehicles to determine starting and braking characteristics, maximum speeds in high and low gear ranges, fuel consumption, and maintenance requirements over a 15-day operating period. Mobility tests over varied terrain were conducted on the test vehicles with and without trailed loads. Ease and convenience of loading the vehicles into the C-47 plane and the CG-4A glider were also determined.
DESCRIPTION: The Crosley 1/4-ton, 4x4 scout car Model CT-3 was powered by a two-cylinder engine developing 13-1/2- bhp at 400 rpm. The vehicle was equipped with a three-speed transmission, two-speed transfer case, mechanical brakes, and quarter-elliptic springs.
CONCLUSIONS: The test vehicle was considered unsatisfactory because of limited carrying capacities, limited mobility as a prime mover in cross-country operations, increased maintenance problems as compared to the standard 1/4-ton vehicle, and insufficient power and speed. The test vehicle was not recommended for replacing or supplementing standard 1/4-ton, 4x4 vehicles.
GENERAL: This 27-page report contains three pages of photographs of the test vehicles and component parts.

SUBJECT: Scout Cars APG 5353/1
TITLE: Report on Test of Pilot Scout Car M2A1
IDENTIFICATION: First Report on Ordnance Program No. 5353; APG 13-1
DATE OF REPORT: 27 October 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the extent of compliance of the pilot model M2A1 Scout Car with Ordnance specifications
METHOD: The test vehicle was operated for 939 miles before receipt and for an additional 293 miles during compliance tests over varied terrain. These tests included weight distribution determination, fording, slope operation, speed, drawbar pull, cooling and safety tests.
DESCRIPTION: The Scout Car consisted of a commercial 4x4, truck chassis with special steel body and continuous gun track around the body interior. The vehicle was manufactured by the White Motor Company and was powered by a Hercules JXD, 6-cylinder, 95-hp engine. The payload capacity was 1850 pounds and the weight of the car was 7640 pounds.
CONCLUSIONS: The test vehicle with minor exceptions met the Ordnance specifications and was recommended for approval. The performance of the vehicle was excellent and superior to all previous scout cars.
GENERAL: This 166-page report includes 10 photographs of the test vehicle and components.

SUBJECT: Scout Cars APG 5395/1
TITLE: First Report on Test of Pilot Scout Car, M3A1
IDENTIFICATION: First Report on Ordnance Program No. 5395; APG 13-2
DATE OF REPORT: 27 July 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability, adaptability, mobility and reliability of the pilot model Scout Car M3A1
METHOD: Numerous engineering and operational tests were performed on the vehicle including determination of center of gravity, load distribution, limits of vision, starting characteristics, obstacle crossing, fording, slope operation, braking, drawbar pull, cooling, and endurance tests. The vehicle was operated a total of 1657 miles, including a 1190-mile overland run, and operation on deep sand, mud, and various other test courses.
DESCRIPTION: The pilot Scout Car, M3A1, was manufactured by the White Motor Car Company. It was a specially designed commercial type 4x4 chassis on which an armored open top body was mounted. Power was supplied by a 110-hp, six-cylinder, liquid-cooled, Hercules gasoline engine. Space was provided for a crew of eight including the driver. A tourelle gun mount was installed in the top of the body.
CONCLUSIONS: The performance of the test vehicle was satisfactory and it was considered superior to any scout car previously tested. It was recommended that, with modifications, the vehicle be adopted as standard. Numerous modifications were listed including a stiffer gun mount, a maximum gross weight of 10,000 pounds, improved springs, and provisions for mounting radio equipment.
GENERAL: The 122-page report contains 12 photographs showing general characteristics of the scout car and various radio installations.

SUBJECT: Scout Cars APG 5395/3
TITLE: First Report on Scout Car M3A1E1 (Buda-Lanova Diesel) and Scout Car M3A1 (Hercules Diesel)
IDENTIFICATION: Third Report on Ordnance Program No. 5395; APG 13-3
DATE OF REPORT: 24 January 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of diesel power for M3A1 series scout car use and to compare its performance with gasoline powered M3A1 Scout Car
METHOD: Two diesel and the one gasoline test vehicles were given highway operation and performance tests over varied terrain. Comparative cold starting, drawbar pull, cooling, slope operation, economy, and speed tests were conducted. Approximate total mileage compiled was 1600 miles for the M3A1 diesel, 8600 miles for the M3A1E1 diesel, and 8300 miles for the M3A1 gasoline scout cars.
DESCRIPTION: The M3A1 Scout Car was powered by a Buda-Lanova model 6-OT-317 diesel engine. The M3A1 diesel scout car was powered by a Hercules, model DJXD engine, and the M3A1 gasoline scout car was powered by a Hercules 6-cylinder, model JXD engine. All three vehicles had approximate net weights of 9800 pounds and carried

loads of 2000 pounds during most tests.
CONCLUSIONS: The diesel test vehicles were acceptable for scout car use and were superior to the gasoline vehicle in economy, fire hazard features and freedom from vapor lock, and were about equal in performance. It was recommended that endurance tests be conducted and that more powerful diesel engines be tested. A more adequate cooling system was also recommended.
GENERAL: This 149-page report includes 17 photographs of the test vehicles and their components.

SUBJECT: Scout Cars APG 5395/4
TITLE: First Report on the Scout Car M3A1E2 (Roof on Scout Car M3A1)
IDENTIFICATION: Fourth Report on Ordnance Program No. 5395; APG Report No. 13-5
DATE OF REPORT: 4 December 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and general suitability of an experimental armor roof for use with Scout Car M3A1
METHOD: The Scout Car M3A1, with the experimental armor roof installed, was operated over varied terrain.
DESCRIPTION: The test roof was made from 1/4-inch armor plate, and weighed approximately 550 pounds including supports and brackets. The roof contained front, side and rear flaps which could be raised or lowered to accommodate various gun elevations.
CONCLUSIONS: The test roof was very unstable during cross-country operation, and interfered with the proper manipulation of the guns. It was recommended that the project to design a suitable roof top be dropped because the advantage gained through overhead protection was completely overshadowed by lack of vision, increase in weight, and interference with operation of armament.
GENERAL: This 25-page report contains 12 photographs of the test roof mounted on the Scout Car M3A1.

SUBJECT: Scout Cars APG 5395/6
TITLE: First Report on Test of Daimler Scout Car (British)
IDENTIFICATION: Sixth Report on Ordnance Program No. 5395; APG No. 13-7
DATE OF REPORT: 16 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the military characteristics of the British Daimler Scout Car
METHOD: Engineering tests including center of gravity, load distribution and ground pressure, limits of vision, maximum and minimum speeds, drawbar pull, acceleration, and resistance to traction were conducted on the test vehicle. Other tests included the determination of gradeability, turning, braking, and starting characteristics, and fording and obstacle-crossing ability. The vehicle was operated a total of 309 miles.
DESCRIPTION: The British Daimler, 4x4, low-silhouette, two-man Scout Car was designed for reconnaissance work over rough terrain. Armor thickness was 7/16-inch on the sides, 1/4-inch on the top and rear of the radiator, and 1-inch on the front. The vehicle was powered by a Daimler 55-hp, six-cylinder, gasoline engine. The power train comprised a fluid flywheel, a Wilson self-changing five-speed transmission, a reversing gear permitting high-speed operation in reverse, a differential and shafting to bevel gear boxes at each corner of the frame, adjacent to the wheels. Four-wheel steering was incorporated and all wheels were independently sprung. The maximum speed was approximately 56 mph.
CONCLUSIONS: The test vehicle, in general, performed satisfactorily. The transmission, armor, and the independent suspension system were considered satisfactory. Disadvantages included an underpowered engine, excessive steering effort, inadequate rear vision, inadequate armament, rough riding characteristics because of a short wheelbase and stiff suspension springs, inaccessibility of engine compartment and driver's seat, and unsatisfactory operation over very rough terrain because of slippage in the fluid flywheel and low ground clearance. It was recommended that no further consideration be given to this vehicle, but that the independent suspension system be studied for possible adoption in wheeled vehicles used for similar purposes.
GENERAL: This 108-page report contains 21 photographs of the test vehicle and limits of vision.

SUBJECT: Scout Cars APG 5511
TITLE: First Report on Test of Allis-Chalmers Full Track Laying Reconnaissance Vehicle V-40
IDENTIFICATION: Ordnance Program No. 5511; APG 17-22
DATE OF REPORT: 9 April 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the general engineering and operating characteristics of the vehicle and its suitability as a scout car and light prime mover
METHOD: Pertinent physical and performance characteristics, including general cross-country and road mobility, were evaluated with a 700-pound payload. A total of 1513 miles of operation were accumulated, 690 of which were on the delivery run from the factory. No towed load was used in the tests.
DESCRIPTION: The test vehicle was designed and built by the Allis-Chalmers Manufacturing Company. It was a full-tracked vehicle powered by a four-cylinder, 50-hp engine. The vehicle weighed 4200 pounds, bare, and seated four men, including the driver.
CONCLUSIONS: The test vehicle was found to be unsatisfactory due to poor slope climbing, and fording ability, and mechanical failures, but it was considered worthy of further development. It was recommended that better crew protection be provided against the weather, and that the power train and operating mechanism be shielded against striking obstacles during travel.
GENERAL: This 162-page report contains 30 photographs showing vehicle construction, field of vision, and mechanical failures.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Scout Cars APG 5539/1
TITLE: First Report on Test of Scout Car M3A1E3 with 37-mm Gun Mount T6
IDENTIFICATION: First Report on Ordnance Program No. 5539; APG 13-4
DATE OF REPORT: 12 August 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of Scout Car M3A1 and Gun Mount T6 as a self-propelled mount for the 37-mm anti-tank gun and to obtain firing test data
METHOD: The test vehicle was given center of gravity, security from observation, flexibility, stability and noise tests. The scout car was operated over a washboard course, and firing tests were conducted. Fifty-one rounds of ammunition were fired at stationary targets while traveling at speeds up to 15 mph.
DESCRIPTION: A 37-mm Gun M3 and 37-mm pedestal-type Mount T6 were installed on a standard M3A1 Scout Car. The test vehicle was manufactured by the Wellman Engineering Company and had a net weight of 9344 pounds and maximum cargo load of 2316 pounds.
CONCLUSIONS: The vehicle was too large to be used as a 37-mm gun motor carriage, and its use was not recommended. The T6 Gun Mount was acceptable for 37-mm Gun M3. The firing stability of the vehicle was satisfactory only when stationary. Muzzle blast did not cause crew discomfort. It was concluded that the rate of aimed fire could be increased by using a semi-automatic breech mechanism similar to that used on the M6 Gun.
GENERAL: This 48-page report includes seven photographs of the test vehicle.

SUBJECT: Scout Cars APG 5887/12
TITLE: First Partial Report; German Wheeled and Tracked Armored Observation Vehicle
IDENTIFICATION: Twelfth Report on Ordnance Program No. 5887
DATE OF REPORT: 4 February 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of various design characteristics of a German wheeled and tracked armored observation vehicle; and to determine the disposition status of the vehicle
METHOD: The test vehicle was inspected.
DESCRIPTION: The test German wheeled and tracked observation vehicle was unique in that it was designed to be equipped with both wheels and tracks. Wheels were provided for the purpose of supporting and propelling the vehicle when operating over relatively smooth terrain. When encountering rough and muddy terrain, the wheels could be retracted permitting the tracks to serve as the means of supporting and propelling the vehicle. The test vehicle, which was badly shot up and missing numerous components, was identified through the British publication "Target" and through GSI Issue No. 60-B-3.
CONCLUSIONS: Inspection revealed that the vehicle was designed for maneuverability and speed regardless of the terrain conditions encountered. Armor thickness was sufficient only for protection against small arms fire. Although GSI Report No. 60-B-3 indicated that an AA LMG may have occasionally been included as vehicle armament, it was felt the vehicle was to be used strictly as an observation vehicle; this was partially substantiated by the fact that no fixed gun mount was found in the test vehicle. A surprising amount of room was provided in the vehicle hull in view of the fact that no turret and basket were incorporated in the vehicle design. Since so many vital parts were missing, it was recommended that no attempt be made to put the vehicle, as a whole, into running condition; and that, if possible, the wheel raising and lowering mechanism be put in working order. It was further recommended that the vehicle be cleaned up and put on exhibition in a closed building.
GENERAL: This 17-page report contains four illustrations of the test vehicle.

SUBJECT: Scout Cars OTAC KG 324
TITLE: Scout Cars T25, T25E1, T25E2 and T25E3
IDENTIFICATION: Project No. KG-324
DATE OF REPORT: 1 October 1943
ORIGIN: Ordnance Tank-Automotive Center, Detroit, Michigan
PURPOSE: To determine the suitability of four slightly-different conversions of 4x4, 1/4-ton trucks to light scout cars
METHOD: Operational testing was done at Fort Knox, Kentucky under the cognizance of the Armored Force Board. Test details and conclusions were recorded in the report of Project No. 410. The four test vehicles were loaded with the equivalent of a three-man crew plus 515 pounds of equipment as prescribed by regulations. The test scout cars were operated cross-country for a total of 1337 miles, were given hill climbing tests, and were subjected to fire from .30 caliber rifles.
DESCRIPTION: Standard Willys-Overland 4x4, 1/4-ton trucks were covered with 1/4-inch thick armor plate in an attempt to convert these vehicles into scout cars. The standard, basic 1/4-ton truck when used for reconnaissance, was overloaded by 240 pounds. With the addition of armor, the T25 Car was overloaded by 785 pounds, the T25E1 was overloaded by 1005 pounds, the T25E2 was overloaded by 1250 pounds, and the T25E3 was overloaded by 1265 pounds.
CONCLUSIONS: The basic 1/4-ton vehicle frame, chassis and power plant could not accommodate the additional weight imposed by the addition of the armor. It was recommended that Scout Cars T25, T25E1, T25E2, and T25E3 be considered unsatisfactory as reconnaissance vehicles and that their development be terminated.
GENERAL: This 135-page report includes eight photographs of the test vehicles, and the Armored Force Board report of Project No. 410.

SUBJECT: Scout Cars PG-2.506
TITLE: Acceptance Test of Scout Car M3A1-White
IDENTIFICATION: Report No. PG-2.506; GMPG Project No. 65-1
DATE OF REPORT: 6 October 1942
ORIGIN: General Motors Proving Ground, Mil-

ford, Michigan
PURPOSE: To determine the acceptability of Scout Car M3A1
METHOD: The test vehicle was operated for 872 miles over various terrain and given standard acceptance tests including mechanical inspection, performance and endurance tests.
DESCRIPTION: The test vehicle was a M3A1 Scout Car, Ordnance Serial No. 5035, manufactured by the White Motor Company and powered by a liquid cooled Hercules, 6-cylinder gasoline engine, Model JXD.
CONCLUSIONS: The performance of the vehicle was acceptable except for dirt penetration into the brakes, and brake line hose contact with the chassis floor. Redesign of the brakes to prevent entry of dirt and hose contact with the chassis floor was recommended.
GENERAL: This 105-page report includes 11 photographs of the test vehicles and damaged components.

SUBJECT: Scout Cars PG-2.723
TITLE: Comparative Durability of Steel and Wooden Bodies on 4x4 Command Reconnaissance Cars
IDENTIFICATION: Report No. PG-2.723; Project No. D-152
DATE OF REPORT: 28 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the serviceability and durability of steel and wooden bodies for the 4x4 command reconnaissance car
METHOD: Six wood-bodied cars and one steel-bodied car were operated in a convoy on a 200-mile endurance test. The vehicles were loaded with 800 pounds, including the driver, and were subjected to rough service.
DESCRIPTION: The 4x4 reconnaissance car was essentially the 1/4-ton, 4x4, truck (Jeep). The test bodies were fabricated almost entirely of wood by the Alma Trailer Co., the Covered Wagon Trailer Co., and the Canadian American Truck Co. A standard steel-bodied vehicle was supplied by Willys-Overland.
CONCLUSIONS: It was recommended that the best features of the three bodies, with numerous reinforcements, be combined in a single body and tested for at least 5000 miles. The chassis components of the test vehicles were poor and failed more frequently than the bodies.
GENERAL: This 267-page report contains 76 photographs showing construction of the various wood bodies and failures encountered in both the bodies and chassis components.

SUBJECT: Scout Cars PG-2.761
TITLE: Desert Test of Scout Car M3A1 — White
IDENTIFICATION: Report No. PG-2.761; GMPG Project No. 51-2
DATE OF REPORT: 3 August 1943
ORIGIN: General Motors Proving Ground (Phoenix Laboratory), Phoenix, Arizona
PURPOSE: To determine the effect of dust and high temperatures, encountered in desert operation, on the M3A1 Scout Car
METHOD: The test vehicle was operated 2020 miles on the Phoenix test area endurance course. Engine cooling and vapor lock studies were made and oil samples were analyzed to determine the extent of dust entrance.
DESCRIPTION: The M3A1 Scout Car was an armored 4x2 vehicle, manufactured by White and powered by a six-cylinder Hercules JXD engine.
CONCLUSIONS: Cooling and vapor lock characteristics were unsatisfactory in extreme heat. Dust infiltration was slight and posed no serious problem. The rear springs bottomed rather readily and damage to several components resulted from rear axle interference. Both springs were broken during the test and the rear differential failed. Modifications were recommended to correct these deficiencies.
GENERAL: This 158-page report contains 17 photographs illustrating deficiencies and failures.

SUBJECT: Scout Cars PG-2.841
TITLE: Supplementary Report on Scout Car M3A1 — White
IDENTIFICATION: Report No. PG-2.841
DATE OF REPORT: 7 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To record the operation of Scout Car M3A1 used during various Ordnance tests
METHOD: The test vehicle was operated for a total of 13,874 miles over the Proving Ground Endurance Tank Route as follows: 7396 miles during Project No. 11, Report Nos. 2.335 and 2.335A-"U" Joints and Engineering; 470-miles during Project No. 30.3, Report No. 2.446-Vapor Lock; 6008 miles during Project No. 93, Report No. 2.841-Tubeless Combat Tires; Project No. 33-12, Report No. 2.629-Spun Steel Fan Pulley; and Project No. 33-31, Report No. 2.776-ABC Brake Control.
DESCRIPTION: The test vehicle was Scout Car M3A1, Ordnance Serial No. 1728, built by the White Motor Co.
CONCLUSIONS: Conclusions and recommendations were incorporated in the individual reports of each sub-project and were not included in this supplementary report.
GENERAL: This 129-page report includes 12 photographs of failed parts and a log of vehicle operation and service.

SUBJECT: Scout Cars PG-2.862
TITLE: Standard Inspection Control Test on Scout Car M3A1 — White
IDENTIFICATION: Report No. PG-2.862; Project No. 206-11
DATE OF REPORT: 9 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine whether the Scout Car M3A1 was built to specification
METHOD: The vehicle was inspected, and performance and brake tested during 536 miles of

operation.
DESCRIPTION: The test Scout Car M3A1, Ordnance Serial No. 14734, was built by the White Motor Company. It was powered by a Hercules JXD, six-cylinder gasoline engine and equipped with a White 43B-AV transmission.
CONCLUSIONS: The only important mechanical or design deficiency of the vehicle was that the air cleaner was not adequately shielded from mud and water thrown up by the front wheels. The right turning radius was 60.3 feet, and the left was 62.5 feet; the specification radius was 57 feet. Acceleration and slope operation were satisfactory, and braking was slightly deficient.
GENERAL: This eight-page report includes two photographs of the vehicle and one photograph of the fouled air cleaner.

SUBJECT: Scout Cars PG-2.902
TITLE: Supplemental Report on 1/4-ton, 4x4, Command Reconnaissance Car — Willys
IDENTIFICATION: Report No. PG-2.902; Project No. D-148
DATE OF REPORT: 2 May 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile test data resulting from operation of a Willys Command Reconnaissance Car from the time it was assigned to Project No. D-148 until it was shipped. (3-15-43, 8-18-43)
METHOD: Five previous different tests were given the vehicle during the time it was assigned to this project. Charts, photographs, logs, and repair records of these projects were accumulated into one report.
DESCRIPTION: This 2383 pound, 60 bhp, Willys-Overland Jeep, Ordnance Serial No. 212044, had Bendix hydraulic brakes, Borg and Beck clutch, and Spicer transfer case.
CONCLUSIONS: Conclusions and recommendations covering each test were to be included in the individual reports of these tests and are not included in this supplementary report.
GENERAL: This 91-page report includes 15 photographs of the vehicle and failed components.

SUBJECT: Scout Cars PG-2.920
TITLE: Standard Inspection Control Test on Scout Car M3A1
IDENTIFICATION: Report No. PG-2.920; Project No. 206-24
DATE OF REPORT: 3 November 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine whether the test vehicle was built to specification
METHOD: The test vehicle was inspected, and performance and brake tested. A total of 707 miles were covered over the Proving Ground courses.
DESCRIPTION: The test vehicle was Scout Car M3A1, Ordnance Serial No. 17398. It was built by the White Motor Co., Cleveland, Ohio. Power was from a six-cylinder, liquid-cooled Hercules JXD engine through a White 43B-AVS transmission.
CONCLUSIONS: The vehicle was satisfactory except for the following: The starter inspection straps were ineffective in keeping dirt out of the starter. The right turning radius was 60.8 feet and the left was 59.5 feet; the specification radius was 57 feet.
GENERAL: This 10-page report includes two photographs of the test vehicle.

SUBJECT: Scout Cars PG-2.987
TITLE: Supplementary Report on Scout Car M3A1 — White
IDENTIFICATION: Report No. PG-2.987
DATE OF REPORT: 16 December 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To record the operation of Scout Car M3A1 used during various Ordnance tests
METHOD: The test vehicle was operated a total of 3330 miles over the Proving Ground Endurance Tank Route during the following tests: Project No. 93, Report No. 2.716 — Tubeless Bead Lock Tires; Project No. 168, Report No. 2.742-9.00 x 20 Tires; Project No. 33-31, Report No. 2.776-ABC Brake Control; Project No. 33-38, Report No. 2.736-Radiator Bug Screen; Project No. 33-41, Report No. 2.837 — Rear Brake Flexible Hose; and Project No. 33-43, Report No. 2.777-Rust Preventive WS-578.
DESCRIPTION: The test vehicle was Scout Car M3A1, Ordnance Serial No. 10332, built by the White Motor Car Co.
CONCLUSIONS: Conclusions and recommendations of each sub-project were incorporated in the individual reports, and were not included in this supplementary report.
GENERAL: This 124-page report includes 21 photographs of failed parts and a log of vehicle operation and service.

SUBJECT: Scout Cars PG-2.1071
TITLE: Durability Test-Scout Car M3A1, White Motor Company
IDENTIFICATION: Report No. PG-2.1071; GMPG Project No. 252
DATE OF REPORT: 11 May 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of a modified Scout Car M3A1
METHOD: The test vehicle was operated 4000 miles over varied terrain and the endurance course. Test weight of the vehicle was 13,000 pounds.
DESCRIPTION: The test vehicle was a modified White M3A1 Scout Car. The modifications consisted of rear axle rubber bumpers, frame reinforcements over the front axle, a half-track front spring hanger on the right side, relocated spare liquid containers under the rear bumper, and an air cleaner with a splash shield.
CONCLUSIONS: The first pair of rubber bumpers failed after 958 miles because of faulty load distribution, and the second pair failed after 3065 miles. The frame reinforcements, the front spring

hanger and the air cleaner splash shield operated satisfactorily. The endurance performance of the rest of the vehicle units was generally satisfactory. Liquid containers under the rear bumper were not considered satisfactory. Further development of the rubber bumper mountings, transfer case and rear axle was recommended.

GENERAL: This 175-page report contains 50 photographs of the test vehicle and failed parts at various mileages.

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Section 34
SEALS AND CLOSURES

SUMMARY

This summary covers resumes of 91 engineering reports written on seals and closures between 1935 and 1955. The reports were prepared at Aberdeen Proving Ground, Maryland; Detroit Arsenal, Center Line, Michigan; Frankford Arsenal, Philadelphia; Tank Arsenal Proving Ground, Utica, Michigan; Rock Island Arsenal, Illinois; General Motors Proving Ground, Milford, Michigan; Army Ground Forces Board No. 2, Fort Knox, Kentucky; Cleveland Tank Plant of General Motors Corporation; and Chrysler Engineering Division, Detroit, Michigan.

A wide variety of seals and closures for assorted uses was subjected to laboratory and proving ground tests. Among others, the following types of seals and closures were investigated: seals or closures for track pins and joints; bearing seals for bogie wheels; rubber seals for turret base ring; gasket materials; periscope segment seals; door weather seals; plastic hardtop closures for trucks; rear wheel brake seal system for trucks; flange sealers; auxiliary engine air cleaner seals; sponge seal for tank cupolas; grommet seals; rubber mastic sealant; rubber turret bearing seals; seals for metal end fiberboard containers; support roller seals; grease seals; polybutane sealants; trailer roof sealant; cable sealing glands; rotary seals for optical instruments; seals for suspension systems; shock absorber rod guide seal; packing glands for main engine primer pump; spline sealer; headlamp-to-hull sealing gaskets; pneumatic equilibrator packing; recoil mechanism packing; circuit breaker neoprene sealing gaskets; packing gland adapter assemblies; and juncton box rubber gaskets.

Among the manufacturers who supplied seals or closures for tests were: Garlock Packing Company, National Beemer Company, U. S. Rubber Company, Armstrong Cork Company, Chicago Rawhide Manufacturing Company, Victor Manufacturing and Gasket Company, General Tire and Rubber Company, National Motor Bearing Company, Johns-Manville Company, Crane Packing Company, Vickers Company, Testaguzza Brothers and Company, GMC Truck and Coach Division, Cannon Electric Company, Keystone Manufacturing Company, Kaydon Manufacturing Company, Goodrich Tire and Rubber Company, Minnesota Mining and Manufacturing Company, Allied Precision Industries, Incorporated, Thickel Corporation, Cadillac Motor Car Division, Monroe Shock Absorber Company, Skinner Motors, Delco-Remy Division, Resistoflex Company, E. F. Houghton and Company, and Auto-Lite Company.

In general the seals or closures were tested for suitability or were compared with other seals or closures to determine which of several test samples performed more effectively for specific applications under given conditions.

REPORT RESUMES

SUBJECT: Seals and Closures AFF-1082
TITLE: Report of Test of Project No. 1082 Ground Joint, Face Type, Seals in Bogie Wheels of Medium Tank, M4A3E8
IDENTIFICATION: Project No. 1082
DATE OF REPORT: 23 July 1946
ORIGIN: Army Ground Forces, Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine the comparative suitability of ground joint, face type and standard seals in bogie wheels of Medium Tank M4A3E8
METHOD: The test and standard lip seals were installed in alternate positions on a medium tank and operated a total of 2064 miles over varied terrain in all types of weather. Records of all bogie wheel lubrication at each 25-hour vehicle check was maintained.
DESCRIPTION: The test ground joint, metal face seals, manufactured by the Chicago Rawhide Company, were of two basic components: a metal ring with a ground surface or face, which was installed over the axle shaft collar, and a similar ring built into a flexible seal body that was pressed into the hub recess. The two ground surfaces were kept in contact by a strip-type expansion spring under a rubber mounting.
CONCLUSIONS: The test seal was found to be inferior to the standard lip type because of excessive wear of the backing plate and the ground face and separation of the seal ring surface from the rubber mounting. It was considered unsatisfactory, but further development and testing were recommended.
GENERAL: This 44-page report includes 10 photographs illustrating ground joint and standard seals before and after test and two photographs of installations.

SUBJECT: Seals and Closures APG 5290
TITLE: First Partial Report on Suitable Seals or Closures for Track Pins and Other Joints
IDENTIFICATION: Ordnance Program No. 5290
DATE OF REPORT: 15 April 1936
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of various

commercial seals and closures for tracks
METHOD: Several commercial seals were laboratory tested on a bearing testing machine. This machine was designed so that a load could be applied to the bearings which the closure was sealing. Leakage could occur only at the seal under test. Sand and dirt were located in the machine so that a failed seal would allow this abrasive material to work into the bearings. Spreader and hat type Garlock Klozures, as well as standard seals were tested in a T1E3 half-track car. Thorough inspections were made during and after the 608-mile test.
DESCRIPTION: The Garlock Klozure seals were manufactured by the Garlock Packing Company and were designed for a 3/4-inch shaft with a 1.375 bore, 3/8-inch thick. The spreader type seal had a ring of spring spreaders designed to keep the sealing member against the shaft. The hat type utilized a rubber ring instead of the spring spreaders. The Beasley closure was a rubber ring operating on the theory that the rubber fibers were in a constant state of tangential and radial stress. The rubber rings were pressed into place and had the same composition as the rubber bushings in the track links. The Milpaco seal, type JIW, was a double seal designed to prevent escape of the lubricant. The unit employed a heavy leather packing with a beveled wiping edge, and a coiled pressure spring to distribute the pressure around the wiping edge and hold the packing member to the shaft.
CONCLUSIONS: It was believed that the length of time the seals performed satisfactorily in the machine was not an indication that they would protect the bearings for any length of time. Field test data were insufficient for evaluation with the data obtained during laboratory tests. The Garlock Klozures proved less effective than the standard seals during the field test and were considered inadequate. Further laboratory and field tests were recommended.
GENERAL: This 36-page report contains 13 photographs of the test seals and apparatus. Also included are two drawings of the bearing testing machine.

SUBJECT: Seals and Closures APG 5290/2
TITLE: Second Partial Report on Suitable Seals or Closures for Track Pins and Other Joints
IDENTIFICATION: Second Report on Ordnance Program No. 5290
DATE OF REPORT: 30 August 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a commercial type seal for application on military vehicles
METHOD: Eight test seals were installed on the right bogie wheels of a half-track truck T5. Seals were installed with lips toward and away from the bearing in order to determine which method of installation would decrease the probability of seal failure. After 1559 miles of operation over varied terrain, the vehicle bogie wheels were removed and the test seals were inspected.
DESCRIPTION: The test commercial seals, identified as Garlock Klozures, were manufactured by the Garlock Packing Company, Palmyra, New York. The seals consisted of the following separate members: a V-shaped hard composition sealing member; a spreader, or spring, which was provided to keep the lip of the sealing member in close contact with the shaft upon which it was installed; a case, or housing, for the seal and spreader; and a circular ring adapter over which the upper edge of the case was crimped to lock the entire unit together.
CONCLUSIONS: The test closures satisfactorily retained grease but were considered unsatisfactory for use on Ordnance vehicles because of their poor durability characteristics. Installation of the seals with their lips toward the bearings decreased the probability of seal failure.
GENERAL: This seven-page report contains one photograph showing the test seal and an earlier design of the test seal.

SUBJECT: Seals and Closures APG 5542/1
TITLE: First Report on Seals and Closures, O. O. Experimental Modified
IDENTIFICATION: First Report on Ordnance Program No. 5542
DATE OF REPORT: 15 September 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of an experimental bogie wheel seal for medium tank M3
METHOD: The test seal was installed in the No. 6 left bogie wheel position of a medium tank M3 and was given an endurance test of 473 miles. The vehicle was operated over 418 miles of paved road, 13 miles on gravel, and over 42 miles of cross-country terrain. The closure was then disassembled and examined.
DESCRIPTION: The test bogie wheel seal was fabricated of steel and had a colmonoy-faced seat.
CONCLUSIONS: The test seal was considered an unsatisfactory closure for bogie wheel bearings. The surfaces showed definite signs of wear, and foreign matter was found on the bearing side and in the bearing grease. In fact, no bogie wheel seals used on production vehicles through the period of this report had been found to be satisfactory. It was recommended that the test seal be modified as set forth in the report and retested.
GENERAL: This 73-page report includes two photographs showing the worn seals, and six drawings.

SUBJECT: Seals and Closures APG 5542/1 Min.
TITLE: First Minor Report on Seals and Closures, O.O. Experimental - Medium Tank Bogie Wheels
IDENTIFICATION: First Minor Report on Ordnance Program No. 5542
DATE OF REPORT: 18 June 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the test oil seals for use on the bogie wheels of medium tank M3
METHOD: The test seals were installed on the left center front and the left center rear bogie wheels of medium tank M3. At the same time, new

standard seals were installed on the right center front and the right center rear bogie wheels. The facility vehicle was operated a total of 843 miles.
DESCRIPTION: The left center rear bogie wheel was equipped with carbon steel seats A176046, and 40 Durometer rings, A176044. The left center front bogie wheel was equipped with Morganite seats A176098 and 35 Durometer rings A176044.
CONCLUSIONS: The standard retainers were declared to be superior to the test seals which had either failed completely or shown excessive wear at the end of test operation. It was recommended that tests on this type of closure be discontinued and that no further consideration be given to their use.
GENERAL: This 19-page report includes two photographs showing the test seals after being removed from the vehicle for inspection.

SUBJECT: Seals and Closures APG 5542/2
TITLE: First Report on Rubber Seals for Turret Base Ring on Medium Tanks
IDENTIFICATION: Second Report on Ordnance Program No. 5542
DATE OF REPORT: 22 November 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effectiveness of the test seals in keeping dirt and foreign matter out of the turret bearing races and the effect they would have on turret traversing
METHOD: Five seals were installed on medium tanks, four of which averaged 2250 miles each of operation over concrete, gravel, and cross-country roads.
DESCRIPTION: These seals consisted of a flat band made of neoprene with a steel coil spring in the center. The bulge in the center, made by the spring, fitted into the space between the turret base and the hull. The test seals were made by the U.S. Rubber Company.
CONCLUSIONS: Before the seals were lubricated there was a marked increase in the turret traversing effort; after lubrication the average increased resistance-to-traversing was 30 ft.-lbs. While the test seals kept out some dust and foreign matter, they were not satisfactory. It was recommended that the test seals not be adopted and that work be continued to improve the standard inner seals currently used on medium tank turrets.
GENERAL: This 28-page report includes three photographs of the test equipment and one drawing of the neoprene seal.

SUBJECT: Seals and Closures APG 5542/2 Min.
TITLE: First Minor Report on Test of Seals and Closures (National Beemer Company) for Half-Track Cars, M2
IDENTIFICATION: Second Minor Report on Ordnance Program No. 5542
DATE OF REPORT: 14 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the durability of the test oil seals with standard seals in the bogie wheels of half-track vehicles
METHOD: Test seals, bearing designations "N" and "NL", were installed on the right side of two half-track vehicles and standard seals were installed on the left side. The vehicles were then operated a total of 1886 and 1866 miles, respectively.
DESCRIPTION: The National Beemer Company used a special synthetic material, Neoplastek, for the sealing members, instead of leather as was used on the standard seals. Neoplastek was a reinforced synthetic cellulose fiber having no cold-flow characteristics under increased pressures and heat. Test seals designated "N" had both sealing members of Neoplastek; the "NL" seals had the inner sealing member of National chrome retanned leather and the outer wiping lip of Neoplastek. The leather was impervious to the softening action of lubricants.
CONCLUSIONS: The test seals were considered unsatisfactory due to a right side bearing failure in both vehicles. The Neoplastek material did not satisfy the requirements for use in the suspension system of half-track vehicles. It was recommended that neither of the two types of oil seals be used in the half-track suspension system.
GENERAL: This 24-page report includes four drawings of the test oil seals.

SUBJECT: Seals and Closures APG 5544/10
TITLE: First Report on Carburetor Dust Seals For Wright R975-EC2 Engine
IDENTIFICATION: Tenth Report on Ordnance Program No. 5544; APG 20-38
DATE OF REPORT: 23 March 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a leather dust seal for the accelerator pump and rubber ring seals for the throttle shaft on the carburetor of the Wright R975-EC2 engine
METHOD: A leather dust seal was installed on the accelerator pump of a Bendix-Stromberg NAR-9D carburetor. Rubber ring seals were installed on the throttle shaft and given a liquid test. The carburetor was then mounted on the engine of a medium tank and operated 70:40 engine hours and 1218 miles; after which the carburetor was removed, and the liquid test repeated. The liquid test consisted of sealing the carburetor to hold a sufficient head of gasoline in the throttle and governor box to check the rate of gasoline leakage past the seals on the throttle shaft.
DESCRIPTION: The accelerator pump seal was a leather cover secured with metal clamps. The rubber, ring-type, seals were placed in grooves on the throttle shaft.
CONCLUSIONS: The test showed evidence that the leather cover would be as satisfactory as the rubber cover previously used, provided there were sufficient metal clamps. Acceptance of the leather cover was recommended until the carburetor could be modified to incorporate an internal pump mechanism or to extend the housing around the present unit. The rubber ring seals were not a satisfactory means of sealing the throttle shaft, and adoption of them was not recommended. A temporary field fix was proposed to seal the accelerator pump, and felt or rawhide seals were

recommended for the throttle and governor shafts.
GENERAL: This 33-page report contains seven photographs showing the standard carburetor and the proposed field fix, the test installation, the throttle shaft and ring seals, and the test setup for measuring throttle shaft leaks.

SUBJECT: Seals and Closures APG 5688/1 Min.
TITLE: First Minor Report on Comparison of Armstrong Gasket Material with Vellumoid and Cork Gasket Materials
IDENTIFICATION: First Minor Report on Ordnance Program No. 5688
DATE OF REPORT: 17 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether the Armstrong gasket material could be substituted for materials currently used on tank and combat vehicles
METHOD: The new Armstrong material Vellumoid, and cork gasket materials were comparatively tested according to manufacturer's sales specifications. Dimensional changes were determined by measuring the samples after 24 hours over calcium chloride at 120°F and again after 24 hours at room temperature. Loss of weight was determined after the samples had been placed in a 212° oven for 3 hours. Absorption of gasoline and oil was measured after immersing the samples in the liquid for 24 hours. Pliability was also tested.
DESCRIPTION: The test material was a fibrated leather substance manufactured by the Armstrong Cork Company. It was made from a paper sheet containing 50% by volume of fibrated leather saturated with 60% of its weight with glue and glycerin; the material was made insoluble with a tanning agent.
CONCLUSIONS: The Armstrong gasket material performed as well as Vellumoid and cork. It was recommended that the test material be used as a substitute for Vellumoid.
GENERAL: This 13-page report includes a listing of the manufacturer's sales specifications.

SUBJECT: Seals and Closures APG 5688/60
TITLE: First Report on Test of Seals for Openings in Combat Vehicles
IDENTIFICATION: Sixtieth Report on Ordnance Program No. 5688
DATE OF REPORT: 1 October 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effect of dust, water and grease on experimental periscope segment seals under field conditions
METHOD: Two periscopes with the experimental seals were installed in a heavy tank M26 and operated 613 miles on cross-country and 219 miles on paved and gravel roads. One segment and seal were installed in the assistant driver's door and the other in the turret roof. The segment and seal in the turret roof were lubricated. A check was made for possible binding of the segment.
DESCRIPTION: The seal was made from Specification 20-116A BCEF, Class SC530 synthetic rubber and included a stainless steel spring to hold the seal in place. In order to use the seals a 1/16-inch groove was machined in the rim of the standard periscope segments.
CONCLUSIONS: The effort required to rotate the segments did not increase when the seals were properly maintained; no deterioration of the seals was evident. No recommendations were made regarding suitability due to limited testing. It was recommended that a ballistic test be conducted on the segment to determine the loss in protection because of the machining modification.
GENERAL: This 22-page report contains three photographs of the seals and a sketch of the segments.

SUBJECT: Seals and Closures APG 5688/90
TITLE: First Report on Bogie Wheel Bearing Seals for Medium Tank with Horizontal Suspension
IDENTIFICATION: Ninetieth Report on Ordnance Program No. 5688
DATE OF REPORT: 30 December 1946
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the suitability of face-type seals and Benson shaft-type seals with standard seals used in bogie wheels
METHOD: The two test-type seals and standard Chicago Rawhide type seals were installed in the bogie wheels of medium tank M4E8. Half of the wheels sealed with face-type seals were lubricated with SAE No. 30 engine oil; the remaining wheels were lubricated with grease. Operations covered 1533 miles of varied terrain. All the seals were removed and inspected after test.
DESCRIPTION: The face-type seal was manufactured by the Chicago Rawhide Manufacturing Company. Its two basic components were a metal seal ring pressed over the axle shaft collar and a similar ring built into a flexible body and pressed into the wheel hub recess. Sealing was accomplished by holding the two surfaces together under pressure by a wave spring. The Benson shaft-type seal was a neoprene rubber seal encased in a metal ring. Two Benson seals were required for each wheel; both seals were pressed together into the wheel hub. Sealing occurred at the spindle where the neoprene surface was held against the shaft by the pressure of sponge rubber located between the neoprene and the case.
CONCLUSIONS: Neither the standard nor the test seals were completely satisfactory. Both the standard Chicago Rawhide and the test Benson shaft-type seals were considered superior to the face-type seal. The most serious weakness in the Benson seal was the cutting and breaking of the sponge rubber. Grease was held within bogie wheel bearings more readily than oil; however, more silica and foreign matter entered the grease-lubricated wheels. It was recommended that development of bogie wheel grease and oil seals be continued. Testing the Benson shaft-type seals in cold weather and a study of permanent sealed bearings for use in bogie wheels were also recommended.
GENERAL: This 34-page report contains eight photographs of the seals as tested.

SUBJECT: Seals and Closures APG 5688/101
TITLE: First Report on Test of Bogie Wheel

Seals for Medium Tank, M4E8
IDENTIFICATION: One Hundred First Report on Ordnance Program No. 5688
DATE OF REPORT: 17 March 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the effectiveness of experimental bogie wheel seals with the standard seal
METHOD: Four types of test seals underwent comparison testing with standard seals while installed in a medium tank, M4E8. The facility vehicle was operated over various test courses until seal failures occurred. Total operation on this set was 785 miles. All seals were then removed, inspected, and another set was installed in the vehicle. This set was operated over similar test courses for 695 miles and was then removed for inspection.
DESCRIPTION: The Victor Manufacturing and Gasket Company seal was of the shaft-type and had two synthetic sealing elements, or lips, enclosed in a metal case. The Ohio Rubber Company seals were of the shaft-type and were similarly constructed, the only difference being that one type had two lips and the other only one. The Chicago Rawhide Manufacturing Company seal was the standard seal for the medium tank, M4E8, with the horizontal volute suspension. This seal had two lips, one of synthetic rubber and the other of leather construction.
CONCLUSIONS: Neither the standard nor experimental seals gave satisfactory performance. They had either functioned improperly, shown excessive wear, or had failed completely. It was recommended that the experimental seals be considered unsatisfactory in their present stage of development and that the field test method of evaluating seals be set aside until a new and more scientific analysis was developed. It was also recommended that the possibilities of utilizing permanently sealed bearings be investigated.
GENERAL: This 46-page report includes eight photographs showing the standard and experimental seals. Also included is a brief outline of a proposed plan for solving the problem of seal development.

SUBJECT: Seals and Closures APG 5693/7
TITLE: First Report on Test of Special Bogie Wheel Seals and Controlled Differential Brake Drum for Universal Carrier T16
IDENTIFICATION: Seventh Report on Ordnance Program No. 5693; APG 24-207
DATE OF REPORT: 3 March 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the comparative merits of Chicago Rawhide and Ohio Rubber bogie-wheel seals, and to determine the life of the controlled differential brake linings and brake drums in Universal Carrier T16
METHOD: The Chicago Rawhide seals were installed in the left idler wheel, and bogie wheels and track support rollers of the left front and right rear suspension assemblies of the vehicle, while the Ohio Rubber seals were installed in the right front and left rear suspension assemblies. Controlled differential brake linings and brake drums were also installed. The vehicle was operated 528 miles over varied terrain.
DESCRIPTION: The Chicago Rawhide seals had two sealing lips, one rawhide and the other, a synthetic composition. Both lips were partially encased in a heavy retainer, and a coil spring was provided to exert the necessary pressure on the lips for proper sealing. The test brake linings, B241145, utilized both diagonal concentric and standard grooves. The test drums were similar to the standard except that they had a finish of 64 rather than 150-micro-inch.
CONCLUSIONS: Little difference was noted in the wear or sealing qualities of the two seals. However, the test mileage was considered inadequate to determine superiority. The controlled differential brake band toggle link and the brake shoe hinge lugs were not satisfactory. It was recommended that further work be done on the differential steering and lubrication in an effort to increase the efficiency of the brake linings.
GENERAL: This 28-page report contains six photographs of the seals, swamp terrain operation, and controlled differential parts.

SUBJECT: Seals and Closures APG TB5-1401/39
TITLE: Desert Tests (1952) Experimental Oil Filter Gaskets
IDENTIFICATION: Thirty-ninth Report on Project No. TB5-1401
DATE OF REPORT: 23 September 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effectiveness of an experimental engine oil filter gasket after repeated filter element changes
METHOD: Experimental gaskets were installed in the oil filter containers of eight 3/4-to-5-ton trucks. These trucks were each operated for approximately 10,000 miles, in ambient temperatures up to 123°F. One oil filter change was made for each truck during the course of the test.
DESCRIPTION: The experimental filter gaskets were made of oil-resistant, reinforced rubber. The physical dimensions were the same as those for standard Ordnance gaskets.
CONCLUSIONS: The test gaskets were found to be unsatisfactory for repeated use and were not recommended.
GENERAL: This 31-page report includes three photographs of a test gasket.

SUBJECT: Seals and Closures APG TB5-1401/44
TITLE: Desert Tests (1952) Special Low Temperature Door Seals
IDENTIFICATION: Forty-fourth Report on Project No. TB5-1401
DATE OF REPORT: 5 January 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of door weatherseals for use under high ambient temperature conditions
METHOD: The test weatherseals were installed on both front doors of two 3/4-ton M37 and two 2-1/2-ton M35 trucks. The vehicles were then

operated under high ambient temperature conditions in the Yuma Test Station area. During the 94-day test period, one vehicle was operated for a maximum of 5158 miles; the maximum temperature encountered was 113°F.
DESCRIPTION: The test items were extruded rubber, door weatherseals for the sides of the doors on 3/4-ton M37 trucks and for the sides and bottom of the doors on the 2-1/2-ton M35 trucks. These strips of rubber were manufactured by the General Tire and Rubber Company from a rubber compound which was previously found to be satisfactory in extreme cold.
CONCLUSIONS: The test weatherseals, based on the limited testing period, were considered satisfactory for use under desert conditions.
GENERAL: This 28-page report includes six photographs of the test weatherseals.

SUBJECT: Seals and Closures APG TT1-19H/1
TITLE: Test of Face Type Seals for Medium Tank Road Wheels
IDENTIFICATION: First Report on Project No. TT1-19H
DATE OF REPORT: 5 January 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the durability of face-type and lip-type grease seals for medium tank M26 road wheels
METHOD: Two experimental face-type seals and two experimental fabricated lip-type seals were installed in the road wheel hubs of a heavy tank T29. No suitable M26 hubs were available. Two standard lip-type seals were used as a control. The tank was driven for 710 miles, mainly over cross-country terrain. Lubrication was performed at intervals of 20 miles of operation at first, and at 40-mile periods later. At each interval, grease samples were taken for laboratory analysis.
DESCRIPTION: Each of the two face-type seals manufactured by National Motor Bearing Company consisted of a bronze face, an O-ring, and eight helical compression springs, all sealed in a 6-inch diameter case. The bronze face of the seal rotated with the road wheel under pressure against a hardened steel plate. The two-piece fabricated lip-type seal, manufactured by Johns-Manville, consisted of a molded composition case and lip, plus a coil tension spring. Two standard type seals, manufactured by Chicago Rawhide Company, were used as controls in the test.
CONCLUSIONS: The face-type seals were rated the most erratic in performance, as they were not designed solely for this particular model tank. The experimental lip-type seals proved comparable to the standard seals. It was recommended that the face-type seals not be used until one of a suitable design could be found and further tested in the field.
GENERAL: This 68-page report includes 23 pages of photographs.

SUBJECT: Seals and Closures APG TT1-19H/2
TITLE: Laboratory Investigations of "Code 5" Seals for Tank Road Wheel
IDENTIFICATION: Second Report on Project No. TT1-19H
DATE OF REPORT: 23 May 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the sealing characteristics of two different types of seals
METHOD: Each test seal was installed in a 26x6 road wheel hub and subjected to laboratory tests. The tests consisted of alternately feeding water and sand to the wheel hubs, continuous operation with the hubs submerged in water, and high speed operation without water or dust.
DESCRIPTION: Test item was a lip-type seal containing a wiper element, seal element, wire spring, and a brass case with two cover plates. One test seal had a sealing element and wiper element of 80-90 durometer as compared to 60-70 durometer for the second seal. The wire spring of the first seal measured 0.024 inch in diameter; the wire spring of the second measured 0.022 inch.
CONCLUSIONS: The test seals proved satisfactory throughout the test. The second test seal proved to be equal or superior to the first seal in every case except for dust exclusion. It was recommended that a seal composed of a hard wiper element, a soft sealing element, and a 0.022 inch diameter wire spring be made available for field testing. It was also recommended that all metal parts be made of steel to reduce scoring or binding during installation or removal.
GENERAL: This 19-page report includes four photographs showing the test bearing and laboratory apparatus.

SUBJECT: Seals and Closures APG TT1-19H/3
TITLE: First Report on Test of Face Type Seals
IDENTIFICATION: Third Report on Project No. TT1-19H
DATE OF REPORT: 30 November 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the durability and performance of an experimental face-type seal with the standard lip-type seals used on medium tanks
METHOD: Four face-type seals were installed on an M46 tank and operated on various paved and cross-country courses. After 4142 miles, the seals were modified and rebuilt to correct initial static sealing deficiencies. Throughout test operations, periodic samples of the light oil lubricant were removed for analysis to determine the presence of foreign matter not excluded by the seals. One test seal was subjected to a 24-hour cold room test at -65°F.
DESCRIPTION: The test seal manufactured by Crane Packing Company was a large, preassembled, self-centering unit which consisted of a sealing face and a mating face plate. The non-rotating portion of the seal was initially anchored within the limits of a four-inch slot, machined in four places about the circumference of the bearing spacer; four equally spaced 27/64-inch diameter holes were used in the modified seal. Protection outside the sealing faces was provided by rubber "O" rings. Modification of the road wheel hub was necessary and a special bearing spacer was used for installation of the seals.
CONCLUSIONS: The face-type seal was superior

to the standard lip-type seal with respect to exclusion of contaminants. Three modified seals failed after 872 miles due to severe wear of the composition dynamic sealing faces. It was recommended that materials of equal hardness be used for rotary and stationary dynamic sealing surfaces. The test seals were considered unsatisfactory; it was felt, however, that, when dynamic sealing deficiencies were overcome, the superior performance of such seals would warrant the redesign of the road wheel hub and arm.
GENERAL: This 102-page report includes 11 photographs of the face-type seals. Also included are manufacturer's drawings and graphs showing wear characteristics of sealing surfaces.

SUBJECT: Seals and Closures APT TT1-19H/4
TITLE: Second Report on Test of Chicago Rawhide Company Face Type Seals
IDENTIFICATION: Fourth Report on Project No. TT1-19H
DATE OF REPORT: 10 December 1951
ORIGIN: Aberdeen Proving Ground, Marylnd
PURPOSE: To determine the ease of installation, endurance, and reliability of experimental and production face-type seals
METHOD: Four experimental seals were installed on M46 tanks and subjected to operation over varied terrain for 5426, 5014, 4009, and 4009 miles, respectively. Production seals were similarly tested for comparison purposes. Emphasis was on cross-country operation and periodic water submergence. Numerous bearing lubricant samples were analyzed after the operational runs to determine the amount of foreign matter present in the seals.
DESCRIPTION: The Chicago Rawhide Manufacturing Company face-type seal was designed for 26-inch diameter tank road wheels. It was a large, preassembled, self-centering unit which included both the sealing-face and mating-face plate. Bronze seal components were used in the experimental models, and the production models used die cast zinc. The modified production seal employed a staked inner guard to eliminate the play between the inner guard and the anchor plate.
CONCLUSIONS: The structural failures of the production seal were successfully eliminated by the modified design. The experimental, modified face-type seal also proved superior in the retention of lubricant and the exclusion of contaminants. It was recommended that the modified production seal be accepted for standardization and that die cast metals other than zinc be used to improve their low temperature properties.
GENERAL: This 37-page report includes 11 photographs of the face-type seals and a sketch showing installation procedure on a T42 road wheel hub.

SUBJECT: Seals and Closures APG TT1-19H/5
TITLE: Second Report on Test of John Crane Face Type Seals
IDENTIFICATION: Fifth Report on Project TT1-19H
ORIGIN: Aberdeen Proving Ground, Maryland
DATE OF REPORT: 28 April 1953
PURPOSE: To compare the endurance and reliability of the John Crane face type seal with the standard lip type seal
METHOD: Four test seals were installed in the modified road wheel hubs of an M46 tank. The light lubricating oil used with the seals was periodically checked for the presence of contaminants. The seals were removed for inspection after 1488 miles of operation.
DESCRIPTION: The test seal was designed for the 26-inch diameter road wheel and was a large self-centering unit which included a sealing face and a mating face plate. The rotating steel face was secured to a flange bolted to the road wheel hub and the fixed portion of the seal was anchored by pins inserted in four equally-spaced holes around the bearing spacer. Sixteen compression springs provided pressure against the sealing faces during installation. Two rubber O-rings provided protection outside the seal faces.
CONCLUSIONS: Laboratory analysis of lubricant samples indicated sufficient exclusion of foreign matter. The modifications necessary to the road wheel hubs, and the lack of complete information regarding sealing characteristics precluded acceptance of the test seals. It was recommended that the seals be redesigned to permit installation on a standard road wheel hub and that the modified seals be tested in direct comparison with current face type seals.
GENERAL: This 37-page report includes five photographs of the test seal and 11 drawings showing seal construction and modifications necessary for installation on road wheel hubs.

SUBJECT: Seals and Closures APG TT1-19H/6
TITLE: Qualification Test of Road Wheel Spindle Seal, Alternate to No. B8364672
IDENTIFICATION: Sixth Report on Project No. TT1-19H
DATE OF REPORT: 14 May 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the Vickers lip-type road wheel spindle seal with the standard face-type seal
METHOD: Six Vickers lip-type test seals and four each of standard lip-type and standard face-type seals, as controls, were installed on a T48 tank. Testing operation was over paved, gravel, and cross-country courses for 990 miles.
DESCRIPTION: The Vickers seal was of the lip-type, each assembly containing one wiper element, one sealing element, two "O"-rings, a spring assembly, a shaft sleeve adapter, a shaft sleeve and other components to encase the above components.
CONCLUSIONS: The shaft sleeve of the Vickers seal rapidly developed grooves and allowed foreign matter to contaminate the lubricant. Finally, it resulted in a loss of the lubricant, whereas the standard type seals gave satisfactory performance during the test. The Vickers seal was considered unsatisfactory.
GENERAL: This 23-page report includes two pages of photographs and one drawing.

SUBJECT: Seals and Closures APG TT1-22-4/1
TITLE: Development of Laboratory Grease Seal Testing Equipment and Procedure, and Basic Tests on the Standard Medium Tank M26 Road Wheel Seal
IDENTIFICATION: First Report on Project No. TT1-22-4
DATE OF REPORT: 23 August 1949
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop satisfactory grease seal testing apparatus and a suitable testing procedure; also to conduct research of lubricants, sealing factors, and other data pertaining to the M25 Medium tank bogie wheel seal
METHOD: The grease seals were tested in the laboratory simulating actual road and field conditions. They were placed on the bogie wheel spindles in both positions, lips in and lips out. Then high-speed runs were made under dry operating conditions, and low-speed trials were run under wet operating conditions; also tests of horsepower losses were recorded.
DESCRIPTION: The testing equipment consisted of one 16-point temperature recorder, one 50-horsepower dynamometer, one 18x18x48-inch metal tank, two M26 medium road wheel assemblies modified for laboratory use, a drum loading arrangement, a water circulating system, two liquid heaters and one hood heater, all engineered to simulate actual road conditions. Standard M26 medium tank road wheel seals and standard Ordnance lubricants were used.
CONCLUSIONS: Satisfactory grease seal testing apparatus and suitable testing procedures were developed over a four-year period. With added volume of testing work, however, the equipment proved inadequate. A new testing machine was proposed to permit twice as much work per man hour. The standard Ordnance lip-type seal currently used in medium tank M26 track suspensions was not entirely satisfactory. It performed best when installed with the lips facing out instead of in. It was found that hub pressures were greater under high-speed dry road conditions than when under low-speed wet operation. It was recommended that a better method of installation be developed so that all lip-type seals could be installed with the lips facing outward in relation to the hubs. Current Ordnance Specification No. 2-107 was not satisfactory, because it included two greases which emulsified with water. It was recommended that this specification be revised to provide a more water-resistant grease. It was also recommended that the grease seal research and development program be continued.
GENERAL: This 231-page report includes ten photographs and two drawings of the test seals and testing equipment.

SUBJECT: Seals and Closures APG TT1-649/15
TITLE: Laboratory Investigations on Sealing Ability and Friction Characteristics of Code 3 (National Motor Bearing) and 5 (Vickers) Seals and Studies of Drag Characteristics of Code 4 (Chicago Rawhide) Seal
IDENTIFICATION: Fifteenth Report on Project No. TT1-649
DATE OF REPORT: 19 January 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate the sealing ability of the National Motor Bearing and Vickers seals, and to obtain information on the relative friction characteristics of all three seals
METHOD: The National Motor Bearing and Vickers seals were laboratory tested simulating field conditions. The grease seal machine and 15 hp dynamotor were used. The Chicago Rawhide seals could not be tested. Friction, with respect to medium tank M26 road wheels, and sealing characteristics of the seals were determined in accordance with a special test procedure included with this report. The Vickers seal was operated first with no wipers, then with a single wiper, and finally with a double wiper.
DESCRIPTION: The National Motor Bearing seal was a face-type arrangement consisting of a bronze rotating sealing face backed by an O-ring and five equally-spaced coil springs. The stationary face, mating with the brass rotating element, was a polished steel surface hardened to 600 Brinell. The Chicago Rawhide seal was also a face-type installation but was considerably larger, and used highly polished steel rubbing surfaces of greater width. The Vickers Company seal was a standard lip-type seal. Its distinctive feature was that its sealing element extruded to compensate for wear.
CONCLUSIONS: The National Motor Bearing and Vickers seals were unsatisfactory as originally supplied. The Vickers seal with a single wiper and with housing screws locked in place operated more satisfactorily than the standard Ordnance seal. The Vickers seal with the double wiper sealed more effectively than the single wiper arrangement; but, in its current form, it could not be installed without hazard to the seal. The sealing ability of the Chicago Rawhide seal was not determined because it required especially-designed hubs. It was recommended that additional development of the Vickers seal be instituted, and that sealing combinations of hard and soft metals not be considered any further.
GENERAL: This 45-page report includes five photographs of the seals.

SUBJECT: Seals and Closures APG TT1-649/19
TITLE: First Report on Test of Seals, Face Type (Code C)
IDENTIFICATION: Nineteenth Report on Project No. TT1-649 (Formerly Project No. TT1-19H)
DATE OF REPORT: 18 December 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare a face-type seal and two experimental lip seals with the standard lip-type seal used on medium tank road wheels
METHOD: Four face-type seals, four lip-type seals, and four standard lip seals supplied by three manufacturers were mounted on the road wheels of an M46 tank and operated 1616 miles over cross-country, paved and gravel test courses. The seals were examined to determine retention of lubricant, exclusion of foreign matter, and endurance.
DESCRIPTION: The experimental face-type seal (Chicago Rawhide) was a preassembled unit which

included the sealing face, a mating faceplate and a composition torsion bushing. Sealing was accomplished by 10 compression springs pressing the faceplate against the mating plate. The Johns-Manville seals consisted of a two-piece fabricated lip-type unit with a molded composition case, a sealing lip and a coil tension spring. One Vickers seal consisted of an aluminum case made in sections, loading springs, and two composition sealing lips, one curving outward and one inward. The other Vickers seal was identical except that it had two wiper lips, both facing outward.
CONCLUSIONS: The Johns-Manville seal was inferior to the standard seal. The Vickers seal, both single and double lip types, did not perform to required standards. The latter's weaknesses were poor retention of lubricants and exclusion of water and foreign matter, and unsatisfactory assembly of component parts. It was recommended that the Johns-Manville face-type oil seal be considered for standardization and used in combat vehicle suspensions after certain modifications in design were made. The Vickers lip seal was considered entirely unsatisfactory.
GENERAL: This 42-page report includes five pages of photographs of the test seals.

SUBJECT: Seals and Closures APG TT1-696/72
TITLE: Test of Plastic Hardtop Closures for Trucks
IDENTIFICATION: Seventy-second Report on Project No. TT1-696
DATE OF REPORT: 26 May 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of plastic hardtop closures for trucks
METHOD: Plastic hardtop closures were tested on 1/4-ton, M38A1 and 2-1/2-ton, M211 vehicles. Ease of assembly and installation were determined and an endurance test was conducted at Aberdeen Proving Ground. Both types of test vehicles were subjected to arctic operation at Fort Churchill, Manitoba, Canada.
DESCRIPTION: All of the closures were of fiberglass construction and were manufactured by Testaguzza Brothers and Company. The M38A1 closure consisted of a roof section, a vertical side and rear section with windows, and two doors with sliding windows. The M211 closure consisted of a roof section and a vertical side and rear section. The sections were attached by bolts through mating flanges and the assemblies were bolted to the cab or body of each vehicle. The doors were hinged at the front and were opened by a push button on the inside and a squeeze-type handle on the outside.
CONCLUSIONS: The kits furnished for M38A1 trucks were difficult to assemble because of mismatched parts and the door locking mechanisms were considered unsatisfactory. The fiberglass itself was satisfactory but a very disagreeable odor emanated from the plastic material throughout the test. It was recommended that the plastic closures be considered unsatisfactory but that development be continued to eliminate the undesirable features mentioned in this report.
GENERAL: This 26-page report includes five photographs of various sections of the fiberglass closures installed on the test vehicles.

SUBJECT: Seals and Closures APG TT3-775/3
TITLE: Test of GMC Experimental Rear Wheel Brake Seal System for Truck, 2-1/2-Ton, 6x6, M207
IDENTIFICATION: Third Report on Project No. TT3-775
DATE OF REPORT: 4 October 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine suitability of the test material
METHOD: Two M211, 6x6, 2-1/2-ton cargo trucks were used. The experimental brake seal was installed in the first vehicle which carried a 5000-pound payload. This vehicle was operated for 2635 miles over adverse cross-country terrain including water, gravel, and sand. Performance was tested by installing sealed units on the left and right intermediate wheels of the second vehicle. After a total of 1354 miles of paved operation, the truck was operated in water above drum height.
DESCRIPTION: The test sealing system was developed by the GMC Truck and Coach Division of the General Motors Corporation. In this system a sealing plate for the brake cover was bolted to the brake drum. The seal was of the double-lip neoprene type and was located near the axle housing. This resulted in a minimum relative velocity between the stationary seal sleeve and the seal. The brake cavities were fitted with vent lines connected through the vehicle ventilating system to the air cleaner.
CONCLUSIONS: The sealing system was considered unsatisfactory because of a large number of deficiencies. The brake units had to be disassembled five times during testing. Installation and maintenance were difficult and time consuming. Leakage and rust collection were factors in the excessive wear of the drum and lining; seal and sleeve wear were also high. Sealing of the front axle brake unit was not possible with this design. It was recommended that the deficiencies be eliminated and testing continued.
GENERAL: This 98-page report contains 31 photographs showing test components and wear resulting from testing.

DA 1068
SUBJECT: Seals and Closures B-4.6.1
TITLE: Improved Gasket Material Test
IDENTIFICATION: Report No. 1068
DATE OF REPORT: 17 July 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the comparative suitability of test and standard cover plate gaskets
METHOD: Two types of test gaskets were installed on transmission inspection covers and fuel tank drain covers of two M46 Tanks. A standard type was installed on one transmission cover and on the oil filter inspection covers of both tanks. The covers were removed and field inspection was made for deterioration and tears of the gaskets after 30 days, 2 months, 7 months, and 8-1/2 months of tank operation.

DESCRIPTION: The test gaskets consisted of SC720 ABFF RIA formula 425 and SC625 FF formula 428 gasket materials designated types A and B. The standard type C consisted of SC400 ABFF gasket material.
CONCLUSIONS: After 7 months of tank operation the Type C gaskets began to deteriorate and after 8-1/2 months they were no longer usable. Types A and B did not show appreciable deterioration and were considered to be an improvement over the standard type C gasket.
GENERAL: This seven-page report includes two photographs of the gasket materials.

DA 1540
SUBJECT: Seals and Closures B-4.11.1
TITLE: Plastisol Coating for Drain Cock Valves
IDENTIFICATION: Report No. 1540
DATE OF REPORT: 7 February 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To develop plastisol-coated valves superior to the standard molded rubber-covered units for sealing draincocks in tanks during fording operations
METHOD: Samples of the test materials were used to coat steel sheets and draincocks. These parts were subjected to hardness, tensile, tear resistance, permanent set, compression set, Taber abrasion, brittle-point, thickness of coating, impact scuff resistance, temperature resistance, load to seal, cyclic closure, static closure, functional, and specification tests. The tests were in accordance with Specifications MIL-R-3065, ZZ-R-601a, D624-48, D412-49T, or L-P-406a.
DESCRIPTION: The plastisol samples tested were E1003 and E1205 Micerosol and CX1080 and CX1081 from Michigan Chrome and Chemical; 4031 Unichrome and 5A80 from United Chromium; Parakote X-154 from Paramount Rubber; and 370-32025 from American Anode.
CONCLUSIONS: CX1080 plastisol was considered suitable for tank draincock coating. Draincock valves properly coated with CX1080 were considered suitable for desert, tropical, and arctic operations. It was recommended that a specification be formulated from the tests covering coated valves and plastisol material.
GENERAL: This 34-page report contains three photographs of the valves and equipment.

SUBJECT: Seals and Closures DA 1590-A
TITLE: Sealer, Flange, XS-153
IDENTIFICATION: Report No. 1590-A
DATE OF REPORT: 10 December 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To re-determine the storage stability and liquid separation in flange sealer, XS-153
METHOD: Determinations were made in accordance with Specification MIL-S-12158 (Ordnance), as revised by its first amendment
DESCRIPTION: The original penetration value, as reported 7 March 1952 in DA report No. 1590, was 261. The value obtained 9 months later on the residue from the same can was 237, which was below the 250 minimum.
CONCLUSIONS: The original penetration values were 235, 236, and 241, or an average of 237. The penetration values, after 96 hours of aging at 158°F: were 271, 267, 266, and 273, or an average of 269. The liquid separation tests revealed no liquid separation. The significance of the aged penetration value, determined by the revised test, was subject to two possible interpretations. Based on the first original penetration, the change was 3.1%, within the specification limits. Based on the revised test, the penetration was 13.5%, outside the specification limits.
GENERAL: This two-page report is not illustrated.

DA 1613
SUBJECT: Seals and Closures B-4.12.8
TITLE: Test of Ball Race Seal
IDENTIFICATION: Report No. 1613
DATE OF REPORT: 20 March 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine compliance of a ball race seal with Specification MIL-R-3065, Grade SC-615 ABEF
METHOD: Determinations were made of the seal's hardness range, tensile strength, and elongation before and after oven aging for 70 hours at 212°F. It was also oil aged for 70 hours at 212°F, and the volume change, tensile strength and durometer hardness determined. The compression set after 22 hours at 158°F and the low temperature brittleness of the seal after five hours at -40°F was determined.
DESCRIPTION: The test ball race seal was designated as Code A, Drawing No. D7384660.
CONCLUSIONS: The specification required an oil swelling within a range of 70 to 120%. The oil swelling effect of the test seal was 52.5%. Although the seal did not meet this specification requirement the deviation was considered an advantage for the intended use and it was recommended that the oil swelling requirements be waived.
GENERAL: This two-page report is not illustrated.

DA 1775
SUBJECT: Seals and Closures B-4.9.2
TITLE: Sealing Materials for Prevention of Galvanic Corrosion
IDENTIFICATION: Report No. 1775
DATE OF REPORT: 11 June 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the most suitable type of sealing material for preventing galvanic corrosion between dissimilar metals
METHOD: The fire resistance, compressibility, pressure, accelerated aging, and galvanic action characteristics of five sealing materials were determined. For the galvanic action tests, cells were made up of 2-inch square, 1/4-inch steel and aluminum blocks separated by a sealing material. The cells were then subjected to a sodium chloride fog for 8 days. Voltage across the cells was recorded on a vacuum tube voltmeter. A second galvanic action test was made on each sample by using six steel-aluminum cells and one steel-

magnesium cell. Size of the blocks was 1/8 x 2 x 3 inches; exposure in sodium chloride fog was for 24 hours. A final galvanic action test was made on the materials by using procedures developed from the first tests.
DESCRIPTION: The test sealing materials were 1/16-inch neoprene tape from the E.I. DuPont de Nemours Company; polyisobutylene mastic from the Minnesota Mining and Manufacturing Company; and types S, N, and OR impregnated felt from the Spring Packing Corporation. Felt, canvas, paper, cardboard, zinc chromate paste, wood, and rubber materials were used as controls.
CONCLUSIONS: Type N impregnated felt provided adequate protection against galvanic action and provided moderate protection against air and water pressures when used as a gasket.
GENERAL: This 45-page report contains 20 photographs of test equipment and results.

SUBJECT: Seals and Closures DA 1837
TITLE: Neoprene Air Cleaner Caps
IDENTIFICATION: Report No. 1837
DATE OF REPORT: 23 July 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To develop an easily applied neoprene cap for use in sealing the air cleaner on the auxiliary engine of the M47 tank during fording operations
METHOD: A form was designed and constructed 10% oversize to allow for curing and drying shrinkage. The form was then dipped in neoprene latex compound to form caps 1/32-inch thick. The on and off the mold curing time was varied to determine the minimum and maximum shrinkage of latex. The mold was redesigned with a reduction in height and diameter; caps with thicknesses ranging from 0.022 to 0.040 inch were made. Tests were then conducted to compare the force necessary to stretch test and standard type caps over the cover of an air cleaner. Further modifications of the form were made; caps, prepared from this final mold design, were checked for water leakage while installed on an air cleaner.
DESCRIPTION: Standard M47 tank auxiliary engine air cleaner caps were 2-1/4 inches high and 5-1/2 inches in diameter; wall thickness was 1/16-inch. The final form of the test neoprene cap was designed to a height of 2-9/16 inches; the diameter of the upper 3/8-inch of the form was 5-5/16-inch, and the diameter of the remaining height of the form was 5-9/16 inch. Test caps were made by dipping the form in latex.
CONCLUSIONS: Neoprene latex caps 0.030 to 0.035-inch thick required approximately 20 pounds less force for installation on the air cleaner than did the old style caps. The test type caps provided protection against water leakage into the air cleaner. It was recommended that the final form design described be considered satisfactory for use in making the test-type caps; and that the wall thickness of the caps range from 0.030 to 0.035-inch (this wall thickness could be produced by three, 2-minute latex dips). It was also recommended that the neoprene caps be cured for 5 hours on the mold form and 96 hours off the mold form at 158°F.
GENERAL: This seven-page report includes one table on shrinkage data.

SUBJECT: Seals and Closures DA 1859
TITLE: Four Samples of Sponge Gasket Material for Sealing Periscopes to Cupolas
IDENTIFICATION: Report No. 1859; Job No. 6548
DATE OF REPORT: 11 August 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether the test sample gasket material provided an effective means of sealing periscopes to cupolas to permit removal without excess binding
METHOD: The sealing surfaces of one seal were cut off 1/16 inch, resealed with neoprene latex, cured, and then assembled. The seal test samples were assembled with narrow holding plates, and with various size stop sleeves higher than standard stops. The periscope was then inserted and the installation was checked for leakage, the force required to remove the periscope was determined, the periscope was reinserted, and after standing for one week, the removal force determination was repeated. The results were then used to determine the adequacy of sealing and ease of removal.
DESCRIPTION: The test samples were: neoprene-coated sponge gasket seal .317 inch thick, manufactured by Sponge Rubber Products, Shelton, Connecticut; neoprene-coated sponge gasket seal .362 inch thick, manufactured by the Detroit Die Cutting Co., Detroit, Michigan; solid rubber gasket seal .077 inch thick, manufactured by the Continental Rubber Works, Erie, Pennsylvania; and neoprene-coated sponge gasket seal .352 inch thick, manufactured by Foamade Industries, Detroit, Michigan.
CONCLUSIONS: The narrow type retainer used with or without metal spacing sleeves in the bolt holes was ineffective in preventing water leakage as it permitted too much of the sponge rubber to be displaced. The softer sponge rubber gaskets conformed to the contour of the periscopes better and made the better seals. A combination of the neoprene-coated sponge seal .362 inch thick used with steel spacing sleeves .192 inch long and the wide retainer offered the most desirable features for a satisfactory seal for turret and tank periscopes.
GENERAL: This 10-page report includes four pages of photographs showing the types of seals that were used in the tests.

DA 1863
SUBJECT: Seals and Closures B-4.12.7
TITLE: Neoprene Latex Boot for Use as a Seal on Tank Control Rods
IDENTIFICATION: Report No. 1863
DATE OF REPORT: 28 July 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To prepare and evaluate a latex boot as a seal on tank control rods
METHOD: The boot was prepared and cured for 36 hours at 200 to 210°F. It was then placed on a 1/2-inch diameter bar and flexed back and forth to determine its reaction to movement in temperatures

ranging from room temperature to -40° F.
DESCRIPTION: The conical boot was made of neoprene latex XL-115. It was 2 inches in diameter at one end, 1/2 inch in diameter at the other end, and 5 inches long. The wall thickness of the material was 1/32 inch.
CONCLUSIONS: The conical design of the boot was not considered practical because the flexure load was concentrated around one circumference. It was flexible at room temperature but the nature of the wrinkle formed by the flexing movement was undesirable. The boot broke at -40° F due to brittleness.
GENERAL: This three-page report includes one drawing of the boot.

SUBJECT: Seals and Closures DA 1939
TITLE: Methods of Securing Turret Seal of Tank M47
IDENTIFICATION: Report No. 1939; Job No. 7402
DATE OF REPORT: 9 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine which of six methods of securing turret ring seal was most satisfactory
METHOD: The following types of fasteners were installed in various sections of a turret ring seal: three arrangements of glove snaps, Lift-the-Dot fasteners, standard belt lacing, and a friction-grip apparatus. The percent of elongation of the seal was determined when extended from 18.5 feet to 22 feet for installation. The force in pounds before failure was also determined for each type fastener.
DESCRIPTION: The glove type snaps were used side by side in a pair, four in a block arrangement, and four in a diamond shaped arrangement. The Lift-the-Dot type fasteners were installed in pairs side by side. The belt lacing was the standard wire type secured by a pin. The friction-grip method consisted of a metal channel two inches wide, one inch high, and four inches long equipped with two pieces of drill rod at each end placed in holes two inches apart and 5/16-inch from the channel bottom. The seal was then threaded through the channel and clamped by bending the U-shaped portions of the channel over the seal.
CONCLUSIONS: Elongation of the seal for installation on the turret would probably subject the seal adjacent to the connection to high tension. The connection made with the Lift-the-Dot fasteners provided adequate security and installation simplicity. Destructive tests resulted in rupture of the rubber rather than fastener failure except the friction-grip apparatus which slipped, and the glove type fastener which failed to snap.
GENERAL: This seven-page report includes one page of photographs and three pages of test data.

SUBJECT: Seals and Closures DA 1951
TITLE: Flange Sealer, XS-157
IDENTIFICATION: Report No. 1951
DATE OF REPORT: 11 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the compliance of the test sealer with the qualification tests of a DA proposed Specification
METHOD: Tests were conducted in accordance with DA Report No. 1265, and the DA proposed specification for flange sealers. The test sealer was subjected to torque drop, plasticity, water permeability, volatile matter, vertical flow, low temperature brittleness, oven aging, and application tests.
DESCRIPTION: The test flange sealer was identified only as XS-157.
CONCLUSIONS: The initial penetration value was slightly low. The aged penetration value exceeded specification limits. Other results were within the specification limits. The test sealer did not comply with the requirements of the DA proposed specification for flanged sealers.
GENERAL: This two-page report includes the qualification requirements contained in the DA proposed specification.

SUBJECT: Seals and Closures DA 2034
TITLE: Test of a Sponge Seal for the Control of Water Leakage Into the Tank Commander's Cupola
IDENTIFICATION: Report No. 2034
DATE OF REPORT: 4 November 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effectiveness of the sponge seal
METHOD: The sponge seal was installed with 0.188-inch spacers and a wide-type retainer ring; observations were made of the amount of water leakage. The same seal was installed without spacers, the screw tightened, and water leakage again determined.
DESCRIPTION: The uncoated sponge seal, 0.272-inch thick, was designed to control the water leakage into the tank commander's cupola.
CONCLUSIONS: Severe leakage was observed around the periscope into the cupola under both conditions of test. The seal exhibited high cold-flow characteristics and was not of sufficient stiffness or thickness. Water leakage through the periscope could be reduced by manipulation of the sponge sealing edges from above; however, this would be impractical under combat conditions. A sponge described in DA Report No. 1859 was recommended as a replacement for the test seal.
GENERAL: This two-page report is not illustrated.

SUBJECT: Seals and Closures DA 2320
TITLE: Test of Grommet Contact Arrangement
IDENTIFICATION: Report No. 2320
DATE OF REPORT: 25 March 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether a Cannon grommet would provide a waterproof seal around the conductors entering an electrical connector
METHOD: The 32-1 contact arrangement electrical connector, which incorporated a Cannon grommet, was subjected to the waterproofness test of Specification 60-977-2. Insulation resistance measurements between the connector contacts and the

shell were made before and after the test.
DESCRIPTION: The test unit was a grommet, incorporated in a 32-1 contact arrangement submitted by the Cannon Electric Company, Los Angeles, California.
CONCLUSIONS: The electrical connector failed to comply with the requirements of the waterproofness test. The failure was caused by the grommet which allowed the entry of water into the interior of the electrical connector. Heat age and temperature change tests were cancelled because of this failure.
GENERAL: This three-page report is not illustrated.

SUBJECT: Seals and Closures DA 2405
TITLE: Investigation of Grease Compatibility and Physical Properties of Three Rubber Turret Bearing Seals
IDENTIFICATION: Report No. 2405
DATE OF REPORT: 18 June 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the compatibility of three types of bearing seals with two types of greases; to determine the conformance of the bearing seals to ASTM Specification D 735-52aT, Grade SC-615-ABCEFF
METHOD: The Keystone grease was applied to all of the surfaces of a 2-inch sample of each of the three turret bearing seals and permitted to stand at room temperature for 400 hours. Weight and volume change of the seals were determined. Similar tests were conducted on new specimens using Kaydon grease. A 28-inch length of each seal was covered on all surfaces with Keystone grease. Identical samples were covered with Kaydon grease. The middle 24 inches of each 28-inch section was extended to 25 inches and held in this position on a board for 400 hours. The specimens were released, measured, and inspected. Tensile specimens of each seal covered with each type of grease, and a specimen unexposed to greases, were elongated 10% for 400 hours at room temperature. At the end of this period the specimens were released and permanent sets were determined. Physical properties of the bearing seals were determined according to ASTM Specification D 735-52aT, Grade SC-615-ABCEFF.
DESCRIPTION: The three turret bearing seals were submitted by the Keystone Manufacturing Company, the Kaydon Manufacturing Company, and the Goodrich Tire and Rubber Company. The MIL-G-10924 grease was supplied by the Keystone Manufacturing Company. The other test grease was manufactured by the Kaydon Manufacturing Company.
CONCLUSIONS: The dimensional stability of the Goodrich seal was superior to that of either of the other seals after exposure to both of the greases. The dimensional stability of all three seals was better after exposure to the Kaydon grease than after exposure to the Keystone grease. None of the three seals complied with the requirements of ASTM D-735-52aT, Grade SC-615-ABC EFF.
GENERAL: This 14-page report is not illustrated.

SUBJECT: Seals and Closures DA 2437
TITLE: Physical Tests of "O" and "T" Rings
IDENTIFICATION: Report No. 2437; Job No. 8353
DATE OF REPORT: 8 May 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the compression set and brittle point characteristics of various "O" and "T" rings
METHOD: The first compression set tests were carried out in accordance with ASTM D-395, Method B. The remaining compression set tests were carried out in accordance with ASTM D-1229-52T with temperatures and storage periods as specified in the work order. The tests for brittleness were performed according to ASTM D-746-44 with the addition that temperature of total failure and cracking stages were determined and reported; brittle point tests were performed on one specimen at a time. Solenoid actuating voltage was 115 volts. A Scott, solenoid-actuated, brittleness tester was used for these tests, and methanol was used as a heat transfer medium.
DESCRIPTION: Two "T" and four "O" rings were tested. The "T" rings were procured from damaged front followers. The first "O' ring was procured from a damaged front follower and had been previously used in a compression set test. The second was new, had a durometer hardness of 68, and was manufactured by Parker Manufacturing Company. The other two had a durometer hardness of 68, and were procured from leaking assemblies. The compression set results for the second "T" ring and all the "O" rings at the temperature of -40°F were inconsistent. In all cases the compression set values for a 22-hour aging period were greater than the compression set values for a 94-hour aging period at the same temperature. There was no logical explanation for this condition and the lack of material prevented a series of retests. A lack of sample material prevented the determination of brittle points in complete accordance with ASTM D-746-52T.
GENERAL: This nine-page report is not illustrated.

DA 2509
SUBJECT: Seals and Closures B-4.12.13
TITLE: Sealing Grommets
IDENTIFICATION: Report No. 2509
DATE OF REPORT: 29 June 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the capability of several test grommets to prevent leakage
METHOD: An experimental five-piece mold for a 7/8-inch grommet having two 3/4-inch holes was prepared and grommets made in this mold were tested for leakage. A full-sized mold containing seven holes was then prepared and grommets made in this mold were tested under a head of 6 feet of water.
DESCRIPTION: The type that had developed leakage were grooved and slitted 50-durometer GR-S grommets (RS-509-ABF). Test material consisted of Plastisol XP-117, uncured neoprene SC-609-ABF, and uncured neoprene SC-509-ABF.
CONCLUSIONS: Although grommets made in the experimental mold developed no leakage, those

made in the full-size mold leaked continuously. This leakage was traced to variation in sizes of the outside diameter of the cables passing through the grommets. It was concluded that grommets alone were inadequate for preventing leakage, and it was recommended that a sealant be used with them.
GENERAL: This five-page report is not illustrated.

SUBJECT: Seals and Closures DA 2720
TITLE: Test of Rubber Mastic Sealant
IDENTIFICATION: Report No. 2720
DATE OF REPORT: 14 January 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effectiveness of a rubber mastic sealant, reinforced with fiberglass strips, when used to stop leakage of a defective, steel fuel cell
METHOD: Approximately 337 inches of slots were cut through the cell wall, adjacent to the seams of the left fuel cell of a 76mm gun tank, T41E1. The exterior surface was wirebrushed until a strip of bare metal, 1-1/2 inches wide, was exposed on each side of the slots. The test sealant was mixed in accordance with the manufacturer's instructions, applied, and allowed to "cure". The fuel cell was subjected to a slosh and vibration test.
DESCRIPTION: The test rubber mastic sealant was manufactured by the Minnesota Mining and Manufacturing Company.
CONCLUSIONS: There was no decrease in pressure within the fuel cell at room conditions, and no evidence of leakage, when the test sealant was submerged in water for 30 minutes. There was no loss of gasoline when the filled fuel cell was placed outdoors for 96 hours. There was no evidence of leakage or seam failure as a result of the vibration and slosh tests. No complete evaluation of the sealing qualities of the rubber mastic sealant could be made until tests had been run under actual vehicle operating conditions.
GENERAL: This three-page report is not illustrated.

SUBJECT: Seals and Closures DA 2737
TITLE: Static Sealing and Self-Lubricating Characteristics of Two Types of Dust-Water Seals
IDENTIFICATION: Report No. 2737
DATE OF REPORT: 8 December 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the static sealing characteristics of the test seals
METHOD: Seals were tested on apparatus constructed by the Detroit Arsenal. Seals were installed on a mandrel of 0.020 eccentricity and measurements made at 0, 90, 180, and 270 degrees rotational displacement. Self-lubricating tests were conducted on an oil seal test machine with no lubrication provided and rotated at 100 rpm for 192 hours in increments of 24 hours. Temperature measurements were made by means of thermocouples.
DESCRIPTION: The two types of seals, designated OS and CR, were manufactured by the Chicago Rawhide Company and the O&S Bearing Company. The OS seal consisted of an inner hardened steel ring, or race, enclosed between nylon-bearing surfaces of one other ring to provide the sealing effect. The slip between inner and outer ring permitted rotational movement as well as a limited radial movement. The CR seal was of conventional design and incorporated the wiping action of a double lip of an elastomeric material on the rotating shaft. These seals were designed for use on the internal arm, torsion bar of the M47 Tank.
CONCLUSIONS: Insufficient tests of OS seals were conducted to evaluate their properties. The CR seals were found satisfactory. No excessive temperatures were observed.
GENERAL: This 11-page report contains four illustrations.

SUBJECT: Seals and Closures DA 2765
TITLE: Evaluation of a Slip-On Type Seal for Metal End Fiberboard Containers
IDENTIFICATION: Report No. 2765
DATE OF REPORT: 30 December 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the slip-on cover type seal for metal and fiberboard containers
METHOD: Forty grams of desiccant were placed into each of seven containers, which were conditioned at 86°F and 100% relative humidity. The desiccant in the containers was weighed at 24, 48, and 72-hour intervals, and the per cent increase in weight was calculated.
DESCRIPTION: The test unit was a slip-on cover type of seal for metal end fiberboard containers.
CONCLUSIONS: The rate of moisture penetration was relatively constant throughout the 72-hour period of conditioning. The size of the container had no apparent effect on the amount or rate of moisture penetration.
GENERAL: This five-page report was not illustrated.

SUBJECT: Seals and Closures DA 2771
TITLE: Support Roller Face-Type Seal Test on 90mm Gun Tank, M-47
IDENTIFICATION: Report No. 2771
DATE OF REPORT: 5 January 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the performance of two experimental face-type seals when used on the M47 track support rollers
METHOD: Each seal was installed on modified track support rollers, which in turn were installed on the rear right and left sides of the test vehicle hull. The test vehicle was operated for 4000 miles on dirt and hard track. Daily inspections were made for oil leakage or mechanical failure of the test seals. After the test the units were disassembled and inspected.
DESCRIPTION: The test units, manufactured by the Crane Packing Company and Chicago Rawhide Company, both of Detroit, Michigan, were support

roller face-type seals for the 90mm gun tank, M47.
CONCLUSIONS: Daily inspections failed to reveal any oil leakage or mechanical failures of the test seals. The final disassembly and inspection of the Crane seal revealed dirt accumulation behind the anchor retaining washer, however this did not affect the seals or performance. Neither seal leaked oil or allowed foreign matter to penetrate the oil cavity. It was recommended that the Crane seal be improved to prevent the accumulation of foreign matter behind the anchor retaining washer.
GENERAL: This 10-page report includes five photographs of the test units.

SUBJECT: Seals and Closures DA 2781
TITLE: Evaluation of Chromium Plating as a Wear Surface for Grease Seals
IDENTIFICATION: Report No. 2781
DATE OF REPORT: 14 January 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the performance of an experimental grease seal with that of a standard seal
METHOD: The grease seals were installed in sets in the testing machine, which was operated in accordance with ASTM procedure except as noted in the report. The spacers were rotated at 900 rpm with filtered oil (SAE 10, Specification MIL-O-2104) heated to 150°F and circulated with the test housing half-full. Performance characteristics and wear were noted and recorded.
DESCRIPTION: The standard spacers, Ordnance No. 7722836, were case-hardened to a depth of 0.005 to 0.010 of an inch. The experimental spacers were chromium plated to a thickness of 0.001 of an inch on unhardened steel. The grease seals were Ordnance No. 7722589. The units were used as a combination seal contact surface and bearing spacer in the suspension components of the M47 tank.
CONCLUSIONS: The first set of spacers, one standard and one experimental, installed in the oil seal testing machine, completed 513 hours of endurance testing. Standard spacer wear at the end of the test was less than that encountered in the field for the same period of usage. After 513 hours, oil leakage past the seal reached 0.28 ml per hour, or 2-1/2 times the specification limit. The second set of spacers was tested for 300 hours. The test procedure deviated from the first only in that the grease seals were interchanged after 200 hours of testing time. After 200 hours, the leakage rate past the experimental spacer had reached 0.44 ml per hour, or four times the specification limit. It was concluded that further testing under field conditions, including water and dirt, was necessary to determine accurately the practicability of substituting chromium plated spacers for the standard type; also, that more carefully controlled processing, such as polishing prior to chromium plating, and more rigid controls in applying the chrome, were required to obtain significant test results. The polishing would help the chromium plating to resist frictional wear.
GENERAL: This four-page report includes one photograph of the standard and experimental spacers, after 100 hours of test time.

SUBJECT: Seals and Closures DA 2814
TITLE: Qualification Test for Polybutene Sealants No. G-43 and No. H-54 with Specification MIL-S-12158 (ORD), Amendment 1
IDENTIFICATION: Report No. 2814
DATE OF REPORT: 9 February 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the compliance of two polybutene sealants with the qualification requirements of Military Specification MIL-S-12158 (ORD), Amendment 1
METHOD: The test procedures incorporated in the specification were used with the following exception: unworked penetration was in accordance with the unworked penetration procedure of Method 311-5 of Specification VV-L-791e, 21 May 1953.
DESCRIPTION: The two tested materials were polybutene sealants, Nos. G-43 and H-54, respectively, submitted by the Burke Research Company, under Contract DA-20-089-ORD-36516.
CONCLUSIONS: Sealants G-43 and H-54 met all qualification requirements of Military Specification MIL-S-12158 (ORD), as amended.
GENERAL: This seven-page report is not illustrated.

DA 2889
SUBJECT: Seals and Closures B-4.9
TITLE: Oil Seals
IDENTIFICATION: Report No. 2889
DATE OF REPORT: 7 April 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the sealing efficiency of all-rubber commercial oil seals
METHOD: The two types of oil seals were mounted without cement in the housing of the testing machine and a 500-hour operation commenced. The rubber surface speed was 2000 fpm at atmospheric pressure with an oil temperature of 215°F. The oil was heated to specified temperature within 1 hour. The operation was in accordance with the SAE 500-hour endurance test procedure dated 16 October 1952.
DESCRIPTION: The all-rubber commercial oil seals were without metal enclosures and were designated as types X and Y. The type X was a single lip seal with no spring and was for use on a 2-1/8-inch diameter shaft. Type Y was a single lip seal using a garter spring and was for use on a 2-1/2-inch diameter shaft. The test seals were manufactured by Johns-Manville and had a commercial nomenclature of Clipper Oil Seals. The type X seals were designated as No. H1/L7 and type Y as No. H1/L5.
CONCLUSIONS: The test oil seals failed to meet the requirements of the test procedure. All of the X type seals failed to run 500 hours, and only three Y type seals of the 12 tested operated for this period. The maximum running time for any X type seals was 206 hours or 41% of the required time. The seal leakage rate was 3.4 times the allowable limit at the end of the test. Only one Y type seal operated for 500 hours without leakage, and most of these seals leaked excessively at early stages.
GENERAL: This 14-page report includes four photographs of seals, accessories, and testing apparatus and four pages of test charts.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Seals and Closures DA 3148 Final
TITLE: Face Type Seals, Performance Test
IDENTIFICATION: Report No. 3148 Final
DATE OF REPORT: 8 December 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the effectiveness of the experimental face type seal with the Ordnance seal
METHOD: Seven "X" and seven "S" face seals, 2-1/16-inch maximum shaft size, were installed in the track support roller of the T41E1 tank, and given an endurance test of 100 hours at 916 rpm (equivalent to 38 mph) and at an oil temperature of 130°F.
DESCRIPTION: The Code "X" oil seals (face type) part No. SS-692, were manufactured by the Cartriseal Corporation, of Chicago, Illinois. The Code "S" oil seals (face type) were Ordnance standard seals, No. 7419935. Both seals had a free height of 1-1/8 inches to the top of the rubber gasket. The "S" seal gasket, however, was 3/32-inch thick, while the "X" seal gasket was 1/16-inch thick.
CONCLUSIONS: All the "X" seals had developed objectionable leakage (10 ml per 100 hours, maximum allowable) at the end of the test. Heat was generated around the contact periphery, which caused blistering of the non-metallic rotor ring. Swelling of the rubber boot and gasket, and separation of the bond on the boot occurred in all the "X" seal tests. Change in leakage rate between 20 and 25 hours of test occurred in all the seals tested. The sealing efficiency of the face seals "X" was not satisfactory when compared with that of the "S" face seals.
GENERAL: This 15-page report includes four photographs of the "X" face seal and its components.

SUBJECT: Seals and Closures DA 3163 F
TITLE: M244 Trailer Roof-Sealer Test
IDENTIFICATION: Report No. 3163 (Final)
DATE OF REPORT: 12 November 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether incorrect mixing or application of the sealer contributed to corrosion of roof panels
METHOD: Four test panels, 10 x 10 inches, each consisting of an aluminum plate and a sealer-coated magnesium plate, were fastened to a frame with aluminum wood screws. Different proportions of sealer and accelerator were used. The ingredients had been mixed previously on an aluminum table top with a spatula. The panels were cured for 24 hours at 72°F and then subjected to a 240-hour salt spray test. Periodic observations of the conditions of the panels were made during the test.
DESCRIPTION: The sealing mixture consisted of 3M sealer, formula EC-801, and accelerator EC-807, supplied by the Minnesota Mining and Manufacturing Company. One mixture was made of 12 grams, and the other of 14.4 grams, of accelerator to 100 grams of sealer.
CONCLUSIONS: The corrosion noted during the test was of a galvanic type and was caused by the action of the salt spray in conjunction with two dissimilar metals. None of the corrosion was caused by the action of the sealer itself, or the sealer in combination with either or both metals. The marked adhesive properties of the sealer in clinging to the mixing tools made it impossible to secure a 100% correct mixture of sealer and accelerator. An excess of accelerator caused the sealer to setup so rapidly that the resulting mixture could not be applied properly. In the presence of an electrolyte this improper application caused the salt spray to increase both speed and the extent of corrosion. Due to the necessity for mixing and applying this two-part sealer under restricted conditions, it was considered unsuitable for military use under field conditions. The use of two dissimilar metals with any sealer between them was not recommended for military trailer roofs or any other installation exposed to the weather.
GENERAL: This 16-page report is not illustrated.

SUBJECT: Seals and Closures DA 3264 F
TITLE: Evaluation of Gland, Cable Sealing
IDENTIFICATION: Report No. 3264 (Final)
DATE OF REPORT: 26 April 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether the performance characteristics of the cable sealing glands met the requirements of the USA Specification
METHOD: The test glands were subjected to applicable test in accordance with the requirements of USA Specification AXS-1659 for waterproofness, temperature change, heat aging, and fungus resistance. Inspection for conformance with the dimensional requirements of Ordnance Drawing No. 7716692, Revision A-8, effective 5 May 1950, was also made.
DESCRIPTION: The test unit was a cable sealing gland designed to provide a waterproof seal at the cable entrance of an electrical receptacle. The gland was manufactured by Allied Precision Ind. Inc., Geneva, Illinois.
CONCLUSIONS: The Allied gland's performance was satisfactory as required by Specification AXS-1659. However, the dimension of the Allied gland was not in accordance with those shown on Ordnance Drawing No. 7716692.
GENERAL: This 12-page report includes one photograph of the test gland.

SUBJECT: Seals and Closures FAR-819
TITLE: Sealing of Optical Instruments, Rotary Seals
IDENTIFICATION: Report No. R-819
DATE OF REPORT: 15 November 1947
ORIGIN: Frankford Arsenal, Philadelphia, Pa.
PURPOSE: To compare the moisture leakage and torque characteristics of the standard rotary seals with that of newly developed rotary seals for optical instruments
METHOD: Special assemblies which could be fitted with the standard or new types of seals were constructed. Seven adhesive polysulfide compounds were given preliminary tests before being injected into the test unit for leakage tests. The preliminary tests determined: (1) the adhesive proper-

ties between 160°F and -45°F; (2) surface oxidation; (3) solidification at -45°F. The sequence of exposure tests was the same for each material tested. Three tubes were used as a test set for each seal, and one seal was tested completely before another was begun. The results were compared with previously determined characteristics of static seals.
DESCRIPTION: The seven compounds were Nos. 2, 6, 7, 8, 9, 10 and 11, designated commercially as EC-612, EC-180, EC-194, EC-481, EC-504, EC-616, and EC-750, respectively, and all manufactured by the Minnesota Mining and Manufacturing Co. Other compounds used in the test were Nos. 3 and 4, designated commercially as Nos. 16166-1 and 16166-2 Thickel compound, and manufactured by the Thickel Corporation.
CONCLUSIONS: The torque value should be in the range of 10 to 20 oz.-in. at 45°F to permit maximum ease of operation, and not less than 1 oz.-in. at room temperature, if no slippage was desired. The No. 2 compound and the two modifications were equally good moisture barriers, but the torque was too high. The manufacturer of Nos. 3 and 4 compounds was working on further modifications to remedy this fault. Silicone high-vacuum grease had desirable torque values, but not quite as good sealing qualities. Some grease oozed out of the confined space along the shaft. Further work on this material was contemplated.
GENERAL: This 17-page report includes three photographs of the test equipment.

SUBJECT: Seals and Closures FAR-975
TITLE: Sealing and Winterization of Fire Control Materiel
IDENTIFICATION: Report No. R-975
DATE OF REPORT: 31 August 1950
ORIGIN: Frankford Arsenal, Philadelphia, Pa.
PURPOSE: To determine the effectiveness of injection sealing as applied to modified existing optical instruments
METHOD: An investigation of the design of three standard fire control optical instruments was made to determine how injection seals could be applied to these instruments with the minimum amount of modification and to determine the effectiveness of these seals. Three elbow telescopes, five panoramic telescopes, and three aiming circles were sealed, using improvised sealing techniques and substitute sealing materials wherever seals could not be formed in the recommended fashion. The effectiveness of the seals was determined by means of internal and external pressures tests.
DESCRIPTION: Injection sealing was a sealing technique in which putty-like or grease-like material was injected into specially prepared grooves and cavities at the joints or openings requiring closure. It was requested that 22 standard instruments be sealed; these consisted of elbow telescopes, panoramic telescopes, and aiming circles.
CONCLUSIONS: It was concluded that modifications of existing optical instruments for injection sealing was not satisfactory or practical. Modifications were made on all 22 of the instruments, but it was believed that the time and expense of sealing all of them was not warranted. Hence, only 11 were sealed. It was recommended that existing optical instruments should not be modified for injection sealing, but that injection sealing should be considered in the design of new instruments.
GENERAL: This 28-page report contains five photographs of the sealed optical instruments. Also included are drawings showing sectional views of the instruments and illustrating the sealing method.

SUBJECT: Seals and Closures GM-CTP 65F
TITLE: Test of Original (Pilot Production) Face Type Seals in T41E1 Suspension
IDENTIFICATION: Report No. 65 (Final)
DATE OF REPORT: 26 September 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the suitability of the face type seals in a T41E1 suspension
METHOD: A number of face type seals were installed in a T41E1 tank, No. 1, which was operated on the test track. The test seals were observed for oil leakage and were inspected for wear.
DESCRIPTION: The test item was designated TR-65 face type seal No. 7419933, and was designed and manufactured by the Cadillac Motor Car Division, of General Motors Corporation.
CONCLUSIONS: The face type seal had several disadvantages compared to the standard lip type seal. It was more complicated to manufacture; it required greater precision in manufacturing; it required more skill precision in manufacturing related parts; it was more costly; it had more torque resistance or power loss; and it made the wheel bearing adjustment difficult and uncertain. Its principal advantage was that it could be lubricated with an oil can instead of a gun. It was recommended that a cost study be made of the face type vs the lip type seal; that a shaft type seal similar to that of the support roller seal be developed for the track wheel hubs; and that consideration be given to the use of the shaft type grease lubricated seal instead of the face type seal in the suspension of the T41E1 tank and related vehicles.
GENERAL: This seven-page report includes two photographs of the face type seals after the test.

SUBJECT: Seals and Closures GM-CTP 177F
TITLE: Test of Shaft Type Support Roller Seals in the T37 No. 1, T37 No. 2, and T41 No. 3 Tanks
IDENTIFICATION: Report No. 177 (Final)
DATE OF REPORT: 23 September 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the ability of a shaft-type support roller seal to retain SAE No. 10 oil for use in cold weather operations
METHOD: The shaft-type support roller seals were installed on T37, No. 2 and T41, No. 3 tanks which were operated for 2356 and 1528 miles, respectively. SAE No. 10 oil was used as the lubricant for this test. The T37, No. 1 tank was not tested.
DESCRIPTION: The test item was the shaft-type

support roller seal, Part No. 7419070. This seal had been operated in the T41E1, No. 1 pilot vehicle for 11,568 miles without replacement.
CONCLUSIONS: The shaft-type seal was very adequate for use with SAE No. 10 oil. The T37, No. 2 tank had 80% of the oil remaining at 99 test miles and 60% after an additional 476 miles. The T41, No. 3 retained 50% of the oil after 571 test miles.
GENERAL: This five-page report is not illustrated.

SUBJECT: Seals and Closures GM-CTP 180F
TITLE: Test of Garlock Seal #2372 and Victoprene Type K Track Road Wheel Seals in T41 #3 Vehicle
IDENTIFICATION: Report No. 180 (Final)
DATE OF REPORT: 27 January 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the suitability of Garlock Seals, No. 2372, and Victoprene Type K seals for tank road wheels
METHOD: Adaptors SK-221 were installed (slip fit) on the wheel spindles of the compensating wheel, No. 1 and 5 positions, on the pilot Model T41 tank; adaptors SK-222 were installed (shrink fit) on the No. 2, 3, and 4 positions. Victoprene Type K seals and Garlock No. 2372 seals were installed in the wheel hubs of the tank on the left and right sides, respectively. The hubs were filled with SAE No. 10 oil and the tank was operated for 599 miles. The effectiveness of the slip fit and shrink fit seal adaptions were compared.
DESCRIPTION: The test items were Garlock seals, No. 2372, and Victoprene Type K seals for tank road wheels. The seals utilized synthetic rubber lips, and the Garlock seal had a "finger-type" spring.
CONCLUSIONS: The Garlock seals were not satisfactory because of bent springs permitting the oil to leak from the hubs at 345 miles. The test of the Victoprene seals was discontinued at 599 miles because test operation of the vehicle was discontinued; none of the seals failed during this period. The slip fit seal adaptors permitted the oil to leak and were considered inadequate. SAE No. 10 oil was retained satisfactorily by the Victoprene seals for special operations such as cold weather for the 599 miles tested. It was recommended that seal spacers or adaptors used in applications where the inner bearing race rotates be a press fit when used with lip-type seals.
GENERAL: This five-page report is not illustrated.

SUBJECT: Seals and Closures GM-CTP 646-2F
TITLE: Shock Absorber Rod Guide Seal Development for T41E1 and T141 Vehicles
IDENTIFICATION: Report No. 646-2 (Final)
DATE OF REPORT: 23 June 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To develop a rod guide seal suitable for use in shock absorbers in which the piston rod attains temperatures as high as 600°F
METHOD: The test multi-lip seals were installed in production control shock absorbers on the T41E1 and T141 vehicles and operated over dry, cross-country terrain at high speeds, until failure. The experimental seals were then installed in Delco shock absorbers and the test repeated.
DESCRIPTION: Delco and Monroe submitted a multi-lip seal from civilian stock and Monroe also submitted multi-lip neoprene rubber rod guide seals. Experimental seals made of Teflon were submitted by Skinner Motors.
CONCLUSIONS: The single, neoprene rubber lip rod guide seal with a leather or neoprene wiper was not satisfactory for use in regular production control shock absorbers over dry, cross-country terrain at high speeds. The experimental rod guide seal, developed by Skinner Motors, increased the life of regular production control shock absorbers. It was recommended that the production samples of Skinner Motor rod guide seals be tested to determine their suitability for use in the shock absorbers on the T41E2 and T141 vehicles.
GENERAL: This seven-page report includes two photographs of the Skinner Motors experimental seals.

SUBJECT: Seals and Closures GM-CTP 693-1
TITLE: Test of Suspension Housing Outer Face Type Seals and Related Sealing Elements
IDENTIFICATION: Report No. 693-1 (Preliminary)
DATE OF REPORT: 13 November 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the most satisfactory face-type outer bearing seal combination for use in the suspension housings of the T41 and T141 vehicles.
METHOD: The seal combinations were installed on the test vehicles according to a procedure outlined in the report. Visual inspection was made at frequent intervals, in addition to maintaining lubrication records, to observe leakage and the extent of any lubrication loss. The vehicles were operated at the Cleveland Tank Plant and the Cadillac Ordnance Proving Ground.
DESCRIPTION: The following items were tested: oil impregnated and wax filled leather faces; .010-inch taper on leather face, with and without a cemented gasket; 1/16-inch raised ring in the center of the leather face; FA-9 rubber labyrinth-type seal face (National Motor Bearing Co.), with and without a cemented gasket; grooved retainer plates with two and with three groove, and the production seal assembly (Vehicle T141, No. 214). The type of cement used on certain of the seals was identified as Allis Chalmers No. 033288. The gaskets used included 50-durometer rubber double ring face gaskets; production rubber single ring fact gaskets were also tested.
CONCLUSIONS: The FX-9 rubber grooved face (labyrinth-type) seal with the 50-durometer rubber, double ring face gasket cemented to the seal proved the most satisfactory of all of the seals tested. These seals were still operating success-

fully on two vehicles at 1985 and 718 miles, respectively. Standard production seals and retainers were used on the T141 for 9438 miles with only very slight seepage. Seals with the .010-inch taper on the leather face and production rubber single ring face gasket on the drive pin end of the seal permitted water leakage into the suspension housings. The grooved retainer with the production seal leaked excessively when it was operated on cross-country terrain. Tests with the oil impregnated, wax filled, and 1/16-inch raised ring, leather face seal resulted in failure or were inconclusive. There were so many variables present during all of the tests that some data contradicted other data. A final report was to have been written after additional mileage had been obtained on the seals.
GENERAL: This 13-page report contains two photographs of the test seals.

SUBJECT: Seals and Closures GM-CTP 720
TITLE: Development of Teflon Shock Absorber Rod Guide Seals
IDENTIFICATION: Report No. 720
DATE OF REPORT: 25 May 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the durability of the production Skinner Teflon seal
METHOD: Shock absorbers containing the Skinner piston rod guide seals were installed on test vehicles and the vehicles operated. Periodic inspections were performed and any leakage and the corresponding mileage were noted. At the completion of the test, or at the time of failure, the shock absorbers were dismantled for inspection. Modification of the seals was performed as indicated by the test results, and the test repeated. This procedure was followed until the development of the wedge-type Teflon seal with circumferential grooves. The test was then discontinued.
DESCRIPTION: The original Skinner Teflon seal, the numerous modifications, and the final development were described in detail in the report.
CONCLUSIONS: The production seals submitted by Skinner Motors would not seal at low shock absorber operating temperatures, thus necessitating a program of further development. The wedge type Teflon rod guide seals with circumferential grooves were found to be the most durable of the several types tested. This type has been released for production with minor changes.
GENERAL: This nine-page report includes three photographs and one detail drawing of the test seals.

SUBJECT: Seals and Closures GM-CTP 932F
TITLE: Durability Comparison Test of Dole Special and Production Packing Glands for Main Engine Primer Pump
IDENTIFICATION: Report No. 932 (Final)
DATE OF REPORT: 8 September 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the relative freedom from packing gland leakage during durability operation of a main engine primer pump fitted with a production packing gland and a Dole special packing gland, respectively
METHOD: The Dole primer pump was mounted on a test fixture and operated for 25 hours at 60 strokes per minute. This test was made with the standard packing gland and then repeated with the Dole special packing gland. A primer pump with the special packing gland was installed in vehicle T41E2 and operated for 3134 miles.
DESCRIPTION: The test items were Dole special primer pump with special packing gland, and a Dole primer pump with standard packing gland. The special packing gland sealing was obtained by the interference fit between the hole in the seal and the O. D. of the piston rod.
CONCLUSIONS: When properly tightened both packing glands remained leak free throughout the tests.
GENERAL: This five-page report includes one photograph of both types of packing glands.

SUBJECT: Seals and Closures GM-CTP 1049F
TITLE: Roadwheel Arm Assembly Spline Sealer
IDENTIFICATION: Report No. 1049 (Final)
DATE OF REPORT: 25 February 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To evaluate the effectiveness of the test sealer in a laboratory bench test and in vehicle operation
METHOD: One road wheel arm was assembled into a housing and the housing was filled with ethylene glycol. It was then subjected to three 24-hour leak tests: (1) at room temperature, (2) at 150°F in the electric oven, and (3) at -4°F to -64°F in the cold box. The assemblies were periodically checked for leakage. Five test arms were installed on two vehicles for durability operation at both the Cleveland Tank Plant and the Cadillac Ordnance Proving Ground. One of the test road wheel arm assemblies was subjected to two additional tests: (1) the front end of the vehicle was dropped from heights of 18 to 45 inches, and (2) the vehicle was subjected to jump tests at speeds up to 18 mph.
DESCRIPTION: The test unit was a Plastilock sealer, manufactured by the B. F. Goodrich Company, applied to the outer edge of the spline of the road wheel arm.
CONCLUSIONS: Use of the sealer did not prevent seepage during vehicle operation, and consequently did not appear to be satisfactory. However, it was noted that none of the test assemblies had both proper shrink fit and two coats of properly cured sealer. It was recommended that further tests be performed using assemblies having increased shrink fit and two coats of properly cured sealer, which required 20 to 30 minutes of drying time between coats, and 12 hours of drying time after the final coat.
GENERAL: This seven-page report includes one photograph showing the extent of sealing in the arm-to-shaft splines.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Seals and Closures GM-CTP 1355
TITLE: Shock Absorber Seal Durability Tests: A. Resistoflex Material; B. Metal Outer Wedge; C. Copper Cone Spacer; M42 Vehicle
IDENTIFICATION: Report No. 1355
DATE OF REPORT: 20 July 1955
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the effectiveness of shock absorber seals
METHOD: The seals were operated on the M42, No. 317 and the M41A1, No. 2358 vehicles at the Cadillac Ordnance Proving Ground and the Cadillac Tank Plant Test Track. Track conditions were "moderately" muddy during most of the test.
DESCRIPTION: The test units were three types of shock absorber seals. The first were Resistoflex Company seals made of a translucent grade of Teflon which had a fine grain, in contrast to the chalky colored and coarse grain material formerly used in production seals. The second type was a metal outer wedge seal, fabricated from one piece of Teflon to prevent bonding. This seal incorporated the same inner Teflon piece as production seals, but the outer piece was made of brass with a gasket and a press fit on the O.D. to provide a seal on the O.D. The third type of seal utilized a copper cone spacer, the purpose of which was to separate and prevent the Teflon wedges from bonding.
CONCLUSIONS: Both the copper cone spacer and metal outer wedge type seals were effective for at least twice as many miles as the production seal. The Resistoflex Company material bonded as tightly and as readily as the material used in production shock absorbers. Dirt in the seals was an important source of failures. The dirt eventually separated the wedge surfaces (either metal or Teflon), which created a direct leakage path for the shock absorber fluid.
GENERAL: This 14-page report contains four photographs of the seals.

SUBJECT: Seals and Closures GM-CTP 1378
TITLE: Durability Tests of Shock Absorber Teflon Rod Seals with Metal Cone Spacers
IDENTIFICATION: Report No. 1378
DATE OF REPORT: 22 November 1955
ORIGIN: General Motors Corporation, Cleveland Tank plant
PURPOSE: To determine the effectiveness of experimental shock absorber seals
METHOD: Six shock absorbers with experimental seals were installed on the M41A1, No. 3729 vehicle at the L-1, L-2, L-3, R-1, R-2, and R-3 positions. The vehicle was operated at the Cadillac Ordnance Proving Ground and at the Cadillac Tank Plant test track. Conditions of the cross-country course varied between hard and frozen to deep mud. Observations were made for signs of oil leaks, and failed shock absorbers were disassembled and inspected.
DESCRIPTION: The test units were shock absorber, Teflon rod seals with metal cone spacers. These spacers were identified as No. 468-X and were manufactured by the Flexible Company.
CONCLUSIONS: It was concluded that the metal cone seal spacers greatly increased the life expectancy of the shock absorbers. The use of these spacers was necessary to prevent bonding, the major cause for seal failure. All six test shock absorber seals operated more than 4000 miles.
GENERAL: This seven-page report contains one photograph of the experimental seal.

SUBJECT: Seals and Closures GM-CTP 1411
TITLE: Durability Tests of an Experimental Shock Absorber Dirt Wiper (Glass Impregnated Teflon) M41A1 and M42 Vehicles
IDENTIFICATION: Report No. 1411
DATE OF REPORT: 7 November 1955
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the durability of the glass Teflon dirt wiper and to compare its performance as rightside up Teflon rod seal versus upside down Teflon rod seal
METHOD: Six shock absorbers were assembled with .002-inch brass spacers between the Teflon rod seal and glass Teflon dirt wiper. Four of the shock absorbers had rod seals in the normal position and two had rod seals with inverted or upside down Teflon seal wedges. The shock absorbers were installed on an M42 vehicle and operated for 333 miles over rough, cross-country terrain.
DESCRIPTION: The experimental rod dirt wiper was of glass filled Teflon which gave 100% seal around the rod.
CONCLUSIONS: All shock absorbers failed after relatively low mileage. The cause of these failures could not be clearly determined. Low mileage at failure made it impossible to evaluate the glass Teflon wiper and the inverted Teflon rod seal. It was recommended that further tests be made to determine the cause of high internal forces that caused these seal failures and also to determine the effectiveness of the glass impregnated Teflon dirt wiper.
GENERAL: This 10-page report includes two schematic drawings and two photographs of the subject wiper.

SUBJECT: Seals and Closures PG-2.443
TITLE: Protecto-Seal Caps on M3 Medium Tanks
IDENTIFICATION: Report No. PG-2.443; GMPG Project No. 30-1
DATE OF REPORT: 15 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effectiveness of Protecto-Seal caps in preventing flooding of gasoline tanks in the Medium Tank M3
METHOD: The sponson and vertical tanks of an M3 were filled with fuel and the caps installed. As the fuel became heated during vehicle operation, observations were made of pressure effect and of the sealing ability of the caps on side slopes.
DESCRIPTION: Two types of Protecto-Seal caps were tested; one with a two-pound pressure release and one with a four-pound pressure release.
CONCLUSIONS: Neither cap was effective in pre-

venting flooding of the gasoline tanks. It was recommended that it would be more effective to provide better sealing of openings between the engine compartment and the fuel tanks, and that provision be made for ventilating the space around the tanks with relatively cool air.
GENERAL: This 8-page report is unillustrated.

SUBJECT: Seals and Closures PG-2.812
TITLE: Medium Tank Bogie Wheel Bearing Seal Test
IDENTIFICATION: Report No. PG-2.812; GMPG Project No. 51-28
DATE OF REPORT: 22 September 1943
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the durability of grease seals on medium tank bogie wheels using all possible combinations of rawhide and neoprene seals, New Departure and Timken bearings, and disk and spoke type wheels
METHOD: The 12 test bogie wheels were installed on a Medium Tank M4A3. Four were lubricated by hand packing before installation and eight by pressure gun and stand pipe. A rapid mileage test of 993 miles was then made over an endurance course. Wheels were removed; bearings inspected for wear; condition of seal, lubricant, and wheel determined; and bearing assemblies photographed as removed and after cleaning.
DESCRIPTION: Materials tested consisted of three spoke wheels with New Departure ball bearings and Chicago Rawhide seals; one spoke wheel with Timken bearing and Chicago Rawhide seal; three disk wheels with Ohio Rubber Neoprene seals and Timken bearings, two disk wheels with Timken bearings and Chicago Rawhide seals; and three spoke wheels with New Departure bearings and Ohio Rubber Neoprene seals.
CONCLUSIONS: After 993 miles neither the rawhide nor neoprene seal was satisfactory when not relubricated. Four of the six sets of neoprene had one or both seals destroyed. In most the Hycar face had separated from the seal. Only one set of rawhide seals failed (L-4 position after 966 miles) but the others did not prevent entrance of dirt. Hand packing did not provide better lubrication, nor was there greater seal life in spoke type wheels. It was recommended that further development work on rawhide seals be done. Final conclusions were withheld awaiting completion of other tests being conducted.
GENERAL: This 39-page report contains 24 photographs of bogie wheel assemblies and failures.

SUBJECT: Seals and Closures PG-2.853
TITLE: Final Report on Test of Ohio Rubber Experimental Bogie and Top Idler Wheel Grease Seals for Half-Track Vehicle
IDENTIFICATION: Report No. PG-2.853; GMPG Project No. 51-38
DATE OF REPORT: 9 September 1943
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the mechanical and sealing properties of one set of experimental bogie and top idler wheel grease seals for a half-track
METHOD: The seals were installed in Half-Track Personnel Carrier M5 which was operated 1551 miles over the durability course and 315 miles on gravel and concrete highways. Highway operation occurred at intervals determined by Signal Corps representatives conducting static discharge tests.
DESCRIPTION: Material tested was one complete set of Ohio Rubber Company's experimental bogie and top idler wheel grease seals.
CONCLUSIONS: With exception of seal failures in L#2, R#1, and R#4, caused by loosening of wheel roller bolt stop nuts on these bogies, all seals and bearings except L#4 were in serviceable condition after 1866 miles of operation. Durability was therefore considered satisfactory. It was recommended that, should members of the Signal Corps determine static characteristics adequate, the seal be considered for installation on half-track vehicles.
GENERAL: This 14-page report contains four photographs of seals and seal plates after test.

SUBJECT: Seals and Closures PG-60202.21
TITLE: Clutch Dust and Grease Seals, Victor Gasket
IDENTIFICATION: Report No. PG-60202.21; TAPG Project No. 93
DATE OF REPORT: 8 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the comparative suitability of experimental and standard clutch dust and grease seals for use with medium tanks
METHOD: The seals were installed on the spindle and hub of a Lipe ventilated clutch. The clutch was installed in an M4A4 Medium Tank and operated for 1277 vehicle miles.
DESCRIPTION: The test items were Victor Gasket synthetic limited contact seal No. 62042 and Chicago Rawhide single bevel leather seal No. TC1061. The standard seals were Chicago Rawhide garter spring type Nos. A163764 and A169132.
CONCLUSIONS: The experimental seals reduced drag a desirable amount, and were as effective in operation as the standard seals. It was recommended that the limited contact seals of Victor Gasket and Chicago Rawhide be substituted for the standard.
GENERAL: This 14-page report contains the results of a Chrysler laboratory test on seal-drag and is not illustrated.

SUBJECT: Seals and Closures PG-61801.84
TITLE: Suspension, Bogie Wheels John Crane Seals, M4 Medium Tank
IDENTIFICATION: Report No. PG-61801.84; TAPG Project No. 78-3
DATE OF REPORT: 15 June 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the comparative suitability of John Crane metal face type, standard Chicago Rawhide double-lip type, and John Crane

improved seals for use on Medium Tank M4 bogie wheels
METHOD: A medium tank was equipped with two standard and ten test seals and operated for 2359 miles. The redesigned test seal was operated in various wheel positions of other vehicles for 2122 miles.
DESCRIPTION: The test John Crane, metal face, bogie wheel seal consisted of a rotating ground surface inner sealing face pressed into the hub and an outer seal consisting of a metal housing, a steel coil spring enclosed in a synthetic rubber bellows, and a ground sealing face assembled in the axle.
CONCLUSIONS: The original test seals were considered unsatisfactory. Chicago Rawhide seals previously tested averaged 2488 miles without failure and the test seals averaged 2204 miles to failure. Failures were caused by dirt accumulating between the seal housing and wheel hub, resulting in the shearing of the locking tab and the adjusting nut lock pin. The redesigned seal was in satisfactory condition after 2122 miles and it was recommended that testing be continued.
GENERAL: This 27-page report contains seven photographs illustrating the test seal assembly and failures. Drawings of the original and redesigned units are included.

SUBJECT: Seals and Closures PG-61806.2
TITLE: Sealing of Rear Door, M4A4 Medium Tank
IDENTIFICATION: Report No. PG-61806.2; TAPG Project No. 33
DATE OF REPORT: 12 February 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effectiveness of a Chrysler experimental rear door seal for Medium Tanks M4A4
METHOD: Test seals were installed on the engine compartment rear doors of two medium tanks which were then operated for 2060 and 1696 miles. Waterproofing qualities were observed during the runs, and condition of the seals was studied after the tests.
DESCRIPTION: The test seal consisted of a section of synthetic rubber (Chrysler Material Standard No. MS 1869) attached to the engine compartment rear door and retained by a metal strip held in position by drive screws. When the door was closed the seal was compressed by about 7/64-inch between the door and hull.
CONCLUSIONS: Although the experimental seal itself was satisfactory when properly installed, sealing of the doors was not effective because of faulty design of the center strip seal which was not changed. It was recommended that this center strip seal be redesigned, that rigid inspection be maintained in production to insure the doors being installed in a plane parallel to the hinge mounting surface, and that the welding of the hinge plate to the hull should be watched to prevent an excess build up of metal which would interfere with the seal.
GENERAL: This 17-page report includes two design sketches of the test seal and rear door.

SUBJECT: Seals and Closures PG-61806.5
TITLE: Revised Rear Door Seal, Medium Tank M4A4
IDENTIFICATION: Report No. PG-61806.5; TAPG Project No. 33-1
DATE OF REPORT: 10 July 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effectiveness of a new-type engine compartment rear door center strip seal for Medium Tanks M4A4
METHOD: The seal was installed on a medium tank which was driven into a river and stopped in water deep enough to cover the top of the engine compartment doors. Effectiveness of the seal in keeping out the water was observed. After 1107 miles of operation, the test was ended and the seal was inspected.
DESCRIPTION: This seal consisted of a flat, hollow strip of synthetic rubber retained in the center off-set of the hull right rear door by a 90° angle iron which was held in position by screws. With the doors closed, the seal was compressed between the off-sets in the two rear doors.
CONCLUSIONS: The seal was found satisfactory and was recommended for acceptance.
GENERAL: This 14-page report includes one photograph of the seal installed and one design sketch of seal details.

SUBJECT: Seals and Closures PG-61806.9
TITLE: Seal-Rear Door, Revised, Medium Tank M4A4
IDENTIFICATION: Report No. PG-61806.9; TAPG Project No. 33-1-1
DATE OF REPORT: 22 January 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effectiveness of a revised rear hull door seal on Medium Tanks M4A4
METHOD: The seal was installed on each of the rear engine compartment doors of a medium tank. The tank was driven into water to within two-inches of the door tops, and leakage was observed. The vehicle was then operated 513 miles and the condition of the seals noted.
DESCRIPTION: The test seal was a flat, hollow "U" shaped strip of synthetic rubber. It was molded in one piece for each of the two rear doors of a Medium Tank M4A4 and fastened to each door by a 90° angle iron, which was held in position by screws.
CONCLUSIONS: The seal was most effective provided the compartment door hinge distance from the hull was within ±1/64-inch of design specification. It was recommended that the seal be released for production and that the ±1/64-inch specification be maintained.
GENERAL: This 19-page report includes two photographs of the seal installed and five design sketches.

SUBJECT: Seals and Closures PG-61806.11
TITLE: Seal, Engine Bulkhead Floor, M4A4 Me-

dium Tank
IDENTIFICATION: Report No. PG-61806.11; TAPG Project No. 38
DATE OF REPORT: 24 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effectiveness of a means of sealing the engine bulkhead, near the floor of the fighting compartment in the M4A4 Medium Tank, against oil leakage
METHOD: A medium tank, with sealed engine bulkhead, was given a 8329 mile run over the endurance tank route.
DESCRIPTION: The bulkhead sealing arrangement consisted of an oil supply tank outlet pipe baffle and a steel baffle plate installed in the drive shaft tunnel floor. No work was done to seal the starter and choke cables or the air inlet tube, as recommended in Chrysler Drawing No. 2556, as this wasn't deemed necessary for this particular test.
CONCLUSIONS: The method of sealing the bulkhead was effective and was recommended for acceptance. It was also recommended that suggested means of baffling the starter and choke cables, and air inlet tube be used.
GENERAL: This 15-page report includes Chrysler Drawing No. 2556 showing the tested and recommended method of sealing the bulkhead.

SUBJECT: Seals and Closures PG-61806.17
TITLE: Demountable Headlamp Sealing
IDENTIFICATION: Report No. PG-61806.17
DATE OF REPORT: 5 June 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the waterproofing effectiveness of experimental headlamp-to-hull sealing gaskets
METHOD: A production and an experimental gasket were installed on the headlamps (Corcoran-Brown) of two tanks, M4 and M4A3. Prior to this installation, the lamps had been removed and inspected. The two vehicles were operated over an endurance course, the condition of which subjected the headlamps to a considerable amount of thrown mud and water. Mileage accumulated was 4619 miles for the M4 and 6665 miles for the M4A3. Failures were noted and the headlamps were inspected at the conclusion of the test. A Corcoran-Brown lamp was removed from each of two new production vehicles and its sealing compound examined. The sealing compound on two Guide headlamps was also checked.
DESCRIPTION: The test items were two experimental seals for demountable headlamps as used on M4 medium tanks. The experimental seals, No. A-265600, were 9/16-inch thick as compared to a thickness of 1/2-inch for the standard seals.
CONCLUSIONS: The sealing qualities of the gaskets were satisfactory and prevented water leakage between the headlamp shaft and tank hull. Corrosion of the contact springs and points in the lower end of the lamp shaft was observed. Although there was good adhesion of the sealing compound to the wires within the stems of the lamps, adherence to the inner walls of the shaft was very faulty. This same adhesion failure was noted on Corcoran-Brown lamps from two new production vehicles. However, the Guide lamps were found to have watertight seals in the upper ends of their shafts. It was therefore recommended that the sealing compound used in the upper end of the shafts on Corcoran-Brown demountable headlamps be improved to obtain better adhesion. It was also recommended that better inspection control be exercised over the machining of these lamp shafts.
GENERAL: This 18-page report contains four photographs of the headlamp seals.

SUBJECT: Seals and Closures RIA 49-1134
TITLE: Pneumatic Equilibrator Packings for Operation at Sub-Zero Temperatures
IDENTIFICATION: Report No. 49-1134
DATE OF REPORT: 7 September 1949
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the type and grade of synthetic rubber packings, the type and grade of packing lubricant, and the method of lubricating the packings best suited for equilibrators which operate at sub-zero temperatures as low as -70°F
METHOD: All the equilibrators used in this investigation were assembled in accordance with standard manufacturing procedure to standard production tolerances. Each equilibrator was assembled with the O-ring packings, the packing lubricant, the O-ring retainers and glands, and charged with nitrogen to the pressure designated for the particular test. Pertinent data, such as sizes of O-ring packings and nitrogen pressures, were recorded. Following assembly and preparation for the test, the completed equilibrator was X-rayed by means of a 22-million volt Betatron in the areas of the piston and stuffing box packings to show the relative positions of the packings and the spaces occupied by the packing lubricant. Nine 155 mm gun equilibrator gymnastication tests were conducted, all but one at sub-zero temperatures between -70° and -75°F. Those that did not fail were also gymnasticated at normal room temperature. The gymnastication tests were designated Nos. 9 through 17A.
DESCRIPTION: Test packings, manufactured by E.F. Houghton and Company, were designated as -70 and 10V70-92 and RIA compound 410 synthetic rubber O-rings.
CONCLUSIONS: Best results were obtained with Company A, Grades -70 and 10V70-92 and RIA Compound 410 synthetic rubber O-ring packings lubricated with hydraulic oil, Army-Navy Aeronautical Specification AN-VV-O-366b. The operational life of O-ring packings at sub-zero temperatures was prolonged (1) by reducing to a minimum the possibilities for their extrusion, (2) by providing them with continuous fluid lubrication, and (3) by making them of a material which remained resilient at the lowest operating temperature. At the time of this report, the testing program had not yet been completed.
GENERAL: This 38-page report includes four photographs of the stuffing box packing area, open

and closed, and the equipment for the test at both sub-zero and normal temperatures.

RIA 49-1574
SUBJECT: Seals and Closures B-4.9.3
TITLE: Hydro-Pneumatic Recoil Mechanism Floating Piston Packings for Normal and Sub-Zero Temperature Operation
IDENTIFICATION: Report No. 49-1574; B-4.9.3
DATE OF REPORT: 28 October 1949
ORIGIN: Rock Island Arsenal, Rock Island, Illinois
PURPOSE: To determine the suitability of experimental packing for all-temperature operation of floating pistons
METHOD: Three 74-mm M1A4 Pack Howitzer Recoil Mechanisms were assembled with various test packings in the recoil mechanisms and charged with nitrogen to a pressure of 1700 psi at a temperature of 70°F. The mechanisms were gymnasticated in a cold room at temperatures ranging from 0 to -70°F and checked periodically with manometer tests. The temperature of the recoil oil, nitrogen, and cold room, length of recoil, duration of cycle and total cycles were recorded hourly during gymnastication. After completion of 10,000 cycles, at sub-zero temperatures, the mechanisms were warmed to room temperature, given manometer tests, checked for nitrogen pressure, floating piston friction, and oil condition. Satisfactory mechanisms were given proof firing tests, additional gymnastication, and additional proof firing, with manometer checks being made after each test.
DESCRIPTION: The types of packing material used were rubber, leather, anti-friction metal, nylon, and Teflon. Oil or grease soaked felt wipers were also used with the packings. The gymnasticator was a device that hydraulically simulated recoil action.
CONCLUSIONS: Hydraulic oil conforming to AN Aeronautical Specification AN-VV-O-366b was considered superior to all other recoil oils tested for sub-zero temperature operation. Felt lubricators on the floating pistons were thought to increase the operational life of the packings at both normal and sub-zero temperatures. Nylon and Teflon plastic showed indications of being satisfactory packing materials. Anti-friction metal cup rings showed definite indications of being superior to silver rings.
GENERAL: This 56-page report contains 32 pages of charts, graphs, drawings, and photographs.

SUBJECT: Seals and Closures RIA 51-981
TITLE: Pneumatic Equilibrator Packings for Operation at Sub-Zero and Normal Temperatures
IDENTIFICATION: Report No. 51-981
DATE OF REPORT: 9 May 1951
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate pneumatic equilibrator packings for operation at extreme temperatures
METHOD: Each equilibrator was assembled with the packings, packing lubricant, and retainers and glands designated for the test. Eleven tests were conducted during which the equilibrators were gymnasticated 20,000 cycles or until failure at a temperature of -70°F and at normal room temperature. The equilibrators were X-rayed in the area of the piston and stuffing box packings to show the relative position of the packings and the spaces occupied by the packing lubricant. These radiographs were taken before, during, and after the testing. Nitrogen pressures were also checked before, during and after the tests.
DESCRIPTION: The following equilibrator packings were tested: O-ring packings lubricated by oil in the grease spaces; O-ring packings lubricated by felt saturated with oil in the grease spaces, and G-T ring packings lubricated by oil in the grease spaces. The test O-rings were made of three materials: RIA compound Nos. 410 and 425 synthetic rubbers and Houghton, Grade -70 synthetic rubber. Oils conforming to Specification AN-VV-O-366b and AN-O-366 were used in the tests.
CONCLUSIONS: Tests results indicated that the functional life of O-ring packings at sub-zero and normal temperatures were prolonged by providing continuous and fluid lubrication. An oil-soaked felt lubricator provided better and longer lasting lubrication to the packings than oil without a retaining aid. The qualities of the synthetic rubber used for packings had a definite effect on the functional life of dynamic packings at normal and especially sub-zero temperatures. The size of dynamic packings was quite critical. The best results were obtained with Houghton, -70 grade, synthetic rubber, O-ring packings with a felt lubricator saturated with Specification AN-O-366 oil in the grease spaces. Test equilibrators utilizing the preceding withstood the gymnastication tests without failure and with only small losses in nitrogen pressure.
GENERAL: This 46-page report contains two radiographs of the stuffing box packing areas of the equilibrators and two photographs of test equipment. Also included are detailed drawings of the equilibrators and lubrication components.

SUBJECT: Seals and Closures RIA 51-1235
TITLE: Hydro-Pneumatic Recoil Mechanism Packings for Normal and Sub-Zero Temperature Operation
IDENTIFICATION: Report No. 51-1235
DATE OF REPORT: 24 April 1951
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate ten types of packing for use in 75mm pack howitzer recoil mechanisms, M1A4 at normal and sub-zero temperatures
METHOD: The various types of recoil mechanism packings were tested in 75mm pack howitzer recoil mechanism, M1A4, by means of gymnastication which closely simulated firing conditions. The packings were gymnasticated a minimum of 10,000 cycles at -70°F and 10,000 cycles at normal temperature
DESCRIPTION: The subject recoil mechanism packings were described in the body of this report.
CONCLUSIONS: The test results showed that: Teflon plastic was superior to all other materials tested for packing shrouds; a felt lubricant saturated with oil on the floating piston was superior to grease; and oil, hydraulic, Army-Navy Aeronautical Specification AN-O-366 (MIL-O-5606) was superior to all other recoil oils tested for sub-zero temperature operation.

GENERAL: This 62-page report includes 12 photographs and 16 detail drawings of the test setup and components.

SUBJECT: Seals and Closures RIA 52-3683
TITLE: Hydro-Pneumatic Recoil Mechanism Packings for Sub-Zero, Normal and Elevated Temperature Operation
IDENTIFICATION: Report No. 52-3683
DATE OF REPORT: 12 March 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To select material which would improve the operational life expectancy of recoil mechanism packings
METHOD: Various types of recoil mechanism packings were tested by eight tests in 75mm pack howitzer recoil mechanisms, M1A6, by means of gymnastication which closely simulated firing conditions at sub-zero, normal, and elevated temperatures. Hydraulic aircraft petroleum base oil, MIL-O-5606 was used for recoil oil in all tests.
DESCRIPTION: Test items consisted of: Teflon packings of the annular and conventional types; standard packings, which had standard synthetic rubber fillers and leather shrouds, with conventional shaped aluminum alloy and/or silver cup rings; and standard packings which had Thiokol filled leather replacing the standard leather shrouds on the floating piston only.
CONCLUSIONS: Teflon plastic packings are suitable for use at all temperatures from -70°F to 300°F. In comparison to conventional packings, Teflon plastic packings are equal in performance; are superior to operational life in all temperatures; produce less wear on cylinder surfaces; and should be economical to produce due to their simple design. Indications were that the aluminum alloy cup rings are better than silver rings because they do not scratch the cylinder surfaces.
GENERAL: This 43-page report contains 10 photographs of test components.

SUBJECT: Seals and Closures RIA 53-2767
TITLE: Pneumatic Equilibrator Packing for Operation at Sub-Zero, Normal, and Elevated Temperatures
IDENTIFICATION: Report No. 53-2767
DATE OF REPORT: 7 October 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the best types and grades of synthetic rubber packings and packing lubricants, and the best method of lubricating the packings for equilibrators
METHOD: Friction and gymnastication tests were performed on equilibrator mechanisms at sub-zero, normal and elevated temperatures. Fourteen gymnastication tests were conducted as follows: 20,000 cycles at -70°F; 10,000 cycles at normal room temperature; and 10,000 cycles at 160°F.
DESCRIPTION: Test equilibrators were 155mm gun equilibrators with synthetic rubber O-ring packings. Special recoil oil USA Specification 2-132, and hydraulic oil, Specification MIL-O-5606 were used.
CONCLUSIONS: Functional life of O-ring packings was prolonged by providing continuous lubrication and by use of back-up washers. Synthetic rubber O-rings were found desirable for maximum life.
GENERAL: This 52-page report includes six photographs and 13 curves.

SUBJECT: Seals and Closures T-60216
TITLE: Circuit Gasket, Klixon, Sealing Gasket, M4 Medium Tank
IDENTIFICATION: Report No. T-60216
DATE OF REPORT: 9 December 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the effectiveness of a neoprene gasket in excluding dust and water from the circuit breaker, and to determine the effect of the gasket on the operation of the circuit breaker
METHOD: The gasket was cut to the outline of the mounting face of the circuit breaker. A hole in the center permitted the circuit breaker setting button to pass through. The circuit breaker and gasket were then mounted on the box which would house them in the tank. The box was filled 1/4 full with AC synthetic dust, mounted on a vibration machine, and run at frequencies continually varying from 7 to 35 cycles per second. The vibration machine was run for 1 hour and then the circuit breaker was removed for inspection. It was tested at 125% load and tripped after 13 minutes and 58 seconds. It was then dismounted and the gasket was removed. Additional tests also were outlined in the report.
DESCRIPTION: The test gasket was made from 3/32-inch neoprene sheet. The circuit breaker was Part No. A-222867.
CONCLUSIONS: A 3/32-inch neoprene gasket effectively sealed the circuit breakers against the entry of dust and moisture, if the surface of the Bakelite case was reasonably flat. The hole for the reset button should be about two thirds the diameter of the button to provide a tight seal; this would not interfere with the performance of the circuit breaker.
GENERAL: This five-page report is not illustrated.

SUBJECT: Seals and Closures T-60216.2
TITLE: Circuit Breaker Sealing Gasket, Klixon, M4 Medium Tank
IDENTIFICATION: Report No. T-60216.2
DATE OF REPORT: 4 March 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine whether a 1/32-inch thick neoprene gasket will effectively dust and moisture proof a Klixon circuit breaker
METHOD: The circuit breakers, with gaskets, were mounted in a steel box, with the reset button facing outward and downward. The box was filled with AC synthetic dust and vibrated at 18 to 55 cycles per second, continuously varying with 1/16-inch total excursion, for 1 hour. The circuit breakers were then mounted on a steel plate, with cutout for the reset button, and submerged in water for 24 hours.

DESCRIPTION: The test materials consisted of four Klixon PLM 120 circuit breakers Part No. A-222867 and four neoprene gaskets 1/32-inch thick, with holes to provide a tight fit over the reset button.
CONCLUSIONS: The 1/32-inch thick neoprene gasket would not effectively seal the Klixon circuit breakers against dust and moisture unless the surface was filed or milled to remove the circular depression caused by the mold injection pins. Inasmuch as sealing of these circuit breakers was imperative, it was recommended that the Spencer Thermostat Company, manufacturers of the Klixon circuit breaker, be directed to mill or otherwise remove the depressions in the Bakelite. It was further recommended that existing circuit breakers be filed when gaskets are installed either in production or in the field.
GENERAL: This seven-page report includes two schematic drawings of the test method.

SUBJECT: Seals and Closures T-60216.2-01
TITLE: Circuit Breaker Sealing Gasket, Klixon PLM and CLM
IDENTIFICATION: Report No. T-60216.2-01
DATE OF REPORT: 19 April 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To conduct a salt spray test on Klixon circuit breaker Model CLM Part No. 222867, with neoprene sealing gasket 1/32-inch thick
METHOD: The circuit breaker with milled surface, was installed on a steel plate with cutout for the reset button. A 1/32-inch thick neoprene gasket was used as the seal. The circuit breaker was subjected to standard ASTM salt spray test for 20 hours. The circuit breaker was tested for performance at 150% rated current. It was then removed from the plate and examined for water leakage.
DESCRIPTION: The test material consisted of Klixon CLM circuit breakers, with milled Bakelite surfaces to eliminate the irregularities caused by the ejector pins on the Bakelite mold. The units were manufactured by the Spencer Thermostat Company.
CONCLUSIONS: These circuit breakers with gaskets, successfully withstood the standard ASTM salt spray test for 20 hours without affecting performance of the breakers, and without leakage of moisture into the contact chamber.
GENERAL: This four-page report is not illustrated.

SUBJECT: Seals and Closures T-60802.2
TITLE: Instruments, Weather-Proofing, Tank Combat and Motor Transport Vehicles
IDENTIFICATION: Report No. T-60802.2
DATE OF REPORT: 22 April 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the weather proofness of combat tank and motor transport vehicle instruments in accordance with specification requirements
METHOD: The instrument cases were subjected to 5 hours of a salt spray test and then cycled five times from -40° to 100°F air, with 95% humidity. A cycle was completed in 4 hours. An immersion test was tried to locate the point of leakage exactly. This test consisted of chilling the instrument in -40°F air and then submerging in 125°F water. Another test tried was immersing the instrument in a mixture of salt and ice water (1:2 by weight) at 0°F and then submerging instrument in 150°F water. This caused a vacuum and pressure on the seal.
DESCRIPTION: A complete list of the test parts and their manufacturers was included in the report.
CONCLUSIONS: Temporary expedients, such as the application of cements to make instruments weather-proof, were not successful. It was practical to seal the instruments hermetically and at least one design of each type of instrument passed all the tests. It was recommended, however, that the test specifications be revised to require total immersion for 5 minutes in salt water at 0°F, followed immediately by immersion for 5 minutes in water at 150°F. Any leakage of water or any expulsion of air during this test should be cause for rejection. A list of the seals which passed these tests was listed in the report and it was recommended that they be adopted by all manufacturers.
GENERAL: This 36-page report includes 21 detail drawings of the test items.

SUBJECT: Seals and Closures T-61806.6
TITLE: Sealing Material-Various Sources
IDENTIFICATION: Report No. T-61806.6
DATE OF REPORT: 18 August 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the characteristics at -40°, 158°, and 212°F, the freezability, and the resistance to water, oil, aromatic gasoline and salt water of 13 sealing materials submitted by four manufacturers
METHOD: The effect of water, salt water, oil and aromatic gasoline on the test sealers was determined by immersing coated steel panels into the liquids for a period of 72 hours. The tests were run at room temperature unless otherwise stated. The solubility in water was obtained by noting the residue left after the water used in the tests had evaporated. The per cent volatile matter was calculated from the loss in weight resulting when samples of the sealers were heated for 72 hours at 158°F. The aging tests were run at room temperature and 158°F. The flow tests were conducted by preparing two flow panels for each sealer. One was immediately placed upright and allowed to stand in this position for 72 hours at room temperature. The second panel was allowed to air-dry for 1 hour and then was placed at an angle of 20° in an oven at 158°F for 72 hours. The cold panels were struck several times against a hard surface and finally thrown onto the surface. The bend test consisted of bending the cold panel through an angle of about 45° and noting the condition of the sealer.
DESCRIPTION: The test materials were intended to seal welded or riveted holes against water, oil,

fuel spillage, etc. Five of the 13 sealing materials were submitted for test by the Parr Paint and Color Company, of Cleveland, Ohio. They were designated Alumilastic "C", "C-2", "C-B", "B", and Zinkrolastic "2C". The Tremco Manufacturing Company, of Cleveland, Ohio, submitted three sealing materials for the test - Tremco 44-36x, 99-70x, and B2-1x. The sealing material, 3M Cement EC-481, was submitted by the Minnesota Mining Company, of Detroit, Michigan. Ford Motor Company, of Dearborn, Michigan submitted four test samples- Asb. Asphalt 5378-A, Asphalt Sealer M5330-A, Dum-Dum M-245, and Tape (no label was on this material).
CONCLUSIONS: All the sealers were stable in water and salt water. The asphalt sealers and the tape were soluble in oil; the Dum-Dum swelled and softened in oil; all the other sealers were unaffected by oil. All the sealers tended to blister or dissolve in aromatic gasoline. Alumilastic "C-2", "B", "C-B" and Tremco 44-36x blistered slightly and were the most resistant to aromatic gasoline. The asphalt sealers and Dum-Dum were completely soluble in the gasoline. All the sealers aged without deterioration. All except the tape became hard, but were not brittle. All the samples tended to soften when heated to 212°F. None of the sealers bled when aging. Alumilastic "B" was quite thin and therefore tended to flow when applied. All the sealers adhered to metal at -60°F when the metal was struck against a hard surface. The following samples did not crack when the metal to which they were coated was bent through a 45° angle at -60°F; Alumilastic "C", "C-B", and "B", Zinkrolastic "2C" and Tremco 99-70x, Alumilastic "C-B" and "C2" were the best of the sealers tested.
GENERAL: This 10-page report contains two tables of the test results.

SUBJECT: Seals and Closures T-60202.25
TITLE: Clutch Grease Seal Drag, Various Types of Seals, Medium Tanks
IDENTIFICATION: Report No. T-60202.25; CX Project No. 129
DATE OF REPORT: 28 September 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the amount of drag produced by various types of medium tank clutch grease seals
METHOD: Eight types of seals were individually tested for drag on a generator driven shaft incorporating only a flywheel and clutch cover. Inner and outer seals were tested individually and in combination. Initial and final drag torques were measured for each 20 minute operational period at 795 rpm. Three hours after operation, the cooled seals were then subjected to breakaway torque tests and final drag torque measurement at 795 rpm.
DESCRIPTION: The following seals were tested: Chicago Rawhide Co. waxed leather and National Motor Brg. Co. oiled leather seals, both employing garter spring loading; a Garlock Packing Co. finger spring loaded synthetic rubber seal; Chicago Rawhide single and double bevel leather seals; two types of Chicago Rawhide single bevel leather seals each having a leather dust ring (the beveled edge of one was reduced from the original 1/8 inch to 3/32 inch); and a Victor Gasket Co. outer synthetic bevel seal.
CONCLUSIONS: Seal drag variation was found to be as great between seals of similar design as between seals of various types. This indicated the manufacturers were not producing seals having consistently low drag characteristics. Because of the necessity of vehicle tests to determine wear, sealing ability, performance at temperature extremes, no recommendations could be made on the drag characteristics of the seals alone. The Victor outer seal appeared to offer the best results.
GENERAL: This 18-page report contains four photographs showing the test setup, a damaged seal, and each of the test seals. A cross-section drawing of a medium tank clutch is included.

SUBJECT: Seals and Closures T-61902.15
TITLE: Transmission - M4 Medium Tank Input and Output Shaft Seals
IDENTIFICATION: Report No. T-61902.15
DATE OF REPORT: 5 January 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the source and cause of lubricant leaks at the transmission shafts and to find a remedy
METHOD: Leakage tests were conducted with various power train assemblies mounted on a dynamometer test stand. Thermocouples were used to obtain temperature readings, and dial indicators were used to check shaft run-out. A tilt stand was used to simulate running at an uphill angle of 15°.
DESCRIPTION: The test material consisted of standard, synthetic and leather oil seals made by Victor Gasket Company and Chicago Rawhide Company; two standard transmissions; an experimental transmission with restricted oil feed hole to output shaft rear bearing; and an experimental transmission with output shaft rear bearing reversed. Various combinations of this material were tested.
CONCLUSIONS: Most leaks from the rear of the transmission occurred at the output shaft between the oil seal diaphragm and the seal. During the test, ten leaks occurred at the output shaft oil seal, eight of which were serious, and only two leaks occurred at the input shaft oil seal, one of which was serious. The standard production Victor seals which leaked showed an out-of-round condition in a majority of cases, with leaks occurring at points diametrically opposite each other. Indications were that the use of the Chicago limited contact seal with synthetic diaphragm would diminish the leakage problem at the output shaft. It was believed that adequate lubrication and reduction in leakage would be effected if the oil hole passage to the output shaft rear bearing were reduced 50% in size. Addition of a shield to the rear of the bearing did not reduce the leakage from the output shaft seal.
GENERAL: This eight-page report is not illustrated.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Seals and Closures T-62207.1-02
TITLE: Waterproof Electrical Equipment, M4A3 Medium Tank, Rotary Switches and Rheostats
IDENTIFICATION: Report No. T-62207.1-02
DATE OF REPORT: 16 April 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop waterproof rotary switches and rheostats
METHOD: Standard production Ordnance switches and rheostats were modified to incorporate a Garlock rotary shaft seal of the double Klozure type. These devices were subjected to 6 psi of pressure and vacuum in addition to modifications of the heat and cold cycle tests outlined in Chrysler Proposal No. 186. The modified test method was included in the report.
DESCRIPTION: The following items were tested; a magneto, dome light, fuel selection, panel lamp, and B/O lighting switches; a stiffness rheostat, and a recoil rheostat.
CONCLUSIONS: The Garlock rotary shaft seal was satisfactorily used to waterproof the rotary switch shafts, rheostat shafts, and similar parts. Devices employing this seal should be mounted in an otherwise water tight box with the shaft protruding, because no attempt was made to seal the switch body or the terminals. It was recommended that die cast shafts be replaced with polished brass, chrome plated, to provide a better surface for the Garlock seal.
GENERAL: This 17-page report contains two photographs of test switches. Also included are diagrams showing the test setup and the installation of seals on various switches.

SUBJECT: Seals and Closures T62207.1-09
TITLE: Waterproof-Electrical Equipment - M4A3 Tanks - Packing Gland Adapter Assemblies
IDENTIFICATION: Report No. T-62207.1-09
DATE OF REPORT: 6 July 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop waterproof packing gland adapter assemblies for use in the M4A3 marine type electrical system
METHOD: The packing gland assemblies were installed into the junction box and tightened until sealed. The box was then tested for leaks at 6 pounds air pressure and 12 inches Hg vacuum. The boxes were then chilled at -40°F, removed from the low temperature and heated to 200°F. After being heated, they were plunged into tap water at 70°F. They were then returned to the -40°F temperature and the cycle repeated.
DESCRIPTION: The packing gland assemblies were composed of straight type adapters and elbow type adapters incorporating a pressure washer and a spring washer.
CONCLUSIONS: The waterproof packing gland adapter assemblies were found to pass specifications and meet all the requirements of the application and were released in sizes of from 1/4 inch to 15/16 inch.
GENERAL: This 12-page report contains three photographs of test components.

SUBJECT: Seals and Closures T-62207.1-010
TITLE: Waterproof-Electrical Equipment - M4A3 Medium Tank Junction Box Gaskets
IDENTIFICATION: Report No. T-62207.1-010
DATE OF REPORT: 6 July 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop waterproof gaskets for the M4A3 medium tank junction boxes
METHOD: Tests were made of both flat and round rubber gaskets laid in a groove cast in the box housing. After the cover was tightened and the box was tested for leaks at six pounds air pressure and 12 inches mercury vacuum; the box was then chilled to -40°F until stabilized; then removed and heated to 200°F until stabilized; then plunged into tap water at 70°F; then returned to the -40°F temperature and the cycling repeated.
DESCRIPTION: The test gaskets were made of flat rubber gasket material and round .225 buna rubber primary cable.
CONCLUSIONS: The flat type gaskets failed to pass the tests due to mutilation. The round, extruded type of gasket was found satisfactory after 12 cycles of tests without leakage or mutilation. Some trouble was experienced in controlling production for the rubber gaskets because they had to be cut to the proper length and cemented before curing. The curing resulted in no uniform lengths or joints. For this reason, the final drawings covered both extruded and molded types. It was felt that molding would keep these objections to minimum.
GENERAL: This 10-page report contains two photographs of the gaskets and foot switch and two drawings.

SUBJECT: Seals and Closures T-62207.1-011
TITLE: Waterproof Electrical Equipment, M4A3 Medium Tanks, Auto-Lite Generator Control Unit
IDENTIFICATION: Report No. T-62207.1-011
DATE OF REPORT: 6 July 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop a waterproof type of regulator unit
METHOD: Regulator units were tested according to Ordnance specifications for heavy-duty waterproof electrical equipment for Class I components. Various methods of sealing were evaluated, and two sealed regulator units with revised gaskets were developed. Testing consisted of 12 temperature and immersion cycles from -40 to 200°F. Salt spray tests were used to determine the suitability of four finish coatings for the die cast parts.
DESCRIPTION: The test items were experimental Auto-Lite, 24-volt, 50-ampere generator control units, Models L6010 and L6179, for the M4A3 medium tank. The Model L6179 regulators were modified to include a seal at the main and terminal box covers, and between the terminal box and regulator case. This seal consisted of a round neoprene gasket recessed into the area of one part, and a compression bead on the adjoining part. Finish coatings tested were Iridite with baked enamel RX-715; Chronak with zinc chromate primer, wrinkle (baked enamel); Chronak with zinc chromate primer; Sperry (flat, block-baked enamel);

and Chronak (A. L. Specification No. 342) with zinc chromate primer (olive drab baked enamel).
CONCLUSIONS: The seal used in the Model L6179 regulators satisfactorily waterproofed the regulator units. It was found that the pipe thread type of fitting for the conduit connection to the terminal chamber, used on these samples, was subject to leakage in the threaded portion of the casting. Tests have shown that fittings of a confined gasket construction are superior to those of the pipe thread type. Production units should therefore incorporate this type of seal at the elbow fittings, making the elbow adjustable for different installations. Salt spray tests showed that Iridite with a baked enamel finish provided better corrosion protection than any of the other finishes.
GENERAL: This 22-page report contains eight photographs of the test regulators and die cast parts.

SUBJECT: Seals and Closures T-62207.1-013
TITLE: Waterproof Electrical Equipment, M4A3 Medium Tanks, Mechanical Speedometers, Tachometers, and Cables
IDENTIFICATION: Report No. T-62207.1-013
DATE OF REPORT: 20 July 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop waterproof speedometers, tachometers, and drive cables
METHOD: The speedometer cables and rotating seals were tested according to the Class I and III specifications of the Ordnance Department Designers Handbook, Section II, dated 1 June, 1945. Four different methods were used in an attempt to seal the speedometer reset stem. Plastic cup type speedometer and tachometer lens and window seals were also tested.
DESCRIPTION: The following items were tested: several Part No. 620854 standard production, Stewart-Warner speedometers with standard reset stems; one speedometer, identical with the preceeding, but with modified reset stem bearings; one Part No. 7054105 speedometer cable with Vinylite sleeving and cotton and kraft paper braid; two No. 7320561 speedometer cables with Flex-O-Tube housing: several Part No. 7057055 speedometer cable shaft seals; and an AC Spark Plug tachometer and speedometer, both incorporating a plastic cup (Lucite) and window seal.
CONCLUSIONS: No successful method for sealing speedometer reset stems was developed, and it was recommended that this reset be omitted on waterproof speedometers. The two types of cables met all of the requirements of the specifications, and the rotating seal was satisfactory for attachment between the cable and the transmission on engine. The plastic cup type lens and window seals passed all of the tests and were recommended for approval.
GENERAL: This 27-page report contains four photographs showing methods of sealing used. Also included is a drawing showing the flexible speedometer drive shaft assembly.

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Section 35
SHIELDS

SUMMARY

The subject, Shields, was not summarized because of the limited scope of the shield reports briefed to date. When a sufficient number of shield reports are briefed that establish trends, a summary will be prepared and made available.

REPORT RESUMES

NOTE

A number of shield report resumes are classified. These resumes appear in Section 35, Volume XI.

SUBJECT: Shields APG 214-2
TITLE: Report on Vision Slit, Disston Experimental, for Tanks M2 (Soft Welded Bead)
IDENTIFICATION: A.P.G. No. 470.5/459
DATE OF REPORT: 17 July 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To ascertain, with .30 caliber ball ammunition, whether the soft welded bead surrounding the vision slit would keep out splash from impacts near the slit; and to determine, with .50 caliber A.P., the ballistic limit of the armor plate as softened near the bead weld.
METHOD: Six rounds of caliber .30 ball ammunition were fired, with a range of 50 yards, and hits were registered on the bead, on the bead edge, and on the armor plate near the bead. Paper placed across the back of the opening was pierced when one instance of splash occurred. Five rounds of .50 caliber armor-piercing ammunition were then fired at the bead from a distance of 100 yards with striking velocities from 2733 to 3860 feet per second. Six additional rounds were directed, with striking velocities between 2817 and 3096 feet per second, at the armor plate with 2-1/2 to 5-inches of the slit.
DESCRIPTION: The vision slit, of unspecified size, was located in the approximate center of a one-inch piece of Disston carburized armor plate 15 inches square. The bead surrounding the slit was formed by welding.
CONCLUSIONS: With .30 caliber standard ammunition, a direct hit on the welded bead resulted in bullet splash, but the bead was considered fully as effective in splash protection as any previously tested. When .50 caliber A.P. was used the ballistic limit for the area within 1-1/2 inches of the bead was set at 2829 feet per second; and the ballistic limit of areas unaffected by welding heat was set at 3058 feet per second.
GENERAL: This five-page report is unillustrated.

SUBJECT: Shields APG 5395/9
TITLE: First Report on Oil Pan Shield for Scout Car M3A1
IDENTIFICATION: Ninth Report on Ordnance Program No. 5395; APG No. 13-10
DATE OF REPORT: 27 October 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the shield for protecting the oil pan, and the effect of the shield on oil temperatures
METHOD: The oil pan shield was installed on the Scout Car M3A1, and operated 1155 miles over varied terrain. The effect of the shield on the oil temperature was checked by operating the vehicle at speeds corresponding to maximum torque, while towing a field dynamometer. Runs were made with and without the shield, and with the shield hand-packed with mud.
DESCRIPTION: The oil pan shield, made from heavy sheet metal, was an open drip pan attached to the vehicle frame by means of brackets. These brackets were welded to the shield and bolted to support brackets which were, in turn, bolted to the vehicle frame. The shield was manufactured by White Motor Company.
CONCLUSIONS: The test shield was very satisfactory, and was recommended both as a standard production part and as a field modification for Scout Car M3A1. It was further recommended that the support brackets be welded instead of bolted to the vehicle frame eliminating ten bolts, washers, and nuts from the installation. Oil temperatures were not appreciably affected by the shield, even when packed with mud.
GENERAL: This 51-page report contains three photographs of the oil pan shield.

SUBJECT: Shields APG 5518/4 Min.
TITLE: First Minor Report on Air Cleaner Failures on Half-Track Car M2
IDENTIFICATION: Fourth Minor Report on Ordnance Program No. 5518; APG 16-16
DATE OF REPORT: 18 June 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effectiveness of air

cleaner splash shields against mud and water
METHOD: Tests over terrain covered with water holes were conducted on M2 half-tracks equipped with temporary splash shields. The Donaldson Corporation then submitted proposed splash shields for evaluation by the Proving Ground.
DESCRIPTION: The experimental splash shields were manufactured by Donaldson Corporation, and were designed to prevent water and mud from entering the air cleaner.
CONCLUSIONS: The proposed shields were considered satisfactory and recommended as a quick fix item for all existing half-track vehicles M1, M2, and M3. It was further recommended that engine combustion air be taken from the crew compartment instead of under the hood.
GENERAL: This 24-page report contains four photographs of the proposed shields.

SUBJECT: Shields APG 5518/19
TITLE: Second Report on Half-Tracks Interference Between Front Tires and Armor Plate
IDENTIFICATION: Nineteenth Report on Ordnance Program No. 5518; APG 16-25
DATE OF REPORT: 7 November 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effectiveness of a rubbing plate in alleviating tire cutting due to front tire and armor plate interference in half-track vehicles
METHOD: The test rubbing plate was installed on a 75-mm Gun Motor Carriage M3, and operated over wash-board terrain at high speed.
DESCRIPTION: The rubbing plate was basically an angle plate designed to cause tire rubbing instead of tire cutting. The plate was centered in the area which indicated tire and armor plate contact.
CONCLUSIONS: The rubbing plate operated satisfactorily and was recommended for use. The front suspension of the half-track vehicle was considered inadequate because of many interferences, and it was recommended that a project be initiated to improve the front suspension by eliminating these interferences.
GENERAL: This 18-page report contains one photograph of the installation of the rubbing plate.

SUBJECT: Shields APG 5696/9
TITLE: First Report on 105-MM Howitzer Motor Carriage M7 - Recuperator Shield
IDENTIFICATION: Ninth Report on Ordnance Program No. 5696 (Project No. 4435/6-20-3-6)
DATE OF REPORT: 1 January 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the test recuperator shield and equilibrator springs in compensating for the muzzle preponderance of a 105-mm howitzer
METHOD: The recuperator shield and equilibrator springs, installed, were driven for 96 miles over extremely rough cross-country terrain, 30 miles over a gravel course, and eight miles over a paved road. The firing test consisted of firing 50 rounds of ammunition with Zone 7 powder charges at various positions of elevation, depression and traverse.
DESCRIPTION: An experimental recuperator shield, made of 1/4-inch steel, and strengthened equilibrator springs were tested on a 105-mm Howitzer Mount M4. The test shield included a long armor cover for the recuperator cylinder and a hinged door in the front of the shield for protection of the recuperator cylinder head. The equilibrator springs were made to compensate for the weight of the shield.
CONCLUSIONS: The test recuperator shield and compensating springs were satisfactory. They were recommended for standardization provided that ballistic protection of the recuperator with armored shields be investigated first.
GENERAL: This 18-page report contains four photographs of the test components.

SUBJECT: Shields APG 5720/3
TITLE: First Report on Truck, 1/4-Ton, 4x4, Unventilated Suppression Shield
IDENTIFICATION: Third Report on Ordnance Program No. 5720; APG 14-43A
DATE OF REPORT: 21 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effect of unventilated shielding on the ignition components of the 1/4-Ton Truck
METHOD: One Ford and one Willys 1/4-Ton, 4x4, Truck with the unventilated box-type suppression shields installed were given over 10,000 miles of highway operation each. Temperatures of two plugs, hood, distributor, and coil were taken with the vehicle operating at 40 mph on pavement in ambient temperatures averaging between 34° and 43°F. Conditions of the ignition components before, during, and after the test were recorded.
DESCRIPTION: The unventilated box-type radio noise suppression shields consisted of No. 16 gauge sheet metal made to totally enclose the spark plugs, high tension leads, distributor, and coil of the truck.
CONCLUSIONS: The suppression shields had no adverse effects on the ignition components of the 1/4-Ton Truck. Numerous spark plug failures were encountered during the test, but they were due to poor quality spark plugs rather than any deficiencies of the suppression shield. It was recommended that the shields be tested on vehicles at higher ambient temperatures before making final approval.
GENERAL: This 34-page report contains four photographs showing installation of the suppression shields. Also four photostats of the detail and assembly drawings of the suppression shield are included.

SUBJECT: Shields APG 6009/8
TITLE: First Report on Heavy Tank M26, Rubber Fenders and Sand Shields Test of
IDENTIFICATION: Eighth Report on Ordnance Program No. 6009; APG 10-195
DATE OF REPORT: 28 November 1945
ORIGIN: Aberdeen Proving Ground, Maryland

PURPOSE: To determine whether fenders and sand shields made of a flexible non-metallic material could replace the standard, metal fenders and sand shields on the M26 Heavy Tank
METHOD: The test sand shields were installed on the heavy tank and observed through a total of 1305 miles operation. Test fenders were installed and observed during a total of 1040 miles of operation. Cross-country, sandy, wooded terrain and paved highways were negotiated during the test runs.
DESCRIPTION: The test sand shields and fenders were similar in design to their standard counterparts. The sand shields and one fender were made of neoprene impregnated canvas duck called Neoform; the other fender was of six-ply rubber.
CONCLUSIONS: The non-metallic shields and fenders were inferior to metal equipment. Neoform fenders and sand shields were considered entirely unsatisfactory. Six-ply rubber fenders were satisfactory from a durability standpoint, but did not provide needed reinforcement and support.
GENERAL: This 39-page report includes 14 photographs of the test shields and fenders installed on the heavy tank.

SUBJECT: Shields APG TT2-777/7
TITLE: Test of Flexible Sand Skirts and Fenders, Tanks M47 and T43
IDENTIFICATION: Seventh Report on Project No. TT2-777
DATE OF REPORT: 19 November 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of U. S. Rubber Company fenders and sand skirts for use on the T43 tank; and to determine the suitability of Southwest Rubber Company sand skirts for use on the M47 tank
METHOD: A T43 tank, equipped with test U. S. Rubber Company fenders and sand skirts, and an M47 tank, equipped with Southwest Rubber Company sand skirts, were operated over varied terrain for 354 and 3193 miles, respectively.
DESCRIPTION: The test U. S. Rubber Company fenders and sand skirts were fabricated from 1/4-inch thick Royalite, which was a rubber-plastic material patented by the manufacturer. Southwest Rubber Company sand skirts were fabricated from a 1/2-inch thick, fabric-reinforced rubber material.
CONCLUSIONS: The U. S. Rubber Company fenders, because of their fragile construction, brittleness, and lack of reinforcement at mounting points, were considered unsatisfactory. It was recommended that they be rejected for use on T43 tanks. The Southwest Rubber Company sand skirts were considered satisfactory and it was recommended that the skirts be accepted in the form of a kit for installation on the M47 tank. It was further recommended that the Southwest Rubber Company sand skirts be considered for use on other track-laying vehicles.
GENERAL: This 27-page report contains five photographs showing the test fenders and sand skirts installed on the facility vehicles.

SUBJECT: Shields PG-2.733
TITLE: Test of Splash Shield for Donaldson Air Cleaner
IDENTIFICATION: Report No. PG-2.733; GMPG Project No. 114-6, Supplement No. 1
DATE OF REPORT: 14 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the efficiency of splash shields for Donaldson Air Cleaners
METHOD: The Donaldson air cleaner and a splash shield were installed on Half-Track Personnel Carrier M3, and operated 877 miles over moderately muddy terrain, and for a short distance (mileage unknown) through 8-1/2 inches of water to see if any water entered the oil reservoir.
DESCRIPTION: The splash shield, a rectangular plate of sheet metal, was installed along the side of the engine at cleaner height.
CONCLUSIONS: The splash shield was considered unsatisfactory for protecting air cleaners on Diamond T Half-Tracks M3. It proved effective against mud splash, but ineffective against water splashing upwards from the right front wheel. Recommendations suggested the possible use of splash guards under the engine compartment to eliminate difficulties from water contamination.
GENERAL: This 10-page report contains two photographs of Donaldson air cleaners installed with air shroud and splash shield.

SUBJECT: Shields PG-2.758
TITLE: Test of Revised Donaldson Air Cleaner (With Splash Shield)
IDENTIFICATION: Report No. PG-2.758; GMPG Project No. 107-1
DATE OF REPORT: 1 June 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effectiveness of a splash shield used with a Donaldson Air Cleaner
METHOD: The test cleaner was installed on a Half-Track Personnel Carrier M5 and operated, at varying speeds, 34 miles on wet and muddy roads, 1200 feet through nine inches of clear water, and over a course fitted with deep mud and water holes.
DESCRIPTION: The test unit consisted of a standard Donaldson cleaner mounted in the original brackets and a splash shield, which utilized five drilled holes in the cowling and dash. The shield covered the front and top of the cleaner.
CONCLUSIONS: The revised cleaner was effective under all but the most severe road conditions. Recommendations specified continued development of a suitable splash shield for the cleaner, and the possible use of a shield under the engine compartment. Although the test cleaner was completely effective against mud splash, the cleaner was subjected to water contamination when the vehicle operated at 15 mph in nine inches of water for 1200 feet, and particularly when making right hand turns through water holes. Installation of the air cleaner and shield was simple.
GENERAL: This 12-page report contains four photographs illustrating splash shields at winch

and front fenders, as part of the air cleaner installation, and beneath the radiators. These latter shields, installed during the test, were effective against radiator and windshield water splash, but ineffective against water splash in the engine compartment.

SUBJECT: Shields PG-2.778
TITLE: Trial Installation Sand Shield Kit E8525 - Medium Tank M4 Series
IDENTIFICATION: Report No. PG-2.778; GMPG Project No. 33-56
DATE OF REPORT: 17 June 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine whether the installation of Sand Shield Kit E8525 on Medium Tank M4A1 was satisfactory
METHOD: The test shield kit was installed on Medium Tank M4A1. Ease of installation and proper fit were determined.
DESCRIPTION: Sand Shield Kit E8525 consisted of a center section, lipped plate about 8 x 1 feet in size and a hooded front and rear section for each side of the tank. Installed, the kit forms a protective skirt slightly above and along each track. This skirt extends down to just above the tops of the bogie wheels along the length of the tank and approximately one foot lower at the front and rear.
CONCLUSIONS: The sand shield kit installation was satisfactory; its effectiveness was not determined.
GENERAL: This nine-page report includes one photograph of the shield kit installed.

SUBJECT: Shields PG-2.858
TITLE: Half-Track, Front Wheel Universal Joint Boot Shields
IDENTIFICATION: Report No. PG-2.858; GMPG Project No. 33-30
DATE OF REPORT: 28 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of front wheel universal joint boot shields for use on half-track personnel carriers
METHOD: The test shields were installed on a Diamond T half-track, Personnel Carrier, and operated 5390 miles over varied terrain.
DESCRIPTION: The front wheel universal joint boot shields, manufactured by Timken-Detroit Axle Company, were designed to protect the front wheel universal joint rubber boots from sharp stones.
CONCLUSIONS: The test shields operated satisfactorily, and were recommended for use. No interference was encountered, and there was no serious accumulation of mud or ice on the shields during the test operation. Only when operated under very severe conditions were the shields bent, but this did not interfere with steering.
GENERAL: This 10-page report includes three photographs of the test shields.

SUBJECT: Shields PG-2.876
TITLE: Final Report on Dust Deflector Modifications Medium Tank, M4A3
IDENTIFICATION: Report No. PG-2.876; GMPG Project No. 51-20
DATE OF REPORT: 15 September 1943
ORIGIN: General Motors Laboratory, Phoenix, Arizona
PURPOSE: To determine effectiveness of a modified dust deflector and its effect on the cooling of the M4A3 Medium Tank
METHOD: The test deflector was installed on a Medium Tank M4A3 and color motion pictures were taken of test vehicle operation and of the operation of a similar vehicle with a standard deflector. Engine temperature surveys were made with standard and with test deflector installed on the vehicle.
DESCRIPTION: The test vehicle was a Medium Tank M4A3, Serial No. 2923. No description of the dust deflector was contained in the report.
CONCLUSIONS: The modified dust deflector was considered satisfactory. The dust cloud was greatly diminished with its use except at high speeds. The cooling of the engine did not appear to be altered by the use of the modified deflector. It was recommended that the modified deflector be adopted for the M4A3 Medium Tank.
GENERAL: This 10-page report contains one drawing of the modification made to the dust deflector and one temperature survey sheet.

SUBJECT: Shields PG-2.978
TITLE: Effect of Splash Shields on Engine Cooling - Half-Track, M3
IDENTIFICATION: Report No. PG-2.978; Project No. 228
DATE OF REPORT: 9 December 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effects of splash shields on engine cooling of the vehicle
METHOD: Road cooling tests were performed on the vehicle both with and without the splash shields. Thermocouples were placed on the vehicle to record the temperature of: the grille, carburetor air, the engine cooling water, the engine oil, and transmission oil. The vehicle was operated at various engine and ground speeds and gear ratios at full throttle and with a towed load.
DESCRIPTION: The vehicle was a Half-Track Personnel Carrier, M3, manufactured by the White Motor Company. The splash shields consisted of pieces of formed sheet metal bolted between the left and right side of the engine and the chassis, between the oil pan and radiator, between the radiator and front bumper, and over the space between the front of the fenders and the bumpers. The shields were designed to protect the air cleaners and radiator from mud splashing.
CONCLUSIONS: The splash shields raised the water temperature differential a maximum of 6°F which was not prohibitive. The shields were not designed for a half-track with a winch. It was recommended that splash tests and further cooling tests with a modified radiator shield be conducted before the shields were adopted.
GENERAL: This 23-page report contains seven

photographs showing installation of the shields and sketches showing relative position of the shields on the vehicle.

SUBJECT: Shields PG-2.1034
TITLE: Installation and Operation Check of Periscope Guards, C100914
IDENTIFICATION: Report No. PG-2.1034; GMPG Project No. 286
DATE OF REPORT: 12 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To install and make installation and operation checks of periscope guards for use on Ordnance Vehicles
METHOD: One of the two guards furnished the Proving Ground was installed on the device hatch of Medium Tank M4A3 Ford. An M6 periscope was installed, and the hatch closed. The turret was traversed by hand to check for gun interference. The gun elevating mechanism was operated manually. The guard was next installed on Medium Tank M4A3 Chrysler, and was checked in same manner. The third installation was made on both hatches of three-inch Gun Motor Carriage M10E1 Fisher.
DESCRIPTION: None.
CONCLUSIONS: The periscope guards fitted satisfactorily on the periscope mounts of the three vehicles used in test. The gun interfered with periscope guards on both medium tanks when depressed and turret traversed. The gun shield of the three-inch Gun Motor Carriage M10E1 interfered with guard when periscopes were turned either direction from straight ahead. It was recommended that periscope guards be considered acceptable for use on M10 Gun Motor Carriages, if it were not objectionable to have periscopes aimed ahead whenever turret is to be traversed. It was also recommended the guards be considered acceptable for use on the M4 series medium tanks, if they are proven sufficiently sturdy to force gun up and over without being damaged.
GENERAL: This 10-page report was not illustrated.

SUBJECT: Shields PG-2.1063
TITLE: Test of Experimental Test Covers for Spring Loaded Idler Adjuster-Half-Track
IDENTIFICATION: Report No. PG-2.1063; GMPG Project 34-153
DATE OF REPORT: 13 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effectiveness of experimental test covers in protecting the idler adjusting screws from rusting.
METHOD: The experimental test covers were installed on an M3 Half-Track, and operated 1069 miles.
DESCRIPTION: The experimental test covers were designed to protect the spring loaded idler adjuster, and consisted of a screw guard assembly and a canvas cover for the idler adjuster screw.
CONCLUSIONS: Sufficient protection was provided for the adjusting screw during the test mileage, but it was believed that holes already worn in the canvas cover would permit entrance of mud and water after further test operation. It was recommended that an improvement be made on the clamp fastening the adjusting screw cover to the adjusting spring retainer; that the screw cover be made of more durable material; and that further testing be conducted after the above improvements were incorporated.
GENERAL: This 14-page report contains six photographs of the test parts before and after testing.

SUBJECT: Shields PG-2.1230
TITLE: Cooling Tests, Half-Track Splash Shield, Check for Production Release, Half-Track M3
IDENTIFICATION: Report No. PG-2.1230; GMPG Project No. 314
DATE OF REPORT: 1 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effect, on the cooling performance of M3 Half-Tracks, of splash shields and hood louvers around the engine compartment
METHOD: Two test vehicles, one with winch and one with roller (different splash shield installations) were subjected to road cooling tests. Runs were made at approximately 10-mph in various gears.
DESCRIPTION: The splash shields tested were fabricated of light sheet metal and canvas and were mounted at the rear of the front bumper and the bottom of the engine compartment.
CONCLUSIONS: The splash shields detracted only slightly from cooling performance, and in view of their effectiveness in protecting the engine compartment from mud and debris, they were recommended for standardization. The hood louvers detracted from, rather than improved, cooling performance and since they had no other purpose, they were not recommended.
GENERAL: This 36-page report contains 15 photographs of the splash shield installations.

SUBJECT: Shields PG-2.1234
TITLE: Durability Tests of Half-Track Splash Shields, Check for Production Release, Half-Track M3
IDENTIFICATION: Report No. PG-2.1234; GMPG Project No. 314
DATE OF REPORT: 8 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of half-track splash shields and their effectiveness in keeping mud out of the engine compartment
METHOD: Shields were installed on two Diamond T half-tracks, M3A1, one with winch and one with roller (different shield installations). These were operated for 617 and 984 miles on the endurance course. No indication of course condition was given in the report.
DESCRIPTION: The splash shields were fabricated of sheet steel with canvas fillers where

freedom of motion was desired. They were installed behind the front bumper and at the bottom of the engine compartment. The canvas fillers on the bottom shield contacted, but were not attached to the engine oil pan.
CONCLUSIONS: Although the durability of the test shields was satisfactory, the fabric fillers on the bottom shields deformed, leaving a gap between the shields and the engine, and allowing considerable mud to enter. It was suggested that the filler strips could be attached to the engine with the oil pan screws. A sharp edge on a canvas shield retaining strip, at the fender-to-bumper shield, was noted and rounded edges were recommended for these strips.
GENERAL: This 14-page report contains five photographs of the shield installation and deficiencies.

SUBJECT: Shields PG-2.1451
TITLE: Revised Exhaust Deflector Plate for Tank Recovery Vehicle M32B1
IDENTIFICATION: Report No. PG-2.1451; Project No. 380
DATE OF REPORT: 27 November 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effectiveness of an exhaust deflector for use with Tank Recovery Vehicle M32B1
METHOD: The test deflector was installed, and with the tank recovery vehicle towing an M4A3 Medium Tank, observation of dust conditions and measurements of carbon monoxide concentrations were made. Motion pictures were taken during operation with and without the test deflector, and with both the standard and test deflector.
DESCRIPTION: The test deflector was made from 16 gage sheet steel, and was attached by hinges to the lower edge of the upper hull back plate. This deflector was to redirect the fan and exhaust blast downward and sideways, and thus relieve the effects of the exhaust gases on the personnel of a towed vehicle.
CONCLUSIONS: The exhaust deflector was not considered necessary because the average concentration of carbon monoxide gas was not sufficient to produce headache symptoms even after prolonged exposure. At peak concentration (200 parts CO per million parts air), a seven-hour exposure was required to produce a headache in the average person. The test deflector had less influence on carbon monoxide concentration than other variables such as wind, engine mixture ratio, and hull openings in the towed vehicles. The use of the deflector resulted in greater agitation of dust, bringing discomfort to the occupants of the towed vehicle. It was recommended that the deflector be abandoned because of the adverse effect on cooling and dust conditions, and of the negligible hazard from carbon monoxide.
GENERAL: This 24-page report contains eight pages of photographs showing vehicle operation.

SUBJECT: Shields PG-60306
TITLE: Installation of Dust Deflector Medium Tank M4A1
IDENTIFICATION: Report No. PG-60306; TAPG Project No. 128-7
DATE OF REPORT: 27 August 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To check the installation and operation of a dust deflector on a Medium Tank M4A1
METHOD: The dust deflector was installed to check for any interference during installation and in the operation of opening and closing.
DESCRIPTION: The dust deflector was welded to the rear of the hull between the hull rear doors and the engine compartment air outlet screen. The test vehicle was a Medium Tank M4A1.
CONCLUSIONS: No interference was encountered during the installation, and operation of the dust shield was satisfactory. The one objection was the possibility of overheating the engine if the driver failed to check its position before starting out.
GENERAL: This six-page report includes two photographs of the test dust deflector installed.

SUBJECT: Shields PG-60705.1
TITLE: Half-Track Personnel Carrier M3, Donaldson Air Cleaner E-7872 Equipped with Various Splash Shields
IDENTIFICATION: Report No. PG-60705.1; TAPG Project No. 97-1
DATE OF REPORT: 10 June 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To develop an adequate and effective splash shield for use with Donaldson air cleaners on M3 Half-Tracks.
METHOD: Three different Donaldson air cleaners were successively installed on a half-track personnel carrier M5 repeatedly driven in third gear at full throttle through 50 feet of six-inch deep water. Various splash shields were also tried (15 to 20 mph). Four quarts of water were drained from the crankcase at 548 miles, and the first White engine had to be replaced after only 876 engine miles because of excessive wear. A total of 1250 miles was covered on the Tank Arsenal Proving Ground endurance course.
DESCRIPTION: The air cleaner tested first was the Donaldson E-7871. It was replaced by a Donaldson E-7872 which featured a shutter control to draw air either from the engine compartment, or from the crew compartment through a 2-1/2 x 6-inch hole in the dash. A Donaldson A9242 cleaner, standard for the International Harvester M5 half-track, was adapted for use with the White engine and tested briefly.
CONCLUSIONS: The four experimental Donaldson splash shields proved inadequate. The E-7872 cleaner, with shutter turned to draw air from the crew compartment, took in 255 c.c. of water in four runs through the 50-foot splash course. A shield fashioned from corrugated cardboard allowed only 5 to 7 c.c. of water to enter the crankcase, but when it was duplicated in sheet metal, with a hole cut in the top to avoid hood hinge interference, about 40 c.c. of water entered the cleaner. After the engine overheated from being covered with

mud, and after the spark plugs wires and shields became burnt from shorting, it was decided to abandon all work on the project in favor of designing a shield to protect the entire engine and radiator.
GENERAL: This 38-page report contains six drawings of the air cleaners and splash shields, and 13 photographs showing various worn engine parts, two splash shields, a clutch pressure plate, and the mud-covered engine and radiator. A report of inspection on the failed engine is also included.

SUBJECT: Shields PG-60705.3
TITLE: Half-Track Personnel Carrier M3 Splash Shield
IDENTIFICATION: Report No. PG-60705.3; TAPG Project No. 97-2
DATE OF REPORT: 9 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To develop a method of preventing mud and water from entering the engine compartment of the Half-Track M3; and to determine the effect of the method on engine cooling
METHOD: A set of splash shields was developed and installed on a Half-Track Personnel Carrier M3, and the vehicle was operated 235 miles over wet and muddy terrain. Temperature checks were made with the test vehicle pulling a towed load and operated at 1600 engine rpm. Tests were made with the radiator shutter open and closed, and with and without shielding installed.
DESCRIPTION: The test shielding consisted of eight sheet metal parts which covered the openings between the front fenders and frame, between the engine and frame, and the openings under the radiator and at the front of the engine.
CONCLUSIONS: The test shielding prevented mud and water from entering the engine compartment and was recommended as standard equipment for the Half-Track Personnel Carrier M3. The temperature test indicated that the shielding reduced by 4°F the temperature of the Ambient air in which the vehicle would operate at maximum torque (1000 engine rpm, wide open throttle - 24 mph, fourth gear) without exceeding the boiling point temperature (235°F) of the water in the radiator top tank. Without the splash shields, the vehicle could operate in 134°F ambient air temperature; with the shields the vehicle could operate in 130°F ambient air temperature.
GENERAL: This 22-page report contains four photographs showing the shielding disassembled, the installation on left side of engine and on the radiator, and the dirt condition of the engine at 235 miles. A schematic drawing of the complete installation is also included.

SUBJECT: Shields T-61813-01
TITLE: Spark Plug Shield and Suppression Assembly Waterproof type - M4 Medium Tank
IDENTIFICATION: Report No. T-61813-01
DATE OF REPORT: 24 May 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the suitability of the spark plug shield and suppression assembly
METHOD: A humidity test included intermittent engine operation in a cold room at -10°F. An electrical leakage test was made by setting the shields in mercury and measuring the voltage between the cable and mercury. Endurance testing consisted of 1850 hours on one engine, and 500 miles on another. Material strength was tested by applying pressure to the shield cavity up to 800 pounds. Screen room radiation tests were conducted to determine radio suppression characteristics.
DESCRIPTION: The spark plug shield and suppression assembly was the waterproof type for M4 Medium Tank. These tests were supplementary to tests covered in Report No. T-61813.
CONCLUSIONS: No trouble was experienced due to condensation. Endurance test on engine was completed with a total of 1850 hours without failure. The shield seal proved effective up to 800 pounds pressure. The suppressor assembly proved as effective as the existing standard signal corps suppressor.
GENERAL: This five-page unillustrated report includes five tests which were supplementary to tests covered in Report No. T-61813.

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Section 36
SPRINGS

SUMMARY

This summary covers 57 report resumes on the testing and development of volute leaf, recoil, and counterrecoil springs, and torsion bars during the period from March, 1939, through December, 1953. In addition to these items, which are covered below, data were also recorded for miscellaneous suspension components such as spring seats, shock isolators, assist springs, spring and shackle backings, and spring protective coatings.

Testing originated at Aberdeen Proving Ground, Maryland; Rock Island Arsenal, Illinois; Tank Arsenal Proving Ground, Utica, Michigan; Chrysler Engineering Division, Detroit, Michigan; General Motors Corporation, Cleveland Tank Plant; Armored Board, Fort Knox, Kentucky; Cadillac Motor Car Division, General Motors Corporation; Detroit Arsenal, Center Line, Michigan; Desert Warfare Board, Camp Young, California; Office, Chief of Ordnance, Detroit, Michigan; General Motors Proving Ground, Milford, Michigan; General Motors Phoenix Laboratory, Arizona; and the Ordnance Tire Test Fleet, Normoyle Field, San Antonio, Texas.

VOLUTE SPRINGS

Experimental work with volute springs included an unsuccessful attempt to recondition, by cold-stretching, used volute springs that had lost much of their original set. Equations were developed for calculating the spring size, stress, and deflection under various loads. Considerable work was performed to develop and improve volute springs for the suspension of M3 and M4 medium tanks. The uniformity and adequacy of heat treatment for volute springs were studied. Short-taper volute spring characteristics were determined. Standard and lead-coated volute springs were given life tests under corrosive conditions to determine the merit of the lead coating. Suspension units utilizing horizontal and vertical volute springs were analyzed comparatively. Various designs and material compositions were studied in an attempt to develop a superior volute spring.

LEAF SPRINGS

Most of the leaf spring test program was devoted to developing improved springs for use on half-track personnel carriage M3 and 75mm gun motor carriage M3. This program involved endurance, performance, spring rates, and comparative testing.

RECOIL AND COUNTERRECOIL SPRINGS

Coil springs for recoil mechanisms for 37, 75, and 76mm guns were tested. The prime objective in developing recoil and counterrecoil springs was to produce a spring capable of returning the gun to battery at any elevation as soon as possible after firing without slamming. This objective was accomplished.

TORSION BARS

Torsion bars for suspensions and tank drivers' doors were investigated. Experimental torsion bars of low, medium, and high hardenability were heat-treated and oil-quenched and then shot-peened. Fatigue characteristics of the bars were determined by cyclic torsional loading.

REPORT RESUMES

SUBJECT: Springs AB 402
TITLE: Test of Heavy Front Springs for Half-Track Vehicles
IDENTIFICATION: Final Report on Project No. 402
DATE OF REPORT: 24 June 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the durability of a heavier front spring for the M3 Half-Track Personnel Carrier
METHOD: Five winch-equipped M3 Half-Tracks were equipped with the test springs and operated from 830 to 1628 miles, for a total spring test mileage of 6554. Approximately one-third of this mileage was over rough cross-country terrain.
DESCRIPTION: The test springs were made by the Mather Spring Company. They were of 11-leaf construction, like the standard, but 3/8 inch greater in total depth and 1/4 inch greater in spring eye diameter. They were also 2-3/4 inches longer than standard and required several non-standard mounting parts.
CONCLUSIONS: No spring breakage occurred during the tests, although, due to the roughness of the terrain and high speeds maintained, axle bending was prevalent. The heavy springs were recommended for production vehicles and field modification.
GENERAL: This 10-page report contains three photographs of bent axles resulting from the test operations.

SUBJECT: Springs AB 603
TITLE: Final Report on Test of Springs No. 483-215 for Medium Tank M4A3E8

TANK AUTOMOTIVE TEST RESUMES

IDENTIFICATION: Final Report, Project No. 603
DATE OF REPORT: 4 October 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the effect of springs (No. 483-215) on the ride, vibration, and general performance characteristics of the Medium Tank M4A3E8
METHOD: A Medium Tank M4A3E8, equipped with the test springs, was operated in comparison with a standard Medium Tank M4A3E8 over paved highways and various cross-country terrain. Firing and ride tests were conducted with both vehicles, using shock absorbers having different control settings. A standard, late production Medium Tank M4A3, with a 76-mm gun and standard vertical volute suspension, was operated over the same course as a comparison vehicle.
DESCRIPTION: The test springs (No. 483-215) were of the volute type for use on a horizontal suspension and had greater load carrying capacity and higher rate than the standard springs. Test spring rate was 2380 lbs./in. with a free height of 13 inches and an average capacity of 7500 pounds at 10-inch compression. Standard spring rate was 1400 lbs./in. with a free height of 14 inches and a capacity of 5700 pounds.
CONCLUSIONS: The test springs produced a harder ride and more vibration than the standard springs, and were considered unsatisfactory for use with present weight vehicles. The present production vertical volute springs and shock absorbers as used on the M4A3 were considered the most satisfactory combination tested. Excessive vibration was experienced with the present Medium Tank M4A3E8, and immediate action was recommended to correct the condition. It was noted that any increase in vehicle weight would require an increase in spring capacity to prevent excessive bottoming.
GENERAL: This five-page report is not illustrated. Tabulated pitching, bottoming, vibration, and ride data are included.

SUBJECT: Springs APG 44-141
TITLE: Fatigue Test of Brake Spring from Ring Mount T-107
IDENTIFICATION: Project No. 6-11-32-2; APG 44-141
DATE OF REPORT: 6 January 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the endurance of the test brake spring
METHOD: The spring was installed in a Baldwin Southwark Spring Fatigue Machine and tested by compressing it to its solid height plus 0.1-inch at a rate of 60 cycles per minute. Permanent set was measured and recorded after every 1000 cycles.
DESCRIPTION: The test spring, Ordnance drawing No. A7012748, was a parallel helical type with an initial free height of 1.204 inches. The compressed height was 0.819-inch; the outside diameter was 0.957-inch, and the wire diameter was 0.149-inch.
CONCLUSIONS: The spring did not fail nor show any appreciable degree of fatigue after a total of 25,000 compression cycles. It took a permanent set of 0.012-inch after 25,000 cycles.
GENERAL: This eight-page report includes a photograph of the test spring.

SUBJECT: Springs APG 5341/19
TITLE: Report on Reconditioned Volute Springs for Light Tanks and Combat Cars
IDENTIFICATION: Nineteenth Report on Ordnance Program No. 5341; APG 23-3
DATE OF REPORT: 9 March 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the possibility of reconditioning volute springs which had lost much of their original strength
METHOD: The first attempt at spring reconditioning consisted of checking the reaction of a spring which had been in use for 5000 miles on a Combat Car M1, then cold stretching. The outer coil and the smallest coil were supported to prevent their being stretched also. After the cold stretch the reaction was again checked, with reactions taken both on compression and release and again at the assembled height of 8-1/2-inches. The spring was then compressed to within 1/4 inch of its solid height and allowed to stand for 24 hours. At the end of 24 hours the reaction was checked. The next phase consisted of stretching the spring cold, heating to 1550°F, quenching in oil, drawing to 800°F, and again checking reaction.
DESCRIPTION: The volute spring tested was made of carbon spring steel, and was used in Medium Tanks T5 and Combat Cars M1.
CONCLUSIONS: Volute springs cannot be satisfactorily reconditioned by cold stretching. Although the spring showed a marked increase in strength after heat treatment and prior to the fatigue test, it would not retain its strength under fatigue stress. It was recommended that a study be made to determine the proper heat treatment for reconditioning volute springs so that they would have satisfactory characteristics.
GENERAL: This seven-page report is not illustrated.

SUBJECT: Springs APG 5518-18
TITLE: First Report on Perch No. 3 Springs for Half-Track Vehicles
IDENTIFICATION: Eighteenth Report on Ordnance Program No. 5518; APG 16-24
DATE OF REPORT: 21 October 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the ability of test Perch No. 3 springs to carry increased loads and prevent track throwing on half-track vehicles
METHOD: Four sets of No. 3 springs were supplied for test. Springs were installed on Half-Track Personnel Carriers M3 at spring heights varying from 8 to 10 inches. Two test vehicles were used and operated for a total of 4944 miles over various terrain with gross loads of 10 tons each. The springs were removed and calibrated to determine load carrying capacity and fatigue effect.
DESCRIPTION: The high capacity, volute, test springs were specially coiled and wrapped to eliminate friction between coils, prevent sag and allow

proper operation of the suspension system. The springs were modifications of the standard No. 1 spring and were supplied by the Spring Perch Company.
CONCLUSIONS: The test springs were considered satisfactory and their use was recommended on all half-track vehicles. The springs were adequate to carry the increased loads and prevent track jumping. Objectionable sag or coil friction did not develop during the tests.
GENERAL: This 33-page report includes log sheets and calibration records of the tests.

SUBJECT: Springs APG 5518/24
TITLE: The First Report on the 75-mm Gun Motor Carriage Heavier Diamond T Front Leaf Springs
IDENTIFICATION: Twenty-fourth Report on Ordnance Program No. 5518; APG 225-66
DATE OF REPORT: 5 March 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance of heavy test springs on front suspension of 75-mm Gun Motor Carriage M3
METHOD: The test vehicle was operated 250 miles on secondary and 135 miles of cross-country roads. Records were kept of failures, and observations were made regarding interferences and riding improvements.
DESCRIPTION: The vehicle used for the test was a 75-mm Gun Motor Carriage M3 equipped with a heavy set of leaf springs manufactured by the Diamond T Motor Car Company. These springs were identical to those used on the 105-mm Howitzer Motor Carriage T19 and consisted of three main leaves, nine secondary leaves, and three rebound clips. The maximum static load capacity of each spring was 4950 pounds.
CONCLUSIONS: The Diamond T heavier front leaf springs were considered unsatisfactory because they failed to improve the vehicle operation. It was recommended that the test springs not be used on the 75-mm Gun Motor Carriage. It was also recommended that the steering arm attaching studs be increased at least 1/8-inch in diameter, to increase shear strength.
GENERAL: This 26-page report includes three photographs of bogie components.

SUBJECT: Springs APG 5518/25
TITLE: The First Report on 75-MM Gun Motor Carriage, Heavier Front Leaf Springs, International Harvester Company
IDENTIFICATION: Twenty-fifth Report on Ordnance Program No. 5518 APG 225-85
DATE OF REPORT: 12 January 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of heavy front leaf springs for use on the 75-mm Gun Motor Carriage
METHOD: The test springs were installed on a 75-mm Gun Motor Carriage M3 and the vehicle was operated a total of 3598 miles, which included 1271 miles on secondary roads, 1153 miles of cross-country operation, 674 miles on concrete, and 500 miles on Belgian Block.
DESCRIPTION: The test International Harvester front leaf springs for the 75-mm Gun Motor Carriage were heavier and longer than the standard springs.
CONCLUSIONS: The test springs were satisfactory after installation of International Harvester front brackets to accommodate the additional length. It was recommended that the Timken front axle housing structure be strengthened, and that the forward hinges on the armor plate engine hood be modified to eliminate interference between the radiator core and the hood bolts.
GENERAL: This 50-page report contains two photographs of vehicle component failures.

SUBJECT: Springs APG 5547/2
TITLE: First Report on Comparative Endurance Test of Front Leaf Springs on Half-Track Personnel Carrier, M3
IDENTIFICATION: Second Report on Ordnance Program No. 5547; APG 19-3
DATE OF REPORT: 31 January 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine which of three types of leaf springs would be most suitable for use in half-track vehicle front suspensions
METHOD: The vehicles were operated over various types of terrain so that spring life could be compared and vehicle operation observed. Most of the testing was conducted in convoy.
DESCRIPTION: The test leaf springs, designed for use on the front of 19,000 pound Half-Track Personnel Carriers M3 were both made by the U. S. Spring and Bumper Company. One of the test springs had a total of 14 leaves, with two rebound leaves. A U.S. Spring safety eye was included in the assembly. The second test spring assembly, referred to as the proposed production desert modified spring, consisted of 13 leaves, also with two rebound leaves. A third control vehicle was equipped with a set of standard half-track ten-leaf springs manufactured by the International Harvester Company.
CONCLUSIONS: The standard International Harvester leaf springs were found to be satisfactory, only one failing after 4375 miles of operation. The experimental, U.S. Spring and Bumper Company, 14- and 13-leaf springs had failed as early as 1519 and 1552 miles of operation, respectively. On the basis of these results, it was recommended that the standard International Harvester front leaf spring be considered satisfactory for use on all half -track vehicles. Numerous deficiencies of other components, noted on the vehicle during test, were also recommended for improvement.
GENERAL: This 161-page report contains 49 photographs showing various views of the test leaf springs.

SUBJECT: Springs APG 5586/1
TITLE: First Comparison Test of Counter Recoil Springs in 37-MM Recoil Mechanism M24
IDENTIFICATION: First Report on Ordnance Program No. 5586; APG 223-2A

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 20 October 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of three special Chrysler counter-recoil springs in 37-mm Recoil Mechanism M24
METHOD: A total of 43 rounds were fired from three Guns M5 whose recoil mechanisms incorporated the three test springs. Elevations ranged from minus 10° 55' depression to 59° 19' elevation.
DESCRIPTION: Of the three test units one was a No. GK-10 Keystone 296-pound static load recoil spring manufactured by the Eaton Manufacturing Company; one a telescope-type, 245-pound static load outer spring and 92-pound static load inner spring, manufactured by Eaton; and the third - a 300-pound static load spring manufactured by Precision Spring Company.
CONCLUSIONS: All three springs were found satisfactory at gun elevations from 10° depression to 60° elevation, the difference in operation characteristics being negligible. They overcame a slight binding condition in the sleigh, but would not overcome a serious resistance to movement. All three were superior to any present type counter-recoil spring and any one of the three would be suitable for adoption as standard equipment.
GENERAL: This 13-page report includes one sketch of the GK-10 Keystone spring.

SUBJECT: Springs APG 5586/2
TITLE: Second Comparison Test of Special Chrysler Counter-Recoil Springs in 37 MM Recoil Mechanism M24
IDENTIFICATION: Second Report on Ordnance Program No. 5586; APG 223-2B
DATE OF REPORT: 21 October 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To test four special Chrysler 37-mm counter-recoil springs and determine the most satisfactory for production
METHOD: A total of 40 rounds were fired from positions of 9° depression to 58-1/2° elevation using the four test springs and a standard counter-recoil spring for comparison purposes. Length of time and recoil were recorded for each round fired.
DESCRIPTION: The four test springs, made of WD 6150 steel, had a free length of 28-1/4 inches, an outside diameter of 2-5/16-inches and used a wire size of 0.283-inches. Load of each test spring at assembled height was 304, 315, 325, and 342 pounds, respectively, and that of the standard spring 235 pounds.
CONCLUSIONS: The standard spring would not return the gun into battery position at elevations above 35°, and return at 35° was slow, whereas all four test springs returned the gun at elevations from 9° depression to 60° elevation. The action of the spring of 304 and 315 pounds load were most satisfactory, recoil time averaging 0.72 and 0.68 seconds, respectively. It was thought that undue stress would result from the use of an unnecessarily high force of the 325 and 342 pound springs. It was recommended that either of the counter-recoil springs of assembled load of 304 and 315 pounds be considered for production.
GENERAL: This six-page report includes the firing records of the tests.

SUBJECT: Springs APG 5720/4
TITLE: First Report on Test of Hercules Super Spring for 1/4 Ton 4x4 Truck
IDENTIFICATION: Fourth Report on Ordnance Program No. 5720
DATE OF REPORT: 14 April 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To conduct a fatigue test on a leaf spring for a 1/4-ton, 4x4, truck
METHOD: Load deflection data were obtained with the Tinius-Olsen Universal testing machine. The spring height was measured from a definite datum plane, and load readings were taken for every inch of deflection up to a total of 5 inches. Load deflection data were obtained after the first 5000 cycles and every 10,000 cycles thereafter. The fatigue test was conducted on a Baldwin Southwark spring fatigue testing machine. The spring was preloaded by 1/4-inch and then deflected 5 inches at a rate of 43 cycles per minute.
DESCRIPTION: The item tested was a rear spring with ten Amola steel leaves, 1-3/4 inches wide, and four rebound clips. The No. 2 leaf, which was wrapped around the eyes of the No. 1 or main leaf, had a H plate. The spring also had an auxiliary or rebound leaf. The ends of the leaves, excluding the No. 1 and No. 2 leaves, were taper rolled. All the leaves, except the No. 2 leaf, had a groove which acted as a retainer for lubricant. The center or tie bolt had a double nut or locking arrangement. The unclamped length of the spring center-to-center of the eyes was 40-9/32 inches and weighed 25 pounds and 14 ounces.
CONCLUSIONS: It was concluded that under the particular conditions of this test, the Hercules Super Spring operated for 237,396 cycles before failure.
GENERAL: This 22-page report includes eight photographs of the tested spring and equipment.

SUBJECT: Springs APG 5723/7
TITLE: First Report on Test of Trucks, 2-1/2-Ton, 6x6, Secondary Bogie Springs and Suspended Driver Seats
IDENTIFICATION: Seventh Report on Ordnance Program No. 5723
DATE OF REPORT: 29 November 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a "secondary spring" applied to a rear bogie suspension of a 2-1/2-ton, 6x6, truck, and a suspended driver's seat
METHOD: Three modified, 2-1/2-ton, 6x6, trucks were loaded with 7-1/2-ton payloads and operated 5000 miles over concrete and fairly-smooth highways.
DESCRIPTION: The secondary bogie spring was of the conventional leaf-type. It was installed in addition to the standard spring. The suspended driver's seat was made by General Motors and was equipped with an adjustable spring.
CONCLUSIONS: The 2-1/2-ton, 6x6, GMC truck

was generally satisfactory. It was recommended that, with the modifications suggested in the body of this report, the truck be permitted to haul a payload limit of 7-1/2 tons.
GENERAL: This 35-page report includes 13 photographs of the equipment tested.

APG TT2-634/7
SUBJECT: Springs B-2.6
TITLE: Report of Test of Boron Steel Torsion Bars for Cargo Tractor M8E2
IDENTIFICATION: Seventh Report on Project TT2-634; APG 15-95
DATE OF REPORT: 16 March 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the feasibility of using boron steel as a replacement for critical alloy steel in highly stressed components
METHOD: A complete set of boron steel torsion bars, together with torsion bar anchors and road wheel arm housings, was installed in a cargo tractor loaded to combat weight. The tractor was operated at full-throttle (16 mph) wherever possible over 1500 miles of cross-country terrain and 110 miles of gravel surfaces. The condition of the suspension was observed during and after the test.
DESCRIPTION: The boron steel torsion bars were tested on a M8E2 Cargo Tractor. A T4E1 Wrecker Kit was installed on the vehicle to simulate cargo weight, bringing the test weight to 66,700 pounds. Chemical and physical properties of the test boss were not included in the report.
CONCLUSIONS: The limited operations indicated the feasibility of using boron steel for torsion bars. No major suspension failure occurred, with the exception of a road wheel arm that required repair after 1190 miles of the 1610 mile test. Additional tests of 4000 miles were recommended to establish life expectancy.
GENERAL: This 16-page report includes five pages of memorandum reports.

C-378
Cad Mtr Car
SUBJECT: Springs B-2.8
TITLE: Experimental Tests Conducted on Torsion Bars Manufactured from 81B60 Steel
IDENTIFICATION: Report No. 378
DATE OF REPORT: 27 February 1953
ORIGIN: Cadillac Motor Car Division, General Motors Corporation
PURPOSE: To determine the fatigue characteristics of experimental torsion bars
METHOD: Test bars were initially heat treated and oil quenched. They were then given a Magnaglo inspection, and acceptable bars were selected for tests. These bars were shot peened and tested for pre-set. Fatigue tests were conducted, consisting of 50,000 cycles with deflection ranging from 7° 43' to 52° 55'. Permanent set in the bars was compensated for at the end of every 10,000 cycles.
DESCRIPTION: The test bars were machined from type 81B60 steel and were of low, middle, and high hardenability grades.
CONCLUSIONS: The location of fatigue failures in the test bars was the same as in the standard steel bars used in the test program. Fatigue failure was initiated at the unpeened blocked tooth on the small end.
GENERAL: This 32-page report contains five charts, showing the heat treatment and set of the bars. Also 19 photographs are included showing microstructure and failure of the bars.

SUBJECT: Springs DA 364
TITLE: Calibration of Spring Number (A) 711941 for the 75-mm Gun T33E1, Tank, M-24
IDENTIFICATION: Report No. 364
DATE OF REPORT: 28 March 1950
ORIGIN: Detroit Arsenal, Centerline, Michigan
PURPOSE: To determine whether a recoil mechanism spring met specifications.
METHOD: The test spring was calibrated by depressing the spring in increments of three inches on a 200,000 pound Baldwin-Southwark Universal Testing machine. The applied load and height of the coils at each increment were recorded.
DESCRIPTION: The recoil mechanism steel spring (A) 7111941 was for use in the 75-mm Gun T33E1, Tank M24. It had been proof fired. Average wire diameter was .614 inch and the approximate free length was 30 inches. There were nine plus total coils and seven active coils.
CONCLUSIONS: The test spring as presently specified and fabricated did not lend itself to a practical application. Such undesirable characteristics as absence of parallelism between the end coils, over-stressing, and unequal distance between coils were found. Recommendations were made for increasing the safety in testing the spring.
GENERAL: This 11-page report includes one drawing and four photographs of the spring and test equipment.

SUBJECT: Springs DWB 109
TITLE: Test of Special Front Springs for 75 mm Gun Motor Carriage M3
IDENTIFICATION: Project No. 109
DATE OF REPORT: 4 January 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To determine the durability and riding characteristics of experimental front springs for 75 mm Gun Motor Carriage M3
METHOD: A light and a heavier spring were installed on M3 Personnel Carriage Half-Track and 75-mm Motor Gun Carriage, respectively, and operated over varied terrain.
DESCRIPTION: The lighter spring consisted of 11 leaves with 2 rebound leaves. The main leaf was made of .312 steel, the next four of .284 steel, and the balance (including the rebound leaves) of .259 steel. The heavier spring was the same as the lighter except the main leaf was made of 3/8-inch steel; the remaining ten leaves of 5/16-inch steel, and the two rebound leaves of .259-inch steel. Both springs were equipped with Safety Eye and were manufactured by the U.S. Spring and Bumper Co.
CONCLUSIONS: The heavier spring with improved safety eye was considered superior to the lighter

type and the standard M3 half-track spring because of the smoother riding characteristics and greater durability permitting higher vehicle speeds over varied terrain. It was recommended that the heavier spring be used as a substitute for the standard M3 Half-Track spring.
GENERAL: This nine-page report contains five photographs of springs with safety eye.

SUBJECT: Springs DWB-140
TITLE: Heavy Front Springs for Half-Track Vehicles, M3 (Final Report) - Armored Board
IDENTIFICATION: Project No. 140
DATE OF REPORT: 4 August 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To determine the durability of experimental front springs for use with Half-Track Vehicles M3 or 75-mm Gun Motor Carriages M3
METHOD: Five sets of the test spring kits were installed on 75-mm Gun Motor Carriages M3, which were operated a total of 7308 miles over varied terrain.
DESCRIPTION: The test springs, manufactured by Mather Spring Company, had 11 leaves. The length was 2-3/4 inches longer than that of the original springs. The eyebolt of the test springs was 7/8-inches in diameter as compared to the 5/8-inch eyebolt used with the original springs. The frame brackets were much larger and heavier than brackets on the original type.
CONCLUSIONS: The test springs were considered superior to the standard type used on M3 half-tracks. Six of the ten main leaves failed at approximately an average of 1400 miles. No eyebolt failure occurred; this was a common failure with the original eyebolts.
GENERAL: This 11-page report contains two pages of photographs of the original and test springs.

SUBJECT: Springs GM CTP 955F
TITLE: Relative Movement of Coils of Volute Bumper Spring During Compression
IDENTIFICATION: Report No. 955 (Final)
DATE OF REPORT: 28 December 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To study the coil action of a volute spring during compression, using first a deep and then a shallow cup
METHOD: The experimental volute springs were installed on a Baldwin tester and loaded by steps. The base plates had been scribed at 45° intervals with lines which were perpendicular to the base plate and continued upward to the tappets. Dial indicators were used to record the expansion or contraction of the No. 1 coil in relation to the base plate. The relative movement of the coils along their circumference was obtained, and the free height of the volute springs was measured before and after they were exercised, to determine the permanent set of the coils. The vertical deflection of the springs when they were loaded was also measured.
DESCRIPTION: The test units were experimental volute bumper spring stop assemblies, incorporating shallow and deep cups.
CONCLUSIONS: The outer coil of the volute spring in the deep cup first rotated when a force of 1000 pounds was applied. With the shallow cup, the outer coil of the spring did not rotate when a force of 25,000 pounds was applied; therefore, this combination seemed most satisfactory for use on the T41E2 and T141 vehicles. Radial contraction of the outer coil of the volute spring was as much as .053 inch with the deep cup and .003 inch with the shallow cup. It was recommended that the volute spring incorporating the shallow cup be subjected to a vehicle durability test.
GENERAL: This 20-page report contains two photographs showing the volute spring stop assemblies and the test equipment.

SUBJECT: Springs N-477
TITLE: Spring and Shackle Bushings
IDENTIFICATION: Final Progress Report; Test No. N-477
DATE OF REPORT: 10 October 1944
ORIGIN: Ordnance Tire Test Fleet, Normoyle Field, San Antonio, Texas
PURPOSE: To compare synthetic with crude rubber spring and shackle bushings
METHOD: Two each of the test synthetic and crude rubber spring and shackle bushings were installed on each of four Diamond T, 4-ton, 6x6 trucks. Synthetic bushings were installed on three identical vehicles. After a maximum operation of 841 miles and a minimum of 714 miles the bushings were removed. Six of the vehicles were then re-equipped with the test bushings installed to form a flange which insulated the spring eye to avoid side slap. Mileages on the second test were accumulated up to 11,209 miles per vehicle.
DESCRIPTION: The test spring and shackle bushings were supplied in synthetic GR-S material by both General Tire and Rubber Company and Manhattan Rubber Division. The bushings were supplied in crude rubber by General.
CONCLUSIONS: The test bushings failed on the first test because of cracking and splitting on the outer and inner shoulders. The bushings on the second test were run until failure resulted. They also showed a tendency to crack and split at low mileages. In all cases the crude rubber bushings wore better and did not crack as readily as the synthetic bushings. The General crude bushings averaged 8337 miles, the General GR-S bushings averaged 6711 miles and the Manhattan GR-S bushings were removed at 6048 miles. Specific recommendations were not included in the report.
GENERAL: This 10-page report is not illustrated.

SUBJECT: Springs OCO KG-20-5
TITLE: Suspension, Half-Track Bumper between Front Axle and Frame
IDENTIFICATION: Project No. KG-20-5
DATE OF REPORT: 24 April 1944
ORIGIN: Office, Chief of Ordnance, Detroit, Mich-

igan
PURPOSE: To design and develop a bump spring for the front wheel suspension of half-track vehicles
METHOD: Several helical and spiral springs were designed for installation between the leaf spring and frame of vehicle. This corrective method proved inadequate. Volute springs having capacities of 1800, 2300, 2600, and 3000 pounds were then procured and tested. With the 3000-pound capacity volute springs installed, a Half-Track Car M2 was operated 2245 miles with relative success on highway, cross-country, Belgian Block, and washboard courses.
DESCRIPTION: The bump spring as installed for test was fabricated by welding a 3000-pound volute spring directly to the original leaf spring saddle. The saddle was then mounted in the conventional manner. When the leaf springs were over-loaded the volute spring came in contact with the vehicle frame.
CONCLUSIONS: Auxiliary volute springs of 3000 pounds capacity could be installed on front wheel suspensions of half-track vehicles. They improved performance and decreased interference. It was recommended that leaf springs of adequate capacity be used to prevent excessive bottoming and axle wind-up and that 3000 pound volute springs be considered satisfactory for quick-fix installations on half-track vehicles in the field.
GENERAL: This 16-page report includes six photographs of the test bump spring installation and two curve sheets of load displacement.

SUBJECT: Springs PG-2.595
TITLE: Spring Rate Test - Heavy Front Springs - Diamond T N-10140
IDENTIFICATION: Report No. PG-2.595; Project No. 114-4
DATE OF REPORT: 27 January 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the spring rate of N-10140 Heavy Front Springs before and after installation on Half-Track M3
METHOD: The spring rate of the test springs was measured on a testing machine. The springs were loaded continuously at 400 to 500 pounds per minute until they were deflected four inches; then unloaded at approximately the same rate. The load at each quarter inch deflection was recorded. Two of the springs were then installed on a Half-Track M3 and the spring rates were again determined.
DESCRIPTION: Four heavy front springs (N-10140) designed for half-track vehicles were supplied by Diamond T Motor Company.
CONCLUSIONS: The average rate of the four springs before installation in the vehicle was 1133 pounds per inch. The average effective rate of the two springs and tires as installed was 898 pounds per inch. Hysteresis noted during the unloading was attributed to the fact the springs were not hammered during the testing nor were they lubricated.
GENERAL: This 11-page report contains two spring rate graphs and one tabulated data sheet.

SUBJECT: Springs PG-2.705
TITLE: Endurance Tests of Heavy Front Springs N-10140
IDENTIFICATION: Report No. PG-2.705; G.M. P.G. Project No. 114-4
DATE OF REPORT: 12 April 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of Diamond T heavy front springs No. N-10140 for half-track vehicles
METHOD: The test springs were installed on a Half-Track Personnel Carrier M3, and operated to failure over an endurance course.
DESCRIPTION: The test springs were Diamond T Motor Company heavy front springs No. N-10140 for half-track vehicles.
CONCLUSIONS: The durability of the test springs was unsatisfactory and use was not recommended. The one spring failed at 1020 miles during a track throwing demonstration and was replaced. The replacement spring and the remaining original spring were both found broken at 3067 miles.
GENERAL: This 12-page report contains three photographs of the failed parts.

PG-2.783
SUBJECT: Springs PG-2.783A
TITLE: Spring Rate Tests and Endurance Test Half-Track Personnel Carrier M3, Front Springs, Mather Spring Company
IDENTIFICATION: Reports No. PG-2.783 and PG-2.783A; GMPG Project No. 114-7
DATE OF REPORT: 23 June 1943 and 6 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability and spring rate of experimental front springs installed on the half-track
METHOD: Two experimental springs were given spring-rate tests on a flexing machine. Spring-rate tests were then conducted after spring installation on a half-track vehicle. Two other springs were installed on a half-track which was operated a total of 2299 miles over an endurance test course.
DESCRIPTION: The experimental springs were manufactured by the Mather Spring Company of Toledo, Ohio. They were installed on the front of International Harvester Co. M3 Half-Track Carriers. The springs were of the leaf type and were mounted to the front axle by U-bolts. They fastened to the frame at the front and rear of the spring by two leaf eyes.
CONCLUSIONS: The spring rate of the two types before installation on the half-track were 1350 and 1353 pounds per inch and after installation were 1000 and 1042 pounds per inch. The life of the test springs fell within the same range as the average of the standard springs. It was recommended that the springs be accepted for use on Ordnance vehicles. It was also recommended that further development for longer life be made.
GENERAL: The two reports have a total of 23 pages and contain two photographs showing endurance test results.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Springs PG-2.1018
TITLE: Front Spring Durability Test on Half-Track Personnel Carriers, M3
IDENTIFICATION: Report No. PG-2.1018; Project No. 246
DATE OF REPORT: 28 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the spring rate on three sets of front springs for Half-Track Personnel Carrier M3
METHOD: The springs were set up in the laboratory and loaded continuously until they were deflected four inches, and then unloaded at the same rate. The load was recorded at each 1/4-inch deflection. The springs were then installed on half-track vehicles and the overall spring rate, the rate of the springs only, and the rate of the tires only were determined.
DESCRIPTION: The test front springs were for Half-Track Personnel Carrier M3. Two sets were supplied by U. S. Spring and Bumper Company and included D-7003, 14-leaf and D-7004, 13-leaf springs. The other set was Ordnance C-125138, 14-leaf springs.
CONCLUSIONS: The average spring rates in pounds per inch as determined were:

SPRING NUMBER	LABORATORY TEST	TEST ON VEHICLE	OVERALL TEST
D-7003	1378	1425	1013
D-7004	1375	1310	965
C-125138	1628	1437	1000

It was recommended that service life of the springs be used as the basis for acceptance.
GENERAL: This 29-page report contains four photographs showing test springs installed on the vehicles.

SUBJECT: Springs PG-2.1018A
TITLE: Spring Endurance Section of Front Spring Durability Test on Half-Track Personnel Carriers, M3
DATE OF REPORT: 8 April 1944
ORIGIN: General Motors Phoenix Laboratory, Arizona
PURPOSE: To determine spring rates and endurance of special springs installed on Half-Track Personnel Carriers M3
METHOD: Three Half-Track Personnel Carriers M3 were equipped with special springs, and a fourth was equipped with standard type for control purposes. Spring rates were determined, and the half-tracks were operated over an endurance test route at speeds of approximately 10 mph.
DESCRIPTION: Equipment tested was 13- and 14-leaf U.S. Spring and Bumper Company springs, International Harvester Company springs, and standard springs #B184530 installed on half-track M3 Personnel Carriers.
CONCLUSIONS: International Harvester springs gave the better performance, averaging 2420 miles before failure. U.S. Spring and Bumper Company 13-leaf springs averaged only 1767 miles, and their 14-leaf spring averaged 1443 miles. The vehicles with U.S. Spring and Bumper Company springs had poor riding qualities. The standard control type gave poorest service, averaging only 1368 miles before failure. Vehicles with standard and International Harvester Company springs had good riding and handling qualities. The #C125138 International Harvester Company springs were recommended for adoption as standard equipment for Half-Track M3 vehicles.
GENERAL: This 43-page report contains 17 photographs of spring failures.

SUBJECT: Springs PG-61801.14
TITLE: M4 Medium Tank Suspension Bottom Spring Seat
IDENTIFICATION: Report No. PG-61801.14; TA PG Project No. 46
DATE OF REPORT: 7 December 1942
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effect of a center bridge in reducing spring seat failures
METHOD: Thirteen spring seats were examined in the physical laboratory. One, not incorporating the modification, had failed in service. The others incorporated the center bridge modification as a welding or a casting. Of the welded, some were subsequently stress relieved; others not. Eight of the spring seats were subjected to load tests.
DESCRIPTION: The center bridge, added to the M4 Medium Tank suspension bottom spring seat, was located between the trunnions as part of the steel casting. Modifications to production spring seats were made by welding a low-alloy steel bridge of 5/8 inch thickness between the trunnions in accordance with drawing No. C-100300. Some had subsequent stress relieving; others not.
CONCLUSIONS: The load capacity of the original spring seat was increased 30% when the center bridge was welded and stress relieved or when a cast bridge was incorporated. Proof testing of the heat treated but unmachined spring seats was recommended.
GENERAL: This 38-page report includes two drawings and 14 photographs.

SUBJECT: Springs PG-61801.33-01
TITLE: Vehicle Test of Volute Springs, Short-Taper Inner Coil
IDENTIFICATION: Report No. PG-61801.33-01; T.A.P.G. Project No. 102
DATE OF REPORT: 2 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of 12 short-taper, inner coil, medium tank, volute suspension springs
METHOD: The test springs were installed on a Medium Tank M4A4 and operated to failure over an endurance course.
DESCRIPTION: The test springs were medium tank, inner coil, volute suspension springs without taper in the active coils and with a variable helix angle. The test springs were manufactured by Eaton

Manufacturing Company.
CONCLUSIONS: The durability of the test springs was unsatisfactory. The springs failed at 498 to 809 test miles. Failure was considered due to manufacturing irregularities, such as high rate of change in helix angle, unsatisfactory coiling notch, insufficient blade thickness and coil gap, and excessive hardness. Test of a set of similar springs without these irregularities was recommended.
GENERAL: This 33-page report contains 12 sketches showing the point of failure of each test spring, five photographs of failed springs, and two engineering drawings of the springs.

SUBJECT: Springs PG-61801.37
TITLE: Front Springs, Half Track Personnel Carrier M3, Auto Car Experimental, X-04176
IDENTIFICATION: Report No. PG-61801.37; Project No. 97
DATE OF REPORT: 29 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of the experimental springs on the Half Track M3
METHOD: A comparison of the standard and experimental spring rates was made at the Chrysler Suspension Laboratory. The experimental springs were then installed on a vehicle which was loaded to a gross weight of 17,500 pounds. Operation was for 2000 miles over concrete, dirt roads, rough dirt, sand and grades up to 32.5%. A load of 5100 pounds per wheel was used for measurement of clearance between tire, armor plate and drag link, and between springs and strike position on the frame. Measurements were taken at 0, 1000, and 2000 miles of operation.
DESCRIPTION: The experimental springs were manufactured by the Autocar Company and installed in front on the M3 Half-Track Personnel Carrier. The spring was of the leaf type with the ends of the second, third, and fourth leaves formed into mounting eyes.
CONCLUSIONS: There were ample clearances at all times under the test conditions. The number three leaf on the left front spring cracked at 2000 miles. The experimental springs gave satisfactory performance for 2000 miles of operation.
GENERAL: This 23-page report contains one photograph showing failure of the spring leaf.

SUBJECT: Springs PG-61801.80
TITLE: Suspension, Rubber Assist Springs, Medium Tank M4A3E2
IDENTIFICATION: Report No. PG-61801.80; T.A. P.G. Project No. 255
DATE OF REPORT: 24 May 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of the test springs for use on Medium Tank M4A3E2 suspensions
METHOD: Four test rubber assist springs were installed in the two rear suspension units of Medium Tank M4A1. Vehicle static height was determined before and after installation. This 71,640-pound vehicle was operated 50 miles over the endurance course. The test springs were then removed and examined.
DESCRIPTION: Each test spring was made of five sections stacked vertically and welded. Each section consisted of four rubber disks sandwiched between five steel disks. An internally-threaded sleeve one inch in diameter and 3/4-inch long was welded to the top of the spring and functioned as a guide during installation.
CONCLUSIONS: The rubber assist springs were found to be unsatisfactory and were not recommended for use.
GENERAL: This 14-page report includes two photographs and a design drawing of the test springs.

SUBJECT: Springs PG-61801.92
TITLE: Revised Rubber Assist Springs for Suspension of Medium Tank M4A3E2
IDENTIFICATION: Report No. PG-61801.92; T.A. P.G. Project No. 260
DATE OF REPORT: 31 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and performance characteristics of two types of rubber assist springs designed for use with volute springs in M4A3 Medium Tank suspensions
METHOD: Two straight-shoulder rubber assist springs were installed in the left rear suspension unit of a 73,860-pound Medium Tank M4A3 and operated 100 miles over endurance courses with two tapered shoulder rubber assist springs installed in the right rear suspension unit. For further test a complete set of the straight-shoulder type was installed and operated 162 miles to failure on a 85,600-pound Medium Tank M4A3E2. Static measurement of the suspension units after installation of new rubber assist springs showed an average height increase of 5/16 inch.
DESCRIPTION: Each straight-shoulder rubber assist spring consisted of rubber and steel disc sections stacked five-high and fastened together both by welding and by attachment of metal spring clips. At the top of each such assembly, 3/4-inch long, threaded sleeve of 1-inch diameter functioned as a guide for installation within the volute suspension springs. The revision incorporated in the design after a previous test (T.A.P.G. Project No. 255) consisted simply of "turning down' the upper steel discs so that they were flush with the rubber in the top section of each such spring. The two tapered assist springs were assembled with a cone-shaped rubber bumper in place of and two upper sections in each spring.
CONCLUSIONS: Because of the lateral movement of the spring seat, the column rigidity of the rubber assist springs was weakened. This resulted in buckling and damage due to contact with the inner coil of the volute spring. The tapered rubber springs functioned somewhat better than the straight-shoulder springs, but all were considered inadequate and were not recommended.
GENERAL: This 15-page report contains two photos of the test assist springs.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Springs PG-61801.103
TITLE: Endurance Test of Chrome-Vanadium Volute Springs — Medium Tank M4 Series
IDENTIFICATION: Report No. PG-61801.103; Project No. 289
DATE OF REPORT: 22 November 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the comparative durability of M4 series volute springs made of chrome-vanadium steel
METHOD: Six test springs were installed on a Medium Tank M4A3. The other springs on the test tank were new, standard production springs. The test vehicle was operated to spring failure at 646 miles.
DESCRIPTION: The test volute springs were similar to the standard production springs except that they were made of chrome-vanadium steel, WD 6150, instead of silicon-manganese steel.
CONCLUSIONS: Four test springs failed after 646 miles. The average mileage to failure for production springs was 1380 miles. The chrome-vanadium springs were not recommended for use.
GENERAL: This 19-page report includes three photographs of the test springs after the test.

SUBJECT: Springs PG-61803.15
TITLE: Test of Door Torsion Bar Springs #EXT 26-655 — Heavy Tank M26
IDENTIFICATION: Report No. PG-61803.15; T.A. P.G. Project No. 404
DATE OF REPORT: 28 August 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of experimental torsion bar springs for the driver's and assistant driver's doors of the Heavy Tank M26
METHOD: Two sets of the experimental torsion bar springs were installed in Heavy Tanks M26, and operated 1012 and 1796 miles, respectively. The springs were adjusted to balance the doors from 1/2 inch to 1-1/2 inches off the seat in the free position. A scale was used to measure the maximum effort needed to raise the doors, and comparative checks were made on torsion bar deflection.
DESCRIPTION: The test door torsion bar springs, EXT 26-655, were 0.450-inch in diameter as compared to 0.438-inch for the standard type.
CONCLUSIONS: The test torsion bar springs had the following advantages over the standard type: 25% more torsional resistance, and greater ease in opening the doors (23 to 42% less effort was required). It was recommended that the test springs be approved for production.
GENERAL: This 11-page report is not illustrated.

RIA 45-2383
SUBJECT: Springs B-5.3
TITLE: Rust Protection Coating Tests on Springs, Brake Shoe Return, Amphibious Vehicles
IDENTIFICATION: Report No. RIA 45-2383
DATE OF REPORT: 16 July 1945
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine a suitable method of preventing failures of break shoe return springs on amphibious vehicles subjected to rust and salt water corrosion
METHOD: Although three lines of investigation were initially considered, the work covered by this report consisted primarily of tests conducted on springs coated with an impervious material. In these tests, four groups of springs were given protective coatings and were subjected, together with a control group, to soaking and drying tests. They were soaked in synthetic sea water, dried, and gymnasticated to failure. Gymnastication was performed at the rate of 1500 strokes per minute, the strokes placing a normal operating load (approximately 80 pounds) on the springs.
DESCRIPTION: Type B-166742, G.M. No. 477474 springs with a 0.146-inch diameter were tested. The four coatings were: Heresite varnish; phenol formaldehyde primer followed by formaldehyde resin finish; phenol formaldehyde primer preceded by Parkerizing and followed by phenol formaldehyde resin finish; and zinc plating of Cronak treated springs baked to release hydrogen embrittlement. The synthetic sea water contained 11 gm/1 of Mg Cl_2, 6 H_2O, 1.2 gm/1 of Ca Cl_2SO4, and 25 gm/1 of NaCl.
CONCLUSIONS: In nearly all cases the springs broke either in the short radius curve of the hook or in the crimped end of the spring. While some increase in spring life was possible by the application of surface protective finishes, it was thought that the principal fault in the springs was one of design rather than surface failure. A change in both the location and the type of the brake shoe return springs was considered desirable.
GENERAL: This 33-page report includes 12 photographs.

RIA 53-2847
SUBJECT: Springs B-2.8
TITLE: Fatigue Tests of Torsion Bar Springs
IDENTIFICATION: Report No. 53-2847
DATE OF REPORT: 30 July 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the fatigue characteristics of two types of torsion bar springs
METHOD: Samples of three types of torsion bars were installed on a testing machine. Half of the bars were twisted in a clockwise direction and the other half in a counterclockwise direction at 7° to 47°, with the small end held stationary. All bars were cycled continuously for 15-1/2 hour periods at 800 to 900 cycles per hour. Creep of the bars was compensated for at 100, 500, 2500, and 6000 cycles, and then every 6000 to 7000 cycles.
DESCRIPTION: Twelve of the torsion bars tested were manufactured by Cadillac Motor Car Division of General Motors Corporation. Four of the torsion bars were manufactured by Maremont Automotive Products, Inc.
CONCLUSIONS: Failure of the bars ranged from 13,000 cycles to 105,000 cycles. Creep ranged from 10 minutes to four degrees, 40 minutes. Longitudinal cracks were the cause for failure in the bars.
GENERAL: Two separate reports on torsion bars from each of the two manufacturers are contained in this 23-page general report.

SUBJECT: Springs T-17842.3
TITLE: Combination Helical and Ring Spring Suspension Units for the M3 Tank
IDENTIFICATION: Report No. T-17842.3
DATE OF REPORT: 7 November 1941
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To design a suspension spring system for M3 Tanks to replace the volute springs
METHOD: A spring system was designed and the necessary drawings for manufacture and installation of the spring system were prepared.
DESCRIPTION: The spring system developed to replace the M3 Tank volute springs consisted of two helical coil springs with a ring spring unit inside each coil spring. The coil springs and the ring springs were installed vertically in the bogie frame in the space provided for the volute springs.
CONCLUSIONS: This report covers only the design of the proposed spring system and no conclusions or recommendations were made.
GENERAL: This 21-page report contains parts list, detail drawings, and installation layout of the proposed spring system.

SUBJECT: Springs T-20815.4
TITLE: Volute Springs; Deflection and Stress Computations
IDENTIFICATION: Report No. T-20815.4
DATE OF REPORT: 23 October 1941
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To establish a set of formulae for computing the load-deflection curve and the stresses in any volute spring coiled with a constant vertical pitch angle
METHOD: Formulae expressing the relationship between load, deflection, and stress were developed from the basic equations which have been formulated by Timoshenko out of the original St. Venant theory.
DESCRIPTION: Formulae were derived for a volute spring constructed from a flat bar coiled into a spiral at a constant vertical pitch angle, resulting in a parabolic spring profile.
CONCLUSIONS: Formulae were established for determining load, stress, and deflection for loads up to and including the point at which the largest coil started bottoming, for loads beyond this point but excluding the maximum load point, and for maximum load under which the spring was compressed solid.
GENERAL: This 20-page report contains two volute spring profile sketches, two curve sheets, and six pages of formulae deductions. Appended to this report is a discussion of the advantages and disadvantages of volute springs designed in excess of the elastic limit of the spring material.

SUBJECT: Springs T-61701.1
TITLE: 75-MM Gun for M4 Tank-Spring Combinations
IDENTIFICATION: Report No. T-61701.1
DATE OF REPORT: 6 March 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To compute and summarize the design characteristics of spring combinations, and to make several specified buffers applicable to a new 76-mm gun recoil mechanism proposed for Medium Tanks M4
METHOD: Theoretical calculations were made for springs of round and rectangular sections. The buffers were manufactured according to Ordnance Drawing B168378.
DESCRIPTION: The many combinations of springs were summarized in this report; following are the data for inner spring No. 201132 and outer spring No. 201133, which were released for the 75-mm gun recoil mechanism:

	INNER	OUTER
Type winding	Left hand	Right hand
Max. O.D.-free	3-1/64	3-15/16
Diam. of wire	.262	.343
Min. I.D.-free	2-13/32	3-1/32
Free Height, approx.	34-1/2	35-1/8
Load at assembled ht.	180-20	318-35
Max. solid ht.	6-1/2	7-1/8
Approx. no. of coils	24.8	20-7/8
Computed spring rate, lbs./in.	14.2	24.0
Computed Vol. of wire, cu. in.	11.4	21.0
Computed Max. stress, solid lbs./sq. in.	175,000	167,500

CONCLUSIONS: None
GENERAL: This 10-page report includes a summary of the design characteristics of numerous spring combinations, a sample calculation, and a design drawing of the modified buffers.

SUBJECT: Springs T-61801.1
TITLE: M3 and M4 Tanks with Larger Volute Springs
IDENTIFICATION: Report No. T-61801.1
DATE OF REPORT: 10 December 1941
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To design a suspension for M3 and M4 Medium Tanks similar to the present production suspension but with volute springs of increased capacity
METHOD: In designing the proposed suspension, attempts were made to keep changes at a minimum. Increased spring capacity was obtained by increasing the width and thickness of the blade and by increasing the O.D. and slightly decreasing the I.D. Sketches were made of only the parts requiring changes, the main suspension bracket and the bottom spring seat, and a layout was drawn of the entire suspension assembly including a separately mounted track support roller. Load and stress curves for the original and proposed springs were computed to obtain desired theoretical data.
DESCRIPTION: A general comparison between the present production spring and the proposed spring was summarized as follows:

	Present Production Spring	Proposed Spring
Outside Diameter	7	8
Inside Diameter	2-9/16	2-1/2
Number of Active Coils	4-1/4	5
Width of Blade (Solid Height of Spring)	6-1/2	7-1/2
Thickness of Blade	.350	.400
Clearance between Coils	.073	.058
Total Spring Deflection (from Free to Solid Height)	6.125	5.750
Theoretical Maximum Stress	260,000	182,000
Load at which 160,000 psi stress is reached	15,000	20,500
Approximate Spring Weight (pounds)	50	79

CONCLUSIONS: A brief outline of the proposed suspension was presented in the load and stress curves and in the sketches of the layout, bracket, and bottom spring seat. The proposed assembly called for removal of the track rollers No. C-74507 from the top of the suspension unit. They were to be replaced by rollers shown on Army assembly drawing No. D-47933 which could be mounted 16 inches toward the rear of each suspension unit. They were to be supplemented by replaceable hardened steel shoes on top of the suspension unit which would protect the main suspension brackets.
GENERAL: This seven-page report contains sketches of the proposed layout, bracket, and bottom spring seat, and load and stress curves for the production spring.

SUBJECT: Springs T-61801.1-02
TITLE: Larger Volute Springs, Development and Testing
IDENTIFICATION: Report No. T-61801.1-02
DATE OF REPORT: 30 September 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To revise the design of proposed larger volute springs for use in M3 and M4 Medium Tanks and to test this revised suspension
METHOD: The redesigned M3 suspension, proposed in Report No. T-61801.1, was developed and constructed in conjunction with a trailing idler. Laboratory tests were conducted on this unit and design changes incorporated during which time the suspension was released for model M3A4 production. Changes in the design included raising the trunnion center 2-1/2 inches, modifying the spring seat and suspension bracket, and improving the method of fastening the gudgeon pins to the suspension bracket. Development tests of the various modified units were covered more fully in Report Nos. T-61901.5 and T-61801.11. Field tests of the original and advance design M4 suspension units were conducted with an M3A4 pilot tank. The original units operated for 2580 miles and the advanced units for 3000 miles. The 17 failures which occurred were to be discussed in another report.
DESCRIPTION: The suspension design as finally adapted for production models M3A4 and M4, with the trunnion center raised 2-1/2 inches (above the original location which was identical with the location on Model M3) was shown on Ordnance dept. Drawing No. D-47527 and also on Chrysler layout No. US-848.
CONCLUSIONS: Raising of the trunnion center 2-1/2 inches improved suspension stability. This design was adapted for Models M3A4 and M4. The spring seats built to the original design were scrapped. The suspension brackets built to the original design were reworked. Stability of the M4 suspension did not equal that of the M3 so that the full benefit of the large volute springs was not realized. However, the M4 stability was improved by changes in the spring seat and suspension bracket. Full stability was obtained by raising the trunnion center two more inches. This work was covered in another report.
GENERAL: This 21-page report contains two photographs of suspension brackets, four suspension sketches, and four drawings.

SUBJECT: Springs T-61801.1-04
TITLE: Modification, with Trunnion Center Raised Two Inches, M4 Medium Tank
IDENTIFICATION: Report No. T-61801.1-04; CX Project No. 42
DATE OF REPORT: 22 January 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To establish the life of the test unit component parts by endurance testing at the Tank Arsenal Proving Ground and on the suspension bump rig
METHOD: Six of the test suspension units were installed on a Medium Tank M4A4 and operated 5781 miles. One of these units was rebuilt with new springs, new rubbing plates on bogie arms and levers, and operated in the laboratory for 100 hours on the suspension bump rig.
DESCRIPTION: The test suspension units were similar to the standard M4 vertical volute spring suspension units except that the trunnion center was located two inches higher in an attempt to reduce spring seat cocking and thereby improving spring life.
CONCLUSIONS: The life of the volute springs in the suspension units with raised trunnion center was considerably better than the life of the volute springs in standard M4 suspension both when operated on the vehicle and on the suspension bump rig. On the bump rig, spring life was increased at least three times. When operated on the vehicle the average spring life was 3270 miles as against 2090 miles average on 16 tanks with the standard M4 suspensions. It was pointed out that only three M4A4 tanks with standard M4 suspension had been run for more than 2000 miles at the TAPG, and the spring life on these three tanks varied between 379 and 7140 miles, with an average of 3460 miles. Because of this wide divergence in spring life, it was felt that the data did not furnish an acceptable base line for Model M4A4 tanks. It was thought that spring life depended greatly upon the tank model used, and therefore it would be more appropriate to employ the "average spring life for tanks of a given model" as a

base line after sufficient data had been obtained. No recommendation was made for further work with the test suspension, since it was not certain that the potential improvement in spring life would be sufficient to warrant all the changes necessary with the raised trunnion center. It was recommended that a further study be made of the factors which cause the apparently wide divergence in spring life between different tank models using the same suspension.
GENERAL: This 68-page report contains spring life data sheets, two layout drawings, and 15 photographs showing test suspension unit components.

SUBJECT: Springs T-61801.4
TITLE: Calculations for Helical Springs as Substitutes for the Chrysler Design Volute Spring No. 962100
IDENTIFICATION: Report No. T-61801.4
DATE OF REPORT: 2 March 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To calculate various possible substitutes for the Chrysler design, 8-inch O.D., volute spring No. 962100
METHOD: Three combinations of springs were calculated in an attempt to duplicate as nearly as possible the load-deflection curve of the volute spring.
DESCRIPTION: The first calculated spring combination consisted of three concentric helical coil springs with the outer spring made of 1-7/32-inch diameter wire and the two inner springs of rectangular wire. The second spring combination consisted of the same outer coil spring, combined with a variable rate coil of rectangular wire wound flat. The third spring combination consisted of the same outer coil used in the first two combinations, combined with 26 Belleville or washer type springs.
CONCLUSIONS: The three-coil combination required 11.4% less weight than the volute spring, and the stresses were in approximately same range. The space restrictions involved imposed a stress on the variable rate coil in the second spring combination higher than should be allowed in practice. The Belleville washer combination offered a weight saving of 20.3% over the volute, and indicated the closest approach to the required load-deflection curve. It was pointed out that the values given in the report were merely calculated values that should be tested on actual samples before any production or service release were made.
GENERAL: This 15-page report includes load-deflection comparison curves, spring data, calculations, and a sketch of the coil spring-Belleville washer combination.

SUBJECT: Springs T-61801.4-02
TITLE: Calculations for Helical Springs as Substitutes for the Production Volute Spring No. C73927
IDENTIFICATION: Report No. T-61801.4-02
DATE OF REPORT: 22 June 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine whether helical coil spring combinations could be used to replace the volute spring No. C73927, in production M3 Tank suspensions
METHOD: Two combinations of concentric helical springs were calculated in an attempt to duplicate the load-deflection of the volute spring.
DESCRIPTION: The first spring combination consisted of two concentric helical coils: an outer spring of 1-5/16 x 7/8-inch rectangular wire wound flat; and an inner spring of 3/4 x 1-1/2-inch rectangular wire wound on edge. The second spring combination consisted of three concentric helical coils; an outer spring of 1-5/16 x 7/8-inch rectangular wire; one inner spring of 13/32 x 1-1/2-inch rectangular wire; and a second inner spring of 1/2 x 1-5/8-inch rectangular wire.
CONCLUSIONS: Helical coil spring combinations that would fit into the seven-inch diameter resulted in impractically high stresses. Because of the high stresses, it was recommended that no attempts be made to produce samples of the calculated springs. It was considered possible to calculate a practical combination of helical coils if the load-deflection curve were to be dropped to allow for the setting which actually occurs during service of the volute spring on a tank.
GENERAL: This eight-page report contains two load-deflection curves and spring data. It supersedes Report No. T-61801.4-01.

SUBJECT: Springs T-61801.5
TITLE: Spring; Volute for M3 Tank Suspension; Laboratory Life Test
IDENTIFICATION: Report No. T-61801.5
DATE OF REPORT: 20 May 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the life characteristics of M3 production springs No. C-73927
METHOD: All tests were run on a reworked Toledo Press described in Report No. 4407.84, at a fixed stroke between 8-1/2 and 6-3/4-inch spring heights, i.e., within 1/4-inch of the solid height.
DESCRIPTION: Two of the volute springs tested were made according to the original specifications: five active coils, 6-1/2 x 0.313 blade, 6100-pound static load. The other nine springs tested were made to subsequent specifications, No. 73927: four and one-half active coils, 6-1/2 x 0.350 blade, 8000-pound static load.
CONCLUSIONS: The two springs made to original specifications failed at 270,000 cycles and 279,000 cycles, respectively; they settled 0.181-inch and 0.590-inch, respectively, before failure. The nine springs made to revised specifications failed between 92,000 cycles and 290,000 cycles (average 152,000 cycles). Their rate of settling within the first 25,000 cycles of the test varied between 0.022 and 0.160-inch per 10,000 cycles (average 0.080-inch). Near the end of the test their rate of settling varied between 0.004 and 0.023-inch per 10,000 cycles (average 0.010-inch). For the entire test on each of the nine springs, the mean set per 10,000 cycles varied between 0.009 and 0.034-inch (aver-

age 0.022-inch). The total set varied between 0.075 and 0.586-inch.
GENERAL: This 29-page report contains a resume of the M3 volute spring history together with calculations, load curves, and six photographs showing failed spring.

SUBJECT: Springs T-61801.6
TITLE: Volute Spring, M3 Tank, American Locomotive Co.
IDENTIFICATION: Report No. T-61801.6
DATE OF REPORT: 6 May 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To check the dimensions and characteristics of three volute springs made by American Locomotive for M3 tanks
METHOD: The test springs were checked against drawing specifications and compared to two similar springs made by the Eaton Manufacturing Company. Load deflection and pitch curves were drawn. The area under the loading curve was obtained by means of a planimeter and computed to be 35,900 inch-pounds for test springs, and 39,100 inch-pounds for Eaton springs, the difference amounting to 8%.
DESCRIPTION: The specified I.D. of the volute spring, part No. C-73927, was 2-9/16 inches minimum. The width at the outer end was supposed to be 4-9/16 inches. An American Locomotive volute spring had an I.D. of 2.51 inches, and a width at the outer end of 3.36 inches.
CONCLUSIONS: The below-minimum I.D. of the test springs caused interference with the pivot pins on the spring seat. A lack of coil concentricity caused excessive wear and friction between the coils. Excessive bull-dozing in manufacture appeared to be the cause of a difference in spring rate between outer and inner coils which allowed a load of only about 12,000 pounds at a 7-inch height, compared to 14,000 or 15,000 pounds for Eaton springs. It was believed that the discrepancies found could be attributed to the general production practice of the vendor.
GENERAL: This 14-page report contains two tables comparing spring measurements to spring specifications, and seven load deflection or pitch graphs.

SUBJECT: Springs T-61801.17
TITLE: Hardness Check, Suspension Spring, Volute, M4 Medium Tank
IDENTIFICATION: Report No. T-61801.17
DATE OF REPORT: 11 February 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the uniformity and adequacy of heat treatment in volute suspension springs made from NE-9262 steel
METHOD: The active coils of a quenched spring and tempered spring were cut and ground into two-inch segments. Representative segments were then nested together in groups of six or eight in a phenol-formaldehyde resin, surfaced with a Blanchard grinder, blued, and marked with cross-sectional lines. About 1800 Rockwell "C" readings were then obtained, tabulated, and diagrammed to show the degree of hardness uniformity existing within each segment and between corresponding areas of the various segments. Curves were drawn to show the frequency distribution of certain Rockwell readings for the five active coils of each spring and for points in segment centers and in the inner and outer sub-surfaces of each segment.
DESCRIPTION: The two No. C-95163B volute springs tested were obtained from the Eaton Mfg. Co., Detroit. Both had been made from NE-9262 steel. One had been production tempered; the other had been quenched but not tempered.
CONCLUSIONS: A reasonably good quench was indicated in the quenched spring where 95% of the readings were between 60 and 64 Rockwell "C". The tempered spring was also generally satisfactory with 95% of the readings between 47 and 50 Rockwell "C". One soft spot, not sufficiently quenched out, was found on the inner surface of one coil. It was believed that a layer of scale between this coil and the next smaller coil caused the insufficient quenching. In both springs the two inner active coils were found to be about one Rockwell point higher in mean value than the two outer active coils. Some improvement in quenching was suggested.
GENERAL: This 21-page report contains a drawing of the volute spring, a photograph of a spring specimen prepared for hardness testing, and 11 hardness diagrams and curve sheets.

SUBJECT: Springs T-61801.20
TITLE: M4 Medium Tank Volute Spring - Laboratory Life Tests
IDENTIFICATION: Report No. T-61801.20; CX Project No. 17
DATE OF REPORT: 28 March 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To compare the life characteristics of three types of M4 Medium Tank volute springs with those of previously tested M3 production springs
METHOD: After laboratory life tests of three types of M4 volute springs, road tests were conducted. Because of subsequent failures in 5580 miles of vehicle operation, the test springs were redesigned. These redesigned volute springs, No. C-95163, initially compressed from their free height to 9-3/4 inches were subjected to repeated load deflections on a converted Toledo press until a failure occurred. The length of the deflection stroke was 1-3/4 inches and the average load applied was 9600 pounds.
DESCRIPTION: The redesigned test volute springs, No. C-95163, differed from the original springs in the following manner: the inner end blade thickness was increased from 1/8 to 3/16-inch; the number of active coils was reduced from 5 to 4-3/4; and the number of tapered active coils was decreased from 1 to 3/4.
CONCLUSIONS: Although the operating stress range was critical, the laboratory life of test M4 volute springs was found to be better than that of

the M3 production springs. The following recommendations were made for future M4 spring development: further improvements in design and manufacturing processes be employed as outlined in this report; consideration be given the complex spring loading which prevailed in the M4 suspension; and a complete co-ordinated analysis of the causes of tank spring failures be conducted. If the best manufacturing processes were followed, it was felt that the test springs would give satisfactory laboratory life tests.
GENERAL: This 79-page report contains four photos showing failed test volute springs. One drawing, 23 curve sheets, and 18 pages of spring computations are also included.

SUBJECT: Springs T-61801.20-01
TITLE: Suspension - Volute Spring M4 Medium Tank, Springs from Different Manufacturers
IDENTIFICATION: Report No. T-61801.20-01
DATE OF REPORT: 11 March 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To compare the operating life characteristics of five types of M4 production volute springs No. C-95163
METHOD: Six samples each of five types of volute springs were submitted for testing. After a chemical analysis and a dimensional and load capacity test of a representative spring of each type, laboratory life tests were performed. These tests employed a constant stress machine, operating at 100 rpm, which subjected the spring to a 4-inch deflection. The spring height at the highest point of a stroke was initially set at 11.75 inches. After spring failures occurred, hardness tests were made at the fracture.
DESCRIPTION: The five types of test M4 production volute springs No. C-95163 were manufactured by the following companies: Eaton Manufacturing Company and American Steel Foundries (both types quenched after reheating); American Locomotive Company, Spring Perch Company, and American Steel Foundries (all three types directly quenched after coiling). The difference in shape of each type of spring was in the number of active coils, extent of taper in the active coils, and variations in the helix angle.
CONCLUSIONS: In descending order, the best life test results were obtained with the following volute springs: American Steel Foundries, American Locomotive Company, Eaton Manufacturing Company, and Spring Perch Company. The somewhat lighter loads required by the slight difference of the first two spring designs accounted for their longer life. The Spring Perch Company springs proved to be appreciably poorer than the Eaton Manufacturing Company type, although both were tested under identical conditions. The method of quenching the test springs had no noticeable effect on spring life. The spring hardness at the point of fracture was found to be satisfactory in all instances. No recommendations were made on the test springs. Recommendations for further volute spring studies were formulated in a separate report which covered other items of this report.
GENERAL: This 95-page report contains three photos showing the manufacturer's anchoring parts used in the coiling process and cross sections of surface decarburization of the different types of springs. One drawing, 15 curve sheets, and 54 pages of spring computations and graphs are also included.

SUBJECT: Springs T-61801.33
TITLE: Volute Spring with Short Inner Taper - Laboratory Life Tests
IDENTIFICATION: Report No. T-61801.33; CX Project No. 87-1
DATE OF REPORT: 26 June 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the comparative durability of experimental, short-taper, volute suspension springs
METHOD: The springs were tested on a constant stress machine in the Chrysler Suspension Laboratory. The test machine compressed the spring four inches from an original height of 11.76 inches on each stroke at the rate of 100 strokes per minute. The springs were kept under an oil spray throughout the test.
DESCRIPTION: The test springs were coiled from standard M4 volute spring production blanks, but were made with six coils, and the taper on the inner active coil was eliminated.
CONCLUSIONS: The first six test springs averaged 103,900 cycles to failure in the laboratory test, and four additional springs with a greater pre-set than the first springs averaged 132,100 cycles to failure. The average life of six production springs was 93,700 cycles. However, the failures indicated manufacturing defects not inherent in the elimination of the taper, and a test of similar springs without these defects was recommended.
GENERAL: This 55-page report contains two photographs showing spring failures, drawings of the standard and test springs, sketches of each spring failure, and five pages of computations used in designing the test springs.

SUBJECT: Springs T-61801.33-02
TITLE: M4 Medium Tank Volute Spring with Short Inner Taper
IDENTIFICATION: Report No. T-61801.33-02; Project No. 87-1-1
DATE OF REPORT: 31 May 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the effectiveness of shortened inner-end taper in increasing the fatigue life of volute springs for medium tank suspensions
METHOD: An experimental spring was computed and designed and 14 such springs were manufactured and tested. Six were operated to failure in an average of 72,600 cycles on a laboratory constant stress machine. Six others were operated to outer coil failure on two Medium Tanks M4A3. Two springs were installed in a production sus-

pension unit and operated successfully for 50 hours on a laboratory bump rig.
DESCRIPTION: The experimental Eaton Manufacturing Company springs were medium tank volute suspension springs with the inner taper reduced from 1-3/4 coils to 1-1/4 coils and the number of active coils reduced from 4-3/4 to 4-1/2. The total number of coils was increased from 6 to 6-1/4, and the clearance between the coils increased from .058-inch to .078-inch. The springs were made without a coiling notch.
CONCLUSIONS: The bump rig life of the two experimental springs thus tested was found to be definitely superior to that of standard springs, some of which had failed after only 10 hours rig operation. Though premature termination of the project prevented continuation of field and stress-machine tests, it was believed that experimentation with different presetting operations quite possibly might have brought spring test life up to standard. No recommendations were offered in view of the incomplete test results.
GENERAL: This 51-page report contains two drawings of the experimental volute springs, 14 diagrams of spring cracking, and a 15-page design data and computation section containing six curve sheets.

SUBJECT: Springs T-61801.40
TITLE: Volute Spring, Lead Coated by Flo-Metl Process, Laboratory Life Tests
IDENTIFICATION: Report No. T-61801.40; CX Project No. 87
DATE OF REPORT: 23 July 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the comparative life of standard and lead-coated M4 volute springs under corrosive oil or water spray and cyclic load
METHOD: Six lead-coated springs and ten uncoated springs were tested for endurance on a constant stress machine operated at 100 rpm with a four-inch stroke. Springs were tested under continuous oil spray and under continuous water spray.
DESCRIPTION: The test springs were Medium Tank, M4 volute suspension springs, part No. C-95163, made by Eaton Manufacturing Company. The lead-coated springs had been pickled and hot dip coated by the Kolene Corporation, by their Flo-Metl process. The original weight was 75 to 76 pounds, and the weight had been reduced 0.5 to 2.1 pounds by pickling. The corresponding reduction in average stock thickness ranged from 0.003 to 0.008-inch.
CONCLUSIONS: Under continuous oil spray, three lead-coated springs averaged 97,500 cycles to failure compared to an average of 93,700 cycles to failure for uncoated springs. Under continuous water spray, three other lead coated springs averaged 52,200 cycles to failure compared to an average of 62,500 cycles for four uncoated springs. It was believed that the rather severe pickling operation produced a surface etching or hydrogen embrittlement which was largely responsible for the early failures of the lead-coated springs. Further test was recommended with the same lead coating but with a different scale removing process. Investigation of corrosion protection was recommended in order to obtain a more uniform coating.
GENERAL: This 34-page report contains 16 diagrams and two photographs of failed springs.

SUBJECT: Springs T-61801.40-01
TITLE: Laboratory Life Test of Lead Coated Volute Springs for Medium Tanks M4
IDENTIFICATION: Report No. T-61801.40-01; CXE Project No. 547
DATE OF REPORT: 20 January 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the effects of Kolene electrolytic cleaning and lead coating on the durability and corrosion fatigue resistance of volute suspension springs
METHOD: Thirteen production springs were tested on a constant stress machine under various conditions to establish test procedures and comparative data. Life tests were made on production and test springs at 100 rpm and 4-inch stroke under continuous oil spray. Corrosion fatigue tests were run on production and test springs at 40 rpm and 3.25-inch stroke under intermittent water spray and with intermittent test machine operation.
DESCRIPTION: The test volute suspension springs were for Medium Tanks, M4, and had been cleaned by the Kolene electrolytic process. Seven test springs were lead coated by the Flo-Metl process and reset after cleaning; two non-coated springs were reset after cleaning; and two were neither coated nor reset after cleaning.
CONCLUSIONS: The Kolene cleaning process did not affect the life of springs reset after cleaning. Kolene cleaned springs that were not reset averaged 49,600 cycles on the life test; cleaned and reset springs averaged 64,900 cycles. Production springs averaged 69,300 cycles on a similar test. The lead coated springs showed no significant improvement in resistance to corrosion fatigue over production springs. Production springs averaged 54,400 cycles on the corrosion fatigue test, and lead coated springs averaged 58,000 cycles. It was considered that the lack of improvement shown by the lead coated springs was due to the fact that the lead coating could not be applied in a sufficiently uniform manner. It was recommended that the lead coating be further tested on springs with greater gap between coils.
GENERAL: This 49-page report contains one photograph of a volute spring tested under water spray.

SUBJECT: Springs T-61801.41-01
TITLE: Bump Rig Test, Suspension, M4 Medium Tank
IDENTIFICATION: Report No. T-61801.41-01; CX Project No. 57-1
DATE OF REPORT: 25 April 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan

PURPOSE: To obtain bump rig endurance data on two experimentally modified vertical volute suspension units
METHOD: One M4 Medium Tank suspension unit was assembled with short taper volute springs and mounted in the bump rig which operated in conjunction with a chassis dynamometer. The first test was run for 50 hours at a drum speed of approximately 50 rpm, corresponding to a road speed of 8 mph. A modified medium tank suspension unit with trunnion center raised two inches was then tested with standard volute springs for 100 hours. Motion pictures were taken.
DESCRIPTION: The suspension unit with short-taper, vertical volute springs conformed with assembly No. D-4727, except that track support guide, track return roller, and track return roller bracket were omitted. The second suspension tested was an experimental unit with a raised trunnion center per Chrysler layout No. U. S. 900 and schematic photograph EH-270 (cf. Report No. T-61801.104).
CONCLUSIONS: The short taper volute springs appeared less subject to cracking than standard production springs which had failed in previous bump rig tests in as short a time as 10 hours. (cf. Report No. T-61801.33-02). Raising the trunnion center two inches appeared to improve the endurance life of standard production springs, although arm and lever rubbing plate wear was appreciably increased by the modification.
GENERAL: This 26-page report contains three photographs showing the wear plates, spring seat, and suspension bracket caps of the suspension unit with raised trunnion center.

SUBJECT: Springs T-61801.41-02
TITLE: Medium Tank Horizontal Volute Spring; Bump Rig Test
IDENTIFICATION: Report No. T-61801.41-02
DATE OF REPORT: 4 April 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine endurance characteristics of a medium tank horizontal volute spring suspension unit on the bump rig test
METHOD: The test suspension unit was operated for 681 hours on a bump rig installed on a chassis dynamometer. The dynamometer drum speed was 50 rpm, equivalent to a road speed of about eight miles per hour; and the entire test operation represented a run of about 5450 miles with approximately 4,100,000 bumps. For the first 200 hours the unit was tested without a shock absorber, and for the remaining 481 hours with a shock absorber.
DESCRIPTION: The test unit was a medium tank, horizontal, volute spring suspension unit for 16-inch track. The suspension unit was tested without the track support guide, track return roller and bracket.
CONCLUSIONS: Operation of the test unit was trouble-free during the first 200 hours. During the remainder of the test, one volute spring broke and another cracked through the coiling notch in the inner inactive coil. Five shock absorbers failed and were replaced during the test. One shock absorber bracket failed after 187 hours. Failure was attributed to the bracket bolts being insufficiently tight. Bogie arm and volute spring temperature readings indicated that atmospheric temperatures would not be exceeded by more than 25°F. It was recommended that operation of the test unit on the bump rig be extended to obtain data on the unit with a cantilever type bracket for 23-inch center-guide track.
GENERAL: This 35-page report contains three photographs of the test setup and of failed bogie wheel tires. Three test graphs, a sketch of bump rig geometry, three shock absorber oil temperature curve sheets, and two drawings of the shock absorber are also included.

SUBJECT: Springs T-61801.103-01
TITLE: Volute Springs, Medium Tank Suspension, Chromium-Vanadium Steel, Laboratory Life Tests
IDENTIFICATION: Report No. T-61801.103-01; CXE Project No. 520
DATE OF REPORT: 1 June 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine reasons for the early fatigue failure of 12 experimental chromium-vanadium steel volute suspension springs; to compare these springs with standard production springs
METHOD: The procedure used by the Eaton Manufacturing Company in making the experimental springs was reviewed; an earlier report on the fatigue testing of 12 experimental springs in comparison with six production springs (silicon manganese steel) was reviewed. Several failed springs and sections were examined by the Vanadium Corporation of America and/or by the Chrysler Metallurgical Laboratory.
DESCRIPTION: The experimental chromium-vanadium steel springs Part No. C-95163, were made from SAE-6150 steel produced by Republic steel. The variation in free helix angle was found to be on the order of Z=1/2, compared to Z=0 for the silicon-manganese steel production springs with which they had been directly compared.
CONCLUSIONS: No serious fault was discovered either in the steel or in the fabrication of the experimental springs which would explain their comparatively short life. It was concluded that SAE-6150 chromium-vanadium steel was not a suitable material. Continued use of silicon-manganese steel was recommended.
GENERAL: This 41-page report contains four graphs, fatigue data and metallurgical reports.

SUBJECT: Springs T-61801.144
TITLE: Increased Rate Volute Springs, Medium Tank
IDENTIFICATION: Report No. T-61801.144; CX Project No. 44-5
DATE OF REPORT: 24 September 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To compare the life of horizontal

volute springs having higher capacity and initial rate with production type springs
METHOD: Three experimental volute springs and two standard springs, compressed from their initial height to 11.75 inches, were subjected to laboratory life tests on a constant stress machine which was set for a 4-inch stroke at 100 RPM.
DESCRIPTION: The test and production volute springs manufactured by the Eaton Mfg. Co., had the following specifications:

PART NO.	INITIAL RATE	BLADE THICKNESS	LOAD AT 10-INCH HEIGHT
483-213	2000	.375	5700
483-214	2000	.375	7000
483-215	2390	.390	7000
C101531*	1390	.344	5700
C55470*	1390	.344	5700

*Standard production design modified from the original Union Spring and Mfg. Co. C55470 design.
CONCLUSIONS: The test high initial rate springs, by having a more favorable distribution of helix angles, gave better results than the production springs. As demonstrated in a later report, the increased life and spring capacity were not obtained by means of a high spring rate, but by means of a greater rate of change in the helix angles as well as an increase in total spring deflection.
GENERAL: This 136-page report contains test data logs and volute spring drawings and calculations. There are no photographs.

SUBJECT: Springs T-61801.145
TITLE: Volute Springs with Variable Helix Angle, Medium Tanks
IDENTIFICATION: Report No. T-61801.145; Project No. 273
DATE OF REPORT: 30 August 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To compare the laboratory life of springs having equal bottoming stress in all active coils with that of production springs
METHOD: Six test springs were subjected to laboratory life tests on a 100 rpm constant stress machine. The length of the deflecting stroke was set at 4.75 inches. The maximum height of the spring at the start of the test was established at 12.5 inches. In the case of five standard springs, a maximum height of 11.75 inches was used and a stress machine stroke of 4 inches.
DESCRIPTION: The test American Steel Foundries volute spring No. 483-283 incorporated a helix angle distribution of "Z = 1" and a total spring deflection of "h = 7.25 inches". The Eaton Manufacturing standard production type had a helix distribution of "Z = 1/2" and a total spring deflection of "h = 6.5 inches". Other characteristics of the two types were identical.
CONCLUSIONS: The average life of five test springs was 172,000 strokes as compared to 231,-300 strokes for the standard type. The Chrysler laboratory attributed the comparative life difference to undesirable spring profile, indicating improper manufacturing technique. Further testing of the spring design was cancelled by an Ordnance directive.
GENERAL: This 59-page report does not include photographs.

SUBJECT: Springs T-61817
TITLE: Shock Isolators, Deflection Tests, Medium Tanks
IDENTIFICATION: Report No. T-61817, CX Project No. 139
DATE OF REPORT: 14 June 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the spring rates and permanent set of six pairs of shock isolators of different steels and gages
METHOD: Twelve shock isolators were mounted in pairs in a specially built fixture for static tests. Load was applied by a ram and the deflection measured.
DESCRIPTION: Each pair of isolators was of different gage steel. Three pairs were made of spring steel, and three pairs of cold rolled steel. These isolators were submitted by the Ordnance Department for use on Medium Tanks.
CONCLUSIONS: The spring steel isolators had practically no set after a 1/8-inch deflection. The cold rolled steel deflectors took an appreciable set for the same deflection. No recommendations were made by the Laboratory.
GENERAL: This 14-page report includes one photograph of the test setup, six tables of load-deflection data and six load deflection curves.

Section 37
SPROCKETS

SUMMARY

This summary covers 55 report resumes on the testing and development of sprockets for use on various half-track vehicles, and light, medium, and heavy tanks. Tests were conducted at Aberdeen Proving Ground, Maryland; Tank Arsenal Proving Ground, Utica, Michigan; Detroit Arsenal, Center Line, Michigan; General Motors Proving Ground, Milford, Michigan; and General Motors Corporation, Cleveland Tank Plant, Ohio. Report data represent the 1942 to 1954 period, with the majority of the testing conducted from 1942 to 1945. Investigations during the World War II span were devoted to improving sprocket tooth contour for increased performance and to improving structural materials and methods of fabrication.

Toward the improvement of materials and manufacturing methods, numerous experimental sprockets were tested in comparison with standard flame hardened sprockets. The following types of steel and steel surfacing were employed in the various test sprockets: cast; cast malleable iron; induction hardened; Colmonoy surfaced; Haynes-Stellite surfaced; SAE 4140, 2320, 1020; NE 1345; Tocco hardened; cast manganese, tungsten carbide, fusion metal coated; and perlitonized.

Of nine reports, three showed cast sprockets to be inferior to the standard flame hardened type while six reports showed cast sprockets equal or superior to the standard with respect to durability and other performance characteristics. Flame cutting the tooth contours had no effect on the life of experimental tank final drive sprockets. All tests on cast sprockets were conducted with light and medium tanks.

Considerable interest was shown in Colmonoy faced sprocket teeth, as evidenced by seven reports on this subject. In each test, from 1/8 to 3/16 inch was machined from the sprocket tooth face and a layer of Colmonoy was electric-welded on each tooth to restore the original contour. In five of the tests, Colmonoy surfaced sprockets exhibited superior (as high as 40% to 50% more) durability or wear characteristics as compared with the standard. However, it was noted in one report that once the Colmonoy layer wore through, the rate of wear was excessive and approached the life figure established for the standard. Another factor considered detrimental was the relatively high cost of fabricating with Colmonoy.

Test reports were also devoted to the development of components such as cap screws, rims, and track support rings, and to reducing track jumping or skipping tendencies. One 1951 report covered tests of five different external devices for reducing track jumping, e.g., guides and wheels to force the track into the pitch line when skipping tended to take place. Though none of the external devices was entirely satisfactory, it was recommended that the possibility of employing an arrangement in the transmission be studied to speed up the inner sprocket hub momentarily during a turn, thereby taking up the accumulated slack between the last road wheel and the sprockets and eliminating the first stage of track skipping. Experimental rubber-mounted tank sprockets did not provide any observable reduction in vehicle vibration.

An example of several miscellaneous tests is one that was conducted on resilient tooth sprockets. They differed from the standard in that the sprocket teeth were mounted on rubber torsion units and were designed to distribute the load over all the teeth. Though satisfactory in some respects, complexity of manufacture was considered to outweigh any advantages derived from future application.

REPORT RESUMES

SUBJECT: Sprockets APG 7-9-1
TITLE: Sprockets, Drive, Morse Chain Company, Medium Tanks M2 & M2A1
IDENTIFICATION: Project No. 7-9-1; APG 224-6
DATE OF REPORT: 22 May 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of cast sprockets
METHOD: The test cast sprockets were installed on Medium Tank M2A1, No. 19, and subjected to a total operation of 225 miles on paved roads and cross-country
DESCRIPTION: The cast sprockets were identical with the standard production Medium Tank M2 and M2A1 sprockets, with the exception that they had been cast rather than forged. They were cast by Morse Chain Company.
CONCLUSIONS: Past tests of cast sprockets had indicated that the method of production was acceptable provided the flame hardening was sufficient. It was recommended that the supplier submit his proposed hardening process and samples.
GENERAL: This 14-page report is not illustrated.

SUBJECT: Sprockets APG 7-9-4
TITLE: Sprockets, Drive, Flame Cut for Medium Tank M3
IDENTIFICATION: Project No. 7-9-4; APG Report No. 224-3

DATE OF REPORT: 20 May 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Pullman Standard Car Manufacturing Company flame cutting and flame hardening processes for M3 Medium Tank sprockets
METHOD: The test sprockets were installed on an M3 Medium Tank and subjected to a total of 1804 miles of operation. Twenty-eight miles of operation were on paved roads and 1776 miles were cross-country.
DESCRIPTION: The Pullman Standard Car Manufacturing Company test sprockets were made by a flame-cutting and flame-hardening process. After the outline of the sprocket was flame-cut the sprocket was normalized at 1550°F for four hours and allowed to cool in the furnace to 500°-600°F and then allowed to cool in still air. The Brinell hardness number of the sprockets was between 187 and 217 after this treatment. The only machining necessary was drilling and counterboring after which the sprocket tooth surfaces were shot blasted prior to flame hardening. Flame hardening was performed by the oxy-acetylene process. The Brinell hardness number of the sprocket was 550-600 after flame hardening.
CONCLUSIONS: Wear on the sprockets appeared normal during the first 1200 miles of operation. After 1200 miles of operation, the rate of wear increased very rapidly until failure occurred at 1804 miles. The flame-hardening process was found to produce a very tough but thin skin on the sprockets. It was recommended that the Pullman Standard sprockets tested not be considered acceptable as a production alternate until such time as the heat treating process was changed to produce the depth of hardness required for a minimum of 2000 miles of operation.
GENERAL: This 29-page report contains four photographs of the test sprockets.

SUBJECT: Sprockets APG 224-5
TITLE: Sprockets, Drive, S. M. Howes for Medium Tank M3
IDENTIFICATION: Report No. APG 224-5
DATE OF REPORT: 20 May 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the cast sprockets as an alternate for the forged sprockets for Medium Tank M3
METHOD: A complete set of the test cast sprockets was installed on Medium Tank M3, No. 1694. After 1197 miles, the left sprocket was removed and installed on Medium Tank M3, No. 1693, on which it operated 249 miles cross-country and four miles over paved roads for a total of 1450 miles. Operation of the right sprocket totaled 3077 miles, 2355 miles of which was over paved roads and 722 was cross-country. The right sprocket was then subjected to ballistic tests with cal. .30 and cal. .50 ball and AP projectiles.
DESCRIPTION: The test sprockets were identical with the standard production Medium Tank M3 sprockets with the exception of being cast instead of forged or flame cut. They were cast by S. M. Howes, Boston, Mass.
CONCLUSIONS: It was recommended that the test cast sprockets be approved for Medium Tank M3 use.
GENERAL: This 22-page report includes a physical test report. It is not illustrated.

SUBJECT: Sprockets APG 5298/34
TITLE: First Report on Comparative Test of Perlitonized and Standard Sprocket Rings for Light Tanks
IDENTIFICATION: Thirty-fourth Report on Ordnance Program No. 5298; APG 224-1
DATE OF REPORT: 3 April 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether the perlitonized sprockets offered any advantages over the standard sprockets
METHOD: One set (two rings) of perlitonized sprockets was installed and operated on the right side of an M1 Combat Car and a standard set was used on the left side. After 1795 miles of operation both sets of sprockets and the tracks were shifted to an M2A3 Light Tank and operated for 545 miles. Both sets of sprockets and the tracks were again installed on the M1 Combat Car and operated for 25 miles, at which time interference occurred between the standard sprockets and the track wedge bolt nuts. The standard sprockets were reversed and vehicle operation continued for 468 miles, at which time interference occurred between the experimental sprockets and the track wedge bolt nuts. An M2A3 Light Tank was equipped with a set of experimental sprockets, a set of standard sprockets, and standard tracks and operated for 3201 miles. Rate of sprocket tooth wear during the test was checked with a pitch gage (template) made to match the tooth profile of the new sprockets.
DESCRIPTION: The experimental sprockets differed from standard sprockets only in material and hardening process. The experimental sprockets were case-hardened by means of a Perliton bath.
CONCLUSIONS: In some cases the experimental perlitonized sprockets exhibited slightly greater wear resistance than the standard sprockets. The perlitonized sprockets did not wear in such a manner as to give a rough fringe of metal along the sides of the sprocket teeth. When perlitonized sprockets were used, the increase in wear of track connectors was negligible. It was recommended that perlitonized sprockets be supplied for light tanks and combat cars only if the cost were no more than, or less than, that of standard sprockets. An increase in the tooth bearing area of sprockets for light tanks was recommended to increase operational life.
GENERAL: This 36-page report contains 17 photographs of the test sprockets and worn track wedge bolt nuts.

SUBJECT: Sprockets APG 5365/42
TITLE: First Report on Sprockets with Colmonoy-Faced Teeth
IDENTIFICATION: Forty-second Report on Ordnance Program No. 5365; APG 224-9
DATE OF REPORT: 1 June 1944

ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare durability of track-laying vehicle sprockets with Colmonoy-faced teeth and standard sprockets
METHOD: The test and standard sprockets were mounted on alternate sides of one Medium Tank M4A3 and four Medium Tanks M4A1. Operation was over varied terrain for a combined total of 7338 miles. Sprocket wear measurements were recorded.
DESCRIPTION: The 10 test sprockets of Colmonoy inlay applied to the tooth surfaces were supplied by the Wall Colmonoy Company. The two standard sprockets were flame-cut and flame-hardened.
CONCLUSIONS: The Colmonoy-faced sprockets were 34% superior to the standard sprockets based on wear per 1000 miles. Wear on the track end connectors and tooth pitch and damage to track or track pins were less with the test sprockets. Development, improved inspection and control of the standard sprocket, and continued testing of the Colmonoy-faced sprockets were recommended.
GENERAL: This 101-page report includes 10 pages of photographs of the test sprockets.

SUBJECT: Sprockets APG 5464/3 Min
TITLE: First Minor Report on Sprocket, Experimental, with Resilient Tooth for Medium Tank
IDENTIFICATION: Third Minor Report on Ordnance Program No. 5464; APG 224-2
DATE OF REPORT: 12 June 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of resilient tooth sprockets for use in M3 Medium Tanks
METHOD: The test sprockets were subjected to a total of 1467 miles of operation: 1006 miles on concrete, 266 miles on gravel, and 195 miles cross-country. The noise reducing qualities of the test sprockets were observed, and the tractive resistance of a tank equipped with the test sprockets was compared with that of a tank equipped with standard sprockets.
DESCRIPTION: The experimental sprockets differed from standard in that the sprocket teeth were mounted on rubber torsion units. This resilient design was an attempt to cause the track load to be distributed over all the teeth instead of concentrating the load on one tooth or a small number of teeth. The sprockets were manufactured by the Inland Manufacturing Division of General Motors Corporation.
CONCLUSIONS: The complexity of manufacture of the resilient type of sprocket tested outweighed its advantages. There was no appreciable noise reduction when the resilient sprockets were used instead of standard sprockets. No appreciable difference in tractive resistance of the M3 Medium Tank was evident when the resilient sprockets were used instead of standard sprockets. Because of difficulties in manufacture and procurement, the resilient sprocket was not recommended for consideration for production; standard sprockets were recommended for use on future production vehicles. Redesign of the pivot screws to permit secure and positive locking was recommended should further consideration be given the resilient sprockets. In the event further consideration be given the resilient sprocket, it was recommended that the sprocket teeth be made of material comparable in hardness to standard sprockets.
GENERAL: This 39-page report contains eight photographs of the test sprocket.

SUBJECT: Sprockets APG 5518/11
TITLE: Final Report on Test of Drive Sprockets for Half Tracks with 1/4-inch Longer Teeth
IDENTIFICATION: Eleventh Report on O.P. No. 5518; APG 224-7
DATE OF REPORT: 1 September 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effect of the 1/4-inch longer sprocket teeth in preventing track jumping at the drive sprocket
METHOD: The test drive sprockets were installed on Half-Track Car M2, No. 2. Operation over concrete and cross-country totaled 2864 miles. Vehicle was operated 435 miles with 14-inch Band Block Tracks and 2429 miles with 12-inch Band Tracks. The operation of the test sprocket on the vehicle while climbing a 60% slope was observed and compared with a vehicle equipped with a standard sprocket, modified guides, modified bogie flanges and spring loaded idler adjustment.
DESCRIPTION: The test drive sprockets were essentially the same as the standard sprockets for Half-Track vehicles. Because of the 1/4-inch extra length, the profile of the teeth was changed slightly.
CONCLUSIONS: The 1/4-inch longer drive sprocket teeth did not show any advantage over the standard drive sprocket. No advantage was gained by using a longer tooth sprocket for operation on 60% slopes. Discontinuance of tests was recommended.
GENERAL: This 20-page report includes five photographs.

SUBJECT: Sprockets APG 5661/11
TITLE: Spicer Malleable Iron Sprocket Hubs for Light Tanks
IDENTIFICATION: Eleventh Report on Ordnance Program No. 5661; APG 224-8
DATE OF REPORT: 28 June 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of cast malleable iron sprocket hubs for light tanks
METHOD: Two test hubs were installed on Light Tank M3, No. 3371, and operated 2045 miles over cross-country, gravel and paved roads. Upon removal, the test hubs and the standard cast steel hubs were subjected to impact tests with the following projectiles: cal. .30 AP, cal. .50 AP, and 37mm APC M51.
DESCRIPTION: The cast malleable iron sprocket hubs were manufactured by the Spicer Manufacturing Company, Toledo, Ohio. The hubs, for light tanks, were cast of malleable iron instead of cast steel (Grade 2) which was the standard material.
CONCLUSIONS: The test sprockets gave satisfactory service when operated on a light tank.

Ballistically, they were somewhat inferior to the standard hub because of a slightly greater tendency to crack under impact. They were recommended for approval only as an alternate.
GENERAL: This 60-page report includes nine photographs of the malleable iron and cast steel hubs after firing.

SUBJECT: Sprockets APG 5661/15
TITLE: First Report on Test of Sprockets, Colmonoy, on Medium Tanks, T25E1 and Heavy Tanks, T26E1
IDENTIFICATION: Fifteenth Report on Ordnance Program No. 5661; APG 224-11
DATE OF REPORT: 26 February 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare durability of hard alloy-coated sprockets with standard sprockets
METHOD: The test sprockets were mounted on a Medium Tank T25E1 and on two Heavy Tanks T26E1. Operation was over level surfaces and some cross-country. The sprockets were operated under varying conditions that made comparison difficult. The sprockets were run without reversing until the test materials were worn through.
DESCRIPTION: The eight pairs of sprockets tested included three pairs of flame-cut, flame-hardened items from standard production. The test sprockets consisted of two pairs each of Colmonoy Sweat-on Paste No. 6, and No. 6 Special Inlay types, and one pair of No. 6 Inlay. The test sprockets were supplied by the Wall Colmonoy Company.
CONCLUSIONS: The test hard-alloy sprockets gave from 10 to 30 percent longer wear than the standard type. No variation in wear rate of driven surfaces of tracks was noted. It was believed that the high cost of Colmonoy sprockets would not justify their use. It was recommended that tests be continued to improve sprocket life.
GENERAL: This 50-page report includes one page of photographs of the test sprockets.

SUBJECT: Sprockets APG 6006/4
TITLE: First Report on Test of Shear Sprockets for Tank Recovery Vehicle M32B1
IDENTIFICATION: Fourth Report on Ordnance Program No. 6006; APG 224-10
DATE OF REPORT: 5 January 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether winch sprockets equipped with shear pins would adequately protect the winch gear trains of Tank Recovery Vehicles M32B1
METHOD: Two sprockets were tested with the winch of a Tank Recovery Vehicle M32B1. Testing consisted of loading the winch cable, with a number of layers of cable left on the winch, through a field dynamometer and measuring the pull on the winch. This pull was then computed on the basis of the bare drum load.
DESCRIPTION: One test item consisted of a winch sprocket and shear hub assembly C70-66443; shear pin 7066440 was used with the assembly. The second test item was a shear pin equipped sprocket designated assembly WSK-3-7-441.
CONCLUSIONS: The pin in sprocket assembly C7066443 was considered adequate in that it failed at a bare drum load of 66,400 pounds, or approximately 10% over the rated capacity of the winch. The pin of sprocket WSK-3-7-441, which withstood 94,250 pounds bare drum load without failing, was considered inadequate for protection of the winch gear train. It was recommended that shear sprocket C7066443, with modification to simplify the replacement of the shear pin, be standardized for use in the Tank Recovery Vehicle M32B1 winch assembly.
GENERAL: This 25-page report contains two photographs of the test winch sprockets. A photostat drawing of winch assembly C7066443 is also included.

SUBJECT: Sprockets APG 6009/5
TITLE: First Report on Heavy Tanks, M26, Experimental Sprocket to Reduce Track Throwing
IDENTIFICATION: Fifth Report on Ordnance Program No. 6009; APG 10-186
DATE OF REPORT: 27 November 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop and test a Heavy Tank M26 drive sprocket with a reduced angle of tooth pressure to minimize track throwing tendency; also to study the sprocket action of the German Mark VI (Tiger) Tank
METHOD: Two sprockets of experimental design were mounted on the left side of a Heavy Tank M26. Two new standard sprockets were mounted on the right side for comparison. T80E1 track was adjusted to standard tension on both sides. An area of smooth soft ground with a gentle slope was used for the test, and motion pictures were taken of sprocket action in tight left and right turns. The German Tiger Tank was operated briefly, but poor vehicle condition prevented operation for motion pictures.
DESCRIPTION: The experimental sprockets had rounded contour teeth with a six degree tooth pressure angle (as compared to 33° for standard sprockets). The M26 Tank had rear sprocket drive; the Mark VI had front sprocket drive. The diameter of the German Tiger Tank sprockets was less than M26 Tank sprockets, and the sprocket pitch on the Mark VI was actually smaller than the track pitch (this caused the sprocket to drive on only one tooth at a time).
CONCLUSIONS: The experimental sprockets caused the track to jump severely in both uphill and downhill operations, while standard sprockets caused track jumping only when the tank was turning in a downhill direction. The experimental sprockets were therefore considered unsatisfactory. It was noted that the front drive sprockets on the Tiger Tank allowed track jumping only in small radius backward turns. Its track was very loose and considering this, there was less jumping tendency than with the M26 — possibly due to the smaller sprocket used. Since previous tests showed that wear increased as sprocket diameter was decreased, it was recommended that solution to the track jumping problem be sought either by

increase of sprocket tooth height or by reduction of side thrust at the sprockets.
GENERAL: This 25-page report contains a brief prior-data-survey and three photographs of standard and experimental sprockets. Two of these are action shots showing the track riding up on the sprocket.

SUBJECT: Sprockets APG TT1-19B/2
TITLE: Test of Sprockets Coated with Tungsten Carbide
IDENTIFICATION: Second Report on OCO Project No. TT1-19B; APG 224-14
DATE OF REPORT: 20 July 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability, durability and life of sprockets having tungsten carbide-coated drive teeth
METHOD: Of the two test sprockets, the one coated with Fusecoat T325 was not tested due to its poor quality. The other, coated with Fusecoat T60 and 80, was mounted on the outside of the right hub of an M46 tank. The inside of this hub mounted a standard flame-hardened sprocket for comparison. The left hub was fitted inside and outside with sprockets rebuilt with Colmonoy, also for comparison. The first phase of the test covered 1469 miles over varied terrain. At 1000 miles, the sprockets were measured for wear. For the second phase, the standard and Fusecoat T60 and 80 sprockets were reversed and the tank operated for 729 miles when the Fusecoat T60 and 80 and standard flame-hardened sprockets were removed because of excessive wear.
DESCRIPTION: The two test sprockets were coated with Fusecoat T325, T60 and 80. These compositions of tungsten carbide, .014 inch to .017 inch thick, were fused to the base metal by Fusion Metal Coating Company, Detroit, Michigan.
CONCLUSIONS: The tungsten carbide coating was of insufficient thickness to give conclusive data. It was recommended that sprockets be coated with tungsten carbide to a depth of at least 3/16 inch and retested.
GENERAL: This 18-page report includes eight photographs of the test sprockets.

SUBJECT: Sprockets APG TT1-19B/10
TITLE: Test of Cast Manganese Steel Sprockets
IDENTIFICATION: Tenth Report on Project No. TT1-19B; APG 224-16
DATE OF REPORT: 25 January 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the wear characteristics of the cast manganese sprockets as compared to standard flame-hardened steel sprockets
METHOD: Two teeth on each of the four test manganese sprockets and four standard sprockets were measured in order to establish their original contour. In all, 500 points were measured and plotted. Two test sprockets were mounted on one hub of a T41E1 Tank and two standard sprockets on the other hub. After 238 miles operation over varied terrain, the sprockets were removed, tooth contour measurements were taken, and weight and hardness readings were recorded. The above procedure was repeated with the other two standard and manganese sprockets mounted on sides opposite from the first installation. This operation totaled 668 miles.
DESCRIPTION: The cast manganese steel sprockets were of the type employed on the Tank, 76mm gun, T41E1, and were interchangeable on the hub with the standard flame-hardened sprockets. They were 7/8 inch smaller in over-all diameter, weighed 76-1/2 pounds, and had a Brinell hardness of 207 against 70 pounds and a Brinell hardness of 547 for the standard sprocket.
CONCLUSIONS: The test cast manganese sprockets were considered unsatisfactory for use on the T41E1 Tank. In the two tests, the test cast manganese sprockets wore 33% and 110% more than the standard flame-hardened sprockets.
GENERAL: This 50-page report includes 17 curves of tooth contours at various mileages and three photographs.

SUBJECT: Sprockets APG TT1-19E/3
TITLE: Sprocket and Track Engagement on Tracked Vehicles, Study of
IDENTIFICATION: Third Report on OCO Project No. TT1-19E; APG 224-15
DATE OF REPORT: 6 July 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effectiveness and feasibility of employing external devices to eliminate sprocket tooth skipping of tracklaying vehicles
METHOD: Five devices to eliminate sprocket tooth skipping were tested on Heavy Tank T30 during tank operation
DESCRIPTION: The purpose of four devices tested was to force the track into the pitch line of the sprocket when skipping tended to take place. Guides or wheels which contacted the end connectors on the inside of the tracks when the track left the sprocket tooth pitch line were mounted on the final drive housing. The fifth device utilized lugs welded to a center guide flange and depended upon friction to accomplish its purpose. Where skipping did not occur, excessive wear and damage to components were evident. The test devices, welded to the final drive, prevented track removal and installation.
CONCLUSIONS: Externally applied devices, which forced the track into the sprocket tooth pitch line, were not entirely satisfactory in eliminating sprocket tooth skipping. It was recommended that the possibility of employing an arrangement in the transmission be studied to speed up the inner sprocket hub momentarily during a turn, thereby taking up the accumulated track slack between the last road wheel and the sprockets and eliminating the first stage of track slipping.
GENERAL: This 18-page report includes five photographs and a sketch of the test devices.

SUBJECT: Sprockets DA 424
TITLE: Investigation of Failed Sprocket No. D-47366 Medium Tank M-46
IDENTIFICATION: Report No. 424

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 25 July 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the cause of excessive sprocket tooth wear of sprocket No. D-47366
METHOD: Two teeth were cut from opposite areas of the sprocket, cross-sectioned, and etched. Metallographic examinations were made of the web area and also of the flame-hardened zone in the sprocket teeth. Three standard 0.505-inch test bars were machined from areas approximately 60° apart; a fourth section was cut, normalized at 1600° F, air-cooled, and machined to a 0.505-inch bar for comparison. These bars were then tested to determine their physical properties. Also, the chemical composition of the sprocket was analyzed.
DESCRIPTION: The test sprocket was a final drive sprocket, No. D47366, taken from a medium tank M46 after 469 miles of operation in an abrasive type of soil.
CONCLUSIONS: Chemical, physical, and metallographic tests failed to reveal metallurgical factors which could directly or indirectly result in excessive wear of the sprocket teeth. Evaluation of the chemical analysis of the sprocket was in conformance with specified composition for WD-8645 steel. Test results showed the material and physical properties to be substantially identical to other sprockets which had performed satisfactorily. It was felt that the extreme wear was caused by abnormal operating conditions in which a very abrasive soil was encountered at high speeds. It was recommended that a program be initiated to develop a more satisfactory abrasion resistant contact surface.
GENERAL: This 12-page report includes four photographs of the test sprocket.

SUBJECT: Sprockets DA 1496
TITLE: Modified Hub and Sprocket Assembly for Medium Tank M46
IDENTIFICATION: Report No. 1496; Job No. 5298
DATE OF REPORT: 18 January 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of a modified hub and sprocket assembly for Medium Tank M46
METHOD: Two of the assemblies were installed on a tank which was then operated cross-country through deep mud, rocks, and gravel. After cross-country operation, the vehicle was operated about one mile on a test track in an attempt to remove accumulated mud. The vehicle was then operated through a stiff, blue clay mud. The test assemblies were given periodic inspections.
DESCRIPTION: The test modified hub and sprocket assemblies for the Medium Tank M46 contained two sprockets, Ordnance Part No. 6547366, each having 13 tapered holes 2-1/2-inches in diameter, and a conical hub, Ordnance Part No. 7722314, with eight escape ports approximately 4x6 inches in size. The hub provided a hollow center outlet 12 inches in diameter.
CONCLUSIONS: The assemblies were effective in preventing excessive mud accumulation only under certain conditions and they did not prevent track throwing. During the cross-country operation of the tank, excess mud was forced through the escape holes of the assembly. When the tank was stopped, however, the hub remained full of mud which hardened and subsequently nullified the value of the escape port. Operation of the tank on the test track did not dislodge the accumulated mud. When the vehicle was operated through the stiff, blue clay mud, the hub filled quickly and the accumulation resulted in track throwing.
GENERAL: This 13-page report contains eight pages of photographs showing the assemblies.

SUBJECT: Sprockets DA 2334
TITLE: Manganese Sprockets for 90-MM Gun Tank M47
IDENTIFICATION: Report No. 2334; Job No. 8119
DATE OF REPORT: 31 March 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate the wear resistance of manganese steel for medium tank sprocket application
METHOD: The experimental sprocket outlines were traced before testing, then the sprockets were installed on a 90-mm Gun Tank M47 and operated to failure (worn to an unserviceable condition). The outlines were retraced over the original outlines after testing to evaluate the dimensional wear.
DESCRIPTION: Two of the set of four sprockets were unhardened; the other two shot-peened with some teeth hammer-peened. All were fashioned of manganese steel.
CONCLUSIONS: None of the sprockets was satisfactory since they had reached an unserviceable condition in 1000 miles of operation and were worn approximately equal.
GENERAL: This six-page report contains four photographs showing the sprocket outlines before and after testing.

SUBJECT: Sprockets GM-CTP 137 F
TITLE: T91E3 Type Rubber Mounted Sprockets with Harris Products Co. No. 69001 Rubber Bushings
IDENTIFICATION: Report No. 137 (Final)
DATE OF REPORT: 17 June 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the effect of rubber-mounted sprockets on vehicle performance characteristics
METHOD: The rubber mounted sprockets were installed on a T37 tank and the vehicle was operated for 918 miles over cross-country courses.
DESCRIPTION: The sprockets were constructed of 8650 steel with the tooth wearing surface induction hardened to 56C Rockwell. The teeth were of standard T91E3 design. The sprockets were made by the Link Belt Company of Indianapolis, Indiana. The bushings were manufactured by the Harris Products Company of Cleveland, Ohio, and were of 60 durometer hardness. The rubber mounted sprocket and hub assembly weighed 320 pounds compared to 275 pounds for the standard

T91E3 sprocket and hub assembly. The sprockets were installed on the T37 tank powered by an AV-1195-2 engine, EX 340-1 transmission, and T91E3 tracks.
CONCLUSIONS: The rubber mounted sprockets did not provide any observable reduction in vibration with the vehicle. Since standard sprockets were not tested in direct comparison, it was not possible to make a direct comparison of actual sprocket life. There was no observable difference between the rubber-mounted sprockets and standard sprockets with regard to tooth action or tooth climbing characteristics. Five of the 12 stop pins were broken off or missing and could not be replaced because the remaining part was rusted in the sprocket hub.
GENERAL: This 10-page report includes five photographs of the test items.

SUBJECT: Sprockets GM-CTP 432F
TITLE: Durability Test of Final Drive Sprockets with Flame Cut Tooth Contour
IDENTIFICATION: Report No. 432 (Final)
DATE OF REPORT: 3 November 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine whether flame cutting the tooth contours of final drive sprockets affected the life of the sprocket or the wear of the track sprocket openings
METHOD: The test sprockets were installed on a T14E1 tank, No. D516, in conjunction with an Inland Mfg. Division track having thicker track guides and unhardened track sprocket openings. The vehicle was operated for 323 miles at the Cadillac Ordnance Proving Ground, during which time the inner track pads came out of the track shoes. Inland Mfg. Division was unable to re-manufacture the track, so the sprockets were re-installed on the right side of the vehicle and new production Link Belt sprockets were installed on the vehicle for testing with tracks with hardened sprocket openings. The sprockets were tested to failure.
DESCRIPTION: The test sprockets, Part No. 7962691, were manufactured by the Morse Chain Company, of Detroit, Michigan.
CONCLUSIONS: The flame cut sprockets lasted for a total of 3141 miles; the Link Belt sprockets lasted for 2818 miles. Both sets of sprockets were removed because the teeth had worn beyond the hardened portion. Flame cutting the tooth contour had no effect on the life of the final drive sprocket. No definite test results were obtained concerning the effect of the flame cut tooth contour on the rate of wear on the track sprocket opening. However, it was felt that the test sprocket would have no effect on the rate of wear on the track sprocket openings.
GENERAL: This seven-page report includes two photographs of the failed test sprockets.

SUBJECT: Sprockets GM-CTP 850
TITLE: Durability Test of International Harvester Rubber Tired Hub and Sprocket Assemblies
IDENTIFICATION: Report No. 850
DATE OF REPORT: 20 May 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the durability characteristics of hub and sprocket assemblies for the M75 vehicle
METHOD: The hub and sprockets were installed on the vehicle M41A1 and subjected to 976 miles of a 2000-mile test over cross-country terrain. The condition of the sprocket, hub, and rubber tire was checked daily.
DESCRIPTION: The T91E3 sprockets were modified to fit the International Harvester hub assembly of the M75 vehicle by having a rubber tire to cushion the track block impact forces during sprocket engagement.
CONCLUSIONS: The hub and sprockets were removed from test after 976 miles because of adhesion failure of the rubber to the hubs. No other deficiencies were noted during the test period.
GENERAL: This eight-page report includes three photographs and one detailed drawing of the subject assembly.

SUBJECT: Sprockets PG-2.423
TITLE: Durability Tests on Sprockets D-47366
IDENTIFICATION: Report No. PG-2.423
DATE OF REPORT: 6 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the performance of cast steel track drive sprockets with that of production track drive sprockets used on a Medium Tank M4A2
METHOD: Production track drive sprockets and test track drive sprockets, installed on the right and left sides of a Medium Tank M4A2, were operated for an average of 897 and 1208 miles, respectively. Observations were made periodically to determine whether test sprocket and track guide interference existed. Following tests, comparisons were made of the average wear of test and standard sprockets; these comparisons were made with the wear of both sprockets computed on the basis of 1000 miles of operation.
DESCRIPTION: The test cast steel track drive sprockets were manufactured by the S. M. Howes Company. Sprockets were designed for use on Medium Tank M4A2. There was no description of the production track drive sprockets.
CONCLUSIONS: There was no interference between track guides and test sprockets. Average wear of the front side of the test sprocket teeth was 0.063 inch. Because of the unusually high and erratic wear of the front side of the standard sprocket teeth, it was considered that the wear results to be expected from normal production sprockets were not truly represented in this test; as a result, no fair comparison could be made between the wear rate of the front side of standard and test sprocket teeth. No significant difference existed between the wear rate of the rear side of the teeth of either sprocket (0.044 and 0.050 inch for test and standard sprockets, respectively).
GENERAL: This 11-page report contains two photographs of test and standard sprockets after test.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Sprockets PG-2.465
TITLE: Test of Haynes-Stellite Sprockets
IDENTIFICATION: Report No. PG-2.465; Project No. 33-2A
DATE OF REPORT: 28 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the performance of Haynes-Stellite track drive sprockets with standard track drive sprockets used on Light Tanks M3
METHOD: Two test sprockets and two standard sprockets were tested concurrently on Light Tanks M3. After a total of 3130 miles, wear measurements were averaged for both types of sprockets.
DESCRIPTION: The teeth of the 3/4-inch wide test sprockets were hard faced with Haynes-Stellite grade No. 1. Stellite hard facing was a cobalt-chromium-tungsten alloy, advertised as not being abrasive. Standard production sprocket teeth had flame-hardened faces.
CONCLUSIONS: The wear of the front and rear sides of standard sprocket teeth was approximately 2.3 times faster than that of the test sprocket teeth. No apparent difference was noted in the abrasive action of either sprocket on track guides.
GENERAL: This 20-page report contains one photograph showing the test and standard sprockets after test.

SUBJECT: Sprockets PG-2.466
TITLE: Test of Cast Steel Final Drive Sprockets on a Medium Tank
IDENTIFICATION: Report No. PG-2.466; Project No. 33-6
DATE OF REPORT: 24 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the performance of cast steel track drive sprockets with standard grade 4C2 steel track drive sprockets used on Medium Tanks M4A2
METHOD: Test and standard track drive sprockets were mounted on opposite sides of a Medium Tank M4A2 and operated for 1082 miles. Effects of sprockets on track block wedge nuts and wear of the sprockets were compared.
DESCRIPTION: The test cast steel sprockets were manufactured by the S. W. Howes Company. Standard sprockets were made of Grade 4C2 steel with flame-hardened facing.
CONCLUSIONS: There was no significant difference in the measured wear of test and standard sprockets. Relatively high interference was noted between the teeth of one test sprocket and the track wedge bolt nuts. Although this feature of the test sprocket appeared serious, it was concluded that severe interference between standard sprockets and wedge bolt nuts was not unusual. It was recommended the test sprockets be considered suitable substitutes for standard sprockets; that the specified shape of sprocket teeth be modified so as to provide greater clearance between sprocket teeth and wedge bolts; and that inspection procedures be established for checking nominal clearances provided.
GENERAL: This 43-page report contains three photographs showing the sprocket interference with track bolts and the sprockets after test. Drawings used in checking out sprocket tooth construction so as to determine the cause of sprocket and bolt interferences are also included.

SUBJECT: Sprockets PG-2.550
TITLE: Test on Haynes-Stellite Sprockets
IDENTIFICATION: Report No. PG-2.550; Project No. 33-2B
DATE OF REPORT: 19 November 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of 3/4-inch and 1-inch Haynes-Stellite sprockets and to summarize data from a previous report
METHOD: Two diametrically opposed teeth, one each of two 3/4-inch and two 1-inch test sprockets were selected for gauge measurement. The sprockets were then installed on a Light Tank M3 and operated on the endurance course for 2950 miles. Upon completion of the test, the sprockets were removed and the wear determined from the tooth profile gauges. Tables were made showing the wear at various points on the tooth as well as the wear per 1000 miles. Comparison of wear with production sprockets was also made.
DESCRIPTION: The test Haynes-Stellite sprockets had hard facings of Haynes-Stellite Grade No. 1. This facing was a cobalt-chromium-tungsten alloy. Production sprockets were hard faced with Colmonoy.
CONCLUSIONS: Based on this test and a previous report on 3/4-inch Stellite sprockets, five of six Stellite sprockets had a durability 2.6 times as great as production sprockets. There was no significant difference between the 3/4- and 1-inch Stellite sprockets. Track and connector wear was equivalent to that of production sprockets. The 3/4-inch and 1-inch Haynes-Stellite sprockets were considered acceptable for use on Ordnance track-laying vehicles.
GENERAL: This 21-page report includes two photographs.

SUBJECT: Sprockets PG-2.633
TITLE: Test of Sprocket Tooth Idlers
IDENTIFICATION: Report No. PG-2.633; Project No. 34-43
DATE OF REPORT: 3 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine durability of sprocket tooth idlers for the Medium Tank M4A2
METHOD: One pair of sprocket tooth idlers was installed on a Medium Tank M4A2. Operation included tractive resistance tests and was for 698 miles over varied terrain.
DESCRIPTION: The test sprocket tooth idlers consisted of sprockets mounted on suitable hubs. A standard idler was used for replacement.
CONCLUSIONS: The test idlers were not sufficiently durable. Tractive resistance was not changed by the use of the idlers, and there was no apparent increase in wear on end connectors. One

idler failed at 278 miles, sprocket screws loosened, and holes were badly worn. The test idlers were not recommended for use or development.
GENERAL: This 19-page report includes three photographs of the test idlers and sprocket attaching screws.

SUBJECT: Sprockets PG-2.678
TITLE: Test of Flame Hardened SAE 4140 Sprockets, Rock Island Arsenal
IDENTIFICATION: Report No. PG-2.678; Project No. 33-19
DATE OF REPORT: 29 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effect, if any, the surface checks resulting from flame hardening had on SAE 4140 steel light tank sprockets
METHOD: Four teeth on each test sprocket were marked with a scriber to permit wear measurements to be taken at the end of the test. The test sprockets were installed on M5 Light Tanks which operated for 2886 miles.
DESCRIPTION: The light tank sprockets tested were made of flame-hardened SAE 4140 steel.
CONCLUSIONS: During the 2886 miles of operation, the test sprockets displayed no cracking or other deleterious effects due to flame hardening checks. Tooth wear was considerably greater than that experienced with Hynes-Stellite and production sprockets tested at GMPG, but it was not considered excessive. After 2886 miles of operation the test sprockets were considerably worn, but still serviceable. It was felt that the greater tooth wear of the test sprockets, as compared to the others mentioned, was due to being run on M5 Light Tanks instead of M3 Light Tanks as were the other sprockets. The flame-hardened sprockets tested were recommended for approval for production.
GENERAL: This 22-page report contains one photograph of the test sprocket.

SUBJECT: Sprockets PG-2.1060
TITLE: Repaired Sprockets - Ni-Hard, Rock Island Arsenal
IDENTIFICATION: Report No. PG-2.1060; GMPG Project No. 34-104
DATE OF REPORT: 25 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the suitability of light tank drive sprockets repaired with the Ni-Hard process and the Hostalloy process
METHOD: Two sets of test drive sprockets were installed on a Light Tank M3A3. The left inner and the right outer sprockets were repaired by the Ni-Hard process; the left outer and right inner sprockets were repaired by the Hostalloy process. Prior to testing, plaster casts were made of three teeth sections of each sprocket. After each 500 miles of the 2942-mile test, the sprockets were removed and checks for wear were made with the plaster casts.
DESCRIPTION: Two of the standard test sprockets were repaired with "Ni-Hard", manufactured by the International Nickel Co. Two other standard test sprockets had been reconditioned with Hostalloy, manufactured by the Haynes-Stellite Co.
CONCLUSIONS: The wear rate of Ni-Hard-repaired sprockets was almost identical to that of new standard sprockets, whereas the wear rate of the Hostalloy repaired sprockets was excessive. Since the cost of repairing a sprocket was 2.3 times the cost of a new one, it was recommended that repaired sprockets be used only if a metal shortage should exist. If repaired sprockets were needed, the Ni-Hard method was recommended because of its superior wearing qualities.
GENERAL: This 45-page report contains one wear graph and 30 photographs showing the condition of the test sprockets during the test.

SUBJECT: Sprockets PG-2.1186
TITLE: Colmonoy Surfaced Carbon Steel Medium Tank Drive Sprockets
IDENTIFICATION: Report No. PG-2.1186; Project No. 253A and B
DATE OF REPORT: 14 June 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the durability of Colmonoy surfaced sprockets with standard production sprockets
METHOD: Plaster templates were made of three teeth on each of four Colmonoy test sprockets and four new standard sprockets. The sprockets were installed on medium tanks with the standard sprockets on the left side and the Colmonoy sprockets on the right side. The sprockets were switched from one side to the opposite side at 1500 miles without changing the direction of rotation. Sprocket wear was measured periodically by comparison with the plaster templates. Both steel and rubber tracks were operated on the test vehicles. One set of test sprockets operated 2508 miles, and the other set operated 2441 miles.
DESCRIPTION: The test sprockets were carbon steel medium tank final drive sprockets with a 1/8-inch Colmonoy metal facing on the sprocket teeth.
CONCLUSIONS: No significant difference in wear was found between Colmonoy and standard drive sprockets, and the use of the Colmonoy sprockets was not recommended. Slight chipping occurred on the edges of the Colmonoy sprocket teeth throughout the test, but this did not affect the wear life of the sprockets. The Colmonoy facing was worn through at approximately 2400 miles, and both test and standard sprockets were removed at the same mileage due to bottoming of the wedge bolt nuts.
GENERAL: This 18-page report contains 30 photographs illustrating sprocket wear, durability data, graphs on comparative wear of both type sprockets, and correspondence.

SUBJECT: Sprockets PG-2.1445
TITLE: Medium Tank Final Drive Sprockets, Colmonoy Surfaced Carbon Steel
IDENTIFICATION: Report No. PG-2.1445; Project No. 253 C & D

DATE OF REPORT: 23 November 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare durability of Colmonoy-surfaced and standard final drive sprockets for medium tanks
METHOD: The test and standard sprockets were installed on alternating sides of two Medium Tanks M4A1 and operated in conjunction with synthetic rubber tracks. Operation was over the endurance course for 2501 miles with one vehicle and 2000 miles with the other. Wear measurements were made before and after the test.
DESCRIPTION: The four test sprockets had teeth surfaced to 3/16 inch with Colmonoy No. 6 facing and hardness values ranging from 61C to 70C Rockwell. The four standard production sprockets with flame-hardened teeth had a hardness of 55C to 60C Rockwell.
CONCLUSIONS: The Colmonoy-surfaced sprockets gave 40 to 50% more wear than the standard sprockets. There was little difference in effect on bushing pin, track and end connector wear between the two types of sprockets. It was recommended that Colmonoy facing be used if metal shortage developed and if costs could be restricted to 1-1/2 times that of standard sprockets. Also, it was recommended that more rigid production inspection be given all sprockets.
GENERAL: This 65-page report includes 16 photographs of the test sprockets and component parts.

SUBJECT: Sprockets PG-2.1457
TITLE: Dimensional and Hardness Check, Various Type Medium Tank Sprockets
IDENTIFICATION: Report No. PG-2.1457; Project No. 383
DATE OF REPORT: 25 November 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine if new types of medium tank sprockets met specifications
METHOD: Six sample sprockets were checked for tooth spacing and profile, bore diameter and hardness. Master layouts were made for each on treated steel layout panels. Locating and checking were performed with a micrometer microscope and trammel. Readings were accurate to ± .002 inch. Sample sprockets were laid on the layouts giving maximum profile of the sample. Machine bore diameter dimensions were found by using a plug gage, and results were accurate to ± .0005 inch. Hardness measurements were made with a Rockwell hardness tester.
DESCRIPTION: Two of the test samples for medium tanks were forged sprockets supplied by Chrysler. Two were rolled-plate sprockets made by Fisher Body Division and two were cast sprockets made by S. M. Howes Company.
CONCLUSIONS: The forged and rolled-plate sprockets gave satisfactory serve. None of the samples was completely within the specified hardness range. The cast samples were not within limits on any of the dimensions checked. It was recommended that tolerances be revised for the forged and rolled-plate sprockets to avoid manufacturing expense. Greater care should be exercised in maintaining adequate width of wedge bolt notches. The use of cast sprockets was not recommended.
GENERAL: This 24-page report includes 11 photographs of the sprockets and layouts.

SUBJECT: Sprockets PG-2.1459
TITLE: Reclaimed Half-Track Drive Sprockets, Colmonoy Alloy Application
IDENTIFICATION: Report No. PG-2.1459; Project No. 34-181A & B
DATE OF REPORT: 6 December 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the durability of standard and Colmonoy sprockets
METHOD: Two sets each of standard and Colmonoy coated reclaimed sprockets were installed on opposite sides of various half-track vehicles. Operation was over the endurance course under dusty conditions. One set of sprockets operated for 3613 miles and the other for 3184 miles. Progressive wear measurements were made.
DESCRIPTION: The test sprockets were reclaimed by a new method of applying Colmonoy alloy by the Wall-Colmonoy Company. The standard sprockets were of the flame-hardened type. The test vehicles included an I.H.C., M5A1, a Diamond T, M3A1 Half-Track Personnel Carrier and two Half-Track Cars M2A1.
CONCLUSIONS: The use of Colmonoy alloy was satisfactory for reclaiming used sprockets. The Colmonoy treated sprockets gave slightly better wear than the standard sprockets. It was recommended that investigation be made to insure proper hardness on standard sprockets. A greater degree of hardness than specified was required for the driving lugs on half-track band cross plates.
GENERAL: This 40-page report includes 19 photographs of the sprockets tested.

SUBJECT: Sprockets PG-2.1621
TITLE: Sprocket and Track Noise Elimination, M4 Series Medium Tank and T26 Series Heavy Tank
IDENTIFICATION: Report No. PG-2.1621; Project No. 423
DATE OF REPORT: 24 May 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of a track sprocket silencing device, which had proved successful on M3 light tanks, for use on the sprockets of Medium Tanks M4 and Heavy Tanks T26E3
METHOD: Before the manufacture and installation of the silencers could be completed, the project was canceled.
DESCRIPTION: The test silencer was designed on the assumption that sprocket noise was caused by the bottoming of the end connectors in the sprocket scallops as they engaged. The silencer, therefore, consisted of a two-piece rubber cushion at the root diameter of the sprocket. The cushion sections were bonded to a formed steel strip which was spot-welded in the bottom of each scallop.

A portion of the sprocket was cut away to receive the silencer so as to produce little change in final scallop contour.
CONCLUSIONS: No conclusions or recommendations were made since no tests were performed.
GENERAL: This 10-page report contains the design and application details for the mounting of the test silencing device on the sprocket of a Medium Tank M4. Three drawings are also included of the proposed installation.

SUBJECT: Sprockets PG-2.1627
TITLE: Experimental Reinforced Idler Wheels and Drive Sprockets - Cargo Carrier, M29C
IDENTIFICATION: Report No. PG-2.1627; Project No. 34-195
DATE OF REPORT: 28 May 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the life characteristics of experimental idlers and drive sprocket with standard units on a Cargo Carrier M29C
METHOD: The experimental idlers and drive sprockets were installed on a Cargo Carrier, M29C. The vehicle was operated for 146 miles over the various test courses at the proving ground.
DESCRIPTION: The experimental idlers and drive sprockets were identical to the standard units except the idlers had two reinforcing rings placed back to back on each side of the wheel and the drive sprocket had one reinforcing ring on each side of the wheel.
CONCLUSIONS: Due to the limited nature of the test no conclusions or recommendations were made.
GENERAL: This seven-page report contains two photographs showing general construction of the test and standard idler and drive sprocket.

SUBJECT: Sprockets PG-60301.1
TITLE: Medium Tank M3 and M4 - Sprocket Hubs 4B1 Steel Castings
IDENTIFICATION: Report No. PG-60301.1; TAPG Project No. 39
DATE OF REPORT: 9 March 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of experimental sprocket hubs, and to compare them with standard hubs
METHOD: The test sprocket hubs were installed successively on two Medium Tanks M3 and M4A1, and operated a total of 3141 miles over the endurance course.
DESCRIPTION: The test sprocket hubs were 4B1 cast steel, manufactured by Iowa Transmission Company, having a yield point of 50,000 psi instead of the standard 55,000 psi. The sprocket rims of the test hubs were solid whereas the standard rims were spoke type.
CONCLUSIONS: The test sprocket hubs were satisfactory, and recommended as an acceptable substitute.
GENERAL: This 11-page report contains one photograph showing the spoke type and solid sprocket hub rims.

SUBJECT: Sprockets PG-60301.2
TITLE: Cast Steel Sprockets, S.M. Howes Company
IDENTIFICATION: Report No. PG-60301.2; Project No. 25
DATE OF REPORT: 10 June 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the acceptability of cast steel sprockets
METHOD: The four test sprockets were installed on two medium tanks. One tank, using five tracks alternately, was operated a total of 2955 miles over the Tank Endurance Test Route. A reversal was made at 2138 miles. The second tank, employing two tracks differing from the other five, was operated a total of 2141 miles with a sprocket reversal at 1240 miles. Comparisons with five sets of previously tested standard production sprockets were made.
DESCRIPTION: The sprockets, for medium tank final drives were manufactured by S.M. Howes Company. They were of cast steel having a yield point of 55,000 psi. The vehicles were Medium Tanks M3 and M3A4. The seven tracks were of steel, rubber, and a combination of steel and rubber.
CONCLUSIONS: The test sprockets operated an average of 2549 miles, which was comparable to standard production sprockets. They were recommended for use on medium tanks.
GENERAL: This 17-page report includes four photographs of the test sprockets.

SUBJECT: Sprockets PG-60301.3
TITLE: S. M. Howes Co. Cast Steel Sprockets Armor Plate Formula — Medium Tank
IDENTIFICATION: Report No. PG-60301.3; Project No. 25-1
DATE OF REPORT: 10 June 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the comparative wearing characteristics of test and standard final drive sprockets operating with steel tracks
METHOD: Four test and four standard production final drive sprockets were installed on two medium tanks for comparative test. Each tank was equipped with two test sprockets on one side and two production sprockets on the opposite side. Operation over the Endurance Test Route totaled 1619 miles for one tank, 1000 miles for the other. Wear measurements and reversals were made throughout the test.
DESCRIPTION: The test sprockets were cast from Pratt and Letchworth Armor Plate Formula and were submitted by S. M. Howes Co. The standard production flame-hardened sprockets were made by Chrysler. The Medium Tanks M4A1 and M4A4 were equipped with steel tracks.
CONCLUSIONS: The average wear per 100 miles was .0191 inch for the test sprocket and .0197 inch for the standard production sprocket. The test sprocket was recommended for production.
GENERAL: This 21-page report includes two photographs.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Sprockets PG-60301.4
TITLE: Medium Tank Carburized Final Drive Sprockets
IDENTIFICATION: Report No. PG-60301.4; Project No. 62
DATE OF REPORT: 19 June 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the comparative wearing characteristics of medium tank final drive sprockets
METHOD: Five test sprockets and five Chrysler production sprockets were installed on two M4A3 Medium Tanks. Maximum mileage over the Endurance Test Route was 3901. Test was terminated when the carburized surfaces had worn through. Five Chrysler production and five Fisher production sprockets were installed on two M4A4 Medium Tanks and operated a maximum mileage of 2674. Wear measurements were made during all tests.
DESCRIPTION: The test final drive sprockets were SAE 1020 steel carburized 1/8 inch deep on the profile of the teeth. They were manufactured by the Tool Steel Gear and Pinion Company, Cincinnati, Ohio. The Chrysler production sprockets were flame-hardened.
CONCLUSIONS: Pitchline wear for the test sprockets was .029 inch for three and .02 inch for two, compared with .022 inch for the Chrysler production sprocket. Neither the test nor the Fisher production sprockets were as satisfactory as the Chrysler, with respect to tooth breakage. It was recommended that 1020 steel-carburized sprockets be hardened to a greater depth.
GENERAL: This 30-page report includes seven photographs.

SUBJECT: Sprockets PG-60301.4-01
TITLE: Medium Tank Carburized Final Drive Sprockets
IDENTIFICATION: Report No. PG-60301.4-01; TAPG Project No. 62
DATE OF REPORT: 1 November 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the wearing characteristics of 2320 and 1020 carburized steel sprockets with those of standard sprockets
METHOD: A Medium Tank M4A4 was equipped with 2320 steel sprockets on the right side and with standard sprockets on the left side. A Medium Tank M4A3 was equipped in a similar manner. Another Medium Tank M4A3 was equipped with 1020 steel sprockets on the right and standard sprockets on the left. The three test vehicles were operated over endurance courses for 1084, 1378, and 2090 miles, respectively. At the approximate mid-point of the tests, due to excessive wear, the positions of the sprockets were reversed. Average wear per 100 miles was determined on all sprockets.
DESCRIPTION: The test final drive sprockets were the same as the standard hardened sprockets except that they were made of 2320 and 1020 carburized steel. All sprockets were manufactured by the Tool Steel Gear and Pinion Company.
CONCLUSIONS: The 2320 steel sprockets showed 2.9% less average wear than the standard sprockets and were recommended for use on medium tanks. The 1020 steel sprockets showed 22.3% more wear than the standard prockets. It was recommended that the 1020 steel sprockets be given no further consideration.
GENERAL: This 25-page report contains two photographs of the test and standard sprockets after the test. Twelve pages of log sheets containing wear data are also included.

SUBJECT: Sprockets PG-60301.5
TITLE: Tocco Hardened Final Drive Sprockets — Medium Tank M4
IDENTIFICATION: Report No. PG-60301.5; Project No. 25-3
DATE OF REPORT: 22 June 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and comparative wearing characteristics of medium tank final drive sprockets operating with steel tracks
METHOD: Two test Tocco hardened and two Chrysler production final drive sprockets were installed for comparative test on an M4A4 Medium Tank. Operation over the Endurance Test Route at various speeds covered 1755 miles. Reversals and wear measurements were made at 1165 miles.
DESCRIPTION: The test final drive sprockets were submitted by the Cullman Wheel Co. They were Tocco hardened by Linberg Steel Treating Co. The Chrysler standard production sprockets were flame hardened. The track was T62 rolled section-riveted steel, weighing 39.3 pounds per shoe.
CONCLUSIONS: The average wear per 100 miles was .020 inch for the Tocco hardened sprockets and .017 inch for the Chrysler production sprockets. The Tocco hardened sprockets were 12.5% less durable than Chrysler standard production sprockets.
GENERAL: This 14-page report includes two photographs.

SUBJECT: Sprockets PG-60301.7
TITLE: Investigation of Loosening of Final Drive Sprocket Cap Screws, Medium Tank
IDENTIFICATION: Report No. PG-60301.7; Project No. 135
DATE OF REPORT: 8 July 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the cause and a method of correction for loosening of final drive sprocket cap screws
METHOD: A new set of sprockets with a new set of place head cap screws were installed in a medium tank and punch marked to determine if loosening of the screws was caused by turning or by thread stretch. Test covered 721 miles of operation.
DESCRIPTION: The test sprockets and screws were standard production items for medium tanks.
CONCLUSIONS: The test established that loosening of the screws was due to turning rather than thread stretch.

GENERAL: This test originally called for special cap screws to be evaluated. This eight-page report is not illustrated.

SUBJECT: Sprockets PG-60301.8
TITLE: S. M. Howes Cast Steel Sprockets — 1-7/16 Thickness
IDENTIFICATION: Report No. PG-60301.8; Project No. 25-4
DATE OF REPORT: 1 October 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the comparative wearing characteristics of medium tank final drive sprockets operating with steel tracks
METHOD: Four test final drive sprockets and four Chrysler standard production sprockets were installed on two medium tanks for comparative test. One tank operated 1670 miles over the Endurance Test Route, the other 402 miles. Reversals and wear measurements were made throughout the tests.
DESCRIPTION: The test final drive sprockets were cast steel units manufactured by S. M. Howes. Thickness of teeth was increased from 3/16 inch to 1-7/16 inch and tooth shoulder radius from 1/4 inch to 1/2 inch. Weight was 83 pounds compared to 75 pounds for the Chrysler standard production flame-hardened sprocket. The medium tanks were M4A4 and M4A3.
CONCLUSIONS: The test sprockets were 24.7% less durable than the standard production sprockets. The wider teeth interfered with track end connectors causing excessive noise. No benefit was derived from the increased shoulder radius.
GENERAL: This 22-page report includes five photographs of the sprockets.

SUBJECT: Sprockets PG-60301.10
TITLE: NE 1345 Steel Sprockets — Chrysler
IDENTIFICATION: Report No. PG-60301.10; Project No. 25-2
DATE OF REPORT: 10 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the wearing characteristics of medium tank final drive sprockets
METHOD: Four test final drive sprockets and four Chrysler standard production sprockets were installed on medium tanks for comparative test. One tank operated 1155 miles over the Endurance Test Route; the other 1657 miles. Sprocket reversals and wear measurements were made to determine the average wear.
DESCRIPTION: The test final drive sprockets of NE 1345 steel were submitted by Chrysler Corp. The Chrysler standard production sprockets were flame hardened. The test vehicles were Medium Tanks M4A4 equipped with steel tracks.
CONCLUSIONS: The test NE 1345 steel sprockets were recommended for production. They were 9% better than the Chrysler standard production sprockets for durability.
GENERAL: This 20-page report includes two photographs.

SUBJECT: Sprockets PG-60301.12
TITLE: Final Drive — Medium Tank, S. M. Howes Cast Steel Sprockets, Increased Pitch Diameter
IDENTIFICATION: Report No. PG-60301.12; Project No. 25-5
DATE OF REPORT: 3 January 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of cast steel sprockets as compared with standard production sprockets
METHOD: Four S. M. Howes sprockets and four Chrysler standard production flame-hardened sprockets were installed for test on medium tanks. The vehicles were operated at various speeds over the endurance test route. Two vehicles were used in the test; one vehicle was operated for 2573 miles and the other for 1486 miles. Set No. 2 consisting of a pair of two S. M. Howes sprockets and two Chrysler sprockets were operated with TD48 Chevron Rubber, T56E1, T49, and T62 Steel Tracks with a weight average of 39 pounds per shoe. Set No. 2 consisted of the same combination of sprockets with T51 Standard Rubber T56E1 and T62 Steel Tracks with a weight average of 39.5 pounds per shoe. Sprockets were measured and compared for wear at the end of the endurance run.
DESCRIPTION: The test sprockets were four S. M. Howes cast steel sprockets having 1/16-inch increased circular pitch and the shoulder radius increased from 1/4-inch to 1/2-inch from that of the Chrysler standard production sprockets which were used for comparison in the test.
CONCLUSIONS: Wear figures indicated that increasing the tooth pitch diameter of S. M. Howes sprockets did not equalize the wear as intended. The effectiveness of the 1/2-inch shoulder radius on the sprockets was destroyed after approximately 1000 miles of operation due to the excessive wear at the roots of the teeth. It was recommended that the Howes sprockets not be used for production.
GENERAL: This 20-page report includes three photographs of test sprockets and a photograph of a Chrysler sprocket tooth with Rockwell hardness chart.

SUBJECT: Sprockets PG-60301.13
TITLE: Colmonoy Surfaced Carbon Steel Medium Tank Final Drive Sprockets
IDENTIFICATION: Report No. PG-60301.13; Project No. 25-6
DATE OF REPORT: 10 December 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and comparative wearing characteristics of Colmonoy surfaced final drive sprockets operating with steel tracks
METHOD: Four Colmonoy surfaced final drive sprockets and four Chrysler production flame-hardened units were installed for comparative test on two Medium Tanks M4A3. The test vehicles were operated over the Endurance Test Route. Set No. 1 of test sprockets consisting of two Colmonoy surfaced final drive sprockets and two standard flame-hardened sprockets were installed on a tank

equipped with T62 Rolled Section, Riveted Steel Tracks. After 1216 miles of operation, the sprockets were installed on a tank equipped with T51 Rubber Block Tracks and test was continued until sprockets were worn out at 1738 miles of total operation. Sprocket set No. 2 consisting of the same combination of sprockets as set No. 1 was installed on a medium tank equipped with T62 Steel Tracks. At 757 miles, sprockets were removed and installed on a second medium tank equipped with T54E1 Cuff Type Steel Tracks and operated for 1775 miles.
DESCRIPTION: The test sprockets consisted of carbon steel sprockets with 1/8 inch machined from the face of each tooth. A 1/8 inch layer of Colmonoy was electric welded on each tooth to bring it up to the standard contour.
CONCLUSIONS: The test of Colmonoy surfaced final drive sprockets showed these units to be an average of 19% more durable at the pitch line and 23% more durable at the root than the standard Chrysler flame-hardened units. The use of 1/8 inch layer of Colmonoy on final drive sprocket teeth was not recommended as it did not provide sufficient increase in sprocket life. It was recommended that a set of sprockets be coated with the maximum thickness at wear points and that comparative wear tests with standard sprockets be repeated.
GENERAL: This 16-page report includes six photographs of test sprockets.

SUBJECT: Sprockets PG-60301.15
TITLE: Test of Medium Tank Final Drive Sprockets and Hubs Having Various Pilot Diameter Fits
IDENTIFICATION: Report No. PG-60301.15; Project No. 183
DATE OF REPORT: 8 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the ease of assembly, suitability, and performance of medium tank final drive sprockets and hubs having pilot diameter fits
METHOD: The test sprocket and hub pilot diameters were measured and the components installed on an M4A3 Medium Tank. The vehicle was operated at various speeds over the endurance test route for a total of 2625 miles. The sprocket cap screws were checked for evidence of loosening during the test.
DESCRIPTION: The four medium tank forged, flame-hardened, final drive sprockets tested were standard in every way except for the diameter of the hub pilot. The hub pilot diameters on these four sprockets were such as to provide a line-to-line fit and .002-inch, .004-inch, and .006-inch interference fits. The two final drive hubs tested were machined to the maximum diameter of the sprocket pilot called for on the drawing. The M4A3 Medium Tank on which the sprockets and hubs were tested was equipped with a new T51 synthetic rubber track.
CONCLUSIONS: The sprockets having .002-inch, .004-inch, and .006-inch pilot diameter press fits were very satisfactory. No sprocket cap screw loosening occurred during the entire 2625-mile test. The sprocket cap screws loosened once after 2163 miles of operation with the line-to-line fit sprocket. Installation and removal of the sprockets were made easily in each case. As a means of preventing loosening of sprocket attaching cap screws, the use of a sprocket-hub press fit of at least .004-inch to .006-inch was recommended.
GENERAL: This 15-page report is not illustrated.

SUBJECT: Sprockets PG-60301.19
TITLE: 3/16'' Colmonoy Faced Final Drive Sprockets, Medium Tank (E.S. 1582)
IDENTIFICATION: Report No. PG-60301.19; Project No. 229
DATE OF REPORT: 11 October 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and wearing characteristics of Colmonoy-faced final drive sprockets and compare them with standard production flame-hardened sprockets
METHOD: The test sprockets were installed in pairs on one side of three M4 Medium Tanks, with standard sprockets used on the opposite side. The sprockets were reversed when the Colmonoy facing wore through. Comparative wear measurements were taken at 800-mile intervals or when sprockets were reversed, whichever occurred first. Comparative wear on end connectors and track pin and bushing life were observed during the test.
DESCRIPTION: The standard sprockets were Chrysler flame-hardened units. The test sprockets were machined to provide a line-to-line to .009-inch interference fit between the bore and the hub of the flange, and a 3/16-inch thick layer of Colmonoy was welded to these sprockets at the pitch line and root. T51, rubber-backed steel, and T48 chevron rubber track were used during the test.
CONCLUSIONS: The Colmonoy-faced sprockets were 21% more durable at the pitch line and 34% more durable at the root than the standard sprockets until the Colmonoy facing started to wear through. Experience on previous tests showed that once the Colmonoy was worn through, the wear rate on the sprockets increased very rapidly because in the process of applying the Colmonoy most of the original flame hardening was lost. It was therefore considered reasonable to assume that the ultimate life of Colmonoy-faced sprockets would be but little greater than that of standard units. Due to varied track failures, not enough mileage was accumulated on any one track to draw comparative conclusions as to track pin and bushing life. However, end connector wear was 45% less on tracks used with the Colmonoy-faced sprockets. It was recommended that no decision be made on the use of Colmonoy facings until tests involving track supporting rings inside the sprockets (TAPG Project No. 309) were completed. The line-to-line to .009-inch interference fit of the test sprockets resulted in the sprocket attaching cap screws remaining tight during the test; therefore, the tighter fit was recommended for use.
GENERAL: This 34-page report contains 13 photographs of the test sprockets.

SUBJECT: Sprockets PG-60301.20
TITLE: Cast Steel Sprockets D47366 (S. M. Howes Company)
IDENTIFICATION: Report No. PG-60301.20; Project No. 290
DATE OF REPORT: 5 December 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine whether the tooth contour, bore diameter, and tooth hardness of eight cast steel sprockets conformed to drawing requirements, and to compare the rate of wear of these cast steel sprockets to that of forged sprockets on both horizontal and vertical medium tank suspension systems
METHOD: The tooth contour, bore diameter, and tooth hardness of the eight cast steel sprockets were checked and compared with drawing requirements.
DESCRIPTION: The eight D47366 sprockets submitted for test were made of cast steel by the S. M. Howes Company.
CONCLUSIONS: The test sprocket tooth hardness was from 54.5 to 62 Rockwell C, which was within the specified limits. The bore diameters measured from 15.750 inches to 15.772, only five of the eight being within the specified 15.750 inches + .005 inch. All the bore diameters were considered too large since trouble had been experienced with sprockets in this bore diameter range loosening in operation. The tooth spacing variation was considered excessive, the variation being as much as .100 inch, and the tooth contour did not conform to the print. The discrepancies were reported and the project was terminated without further testing being accomplished and prior to installation on testing vehicles.
GENERAL: Ths 10-page report contains one photograph of a test sprocket.

SUBJECT: Sprockets PG-60301.21
TITLE: Test of Experimental Sprockets on Medium Tanks, M4A3E8
IDENTIFICATION: Report No. PG-60301.21; Project No. 612
DATE OF REPORT: 9 January 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and comparative wearing characteristics of four sets of experimental final drive sprockets on M4A3E8 Medium Tanks
METHOD: Four sets of experimental final drive sprockets and four sets of production flame-hardened units were installed on M4A3E8 Medium Tanks equipped with T66 tracks. These vehicles were then operated over the endurance test route. Comparative sprocket wear measurements were taken every 500 miles.
DESCRIPTION: The four sets of final drive sprockets tested had various pitch diameters and tooth contours: One set had increased tooth pitch to compensate for track stretch; another set had revised tooth contours to reduce the wear at tooth-to-track contacts; the third set used support rings bolted to the sprockets to preserve tooth root diameters; and the fourth set had Tocco-hardened teeth to provide a more uniform tooth profile hardness.
CONCLUSIONS: Except for the Tocco-hardened units, all of the experimental final drive sprockets were found to be more durable than the standard sprockets. Previous tests showed that the increased pitch diameter, and also the revised tooth contour, contributed to increased sprocket life. However, the results of this test showed that support of any kind at the root of the tooth, either extended shoulders or track support rings, had a definite, favorable influence on sprocket tooth life. It was recommended that a modified sprocket track support ring be developed to permit use of either T80 rubber-backed steel track or T66 all-steel track.
GENERAL: This 43-page report contains 19 photographs showing extent of wear on the sprockets tested.

SUBJECT: Sprockets PG-60301.22
TITLE: Test of 25.250 Pitch Diameter Sprockets for Medium Tank M4
IDENTIFICATION: Report No. PG-60301.22; Project No. 607
DATE OF REPORT: 3 March 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the wear and durability characteristics of two sets of experimental Medium Tank M4 sprockets with those of standard sprockets
METHOD: Two sets of experimental final drive sprockets and two sets of standard production sprockets were installed on M4 Medium Tanks and operated for approximately 3000 miles over an endurance test route. To determine sprocket tooth wear, a pattern was made of two diametrically opposed teeth on each new sprocket. At 500-mile intervals, the pattern was placed over the tooth and a feeler gauge was used to measure the clearance. Points of wear were measured approximately at the pitch circle and at the root.
DESCRIPTION: One set of test sprockets, with 25.250-inch pitch diameter and a generated tooth profile, was operated with T74 rubber-backed steel tracks. The other set, with 25.250-inch diameter and standard tooth profile, was operated with T48 modified chevron rubber tracks.
CONCLUSIONS: Both sets of experimental sprockets exhibited better wear characteristics than the standard sprockets. The set with the T74 tracks operated for 3598 miles and had 17% less wear at the pitch line and 23% less wear at the root than the standard sprockets. The set with T48 tracks operated for 2976 miles and had 50% less pitch-line wear and 23% less root wear. It was recommended that further tests be conducted with sprockets having 25.250-inch pitch diameter, standard tooth profile, and using track support rings constructed in the manner suggested in Report No. PG-60301.21.
GENERAL: This 22-page report contains four photographs of the test sprockets and six pages of test data.

SUBJECT: Sprockets PG-60301.23
TITLE: Track Support Sprockets — Medium Tank

TANK AUTOMOTIVE TEST RESUMES

T25E1 and Medium Tank M4A3 (E8)
IDENTIFICATION: Report No. 60301.23; T.A.P. G. Project No. 309
DATE OF REPORT: 9 June 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To observe the effect on track operation and life of track support rings installed on final drive sprockets, and to determine their value in reducing sprocket wear
METHOD: Two test installations were made, one on Medium Tank M4A3 and, later, M4A1 equipped with outside-guided, T49 cast steel tracks, and the other on a Medium Tank T25E1 with Sheldrick design, center-guided, steel tracks. Two runs were made with the M4 Tanks, one with support rings on both sprockets for 2446 miles, and a second, of 3503 miles, with one support ring installation and one standard sprocket assembly. The T25E1 Tank, equipped with the support ring installation on both sides, was operated only 509 miles before orders for its shipment were received. New tracks and sprockets were used for all tests. Operation was over the Proving Ground endurance test course.
DESCRIPTION: The support rings were made from used sprockets, turned down to the pitch diameter minus twice the depth from bogie surface to track pin center for the appropriate track. They were then cut in half and reassembled, by welding, on the sprocket hubs (two rings per hub). For the T25E1 installation, with center-guided track, the rings were welded to the inside edges of the sprocket flanges on the final drive hubs. For the outside-guided track T49 used on the M4 Tanks, the rings had to be mounted nearer the centers of the hubs to clear the guides. The diameter of the rings (above) was such that they assumed the radial load due to track weight and tension and the only load on the sprocket teeth was the tangential driving load.
CONCLUSIONS: The best wear comparison was obtained from the second M4 run in which support ring and standard installations were operated simultaneously. Average sprocket tooth wear measured at pitch and root points, for the support-ring installation, was 0.004 inch per 100 miles as against 0.006 to 0.007 inch per 100 miles for the standard sprocket assembly. No increase in track-throwing tendency was noted in any test. The rings apparently did not affect track life with steel tracks though it was noted that the high unit loadings, occasioned by the narrowness of the support rings, might be a serious factor with rubber tracks. Another objection was that the support ring diameter (see Description, above) would be unique for almost every sprocket-track combination. In the limited mileage covered, no results were obtained from the T25E1 installation which would contradict the conclusions drawn from the M4 operation. Because of the improvement in sprocket life, further development was recommended.
GENERAL: This 26-page report contains five photographs showing comparative sprocket wear and the M4 installation. A drawing shows details of the T25E1 installation. Also included is a graph of total sprocket tooth wear versus mileage, for support-ring and standard installations tested in the second M4 run.

SUBJECT: Sprockets PG-60301.27
TITLE: Experimental Induction Hardened Drive Wheel Sprockets — M29C
IDENTIFICATION: Report No. PG-60301.27; Project No. 403
DATE OF REPORT: 6 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the wear characteristics of induction-hardened and flame-hardened drive wheel sprocket teeth for use on Cargo Carrier M29C
METHOD: Experimental sprockets were installed on two Cargo Carriers M29C and operated with standard production sprockets in opposite positions for comparison purposes. Sprocket teeth were examined periodically to obtain wear information. Tooth hardness patterns were established with a Shore scleroscope.
DESCRIPTION: The experimental sprockets differed from the standard sprockets only in the method used to harden the drive teeth, i.e., electric induction heat instead of flame. These sprockets, designed for use on Cargo Carrier M29C, were operated in conjunction with a center-guide, all-steel track.
CONCLUSIONS: The induction-hardened drive wheel sprockets wore excessively at the teeth ends. Hardness patterns of both types indicated that hardness was comparable, except that better hardness was obtained at the teeth ends by the flame method. It was recommended that the specified depth of hardness, regardless of method, be increased from 1/16 inch to 3/16 inch because the production sprockets were of that depth. It was also recommended that, if further experimentation with hardened parts be considered, care should be exercised to insure proper hardening of tooth ends.
GENERAL: This 15-page report contains three photographs of the test sprockets, two data sheets, and hardness patterns of both types of sprocket teeth.

SUBJECT: Sprockets PG-61801.149
TITLE: Experimental Reinforced Idler Wheels, and Drive Sprockets, Cargo Carrier M29C
IDENTIFICATION: Report PG-61801.149; Project No. 392
DATE OF REPORT: 9 November 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of reinforced drive wheel sprockets and idler wheels
METHOD: Two test drive wheel sprockets were operated on M29C Cargo Carriers over the endurance test route. They were operated for 833 and 1554 miles. Two test idler wheels were also operated on M29C Cargo Carriers. One failed at 2671 miles, the other was still in service at 3130 miles.
DESCRIPTION: The test drive wheel sprockets were standard except for a reinforcing ring 3/8 inch wide and 1/4 inch thick around the inner circumference. The test idler wheels were also standard except for a reinforcing ring of the same cross-sectional area added to the one that was present.

CONCLUSIONS: The use of reinforcing rings in the drive wheel sprockets was recommended. Because there were no standard idler wheel failures, the extra reinforcing ring was considered unnecessary. One drive wheel sprocket failed because of track jumping, the other because of hub to flange rivet failure. The reinforcing plate failed on one of the idler wheels; the other was still serviceable at the conclusion of the test.
GENERAL: This 19-page report includes four photographs.

SUBJECT: Sprockets T10
TITLE: Test of Fusion Metal Coated Sprockets
IDENTIFICATION: Report No. T10
DATE OF REPORT: 24 November 1950
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the wear characteristics of two types of sprockets on the T37 vehicle
METHOD: Flame hardened sprockets were installed on the left side of a T37 vehicle and the sprockets with fusion coated tooth surfaces were installed on the right side of the vehicle. An Inland T87-type track was used, and the vehicle was operated 411 miles. The sprockets and track were then removed and tested on a T37-2 vehicle for 518 miles, making a total of 929 miles.
DESCRIPTION: The test units were flame hardened sprockets and sprockets with fusion coated tooth surfaces for the T37 vehicle. Both units were identified as Part No. 2-7386615.
CONCLUSIONS: The rate of wear was considerably less on the fusion coated sprockets during the first part of the test. As the test progressed, the rate of wear on the fusion coated sprockets increased more rapidly than it did on the flame hardened sprockets. The right track end connectors showed excessively more wear all through the test, and at the end of the test were worn beyond further use. However, the connectors on the left track were capable of reuse.
GENERAL: This 10-page report contains two photographs of the end connector wear on the T87 track.

SUBJECT: Sprockets T-60301.24
TITLE: Sprocket Development - Medium Tank
IDENTIFICATION: Report No. T-60301.24; CXD Project No. 242
DATE OF REPORT: 5 June 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop sprockets of one pitch diameter and one profile for use on medium tanks with 16-1/2-inch binocular or 23-inch type tracks
METHOD: A total of 12 tests were conducted with experimental and production sprockets with and without support rings on medium tanks to obtain sprocket wear data. Sprocket wear per 100 miles at pitch line was figured by taking the sum of the wear on the driving side and trailing side (average value for each sprocket) and dividing this total wear at the pitch line by the number of hundred miles the sprocket ran. Sprocket wear at the root per 100 miles was figured by considering either the driving or trailing side root wear (whichever was maximum) but not both. This average value for the sprocket was divided by the number of hundred miles the sprocket ran. Tooth hardness checks were made with a scleroscope or a Rockwell hardness testing machine. Pitch line and root wear measurements were determined by using templets.
DESCRIPTION: All test sprockets were flame-hardened except two which were induction hardened. The pitch diameter of the experimental sprockets was increased over that of the standard production units. The tooth profile was the same as the production sprockets in some units and in others a generated tooth profile was used.
CONCLUSIONS: The results of the tests covered in this report indicated that the life of the production sprocket could be exceeded by 50%, without the use of support rings, by using an increased pitch diameter and improved hardening methods. It was also indicated that the sprocket life could be doubled with the use of support rings in conjunction with increased pitch diameter and improved hardening.
GENERAL: This 108-page report contains 34 photographs showing sprocket tooth wear of both production and experimental sprockets.

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Section 38
STOWAGE

SUMMARY

This summary covers resumes of 40 engineering reports written on stowage between 1942 and 1952 at Rock Island Arsenal, Illinois; The Antiaircraft Artillery Board, Camp Davis, North Carolina; The Armored Board, Fort Knox, Kentucky; Army Ground Forces Board No. 2, Fort Knox, Kentucky; Army Field Forces Board No. 1, Fort Bragg, North Carolina; Aberdeen Proving Ground, Maryland; Detroit Arsenal, Center Line, Michigan; The Field Artillery Board, Fort Bragg, North Carolina; Research and Development Board, Washington, D. C.; The Infantry Board, Fort Benning, Georgia; Landing Vehicle Board, Fort Ord, California; Office, Chief of Ordnance, Detroit, Michigan; Tank Destroyer Board, Camp Hood, Texas; and Chrysler Engineering Divsion, Detroit, Michigan.

The majority of the reports was concerned with listing necessary stowage items for specific vehicles and arranging the items in the most efficient manner. The stowage lists generally included ammunition, boxes, racks, guns, spare parts, accessories, tools, and personnel equipment. Four reports were devoted to the long-term storage of Ordnance materiel; one of the four, a two-volume 202-page report containing 740 abstracts of material, related to storage problems. Three reports covered problems of loading 3/4-ton, 4x4, trucks and weapon carriers and 1-1/2-ton, 4x4, bomb service trucks, M6, in AAF C46 and C47A cargo planes.

Stowage arrangements were studied for the following vehicles: tractors, M6 and M8; 105mm howitzer motor carriages, M7 and T76; 75mm howitzer motor carriages, M8 and T30; 81mm mortar motor carriages, M4 and M21; 155mm gun motor carriage, M83; light armored car, M8; tank recovery vehicle, T2; half-track, M3A2; cargo carrier, T43E1; medium tanks, M4 series; 1/4-ton, 4x4, truck; 3/4-ton, 4x4, cargo trucks; 1-1/2-ton, 4x4, bomb service trucks, M6; half-track cars, T29 and T31; 37mm LVT(A) (1); 75mm howitzer LVT(A) (4); half-track, M3; and medium tank, M47.

PACKAGING OF PRECISION ORDNANCE MATERIAL

A test was conducted in 1950 to develop new and improved packaging methods for the long-term storage of precision parts. The standard method of packaging antifriction bearings was inadequate for protecting precision parts in long-term storage. Metal containers having three types of closures, namely of the paint can type, coffee can type and food can type, failed to withstand the rough handling test of eight cycles in a 7-foot revolving tumbling drum. The semirigid polyethylene containers, when sealed by use of a high frequency induction sealing method, maintained a satisfactory seal after 275 revolutions in a 7-foot revolving drum and after cyclic exposure treatment. The semirigid polyethylene containers, having an inner wrap of VPI paper around the bearing and sealed in a polyethylene bag, protected in every instance the packaged part from corrosion. The use of a semirigid polyethylene container was considered to be the simplest and most reliable method for packaging precision parts for long time storage under rough handling conditions. It was recommended that the storage method of packaging antifriction bearings and similar parts be limited to domestic shipment only; that semirigid polyethylene containers be specified for packaging bearings and other precision parts contained in sealed polyethylene bags for overseas shipment and for long time storage; and that Specification JAN-P-197 Preservation, Packaging, and Packing of Antifriction Bearings and Bearing Parts, be modified to specify such packaging methods.

REPORT RESUMES

SUBJECT: Stowage AAB 1-G-4
TITLE: Test of Ammunition and Cargo Box Mounted on Tractor, M6
IDENTIFICATION: Project No. 43; 1-G-4
DATE OF REPORT: 5 January 1944
ORIGIN: The Antiaircraft Artillery Board, Camp Davis, North Carolina
PURPOSE: To determine the suitability of special cargo and ammunition boxes for antiaircraft artillery use
METHOD: Test ammunition and cargo boxes were loaded on an M6 Tractor. Following vehicle loading checks, the tractor was operated for 46 miles over various types of terrain. An inspection was then made to determine if the loaded cargo and ammunition boxes had shifted during operation.
DESCRIPTION: The test open-top cargo and ammunition boxes formed three compartments when placed on the cargo bed of a Tractor M6. The left and right box each measured 35 inches wide x 78 inches long; the center box was 46 inches wide x 78 inches long. Hinged doors of the boxes were placed at the rear of the vehicle. The following equipment was carried in the boxes: two reels of 20-conductor cable; one nitrogen cylinder; 22 two-round boxes of 4.7 inch AA gun-propelling charges

and an equivalent number of projectiles; and other 4.7 inch gun, vehicle, and gun-crew equipment. A tarpaulin was used to cover the open top boxes.
CONCLUSIONS: The cargo boxes as tested were satisfactory. Required modifications included lowering the brackets used for fastening the cargo tarpaulin to a point at which the tarpaulin cover could be pulled tight across the top of the cargo boxes; and adding hand holds on the boxes for the purpose of permitting personnel to support themselves when fastening the tarpaulin top cover. It was also recommended that insulation be placed between the cargo boxes and vehicle engine compartment in future vehicle installations.
GENERAL: This 13-page report contains five photographs showing test boxes installed on the vehicle. Drawings showing the equipment loading arrangement in each of the boxes during testing are also included.

SUBJECT: Stowage AB 136-4
TITLE: Supplemental Stowage and Equipment List for 105 MM Howitzer Motor Carriage, M7
IDENTIFICATION: Project No. 136-4
DATE OF REPORT: 19 July 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the stowage and equipment requirements of the Howitzer Motor Carriage M7
METHOD: During a conference held at American Locomotive, Schenectady, New York, discrepancies, differences, and modifications with respect to stowage and equipment requirements of the Howitzer Motor Carriage M7 were resolved and reconciled.
DESCRIPTION: The stowage list submitted contained the names of items to be stowed in their locations in the M7 Howitzer Motor Carriage.
CONCLUSIONS: A composite list of all personnel and vehicle equipment and their stowage positions is included in Appendix B of this report. It was recommended that these requirements be adopted as standard for the Howitzer Motor Carriage, M7, and that all previous lists be declared obsolete and destroyed.
GENERAL: This 16-page report is not illustrated.

SUBJECT: Stowage AB 136-9
TITLE: Containers and Hangers for Stowage of Accessories and Equipment of the 75-MM Howitzer Motor Carriage, T30
IDENTIFICATION: Project No. 136-9
DATE OF REPORT: 23 May 1942
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To plan and design suitable brackets and boxes for stowage of accessories and equipment to be carried in 75-mm Howitzer Motor Carriage, T30
METHOD: An original plan and drawings for the stowage for the 75-mm Howitzer Motor Carriage, T30 were studied together with a list of essential items to be carried in vehicle. Items of equipment were positioned according to their relative combat value.
DESCRIPTION: The stowage plan considered both personnel and equipment. The individual items and their stowage positions were listed.
CONCLUSIONS: The positioning of items of equipment as submitted in proposal drawing was the most efficient possible. It was recommended that a stowage plan as submitted be adopted as standard for the 75-mm Howitzer Motor Carriage, T30. It was also recommended that items of equipment listed in the stowage plan, less personnel, individual equipment and ammunition be considered as part of the vehicle and furnished as such.
GENERAL: This 14-page report includes complete stowage list and plan view vehicle drawing of stowage arrangement.

SUBJECT: Stowage AB 136-10
TITLE: Containers and Hangers for Stowage and Equipment in Light Armored Car, M8
IDENTIFICATION: Project No. 136-10
DATE OF REPORT: 23 March 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the equipment necessary to provide for efficient combat stowage
METHOD: A conference was held at the Ford Motor Company Dearborn, Michigan, to make a list of the equipment necessary to outfit the vehicle. This list was approved and a vehicle was equipped with the items suggested.
DESCRIPTION: The Light Armored Car, M8, Stowage items included the following: boxes, brackets, guns, spare parts, accessories, and tools.
CONCLUSIONS: It was concluded that the items, as listed in the report, were required to stow the vehicle for combat.
GENERAL: This nine-page report contains a complete list of the items necessary to stow the M8 vehicle.

SUBJECT: Stowage AB 136-13
TITLE: Stowage and Equipment List for 75-MM Howitzer Motor Carriage, M8, Light Tank Chassis, M5
IDENTIFICATION: Project No. 136-13
DATE OF REPORT: 9 March 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To provide for efficient combat stowage of the 75-mm Howitzer Motor Carriage M8
METHOD: A complete stowage and equipment list for 75-mm Howitzer Motor Carriage M8 was compiled.
DESCRIPTION: The stowage and equipment list included personnel, individual and organizational equipment, vehicular equipment, and stowage position data.
CONCLUSIONS: The Armored Force Board concluded that items as shown in list were required to stow test vehicle for combat and recommended that list be adopted as standard and that it be reproduced by Headquarters, Armored Force, for distribution to all troops equipped with 75-mm

Howitzer Motor Carriage M8.
GENERAL: This 11-page report is not illustrated.

SUBJECT: Stowage AB 136-16
TITLE: Containers and Hangers of 81-MM Mortar Motor Carriage, M4
IDENTIFICATION: Project No. 136-16
DATE OF REPORT: 28 July 1942
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the necessary items of equipment for test vehicle and to provide stowage facilities for these items
METHOD: A list of essential items was drawn up and vehicle was stowed with this equipment. Necessary brackets, boxes, and the like were adopted from Armored Force vehicles already in production wherever possible.
DESCRIPTION: The parts and equipment list as drawn up included individual equipment, vehicular equipment, and stowage positions.
CONCLUSIONS: It was concluded that stowage list was complete and stowage plan efficient. It was recommended that they be made standard, the list be reproduced for distribution to using troops, and that brackets and boxes as shown in Project P-261 be put into production.
GENERAL: This 22-page report includes nine drawings of stowage equipment.

SUBJECT: Stowage AB 136-19
TITLE: Report on Stowage of Half-Track Mortar Carriage, M4A1
IDENTIFICATION: Project No. 136-19
DATE OF REPORT: 18 February 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of a modified stowage list for use with Half-Track Mortar Carriages M4 and M4A1
METHOD: Various items were added to the original stowage list of the vehicle. A completely stowed pilot production model of the Half-Track Mortar Carriage M4A1 was then inspected by a representative of the Stowage Section, Armored Forces Board.
DESCRIPTION: The stowage list developed paralleled the stowage list originally published for the modified Half-Track Mortar Carriage M4, dated July 25, 1942. The following items were added to the list: Flag Set M238; Panel Set AP50; and gasoline Cooking Stove M1941. In addition, the list was revised to include the standard list of gun spare parts, accessories, and tools. Ammunition for the cal. .30 machine gun of the test vehicle was increased from 1500 to 2000 rounds.
CONCLUSIONS: The stowage boxes and brackets as installed on the production model vehicle, were considered satisfactory. It was recommended that the proposed stowage list be accepted for use on Half-Track Mortar Carriage M4A1, and that the list, with minor exceptions, be considered suitable for use with modified Half-Track Mortar Carriages M4.
GENERAL: This 18-page report contains no photographs.

SUBJECT: Stowage AB 136-24
TITLE: Stowage of Tank Recovery Vehicle, T2
IDENTIFICATION: Project No. 136-24
DATE OF REPORT: 1 January 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To establish the stowage requirements of a Tank Recovery Vehicle, T2
METHOD: A conference was held at the Baldwin Locomotive Works in order to reconcile all discrepancies, differences, and modifications with respect to the installation of boxes, brackets, and equipment in the Tank Recovery Vehicle, T2.
DESCRIPTION: Individual and vehicular equipment lists, including required containers and hangers for efficient stowage, were developed for use with the Tank Recovery Vehicle, T2.
CONCLUSIONS: The proposed stowage list was recommended for adoption for use with the Tank Recovery Vehicle, T2. The list was to be reproduced and distributed to all using troops.
GENERAL: This 52-page report is not illustrated.

SUBJECT: Stowage AB 136-33
TITLE: Boxes and Brackets Necessary for Stowage of Equipment in Truck, 1/4-Ton, 4x4
IDENTIFICATION: Project No. 136-33
DATE OF REPORT: 9 August 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To study the need for stowage provisions (brackets, tiedowns, boxes, etc.) in the 1/4-ton, 4x4 truck
METHOD: A list of equipment to be stowed was prepared, including items of individual and organizational equipment common to all organizations, and various often-carried items for which stowage provisions were considered advisable. Stowage provisions were developed, fabricated and installed in the vehicle. Testing was over secondary roads and cross-country terrain.
DESCRIPTION: Common equipment to be stowed in the 1/4-ton truck included blanket rolls, rations, small arms and ammunition, first aid and de-contamination equipment. Additional often-carried items included the 60-mm mortar and ammunition, mechanics hand tool set, and camouflage net. Other items for which stowage was provided or modified included water or gasoline cans and pioneer tools. The stowage provisions installed on the vehicle were in the form of tie-down loops and straps, and special brackets, including the Universal Rifle Bracket.
CONCLUSIONS: The stowage provisions developed during the test were considered satisfactory and desirable and were recommended for incorporation into production vehicles.
GENERAL: This 29-page report contains 19 photographs and four drawings illustrating the construction, installation and application of the experimental stowage equipment.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Stowage AB 136/35
TITLE: Stowage of 81-MM Mortar Carrier M21 (T19) (Forward Firing)
IDENTIFICATION: Project No. 136-35
DATE OF REPORT: 8 July 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To provide efficient combat stowage for the improved 81-mm Mortar Carrier M21 (T19)
METHOD: A complete stowage list was drawn up and a pilot model was completely stowed by the Stowage Section of the Armored Force Board at Fort Knox, Kentucky
DESCRIPTION: The stowage list as compiled for test vehicle included equipment, armament, and supplies for personnel, individual, and vehicle. Stowage position for equipment was also included.
CONCLUSIONS: The stowage list as contained in report was considered satisfactory. It was recommended that list be adopted as standard and be reproduced by Headquarters, Armored Force, for distribution to troops equipped with the 81-mm Mortar Carrier M21 (T19).
GENERAL: This 15-page report is not illustrated.

SUBJECT: Stowage AB 136-37 (1)
TITLE: Test of Stowage Boxes, Brackets and Compartments in Half-Track T29 (M3A2)
IDENTIFICATION: Project No. 136-37 (First Report)
DATE OF REPORT: 19 October 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To develop an efficient combat stowage list and arrangement for the T29 (M3A2) Half-Track
METHOD: A proposed stowage list and equipment arrangement plan was developed. The test vehicle was equipped with brackets and stowage provisions. The arrangements were then tested by having the half-track carry a squad of infantry and their equipment.
DESCRIPTION: The test vehicle was an M3A2 Half-Track. Stowage provisions included seating for 12 men with combat equipment, plus armament (.50 and .30 Cal. machine guns) and ammunition, mines and grenades, and radio equipment.
CONCLUSIONS: The proposed stowage list and facilities proved satisfactory for the M3 series half-track vehicle and was recommended for standardization.
GENERAL: This 22-page report contains five photographs illustrating the combat-stowed test vehicle.

SUBJECT: Stowage AB 136-37 (2)
TITLE: Revised Stowage List for Half-Track, M3A2
IDENTIFICATION: Project No. 136-37 (Second Report)
ORIGIN: The Armored Board, Fort Knox, Kentucky
DATE OF REPORT: 25 January 1944
PURPOSE: To develop an efficient combat stowage list, and vehicle stowage facilities, for the M3A2 Half-Track
METHOD: A revised stowage list was prepared as a result of requests by Army Ground Forces and revisions in Organizational and Vehicular Equipment Tables.
DESCRIPTION: The revised stowage proposal included provisions for seating 13 men, individual and organizational equipment, weapons, tools, and ammunition. No modifications in vehicle stowage facilities, brackets, boxes, etc. were indicated.
CONCLUSIONS: The revised proposal presented in this report was felt by the Armored Board to be an efficient combat stowage list, and in accord with AGF requirements and the latest T/O and E's.
GENERAL: This 12-page report is not illustrated.

SUBJECT: Stowage AB 136-40
TITLE: Stowage List for 105-MM Howitzer Motor Carriage, T76
IDENTIFICATION: Project No. 136-40
DATE OF REPORT: 12 December 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To provide efficient combat stowage for the 105-mm Howitzer Motor Carriage T76
METHOD: A complete stowage list was drawn up and pilot model vehicle was stowed.
DESCRIPTION: The stowage list consisted of three sections: (1) the crew; (2) items of individual and organizational equipment and supplies; (3) vehicular equipment. Stowage position of equipment was also included.
CONCLUSIONS: The Armored Board concluded that the items listed were required to equip test vehicle for combat. It was recommended that stowage list be adopted as standard and be reproduced for distribution to troops equipped with 105-mm Howitzer Motor Carriage T76.
GENERAL: This 13-page report is not illustrated.

SUBJECT: Stowage AFF 1085
TITLE: Stowage of Cargo Tractor, M8, When Used as Prime Movers of 90-MM Antiaircraft Gun
IDENTIFICATION: Project No. AFF-1085
DATE OF REPORT: 20 January 1948
ORIGIN: Army Ground Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine an efficient method of stowing ammunition, equipment, and of seating personnel in the Cargo Tractor M8 when used as a prime mover of the 90-mm antiaircraft gun
METHOD: A study was conducted to determine stowage for the ammunition, equipment, and personnel. The necessary racks, bins, and shelves were then constructed and the vehicle stowed.
DESCRIPTION: The Cargo Tractor M8 was a full-tracked vehicle based on the Light Tank M24 chassis. It was powered by a Continental R975-D4, 9-cylinder, radial, 485-hp, gasoline engine. Cargo Tractor M8 weighed 41,000 lbs. empty.
CONCLUSIONS: It was concluded that a maximum of 124 rounds of 90-mm ammunition could be carried in the Cargo Tractor M8, when used as a prime mover for a 90-mm antiaircraft gun. Ample room was provided for 16 men and their equip-

ment. Tools, cable and reel, water and oil cans, and spare tire were all neatly and adequately stowed. The weight of the vehicle, as stowed, was evenly distributed. Total weight of stowage and personnel was 10,500 lbs.
GENERAL: This 49-page report includes stowage lists, diagrams, and 11 photographs of the vehicle and stowage.

SUBJECT: Stowage AFF-3646
TITLE: Stowage Plans for Cargo Tractor, M8
IDENTIFICATION: Project No. FA-3646
DATE OF REPORT: 30 June 1948
ORIGIN: Army Field Forces Board No. 1, Fort Bragg, North Carolina
PURPOSE: To prepare stowage plans for the Cargo Tractor M8 when used as a prime mover or fifth section for the 155-mm gun battery or an eight inch howitzer battery
METHOD: Four tests were made of body mock-ups for the cargo tractor. The first and second were bodies for use of the vehicle with a 155-mm gun battery, as a prime mover, and a fifth section, respectively. The third and fourth body mock-ups were for use of the vehicle with an eight-inch gun battery, as a prime mover, and fifth section respectively. The bodies were loaded with full combat equipment and weight of the loaded vehicle was computed.
DESCRIPTION: The first mock-up body for use as a prime mover for a 155-mm gun carried section personnel and had stowage space for 30 rounds of ammunition, section tools, and equipment. Total weight was 50,750 pounds. The second, third, and fourth mock-ups used the same body. The only difference was in the amount of personnel and equipment carried. Total weight of the second body was 47,200 pounds, the third was 52,500 pounds and the fourth was 49,450 pounds.
CONCLUSIONS: Plans of a recommended body kit were included in Appendix G of the report. It was recommended that a fifth section vehicle should have the same stowage arrangements as a prime mover. The unmodified standard body of the Cargo Tractor M8 was unsuitable. A modification of the track suspension system was recommended for heavier loads.
GENERAL: This 54-page report contains 24 photographs showing general characteristics of the M8 Tractor, body mock-ups, stowage plans and equipment carried.

SUBJECT: Stowage AFF-5249
TITLE: Stowage Test of Tractor, Cargo, T43E1
IDENTIFICATION: Partial Report on Project No. FA-5249
DATE OF REPORT: 28 December 1950
ORIGIN: Army Field Forces Board No. 1, Fort Bragg, North Carolina
PURPOSE: To determine the suitability of the cargo body and of the body kit of the Cargo Tractor, T43E1 for stowage of crew equipment and ammunition of 155-mm howitzer section and of an ammunition vehicle of the 155-mm howitzer battery
METHOD: Stowage of crew, equipment and 36 rounds of ammunition of a 155-mm howitzer section were stowed in the tractor cargo body for test one. Test two consisted of determining the stowage of crew, equipment and 90 rounds of ammunition of a howitzer battery ammunition vehicle in the tractor cargo body. A mock-up of a body kit was installed on the tractor and tests one and two were repeated for tests three and four. Tests one and two were made with and without projectile racks.
DESCRIPTION: For tests one and two the cargo body of the T43E1 Cargo Tractor was used. In tests three and four the sides of the cargo body were replaced by a mock-up of a body kit. The kit had two sides containing storage compartments and bins, and seats for a gun crew.
CONCLUSIONS: A body kit based on plans included in the report was recommended for efficient and secure stowage of howitzer and ammunition section loads of a 155-mm battery. The unmodified body of the cargo tractor was unsuitable for the stowage of crew, equipment and ammunition of an 155-mm howitzer battery.
GENERAL: This 13-page report contains nine photographs showing the stowage of the vehicle in the various tests. Also included in the report was a drawing of a body kit for the T43E1 Cargo Tractor.

SUBJECT: Stowage APG 5568/7 Min.
TITLE: First Minor Report on Stowage of Medium Tank M4
IDENTIFICATION: Seventh Minor Report on Ordnance Report No. 5568; APG-10-83 (Project No. 3-19-2)
DATE OF REPORT: 21 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the most satisfactory stowage locations for equipment and to develop the necessary brackets
METHOD: Brackets were designed, manufactured, and installed in a Medium Tank M4A4. Bracket shapes and locations were determined by use of a tank mock-up.
DESCRIPTION: The brackets and their locations varied, depending on the vehicular design. Ordnance Drawing numbers applicable were included in the report.
CONCLUSIONS: The design and location of the stowage brackets were satisfactory. It was recommended that the brackets be installed in all Medium Tanks M4.
GENERAL: This 56-page report contains 27 photographs of the brackets in the tank mock-up.

SUBJECT: Stowage APG 5732/2
TITLE: First Report on Trucks, Cargo, Airborne, Frame Splicing Kits
IDENTIFICATION: Second Report on Ordnance Program No. 5732; APG 14-40
DATE OF REPORT: 16 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of frame splicing kits for aiding in the disassembly of vehicles prior to loading on a C-47A Transport Plane; and to determine the structural suitability of the splice assembled test vehicles
METHOD: The bodies and frames of various

vehicles were disassembled and sectioned by means of cutting torches and saws. Splicing kits, developed by the respective vehicle manufacturers, were then installed on the sectioned vehicles. Following reassembly, a study was made to determine the time required to disassemble the vehicles, load the sections into a C-47A Cargo Plane, unload the sections, and reassemble the vehicles. A 1000-mile operation over various types of terrain was then conducted with each vehicle.
DESCRIPTION: Frame splicing kits were developed by the respective manufacturers for use with the following trucks: GMC 2-1/2-ton, 6x6; a Chevrolet 1-1/2-ton, 4x4, cargo and Chevrolet M6 Bomb Service; and a Dodge 1-1/2-ton, 6x6, personnel carrier and a 3/4-ton, 4x4, weapons carrier. Each manufacturer specified the method of sectioning his vehicles. The kits consisted of the required materials for connecting the sectioned vehicle assemblies. These kits included body splicing plates, bed splicing angle irons, bolts, flexible line and two shut-off valves for the sectioned brake hydraulic system, and shut-off valve and flexible line for the gas tank.
CONCLUSIONS: The structural strength of the vehicles was not weakened by the use of splicing kits. Loading of the sectioned vehicle parts on the transport was satisfactory. With various modifications, the methods employed for splicing the respective frames and bodies of the vehicles were satisfactory. It was recommended that all frame splicing kits be furnished with complete installation instructions and photographs showing each detailed step, and a demountable ramp be used for loading all vehicles of over 1/4-ton capacity.
GENERAL: This 272-page report contains 174 photographs showing views of the step-by-step procedure followed in installing the kits and views of loading and unloading. Drawings showing location of the vehicle sections in the plane are also included.

SUBJECT: Stowage DA 1585
TITLE: Modification of 90-MM Ammunition Stowage for the Medium Tank M47
IDENTIFICATION: Report No. 1585
DATE OF REPORT: 5 March 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To improve the accessibility of stowed 90-mm ammunition in the M47 Medium Tank
METHOD: The project was divided into two phases. One phase was to develop a quick, economical system to make the semi-ready ammunition readily available; the other phase was to provide maximum selectivity of available ammunition. Working models of both systems were built.
DESCRIPTION: In phase one, the bulkhead behind the bow gunner and the two attached Cal. .30 ammunition stowage racks were removed to provide access to the stowed ammunition. The fire extinguisher bottles and lines were relocated, and a new Cal. .30 ammunition rack was installed behind the bottles. Phase one exposed 16 rounds of ammunition but permitted selectivity of only two. Phase two included the development of a unit which provided space for 12 rounds, with selectivity limited to eight rounds. The operation of both systems depended on the instant removal of the back of the bow gunner's seat.
CONCLUSIONS: The accessibility of the stowed 90-mm ammunition was improved by the various modifications incorporated during the two-phase development program. These modifications were considered adaptable, in kit form, to field modifications. If the system developed in phase two was installed during production of the vehicle the operation would be simplified because the system could be installed in one piece before the turret was installed.
GENERAL: This 40-page report contains 30 photographs of the modified stowage system.

SUBJECT: Stowage FAB 0-108-L (2)
TITLE: 155-MM Gun Motor Carriage, T83, Cargo Carrier, T30
IDENTIFICATION: Second Partial Report; Test No. 0-108-L, Item No. 786
DATE OF REPORT: 18 December 1944
ORIGIN: The Field Artillery Board, Fort Bragg, North Carolina
PURPOSE: To determine the suitability of a Tractor, High Speed, 18-ton, M4, with Trailer, Ammunition, 8-ton, M23, for use in transporting the ammunition, gun crew, and equipment of 155-mm Gun Motor Carriages T83
METHOD: The maximum number of projectiles and powder which could be carried in the tractor when loaded with and without a four man gun crew, equipment, and machine gun was determined. The tractor, loaded with the maximum amount of ammunition and towing a trailer, was operated over varied terrain for 1454 miles; an additional 204 miles was conducted with a gun crew and equipment included in the vehicle load.
DESCRIPTION: The test vehicles were standard Tractor, High Speed, 18-ton, M4 and a Trailer, Ammunition, 8-ton, M23. No other formal description of the test vehicles was provided.
CONCLUSIONS: It was recommended that the tractor with ammunition trailer be considered satisfactory for use as a cargo carrier for the Gun Motor Carriage T83 provided the following modifications were made: ammunition racks were to be moved to the center of the crew compartment in place of personnel equipment; and a tarpaulin of greater dimension was to be fabricated for use with the vehicle.
GENERAL: This 10-page report contains two photographs showing stowage of the vehicle. Also included is a stowage list for the tractor used with the 155-mm Gun Motor Carriage, T83.

GRG 12-13-50
SUBJECT: Stowage B 5.6
TITLE: Proceedings of Panel on Ordnance Materials Meeting on Preservation of Material and Packaging
IDENTIFICATION: Report No. GRG 12-13-50
DATE OF REPORT: 13 December 1950
ORIGIN: Research and Development Board, Washington, D.C.
PURPOSE: To evaluate storage procedures used

on various Ordnance equipment; to determine the suitability of equipment used for testing Ordnance storage packages under simulated tropical conditions
METHOD: A series of discussions were held on the packaging of Ordnance materiel. Non-classified information covered in these discussions was published in the form of proceedings.
DESCRIPTION: Papers on the following subjects were given in this report: Field Conditions and Environmental Factors, Simulated Tropical Conditions in the Laboratory, Degradation of Electrical Equipment Owing to Tropical Atmosphere, Ordnance Field Problems, Textile and Leather Problems, Tropical Testing Chamber at Ft. Belvoir, Vapor Phase Inhibitors, Moisture and Fungus Protection, Ordnance Packaging Development, The Engineering Approach to Preservation and Packaging Problems, The Fort Sherman Tests, Airborne Packaging Problems, and Wood Preservation.
CONCLUSIONS: Procedures followed in packaging and stowing Ordnance equipment were outlined in the various discussions. Corrective measures for improving storage and shipping methods of Ordnance equipment, and methods of improving other factors with reference to various climatic conditions were also included in the discussions.
GENERAL: This 118-page report contains 25 photographs.

SUBJECT: Stowage IF 1292
TITLE: Pioneer Equipment, Motor Vehicle Set No. 1 for 1/4-Ton Truck
IDENTIFICATION: Report No. 1292
DATE OF REPORT: 6 January 1942
ORIGIN: The Infantry Board, Fort Benning, Ga.
PURPOSE: To determine where and how the Pioneer Equipment Motor Vehicle Set No. 1 should be carried on 1/4-ton trucks
METHOD: The equipment was mounted on various parts of the 1/4-ton truck. Advantages and disadvantages of the different locations were studied.
DESCRIPTION: The equipment consisted of a rack, pick, pick handle, axe, and shovel. The 1/4-ton trucks were Bantam, Ford, and Willys.
CONCLUSIONS: Satisfactory stowage was accomplished.
GENERAL: This 18-page report contains nine illustrations of the equipment stowage on the various vehicles.

SUBJECT: Stowage IF 1842
TITLE: Stowage Hangers for Truck, 1/4-Ton, 4x4
IDENTIFICATION: Report No. 1842
DATE OF REPORT: 31 July 1945
ORIGIN: The Infantry Board, Fort Benning, Ga.
PURPOSE: To determine the combat uses, load nature and distribution, and additional stowage requirements of the 1/4-ton, 4x4 truck
METHOD: A study was made to ascertain the extent and variety of the extra tasks currently demanded of the truck by Infantry troops; what improvisations were tried to enable it to perform these tasks, and to what extent, if any, the improvised appliances interfere with the normal functions and capabilities of the vehicle.
DESCRIPTION: The vehicle studied was a 1/4-ton, 4x4 truck. It was a light weight (2500 pounds), vehicle with an open type body providing space for two crew men and two passengers or cargo. The sources relied upon in this report were tables of equipment and presently recognized loading methods, canvass of personnel with recent combat experience in various theaters, and a study of the effect of the proposed devices on the vehicles in cross-country operations.
CONCLUSIONS: The conversion of the truck into carriers by the addition of external devices decreases the performance and reliability of the vehicle. It was recommended that requirements for additional cargo space in 1/4-ton vehicles be met by designing an additional type vehicle, increasing the allowance of 1/4-ton, 4x4, trucks and providing more 1/4-ton, 2-wheel trailers.
GENERAL: This 89-page report contains illustrations of field modifications of the vehicles, vehicle assignment in an Infantry Regiment and present vehicle loading.

SUBJECT: Stowage LVB 2
TITLE: Stowage of Landing Vehicle Tracked (Armored) 37-MM Gun LVT (A)(1)
IDENTIFICATION: Report No. LVB 1-R-1; Project No. 2
DATE OF REPORT: 19 June 1944
ORIGIN: Landing Vehicle Board, Fort Ord, Cal.
PURPOSE: To list and provide stowage for all items of equipment necessary in combat operation of 37-mm gun, armored and tracked landing vehicle
METHOD: The test vehicle was weighed both empty and stowed. The position of all stowage was determined for proper balance and to provide the greatest combat efficiency of the vehicle. Check was then made for vehicle trim in open and still water and rocket firing was conducted while at sea.
DESCRIPTION: The 37-mm gun, armored and tracked landing vehicle LVT (A)(1) was an amphibian hull on the armored amphibian tractor LVT (A)(2). Stowage consisted of a six-man crew and equipment; armament including a 37-mm gun, M6; three cal. .30 machine guns and ammunition; and vehicular equipment including tools, spare parts, and accessories.
CONCLUSIONS: The test vehicle, as stowed, was satisfactory with the trim, operating characteristics and ease of installation being acceptable. The adoption of this stowage list for the vehicle was recommended.
GENERAL: This 91-page report includes 75 photographs of the test vehicle and stowage items.

SUBJECT: Stowage LVB 2A
TITLE: Stowage of Landing Vehicle Tracked (Armored) 75-MM Howitzer, LVT (A)(4)
IDENTIFICATION: Project No. 2A
DATE OF REPORT: 19 June 1944
ORIGIN: Landing Vehicle Board, Fort Ord, Cal.

PURPOSE: To list and provide stowage facilities for all items of equipment necessary in combat operation of an LVT (A)(4)
METHOD: A stowage list was made up of the items and parts required to maintain, sustain and operate the vehicle, armament and personnel. The inside and the rear deck of the vehicle were modified by welding and fastening brackets and shelves for stowing the equipment. The operating characteristics and trim of the vehicle with and without load were determined in still and open water.
DESCRIPTION: The vehicle was an amphibian 75mm howitzer motor carriage built on the chassis of an armored amphibian tractor LVT (A)(2). It was a full tracked vehicle. The equipment requiring stowage space included rocket launchers, camouflage net, pioneer tools, rations, miscellaneous personnel equipment, .50 caliber machine gun, .45 caliber submachine guns, rocket launcher, howitzer, machine gun ammunition; a .30 caliber carbine, and spare parts, tools, and accessories for vehicle and armament. The total weight of the stowed equipment was 4335 pounds.
CONCLUSIONS: Installation of the required equipment on the vehicle was successfully performed by a tank battalion welder and helper using standard material (steel rod, sheet metal, web belts, etc.). Trim of the vehicle was satisfactory in the water. It was recommended that the manufacturer install all necessary brackets, straps, boxes, etc. and that the stowage list included in the report be adopted.
GENERAL: This 83-page report contains 61 photographs showing testing of the vehicles, required equipment, and stowage of the equipment.

SUBJECT: Stowage LVB 2C
TITLE: Stowage of Landing Vehicle Tracked (Unarmored) LVT (4)
IDENTIFICATION: Project 2C
DATE OF REPORT: 10 October 1944
ORIGIN: Landing Vehicle Board, Fort Ord, Cal.
PURPOSE: To determine the suitability of the specified stowage of a Tracked Landing Vehicle LVT (4); and to determine the effect of the added weight of two Rocket Launchers, Mk VII, on vehicle performance in water
METHOD: The test vehicle was weighed empty and stowed. All vehicle and individual equipment was stowed according to the instructions listed in TM 9-776, T/O and E 17-126, and T/O and E 17-127. Following stowage, the vehicle was checked for trim in still and open water. Sand bags used for simulating the weight of two, 12 round, 4.5 inch, automatic Rocket Launchers, Mk VII, and ammunition were then placed on each side of the vehicle cab; in order to trim the vehicle for water operation, 1200 lbs. of sand were placed in the rear of the cargo compartment and vehicle operations were again conducted.
DESCRIPTION: The Amphibious Vehicle LVT (4), powered by a seven cylinder, radial, air-cooled engine, was an unarmored amphibian tractor with a rear ramp. Primary vehicle armament consisted of two cal. .30 Machine Guns, M1919A4, (flexible) and two cal. .50 Machine Guns, M2HB.
CONCLUSIONS: The stowage of the test vehicle was considered satisfactory. Trim and operating characteristics of the vehicle with added weight in the rear of the hold were suitable. Although the additional weight of the sandbags used in simulating the rocket launchers did not appear to affect the vehicle water line draft, it was considered the weapons could not be satisfactorily mounted on the vehicle with other stowage items in place. It was recommended that the slightly modified stowage list included in the report be adopted for use with the LVT (4) vehicle; and that the original stowage list specification be changed to conform with the modified list.
GENERAL: This 83-page report contains 52 photographs showing various views of the equipment stowed in the test vehicle and the appearance of the loaded vehicle during water operations.

OCO 8-15-45
SUBJECT: Stowage B 5.6
TITLE: Long Term Storage of Ordnance Materiel
IDENTIFICATION: OCO 8-15-45
DATE OF REPORT: 15 August 1945
ORIGIN: Ordnance Department
PURPOSE: To recapitulate the analysis and purpose of the Long Term Storage Project for Ordnance Materiel, to render an account of achievements to the date of the report, to record all miscellaneous information relating to the project, and to outline the future approach to the problem
METHOD: Different chapters of the report were devoted to a discussion of various phases of the project. In the chapter on miscellaneous information, the sources of information for each topic were given.
DESCRIPTION: This report consisted of six sections as follows: Objects of Report, Analysis of the Problem, Summary of Work Accomplished, Summary of Miscellaneous Information, Proposed Engineering Analysis of Packaging, and Outline of Future Work.
CONCLUSIONS: In the analysis of the problem, long term storage was defined as a period of time up to 50 years. Since oxygen and water were considered the most important factors affecting storage, if was believed that packaged materials should have a dry, cool, inert atmosphere. It was thought that satisfactory packaging should require little or no maintenance, be tactically redeployable, require minimum disassembly, be economical and practical from an engineering standpoint, and include first echelon parts, tools, and accessories. In the summary of work accomplished, an account was given of the applications of commercial and special steel shipping drums, aluminum fabrications, and spray formed plastic coatings. In the section on miscellaneous information, the following subjects were included: Corrosion in Air, Aluminum, Use of Wood for Blocking, Bearings and Brinneling of Bearings, Lubricants and Preservatives, Filling and Sealing of Drums, Discussion on Storage of Recoil Mechanism, Protective Finishes, Storage of Rubber, Dehydrating Agents, The Solar Radiation Breather, and Humidity Measurements. In the section on the proposed engineering analysis of pack-

aging, it was thought that the following factors should be considered: initial cost, operating and maintenance costs, acceptance test costs, placement and storage costs, cost of restoration to active status, transportation costs, life of package, availability of materials and of manufacturing establishments, and consideration of whether the facility packing equipment was prepared to process it. In the section outlining the future approach to the problem, an outline of the research program was presented together with the work that was currently being done.
GENERAL: This 82-page report contains several photographs.

OCO 9-15-45
SUBJECT: Stowage B 5.6
TITLE: Report on Literature Survey for Long-Term Storage
IDENTIFICATION: OCO 9-15-45
DATE OF REPORT: 15 September 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To conduct a survey of all written material, foreign and domestic, pertaining to long-term storage of various items of military equipment
METHOD: Abstracts of all relevant articles and publications were prepared. Each abstract was provided with sufficient identifying information to enable procurement of the original material. An indexing code was devised whereby each abstract was given numbers referring to specific subjects in the following groupings: factors, materials, items, barrier materials, and atmosphere or media. This work was done by Batelle Memorial Institute.
DESCRIPTION: The report consisted of 740 abstracts on a wide variety of subjects relating to storage.
CONCLUSIONS: In accordance with the instructions for preparation of this report, none of the articles were evaluated.
GENERAL: This 202-page report is in two volumes.

OCO-D
SUBJECT: Stowage B 5.6
TITLE: Research Reports on Long Term Storage of Ordnance Materiel
IDENTIFICATION: Report OCO-D
DATE OF REPORT: 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To compile all available information on long term storage of Ordnance materiel
METHOD: Resumes of procedures used by numerous manufacturers and military installations for the long-term storage of Ordnance materiel were written by personnel who actually visited the locations where the materiel was stored.
DESCRIPTION: The materiel included all types of Ordnance materiel, vehicles, engines, fabrics, meters, etc., prepared for long-term storage.
CONCLUSIONS: The resumes consisted of discussions, conclusions, and recommendations presented by the manufacturers and military installation personnel on the methods which were used in the long-term storage of all types of Ordnance materiel. Proposed storage procedures for the materiel were outlined in the various resumes.
GENERAL: This 153-page report is not illustrated.

SUBJECT: Stowage OCO KG-349
TITLE: Half-Track Cars, T29 and T31
IDENTIFICATION: Project No. KG-349
DATE OF REPORT: 29 April 1944
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To develop a complete stowage plan to combine the essential features of the Half-Track Cars M2 and M5, and the Half-Track Personnel Carrier M3 and M5 into one basic vehicle arrangement with interchangeable features
METHOD: The situation was discussed and analyzed and a stowage plan was developed. Pilot models T29 and T31 were built according to plan.
DESCRIPTION: Some of the military characteristics of the T29 and T31 vehicles are listed below:
Type: Half-Track vehicles
Crew: From two to 13

Physical Characteristics:	T29	T31
Gross weight, pounds	18,800	19,500
Over-all length, inches	243-5/8	249-1/16
Over-all width, inches	86-1/2	86-7/8
Over-all height, inches	89	91
Power plant	White 160AX	IHC Red 450

Armament (normal):
One .50 caliber machine gun
One .30 caliber machine gun
One .45 caliber sub-machine gun
One launcher, anti-tank rocket

Performance:	
Sustained speed under load, mph	45
Maximum grade ability, percent	60

CONCLUSIONS: The stowage arrangement developed for Half-Track Cars T29 and T31 satisfactorily combine the essential features of Half-Track Cars M2A1 and M9A1, and Half-Track Personnel Carriers M3A1 and M5A1 into one basic-type arrangement. It was recommended that: future production of Personnel Carrier M3A1 be revised to incorporate the body modifications of pilot Half-Track Car M3A2; that future production of Half-Track Personnel Carrier M5A1 be revised to incorporate the body modifications of the first pilot Half-Track Car T31, and be designated Half-Track Car M5A2.
GENERAL: This 35-page report includes four photographs of the test vehicles.

SUBJECT: Stowage OCO KG-417 (1)
TITLE: Trucks, Cargo, Airborne (Truck, 2-1/2-Ton, 6x6)
IDENTIFICATION: Project No. KG-417 (First Report)
DATE OF REPORT: 20 July 1944
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To develop efficient means whereby 2-1/2-ton cargo and dump trucks could each be divided and loaded for transporting by AAF Cargo

Airplanes C47A
METHOD: The long wheelbase dump truck was disassembled, the frame and body cut, and bolting tie plates installed. The two load groups, weighing 4379 pounds and 5211 pounds, were then loaded in turn into the hull of a C47A Cargo Plane by means of a special loading ramp and dolly. The plane's flying characteristics carrying each load were observed.
DESCRIPTION: The vehicles considered were the 2-1/2-ton long and short wheelbase cargo trucks and the 2-1/2-ton long wheelbase dump truck. The kit, developed by General Motors, consisted of parts for splicing either the wood or steel body of the trucks and their frames, a brake shut-off valve, bolting flange plates to modify the closed cab windshield, and a pneumatic-tired single wheel dolly.
CONCLUSIONS: The kits were considered satisfactory for shipping these trucks by AAF Transport Airplane C47A. The rear assembly grouping of the truck did not disturb the normal-flight characteristics of the plane. Due to the higher center of gravity of the front section grouping, the plane did not turn as rapidly as desired and was 1/2 degree nose heavy. This was not considered serious.
GENERAL: This 57-page report includes stowage drawings and 19 photographs of the vehicles, kit installations, and loading.

SUBJECT: Stowage OCO KG-417 (2)
TITLE: Trucks, Cargo, Airborne (Truck, 3/4-Ton, 4x4)
IDENTIFICATION: Report No. 2; Project No. KG-417
DATE OF REPORT: 25 July 1944
ORIGIN: Office, Chief of Ordnance, Detroit 32, Michigan
PURPOSE: To determine a loading procedure for the trucks, 3/4-ton, weapons carrier into the C47A Cargo Airplane which will eliminate removal of the rear axle assembly
METHOD: The vehicle was modified as described below and was loaded into and unloaded from the C47A aircraft.
DESCRIPTION: A standard 3/4-ton, 4x4 weapons carrier was prepared for loading into a C47A Cargo Airplane by removal of the body, fenders, right headlight brush guard, bumper, right bumper brackets, running boards, and right rear bumperette. The floor section beside the driver's seat was cut away from the rear of the cowl-post brace at a 45-degree angle to the seat-riser flange. This cut continued rearward to the floor cross-sill and then outward along the edge of the sill to a point one inch past the centerline of the floor to the frame body bolt.
CONCLUSIONS: A successful loading procedure was evolved which did not require removal of the rear axle, did not require excessive time, utilized a standard loading ramp, and eliminated requirement for brake line shut-off valves and loading dollies. This procedure was superior to a previous one as outlined in APG Report No. 14-40, Project 3297. It was recommended that the future procurement of the carrier include modification to the floor section.
GENERAL: This 24-page report includes a drawing of the floor modification, stowage diagram, and nine photographs of the former loading procedure.

SUBJECT: Stowage OCO KG-417 (3)
TITLE: Truck, 1-1/2-Ton, 4x4, Bomb Service, M6, Airborne
IDENTIFICATION: Project No. KG-417
DATE OF REPORT: 16 March 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To modify Truck, 1-1/2-ton Bomb Service, M6 to permit it to be loaded into either the C46 or C47A Cargo Aircraft for transportation
METHOD: The basic vehicle was modified as described below. It was loaded into and unloaded from a Cargo Airplane C47A.
DESCRIPTION: A standard 1-1/2-ton, 4x4 Bomb Service Truck M6 was modified as follows: the rear fenders, bomb-lift superstructure, body bed, and rear axle and spring assembly were removed from the vehicle; splice plates and support gussets were made and installed; the four rivets attaching the rear-frame cross member to the left side frame rail were replaced with 7/16-inch bolts; and a dolly-mounting bracket was attached to the left-side frame rail opposite the right frame rail splice point.
CONCLUSIONS: The modified Bomb Service Truck M6, was loaded into the aircraft satisfactorily. The procedures were more efficient than those presented in APG Report No. 14-20, Project 3297. It was recommended that future procurement of Bomb Service Trucks M6 be by modification of the basic vehicle as proposed in this report.
GENERAL: This 19-page report includes a drawing of proposed modification to truck M6 and seven photographs.

SUBJECT: Stowage OCO KG-417 (4)
TITLE: Truck, 3/4-Ton, 4x4, Weapons Carrier, Airborne, Loading Procedure for C47A Cargo Aircraft
IDENTIFICATION: Report No. 4; Project No. KG-417
DATE OF REPORT: 10 March 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine a loading procedure for the 3/4-ton weapons carrier into the AAF Cargo Airplane C47A
METHOD: Different loading methods were tried with the vehicle stripped and the chassis divided into two sections. Finally a procedure was used which did not necessitate dividing the chassis in two parts. Components were stripped from the truck, a brake shut off assembly was installed, and a portion of metal from the left rear corner of the seat box was removed. Actual loadings were then made and the procedure photographed.
DESCRIPTION: The test vehicle was a 3/4-ton, 4x4 weapons carrier weighing 5515 pounds.
CONCLUSIONS: The procedure developed for loading the weapons carrier into the airplane with-

out dividing the chassis in two was successful.
GENERAL: This 41-page report includes material pertaining to the old loading procedure but does contain 11 photographs of the newer method and a drawing of the seat box modifications.

SUBJECT: Stowage OCO KG-417 (5)
TITLE: Truck, 1-1/2-Ton, 6x6, Cargo, Airborne
IDENTIFICATION: Report No. 5, Project No. 417
DATE OF REPORT: 24 August 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine a procedure for loading a 1-1/2-ton, 6x6, cargo truck into the AAF Cargo Airplane C47A
METHOD: The truck was disassembled, the frame and body were cut in two parts, and bolting tie plates were installed. A dolly was mounted on the rear of the front section. Actual stowage in the plane was tested to determine efficiency and weight distribution.
DESCRIPTION: The 1-1/2-ton Dodge truck weighed 6800 pounds as prepared for stowage with the dolly attached. The preparation kit consisted of parts for splicing the body and frame of the truck together, a brake shut-off valve, a pneumatic-tired single wheel dolly, and rubber tubing for fuel supply.
CONCLUSIONS: The preparation kit was satisfactory, and an efficient stowage procedure was devised.
GENERAL: This 28-page report includes a stowage diagram of the vehicle, frame splicing, and stowage in the plane. It also contains 11 photographs of the test vehicle.

SUBJECT: Stowage OCO KG-417 (6)
TITLE: Truck, 1-1/2-Ton, 4x4, Cargo, and Truck, 1-1/2-Ton, 4x4, Bomb Service, M6
IDENTIFICATION: Report No. 6; Project No. KG-417
DATE OF REPORT: 24 August 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To establish a procedure for loading the 1-1/2-ton cargo truck and 1-1/2-ton Bomb Service Truck, M6, into the AAF Cargo Airplane, C47A
METHOD: The cargo truck was disassembled, the frame and body cut in two parts, the cab top cut off, bolting tie plates installed, a dolly fastened to the rear of the front section, and a brake shut off valve installed. Actual stowage in the plane was tested to determine efficiency and weight distribution.
DESCRIPTION: The 1-1/2-ton Chevrolet cargo and bomb service trucks weighed, with dolly, 5755 pounds and 6250 pounds, respectively, and had wheelbases of 145 inches and 125 inches respectively. The preparation kit consisted of parts for splicing the body and frame of the truck, a brake line shut off valve, rubber fuel line connections, and pneumatic-tired, single-wheel dollies for supporting each half chassis when knocked-down for air transport.
CONCLUSIONS: The preparation kit was satisfactory and efficient stowage of the cargo truck in one plane was accomplished. A universal splicing kit was evolved for these two vehicles and was installed on a cargo truck and a bomb service truck by the Divco Corp., Detroit. These trucks successfully completed 1000 miles of testing at APG. Although the bomb service truck was not actually stowed in the plane, no difficulty was anticipated because its wheelbase was shorter than that of the cargo truck. As the weight of the bomb service truck exceeded the payload allowance for shipment as a single load it would have been necessary to make two shipments.
GENERAL: This 40-page report includes 20 photographs of the vehicles and kit installations.

SUBJECT: Stowage OCO KG-417 (7)
TITLE: Trucks, 3/4-Ton, 4x4, 1-1/2-Ton, 6x6, and 2-1/2-Ton, 6x6, Airplane, Suspended
IDENTIFICATION: Report No. 7; Project No. 417
DATE OF REPORT: 5 September 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine the suitability and efficiency of mounting and transporting Ordnance trucks 3/4-ton, 1-1/2-ton, and 2-1/2-ton, under the fuselage of AAF Airplane, C54A
METHOD: A frame was attached to each truck in turn. The truck-frame assembly was hoisted into position and test flights made.
DESCRIPTION: The frames built by Dodge Bros. for carrying the 3/4-ton and 1-1/2-ton trucks were identical and consisted of two side members, which were attached to the wheels of the truck, and two horizontal cross members which joined the side members at the top. The 2-1/2-ton truck frame, built by General Motors, consisted of two side members joined to the hubs, after the wheels were removed; two horizontal cross-pieces and an "A" frame attached to the rear. The two external hoists of the plane were designed to carry a light tank. Hydraulic pumps and cylinders were provided for hoisting the vehicles into place by four cables. With the vehicle in position the hooks were closed and the hydraulic pressure relieved. The cables were then removed from the frame and hoisted clear. The frame-truck assemblies weighed 5772, 7925, and 11,665 pounds.
CONCLUSIONS: The framework assemblies permitted ready attachment and satisfactory air transport of these trucks under the fuselage of the AAF Airplane, C54A. A slight aerodynamic vibration was experienced in flight with all trucks. The vibration was not felt in the controls but seemed to be the action of turbulent air on the fuselage aft of the trucks. It didn't increase with speed and wasn't considered serious. The effect on range due to drag of the external truck was only slightly adverse causing a reduction of up to 18%.
GENERAL: This 113-page report includes 42 photographs.

SUBJECT: Stowage RIA 50-2187
TITLE: Packaging of Precision Ordnance Material
IDENTIFICATION: Report No. 50-2187

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 11 September 1950
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To develop new and improved packaging methods for the long-term storage of precision parts
METHOD: Inner wrap materials such as Kimpack, heat sealed polyethylene bags and vapor phase inhibited paper, were used for packaging antifriction bearings, precision instruments and inspection gages. Representative packaged bearings were tested using rough handling in the drum tumbler and cyclic exposure to temperatures ranging from -70° to 160°F for periods of 15 minutes to 16 hours under varying conditions of humidity and water immersion.
DESCRIPTION: None.
CONCLUSIONS: The standard method of packaging antifriction bearings was inadequate for protecting precision parts in long term storage. Metal containers having three types of closures, namely of the paint can type, coffee can type and food can type, failed to withstand the rough handling test of eight cycles in a 7-foot revolving tumbling drum. The semi-rigid polyethylene containers, when sealed by use of a high frequency induction sealing method, maintained a satisfactory seal after 275 revolutions in a 7-foot revolving drum and after cyclic exposure treatment. The semi-rigid polyethylene containers, having an inner wrap of VPI paper around the bearing and sealed in a polyethylene bag, protected in every instance the packaged part from corrosion. The use of a semi-rigid polyethylene container was considered to be the simplest and most reliable method for packaging precision parts for long time storage under rough handling conditions. It was recommended that the storage method of packaging antifriction bearings and similar parts be limited to domestic shipment only; that semi-rigid polyethylene containers be specified for packaging bearings and other precision parts contained in sealed polyethylene bags for overseas shipment and for long time stowage; and that Specification JAN-P-197 Preservation, Packaging, and Packing of Antifriction Bearings and Bearing Parts, be modified to specify such packaging methods.
GENERAL: This 29-page report includes 11 photographs of the various types of containers before and after tumbling and after cyclic exposure.

SUBJECT: Stowage TDB 204
TITLE: Stowage of M3 Half-Track when used as Prime Mover for 3-Inch Gun
IDENTIFICATION: Project No. 204
DATE OF REPORT: 21 January 1944
ORIGIN: Tank Destroyer Board, Camp Hood, Texas
PURPOSE: To conduct a study of stowage for Half-Track M3 when used as a prime mover for 3-inch Gun M5
METHOD: The test vehicle was combat loaded, with complete stowage and a crew of 10 men, and operated for 50 miles over varied terrain.
DESCRIPTION: Stowage for the Half-Track M3, was as directed per SNL-C-40, SNLG-102, SNL-B-38, T.E., OVML list of accessories and equipment for the Half-Track Personnel Carrier M3.
CONCLUSIONS: The stowage boxes, brackets, and the field modifications suggested by the Tank Destroyer Board were recommended for the Half-Track M3 when used as a prime mover for the 3-inch Gun. The basic stowage list provided efficient stowage for the Half-Track M3.
GENERAL: This 34-page report contains 15 pages of photographs of the stowage facilities on Half-Track M3.

SUBJECT: Stowage T-61905.4
TITLE: Pilot Models, M4E5 Medium Tank (105-MM Howitzer)
IDENTIFICATION: Report No. T-61905.4; CX Project No. 151
DATE OF REPORT: 15 October 1943
ORIGIN: Chrysler Corporation, Detroit, Michigan
PURPOSE: To provide a record of the steps involved in the construction of two pilot models of the Medium Tank M4E5 (105mm howitzer)
METHOD: A special gun mount, designed by Ordnance, was incorporated into a basic M4 turret. This mount was fitted with a dummy 105mm howitzer to provide a space check. Vehicle components were relocated as necessary to accommodate the gun and ammunition.
DESCRIPTION: The test Medium Tank M4E5 (105mm howitzer), manufactured by the Pressed Steel Car Company, was built on the M4 chassis. Power was furnished by a Continental R975, radial, gasoline engine. These two pilot models were almost completely stripped of stowage provisions and wiring and then rebuilt to the M4E5 specifications. Provision was made for stowage of 68 rounds of 105mm ammunition. Practically all of the electrical equipment, including the battery box, auxiliary engine-generator set, generator regulators, and master control box, were installed in the left sponson to maximize the floor space available for this stowage. The weight of each pilot model, without vehicular stowage, howitzer, or ammunition, was approximately 31 tons. A partial, cutaway, turret basket was used and power traverse was eliminated. The experimental 105mm mount did not incorporate a stabilizer.
CONCLUSIONS: These vehicles were not tested before shipping but difficult removal of the 105mm ammunition from the floor-mounted stowage boxes was foreseen. Other installations were apparently satisfactory.
GENERAL: This 26-page report contains six drawings showing the location of stowage items and other components in the pilot models. Required stowage specifications, furnished by the Armored Force Board, are also included. The test was initiated by Chrysler Corporation proposal No. 98, and was authorized by D.O.D. directive No. 160/46911.

Section 39
SUSPENSIONS

SUMMARY

This summary covers resumes of 184 engineering reports written on suspension systems and components between 1938 and 1955.

SUSPENSION TESTING

Prior to World War II, all suspension testing was conducted at Aberdeen Proving Ground, Maryland. However, the sudden need for a tank suspension that could meet World War II combat requirements brought about an expanded test program. Facilities at the following field force and Ordnance test centers were added to those at Aberdeen: The Armored Force Board, Fort Knox, Kentucky; Desert Warfare Board, Camp Young, California; Tank Arsenal Proving Ground, Utica, Michigan; and General Motors Proving Ground, Milford, Michigan. The Chrysler Corporation Engineering Division performed a considerable amount of development work on volute springs. In addition, institutions, such as the Case School of Applied Science, Cleveland, Ohio, were called upon for special test programs. Manufacturers, such as the Monroe Auto Equipment Company, cooperated to the fullest extent.

Although most of the reports concerned field testing, a number of reports prepared by Chrysler were based on laboratory tests and theoretical calculations. Standard stress analysis apparatus and chemical and metallurgical facilities were used in the laboratory as well as such special equipment as a reworked Toledo Press and a constant stress machine for studying the fatigue characteristics of volute springs.

The primary objective of nearly all field tests was the determination of suspension and component durability. Vehicles equipped with test suspensions were operated over an endurance course until a major failure occurred or for a specified distance. Most endurance courses incorporated one or more of the following surfaces, in lengths varying from a few yards to several miles: gravel, concrete, and dirt roads, cross-country terrain, mud and sand routes, washboard or Belgian Block strips, and various obstacle courses. Operations were made under all types of weather conditions. In addition to durability determinations, many test programs called for the investigation of ease of maintenance, serviceability, and such performance characteristics as gun platform stability, ride, and crew comfort.

Reports covering the period from the beginning of World War II to 1952 indicate a steady development of electronic equipment for investigating pitch, bounce, vibration damping, and resonance (factors affecting ride characteristics). Pitch and bounce characteristics were frequently studied by obtaining trace-line photographs at night while the test tank (with lights installed at certain points) operated over various courses in front of a camera with an open shutter.

VERTICAL VOLUTE SUSPENSIONS

Bogie-type vertical volute suspensions were developed for use on light and medium tanks of the M3 and M4 series as well as for use on many half-track vehicles.

Although vertical volute suspensions were standard for many Ordnance tracklaying vehicles prior to, and during, World War II, performance and durability characteristics were never entirely satisfactory, especially when compared with those of horizontal volute and torsion bar systems. The presence of sliding friction surfaces, difficulty in providing external damping, and relatively short volute spring life (average: 1500 miles) were the chief deficiencies exhibited by the vertical volute suspension. The horizontal volute suspension, on the other hand, contained no sliding friction surfaces, incorporated a shock absorber, and provided a more nearly true axial loading of the volute springs, which increased spring life. Improved volute spring design and manufacturing processes also contributed to bringing horizontal volute spring life to a 2500-mile average. Superior riding qualities, increased tire and track life, and the marked ability to resist track throwing were additional advantages, as compared with vertical volute systems. Torsion bar suspensions, in turn, were a distinct improvement over both types of volute suspensions.

HORIZONTAL VOLUTE SUSPENSIONS

The first report on the testing of horizontal volute suspensions appeared in May, 1942. Vertical, horizontal, and trailing idler suspensions, with and without shock absorbers, were compared on M3 medium tanks, and additional development work was recommended for the horizontal volute systems. Following this initial report, more than 45 reports were written on the laboratory and field testing of horizontal volute suspensions.

The bulk of these reports was related to a development program established by an Ordnance directive, October 28, 1943. The directive specifically outlined the following work, which was completed by April, 1945: weight analysis, interference study, servicing methods study, stress analysis, bump rig tests, volute spring fatigue life tests, shock absorber life tests, deflection and rupture tests on individual parts, chemical and metallurgical analyses, photographic work, vehicular pitch tests, and obstacle climbing tests. The fact that all M4 series medium tanks used in

Korea were equipped with the horizontal volute (E8) suspension indicates that this program was successful within the design limits and inherent disadvantages of bogie type suspensions.

INTERFERENCES

A thorough study of suspension interference in the laboratory and field revealed that interferences existed between the shock absorber and volute springs during extreme rebound of the bogie unit; between the shock absorber end clamp bolt and the track center guide during extreme bogie action; and between track center guide and the sprocket hub. These interferences together with several minor interferences were eliminated by the time the suspension was in full production.

DEVELOPMENT AND LIFE TESTS ON SHOCK ABSORBERS

As a result of a coordinated program of laboratory and proving ground testing, and with the cooperation of the Monroe Auto Equipment Company, a new design shock absorber was developed and adopted as standard for production. This combined the best features of a design originally developed for a vertical volute suspension with an enlarged reservoir which contributed to increase oil and air capacity and lower, more uniform seal pressures.

The most critical problem solved was that of frequent shock absorber bushing failures. Various bushing compounds of natural and synthetic rubber were tested for several weeks both at the proving ground and on a laboratory fixture designed to duplicate service failures. Subsequent redesign resulting from these tests altered the suspension arm so that the shock pin could be cushioned by one bushing instead of two fitted into the arm. A 1/8-inch thick wall of natural rubber in this installation provided satisfactory bushing life. A number of other changes, requiring an equal amount of development, were made before over-all shock absorber performance and durability were obtained.

CHEMICAL AND METALLURGICAL ANALYSIS OF PARTS

The only suspension parts which were analyzed completely consisted of failed parts from various proving grounds. However, every component part of ten pilot production suspensions was checked for hardness; case hardened pieces were also checked for case depth. Where unsoundness was suspected, Magnaflux examinations were made. Almost all parts examined were reported to be within specifications. In fact, the only metallurgically deficient parts encountered during the history of the horizontal suspension were discovered before installation on the vehicle.

OBSTACLE CLIMBING TO DETERMINE REQUIRED TRACK AND SUSPENSION STOPS

At TAPG, a medium tank M4A3E8 with horizontal suspension successfully negotiated 2-foot and 3-foot vertical walls, steep mounds of earth 3 feet and 4 feet high, and ascended a 60% slope. An opening or trench with vertical walls, 8-1/3-feet apart, could be spanned without dropping the nose of the tank into the trench. This performance was superior to the vertical suspension and was due to the greater bogie action designed into the horizontal suspension.

Tests of this nature, along with other considerations, established the practicability of using stops on the No. 1 and No. 6 suspension arms which were limited in rebound at 25-1/2° below horizontal position. It was also established that no stops were necessary on the No. 2, No. 3, No. 4, and No. 5 arms.

CUPPED DESIGN VOLUTE SPRINGS

A comparison of the life of a cupped design volute spring with a new-type production spring was made in a 1954 test. The proposed design spring consisted of a supporting cup welded to the base plate and with the inactive coil of the spring attached to the cup with one short weld. Four base plate stop assemblies were made, two having 1/8-inch wall thickness, and two having 3/8-inch wall thickness. The cupped design spring and the production design spring appeared equal in durability and both were superior to the obsolete production design.

CHARACTERISTICS OF TWO TYPES OF EXPERIMENTAL VOLUTE SPRING ASSEMBLIES

Determination of the durability characteristics of two types of experimental volute spring assemblies was made in a 1955 test. The test units were two types of experimental volute bumper spring for M41A1 and M42 vehicles. Both types were retained in a 1-inch deep cup that was welded to the base plate. The main difference between the two was that one had two welds spaced 180° apart, while the other had only one weld. A 3/16-inch weld was specified in the design. Both experimental types of volute spring stops obtained greater mileages than would normally be expected of production type springs. The double weld type theoretically was a better design since it resisted both fore and aft forces and was symmetrical for use on both sides of the vehicle. The weld used was found to have a good factor of safety. Because the single weld caused distortion and greater "runout" at the tappet end of the spring, the double weld type was easier to manufacture. The double weld volute type spring stop, it was concluded, should be released for production in place of the standard volute spring stop.

BOGIE WHEELS

The width, diameter, and method of fabricating of bogie wheels were the major considerations found in some 20 reports written in 1943, 1944, and 1945. As the demand for heavier tanks grew, bogie wheels of increased width and diameter were employed to support the additional weight and to provide adequate ride and gun platform stability characteristics.

A great deal of attention was given to the type and method of welding fabricated bogie wheels. Improved welding procedures eventually led to more durable constructions. In one instance, in 1943, a 22-inch, all-steel bogie wheel was tested on a

medium tank equipped with both steel and rubber tracks. Early track failure occurred, accompanied by excessive heat buildup in the track block, and hence all-steel wheels were not recommended, nor was any further evidence offered that they were tried again.

BOGIE TIRES

Many rubber compounds, both natural and synthetic, were tested in an effort to improve bogie tire durability. Since rubber compounding formulae were seldom offered in the reports, correlation of rubber compounding and physical characteristics is not possible. However, in several of the reports on bogie tires (1943-45), results revealed that synthetic rubber was as good, if not better, than natural rubber with respect to resistance to wear, cutting, chunking, and heat buildup.

The problem of separation at the tread and tie-gum was improved by the use of a ty-ply cement construction. Of several types of tread surfaces tested, either smooth or four-groove was found superior to single-groove, except in one report, where the incorporation of any grooved surface was considered superior to a smooth surface. This inconsistency was not resolved in subsequent tests.

Test results also indicated that the following design limits were being approached: (1) tire width should not be more than 7 inches; if greater width is required, two tire sections should be used instead of one; (2) tire diameter should be as large as practicable; and (3) tread thickness should be limited to an amount necessary to overcome danger of blowout.

SUPPORT ROLLERS

During the test program covered by a few reports (1943-45), the following support rollers were investigated: cast, fabricated (welded), plastic-steel disc, fabric-steel combinations, and sandwich-type support rollers. Cast rollers were found to have the longest endurance life of all types tested. Mounting support rollers on the side of the hull was considered superior to mounting on the top of the suspension units.

SHOCK ABSORBERS

Although no single report was devoted to the testing of shock absorbers, at least 15 reports contained mention of various unsatisfactory shock absorber conditions, ranging from inadequate seals to weak eye pin locking devices. These reports covered all types of tracklaying vehicles operating under nearly all types of weather and proving ground conditions. The successful development of shock absorber components for the horizontal volute suspension is also included in several of these reports.

BEARING SEALS

Both lip and face-type bearing seals were tested for use with support rollers, bogie and idler wheels, and face-type seals were considered superior in most tests. These seals resulted in longer life and permitted use of lighter lubricants. They also appeared to adjust more readily to load deflection than did lip-type seals. Labyrinth arrangements provided outside the seal zone were often used successfully to inhibit the entrance of mud, water, and dust.

RUBBER TORSION UNITS

One of the first attempts to incorporate rubber torsion units in bogie suspension was made in 1938. Stresses were calculated and a drawing made of a unit which consisted of eight, 1/2-inch rubber discs separated by steel plates and assembled at the ends of concentric bogie axles in light tanks and combat cars. The rubber discs were placed under axial compression and were designed to resist torsionally the turning movement between the axles. One bogie arm and wheel were attached to the outer axle and another bogie arm and wheel were attached to the inner axle. Although this proposed design was recommended for consideration, the only record of a test appears in another report which referred to the "pre-loaded" units as being unsatisfactory. This report was chiefly concerned with the test of "full-molded type torsion units" which consisted of three concentric, 3-inch rubber bushings and four steel sleeves molded together to form a doughnut. The rubber was not placed under radial compression. The inner and outer sleeves were serrated to engage serrations on the axles. Ten doughnuts were assembled on each bogie axle. These units were found unsatisfactory and further testing of molded types was not recommended for light tanks. However, similar units tested later in 1938 on the combat car, T5E4, were found to have enough merit to warrant further consideration. A revised unit of this type was tested in the laboratory in 1939, but was found inferior to the unit used on the combat car, T5E4. Continuation of tests on the combat car, T5E4, was recommended.

In 1941 a report recommended that the project for the development of rubber torsion suspension elements be discontinued. Volute steel springs, it was concluded, were superior to rubber torsion units with respect to durability, reliability, and ease of maintenance. The substitution of volute springs for rubber torsion units in trailing idlers was also recommended in this report.

HALF-TRACK SUSPENSIONS (VARIOUS BOGIE TYPES)

In the tracklaying sections of half-track vehicles, suspension units were employed that were similar to those used in tanks, though early types, and some used during World War II, featured various articulated bogie systems. The reports on a number of different half-tracks and bogie systems indicate that the problems inherent in any bogie system were encountered, as well as such fundamental considerations as structural and material strength of components.

INDEPENDENT SUSPENSIONS

Two types of independent suspensions, the Christie and the torsion bar, were covered in these reports. Each unit of a Christie type suspension consisted of a pivotally mounted suspension arm

sprung with a helical coil spring acting in compression. A report written in May, 1942, concluded that the Christie type combat car, T4, suspension was applicable to M4 medium tanks, though application was never effected. Undoubtedly, the additional space required for the internally mounted helical springs, insufficient damping, and the momentum of the volute suspension program were factors which contributed to abandoning consideration of Christie suspensions for tanks. In addition, the advantages inherent in an independent suspension were considered best utilized in the torsion bar suspension system.

The first of the reports on torsion bar suspensions was dated March, 1944, and was devoted to a proof test of the pilot medium tank, T23E3. Subsequent reports included the development of torsion bar suspensions on medium tanks, T20, T20E3, M26, M4E4, and light tank, M24. This development program led to the present standardization of torsion bar suspensions for all production tanks; light, medium, and heavy. The basic arrangement of these suspensions was essentially the same for each type of tank with the major difference being in the number and size of the road wheels.

As the torsion bar systems were developed, comparison tests with volute bogie types showed the torsion bar systems to be superior in many respects. The individually sprung wheels of the torsion bar suspension adjusted themselves more readily to irregular terrain than did the wheels of the bogie type. However, the action of the bogie suspension provided very good compensating track-tensioning action. A compensating idler or tensioning roller was used in torsion bar systems to maintain proper track tension.

Compared to the bogie suspension, the torsion bar suspension also offered greater interchangeability of components, increased protection to ballistic attack, and to a lesser degree, simplicity of manufacture and ease of maintenance. In addition, the torsion bar system, due essentially to its greater energy-storing capacity, provided better riding characteristics than did the volute bogie type.

The torsion bar system was also superior with respect to spring durability. Most torsion bars operated satisfactorily for at least 4000 miles. As noted previously, the average endurance life of a vertical volute spring was 1200 miles, while a horizontal volute spring lasted approximately 2500 miles.

MISCELLANEOUS APPLICATIONS

A preliminary design study of a leaf-spring suspension for application to the medium tank, M4, was made in 1943. The proposed system consisted of bogie assemblies made up of a pair of articulated 20-inch diameter, 9-inch wide bogie wheels and four laminated, semielliptic springs. Insufficient wheel deflections were established as the chief reason for not pursuing the design study.

In 1944, the operational and performance characteristics of a T22 tractor suspension adapted to a medium tank, M4A4, were studied. Each suspension unit contained a large and small volute spring horizontally opposed at the small ends with the large spring toward the front of the vehicle. The large end of the springs was held in place by deep, cup-shaped cast steel spring seats with a trunnion on each side. The trunnions were rubber bushed and clamped to the upper extension of the bogie arms. The test mileage was not considered sufficient to warrant definite recommendations, though various failures and deficiencies encountered during the test indicated that many problems would have to be solved before a successful adaptation could be effected.

Calculations were made by Chrysler during March, 1942, on 8-inch helical spring combinations as substitutes for volute springs in bogie type suspensions. The spring combinations included round and rectangular helical, and Belleville springs. The calculations showed that a combination of a round helical coil and 26 Belleville springs offered a weight saving of 20% over the volute, with a desirable load-deflection curve. Tests of actual samples were recommended if production release was desired. Calculations made on smaller diameter springs indicated that performance would not be satisfactory.

AXLE SHAFTS ON M34 OR M35 TRUCKS

Determination of the endurance characteristics of two new types of front axle shafts was made in a 1953 test. The front axle shafts had axle diameters of 1-1/2 inches and 9-9/16 inches. The standard front axle shaft had a diameter of 1-7/16 inches. Each of the test shafts was heat-treated by a new process. Both types of test axles were of sufficient strength to satisfy the requirements of M34 and M35 trucks and it was recommended that they be considered acceptable for use in these vehicles.

M47 DUMP TRUCK SPRINGS ON M34 AND M35 TRUCKS

Comparison was made in a test in 1953 of the performance of M47 front springs with the standard springs used on the M34 and M35 cargo carriers. The test suspension had a greater spring camber and larger front axle bumpers than the standard suspension. The frame of the M35 truck with the test springs bottomed less frequently than did a similar vehicle equipped with standard springs. It was recommended that the M47 dump truck springs be considered suitable for use on the M34 and M35 cargo carriers.

M41 VEHICLE WHEEL AND TRACK LOSSES

In 1954, a test was conducted to determine the horsepower losses in the wheels and tracks of the M41 vehicle suspension system while under no road load. Test items were the component parts of the M41 vehicle suspension system. Results of the tests showed that two-thirds of the loss of horsepower occurred in the wheels while the remaining one-third occurred as a result of track tension and bearing and sprocket friction losses.

REPORT RESUMES

NOTE

A number of suspension report resumes are classified. These resumes appear in Section 39, Volume XI.

SUBJECT: Suspensions AB 132
TITLE: Fabreeka Spring Pads, Light Tank M2A4
IDENTIFICATION: Project No. 132
DATE OF REPORT: 9 March 1942
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To determine whether Fabreeka spring pads would prevent light tank volute spring breakage
METHOD: Two M2A4 Light Tanks, equipped with spring pads located between the tops of the two volute springs and housing of each suspension unit, were operated for 1393 and 1664 miles, respectively.
DESCRIPTION: The test Fabreeka spring pad was made of multiple layers of rubberized fabric vulcanized into a pad 3/4-inch thick and attached to an identically shaped 1/8-inch thick metal plate. One pad was used with each pair of volute springs. In order to prevent the cutting of the fabric, the metal side of the pad was placed against the springs.
CONCLUSIONS: Operation was discontinued on the low mileage vehicle when a volute spring failed as a result of a fracture similar to those experienced with vehicles not employing pads. Although no spring failures occurred on the second tank after its period of operation, the test pads were considered unsatisfactory for spring protection and further testing was not recommended.
GENERAL: This nine-page report contains three photographs illustrating the test pad.

SUBJECT: Suspensions AB 203
TITLE: Test of Half-Track Springs (Perch)
IDENTIFICATION: Project No. 203
DATE OF REPORT: 12 January 1942
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of Spring Perch Company front springs and volute springs for use with half-track vehicles
METHOD: Test front springs were installed on four half-track vehicles and operated over cross-country courses for approximately 300 miles at various vehicle speeds. Four test volute springs were also installed on the track suspension of one of the test vehicles and 214 miles of testing was conducted with the vehicle alternately loaded with and without an additional 4600 pounds in the front and 12,600 pounds at the rear.
DESCRIPTION: The test front springs were of a new design manufactured by the Spring Perch Company. The test volute springs were made of 6-1/8 x 5/16-inch material and had a free height of 10-1/4 inches as compared to 12-3/4 inches for standard springs. No additional information was given.
CONCLUSIONS: The test front springs were superior to the standard springs in resistance to breakage and equal with respect to riding characteristics. The test volute springs were not entirely satisfactory because they settled to a point that affected track adjustment. However a 1-1/2-inch spacer used with the springs improved this condition. The test front springs were recommended for production, whereas the volute springs were considered adequate only until all 6-1/8 x 5/16-inch material at the manufacturer was used up and a new design developed.
GENERAL: This three-page report is not illustrated.

SUBJECT: Suspensions AB 203-1
TITLE: Test of Half-Track Springs (Perch No. 3)
IDENTIFICATION: Project No. 203-1
DATE OF REPORT: 28 February 1942
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of a new design of volute spring for half-track vehicles
METHOD: The test springs were installed on a Half-Track Car M2 and operated for a total of 300 miles, 126 miles of which were over cross-country terrain. The front axle and rear bogies were loaded to 4750 pounds and 12,750 pounds, respectively.
DESCRIPTION: The test springs were manufactured by the Spring Perch Company. These volute springs were made from 7-1/2 x 11/16-inch stock, which was heavier and wider than the steel used in previous springs. The free height of these springs was 10-1/2 inches; the installed height was 9-1/2 inches on the unloaded vehicle and nine inches when the vehicle carried a full payload of 3600 pounds.
CONCLUSIONS: It was concluded that: the test springs were more suitable for half-track vehicles than previous springs; spring deflections were sufficiently small to preclude frequent track adjustments; lack of spring internal friction helped prevent the bogie rollers from jumping the track guides; and the ride was slightly harder when the test springs were used. It was recommended that: the test springs be adopted as standard for Half-Track Cars M2, Half-Track Personnel Carriers M3, Half-Track Motor Carriers M4, and all cannon motor carriages based on these chassis; all replacement springs be of this type; and special effort be made to obtain this type of spring for 105-mm Howitzer Motor Carriages T19.
GENERAL: This three-page report is in letter form.

SUBJECT: Suspensions AB 295
TITLE: Test of Spring Loaded Idler for Half-Track

TANK AUTOMOTIVE TEST RESUMES

IDENTIFICATION: Project No. 295
DATE OF REPORT: 22 October 1942
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of spring loaded idlers for use on half-track vehicles
METHOD: The test spring loaded idlers were installed on a Half-Track M2 and a Half-Track M3. Operation was over rough cross-country terrain, including deep ruts and mud. The M2 vehicle was operated for 342 miles and the M3, for 620 miles. The initial test was conducted with volute springs in the idler assembly. Coil springs were then tested with the assembly on the same vehicles for 279 miles and 281 miles under the same conditions.
DESCRIPTION: The spring loaded idler consisted of a bearing and seat, screw assembly, separator, inner and outer springs, pin anchor and dust shield. The test assembly was designed to prevent damage to the idler and jack shaft.
CONCLUSIONS: The test idler assembly tended to eliminate track throwing and its use substantially reduced the need for maintenance. The idler assembly with coil springs was the more effective in preventing damage to idler and jack shaft. It was recommended that spring loaded idlers be adapted for all half-track vehicles and that coil springs be used in preference to volute springs. It was also recommended that modification kits be furnished for installing the idlers on half-track vehicles in the field.
GENERAL: This 12-page report includes four photographs of the test idlers.

SUBJECT: Suspensions AB 405
TITLE: Horizontal Volute Spring Suspension, Medium Tanks M4A3 and M4A4
IDENTIFICATION: Project No. 405
DATE OF REPORT: 2 August 1943
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To compare the durability and performance of the test suspension and the production suspension D74527
METHOD: Test suspensions were installed on Medium Tanks M4A3 and M4A4 and operated for 3015 and 3120 miles, respectively. Terrain varied from level highway to rough cross-country with steep slopes, dust, and deep mud.
DESCRIPTION: The test horizontal volute spring suspension was similar to the production vertical volute suspension. If differed primarily in that the test springs, when placed in compression by either the front or rear assembly arms, transferred this energy to the opposite arms to keep them loaded, thereby keeping tension on the track. The front and rear bogie assemblies were equipped with fluid type shock absorbers. Support rollers were mounted individually on the hull side instead of on the bogie assembly brackets.
CONCLUSIONS: It was concluded that the benefits obtained from the test suspension were not sufficient to warrant its adoption, and that every effort be concentrated on developing a suspension unit employing dual bogie tires and 24-inch center-guide tracks as soon as possible.
GENERAL: This 30-page report includes 12 photographs of the test suspension installed and failed suspension components.

SUBJECT: Suspensions AB 512
TITLE: Final Report of Test of Medium Tank, M4E4
IDENTIFICATION: Final Report on Project No. 512
DATE OF REPORT: 7 July 1944
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To conduct a service test on the torsion bar suspension for Medium Tanks M4E4 and draw comparisons between this and the standard, vertical volute spring, suspension with regard to durability, tire life, and flotation
METHOD: The complete service test was not conducted because of a communication from OCO, Detroit, advising that the torsion bars in the test vehicle suspension were inadequate. Operation of the test vehicle was limited to hill climb, flotation, and limited low-speed cross-country testing for a total of 321 miles.
DESCRIPTION: The test vehicle was an M4A2E4 Medium Tank, made from a standard, G.M. Diesel-powered, M4A2, by substitution of the torsion bar (E4) suspension for the standard volute spring suspension. A 24-inch, single-pin, center-guided, cast steel, track was used on this vehicle. Six dual, rubber-tired road wheels, and three dual, rubber-tired track support rollers, were mounted on each side of the tank.
CONCLUSIONS: The torsion bars as received were too weak for this vehicle and, although stiffer torsion bars were being shipped for test, the torsion bar suspension was considered unsatisfactory for M4 Tanks. This was the result of unsatisfactory durability and flotation characteristics discovered in the limited testing. However, the poor durability resulted at least in part, from the weak torsion bars as did possibly the low ground clearance which contributed to poor flotation. Poor traction and self-cleaning of tracks, not attributable to the torsion bar suspension, also detracted from flotation. Because of the above, and the non-interchangeability of suspension components, it was recommended that no further consideration be given to the suspension as tested on the M4A2E4 Tank.
GENERAL: This 21-page report contains 12 photographs of the test tank, part failures, and flotation operation.

SUBJECT: Suspensions AB 578
TITLE: Test of Spaced Suspension with Extended End Connectors for Medium Tank
IDENTIFICATION: Project No. 578
DATE OF REPORT: 18 January 1945
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the ease of installation, durability, and performance obtainable with 4-1/2-inch suspension spacers used in conjunction with double extended end connectors on a Medium Tank M4A3
METHOD: An M4A3 Medium Tank was modified to accommodate 23-1/2-inch tracks by application of a spaced suspension kit. Extended end connectors

were installed on both inboard and outboard sides of T54E2 track. The tank was operated 1533 miles over various terrain. Handling characteristics were noted, but terrain conditions were not suitable for performance comparison with the standard medium tank.
DESCRIPTION: The suspension spacer kit contained a 4-1/2-inch cast steel spacer bracket for each bogie assembly, and similar brackets for each idler. Two 4-1/2-inch forged extensions were provided for the sprockets. All brackets were welded to the tank hull. The sprocket extensions were attached by means of stud bolts. The T54E2 track was of double-pin, steel chevron type. Double extended end connectors and suspension modification components added 2140 pounds to vehicle weight. Ground pressure was estimated to be 10 psi.
CONCLUSIONS: The modification required 197-2/3 man-hours, though 100 man-hours was estimated for experienced personnel. Correction of several minor deficiencies in bracket design and/or installation instruction was suggested. During the durability test, two studs broke in one sprocket extension. Five support rollers were replaced, with failures attributed to factors other than the increased track weight. Incorporation of bolt fastening to supplement or replace welding was suggested to facilitate installation. Handling characteristics were superior to the standard vehicle and adoption of suspension spacers, with improvements, was recommended. It was noted that the traction afforded by flat rubber block of T51 type was not sufficient to justify use with double extended end connectors. Development of an extended end connector to permit the attachment of grousers was suggested.
GENERAL: This 19-page report contains six photographs of the suspension spacer brackets.

SUBJECT: Suspensions AB 607
TITLE: Test of Medium Tank T23E3
IDENTIFICATION: Project No. 607
DATE OF REPORT: 17 July 1945
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of the test suspension, and to determine the practicability of a redesigned ammunition stowage arrangement
METHOD: The test suspension, together with wide tracks, was installed on a Medium Tank T23E3 which was equipped with the redesigned ammunition stowage system. This vehicle was operated for 2082 miles over cross-country terrain and highways. The vehicle was stowed and fired under simulated combat conditions to test the adequacy of the ammunition arrangement.
DESCRIPTION: The test torsion bar suspension system was identical to that on Medium Tank T25-E1. It utilized dual 26 x 4-1/2-inch bogie wheels with rubber tires. A 19-inch steel, center-guide track was used. The redesigned stowage arrangement applied to the 76-mm ammunition. This arrangement provided for 84 rounds of ammunition and eliminated the turret basket.
CONCLUSIONS: The test suspension and center-guide tracks were found superior to vertical volute-type suspensions with a track using outside guides for use on Medium Tanks T23 or T23E3. However, it was felt that no further consideration should be given to 19-inch tracks because of short life and excessive maintenance required. The test suspension also provided a more stable gun platform than the vertical volute-type suspension. The test ammunition stowage arrangement was considered an improvement and was recommended for production use.
GENERAL: This 21-page report includes five photographs, two of the suspension and three of the ammunition stowage arrangement.

SUBJECT: Suspensions AB 659
TITLE: Test of Three Medium Tanks, T23 with 23-Inch Tracks and Horizontal Volute Suspension
IDENTIFICATION: Project No. 659
DATE OF REPORT: 27 August 1945
ORIGIN: Armored Board, Fort Knox, Kentucky
PURPOSE: To test the durability and general performance of a horizontal volute suspension on Medium Tank T23
METHOD: Three 82,000-pound Medium Tanks T23 were equipped with horizontal volute suspensions and 23-inch center guide T80 tracks. Suspension failure in operation on the Armored Board test course occurred at 674, 692, and 792 miles, respectively. One suspension was then rebuilt and operated an additional 990 miles to failure.
DESCRIPTION: The horizontal volute suspension for Light Tank T23 was not further described in this report. Bogie wheels had 20-1/2 x 6-1/2-inch rubber tires.
CONCLUSIONS: The bogie wheel guide flanges wore excessively as shown by a distance of 3-15/16 inches between bogie wheels when new, compared to an average of 5-1/2 inches at failure with flanges worn completely off most tires. It was recommended that bogie wheel guide flanges be hardened. Bogie wheel bearing seals permitted entry of dirt into bearings and improvement was recommended. Larger sprocket fastenings were also suggested to eliminate shearing of sprockets from drive hubs. The horizontal volute suspension improved the stability and general performance of Light Tank T23. The durability of the T80 track, insofar as observed, was satisfactory. A higher grouser was recommended to increase traction.
GENERAL: This 14-page report contains seven photographs showing the horizontal volute suspension system and excessive bogie flange wear.

SUBJECT: Suspensions AFF 5249B
TITLE: Tractor, Cargo, T43E1, Equipped with Special Compensating Wheels
IDENTIFICATION: Partial Report on Project No. 5249B
DATE OF REPORT: 18 July 1952
ORIGIN: Army Field Forces Board No. 1, Fort Bragg, North Carolina
PURPOSE: To determine the suitability of test compensating wheels when the vehicle was used as a prime mover and bulldozer for medium artillery units

METHOD: The tractor was operated a total of 547 miles towing a 155-mm howitzer over paved roads, wet and dry dirt roads, and cross-country. Six hours of bulldozing operations were performed by the vehicle in sandy clay and soil.
DESCRIPTION: The test compensating wheels had flat, track-contact surfaces. They had the same construction as conventional wheels except that each wheel had 12 one-half inch gussets welded between the inner and outer wheel sections. The gussets were designed to provide rigidity and sufficient open area around the perimeter of the wheel to allow dirt to fall through the wheel.
CONCLUSIONS: The compensating wheels were mechanically unreliable because of excessive wear and broken welds. The operating characteristics of the wheels were satisfactory. It was recommended that the quality of the wheels be improved by better welds and more track-contact surface.
GENERAL: This 12-page report contains five photographs showing construction of the test wheels and failures encountered.

SUBJECT: Suspensions APG 3875/1
TITLE: First Report on Ride Test Comparison Between the Medium Tank T20E3 with Torsion Bar Suspension and Medium Tank M4A1 with Standard Suspension
IDENTIFICATION: First Report on Ordnance Program No. 3875; APG 10-145
DATE OF REPORT: 25 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the comparative ride characteristics of a Medium Tank T20E3 with torsion bar suspension and a Medium Tank M4A1 with standard suspension
METHOD: The Medium Tanks T20E3 and M4A1 were operated over various courses at speeds ranging from five to 20 miles per hour. The pattern of vehicle movement was recorded by exposing camera film to lights on the vehicles as they were operated in darkness.
DESCRIPTION: The Medium Tank T20E3 was a full track-laying vehicle weighing 62,000 pounds. The test vehicle was equipped with a torsion bar suspension system consisting of 12 torsion bars on which were mounted twelve 26 x 4-1/2-inch dual bogie wheels. Four of the wheels were equipped with Monroe direct acting shock absorbers. Armament consisted of a 76-mm Gun M1 with a coaxially mounted cal. .30 1919A4 Machine Gun, a cal. .30 1919A4 Machine Gun in a bow mount and one cal. .50 H.B. M2 Machine Gun mounted on turret hatch A.A. mount. The vehicle was powered by a Ford GAN V-8 liquid-cooled engine with a rated 470 horsepower at 2800 rpm.
CONCLUSIONS: The ride characteristics of the Medium Tank T20E3 were superior to those of Medium Tank M4A1. It was recommended that the torsion bar suspension as installed on Medium Tank T20E3 be accepted as standard suspension for vehicles of the type tested, provided maintenance and durability requirements could be met.
GENERAL: This 56-page report includes five photographs of Medium Tank T20E3, seven sheets illustrating vehicle ride pattern, and 10 sheets of deflection charts.

SUBJECT: Suspensions APG 5235/4
TITLE: Report on the Full Molded Type of Rubber Torsion Units on the Light Tank T3
IDENTIFICATION: Fourth Report on Ordnance Program No. 5235; APG 23-1-1
DATE OF REPORT: 10 August 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of molded rubber torsion units for use on a Light Tank T3
METHOD: Test units of Firestone and Goodyear manufacture were installed in a Light Tank T3 and operated for 230 miles.
DESCRIPTION: The torsion units consisted of three concentric, three-inch rubber bushings and four steel sleeves molded together to form one doughnut. The inner and outer sleeves were serrated to engage serrations on the bogie axles. Ten doughnuts were assembled on each bogie axle.
CONCLUSIONS: The molded rubber torsion units were considered unsatisfactory because slippage destroyed the bond between the rubber bushing and the sleeve. The performance of the molded units was considered no better than pre-loaded units previously tested and found unsatisfactory. It was recommended that tests of molded torsion units for Light Tank T3 be discontinued.
GENERAL: This 37-page report contains one photograph showing four typical torsion units at the end of the test and 12 photographs of rideograph records made with rubber torsion units on the test vehicle. A drawing of the test unit and graphs of load deflection and angle setting are included.

SUBJECT: Suspensions APG 5288/1
TITLE: First Partial Report on the Test of the Half-Track Truck T5E2
IDENTIFICATION: First Report on Ordnance Program No. 5288; APG 16-1a
DATE OF REPORT: 4 March 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the modified bogie and to suggest corrections
METHOD: The modified bogie unit was further modified at the proving ground prior to testing. The vehicle with the modified bogie was then loaded with 3600 pounds and operated a total of 1487 miles over paved roads and cross-country. Speeds up to 35 mph on paved roads and 15 mph over cross-country were maintained. An experimental 10-inch rubber block track was used.
DESCRIPTION: The test vehicle was a T5 Half Track Truck; parts used in the modification of the bogie system were a spring seat, stop pin spacers and a spring seat stud. Parts modified at the proving ground were front, rear and main bogie spacers, main springs, and stop pins. The modifications were designed to provide means of lubricating the rotating parts of the bogie, more flexibility, better strength and less cutting or grooving of the tracks.
CONCLUSIONS: The number of part failures was

reduced, the flexibility of the system was not restricted, and the cutting or grooving of the track was stopped by the modifications. Reversing of the bogie wheels and the entire bogie was eliminated. It was recommended that, where practical, the Half-Track Trucks T5 in the field be modified with the test parts.
GENERAL: This 20-page report contains two photographs showing the modified bogie assembly and the track at the completion of testing.

SUBJECT: Suspensions APG 5298/15
TITLE: Report on a Design Study of a Torsion Suspension Unit Using Pre-Loaded Rubber
IDENTIFICATION: Fifteenth Report on Ordnance Program No. 5298; APG 23-1
DATE OF REPORT: 9 March 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To design a suspension arm torsion unit with a replaceable rubber torsion element and with provision for applying any desired pre-load.
METHOD: Forces and stresses were calculated for a rubber torsion unit supporting two bogie wheels on a Light Tank M2, and a drawing made of a proposed suspension unit.
DESCRIPTION: The rubber torsion unit consisted of eight, 1/2-inch rubber discs separated by steel plates and assembled on the end of the inner bogie axle. The rubber discs were placed under axial compression to absorb the turning movement between the axles.
CONCLUSIONS: It was recommended that consideration be given to manufacture and test of a set of the proposed torsion units, and that the design be submitted to the SAE Sub-Committee on Rubber Products for criticism and suggestions.
GENERAL: This four-page report contains one drawing of the proposed torsion unit.

SUBJECT: Suspensions APG 5298/43
TITLE: First Report on Study of Rubber Noise Insulation of Drive Hubs, Bogie Wheels, and Idler Wheels for Light Tanks
IDENTIFICATION: Forty-Third Report on Ordnance Program No. 5298; APG 23-5
DATE OF REPORT: 24 July 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of rubber insulated sprockets, bogie wheels, and idlers; their effect on noise level, and on wear of other parts of the vehicle
METHOD: The rubber insulated units were installed on a Light Tank M2A4 for field dynamometer tests to compare drawbar pull and resistance to traction with an M2A4 vehicle equipped with the standard suspension. Measurement of sound levels in a test vehicle employing both standard and rubber insulated suspensions was made with Recording Sound Frequency Analyzer. Noise level was determined with a microphone inside and outside the tank operating on level concrete at 5, 10, 15, 20, 30, and 40 mph. Runs were made towing the vehicle to eliminate engine noise and obtain the noise level caused by the track and suspension alone. The Light Tank M2A4 with rubber mounted suspension was then operated 1047 miles over paved, gravel, and cross-country routes.
DESCRIPTION: The rubber insulated suspension unit consisted of rubber sandwiched between two metal plates held in place in the bogie wheel and on the idler wheel by raised metal plugs. Internal construction of the sprocket hub consisted of alternate sections of rubber and steel comparable to a multiple disc clutch. These test units increased the vehicle weight 1100 pounds.
CONCLUSIONS: Over-all noise level was reduced only one to two decibels and did not justify the 1100 added pounds. Riding qualities were not improved though reduction in shock to the driving train might have resulted. Strength of the test units appeared satisfactory. Resistance to traction tests showed definite advantage for rubber insulated units, apparent from a reduction of the "hump" in the resistance to traction curve between 10 and 20 mph. It was recommended that tests of rubber insulated units be dropped as a special project, and reopened when all components of the tank had been progressively quieted.
GENERAL: This 60-page report contains eight photographs of rubber insulated suspension, resistance and horsepower noise curves, and tank noise data.

SUBJECT: Suspensions APG 5298/55
TITLE: First and Final Report on Rubber Torsion Units in Trailing Idler Arms of Combat Cars and Light Tanks
IDENTIFICATION: Fifty-Fifth Report on Ordnance Program No. 5298; APG 23-6
DATE OF REPORT: 9 August 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether rubber torsion units could be satisfactorily substituted for volute springs in light tanks and combat cars
METHOD: The different rubber torsion units were tested by both vehicle installation and operation and by testing machine.
DESCRIPTION: The torsion units covered in this report were of three types manufactured according to Drawings B145900, B145958, and B145959. They consisted of three metal shells separated from each other by layers of rubber. All of the metal shells were made of seamless steel tubing (.35 to .45 carbon), the outer shell had 48 serrations. Separating the outer shell from the central shell was a concentric ring of rubber (50-53 Shore durometer hardness) about 1/2-inch thick. Separating the central and inner shells was another concentric layer of rubber (65-68 Shore durometer hardness) about 3/8-inch thick. The inner shell had 72 serrations. The difference in hardness of the two rubber rings was to allow for the difference in radial movement between the inner and outer rubber. The rubber was vulcanized to the brass-plated shells.
CONCLUSIONS: The rubber torsion units were unsatisfactory because of short and indefinite life, and instability. Volute springs proved superior to rubber torsion units because of longer life, more reliability, and ease of replacement. It was recommended the project for the development of

rubber torsion suspension elements be discontinued. It was also recommended that all combat vehicles utilizing rubber torsion unit type of trailing idler be converted to volute springs.
GENERAL: This 58-page report contains nine photographs showing rubber torsion unit failure.

SUBJECT: Suspensions APG 5322/2
TITLE: First Partial Report on Rubber Torsion Suspension Units in Combat Car T5E4
IDENTIFICATION: Second Report on Ordnance Program No. 5322; APG 11-4B
DATE OF REPORT: 31 August 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of rubber torsion suspension units for use on light tanks or combat cars
METHOD: Goodyear and Firestone test suspension torsion assemblies were separately tested on a Combat Car T5E4. Testing was conducted over various types of terrain.
DESCRIPTION: The test Goodyear Rubber torsion units, B145861, and Firestone rubber torsion units, B145884, differed only in the type of rubber used. Each unit consisted of two concentric rings of rubber separated by a steel brass-plated sleeve. One of two additional sleeves, each having 48 serrations, was located inside the inner rubber concentric ring while the other sleeve was located over the outer rubber ring. The concentric rubber rings were in turn vulcanized to the metal sleeve surfaces. Both test units were used on the rear bogie and trailing idler positions of a Combat Car T5E4; the front bogie suspension of the vehicle was equipped with volute springs.
CONCLUSIONS: The test Goodyear torsion units failed after 254 miles of operation; vehicle test weight was 13,700 pounds. Firestone units, used for 302 miles at a vehicle weight of 13,700 pounds and 999 miles at a vehicle weight of 18,800 pounds, had generally operated satisfactorily during the testing period. Although indicating good performance, it was recommended an additional set of Firestone units be submitted for further severe tests before being considered suitable for use on production vehicles.
GENERAL: This 21-page report contains two photographs showing views of the test rubber torsion suspension units.

SUBJECT: Suspensions APG 5322/4 (p)
TITLE: Second Partial Report on Rubber Torsion Units Furnished by General Tire and Rubber Company for Combat Car T5E4
IDENTIFICATION: Fourth Partial Report on Ordnance Program No. 5322; APG 23-2
DATE OF REPORT: 1 March 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the suitability of the test torsion units with previously tested units. To determine the desirability of a sample method of assembling the units
METHOD: Five torsion units were assembled (bonded together) according to directions furnished by the General Tire and Rubber Company. They were then separately installed in a torsion testing device and loaded in increments up to 1200 lbs.-ft. Inner and outer ring angular deflection readings were taken, and permanent set was noted.
DESCRIPTION: The test torsional units were concentric assemblies, four inches long, with an outside diameter of 5-3/4 inches. Each included an inner and outer steel sleeve; a rubber bushing was bonded to the outside of the inner sleeve; four 90° steel, circular compression segments surrounded this rubber bushing and were themselves surrounded by an outer rubber bushing, which was enclosed by the steel outer sleeve.
CONCLUSIONS: The test torsion units were unsatisfactory; their load-deflection ratio was inferior to similar units then under test on Combat Car T5E4. It was recommended that further testing of the proposed method of assembly be discontinued until further data were available and that further testing of similar torsion units on Combat Car T5E4 be continued.
GENERAL: This 14-page report contains a description of the proposed bonding method for assembly and two sketches showing the torsion unit and an assembling fixture.

SUBJECT: Suspensions APG 5341/20
TITLE: Report on Special Nitrided Units for Suspension in Light Tanks
IDENTIFICATION: Twentieth Report on Ordnance Program No. 5341; APG 23-4
DATE OF REPORT: 21 April 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of various special, nitrided units for use in suspensions of light tanks and combat cars; to compare these units with each other and with the standard type; and to determine their durability
METHOD: The test units were installed in three of the suspension units of a Combat Car M1. The fourth suspension of the vehicle was an A.P.G. suspension with two volute springs welded butt to butt and mounted horizontally. The test vehicle was operated over a standard endurance course until the units failed or became excessively worn.
DESCRIPTION: One set of test units, drawing C55286A, consisted of standard guides and a special, three-piece gudgeon. The ends of the gudgeon were made in the form of caps which fitted over the ends of the gudgeon proper and were free to rotate on the gudgeon. The ends of the caps rode in the vertical guides. Another set of test units, drawing D33469, consisted of a short gudgeon, which did not ride in the guides, and a fixed, spring guide plate. This plate had two holes through which the vertical volute springs passed. The plate was mounted at the bottom of the outside coil of the volute springs and was designed to maintain the spring position. The third set of test units, drawing C55286E, consisted of a standard gudgeon and standard guides. All the test parts were nitrided.
CONCLUSIONS: Test set D33469 failed after three to five miles operation on pavement due to the gudgeon moving to the rear and remaining in that position. Inspection after removal revealed that the volute springs were permanently deformed. Test

set C55286E failed due to excessive wear after 490 miles of operation. All wear occurred on the rear surfaces of the guides and of the gudgeon. Both the D33469 and the C55286 units were considered unsatisfactory. The set C55286A failed due to excessive wear after 2279 miles of operation. Although this set was superior to the above units, it was considered to have no advantage over the original suspension units. None of the test units was recommended for production. It was noted that a suspension incorporating nitrided gudgeon rollers and guides was being tested concurrently on a Light Tank M2A3 with apparent success.
GENERAL: This 28-page report contains 14 photographs of the various units after test and of the M2A3 nitrided gudgeon roller and guide.

SUBJECT: Suspensions APG 5464/13 Min
TITLE: First Minor Report on Suspensions, Light and Medium Tanks M3 (Fabreeka Spring Pads)
IDENTIFICATION: Thirteenth Minor Report on Ordnance Program No. 5464; APG 23-7
DATE OF REPORT: 9 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the wear of upper spring seats employing test spring pads with that of upper spring seats not equipped with pads
METHOD: Light and medium tanks were operated with and without upper spring seat test pads over endurance courses for approximately 3500 to 6300 miles. Inspection of the test pads and suspension was made after the test operation.
DESCRIPTION: The test spring pad, made by Fabreeka Products Company, consisted of a 7-inch diameter laminated phenol plastic section, 9/16-inch thick, bonded to a 1/8-inch metal plate. The pads formed the upper spring seats for vertical volute springs of light and medium tank suspensions, and were inserted with the metal side toward the spring.
CONCLUSIONS: Use of the test spring pads reduced wear of upper spring seats in the bogie suspension of medium tanks. Inspection of pads in light tanks indicated that they would reduce wear on the upper spring seats of the suspension brackets. No conclusions were drawn on whether the pads increased or decreased the life of volute springs. It was recommended that Fabreeka spring pads be included in future production models of medium and light tanks.
GENERAL: This 19-page report contains six photographs of suspension brackets and spring pads and a sketch of the right front medium tank suspension bracket.

SUBJECT: Suspensions APG 5464/14
TITLE: First Minor Report on Gudgeon Pin Bushing, Enlarged Medium Tank M3
IDENTIFICATION: Fourteenth Minor Report On O.P. 5464 APG 23-8
DATE OF REPORT: 14 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether enlarged gudgeon pin bushings would increase the freedom of bogie arm action and facilitate gudgeon pin removal.
METHOD: Oversize gudgeon pin bushings were installed on all right suspension units of Medium Tank M3, and standard bushings were installed on left suspension units. After 371 miles of cross-country and concrete operation, the pins and bushings were removed and inspected. The suspensions were reassembled and the vehicle operated for an additional 1033 miles.
DESCRIPTION: The test gudgeon pin bushings were 0.004 oversize. The inside diameter of the test bushings was 1.883 + 0.001 as compared with 1.879 + .001 inside diameter of the standard bushing (A-187138).
CONCLUSIONS: The enlarged gudgeon bushings did not improve the freedom of action of the medium tank suspension. No apparent reduction in effort to remove the gudgeon pins was found when the enlarged bushings were used. It was recommended that test of these enlarged gudgeon pin bushings be discontinued and that other means of freeing the action of the gudgeon pins be explored.
GENERAL: This 18-page report contains three pages of inspection data.

SUBJECT: Suspensions APG 5518/6 Min
TITLE: First Minor Report on Test of Volute Springs for Half-Track Vehicles
IDENTIFICATION: Sixth Minor Report on Ordnance Program No. 5518; APG 23-9
DATE OF REPORT: 20 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of four test sets of volute springs for use on half-track vehicles
METHOD: The test springs were installed in standard half-track vehicles and operated over various test courses under varying load conditions to simulate actual operation. The springs were removed periodically during the test for calibration to determine the effect of the field operation on the springs.
DESCRIPTION: Two of the test volute spring sets were manufactured by the Spring Perch Company, and one set was manufactured by the White Motor Company. The fourth set was designated as "Light Tank springs, 6000 pounds."
CONCLUSIONS: None of the sets of springs tested were heavy enough for the loads carried on half-track vehicles. Excessive spring sag developed after a relatively short period of operation. All of these springs were too closely wrapped, causing excessive internal friction. It was recommended that the test springs be considered unsatisfactory for use in the suspension systems of half-track vehicles.
GENERAL: This 33-page report contains one photograph of a Fabreeka spring pad tested under another project, and a drawing of one of the Perch springs. A force diagram of the half-track suspension system is also included.

SUBJECT: Suspensions APG 5518/14
TITLE: First Report on Half-Track Cars, Prevention of Track Throwing

IDENTIFICATION: Fourteenth Report on Ordnance Program No. 5518; APG 16-23
DATE OF REPORT: 1 October 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To reduce track throwing, and jackshaft and rear idler bending tendencies of half-track car suspensions
METHOD: A series of half-track vehicles were equipped with numerous suspension-supporting and idler-adjusting devices and tested by operation over the Proving Ground courses.
DESCRIPTION: Two test vehicles, received from the Diamond T Motor Company, were of primary importance: the first of these was equipped with a rear axle running the width of the vehicle and supporting the rear idler instead of the standard shackle mounting. The vehicle was also equipped with No. 3 Perch Company volute springs, modified bogie flanges, and closed-wing track guides. The second half-track vehicle was equipped with a factory installation of the spring-loaded idler adjustment, closed-wing track guides, No. 3 Perch Company volute springs, and modified bogie wheels.
CONCLUSIONS: As a result of satisfactory performance, the following was recommended: that the spring-loaded idler adjusting devices be accepted and installed on half-tracks; that castellated nuts and cotter pins be used instead of elastic stop nuts on bogie roller bolts and bogie frame tie bolts; that the diameter of guide block locking pins be increased from 5/32 to 1/4-inch, and that block guide and link and block pin be modified to suit; and that straight wing track guides, modified bogie flanges, and the No. 3 Perch volute springs be installed on all half-track vehicles.
GENERAL: This 138-page report includes 47 photographs and 14 pages of drawings of the test devices.

SUBJECT: Suspensions APG 5518/21
TITLE: First Report on Cold Weather Devices for Half-Track Suspension
IDENTIFICATION: Twenty-first Report on Ordnance Program No. 5518; PAG 16-27
DATE OF REPORT: 23 November 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effectiveness of a scraper device for removal of ice and snow from the suspension system of half-track vehicles
METHOD: The test scraper device, after design and construction, was bolted to the frame of the Half-Track Personnel Carrier M3. The vehicle was then operated for 164 miles over various terrain including mud conditions to determine the action of the scraper.
DESCRIPTION: The scraper device was a blade fabricated from No. 1020 steel and attached to the frame. Special scrapers were made for spring-loaded idlers and mounted to the idler shackle. The test device was designed to keep the suspension sprockets and idlers clear from ice and snow.
CONCLUSIONS: The test scraper device was satisfactory in mud operation for clearing the sprockets and idlers on half-track suspensions and indicated the same ability in ice and snow. It was recommended that methods of mounting the device be modified and that the device be made into kits and used on all half-track vehicles intended for operation in ice and snow.
GENERAL: This 36-page report includes three photographs of the test device installed and four drawings of the item.

SUBJECT: Suspensions APG 5534/7
TITLE: First Report on Auxiliary Volute Springs for Front Suspension of 75-MM Gun Motor Carriage M3
IDENTIFICATION: Seventh Report on Ordnance Program No. 5534; APG 23-13
DATE OF REPORT: 14 January 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether front suspension interferences were eliminated, or reduced appreciably, by the use of Body Buoy Auxiliary Volute Springs in combination with the standard front leaf springs
METHOD: The four pairs of volute springs tested were installed in a 75-mm Gun Motor Carriage M3 and operated over extremely rough terrain for 52, 160, 811, and 2245 miles, respectively.
DESCRIPTION: The capacities of the individual springs in the four sets of springs were 1800, 2300, 2600, and 3200 pounds. The bases of the three pairs of springs with the lowest rates were retained in saddles which were mounted in the center on top of the front suspension leaf springs by means of the U-bolts that formerly retained the rubber bumper brackets. The 3200-pound capacity volute springs were welded directly to the rubber bumper brackets to eliminate interferences encountered when using the larger diameter saddles supplied with the 3200-pound capacity springs. In all cases built-up Fabreeka bumpers mounted on brackets welded underneath the frame were used as bottoming cushions for the tops of the volute springs.
CONCLUSIONS: The 3200-pound capacity auxiliary volute springs were found to be satisfactory for use on the 75-mm Gun Motor Carriage M3 and on all half-track vehicles using springs other than International Harvester leaf springs. The other lower capacity springs were unsatisfactory. It was also determined that the Timken front axle housing was structurally weak, and strengthening was recommended. An experimental wind-up pad between the frame and the rear half of the front leaf springs was also recommended to prevent universal joint oil pan interference; also to prevent spring breakage.
GENERAL: This 58-page report contains four photographs showing spring installations and component failure. Also included are daily log sheets, spring calibration data, and sketches of the various installations.

SUBJECT: Suspensions APG 5549/3
TITLE: First Report on Multiple Gun Motor Carriage, M15, Rear Suspension System
IDENTIFICATION: Third Report on Ordnance Program No. 5549 (Project No. 1303/6-2-6-10) - APG 225-87

DATE OF REPORT: 25 January 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the test rear suspension system for use on a Multiple Gun Motor Carriage M15
METHOD: The test rear suspension system was installed in a Gun Motor Carriage, M15, and operated for 3300 miles. Various bogie crabs were used during the test.
DESCRIPTION: In the initial phase of the test, one set of 1/4-inch spring seat spacer washers and a 1/4-inch spacer ring for the large end of the volute spring were used together with a set of special bogie crabs with a higher Brinell hardness than standard, and one set of number three perch bogie volute springs of 14,000 pounds capacity. In the second phase of the test, 25,000 pound capacity bogie volute springs and one set of 1/2-inch washers for mounting between the bogie spring block and the springs were used.
CONCLUSIONS: The heavier bogie volute springs and the 1/4-inch spring seat spacer washer for the small end of the spring were satisfactory. Bogie crabs, manufactured by the Autocar Company were satisfactory; the White Company bogie crab failed. It was recommended that the Autocar bogie crab be accepted after minor modifications listed in the report were made.
GENERAL: This 93-page report contains 13 photographs illustrating test failures.

SUBJECT: Suspensions APG 5568/51
TITLE: First Report on Ride Test Comparison of the Medium Tanks M4A1, M4E8, and M4E4
IDENTIFICATION: Fifty-First Report on Ordnance Program No. 5568; APG 10-162
DATE OF REPORT: 1 December 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the ride characteristics of the Medium Tank, M4E4, and compare them with those of the M4A1 and M4E8
METHOD: Three medium tanks, and M4E4, M4A1, and an M4E8, were operated over various terrain while using a ride indicator to obtain a record of each vehicle ride characteristic.
DESCRIPTION: The test Medium Tank M4E4 was a standard vehicle except for the suspension system. The road wheels of the vehicle were individually sprung on torsion bar springs. The vehicle mounted twelve pairs of dual, demountable disc wheels, 26 x 5-1/2 inches; six dual, rubber covered, 14-inch track support rollers; two 13 teeth 27.07-inch pitch diameter sprockets driving through a cored opening in the track shoes; eight Monroe direct acting shock absorbers mounted in the one, two, four, and five positions on the right and left sides; two 24-1/2-inch rubber covered idler wheels connected to the number six wheel support arm; and two cast-steel, center guide, rubber bushed, 24-inch wide tracks with a six-inch pitch for each block. The M4A1 had a standard vertical volute spring suspension with rubber block tracks. The M4E8 had a horizontal volute spring suspension buffered by telescopic-type hydraulic shock absorbers and had 23-inch cast-steel, center guide, rubber bushed tracks.
CONCLUSIONS: The M4E4 rideability, with the torsion bar suspension system, was generally superior to that of the M4A1 and M4E8. However, the M4E4 was inferior in ride characteristics when operating over hard surfaces. It was recommended that the torsion bar system be considered for M4 tanks and that a durability test of the system be conducted.
GENERAL: This 78-page report contains 16 photographs of the test vehicle and 33 photostats of the ride indicator records.

SUBJECT: Suspensions APG 5568/52
TITLE: First Report on Medium Tank, M4E8, Engineering Tests
IDENTIFICATION: Fifty-Second Report on Ordnance Program No. 5568; APG 10-163
DATE OF REPORT: 6 December 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate the horizontal volute spring suspension on Medium Tank M4E8
METHOD: The test vehicle was operated 895 miles over various test courses, and firing stability tests and ride tests were conducted.
DESCRIPTION: The test vehicle was a Medium Tank M4A3, equipped with a horizontal volute spring suspension and 23-inch center guide tracks and designated M4E8. The suspension system consisted of three bogie assemblies on each side of the tank, two horizontal volute springs in each bogie assembly operated in conjunction with a hydraulic shock absorber mounted horizontally between two support arms on each bogie assembly.
CONCLUSIONS: The horizontal volute spring suspension was considered superior to the vertical volute spring suspension, and substitution of horizontal for vertical volute spring suspensions was recommended if the volute springs were to be continued in use. Ride quality, firing stability, and obstacle crossing ability of the test vehicle were superior to those of Medium Tank M4A3; and it was virtually impossible to throw the track.
GENERAL: This 162-page report contains 31 photographs of the test vehicle and test operations.

SUBJECT: Suspensions APG 5642/5
TITLE: Second Report on Light Armored Car M8E1
IDENTIFICATION: Fifth Report on Ordnance Program No. 5642; APG 12-9
DATE OF REPORT: 18 June 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and mechanical reliability of forged upper support arms to link vehicle torsion bars with front wheels on the Light Armored Car M8
METHOD: The forged upper support arms were installed to replace cast arms on the Light Armored Car M8E1 and the vehicle was operated over 139 miles of gravel, 472 miles of concrete, and 1128 miles cross-country.
DESCRIPTION: The test support arm was a component of the torsion bar parallelogram front wheel suspension system. Both the upper and

lower arms were pivoted to the spindle housing of the wheel and attached to a supporting bracket on the side of the vehicle. The upper arm was splined to a torsion bar running along the side of the hull. The front wheels were suspended independently from the torsion bar spring, and power reached them through outer and inner axles which drove through two constant velocity universal joints.
CONCLUSIONS: The test support was considered a satisfactory component, although the caster and kingpin inclination built into the front wheel suspension did not straighten the vehicle after a turn. Various mechanical elements required strengthening and/or design changes to correct the deficiencies encountered.
GENERAL: This 82-page report includes 18 photographs of the Armored Car M8E1, suspension details, and failed parts. One sketch of the side armor reinforcement is also included.

SUBJECT: Suspensions APG 5661/12
TITLE: Suspension, Horizontal Volute Springs for Medium Tank
IDENTIFICATION: Twelfth Report on Ordnance Program No. 5661; APG 23-12
DATE OF REPORT: 23 November 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the relative gun platform stability of Medium Tanks equipped with horizontal volute spring suspensions, both with and without shock absorbers, and vertical volute spring suspensions; and to determine the proper shock absorbers for use with the horizontal volute spring suspensions
METHOD: Actual and simulated firing tests were conducted with the vehicle equipped both with and without shock absorbers and the horizontal volute spring suspension. Pitch, roll, and acceleration data on the various suspension shock absorber combinations were obtained by the use of a Sperry Pitch, Roll, and Ride Recorder. Road tests were conducted to determine shock absorber life and action.
DESCRIPTION: The Medium Tank M3 tested was equipped with a pilot horizontal volute spring suspension designed by the Ordnance Office and manufactured by the Chrysler Engineering Company. It was originally equipped with Monroe shock absorbers, but later shock absorbers made by the Cleveland Pneumatic Tool Company were tested.
CONCLUSIONS: It was felt that so many factors were involved in gathering information on the ride quality and platform stability of a vehicle such as the one tested, that it was practically impossible to keep all the factors constant and obtain concrete information. However, the results obtained during the test were considered as giving an indication of the relative performance of the various setups. The medium tank equipped with horizontal suspension, shock absorbers, and standard rubber block tracks, easily negotiated a 36-inch vertical obstacle, while a medium tank with standard vertical suspension had difficulty in negotiating a 24-inch vertical obstacle, and could not negotiate a 36-inch obstacle. Both the original Monroe and the latest type Cleveland Pneumatic Tool Company shock absorbers, were mechanically more reliable than the standard vertical volute spring suspension, and seemed to offer a more stable gun platform. It was recommended that serious consideration be given to the horizontal type suspension for replacement of the then standard vertical volute spring suspension on medium tanks.
GENERAL: This 184-page report contains 13 photographs showing over-all views of the suspension and also its components. Also included are 96 daily log sheets and 25 data curve sheets on the pitch and roll tests.

SUBJECT: Suspensions APG 5661/17
TITLE: First Report on Spaced Suspension and Extended End Connectors for Light Tank M5A1
IDENTIFICATION: Seventeenth Report on Ordnance Program No. 5661; APG 23-14
DATE OF REPORT: 3 March 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and mud performance of a spaced suspension and extended end connectors; and to determine the weight increase incurred by their use
METHOD: The traction test consisted of driving a Light Tank M5A1 into prepared mud and coming to a complete stop. The throttle on the test vehicle was opened slowly until 100% track slip occurred. Drawbar pull was obtained with a field dynamometer just at this time and the tractive coefficient was determined. This procedure was observed on two vehicles; one having the flat rubber block tracks, T16, with standard end connectors, and the other using extended end connectors on both sides. The endurance operation consisted of 1303 miles of which 769 were cross-country, 444 gravel roads, and 90 paved roads.
DESCRIPTION: The spaced suspension was merely a standard vertical volute spring suspension for Light Tank M5A1 set out from the hull by steel spacers approximately 2-1/2 inches thick. These spacers were welded to the hull; and the idler, track support rollers, and suspension brackets were bolted to the spacers. The extended end connectors were identical with the standard connectors except for an extension, commonly known as the "Duck Bill", welded to the end. It increased the over-all length of the standard end connectors from 1.5 to 5.0 inches and increased the width of the track to 18-9/16 inches. Added weight to the vehicle was calculated to be 1200 pounds.
CONCLUSIONS: Although the extended end connectors appreciably decreased the unit ground pressure, they were not satisfactory for general cross-country operation. Bogie and idler wheel tire life was considerably reduced due to excessive guide cutting when using the extended end connectors. The method of spacing the suspension out from the hull, however, was satisfactory. It was recommended that the extended end connectors not be adopted for use on Light Tank M5A1 except as a limited expedient; that, in all future track design and development, the basic track width be made sufficient to provide necessary

flotation without having to resort to extensions.
GENERAL: This 39-page report contains 13 photographs of the test suspension, the test vehicles, and track components.

SUBJECT: Suspensions APG 5661/19
TITLE: First Report on Spaced Suspension and Extended End Connectors for Medium Tanks M4
IDENTIFICATION: Nineteenth Report on Ordnance Program No. 5661; APG 23-15
DATE OF REPORT: 26 May 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To install suspension spacers and double extended end connectors on a Medium Tank M4A3; to determine the flotation, traction, and other performance characteristics obtainable with widened track; and to note vehicle weight increase and parts durability
METHOD: Suspension spacers were welded to a medium tank hull; extended end connectors were installed on T54E2 track; and vehicle weight was found to total 73,000 pounds. The test vehicle was operated in deep mud in competition with a 68,000-pound Medium Tank M4A1 equipped with standard T54E1 steel chevron track. Traction coefficients were obtained by measuring drawbar pull at the point of 100% track slippage and dividing by vehicle weight. "Go and no-go" comparisons were also made in swampy and rough terrain. The test vehicle was operated 839 miles before discontinuance of the endurance phase.
DESCRIPTION: The standard vertical volute suspension units were spaced out 4-1/2 inches from the tank hull by special cast steel spacer brackets arc-welded to the hull. Special extensions for sprocket hubs were also installed. The extended end connectors were of welded "duckbill" type and, installed on both inboard and outboard sides of the track, increased the standard 16-9/16-inch track width to 23-11/16 inches.
CONCLUSIONS: Ground contact area was increased 43% and unit ground pressure reduced from 14.3 psi to 10.3 psi by the use of double extended end connectors. Traction was reduced, and guide cutting and track throwing tendency were somewhat increased. Extended end connector durability appeared comparable to that of T54E2 steel chevron track, except that operation on rocky or wooded terrain resulted in reduced extension plate life. About 180 man-hours were required for the test installation, and vehicle weight was increased 3 percent. Only limited acceptance and use of spaced suspension and double extended end connectors were recommended. End connector modification to permit attachment of grousers was suggested to improve traction.
GENERAL: This 70-page report contains seven photos of test parts and installations.

SUBJECT: Suspensions APG 5661/20
TITLE: First Report on Suspension, Whiffletree, on Medium Tank M4E8
IDENTIFICATION: Twentieth Report on Ordnance Program No. 5661; APG 23-16
DATE OF REPORT: 23 July 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate the effect of rubber-bushed suspension arms on tire life as compared with that of the standard suspension arms; the vehicle handling qualities as affected by the rubber-bushed suspension arms; the durability of the rubber-bushed suspension arms; and the comparative durability between rubber bushings with different wall thicknesses
METHOD: The rubber-bushed suspension arms with thick and thin wall rubber bushings were mounted alternately on the right and left-hand sides of a Medium Tank M4A3 (E8), and the vehicle was operated 1743 miles. It was equipped with synthetic rubber test tires. Another identical tank had test tires of the same compound mounted in identical positions on standard suspension arms. Both vehicles weighed 76,000 pounds and were run on T66 steel tracks. The vehicles were operated concurrently at speeds up to 25 mph, until failure of 18 of the test tires furnished. Operation was on 75% smooth gravel and 25% smooth concrete. A chart was made to compare tire wear results of the rubber-bushed suspension arms against the standard suspension arms.
DESCRIPTION: The rubber-bushed whiffletree suspension arms were designed to allow articulation of the dual bogie wheels thereby giving equal tire loading when the track was tilted up to 5°. Six of the arms had bushings 0.27 inch thick, and six were 0.22 inch. Test tires were Goodrich synthetic, 20-1/2 x 6-1/4.
CONCLUSIONS: There was no appreciable difference in the tire life, as affected by the rubber-bushed suspension arms, when compared with standard suspension arms. Both the thick and thin walled rubber-bushed suspension arms had satisfactory durability, and the rubber-bushed arms caused no apparent difference in vehicle handling characteristics. It was recommended that the rubber-bushed suspension arms be tested further over a course which would more readily show the value of articulating suspension arms.
GENERAL: This 62-page report contains four photographs illustrating pertinent components of the suspension assembly and views of the actual test run.

SUBJECT: Suspensions APG 5720/2
TITLE: First Report on Test of Truck 1/4-Ton, 4 x 4 - Suspension System
IDENTIFICATION: Second Report on Ordnance Program No. 5720; APG 14-44
DATE OF REPORT: 19 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability and desirability of incorporating heavier springs into the design of the 1/4-ton truck
METHOD: Eight vehicles were used in the test. Two types of shock absorbers and two types of heavy springs were mounted on the test vehicles in various combinations with the standard equipment and with loads of 800 and 1600 pounds. A test course consisting of eight miles of smooth concrete road and eight miles of Belgian Block road was used. Maximum speed over the Belgian

Block road was 25 mph. The vehicles were operated over the test course in an accelerated life test.
DESCRIPTION: The test vehicles were manufactured by Ford Motor Car Company and Willys. The two types of shock absorbers were manufactured by Monroe Auto Equipment Company and Gabriel. The two heavy springs were types A-8463 and A-8464.
CONCLUSIONS: It was recommended that production 1/4-ton, 4 x 4 trucks be equipped with heavier type springs with increased camber, that all spring leaves be shot blasted, that the life of the shock absorbers be improved, and that the vehicle frames be reinforced. It was found that the standard spring was satisfactory if the shock absorbers were properly maintained and not permitted to malfunction.
GENERAL: This 99-page report contains 75 photographs showing results of the test on the vehicle frame, springs, and shock absorbers.

SUBJECT: Suspensions APG 5734/1
TITLE: First Report on Ride Test Comparison Between the Medium Tank T20E3 With Torsion Bar Suspension and Medium Tank M4A1 With Standard Suspension
IDENTIFICATION: First Report on Ordnance Program No. 5734
DATE OF REPORT: 25 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the most suitable of two types of tank suspension in regard to the vehicle's ride characteristics
METHOD: A medium tank T20E3 equipped with the test suspension and a medium tank M4A1 equipped with the standard suspension were operated at 5 and 20 mph over several test courses including level concrete, rough Belgian Block, high transverse washboard, staggered concrete washboard, and cross-country terrain. Data regarding the vehicle's ride characteristics were obtained from a "R-S Ride Indicator" installed in each vehicle in the center of the turret floor. Lights were placed on the medium tank T20E3 in various positions and the vehicle was run, in front of a camera with an open shutter, over level concrete, Belgian Block, coarse washboard, and intermittent convex contours courses. The total test mileage was 82 miles.
DESCRIPTION: The medium tank T20E3 was a full tracklaying vehicle weighing 62,000 pounds as tested. Its primary armament consisted of a 76mm gun, M1. The vehicle was powered by a Ford GAN V8 liquid-cooled engine rated at 470 hp at 2800 rpm. The power train consisted of a combination torque converter-gear transmission, a controlled differential, and two final drives. The test suspension was of the torsion bar type, consisting of 12 torsion bars on which were mounted twelve 26x4-1/2-inch dual bogie wheels of which numbers 1, 2, 5, and 6 were equipped with Monroe direct acting shock absorbers. It had two 24-1/2-inch diameter idlers mounted in the front for track slack compensation. Each track was returned to the bogie wheels by means of three pairs of dual rubber covered 13-1/2-inch diameter track support rollers. The track was a cast steel, center guide, rubber-bushed track, 18-inches wide from pin to pin with a 6-inch pitch. The medium tank M4A1 was a standard production unit.
CONCLUSIONS: The ride characteristics of the medium tank T20E3 were superior to those of the medium tank M4A1. It was recommended that the test torsion bar suspension be accepted as standard for vehicles of this type provided the maintenance and durability requirements could be met. It was felt that items requiring relatively fine adjustment, such as sighting and fire control equipment, would retain their adjustment for a longer time in the test vehicle than in the standard vehicle.
GENERAL: This 59-page report includes 14 photographs of the test vehicle and photostats of the light test.

SUBJECT: Suspensions APG 6004/11
TITLE: First Report on Heavy Tank M26, Elimination of the Compensating Action of the Front Idler
IDENTIFICATION: Eleventh Report on Endurance Program No. 6004; APG 10-181 (Project No. 4361/3-43-12)
DATE OF REPORT: 3 October 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether compensating idler action was necessary for satisfactory vehicular and track performance
METHOD: The idler compensating action on a Heavy Tank M26 was eliminated. This tank was then test operated for 1098 miles: 868 miles cross-country, 35 miles in sand, 91 miles on a gravel road, and 104 miles on highways.
DESCRIPTION: The test tank was a standard Heavy Tank M26 with the compensating action between the track idler and the front road wheel eliminated. This was accomplished on the test tank by cutting the idler spindle mount from the front road wheel arm. This idler spindle mount and a portion of the arm assembly were moved forward about two inches, rotated 20 degrees in a clockwise direction and affixed to the hull side plate.
CONCLUSIONS: It was found that the compensating idler feature was not absolutely necessary for proper track and vehicular performance, but that more satisfactory pitch control was provided on vehicles with a compensating idler.
GENERAL: This 42-page report contains four photographs of the test vehicle and the modification performed to eliminate idler compensation

SUBJECT: Suspensions APG 6004/15
TITLE: First Report on Heavy Tank M26, Suspension Components
IDENTIFICATION: Fifteenth Report on Ordnance Program No. 6004 APG 10-202
DATE OF REPORT: 6 February 1946
ORIGIN: Aberdeen Proving Ground, Maryland

PURPOSE: To determine the efficiency of various suspension modifications incorporated on the Heavy Tank M26
METHOD: Various suspension combinations were installed on Heavy Tanks M26, and operated over a special test course. By means of photographs measurements were taken of the path of the suspension components as the vehicle traversed the test course. Strain gauge measurements of the loads on the front shackle arms were taken, and a strain gauge drawbar was used to measure the stresses imposed upon the 90-mm gun elevating mechanism.
DESCRIPTION: The test suspension components were: modified torsion bars increased to 2.35 inches diameter, thereby increasing capacity by 15%; shock absorbers were standard, except for a change in valving to permit 50% increase in control, and special shock absorbers 3-1/3 inches shorter than the standard but having the same control; larger road wheel hubs with Timken 749A inner bearings; and hydraulic bump stops, with increased capacity over the standard spring type for the No. 1 road wheel only, manufactured by Delco Products Division of GMC.
CONCLUSIONS: The test road wheel inner bearings, torsion bars, and auxiliary shock absorbers on the front road wheel arms proved satisfactory, and were recommended for production. A torsion bar of larger diameter than 2.35 inches was recommended for the Nos. 1 and 2 road wheels; and the auxiliary shock absorbers should be installed so as to utilize the greatest possible percentage of their full travel. The hydraulic bump stop was considered unnecessary and further tests were recommended to determine means of eliminating idler wheel contact with the ground or cushioning the shock of this contact. An improved suspension would decrease the shock loads imposed on other components such as the elevating mechanism.
GENERAL: This 111-page report contains 12 photographs of the test components and test course, one oscillatory graph on strain gage measurements, 16 graphs on loads imposed on road wheel arm shackles and elevating mechanism, and 20 curve sheets on the various suspension combinations.

SUBJECT: Suspensions APG 6008/3
TITLE: First Report on Limber, Heavy Carriage M5, Non-Heat Treated Axle Spindles
IDENTIFICATION: Third Report on Ordnance Program No. 6008 APG 42-17
DATE OF REPORT: 26 May 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether limbers with non-heat treated spindles were suitable for military use
METHOD: The three Heavy Carriage Limbers, M5, were coupled to Ammunition Trailers, M23, and operated 217, 264, and 274 miles, respectively. At the end of the test the spindles were radiographed for defects and tested for hardness, and the axles were shipped to Parish Pressed Steel Co. for magnaflux inspection.
DESCRIPTION: The test limbers were Heavy Carriage Limbers, M5, manufactured by the Heit Company with non-heat treated axle spindles. The limbers were modified for use with Ammunition Trailer, M23.
CONCLUSIONS: The road test disclosed no deficiencies in spindles or axles, and no flaws or defects were found when the spindles were radiographed. Hardness of the spindles between the bearing seats was: right spindles 187, 229, and 187; left spindles 229, 197, and 197. Magnaflux inspection showed short cracks of approximately 1/4-inch, but these were not believed caused by fatigue or considered sufficient to cause failure of axles. It was concluded that the limbers were capable of withstanding severe operation and were suitable for military use. It was recommended that the limbers manufactured with non-heat treated spindles be used for military purposes and that they be modified to permit use with Ammunition Trailers, M23.
GENERAL: This 22-page report contains one photograph of the modified limber.

SUBJECT: Suspensions APG 6009/1
TITLE: First Report on Test of Heavy Tank M26, Modified Suspension, Suitability for Heavy Tanks T29 and T32
IDENTIFICATION: First Report on Ordnance Program No. 6009; APG 10-179
DATE OF REPORT: 1 October 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether pusher-type suspension arms could be used instead of trailing arms on the leading road wheels of Heavy Tanks M26, T29, and T32
METHOD: No. 1 road wheels, suspension arms, and torsion bars were removed from a Heavy Tank M26, and Nos. 2, 3, and 4 wheels, arms, and torsion bars were reversed. The vehicle was operated over vertical walls, washboard course, and a bridging device. Motion pictures were made of the operation of the test suspension.
DESCRIPTION: The test suspension was a modified torsion bar suspension for Heavy Tank, M26, Serial No. 14, with No. 1 road wheel removed and pusher type suspension arms installed on Nos. 2, 3, and 4 road wheels.
CONCLUSIONS: The original suspension with trailing suspension arms was superior to the test suspension with pusher arms. Extensive suspension modification would be required to develop a satisfactory pusher type arm. Use of pusher arms was not recommended.
GENERAL: This 26-page report contains six photographs of the test vehicle and suspension.

SUBJECT: Suspensions APG 6009/13
TITLE: First Report on Medium Tank M26, Auxiliary Spring Loaded Idlers
IDENTIFICATION: Thirteenth Report on Ordnance Program No. 6009; APG 10-209
DATE OF REPORT: 10 September 1946
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and effectiveness of auxiliary spring-loaded idlers in

eliminating or reducing track throwing on a rear sprocket-driven medium tank
METHOD: An auxiliary spring-loaded idler assembly was installed between the No. 6 road wheel and sprocket on each side of Medium Tank, M26. The test vehicle and an M26 control vehicle were then operated on turns varying in radii from 30 to 60 feet at speeds from 3 to 20 mph. The durability of the idlers was determined by 250 miles operation cross-country and 100 miles operation on gravel roads.
DESCRIPTION: The test idler assemblies were designed to take up track slack during vehicle turning and reduce track throwing tendencies. The idler assembly consisted of a modified track support roller mounted on a suspension arm and torsion bar. In order to make room for this auxiliary idler arrangement, the final drive unit was revolved 60 degrees rearward and clamped into position by use of a bracket.
CONCLUSIONS: The test idlers reduced track throwing and were considered sufficiently durable. It was recommended that these idler assemblies be installed as standard equipment on Medium Tanks M26 and that they be tested for use on other vehicles, especially Heavy Tank T32.
GENERAL: This 56-page report includes 22 photographs of the idler components and their assembly and installations.

SUBJECT: Suspensions APG 6009/18
TITLE: First Report on Performance Test of Suspension Cams on Medium Tank M26
IDENTIFICATION: Eighteenth Report on Ordnance Program No. 6009; APG 23-17
DATE OF REPORT: 13 May 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether or not a cam suspension, replacing the front road wheel arm shackle, would improve the riding qualities of the vehicle; and to determine the effect of the cam suspension on the life of the No. 1 road wheel bearings
METHOD: A set of test suspension cams was installed on a Medium Tank M26, and the vehicle was operated over a bump course. A standard vehicle and the test vehicle were then equipped with R-S Ride Indicators and operated in convoy on various washboard and Belgian Block courses.
DESCRIPTION: The test components consisted of cam-shaped steel segments welded to the front spring and road wheel suspension arms. Installation was made by removing the front spring arm shackles and welding one cam to the front spring arm and the other to the front road wheel arm, so that the hardened convex surfaces of the cams faced each other. In operation the cams bore against each other, and as the road wheels were deflected, a sliding action took place between the cams as the load was transmitted to the torsion bar and shock absorber.
CONCLUSIONS: The ride quality obtained from the cam suspension over severe terrain was superior to that obtained from the standard M26 suspension. Over moderate terrain, however, the ride quality was inferior to that of the standard suspension; the degree of pitch of the hull was somewhat reduced, but the vertical acceleration imparted to the hull was greater. The life of the No. 1 road wheel bearings on the test vehicle was improved. It was recommended that the cam design be considered a satisfactory means of reducing the pitch when greater stability is desired. It was further recommended that the cam design be made available for installation on suspensions where over-load conditions exist, causing front road wheel bearing failures.
GENERAL: This 75-page report contains five photographs illustrating the test installation and a paper entitled "The Riding Qualities of Automotive Vehicles."

SUBJECT: Suspensions APG Ar-18565
TITLE: Investigation of Methods of Failure of Torsion Bar Support Housing Fastenings
IDENTIFICATION: Report No. Ar-18565; Project No. TT1-5
DATE OF REPORT: 1 August 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To investigate weaknesses of tank road arm support bolts exposed to mine blast
METHOD: Two single mines were statically detonated in a position at which bolts in the road wheel arm support bracket had failed in a previous test (Firing Record Ar-17429). The mines were detonated singly, even with the outer edge of the track and outboard, on opposite sides of the test tank.
DESCRIPTION: The test vehicle was a Tank T26E5 which had an individually sprung wheel, torsion bar type of suspension exactly like that of the M26 tank. The test mines were Heavy, AT, T6E1 Mines.
CONCLUSIONS: All bolts which failed in this test, with mines located outboard of the road wheel, failed in shear. Failures which occurred in other mine tests (see Firing Record Ar-18536) indicated that for mines detonated inboard, under the hull, tensile failures might occur. Apparently, when mines were detonated outboard, the whole road wheel, arm, and bracket assembly slid along the sloping hull surface to which it was bolted, causing the bolts to be sheared off flush with the hull surface. When mines were detonated at certain locations inboard, the hull armor was pushed upward away from the bracket, causing tensile failures in the bolts. It appeared that a blast had to be of sufficient magnitude to break the double pin track before it could cause failure of the road arm support bracket bolts.
GENERAL: This 20-page report contains four photographs: two of damage to the test tank, one of micro-etched longitudinal sections of the support bolts, and one photomicrograph of transverse and longitudinal cross sections of the support bolts.

SUBJECT: Suspensions APG TT1-19/2
TITLE: Final Report on Test of Sarsal Track Adjusting Screw
IDENTIFICATION: Second Report on Project No. TT1-19; APG 21-140

DATE OF REPORT: 27 December 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine durability, reliability, and ease of operation of the Sarsal device under field conditions
METHOD: The device was installed on an M24 Light Tank and operated 527 miles. Various locking and sealing devices were tried during the tests. Adjustments were made in the field using the device, and it was disassembled periodically to note entry of foreign matter.
DESCRIPTION: The Sarsal device was an anti-friction nut designed to permit operation of a screw under heavy loads with a minimum of effort. Sliding friction in the threads was eliminated, the rolling friction of a set of steel balls being substituted. For use in adjusting tank track tension it could be installed on the tension adjusting screws of tanks so equipped, permitting easy adjustment by one man without special tools.
CONCLUSIONS: With the final provisions for sealing and locking used in the test, the device was satisfactory though the design could still be improved. Shock and vibration did not affect it. Adjustments could easily be made in less than five minutes without special tools. Though the M24 Light Tank was out of production at the time of the test, the device was adaptable for use on T41, T42, and T43 tanks.
GENERAL: This 29-page report contains 13 photographs showing the device disassembled, assembled, and installed. Detailed test procedure and data are included.

SUBJECT: Suspensions APG TT1-19/3
TITLE: Final Report on Test of Cast Steel Intermediate Suspension Arm Assemblies, Medium Tank
IDENTIFICATION: Third Report on Project No. TT1-19; APG 23-21
DATE OF REPORT: 27 October 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of cast steel intermediate road wheel arm assemblies for use on medium tanks
METHOD: Five right and five left test intermediate road wheel suspension arm assemblies were installed on a Medium Tank, M46, and operated a total of 4640 miles over various test courses.
DESCRIPTION: The test road wheel arms were the same as the standard arms for the M46 vehicle except that cast steel was used instead of forged steel. The minimum yield point for the cast steel arm was specified as 130,000 psi as compared to 125,000-157,000 psi estimated yield range for the forged arm. The centerline of the spindle bore of the test arms was offset 1° from the centerline of the core to compensate for upward deflection of the outer end of the spindle. When installed, under no load, the outer end of the spindle pointed toward the ground at 1° angle.
CONCLUSIONS: The test cast steel suspension arm assemblies, when strictly conforming to specifications, were as strong and as durable as the standard forged assemblies. Failures of two arms were traced to porous castings and too small a cross-sectional area near the spindle core. To eliminate this type failure, it was recommended that rigid control and inspection be maintained during manufacturing and that the cross-sectional area near the core be increased. The 1° positive camber successfully compensated for deflection of the arm and bearing assemblies and was recommended for incorporation in cast steel arms. It was further recommended that cast intermediate and rear suspension arm assemblies be considered for standardization on combat vehicles.
GENERAL: This 17-page report contains four photographs of failed arms.

SUBJECT: Suspensions APG TT1-19B/22
TITLE: Final Report on Determination of Life Cycle for Torsion Bars
IDENTIFICATION: Twenty-second Report on Project No. TT1-19B
DATE OF REPORT: 6 October 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the deflection cycles of a torsion bar on an M47, 90mm gun, tank during 25,000 miles of vehicle operation
METHOD: An M47, 90mm gun, tank was instrumented to record full and fractional deflections and rebound of the left front and left rear torsion bars. The vehicle was operated 89.5 miles on cross-country terrain. "Bump" and "rebound" deflections were counted, data being used to compute the number of twist cycles in 25,000 miles of operation.
DESCRIPTION: A mechanical-electrical type counter, connected to the road wheel arm by a link-work arrangement, recorded one-fourth, one-half, three-fourths, and full movement of the road wheel arm in the positive directions, and one-fourth and one-half movement in the negative direction. Since movement of the road wheel arm resulted in a proportional twist of the torsion bar, the acquired data represented torsion bar deflection.
CONCLUSIONS: The data obtained during this test were accurate only for cross-country operation. Full or fractional deflections would be different on other types of surfaces.
GENERAL: This 22-page report contains a laboratory report and a profile diagram of the Perryman cross-country course.

SUBJECT: Suspensions APG TT1-19B/38
TITLE: First and Final Report on Test of Boron Steel Trailing Idler Arms for T98E1 and T99E1 Self-Propelled Howitzers
IDENTIFICATION: Thirty-eighth Report on Project No. TT1-19B
DATE OF REPORT: 20 January 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Boron steel as an alternate material for highly stressed components currently fabricated of critical alloy steel
METHOD: Two sets of Boron steel trailing idler arms were installed on the T98E1 and T99E1 self-propelled howitzers and operated in conjunc-

tion with other tests of these vehicles. The mileage accumulated on each was approximately 1252 miles.
DESCRIPTION: The Boron steel arms were identical in appearance to the standard steel arms (7332517, arm, left trailing idler wheel; 7764540, arm, right trailing idler wheel) used on the T98E1 and T99E1 vehicles.
CONCLUSIONS: The trailing idler arm assembly components displayed poor durability resulting in an incomplete evaluation of the Boron steel idler arms. It was recommended that a retest of the arms be conducted only after more durable trailing idler arm assembly components were developed to insure an adequate test.
GENERAL: This 39-page report includes eight photographs of test failures.

SUBJECT: Suspensions APG TT1-19S/1
TITLE: Qualification Test of Helical Torsion Spring Suspension
IDENTIFICATION: First Report on Project No. TT1-19S
DATE OF REPORT: 23 March 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the characteristics of a helical torsion spring suspension for application to track-laying vehicles
METHOD: The experimental helical torsion spring suspensions were installed on a medium tank M46A1 and driven 183 miles over severe cross-country terrain.
DESCRIPTION: The helical torsion spring suspension unit consisted of a large helical spring of rectangular cross-section with an integral axial tang at each end. One end was anchored to the housing face plate, the other end being free to move radially and axially with the road wheel arm spindle on a splined carrier anchor.
CONCLUSIONS: Two of the suspensions failed under test because of material, manufacturing, and design deficiencies. It merited further research, however, because the suspension would give an over-all lower silhouette, besides saving weight in having less armor plate resulting from lower height. Recommendations were made to improve spring material, loading conditions, spring end retention, and bearing lubrication.
GENERAL: This 42-page report includes 17 photographs.

SUBJECT: Suspensions APG TT1-19T/8
TITLE: Test of Experimental Titanium Alloy Front Road Wheel Arm for Tank, 90mm Gun, M47
IDENTIFICATION: Two Hundred Fortieth Report on Project No. TB5-1401 and Eighth Report on Project No. TT1-19T
DATE OF REPORT: 21 March 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of titanium alloy for suspension components utilized under low temperature environmental conditions
METHOD: An experimental left road wheel arm was installed on tank, 90mm gun, M47 with a standard control road wheel arm on the right. The arm was tested by cold soaking followed by cold-weather operation for 7 miles. Test operations were conducted at Fort Churchill, Manitoba, Canada.
DESCRIPTION: The test assembly, Part No. D-7328857, consisted of titanium alloy arm, Part No. E7328804; wheel spindle of titanium alloy, Part No. C5602433; and arm spindle of boron steel. Part No. C7021543.
CONCLUSIONS: The titanium alloy road wheel did not prove satisfactory for cold-weather operation and was not recommended. The test arm failed after 7 miles of cross-country operation after having been cold soaked in ambient temperatures ranging between 1°F and -15°F.
GENERAL: This 41-page report includes three photographs of the failed road wheel arm.

SUBJECT: Suspensions APG TT1-20-17/1
TITLE: Test of Independent Front Wheel Suspension for Truck, 2-1/2-Ton, 6 x 6
IDENTIFICATION: First Report on Project TT1-20-17; APG 23-18
DATE OF REPORT: 5 May 1948
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine effectiveness and durability of an experimental independent front wheel suspension for transport vehicles
METHOD: A 2-1/2-ton, 6 x 6 truck with independent torsion bar type of front wheel suspension and a standard truck of the same type were loaded with 5000 pounds and operated 10,000 miles over various types of roads. Turning radii, steering characteristics, ride qualities, and possible use of chains and cross-country tires on front wheels were determined.
DESCRIPTION: The test equipment was an independent front wheel suspension system for a 2-1/2-ton truck. The test suspension was a planar, parallel link suspension with torsion bar springs parallel to the frame side rails instead of coil springs. A direct acting shock absorber was used in each wheel. The test suspension was installed on a standard 2-1/2-ton, 6 x 6, long wheel base truck with cargo body, banjo type axles, and front mounted winch. Another truck of the same type with standard front wheel suspension was used as a control vehicle.
CONCLUSIONS: The riding and steering qualities of the test vehicle were superior to those of the standard vehicle. There was less road shock transmitted to the steering and less front tire wear on the test vehicle than on the standard vehicle, and the torsion bar springs out-lasted several sets of front leaf springs on the standard truck. Difficulty was encountered with cracking of the test truck frame at the torsion bar rear anchor bracket, and it was recommended that further study be made of the test suspension to eliminate frame failures.
GENERAL: This 50-page report contains 21 photographs of the front wheel suspension installation before and after testing.

SUBJECT: Suspensions APG TT1-20-21/1
TITLE: Study and Test of German 3/4 Track Suspensions

IDENTIFICATION: First Report on Project TT1-20-21; APG 23-19
DATE OF REPORT: 15 November 1948
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate merits of a German interlaced suspension and needle bearing track by field tests and comparison with a standard Light Tank M24
METHOD: Two Light Tanks M24, one equipped with tracks and suspension from a German 12-ton 3/4 track prime mover were tested and compared for resistance to traction when towed in neutral with final drives connected, disconnected, and with track removed; deceleration on concrete by recording distance coasted from 5, 10, 15, and 20 mph road speeds; and road load and full load resistance to propulsion on the bituminous concrete dynamometer course using a propeller shaft torquemeter.
DESCRIPTION: Material tested consisted of a suspension from a German 12-ton, 3/4 track prime mover adapted to the Light Tank M24 by installing the torsion bar housings beneath hull floor of the tank. German idlers, sprockets, and 16-inch needle bearing track were adapted. The turret of the M24 was removed to bring over-all weight down to 32.800 pounds. Standard Light Tank M24 with turret removed was used for comparison.
CONCLUSIONS: Towed resistance of the standard Light Tank M24 on bogie wheels averaged 20% more than the light tank equipped with German interlaced suspension. At two mph, the German track and suspension resistance was 37% less than M24 with steel tracks and 54% less than with rubber tracks. As speed was increased percentage of advantage decreased. In the deceleration tests distances were greater for the vehicle equipped with German tracks. All in all the German prime mover interlaced suspension and needle bearing track seemed to have advantages in terms of resistance to movement on pavement at speeds below 15 mph. Weaknesses of adaptation and steering difficulties in mud precluded contemplated testing in mud. It was therefore recommended the project be canceled.
GENERAL: This 65-page report contains 15 photographs of the M24 equipped with German suspension and tracks and detailed photographs of parts.

SUBJECT: Suspensions APG TT1-696/6
TITLE: Testing and Development of Track and Suspension System Components for New Amphibian Vehicles
IDENTIFICATION: Sixth Report on Project No. TT1-696; APG 23-20
DATE OF REPORT: 9 February 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To obtain data necessary for establishing ride and stability characteristics of existing LVT vehicles for comparison with new track and suspension systems now being developed
METHOD: Drop tests were conducted to determine natural frequency of the suspension and to obtain the damping decrement. Either the side or the rear of the LVT's was raised with a crane and the vehicles set oscillating by releasing from a height of two or three inches. The amplified output of a Statham 2G Accelerometer pickup unit was recorded by a magnetic oscillograph. The vibration spectrum of the LVT's was obtained at various points on the vehicles. A General Radio Type 759 crystal pickup, a 761 vibration meter, and a 762 vibration analyzer were used to obtain data for plotting acceleration against frequency at various vehicle speeds on hard packed gravel, wet sand, and in water. Acceleration records were obtained using a 6-element accelerometer with the test vehicles negotiating a 12-inch log at 2/3 mph operating on hard packed gravel, operating on the gun stabilizer course, and operating on turf.
DESCRIPTION: The LVT (4) was a full-tracked cargo and troop carrying amphibian vehicle designed for use in rough terrain, swamp land, and for beach landings through surf. The LVT (A) (5) was the same type vehicle except that it mounted a turret incorporating a 75mm Howitzer.
CONCLUSIONS: Natural frequency of the LVT's was about 2.8 cps, and the damping decrement was 0.5. The static deflection, bump clearance, and damping were considered major factors influencing the ride and vibration characteristics of a vehicle. As these factors were not all compatible, the suspension design must be proportioned to produce an adequate compromise. Steady static vibrations noted in the hull were below 100 in./sec./sec. (1/4G) and were considered to be of more importance from the standpoint of sound than vehicle stability. Transient vibrations with peak values up to 5.42 G were recorded in the hull. It was recommended that fatigue vibration tests of amphibious vehicles include drop tests and vibration spectrum investigation. An investigation of Reed gages for use in obtaining peak values of transient vibrations was also recommended.
GENERAL: This 82-page report contains four photographs of test instrumentations installed on vehicle, and 34 curve and data sheets.

SUBJECT: Suspensions APG TT1-696H/1
TITLE: Test of Axle Shafts on M34 or M35 Trucks
IDENTIFICATION: First Report on Project No. TT1-696H
DATE OF REPORT: 23 November 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the endurance characteristics of two new types of front axle shafts
METHOD: Both types of front axle shafts were tested on M35 vehicles weighted with 10,000-pound payloads; the front axle load for each vehicle was 6140 pounds. Test operations covered a total of 3486 miles over paved, Belgian Block, and cross-country courses.
DESCRIPTION: The front axle shafts had axle diameters of 1-1/2 inches and 1-9/16 inches. The standard front axle shaft had a diameter of 1-7/16 inches. Each of the test shafts was heat-treated by a new process.
CONCLUSIONS: Both types of test axles were of sufficient strength to satisfy the requirements of M34 and M35 trucks; it was recommended that they

be considered acceptable for use in these vehicles.
GENERAL: No photographs are included in this 20-page report.

SUBJECT: Suspensions APG TT1-696J/2
TITLE: Test of M47 Dump Truck Springs on M34 and M35 Trucks
IDENTIFICATION: Second Report on Project No. TT1-696J
DATE OF REPORT: 20 October 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the performance of M47 front springs with the standard springs used on M34 and M35 cargo carriers
METHOD: An M35 truck was equipped with M47 dump truck springs and axle bumpers and operated over paved, sand, Belgian Block, and cross-country courses. An M35 truck equipped with standard springs was similarly tested. Both trucks were weighted with a 10,000-pound payload and the distances between the axle and the frame were measured before and after test operations.
DESCRIPTION: The test suspension had a greater spring camber and larger front axle bumpers than the standard suspension.
CONCLUSIONS: The frame of the vehicle with the test springs bottomed less frequently than did the one with standard springs. It was recommended that the M47 dump truck springs be considered suitable for use on the M34 and M35 cargo carriers.
GENERAL: This 23-page report includes one photograph showing the condition of the front axle bumpers of both test trucks after testing.

SUBJECT: Suspensions APG TT1-699/2
TITLE: Ride Characteristics of Light Tank M24, Study and Development of (Test of Light Tank M24, Loaded to 50,000 Pounds)
IDENTIFICATION: Second Report on Project No. TT1-699; APG 39-2
DATE OF REPORT: 7 March 1949
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Light Tank M24 suspension systems for use with 50,000-pound vehicles; to observe the resulting ride characteristics
METHOD: Two M24 Light Tanks, each loaded to weigh 50,000 pounds, were used for testing. The first vehicle, employing standard tracks, and the second vehicle, using an increased width track, were operated over various types of terrain for 2366 and 1505 miles, respectively.
DESCRIPTION: The test suspension of the first vehicle was basically a standard M24 arrangement with the 1.734 and 1.890-inch diameter springs used at the rear and forward wheel positions replaced by ten torsion bar springs, 1.890 inches in diameter. The suspension components of the second vehicle were moved out 2-1/2 inches from the hull to allow the use of a 21-inch steel and rubber track T87. Volute spring bumper assembly C102465, used on the Medium Tank M26, and shock absorbers, No. X-2840, having 50% more shock control than the standard M24 type, were also used on this vehicle.
CONCLUSIONS: Because of continuous failures, the standard M24 suspension system bumper springs C108324, road wheels D76489, shock absorbers C136964, lip type oil seals, and 1.890-inch torsion bars, used with these parts, were considered unsatisfactory. Test shock absorber X-2840 and bumper spring C102465 were considered satisfactory for use with 50,000-pound vehicles; i.e., provided the shock absorbers be redesigned with snug-fit attaching pins at both ends to prevent dirt from entering the unit and fluid from leaking out. Although the test absorbers and springs improved the fatigue life of the 1.890-inch torsion bars, it was felt that the torsion bar was still unsatisfactory. It was recommended that more adequate lip type oil seals be developed. Because heavier bump springs and shock absorbers were used to improve torsion bar endurance, the vehicle riding characteristics were not as satisfactory as that of standard equipped suspension vehicles.
GENERAL: This 70-page report contains nine photographs showing views of the test tank as well as suspension parts damaged in operation, and track wheel support and torsion bar photostat drawings.

SUBJECT: Suspensions APG TT1-719A/6
TITLE: Test of Sway Bars for Truck, Utility, 1/4-Ton, 4x4, M38A1
IDENTIFICATION: Sixth Report on Project TT1-719A; APG 14-193
DATE OF REPORT: 5 June 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the sway bars on the M38A1 Utility Truck
METHOD: The test vehicle with sway bars attached was operated a total of 2803 miles over Belgian Block, spaced and radial corrugation, paved side slope, gravel, and cross-country courses. The vehicle was tested with no payload, 800 pounds payload, and 1200 pounds payload.
DESCRIPTION: The 1/4-Ton Utility Truck used in this test had springs of 165 lb./in. rate and a sway bar for each axle. Each sway bar consisted of a 3/4-inch steel bar extending across the truck below the frame and supported in rubber grommets by brackets to the side rails, the ends of the bar being turned toward the corresponding axle to form lever arms. The ends of the arms were connected to the axle by vertical rods mounted to the spring clip plates on rubber grommets and linked to the lever arms by rubber insulated connections. A change in deflection of only one of the springs imposed a movement on the sway bar to transfer some of the additional load to the opposite spring.
CONCLUSIONS: It was recommended that sway bars in conjunction with 165 lb./in. rate springs not be considered for use on the 1/4-Ton, 4x4, M38A1, Utility Trucks, since the trucks now being produced incorporate 224 lb./in. rate springs which maintain, without sway bars, the desirable vehicle performance and stability characteristics. Sway bars were necessary on the 1/4-ton truck with springs rated at 165 lb./in. to obtain satisfactory performance and stability characteristics.

GENERAL: This 51-page report contains six photographs showing installation of the sway bars on the vehicle and deficiencies encountered during testing.

SUBJECT: Suspensions APG TT1-719-J2/1
TITLE: Test of "Code A" Tandem Suspension
IDENTIFICATION: First Report on Project No. TT1-719-J2; APG 23-22
DATE OF REPORT: 1 November 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability and durability of a test tandem suspension for use on new Ordnance 12-ton semi-trailers
METHOD: A 11-15-ton single axle van semi-trailer was modified by removing the single axle suspension and installing the test tandem suspension. The semi-trailer was loaded to 36,650 pounds and towed by a 5-ton truck-tractor for 5044 test miles.
DESCRIPTION: The test tandem suspension, Model 336-3, made by the Neway Equipment Co., was rigidly mounted to the semi-trailer frame through trunnion leg castings to which was anchored the trunnion tube. A conventional semi-elliptic spring assembly which required no lubrication was rubber-mounted to the trunnion tube to permit longitudinal oscillation. The spring ends were anchored to dowels which were part of the axle saddle casting. Spring end caps, compressing rubber pads held the spring ends firmly on the dowels. This assembly permitted normal spring action and lateral axle articulation and absorbed braking torque. Design of the suspension was symmetrical about the center and provided for maximum interchangeability. For ease of maintenance, the suspension could be rolled free of the trailer by removing four bolts from each trunnion clamp and raising the rear of the trailer for clearance.
CONCLUSIONS: During the test, it was observed that the test semi-trailer possessed adequate stability and good riding qualities. Inspection after the test revealed no deficiencies in the suspension, or in the frame and body of the semi-trailer. No maintenance was required during the test and no lubrication was needed because the trunnion shaft was mounted in rubber bushings. The test suspension was considered suitable for use on full trailers or semi-trailers designed to carry tandem axle loads up to and including 36,000 pounds, and was recommended as satisfactory for use on the new Ordnance Corps 12-ton semi-trailer.
GENERAL: This 33-page report contains three photographs of the test vehicle and the test suspension assembly, and a sketch of the suspension.

SUBJECT: Suspensions APG TT2-760/52-144
TITLE: Damping Characteristics of T48 Tank with Shock Absorbers and Snubbers
IDENTIFICATION: Report No. 52-144 on Project TT2-760
DATE OF REPORT: 17 October 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suspension damping characteristics, angular displacement, and accelerations on the tank, 90mm gun, T48, with hydraulic shock absorbers, friction snubbers installed, and without shock absorbers.
METHOD: The tank, 90mm gun, T48 was used on the 18-inch drop tests, the angular displacement, and vibration tests on the 6-inch washboard course when the vehicle was equipped as follows: without shock absorbers; standard hydraulic shock absorbers; Houdaille-Hershey friction snubbers; and Delco experimental hydraulic shock absorbers.
DESCRIPTION: The test units were designated as follows: Houdaille-Hershey friction snubbers, standard shock absorbers Model 992A3, and Delco experimental hydraulic shock absorbers Model EX42910.
CONCLUSIONS: Both the friction snubbers and the experimental shock absorbers were designed to provide less damping than the standard hydraulic shock absorbers. The pitch damping decrement findings indicated that this had been accomplished.
GENERAL: This 18-page report includes 11 photographs of vibration studies.

SUBJECT: Suspensions APG TT3-618/1
TITLE: Test of Axle, Trailing, Self-Steering Type on Truck, 6-Ton, 6x6, Cargo
IDENTIFICATION: First Report on Project No. TT3-618; APG 14-105
DATE OF REPORT: 1 July 1948
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine effect of the self-steering axle on the vehicle and its performance
METHOD: The vehicle was given a preliminary inspection before tests. A six-tone load was placed in the vehicle. Weight reaction, turning radii, obstacle cross ability, slope operation, mud and snow operation, fuel consumption, braking, and tire wear tests were made on the vehicle. Operation tests of the vehicle were conducted with the steering axle locked and unlocked over 5000 miles of paved roads, 3000 miles of gravel roads and 1000 miles of cross-country.
DESCRIPTION: The self-steering axle was mounted as the trailing axle of a Timken-Detroit tandem rear axle and was manufactured by the Oliver Ayers Axle Company. The unit was installed on a 6-ton, 6x6, cargo truck. The torque arm springs and axle were modified and a pivot and locking device were added to the center of the axle housing. The axle could pivot a maximum of six degrees.
CONCLUSIONS: The effect of the self-steering axle on fuel consumption, tire wear, maintenance, maneuverability, and vehicle control was unfavorable. It was recommended that the self-steering axle be given no further consideration for use on military vehicles.
GENERAL: This 80-page report contains 11 photographs showing general construction and installation of the steering axle. Also included is an Automotive Laboratory Report No. 47-8 on deceleration, fuel consumption and power loss of the vehicle with self-steering axle.

SUBJECT: Suspensions APG TT3-742/3
TITLE: Test of Truck, Commercial W/Independent

Front Suspension (Canadian)
IDENTIFICATION: Third Report on Project No. TT3-742
DATE OF REPORT: 28 December 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of an independent front-wheel suspension in converting commercial trucks to military use quickly
METHOD: After the initial mechanical inspection, lubrication, and the weight distribution determination, the vehicle was operated for 130 miles over various test courses including slopes up to 31.5%.
DESCRIPTION: The vehicle used in the test was the standard production model truck F-6B, Ford 1953 series modified to include an all-wheel drive and independent front wheel suspension. The front wheel drive system consisted of a Ford light truck axle, shortened to allow a rigid mounting between the vehicle frame side rails. Power was transmitted to the wheels through double universal-jointed shafts and final drive drop gear case assembly located within each wheel. In the front suspension system, the king pins were supported, longitudinally, by a pair of parallel trailing arms that pivoted on a pair of tubes located squarely across the vehicle just ahead of the radiator. To provide springing for the front wheels, the lower arms were constructed as a large wishbone and projected beyond the pivot point to connect to a large coil spring assembly for each front wheel. These coil springs were set vertically just ahead of the tubes on which the arms pivoted. Sway bars were provided to control front end roll and shock absorbers were included in the IFS (Independent front suspension) kit.
CONCLUSIONS: The IFS kit was generally satisfactory; however, further development work was considered necessary to improve the ride, mobility, steering and breaking characteristics before it could be considered for military use. It was recommended that further development be left to the Directorate of Vehicle Development of Canada.
GENERAL: This 16-page report includes three photographs of the test units.

C-Y-6629/2
IHC
SUBJECT: Suspensions B 2.5
TITLE: Phase 2 - Develop Heat Treatment for Nodular Iron Track Rollers Using Oil as a Quenching Medium
IDENTIFICATION: Report No. C-Y-6629/2
DATE OF REPORT: 22 September 1952
ORIGIN: International Harvester Company, Chicago, Illinois
PURPOSE: To develop a heat treatment for nodular iron track rollers, using oil as the quenching medium
METHOD: Reference measurements were made of two nodular iron track rollers before heat treatment. The rollers were then loaded into an electric-fired rotary hearth furnace at half-hour intervals and heated to 1600°F. The total time in the furnace was approximately 3-1/2 hours. As each roller was removed, it was immediately quenched in mildly agitated oil at 80°F. After a total immersion time of 7 minutes, the rollers were removed from the oil and checked for Brinell hardness. The rollers were then tempered at 380°F for 3 hours and rechecked for hardness. After grit blasting, the rollers were remeasured for any dimensional changes. A section was then cut from each roller and a cross-sectional hardness traverse was made. A microscopic examination of sections taken from the edge and center of each roller was made.
DESCRIPTION: The two double-flange TD-24 Track Rollers tested were made of nodular iron. The melt for one roller had been inoculated with a copper-magnesium alloy, the other with a nickel-magnesium alloy.
CONCLUSIONS: The specified minimum hardness of 52 Rockwell "C" was not met by either of the rollers, but it appeared obvious that only the nickel-magnesium inoculated nodular iron need be considered. With improved quenching technique and some changes in foundry practice, it was felt that it would be possible to obtain hardnesses that would meet the specified requirements.
GENERAL: This 10-page report contains four pages of sketches and photomicrographs.

C-Y-6629/3
IHC
SUBJECT: Suspensions B 2.4
TITLE: Phase 3 - Determination of the Hardenability of Nine Heats of Nodular Iron Used in Casting TD24 Track Rollers
IDENTIFICATION: Report No. C-Y-6629/3
DATE OF REPORT: 5 November 1952
ORIGIN: International Harvester Company, Chicago, Illinois
PURPOSE: To determine the hardenability of nine heats of nodular iron used in casting TD24 Track Rollers
METHOD: Standard test bars were machined from the test material and were heat treated in accordance with ASTM specifications for end quench hardenability tests. The hardening temperature used was 1600°F. After hardening, parallel flats were ground longitudinally at 180° for a depth of .015 inch, and a hardness traverse was taken on each side. The readings were averaged and plotted on standard end quench hardenability forms. Representative sections from both "as cast" and normalized risers and Y-blocks were cut, mounted, and polished for examination of the microstructure. Several risers from each heat were heated to 1600°F and held at temperature for one hour, followed by quenching in moderately agitated oil at 120°F. Brinell hardness readings were taken using a tungsten carbide ball indentor.
DESCRIPTION: The nodular iron used for the end quench hardenability test bars were in the form of risers cut from the cast track rollers. The nodular iron tested came from nine different heats: 566, 575, 578, 585, 592, 598, 611, and 620.
CONCLUSIONS: With the exception of heat 620, it was considered possible to harden track rollers of nodular iron to meet specified minimum hardness requirements.
GENERAL: This 22-page report contains 16 pages of sketches, photomicrographs, and end quench hardenability curves.

SUBJECT: Suspensions DA 568
TITLE: Metallurgical Investigation of Bent Suspension Arm No. 7526887, Medium Tank M-46
IDENTIFICATION: Report No. 568
DATE OF REPORT: 27 November 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the metallurgical characteristics of the test unit
METHOD: The suspension arm was subjected to radiographic and chemical analyses. Examinations were made of two transverse sections cut adjacent to the large and small bosses. Physical tests and hardness measurements, as well as a micro-examination were performed.
DESCRIPTION: The test unit was a cast steel suspension arm, No. 7526887, which had been bent after a test run on a tank, M46. The maximum twist was in the thin section of the arm adjacent to the spindle.
CONCLUSIONS: It was found that the displacement at the spindle extremity was 3/4 inch. The cored internal surfaces of the cast arm showed the presence of hot tears, resulting from an improper foundry practice. However, it was not indicated that these defects contributed to the failure. The insufficient resistance of the arm to bending was produced by a combination of low yield strength and possible design factors. The micro-analyses revealed the presence of free ferrite. It was recommended that the load requirements of the part should be further investigated to determine the necessity of any design changes.
GENERAL: This 13-page report contains five photographs of the test unit.

SUBJECT: Suspensions DA 685
TITLE: The Effect of Transverse Loading on Cast Arm, Part No. 7728453 and Comparison with Forged Arm, Part No. 79865
IDENTIFICATION: Report No. 685
DATE OF REPORT: 8 February 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the performance characteristics of a cast road wheel arm with those of a forged road wheel arm
METHOD: Physical properties determined for both types of arms included surface BHN, yield point, and tensile strength. Each type of arm assembly was evaluated by means of controlled dynamic and static testing. The assemblies were subjected to severe transverse loading during operation in a medium tank, M46. Analyses of the stress distributions and the strain magnitudes were conducted using stress coatings and strain gage indicators. The transverse loadings of each arm assembly were controlled.
DESCRIPTION: The case arm, No. 7728453, was a component designed for incorporation in the left intermediate and rear wheel arm assembly, No. 7379075, of the medium tank, T42. The forged arm, No. 79865, was used in a similar assembly, designated as No. 7014029.
CONCLUSIONS: The forged arm was the most rigid and least highly stressed of the two units. This arm was shown to be 60% as flexible vertically and 91% as flexible horizontally as the cast arm, when both were subjected to a 24,000-pound transverse load. The cast arm was permanently deformed by testing due to below specification physical properties and unsatisfactory metal distributions. Maximum tensile and compressive stresses of the cast arm were 124,000 psi and 112,000 psi, respectively; the transverse load during static testing which corresponded to the 124,000 psi was 23,500 pounds. Recommendations were made with regard to certain dimensional changes for improving the strength of the cast arm assembly.
GENERAL: This 35-page report contains seven photographs of the arm assemblies and test equipment.

DA 979
SUBJECT: Suspensions B 2.8
TITLE: Assembly of Suspension Arms by the Heat and Shrink Method
IDENTIFICATION: Report No. 979
DATE OF REPORT: 1 April 1949
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the furnace and oxy-acetylene methods of assembling suspension arms
METHOD: In the oxy-acetylene method, heating was done by two operators using Smith No. 5 welding torches with No. 69 single flame tips. The heat from the two torches was applied uniformly to the mass adjacent to each spindle hole and tempilsticks were used to assure a relatively even temperature distribution and a final temperature of 750°F to 775°F. In the furnace method, heating was done by means of a propane gas draw furnace. A dummy steel block inserted in the furnace was used for tempilstick temperature measurements.
DESCRIPTION: Specifications of the arm assembly used for the oxy-acetylene method were: forge spindle hole, 4.769 inches; small spindle hole, 3.250 inches; pivot hole, 2.432 inches; large spindle diameter, 4.786 inches; small spindle diameter, 3.2595 inches; pivot diameter, 2.441 inches. The dimensions of the arms used in the furnace method were within the limits of the same drawing used to make the arm assembly for the oxy-acetylene method.
CONCLUSIONS: For practical purposes, both the oxy-acetylene and furnace methods produced the same dimensional condition of hole expansion at 750°F, provided that care was taken to heat the mass around the hole area thoroughly. It was believed that oxy-acetylene torch heating would prove more favorable in production if properly controlled.
GENERAL: This 12-page report is not illustrated.

DA 1127
SUBJECT: Suspensions B 2.8
TITLE: Serviceability of Modified Torsion Bar
IDENTIFICATION: Report No. 1127
DATE OF REPORT: 27 July 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine if an increase in the allowable machining tolerance on a torsion bar, part number 7035898, would affect its service life on an M46 Medium Tank
METHOD: Torsion bars on an M46 Medium Tank were replaced with experimental torsion bars with

clockwise and counterclockwise preset. The tank was given a thorough mechanical inspection and then driven 2000 miles over a test track, washboard courses, and rough terrain at maximum safe speed. At the end of 500, 1000, 1500, and 2000 miles of operation, the bars were removed for visual and magnetic inspections. Dimensions of the bars were checked before and after the test.
DESCRIPTION: The test vehicle was an M46 Medium Tank. Four torsion bars were used, two with clockwise and two with counterclockwise pre-set.
CONCLUSIONS: Increasing the allowable machining tolerances on the torsion bars did not affect their service life.
GENERAL: This 47-page report contains 38 figures showing the allowable machining tolerances, condition of the bars during the test, tank component failures, and test terrain.

SUBJECT: Suspensions DA 1725
TITLE: Test of Powdered Metal Bearings
IDENTIFICATION: Report No. 1725
DATE OF REPORT: 14 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the bearings for use on the medium tank
METHOD: The bearings and spacers were installed on their respective shafts; shaft shims were fabricated and installed to allow .003 to .005 end play on the bearings. The arms were installed on an M46 medium tank which was operated on a test track and cross-country roads for 2000 miles. The bearings were inspected periodically during the test. Failures were noted and bearings replaced when necessary.
DESCRIPTION: The Haller Well, road arm and compensating arm, powdered metal bearings were supplied by the Michigan Powdered Metal Bearing Company.
CONCLUSIONS: The test bearings showed limited possibilities for use on the medium tank. An inspection after 500 miles of testing revealed that the front compensating bearings had failed. Periodic inspection indicated peripheral and axial progressive cracking of the road bearings. However, these bearings were still serviceable after 2000 miles of operation. The bearing surfaces in the housings were rough, the diameters were untrue, and the shafts were not hardened. Extensions of the inner bearings beyond the end of the shaft eliminated some of the effective bearing area. The clearance between the bearings and housing was excessive in some cases. It was recommended that further tests be conducted with these bearings, after the design had been improved; the installation method should also be revised.
GENERAL: This 31-page report contains 16 photographs of the bearings.

DA 2659
SUBJECT: Suspensions B 2.8
TITLE: Boron Steel Shackle Pins and Spindles on Rear Compensating Idlers
IDENTIFICATION: Report No. 2659
DATE OF REPORT: 9 October 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of boron steel shackle pins and spindles on rear compensating idlers in the suspension of the 90-mm M47 Tank
METHOD: The shackle pins and spindles were installed in the tank in accordance with normal procedure and were removed and inspected after the vehicle was operated for 2000 miles.
DESCRIPTION: The test items consisted of four boron steel shackle pins and four boron steel compensating idler spindles.
CONCLUSIONS: At the conclusion of the 2000-mile test, all test parts were found serviceable. Inspection of shackle pins revealed only normal scoring. Spindles showed no evidence of damage. On the basis of this test, the boron parts were considered satisfactory for their proposed use.
GENERAL: This six-page report contains a drawing of one of the shackle pins and a table of the shackle pin dimensions before and after testing.

SUBJECT: Suspensions DA 3002 F
TITLE: Test of Torsion Springs for Road Arms on Medium Tanks
IDENTIFICATION: Report No. 3002 (Final)
DATE OF REPORT: 29 July 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the torsion spring for the suspension of the medium tank
METHOD: The torsion spring assemblies were installed in an M46 medium tank, and the clearances, space required, and space saved by the assemblies were noted. The vehicle was operated over various types of terrain. Two sets of springs were tested.
DESCRIPTION: The test units were coil-type torsion spring suspension components for road arms on the medium tank.
CONCLUSIONS: The coil-type springs were not permitted to operate for a sufficient length of time to evaluate their usefulness on the medium tank properly. The first set of springs installed in the suspension system of the M46 tank failed at 537 miles, apparently because of faulty manufacture. The second set of springs did not fail during 489 miles of operation.
GENERAL: This 12-page report is not illustrated.

SUBJECT: Suspensions DA KG-20-13
TITLE: Suspension, Spaced to Improve Flotation of High Speed Tractors, M4 and M5
IDENTIFICATION: Project No. KG-20-13
DATE OF REPORT: 5 November 1946
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of extended end connectors and spaced track suspensions for use with M4 and M5 Tractors
METHOD: An M4 Tractor was equipped with spaced suspensions and tracks using double extended end connectors, and another M4 Tractor was equipped with a standard suspension and tracks using single extended end connectors. The two test vehicles were operated over various types of

terrain, including very swampy areas at Fort Bragg, North Carolina. Two M5 Tractors were equipped in the same manner as the M4 vehicles and operated under identical conditions.
DESCRIPTION: The suspensions of an 18-ton M4 and 15-ton M5 Tractor were moved 3-1/2 inches out from both sides of the respective hulls. Extended end connectors, classified as a "double" arrangement, were employed on both sides of each track. The standard suspension M4 and M5 Tractors employed end connectors on just the outside of each track. This arrangement of end connectors was designated as "single".
CONCLUSIONS: The maneuverability of the tractors equipped with both "single" and "double" extended end connectors was an improvement over that of standard equipped vehicles. Because of a considerable improvement in over-all operation, regardless of terrain, it was recommended that ultimately all M4 tractors be equipped with "double" extended end connectors. A 2-inch high grouser, or integral grouser, track was recommended for development and use with the M4 vehicle. Because of unsatisfactory swamp operation, resulting in track throwing, it was recommended that improved end connectors be developed and tested before being used with the M5 Tractor.
GENERAL: This 36-page report contains 10 photographs illustrating the vehicle installation of the extended end connectors, end connectors which failed in operation and damaged bogie tires. Drawings of test parts and the method of spacer installation are included.

SUBJECT: Suspensions DA KG-618
TITLE: Truck, 6-Ton 6x6, with Trailing (Self-Steering) Axle
IDENTIFICATION: Final Report on Project No. 618
DATE OF REPORT: 7 January 1949
ORIGIN: Detroit Arsenal, Center line, Michigan
PURPOSE: To determine whether the trailing axle would favorably affect tire wear, fuel consumption, maintenance and control of the 6-ton truck
METHOD: The vehicle was operated for 9000 miles over paved and gravel roads, and cross-country with the test mechanism operating as the rear axle in the bogie. The mechanism was in operation 65% of the time and locked out the balance of the time for comparative purposes.
DESCRIPTION: The test 6-ton, 6x6 truck was equipped with a self-steering, trailing, tandem axle device. The axle device permitted rotation of six degrees each way from the normal position and when in the locked-out position operated as a conventional axle.
CONCLUSIONS: The mechanism was not recommended for use on military vehicles. It required frequent greasing and caused increased tire wear and fuel consumption and unfavorably affected maintenance, maneuverability and control of the vehicle.
GENERAL: This 14-page report includes four photographs of the mechanism.

SUBJECT: Suspensions DWB 64
TITLE: Test of Experimental Bogie Suspension for Medium Tank M3
IDENTIFICATION: Project No. 64
DATE OF REPORT: 4 September 1942
ORIGIN: Desert Warfare Board, Camp Young, Indio, California
PURPOSE: To determine the suitability of an experimental bogie suspension for M3 Medium Tanks
METHOD: Experimental bogie assemblies were installed on an M3 Medium Tank, and operated under service conditions over rugged desert terrain for one month.
DESCRIPTION: The experimental bogie suspension was a vertical volute spring suspension of the same design as the standard M3 Medium Tank suspension except that the volute springs, spring housings, spring seats, and bogie arms in the test suspension were heavier than standard. The bogie arm spacers were eliminated, and the track support roller was positioned on a bracket behind the top of the housing instead of immediately above it.
CONCLUSIONS: The test suspension was considered unsatisfactory in the test stage of development because of failures of the suspension arms and the spring seats; however, the test suspension was considered to have definite advantages, and further development was recommended.
GENERAL: This seven-page report contains four photographs of the experimental bogie suspension.

SUBJECT: Suspensions DWB 87
TITLE: Spring Loaded Idler Assembly for Half-Track Vehicles
IDENTIFICATION: Project No. 87
DATE OF REPORT: 7 October 1942
ORIGIN: Desert Warfare Board, Camp Young, Indio, California
PURPOSE: To compare the spring-loaded idler with the currently-used idler brace
METHOD: Four spring-loaded idler assemblies were field installed on Half-Tracks M3. These vehicles and unmodified vehicles were operated over rocky terrain conducive to track throwing and idler bracket bending. Vehicles averaged 300 miles of operation.
DESCRIPTION: The test spring-loaded idler assembly consisted of a volute spring acting between a spring seat bracket bolted to the frame of the chassis just behind the bogie housing and the idler shackle. Two adjustments were possible: the set-screw in the rear of the idler shackle could be adjusted to allow the shackle to swing rearward and increase track tension; and the spring compression could be controlled by a stop nut resting against the seat of the volute spring.
CONCLUSIONS: The test spring-loaded idler was superior to the idler brace in eliminating track throwing tendencies and was recommended for immediate adoption.
GENERAL: This six-page report includes three photographs of the spring-loaded idler.

SUBJECT: Suspensions GM CTP 798 F
TITLE: Effect of Eliminating No. 2 Shock Ab-

sorbers from Vehicle Suspension System
IDENTIFICATION: Report No. 798 (Final)
DATE OF REPORT: 2 June 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the effect of eliminating the No. 2 position shock absorbers on the ride and handling characteristics of the tank, and the life and operating temperatures of the Nos. 1 and 5 position shock absorbers
METHOD: Unknown to the driving personnel, a tank was equipped with dummy shock absorbers (shell only) in the No. 2 positions. The driver and the observer drove the vehicle, so equipped, two laps on the Cadillace Ordnance Proving Ground course. They were then requested to write their impressions of the ride. During this period a crew removed the dummy shocks from the vehicle. Without knowledge of the changes made to the suspension, a second ride was taken by the men. The same routine was followed for this, as well as for a third ride.
DESCRIPTION: The tank used in the test was No. X-518.
CONCLUSIONS: From the written impressions of the three rides, it was evident that there was a difference in riding quality when the No. 2 shock absorbers were removed from the suspension system. There was no noticeable difference in the control of the vehicle with the No. 2 shock absorbers omitted. The effects on the life of the No. 1 and 5 position shock absorbers, and their operating temperatures with and without the No. 2 position shock absorbers, were not obtained.
GENERAL: This five-page report is not illustrated.

SUBJECT: Suspensions GM CTP-814
TITLE: T88E1 Track Vibration Evaluation
IDENTIFICATION: Report No. 814
DATE OF REPORT: 29 May 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant, Cleveland, Ohio
PURPOSE: To compare the vehicle vibration characteristics when the vehicle was equipped with various suspension components
METHOD: The test vehicle was equipped and tested with each of the following suspension components: T88E1 track and steel compensating wheels; T91E3 tracks and steel compensating wheels; T91E3 track and road wheel compensating wheels; T91E3 track and contour tire road wheel. The tests were conducted similarly to the previous vibration tests described in TR-813.
DESCRIPTION: The Firestone Company standard production road wheels, U.S. Royal contoured road wheels, steel compensating wheels, standard production T91E3 track, and T88E1 track (double pinned, rubber chevron) were used in the test.
CONCLUSIONS: The T88E1 track was the most satisfactory suspension component tested in regard to reducing over-all vehicle vibration. The contour tire road wheel compensating wheel was better than the Firestone road wheel compensating wheel at the control positions as well as the compensating wheel positions. Both were an improvement over the production-type compensating wheel.
GENERAL: This 12-page report includes one photographs of the lift sprocket transverse position accelerometer and two graphs of test findings.

SUBJECT: Suspensions GM CTP-820
TITLE: Evaluation of Track Support Roller Struts as a Means of Reducing Hull Cracking Vehicle T141 No. 2
IDENTIFICATION: Report No. 820
DATE OF REPORT: 14 April 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant, Cleveland, Ohio
PURPOSE: To determine whether support struts installed between the suspension housings and support rollers mounts would prevent armor cracks
METHOD: The strut assemblies were welded into position and placed in the Baldwin testing machine to determine the torque required to obtain a 6000 pound compression load. The R-1 support roller position was used to set up a procedure for adjusting and periodic checking during operation. The strut assemblies and the necessary instrumentation were installed and the vehicle operated for 3007 miles over various test courses. The vehicle was periodically inspected for indication of hull cracks.
DESCRIPTION: The test items were designated as support struts.
CONCLUSIONS: The struts did not prevent armor cracks. Cracks had developed at all support roller positions except L-2 and R-2, both ends of the gun mount base beam, left idler mount pad and gussets.
GENERAL: This 27-page report includes 17 photographs and one curve sheet of the test results.

SUBJECT: Suspensions GM CTP 890 F
TITLE: Impact on Base Plate of Suspension Arm Bumper Spring Stop from Positions 3 and 4 Compared with Positions 1, 2, and 5
IDENTIFICATION: Report No. 890 (Final)
DATE OF REPORT: 20 November 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the extent of impacting on the volute spring plates from positions 1, 2, 3, 4, and 5, and to determine if the No. 3 and No. 4 bump stop springs are necessary
METHOD: Several springs were obtained from vehicles and were cut from the base plate by an electric arc for inspection. The amount of impact was determined by measuring between a plane intersecting the inside circumference of the area of contact between the spring and the plate and the center of the plate. Several springs were installed on the T41E1 vehicle and subjected to vehicle drops of 6, 12, 18, and 24 inches.
DESCRIPTION: The test items were designated as stop assembly plates No. 7984869.
CONCLUSIONS: From the limited number of stop assemblies inspected, it would appear that the assemblies at positions 3 and 4 were serving a useful purpose.
GENERAL: This 12-page report contains eight photographs of the test stop plates.

SUBJECT: Suspensions GM CTP 1113
TITLE: Impact Tests of Lever Arms with Induction Braze Replacing the Weld to Seal the Serrations
IDENTIFICATION: Report No.1113
DATE OF REPORT: 24 February 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the effectiveness of induction brazing as a means of sealing lever arm serrations
METHOD: The two front lever arms were installed on the M41, No. 923 vehicle in the R-1 and L-1 positions. The vehicle was complete but not combat loaded and weighed 36,000 pounds. The rear of the vehicle was mounted on pyramid blocks, and the front was raised and dropped at various heights up to 60 inches. The effects of the impacts on the lever arms were observed during the tests. These impacts were considered comparable to the severest conditions which would be encountered by the vehicle in service.
DESCRIPTION: The test items were two front lever arms on which induction brazing had been used to seal the serrations in place of the production weld. The right arm was identified as No. 7419922, and the left as No. 7419921.
CONCLUSIONS: The induction brazing did not produce as effective a seal as welding or the use of a commercial sealer.
GENERAL: This 12-page report contains six photographs showing the vehicle, test setup, and vehicle damage resulting from the tests.

SUBJECT: Suspensions GM CTP 1118
TITLE: Durability Test of a Road Wheel Lever Arm Spindle Sealing Design
IDENTIFICATION: Report No. 1118
DATE OF REPORT: 23 November 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To evaluate the sealing effectiveness of the increased shrink fit and the sear on road wheel lever arms for vehicle durability operation
METHOD: The shrink fit on the lever arm was increased and two coats of Plastilock Sealer No. 604 applied. After curing was complete, the shaft was installed by hand into a lever arm which had been heated to approximately 700°F. The lever arms were then installed on vehicles for a durability test over cross-country and hard surface terrain.
DESCRIPTION: The test units were lever arms incorporating an increased shrink fit (.003 to .007 inch to proposed production of .0084 to .0134 inch) and B.F. Goodrich Plastilock No. 604 applied to the spline and properly cured.
CONCLUSIONS: The use of sealer and the increased shrink fits did not completely prevent seepage. Although the amount of oil lost through seepage was too small to measure, there was always evidence of seepage at the serrations.
GENERAL: This six-page report includes one photograph of the installed road wheel.

SUBJECT: Suspensions GM CTP 1123 F
TITLE: M42 Vehicle Wheel and Track Losses
IDENTIFICATION: Report No. 1123 (Final)
DATE OF REPORT: 22 June 1954
ORIGIN: General Motors Cleveland Tank Plant
PURPOSE: To determine the horsepower losses in the wheels and tracks of the M41 vehicle suspension system while under no roadload.
METHOD: The M41 vehicle was mounted on blocks, and tests were conducted on the compensators, idlers, road wheels, and tracks, while the tracks were on the vehicle and while the tracks were off the vehicle. Another test was conducted on the track blocks for hysteresis loss. The track bushings were tested on the Baldwin Machines by pinning two new blocks together, one block being fastened to the table of the Baldwin machine, and the other being attached to the moving member of the Baldwin. Force was applied and measurements were taken of the results.
DESCRIPTION: Test items were the component parts of the M41 vehicle suspension system.
CONCLUSIONS: Results of the tests showed that 2/3 of the loss of horsepower occurred in the wheels while the other 1/3 occurred in the track tension, bearing and sprocket phenomena.
GENERAL: This 10-page report is not illustrated.

SUBJECT: Suspensions GM CTP 1195 F
TITLE: Durability Test of Cupped Design Volute Springs
IDENTIFICATION: Report No. 1195 (Final)
DATE OF REPORT: 23 November 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To compare the life of a cupped design volute spring with a new type production spring
METHOD: The test assemblies were installed on two different type vehicles, M41A1 and M42, and operated until failure.
DESCRIPTION: The proposed design spring consisted of a supporting cup welded to the base plate and with the inactive coil of the spring attached to the cup with one short weld. Four base plate stop assemblies were made, two having 1/8-inch wall thickness, and two having 3/16-inch wall thickness.
CONCLUSIONS: The cupped design spring and the production design spring appeared equal in durability and both were superior to the obsolete production design.
GENERAL: This 10-page report contains five photographs.

SUBJECT: Suspensions GM CTP 1245 F
TITLE: Durability Test of Road Wheel Lever Arm Assemblies Incorporating Shrink Fit Diameters and Shear Pins
IDENTIFICATION: Report No. 1245 (Final)
DATE OF REPORT: 23 November 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the oil seal and durability characteristics of modified road wheel arm assemblies

METHOD: The lever arms were installed and operated on the M41A1 vehicle.
DESCRIPTION: The test units were production lever arms incorporating shrink fit diameters and using two roll pins in each pin location to replace the serrations.
CONCLUSIONS: The shrink fit on the diameter of the shaft eliminated oil seepage locations; the use of roll pins appeared to be a satisfactory method of controlling movement between the arm and the shaft. Movement between the lever arm and the shaft was observed during the test; the movement was due to the collapsing of the spindle and allowed the vehicle to sag 3/8-inch. However, this was not considered a serious problem, and probably could be eliminated by the use of solid pins.
GENERAL: This nine-page report contains three photographs showing the effects of testing on the lever arm.

SUBJECT: Suspensions GM CTP 1251 F
TITLE: Impact Test of Bump Stop Support With Five Attaching Bolts
IDENTIFICATION: Report No. 1251 (Final)
DATE OF REPORT: 14 June 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine whether five bolts attaching a bump stop support were strong enough to be used without a weld
METHOD: The modified bump stop support was installed on the L-5 position of the No. 3, M42 vehicle, and the five attaching bolts were torqued to 325 ft.-lbs. The regular production bump stop support with four attaching bolts and weld was installed on the R-5 position. The front of the vehicle was mounted on pyramid shaped blocks and the tracks were removed. The rear of the vehicle was raised and dropped from heights of 6 to 42 inches above the concrete. Damage to the bump stop supports was observed and recorded.
DESCRIPTION: Five attaching bolts were used to attach bump support, SK-2072, to a vehicle, M42, instead of four bolts and a weld.
CONCLUSIONS: It was concluded that the five attaching bolts used to attach the bump stop support were adequate for "normal" vehicle service conditions. Neither the production nor the modified bump stop support broke loose from the hull during the impact tests.
GENERAL: This 10-page report contains five photographs of the production and modified bump stop supports and bolts used on the latter.

SUBJECT: Suspensions GM CTP 1272 F
TITLE: Durability Test of Roadwheel Lever Arm Assemblies with Shortened Serrations
IDENTIFICATION: Report No. 1272 (Final)
DATE OF REPORT: 25 October 1954
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To evaluate increased shrink fit diameters and shortened serrations on road wheel lever arm assemblies
METHOD: Three experimental lever arms were installed on a No. 1416, M41A1 vehicle on the L1, L5, and R1 positions. The vehicle was operated for 3,470 miles over hard and cross-country terrain. A torsion bar counter was installed on the vehicle to record the number of "full bumps" during the test.
DESCRIPTION: The test units were production lever arm assemblies modified to incorporate increased shrink fit diameters and shortened serrations.
CONCLUSIONS: There were no seepage indications at the serrations and no indications of movement between the lever arm and the shaft.
GENERAL: This five-page report contains a drawing showing a cross section view of the modified lever arm.

SUBJECT: Suspensions GM CTP 1312 F
TITLE: Suspension Lockout Devices for M42 Vehicles
IDENTIFICATION: Report No. 1312 (Final)
DATE OF REPORT: 25 January 1955
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To test the effectiveness of three different suspension lockout devices
METHOD: The three suspension lockout devices were tested separately and the operating characteristics of each were observed and recorded.
DESCRIPTION: The three suspension lockout devices tested were: 1) the folding ramp; 2) front track steel strut and sprocket steel tee bar; 3) front support roller strut and sprocket steel tee bar. The folding ramp device separated the track support rollers from the road wheels and had the greatest amount of stability since it utilized four of the five road wheels per side and full track contact with ground. For the front support roller strut and sprocket steel tee bar device, the front and rear struts both utilized the track to gain effective ground contact.
CONCLUSIONS: The folding ramp device was cumbersome to handle and stow. For the front track steel strut and sprocket steel tee bar, the surface in contact with the ground at the front was relatively small and in soft mud could prove somewhat ineffective. The unit at the rear utilized the track area under the rear wheel and in soft mud would be somewhat better than the front. The three methods were not rated as to their effectiveness in stabilizing the vehicle against gunfire. By shaking the gun mount by hand, it appeared that each method produced some advantage.
GENERAL: This 16-page report includes 10 photographs of the three suspension lockout devices in place before lockout and in lockout position.

SUBJECT: Suspensions GM CTP 1370
TITLE: Durability Test of Two Types of Experimental Suspension Arm Volute Spring Stops M41A1 and M42 Vehicles
IDENTIFICATION: Report No. 1370
DATE OF REPORT: 1 August 1955
ORIGIN: General Motors Corporation, Cleveland Tank Plant

PURPOSE: To determine the durability characteristics of two types of experimental volute spring assemblies
METHOD: Double weld and single weld type springs were installed on the five right and left positions, respectively, of the M41A1 vehicle, No. 3729. This vehicle was operated 2001 miles on a test track and 2001 miles over cross-country terrain. The springs were then transferred to the M42, No. 317 vehicle, which was operated until the springs failed. Conditions on the test course ranged from hard and frozen to very deep, sloppy mud.
DESCRIPTION: The test units were two types of experimental volute bumper springs for M41A1 and M42 vehicles. Both types were retained in a 1-inch deep cup that was welded to the base plate. The main difference between the two was that one had two welds spaced 180° apart, and the other had only one weld. A 3/16-inch weld was specified in the design.
CONCLUSIONS: Both experimental types of volute spring stops obtained greater mileages than would normally be expected of production type springs. The doulbe weld type was theoretically a better design since it resisted both fore and aft forces and was symmetrical for use on both sides of the vehicle. The weld used was found to have a good factor of safety. Because the single weld caused distortion and greater "runout" at the tappet end of the spring, the double weld type was easier to manufacture. The double weld volute type spring stop should be released for production in place of the present volute spring stop.
GENERAL: This 12-page report contains six photographs of both types of bumper springs.

SUBJECT: Suspensions OCO KG-20-4
TITLE: Suspension, 40 MM Gun Motor Carriage T54E1, Spring Checks, for Firing
IDENTIFICATION: Project No. KG-20-4
DATE OF REPORT: 22 March 1944
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To design, fabricate, and test spring checks for the suspension of the 40-mm Gun Motor Carriage T54E1; also to determine the possible use of this mechanism, during firing, for effective aircraft fire
METHOD: A device was designed and fabricated for the 40-mm Gun Motor Carriage to block out suspension springs during fire periods. A firing program was conducted on the 40-mm Gun Motor Carriage, both with and without this spring block-out or check system.
DESCRIPTION: The proposed spring check was designed by the Houde Engineering Division of the Houdaille-Hershey Corporation. The device consisted of a linkage between the suspension arms and the suspension bracket of a half-track vehicle. The linkage could be held in riding position or be allowed to move by engaging or disengaging gearing, one half of which was attached to the linkage, the other half of which was attached to the vehicle frame. The linkage was hand-operated and controlled from the driver's seat.
CONCLUSIONS: Firing dispersion records and hop records showed that the spring block-out system did not increase the stability or rigidity of the gun platform. It was recommended that this method of achieving vehicle stability be considered unsatisfactory and no further development work be done on this project.
GENERAL: This 44-page report includes six photographs of spring block installation, one photograph of the 40-mm Gun Motor Carriage, and four drawings of spring block-out design.

SUBJECT: Suspensions OCO KG-20-6
TITLE: Suspension, Torsion Bar with Volute Helper Springs, for Medium Tank T-20
IDENTIFICATION: Project No. KG-20-6
DATE OF REPORT: 15 March 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To develop an independently sprung torsion bar suspension for Medium Tank T20
METHOD: General Motors Corp. designed and developed test torsion bar suspension which was installed on a T20E3 Medium Tank, and operated 1400 miles over General Motors endurance course, and at Aberdeen Proving Ground. Comparative ride data were obtained on the T20E3 Medium Tank with torsion bar suspension and a Medium Tank M4A1 with standard suspension.
DESCRIPTION: The torsion bars were 2-inch bars with an effective length of 74 inches each. The track was a cast steel, center guide, rubber bushed, 18-inch track. The weight of the suspension and track was 13,500 pounds; of the track, 4200 pounds, and of the vehicle, 64,000 pounds.
CONCLUSIONS: The independently sprung experimental torsion bar suspension system was considered satisfactory for medium tanks weighing 30 to 35 tons. Similar types were recommended for all tracklaying vehicles. The ride characteristics of the T20E3 tank with the torsion bar suspension was superior to that of the M4A1 tank with standard suspension. It was also recommended that presetting of torsion bars be regarded as an essential operation in their manufacture.
GENERAL: This 78-page report contains 25 photographs including micrographs of torsion bar specimens, mock up installations of torsion bars, and the test vehicle. Also included are torsion bar calculations, short treatises on torsion bar design, presetting of torsion bars, and graphs of riding characteristics.

SUBJECT: Suspensions OCO KG-20-7
TITLE: Suspension, Torsion Bar, 24-Inch Wide, Steel, Center Guide Track for Medium Tank, M4
IDENTIFICATION: Project No. KG-20-7
DATE OF REPORT: 1 June 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To design a torsion bar suspension for Medium Tanks M4, and to compare ride and stability with that of Medium Tanks M4A4, T20E3, and M4E8 with torsion bar suspension
METHOD: A torsion bar suspension system was designed for Medium Tanks M4. Two tanks were

built by Fisher Body, and operated 1900 and 1600 miles per vehicle at GMPG. One tank was returned to Fisher for an increase of spring capacity and improvement of bump spring mountings, then shipped to Aberdeen Proving Ground for further tests. At Aberdeen an R-5 Ride Indicator was used to graphically record vertical acceleration, bounce on left and right sides of hull, and pitching tendency on Belgian Block road and in cross-country operation. Trace-line night photography was also used to determine pitch on comparison with standard-suspension tanks. Tractive resistance of each vehicle was measured at speeds between 2 mph and 25 mph.
DESCRIPTION: The test torsion bar suspension as installed on the Medium Tank M4E4 utilized six 26-inch wheels per side. Road clearance was 8 inches. Arm No. 1 was a trailing type, other arms were the leading type. A track slack compensating device was attached to the rear wheel support arm to reduce "diving" and "squatting". The test suspension was about the same weight as a standard suspension. Single-pin, 24-inch cast steel, center guide tracks were used on the experimental M4 tanks.
CONCLUSIONS: The test tank exhibited less tractive resistance and less bottoming tendency on rough ground than either of the M4A4 and M4E8 tanks with standard vertical volute or standard horizontal volute spring suspension. The Medium Tank T20E3, however, proved notably superior in ride characteristics to all M4 type tanks. Independently sprung suspensions with torsion bar and auxiliary bump springs were considered satisfactory in principle, but production of the Medium Tank M4E4 was not recommended.
GENERAL: This 104-page report contains 10 photographs and four drawings of M4E4 suspension parts, and 17 night ride photos. A comparative tractive resistance curve sheet and 32 Impact-Register charts are also included.

SUBJECT: Suspensions OCO KG-20-9
TITLE: Suspension, Heavy Tractor, T22, Adaptation to Medium Tank, M4
IDENTIFICATION: Project No. KG-20-9
DATE OF REPORT: 3 May 1944
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine the suitability of adapting the Heavy Tractor T22 suspension system to the Medium Tank M4A4
METHOD: Chrysler Engineering made design studies for adaptation of the test suspension system. A pilot vehicle was built and tested for three miles at Detroit Tank Arsenal. The vehicle was shipped to Allis-Chalmers for further design improvement, especially to eliminate guide cutting. Test operations then continued at Tank Arsenal Proving Ground, Utica, Michigan for 187 miles.
DESCRIPTION: The test suspension was a horizontal volute spring type and the track was a double-pin, rubber-bushed, rubber-backed, center-guided, steel grouser track.
CONCLUSIONS: The test suspension proved inadequate to sustain the weight of the M4A4 Medium Tank, and was therefore rejected. During and after 187 test miles at Tank Arsenal Proving Ground, tire failures, loose wheel locknuts, leaking wheel shaft oil seals, and a bent wheel shaft resulted, all apparently due to the volute bogie springs.
GENERAL: This 53-page report contains eight photographs of the Allis-Chalmers suspension system adapted to the M4A4 Medium Tank.

SUBJECT: Suspensions OCO KG-20-10
TITLE: Suspension, Horizontal Volute Spring for Medium Tanks with 23-Inch Wide Tracks (M4A3E8)
IDENTIFICATION: Project No. KG-20-10
DATE OF REPORT: 15 July 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine the suitability of horizontal volute spring suspensions for use on Medium Tanks, M4
METHOD: The test suspension and related components were installed on Medium Tanks M4A3E8 and operated at the GMPG and TAPG proving grounds over all types of terrain. The condition of bogie wheels and assemblies, shock absorbers, sprockets, road wheel axles, and various types of tracks and other components was studied during the testing period; each of these items, partially covered in this report, was discussed in detail in separate reports.
DESCRIPTION: The test horizontal suspension was used with a 23-inch wide track. Two parallel volute springs in a horizontal position were used in each suspension unit. Shock absorbers were mounted directly above the springs. A cantilever bracket was used to secure each suspension unit to the hull.
CONCLUSIONS: The maintenance intervals and ride characteristics of the horizontal suspension were considered superior to those of the vertical volute spring suspension. The test suspension with 23-inch wide tracks reduced ground pressure from 14.5 to 11 psi. The use of 20-1/2 x 6-1/4-inch bogie tires resulted in an increase of synthetic rubber tire life of 33% and 100% for rubber and steel backed tracks, respectively, compared to tire life with vertical volute spring suspension. It was recommended that the horizontal spring suspension be released for use on all Medium Tanks, M4, and similar vehicles employing the M4 suspension.
GENERAL: This 75-page report contains 10 photographs showing the test suspension assembly and installation and various track components used during the test.

SUBJECT: Suspensions OCO KG 20-15
TITLE: Suspension, Combat Vehicles with Improved Ride and Weight Carrying Capacity
IDENTIFICATION: Project No. KG-20-15
DATE OF REPORT: 15 November 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine the suitability of experimental volute springs for use on military vehicles
METHOD: Six experimental volute springs were

laboratory life-tested in comparison with standard volute springs. The standard springs were tested at an energy input of 25,200 in.-lbs. The experimental springs were accidentally tested at an energy input of 34,700 in.-lbs., rather than at the 31,000 in.-lbs. as was specified in the test directive.
DESCRIPTION: The test volute springs differed from the standard springs in that the free helix angle of the experimental springs was varied to equalize the stress in the individual coils. This design increased the maximum spring deflection from 6-1/2 to 7-1/2 inches and the free height of the spring by approximately 3/4 inch.
CONCLUSIONS: Test results were considered inconclusive, since manufacturing equipment which existed could not be used to hold variations in the helix angle of the experimental spring to drawing specification requirements. Because of the error in the input energy used on the test springs, no direct comparison could be made between the standard and experimental springs. It was recommended no further development work be conducted on the experimental springs until manufacturing facilities were developed for the accurate control of the variable pitch helix angle used in spring construction.
GENERAL: This 14-page report contains a drawing of the experimental spring.

SUBJECT: Suspensions OCO KG-20-18
TITLE: Suspension, Litter, 3/4-Ton Ambulance
IDENTIFICATION: Project No. KG-20-18
DATE OF REPORT: 20 February 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To determine the ride characteristics of shock resistant mounted litters used in a 3/4-ton ambulance; to compare the results with modified external suspension and standard external suspension equipped ambulances
METHOD: The three test vehicles were operated over identical terrain in the vicinity of the Medical Department Equipment Laboratory, Carlisle Barracks, Pa. A graphical recording device was used to measure the impact imposed on the respective litters, which were loaded to 200 pounds. The impact recording device was also used to determine the intensity of vehicle top sway.
DESCRIPTION: The first test vehicle was equipped with special litter mountings made up of volute springs and shock absorbers. The second vehicle had standard mounted litters, but softer leaf springs and larger shock absorbers were used on the vehicle external suspension. Standard litter and external suspension mountings were used on the third vehicle.
CONCLUSIONS: Although vertical shock was considerably reduced, top sway of the first vehicle was greater than that of the standard ambulance; it was also more difficult to load than the standard type. The special suspension of the second vehicle gave better riding characteristics than the standard ambulance, but not as good as the one equipped with special litter mountings. Side sway and fore-and-aft litter movement were as objectionable as vertical accelerations in all cases. On the basis of the above results, it was recommended that the test devices not be accepted. Further improvements were suggested to reduce shocks caused by fore-and-aft accelerations, possibly a combination of the two systems tested.
GENERAL: This 19-page report contains two photographs showing the installations of the litter suspension in the first vehicle and the external shock absorbers and leaf springs of the second vehicle. A photostat drawing showing the method of installing the litter suspensions of the first ambulance also is included.

SUBJECT: Suspensions OTAC KG-20-1
TITLE: Suspension, Leaf Spring, for Medium Tank, M4
IDENTIFICATION: Project No. KG-20-1
DATE OF REPORT: 1 September 1943
ORIGIN: Ordnance Tank Automotive Center, Detroit, Michigan
PURPOSE: To make a preliminary design study of a leaf-spring suspension for application to the Medium Tank, M4
METHOD: A layout was prepared to incorporate semi-elliptic leaf springs and a 24-inch wide track in Medium Tank M4 suspension systems. Drawings were studied to determine suitability of design.
DESCRIPTION: The proposed suspension system was a leaf spring suspension designed for a 24-inch wide track. The bogie assemblies were made up of a pair of articulated 20-inch diameter, nine-inch wide dual bogie wheels and four laminated, semi-elliptic springs. Three bogie assemblies on each side of the vehicle made up the suspension for the vehicle.
CONCLUSIONS: From the studies made in this report it was concluded that a leaf type spring suspension was not suitable for use on the Medium Tank M4 because the wheel deflections obtainable were insufficient.
GENERAL: This 23-page report includes drawing TADB-E-1060 "Side Elevation of Tank with Leaf-Spring Suspension," drawing TADB-E-1061 "Track Support Rollers," TADB-E-1063 "Sprocket Modification," drawing TADB-E-1064 "Cross Section Leaf Spring Suspension Unit," and drawing X-46902-B "Wheel Assembly."

SUBJECT: Suspensions N-534
TITLE: Temperature Checks of Rubber Axle Bumpers
IDENTIFICATION: Final Progress Report; Test No. N-534
DATE OF REPORT: 13 February 1945
ORIGIN: Ordnance Tire Test Fleet, Normoyle Field, San Antonio, Texas
PURPOSE: To determine actual temperature generated in rubber axle bumpers during operation
METHOD: Rubber Axle bumpers were installed on two 1/4-ton Ford trucks, two 3/4-ton Dodge trucks with maximum payloads, and four 2-1/2-ton GMC trucks with maximum and 5-ton payloads. Operation was over varied terrain at a maximum speed of 45 mph. Potentiometer and ambient temperature readings were taken at various intervals

with the vehicles in motion.
DESCRIPTION: The rubber bumpers were mounted on the axle to provide protection to axles, springs, and frame from compression and shock.
CONCLUSIONS: There was no appreciable temperature generated within the rubber bumpers during operation. Bumper temperatures varied from 65°F to 90°F. Engine and exhaust heat increased bumper temperatures slightly. Specific recommendations were not included in the report.
GENERAL: This 12-page unillustrated report includes temperature recordings of the test.

SUBJECT: Suspensions PG-2.572
TITLE: Demonstration of Trailer Suspension Willamette-Hyster Company
IDENTIFICATION: Report No. PG-2.572; GMPG Project No. 81
DATE OF REPORT: 18 December 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To demonstrate a Willamette-Hyster trailer and its suspension
METHOD: The test trailer was loaded with a 12-ton pay load and driven over the alternating bumps on the ride loop, over a ditch, and over the Belgian Blocks. Turns were demonstrated on the skid pad. Moving pictures were taken of the operations and filed at the Proving Ground. A group of officers from the Development Branch and representatives of the Willamette-Hyster Company and Larison Axle Company observed a demonstration of the test trailer at General Motors Proving Ground.
DESCRIPTION: The test trailer was a semi-trailer with an articulated, walking-beam type bogie suspension. The trailer was manufactured by the Willamette-Hyster Company and was designed for use in the logging industry.
CONCLUSIONS: As far as could be observed the rear wheel load dividing device functioned properly, and no difficulties were encountered during the operations.
GENERAL: This four-page report is not illustrated.

SUBJECT: Suspensions PG-2.579
TITLE: Failure Frequency on Components of the Suspensions and Track Systems of Medium and Light Tanks
IDENTIFICATION: Report No. PG-2.579
DATE OF REPORT: 23 December 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile failure frequency charts on components of the suspension and track systems of medium and light tanks operated at General Motors Proving Ground
METHOD: Charts were prepared covering the failures of the following suspension and track parts in medium and light tanks which had operated up to 4000 miles: bogie wheels, support rollers, rear idlers, track pins, end connectors, track blocks, bogie arms, gudgeon pins, and bogie springs. Track throwing was also recorded. Special failure designations were used to indicate whether the failure required an adjustment or whether the vehicle was immobilized, whether the parts were standard or experimental, and the type of test on which they were run. Data were assembled in classes by size and by engine type.
DESCRIPTION: Data were obtained on M3 and M4 series Medium Tanks and on the M3 and M5 series Light Tanks.
CONCLUSIONS: On the medium tanks, bogie wheel failures were considered excessive and the failures increased in frequency when steel tracks were substituted for rubber tracks. Production track support rollers functioned satisfactorily with rubber tracks, but excessive failures occurred with steel tracks. It was felt that experimental rollers showed considerable promise. Volute spring failures occurred at lower mileage on vehicles with heavy engines than on vehicles with light engines. End connector and track block failures were not excessive, and little difficulty was experienced with track throwing. Bogie arm failures were discovered chiefly when the suspension was disassembled to replace other parts. Pin breakage with steel tracks was considered serious. On the light tanks, there were few pin failures, and very little difficulty resulted from bogie wheels and track support rollers. Rubber track mileage was satisfactory; mileage with steel tracks was unsatisfactory. Trailing idlers were also considered unsatisfactory.
GENERAL: This 70-page report contains 42 failure frequency charts.

SUBJECT: Suspensions PG-2.599
TITLE: Test of 15 Sample Unit Combination Coil and Belleville Spring Clusters, Medium Tank M3
IDENTIFICATION: Report No. PG-2.599; GMPG Project No. 21
DATE OF REPORT: 1 February 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of 15 sets of coil and Belleville washer bogie springs
METHOD: The test coil springs and Belleville washer clusters were installed in the left Nos. 3 and 4 and the right Nos. 1, 2, 5, and 6 positions on a Medium Tank M3 in place of volute bogie springs, and new standard volute springs were installed in the other six positions. The vehicle was then operated on a special course laid out to furnish severe bogie spring action.
DESCRIPTION: The test spring assemblies consisted of heavy coil springs and stacks of Belleville spring washers with sleeves fitted in the coil springs.
CONCLUSIONS: The coil and Belleville washer bogie springs were entirely unsatisfactory for use on Medium Tanks with the bogie suspension tested. It was recommended that no further work be done on bogie springs of this type. It was further recommended that the standard Medium Tank bogie suspension be entirely redesigned.
GENERAL: This 22-page report contains 12 photographs showing component failures.

SUBJECT: Suspensions PG-2.608
TITLE: Special Spring and Suspension Tests — Half-Track Vehicles
IDENTIFICATION: Report No. PG-2.608; GMPG Project No. 85
DATE OF REPORT: 10 February 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the deflection characteristics of the rear suspension on a Half-Track Personnel Carrier, M3; and to compare the front spring rate of standard springs with that of International Harvester front springs
METHOD: Tests were made with the vehicle tracks on adjacent platform scales and the vehicle loaded to produce maximum spring deflection. Intermediate points of spring deflection were determined by gradually reducing the spring load with hydraulic jacks. Tests were made with a horizontal load applied to the idler and with track guides riding the sprocket. Deflection of suspension components was determined with the springs replaced by rigid spacers.
DESCRIPTION: Tests were made on a Diamond T Half-Track Personnel Carrier M3 with Spring Perch number three springs and with standard and International Harvester front springs.
CONCLUSIONS: The effective spring rate of the rear suspension was widely variable, depending on the track tension. High track tension resulted in soft effective springing and increased friction in the rear suspension. Deflection of the bogie bracket contributed to the soft spring rate. The jackshaft housing and sprocket, rear idler wheel, spindle, shackle, and shaft showed appreciable deflection under track tension. The cumulative deflection of the rear suspension components under 16,000-pound load reduced the length of the track path 14 inches and reduced the outer perimeter of the track path 1.25 inches less than the inner perimeter. The spring rate of standard front springs averaged 770 pounds per inch, and the spring rate of International Harvester front springs averaged 1140 pounds per inch. Construction and test of a redesigned rear suspension with an outboard support member for the sprocket and idler were recommended to reduce deflection.
GENERAL: This 75-page report contains 75 deflection graphs, nine photographs of the test arrangement, and one drawing of the proposed redesign of the rear suspension.

SUBJECT: Suspensions PG-2.671
TITLE: Metallurgical Investigation of Failed Suspension Parts
IDENTIFICATION: Report No. PG-2.671; GMPG Project No. 34-94
DATE OF REPORT: 29 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the cause of failure of an equalizer arm and a bogie spring seat from a Medium Tank M4
METHOD: A chemical analysis was made of each of the failed parts, and physical property tests were made on bars cut from the parts. Samples of each part were etched and examined microscopically. The tests were made at General Motors Research Laboratories.
DESCRIPTION: The test parts were a bogie spring seat and an equalizer arm from the suspension of a Medium Tank M4. Failure of the parts occurred at Camp Young.
CONCLUSIONS: Failure of the equalizer arm was due to hot tears formed in the mold or during shakeout. Failure of the bogie spring seat was due to a ferrite network resulting from improper heat treatment. Improved melting and casting procedures were recommended to improve the equalizer arm, and a change in chemical composition or heat treatment was recommended to improve the spring seat.
GENERAL: This 17-page report contains seven photographs and photomicrographs of the test parts.

SUBJECT: Suspensions PG-2.676
TITLE: 1500 Mile Test of Medium Tank M3 Modified for Rear Drive
IDENTIFICATION: Report No. PG-2.676; GMPG Project No. 74
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of an M3 suspension for a rear sprocket driven vehicle
METHOD: The test vehicle was operated backward for 1137 miles on an endurance course.
DESCRIPTION: The test vehicle was a Medium Tank M5A3E2 with the 37-mm gun and mount removed and the driver's seat and controls installed in the turret with the turret facing the rear. The differential carrier was inverted to reverse the direction of sprocket rotation. The vehicle was equipped with two GM diesel engines, and an experimental GM 1X3030 hydraulic torque converter transmission. The vehicle weighed 62,000 pounds.
CONCLUSIONS: Because of a succession of power plant and transmission failures this test was terminated after 1137 miles. There was no evidence of undesirable suspension characteristics on the rear sprocket operation.
GENERAL: This 175-page report includes 63 photographs of component failures.

SUBJECT: Suspensions PG-2.707
TITLE: Construction and Test Operation of the Track Slack Compensating Mechanism for Half-Track Car M2
IDENTIFICATION: Report No. PG-2.707; GMPG Project No. 29
DATE OF REPORT: 21 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effectiveness and durability of an experimental track slack-compensating mechanism for Half-Track Car M2
METHOD: A static loading test was made to determine the degree of slack compensation. The test mechanism was then installed on a Half-Track Car M2, White; and the test vehicle was operated on the endurance route for 1171 miles.
DESCRIPTION: The compensating mechanism

consisted of a mechanical linkage between the bogie assembly and the idler wheel that moved the idler back and forth to compensate for track slack. The linkage incorporated an adjusting turnbuckle to compensate for track and suspension wear. The mechanism did not include springs and was rigid except for slight flexing and loose tolerances in the components.
CONCLUSIONS: The static test revealed that the mechanism slightly under-compensated for track slack. The tracks were thrown as frequently as other vehicles without a spring loaded idler. Because of the lack of a spring member in the mechanism, high forces resulted in the track system when obstructions passed between the bogie wheels and the track, tending to bend and distort the weaker parts. It was felt that compensator mechanisms should be provided with a spring member within the system to relieve those high forces. A number of compensating mechanism parts were worn at the end of the test and would have given trouble had the test continued. It was recommended that future compensating mechanism design be considered in the light of their limitations as described in detail in the report.
GENERAL: This 131-page report contains daily log sheets, repair records, and 46 photographs showing the test installation and part failures.

SUBJECT: Suspensions PG-2.717
TITLE: Test of 11-Inch Track Support Rollers, Motor Wheel Corporation
IDENTIFICATION: Report No. PG-2.717; GMPG Project No. 34-35
DATE OF REPORT: 10 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the endurance of 12 experimental 11-inch track support rollers
METHOD: The test rollers were installed on a Medium Tank M4A2, Pullman, and operated on the endurance tank route for a total of 3458 miles using both steel and rubber tracks 2046 and 1412 miles, respectively.
DESCRIPTION: The test rollers were of welded steel construction, 11 inches in diameter, with drop-center rims.
CONCLUSIONS: The test rollers had longer life than any other rollers previously tested, and lasted several times longer than standard welded rollers when operated with steel tracks. It was recommended that the type of construction embodied in the test rollers be approved, but that the drop-center rim should be eliminated; that the decision between the test roller construction and the cast type be made from the production standpoint, and that the diameter of medium tank track support rollers be made 11 inches. The adoption of the last recommendation would entail sending a pair of bracket-to-shaft spacers with every replacement roller to be used on the M3 suspension, but would eliminate the use of the spacers that are used to raise the tracks above the skid plates on the M4 suspension.
GENERAL: This 16-page report contains two photographs showing roller wear and failure.

SUBJECT: Suspensions PG-2.719
TITLE: Test of Medium Tank Track Support Rollers Automotive Material Corporation
IDENTIFICATION: Report No. PG-2.719; GMPG Project No. 34-69
DATE OF REPORT: 10 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of two medium tank track support rollers manufactured by Automotive Materials Corporation
METHOD: The two track support rollers were installed on a Medium Tank M4A2 with T49 cast steel tracks and operated 2013 miles over hard-surfaced, gravel, and cross-country road at speeds up to 28 mph.
DESCRIPTION: Two laminated track support rollers manufactured by Automotive Materials Corporation were tested. One roller was constructed of plastic and steel discs, the other of fabric and steel.
CONCLUSIONS: The plastic and steel roller failed at 427 miles; the fabric and steel roller failed at 2013 miles. The higher of these mileages was below that of production cast steel and experimental fabricated steel rollers. The Automotive Material Corporation rollers were considered unsatisfactory, and it was recommended that no further work be done on them.
GENERAL: This 12-page report contains a photograph of one test roller after failure.

SUBJECT: Suspensions PG-2.744
TITLE: Test of Medium Tank Sandwich Type Track Support Rollers — Goodyear
IDENTIFICATION: Report No. PG-2.744; GMPG Project No. 34-53
DATE OF REPORT: 30 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of six sandwich-type track support rollers
METHOD: The test rollers were installed on Medium Tanks M4A3 and M3A3 equipped with steel tracks and operated over hard-surfaced, gravel, and cross-country road at speeds up to 28 mph and grades up to 25%.
DESCRIPTION: The materials tested were six sandwich-type (Harris Bushing) track support rollers, manufactured by Goodyear Tire and Rubber Company. The sandwich construction consisted of two rubber bushings installed on the rim of the roller and covered by two outer rings.
CONCLUSIONS: Three of the rollers failed after 475, 650, and 1954 miles of operation. The outer rims were broken or lost, and the rubber bushing became loose or was lost. The other three rollers operated 650, 1789, and 1789 miles without failure. The test rollers were less durable than standard cast steel rollers. The test rollers were not recommended for production or further development work.
GENERAL: This 15-page report contains three photographs of test roller failures.

SUBJECT: Suspensions PG-2.759
TITLE: Track Suspension Test on 75-MM Gun

Carriage T67 Buick
IDENTIFICATION: Report No. PG-2.759; Project No. D-140
DATE OF REPORT: 21 June 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the operational and durability characteristics of the track and suspension system of the 75-mm Gun Carriage T67
METHOD: Operation and durability tests of 5000 miles were authorized but the project was closed by directive after 767 miles of Proving Ground operation. The vehicle was operated for endurance over the strategical tank route including unimproved country road, gravel, cross-country, blacktop, concrete, Belgian Block, and asphalt seal coated concrete. Periodic inspections and repairs were made when needed.
DESCRIPTION: Material tested was the track and suspension system of the 75-mm Gun Motor Carriage T67 Buick.
CONCLUSIONS: The riding qualities were considered outstanding; little difficulty was encountered in maintaining proper track tension, and at no time was a track thrown. Bogie wheel tire and bearing life were good; failures were loose rivets and cracked wheel rim bellies. A large number of track shoes was cracked, and it was difficult to keep track pin bolts tight. Failures occurred in both front compensating spindles and in shock absorbers and related parts. It was recommended that the track and suspension system in general be considered satisfactory. However, study and redesign of the shock absorber system to eliminate failures were recommended; also improvement in the track to avoid cracked blocks and loosened lock bolts.
GENERAL: This 199-page report covers only operation of the track and suspension system, but other data are included as a matter of record. This data includes nine photographs of the Gun Motor Carriage T67; mechanical inspection sheets; specification characteristic data; speedometer, odometer, and tachometer calibrations; speed schedule; map and profiles of route; daily log sheets, repair detail sheets, and 78 photographs of failures.

SUBJECT: Suspensions PG-2.811A
TITLE: Supplement to Report on Durability Test, Half-Track Personnel Carrier M3, Diamond T
IDENTIFICATION: Report No. PG-2.811A; Project No. 114
DATE OF REPORT: 26 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the cause of failure of a front wheel spindle used on a Half-Track Personnel Carrier M3
METHOD: An examination was made of the spindle of an M3 personnel carrier. Metallurgical tests were then conducted.
DESCRIPTION: The test front wheel spindle was a component used on a Half-Track Personnel Carrier M3. Drawings of the spindle specified a hardness of 217-225 Brinell.
CONCLUSIONS: The failure of the spindle occurred in the fillet and large shoulder. A second crack had started in the fillet between the large and small diameter cylinders. Sections cut from the flange and cylindrical portion of the spindle showed inadequate heat treatment; points on sections where little or no metal had been machined away after forging were soft at the surface. The hardness of the spindle was 187 Brinell. It was recommended that more care be taken by the manufacturer to assure proper hardness; and that if superior strength was desired, NE 1345 or NE 9440 steel heat treated to 255-321 Brinell be used.
GENERAL: This nine-page report contains one page of photographs showing the metallurgical structure of the failed test spindle sections.

SUBJECT: Suspensions PG-2.815
TITLE: Determination of Chemical and Physical Properties of Bogie Crab Assemblies
IDENTIFICATION: Report No. PG-2.815; GMPG Project Nos. 200, 201
DATE OF REPORT: 3 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the yield point, ultimate load, hardenability, hardness, and chemical composition of two bogie crab assemblies
METHOD: Each of the crabs was tested as an assembly to determine load deflection. Dial indicators located above the crabs over the center line of the pin on each side of each crab indicated vertical deflection at these points, and the data were plotted. Hardenability tests and chemical analyses were made of both crab assemblies. Interior and surface hardness was also determined. Transverse sections were cut from one arm of each crab just outside the tie bar and microexamination made.
DESCRIPTION: Materials tested were two bogie crab assemblies supplied by Autocar Company, Ardmore, Pa., and White Motor Company, Cleveland, Ohio.
CONCLUSIONS: The Autocar crabs had a higher indicated load deflection limit than did the White crabs. Chemical analysis showed arms of the Autocar crab to be 3135 steel and the tie bar NE8739; the White arms were 4047 steel and tie bar NE9437. Surface hardness of both crab arms was lower than the interior. White tie bar and arms were harder than the Autocar. Micro examination of sections of both crabs showed severe decarburization at the surface and presence of free ferrite throughout. Hardenability tests indicated that the steel used in each crab had insufficient hardenability for section size. It was recommended that a material be used for the crab arms which would harden to 50 Rockwell "C" or harder for at least 9/16-inch from the quenched end of the hardenability bar. NE9445 and 8745 steels were considered suitable for these parts, and the Brinell limits should be raised to 302-352 to raise the yield points. It was recommended also that weldability be considered in selecting a material.
GENERAL: This 29-page report contains two pages of micrographs representative of interior

structure of crabs tested, load deflection curves, and two SAE hardenability charts.

SUBJECT: Suspensions PG-2.821
TITLE: Spring Loaded Idler Field Service Fix, Half-Tracks
IDENTIFICATION: Report No. PG-2.821; Project No. 119
DATE OF REPORT: 16 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the performance of a spring loaded idler field service fix on half-track vehicles with that of the production fix
METHOD: Prior to installation on the test vehicle the spring rates of the field service fix springs were determined. The field service fix spring loaded idlers were installed on a half-track vehicle in accordance with the installation prints. The half-track vehicle was then operated on the endurance course for a total of 4944 miles.
DESCRIPTION: The spring loaded idler field service fix for one vehicle consisted of two springs and the necessary shackles and hardware for installation on a half-track vehicle.
CONCLUSIONS: The test fix was easily installed, only a few minor changes were required to adjust clearances. It was found advisable to adjust the springs to the loosest point possible to keep track tension down. It was impractical to set track tension by spring length measurements, as done on production fix springs, because of the high spring rate and variation in free spring lengths as determined in the pre-installation tests. It was recommended that the spring loaded idler field service fix be considered satisfactory. It was further recommended that the spring rates and free lengths of the springs be made more uniform so that some standard method of setting track tension could be developed.
GENERAL: This 28-page report contains two photographs of the material tested and graphs of the spring rate tests.

SUBJECT: Suspensions PG-2.824
TITLE: Autocar Front Spring Keeper and Volute Spring Assembly No. X-4180, Half-Track Personnel Carrier M3
IDENTIFICATION: Report No. PG-2.824; Project No. 185
DATE OF REPORT: 6 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the spring rates of the test volute springs before vehicle installation, and combined spring rates of installed front spring and volute spring; to determine the effect of the test spring assemblies on the endurance of half-track front springs
METHOD: Before the test springs were installed, spring rate tests were conducted and the force to deflect them 1/2-inch was determined. After installation in a Half-Track Personnel Carrier M3, Diamond T, a test was run for downward deflection of the body, and minimum clearance between front propeller shaft and rear of the heavy splash shield. Because the capacity of the scales used was exceeded soon after the volute springs made initial contact, the spring rate curve beyond this point was calculated using as a basis the rate of the front springs of the vehicle up to this point, extrapolating this curve, and superimposing the predetermined deflection curve of the volute springs only. Endurance operation with one set of test springs was begun but an accident prevent completion of the test. A second set operated on Multiple Gun Motor Carriage M16, White, and a Half-Track Personnel Carrier M3, Diamond T, for a total of 3715 miles before the project was terminated.
DESCRIPTION: Materials tested were two pair of front spring keepers and volute spring assemblies, Autocar No. X-4180, for use on Half-Track Personnel Carrier M3.
CONCLUSIONS: The effect of volute spring assemblies on endurance of half-track front springs was inconclusive because an insufficient number of samples was tested and hence, no recommendations were made. The first set tested was damaged in an accident after 1829 miles and tests on the second set were terminated by directive after a total of 3715 miles. One of the front springs on the latter vehicle was found broken when removed. Maximum deflection to the bottom, of volute springs averaged 0.8 inch before test. Force to deflect them 0.5 inch ranged from 660 to 810 pounds. At maximum bump condition, minimum clearance between front propeller shaft and rear of the heavy splash shield was 13/32 inch. Because of the wide variation in front spring life, it was recommended that at least six samples of such test material be used in each test.
GENERAL: This 27-page report contains in addition to spring rate curves, four photographs of the Autocar keepers and volute spring assemblies and a photograph of a broken front spring found in the Half-Track Personnel Carrier after test.

SUBJECT: Suspensions PG-2.855
TITLE: Dynamic Loading of Bogie Assemblies on Various Tqpes of Terrain, Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.855; GMPG Project No. 216
DATE OF REPORT: 25 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To measure loading of bogie wheels on Medium Tank M4A4 with horizontal spring suspension under actual operating conditions and to evaluate the effect of grade, speed, sprocket torque, and character of terrain on loading and distribution of load among individual wheels.
METHOD: Flexible control cables were attached to each bogie assembly of a Medium Tank M4A4 so that as the bogie springs deflected, proportional movements were communicated to three pens on a wax paper recorded. The paper drive of the recorder could be started or stopped to graph spring motion while the vehicle was operating over various types of terrain. The recorder was calibrated by removing the tracks and then raising and lowering the vehicle with jacks to allow one pair of

bogies to rest on platform scales which indicated the load on the assembly corresponding to various deflections. Templates were prepared from spring rate curves and used in interpreting charts in terms of bogie assembly loads. Variations in track tension were considered.
DESCRIPTION: Equipment tested was a Medium Tank M4A4 with a horizontal volute spring suspension system.
CONCLUSIONS: Only enough analysis of the suspension mechanics had been made to show that test data were reasonable and accurate. Total load on bogie tires was 25% greater than vehicle weight on the tank tested due to initial track tension. In service, track adjustments might give tire loads of 50% more than vehicle weight. The sum of loads on all bogie tires remained approximately constant for all grades and sprocket torques. Grade operation, accelerations, and drawbar loads produced an appreciable change in load distribution from front to rear bogies, while the center bogie load remained constant. Over rough terrain bogie springs bottomed repeatedly with loading more extreme and bottoming more frequent on front bogies. At 13.5 to 15 mph, passing of center bogie wheels over individual track blocks created resonance in springs of about 40 cps. Front and rear bogie assemblies showed little tendency to vibrate. It was recommended that effects of load changes on bogie wheels be included in any analysis of bogie tire failures.
GENERAL: This 24-page report contains charts and curves showing spring deflection under various conditions and two photographs of the recorder device for bogie spring deflection.

SUBJECT: Suspensions PG-2.897
TITLE: Field Modification Type Bogie Wheel Flanges — Half-Tracks
IDENTIFICATION: Report No. PG-2.897; Project No. 34-92
DATE OF REPORT: 18 October 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of eight half-track bogie hub assemblies with field modification type bogie-wheel flanges
METHOD: The test bogie hub assemblies were installed on a Half-Track M5, and were operated a total of 2494 miles.
DESCRIPTION: The test bogie hub assemblies with field modification type bogie wheel flanges were manufactured by the Candler Warehouse Co.
CONCLUSIONS: The life of the eight bogie hubs varied from 1002 to 2494 miles, and failure was due entirely to bearing failures. None of the hub flanges was seriously damaged. There were several tracks thrown at the beginning of the test only because of idler toe-in. No recommendations were made because of insufficient test mileage.
GENERAL: This 21-page report contains 10 photographs of the bogie hub assemblies at various test miles.

SUBJECT: Suspensions PG-2.934
TITLE: Cruiser Tank Mark VI, Suspension Tests
IDENTIFICATION: Report No. PG-2.934; GMPG Project No. 67
DATE OF REPORT: 25 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the feasibility of substituting U. S. made half-springs for British-made full length springs on British Cruiser Mark VI tanks; also, to evaluate the performance of Monroe shock absorbers and a Buckeye-built transmission and steering unit.
METHOD: Test half-springs, shock absorbers, and a transmission unit were installed in a Cruiser Mark VI tank and operated for 653 miles. The half-springs were measured for free length, load, and rate before and after test.
DESCRIPTION: The test shock absorbers were hydraulic, direct acting, Monroe type-X2383, and were mounted on the front and rear suspension units. The transmission was made by the Buckeye Traction Ditcher Company. The test springs were helical coil springs manufactured by the Eaton Spring Manufacturing Company for use in the Christie-type suspension of the British Mark VI Cruiser tank. Two test springs were used in each spring tube in place of the original single spring.
CONCLUSIONS: The Eaton half-springs performed satisfactorily during the 653 miles of test operation. The shock absorbers failed at 450 miles and were returned to the manufacturer. The shock absorbers were considered unsatisfactory because two intake valve discs broke, and all base valve discs failed after working under load. The transmission operated satisfactorily, but no recommendations were made because of early project termination.
GENERAL: This 126-page report contains a profile drawing of the Mark VI Cruiser tank and five pages of tank specifications. The report contains 32 log sheets, 20 repair detail sheets, and 23 photographs showing a broken shift lever and other failed parts.

SUBJECT: Suspensions PG-2.947
TITLE: Interference Check, Increased Section of Bogie Crab D48407
IDENTIFICATION: Report No. PG-2.947; Project No. 235
DATE OF REPORT: 6 November 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine whether a bogie crab with increased section would operate without interference in the standard half-track bogie bracket
METHOD: A standard half-track bogie crab was built up with lead to the specified increased section and operated 45 miles on a Diamond T Half-Track M3. The test crab was also installed on a Gun Motor Carriage M16, a Personnel Carrier M5, and an Autocar Personnel Carrier, M3. Interference was checked on each installation. Interference was also checked in the position of maximum volute spring deflection by substituting seven-inch sleeves for the volute springs.
DESCRIPTION: The test crab was a standard half-track, bogie crab part No. D48407, with each leg

built-up about 1/2-inch in vertical dimension at the point of maximum bending moment in accordance with Ordnance Drawing No. 129620-1.
CONCLUSIONS: The modified bogie crab showed no significant interference on any of the test installations, and it was recommended that the built-up bogie crab be considered satisfactory as far as interference was concerned.
GENERAL: This 21-page report contains seven photographs and a drawing of the modified bogie crab.

SUBJECT: Suspensions PG-2.1035
TITLE: Modification of Half-Track Spring Loaded Idler
IDENTIFICATION: Report No. PG-2.1035; Project No. 260
DATE OF REPORT: 5 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability and the operating characteristics of a modified half-track idler loading mechanism
METHOD: The modified idler loading mechanism was installed on Half-Track M9A1, and vehicle was operated on grades up to 60% and over rough terrain. Maximum track deflections with maximum engine torques were observed while the vehicle was run in low gear, at full throttle on concrete. The vehicle was then pulled to a standstill, with the tracks spinning by using two dynamometer trucks. The maximum drawbar power was 14,000 pounds under these conditions. For comparison, tests were run on Half-Track Personnel Carrier M3 equipped with standard double idler loading spring.
DESCRIPTION: The test idler loading assembly was a simplified, spring unit in which only the outer spring of the standard loading mechanism was used.
CONCLUSIONS: The test loading assembly was considered as satisfactory as the standard production mechanism. It was not possible to bottom either the standard or the simplified idler loading spring with the maximum track deflection developed by maximum engine torque. It was recommended that the test idler loading mechanism be adopted as standard.
GENERAL: This 23-page report includes two photographs of the test idler installation and two photographs illustrating the method of recording deflection.

SUBJECT: Suspensions PG-2.1106
TITLE: Track and Suspension Test, Medium Tank M4A2E4 — Fisher
IDENTIFICATION: Report No. PG-2.1106; Project No. 285
DATE OF REPORT: 18 April 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability and riding qualities of the E4 torsion bar suspension as installed on two pilot model M4A2E4 medium tanks; and to determine the effect of this suspension on the durability of standard track
METHOD: Two pilot model M4A2E4 tanks, Proving Ground Nos. 8394 and 8391, were tested on the endurance course. No. 8394 was operated a total of 195 miles before the tests were cancelled. No. 8391 had operated only 27 miles when parts were taken from it to repair damage to No. 8394 which occurred at 91 miles. Though No. 8391 was later repaired with new parts, no further testing was done. These tanks were shipped to other facilities, TAPG and Fort Knox, for further testing.
DESCRIPTION: The E4 suspension on these vehicles was of the torsion bar type, with six independently suspended dual road wheels on each side. Each dual wheel was mounted on a suspension arm attached to one end of a torsion bar at the hull. The other end of each torsion bar was secured in a splined recess inside the hull, at the opposite side of the vehicle. This necessitated a 5-1/2-inch offset between opposite wheels. Overtravel was limited by volute bottoming springs mounted on the hull in the path of the suspension arms. Direct acting shock absorbers were mounted between the hull and the suspension arms of wheels Nos. 1, 2, 5, and 6 only. The test tracks were 24-inch, single-pin, interlocking, center guided cast steel tracks. Series-type rubber bushings were used and the track weight was 39.1 lbs. per shoe, complete.
CONCLUSIONS: Due to the limited test mileage no conclusions or recommendations regarding durability of track or suspension could be made. The suspension failure that occurred on vehicle No. 8394 at 91 miles apparently stemmed from failure of one of the shock absorber mounting pins. Difficulties encountered in replacing suspension parts were noted, indicating the need for special tools or design changes to facilitate torsion bar installation. Failure of one track shoe at 108 miles was attributed to unsoundness of the casting rather than suspension action. Riding qualities, in the opinion of the drivers, were superior to those of previous (volute-sprung) M4 tanks.
GENERAL: This 42-page report contains 25 photographs showing construction, installation, and failures of suspension and tracks.

SUBJECT: Suspensions PG-2.1151
TITLE: Metallurgical Tests of Bogie Frame Assemblies for Half-Tracks
IDENTIFICATION: Report No. PG-2.1151; GMPG Project No. 279
DATE OF REPORT: 2 June 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct metallurgical and chemical analyses of the stress relieved weld material between the oil seal pins and bogie frames of two half-track bogie frame assemblies
METHOD: The metallurgical and chemical analyses were made in accordance with the procedure outlined in Research Laboratory Report No. M1500.
DESCRIPTION: The two half-track bogie frames examined were sample 249A — inner bogie frame, Ordnance part No. C86083; and sample 249B — outer bogie frame, Ordnance part No. C86082. The welds between the bogie frame and the oil seal pin were stress relieved by heating to 900°F for three hours. The welding rod used was crucible armorized

molybdenum modified grade No. 6.
CONCLUSIONS: The laboratory analyses showed that there had been a marked improvement in the welding technique and stress relief of the welds. It was recommended that similar bogie frames be given an endurance test to evaluate the metallurgical improvement in the weld between the oil seal pin and bogie frame.
GENERAL: This 22-page report contains laboratory test results and 10 photographs showing detail and assembly drawings of the components, photomicrographs, and the assemblies as cut for examination.

SUBJECT: Suspensions PG-2.1204
TITLE: Modified Bogie Frame Assembly (Horizontal Oil Pin Slots) Half-Track Vehicles
IDENTIFICATION: Report No. PG-2.1204; Project No. 114-1
DATE OF REPORT: 16 May 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the comparative durability of modified inner bogie frame assemblies
METHOD: Four test Autocar bogie frames were installed on a Half-Track Personnel Carrier M3, and operated a maximum of 5286 miles over the endurance route. After 3066 miles, inner and outer bogie frames manufactured by International Harvester Co. were installed on the vehicle, and operated 2220 miles.
DESCRIPTION: The test bogie frame assemblies, manufactured by Autocar and International Harvester, were modified to prevent weld failures at the oil seal pin. Instead of milling the slots in the oil seal pins at right angles to their common centerline, the slots were milled horizontally or parallel to the pin centerline. This effected an increase in section modulus and an improved distribution of the weld between the oil seal pin and inner bogie frame.
CONCLUSIONS: The test Autocar bogie frames failed as follows: one at 2801, two at 3066, while one was still operable after 5286 miles. The International Harvester frames operated 2220 miles without failure. The standard bogie frames had averaged 4308 miles to failure, but failure had occurred as early as 372 miles of operation. It was recommended that, after welding the oil seal pins to the assembly, the assembly be stress-relieved, and further testing conducted.
GENERAL: This 17-page report contains four photographs showing macrographs of the failed welds, and the failed test frames.

SUBJECT: Suspensions PG-2.1223
TITLE: Test of Front Spring Anti-Windup Stops (White Motor Co. No. 418236) — Half-Track
IDENTIFICATION: Report No. PG-2.1223; GMPG Project No. 293
DATE OF REPORT: 20 June 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effectivenss of anti-windup stops on half-track front springs in preventing interference between front axle and engine under extreme spring windup conditions
METHOD: The windup stops were installed on a Half-Track Personnel Carrier M3A1, and the oil pan was coated with modeling clay. The vehicle was then driven over severe bumps, with brakes applied fully just before each bump to produce maximum spring windup. The minimum clearance reached was determined from the impressions made in the clay.
DESCRIPTION: The experimental spring stops were fabricated of steel and installed on the vehicle frame just forward of the spring shackle. They were designed to limit spring travel, under extreme windup conditions, to a value which would provide clearance between the front axle and the oil pan. Denting of the engine oil pan by the front axle drive shaft universal joint had been a frequent occurrence in vehicles of this type.
CONCLUSIONS: The minimum clearance under severe conditions, with spring stops installed, was 1/4-inch. The stops were recommended both for production and for modification of vehicles in the field.
GENERAL: This 11-page report contains three photographs, illustrating the need for, and installation of, the experimental stops.

SUBJECT: Suspensions PG-2.1235
TITLE: Supplementary Report on Medium Tank M4A2E4 — Fisher
IDENTIFICATION: Report No. PG-2.1235; GMPG Project No. 8391 (Project No. 285)
DATE OF REPORT: 8 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: The test Medium Tank M4A2E4 was assigned to Project No. 285 for the purpose of conducting a 2000-mile track and suspension test
METHOD: The test vehicle was given mechanical inspection and a 25-mile road test after which the test was cancelled.
DESCRIPTION: The test vehicle was a Medium Tank M4A2E4, manufactured by Fisher Body Division, Serial No. 2107 and was a full-tracked vehicle weighing 67,285 pounds.
CONCLUSIONS: The test was of such short duration when the vehicle was transferred to Project No. 154-1, no conclusions could be made. Minor repairs were required including installation of two new shock absorbers and several bogie wheels and track support rollers.
GENERAL: This 30-page report includes nine photographs and eight repair detail sheets compiled from test operations while test vehicle was assigned to Project No. 285 from 19 November 1943 to 18 January 1944.

SUBJECT: Suspensions PG-2.1271
TITLE: Horizontal Spring Suspension (Without Shock Absorbers) — Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG 2.1271; Project No. 110B
DATE OF REPORT: 3 August 1944
ORIGIN: General Motors Proving Ground,

Milford, Michigan
PURPOSE: To determine the durability and comparative obstacle scaling ability of an experimental horizontal volute spring suspension without shock absorbers on a Medium Tank M4A4
METHOD: The test suspension was installed on a Medium Tank M4A4 and operated 1738 miles with steel tracks, 838 miles with rubber tracks, and 568 miles with steel-fabric tracks. Comparative vertical obstacle scaling ability tests were conducted with 18, 24, and 36-inch obstacles.
DESCRIPTION: Each bogie assembly in the test suspension was equipped with a pair of volute springs installed horizontally inside the bogie mounting bracket. The springs were seated on pins through the bogie arms. The standard suspension at the time of this test was of the vertical volute spring type.
CONCLUSIONS: The suspension operated satisfactorily throughout the test except for failure of track support rollers. The test vehicle with horizontal volute spring suspension exhibited superior obstacle crossing ability. Since this test suspension had been obsoleted by a similar, improved suspension, further testing was not recommended.
GENERAL: This 62-page report contains one photograph showing the test suspension installed and 42 photographs showing failed track support rollers, bogie, and idler wheels.

SUBJECT: Suspensions PG-2.1275
TITLE: Tests of Straddle-Mounted Spring-Loaded Idler Assembly for Half-Track Vehicles
IDENTIFICATION: Report No. PG-2.1275; Project No. 300
DATE OF REPORT: 25 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine whether a straddle-mounted spring-loaded idler assembly would minimize the loading on the idler axle, shackle, and shackle post of half-track vehicles
METHOD: A Half-Track Personnel Carrier M3A1 equipped with a test straddle-mounted spring-loaded idler assembly was operated over various types of terrain for a total of 2065 miles. A recorder which would graphically indicate spring deflection was equipped on the vehicle. Vehicle speed at various towed loads was held at 2 mph.
DESCRIPTION: The test straddle-mounted spring-loaded idler assembly was constructed from International Harvester Company Layout No. AM-17248-Half-Track. The assembly consisted of a yoke which straddled the idler; the yoke was, in turn, journaled to the idler axle. With this installation, the idler spring thrust could be applied at the center of the idler in equilibrium with track forces.
CONCLUSIONS: The idler assembly, although displaying some satisfactory tendencies, was considered unsatisfactory as tested and was not recommended. Advantages of the straddle-mounted idler were: the yielding and towing-in of the idler shackle post was reduced; and the assembly practically eliminated cocking and consequent friction in the idler loading mechanism. It was recommended that development be continued on the test assembly with the object of obtaining the optimum spring rate, improving the manner of retaining the spring, and the elimination of possible interferences; that half-track jackshafts be reinforced in order to eliminate the failure of this vehicle component; and that sprocket and track drives of the vehicle be improved in order to eliminate track throwing.
GENERAL: This 72-page report contains 21 photographs showing the test installation and drawings of the assembly.

SUBJECT: Suspensions PG-2.1279
TITLE: Horizontal Spring Suspension (with Shock Absorbers) Medium Tanks
IDENTIFICATION: Report No. PG-2.1279; GMPG Project No. 10
DATE OF REPORT: 17 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of a horizontal spring suspension on a Medium Tank M4A4; to compare the performance with that of the standard suspension, particularly with respect to wall scaling ability; and to evaluate shock absorber performance during the tests
METHOD: Front and rear tests suspension units with shock absorbers were installed on each side of a Medium Tank M4A4, equipped with T49 cast steel track. The center units were installed without shock absorbers. The test vehicle was operated over various endurance courses for 3430 miles. During the test operations, the test vehicle and two medium tanks with conventional suspensions were tested for comparative wall scaling ability on vertical walls 18, 24, and 36 inches high. The tanks with conventional suspensions were equipped with rubber chevron T48 Tracks and steel chevron tracks. At 2141 miles the T49 tracks on the test vehicle were replaced with standard T54E1 steel tracks.
DESCRIPTION: Each unit of the test suspension contained two volute springs installed horizontally instead of vertically as in the standard suspension. The spring seats were attached to the bogie arms by pins and were free to swivel on the pins. Where used, a direct acting hydraulic shock absorber was connected between brackets mounted on the bogie arms.
CONCLUSIONS: The following suspension parts gave unsatisfactory performance during the test: shock absorbers, track support rollers, and bogie arms. Modified shock absorbers with increased piston rod diameter and lower oil reservoir dome installed during the test exhibited improved performance over the original shock absorbers, and it was recommended that additional tests be conducted with these modified units. Fifteen sleeve-to-hub weld metal failures occurred in the track support rollers. Improvement of the track support roller design was recommended. Two bogie arms cracked after 631 and 1755 miles of operation, and one bogie arm stop cracked after 1755 miles. Strengthened bogie arms were recommended to prevent cracking. Bogie tire life with the steel tracked test vehicle surpassed that of vehicles with standard suspensions. The test vehicle with shock

absorbers rode as well or slightly better than the standard vehicles, and much better (with less pitch) than the test vehicle without shock absorbers.
GENERAL: This 71-page report contains 31 photographs of the test suspensions installed and removed from the test vehicle, failed bogie arms, track support rollers, and shock absorbers. One drawing of the shock absorber assembly also is included.

SUBJECT: SUSPENSIONS PG-2.1339
TITLE: Tests of Hydraulic Track Tensioning Device for Half-Tracks
IDENTIFICATION: Report No. PG-2.1339; Project No. 34-168
DATE OF REPORT: 7 September 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the performance of an experimental track tensioning device with that of the standard arrangement
METHOD: Standard and experimental tensioning devices were alternately installed on the rear idlers of a Half-Track Personnel Carrier M5A1. Vehicle acceleration and deceleration characteristics and tractive resistance were compared for each type of installation. Deflection in inches of the standard and experimental devices was measured and plotted against vehicle drawbar pull, in pounds. The test tensioning device was then used in a 2000-mile durability run.
DESCRIPTION: The test hydraulic track tensioning device was designed to replace the rear idler loading springs on standard half-track vehicles. A hydraulic shock strut was mounted coaxially in a relatively soft helical spring. A valve arrangement caused the strut to resist high compression loads, while allowing free extension of the spring to take up slack in the track. The device was expected to reduce idler deflection under heavy load, thereby decreasing track-throw tendency. Also, initial track adjustment was to be looser to improve vehicle performance. Strut travel was 1-3/4 inches versus more than 2-1/2 inches in the standard arrangement.
CONCLUSIONS: The hydraulic device was not recommended since it was found incapable of improving vehicle performance. It provided less suspension protection than the standard arrangement, was more complex, and more expensive. On moderately rough ground, the oscillatory idler action jacked out the strut and increased track tension. The pressure relief valve was considered too small and too slow to prevent serious suspension damage in case a track were thrown. (Its reaction time was about two seconds.) High friction in the mechanism and the small effect of spring thrust made the idler response to steady drawbar loads no more satisfactory than the standard arrangement. No track throwing occurred. Further development was recommended to obtain instant collapse of the strut under otherwise damaging loads, to eliminate the jacking action of the strut with by-pass ports in the cylinder wall, and to incorporate a lighter spring. Top vehicle speeds and acceleration and deceleration characteristics were very similar for both installations.
GENERAL: This 45-page report contains one drawing and two photographs of the installations.

SUBJECT: Suspensions PG-2.1405
TITLE: Test of End Connector Interference with Modified Trailing Idler Arm, Light Tank M5A1, Cadillac
IDENTIFICATION: Report No. PG-2.1405; Project No. 34-149
DATE OF REPORT: 26 October 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the location and extent of interference between the end connectors and suspension components of a Light Tank M5A1; and to determine whether modified trailing idler arms would reduce the interference
METHOD: Location of the points of interference between the track and the suspension on Light Tank M5A1 was determined under static conditions on a 12-inch vertical wall, a 6 x 8-inch railroad tie, and on 12-inch concrete humps. Location of the points of dynamic interference was determined by operating the vehicle cross-country and over an obstacle course. The trailing idler arm was then modified, and the vehicle was operated 1138 miles on an endurance course.
DESCRIPTION: The test vehicle was a Light Tank M5A1 with standard suspension components. In an attempt to eliminate suspension and track interferences, the idler arms were modified by removing the inner stop from the right arm and the outer stop from the left arm.
CONCLUSIONS: Interference occurred between the tips of the track guides and all bogie arms and the trailing idler arm during both static and dynamic tests. Most serious interference occurred between the guides and the trailing idler arm and resulted in broken guides. Test data covering the effect of the modified idler arms were inconclusive, and further testing was recommended if failures increased.
GENERAL: This 33-page report contains 19 photographs showing types of end connector interference, broken guides, and the modified idler arms.

SUBJECT: Suspensions PG-2.1565
TITLE: Rubber Bushed Bogie Arms Medium Tank Suspension Center Guide Track
IDENTIFICATION: Report No. PG-2.1565; Project No. 34-187
DATE OF REPORT: 17 April 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effect of rubber bushed bogie arms on bogie tire life; to compare two types of rubber bogie arms bushings
METHOD: One standard M4A3 Medium Tank weighing 77,600 pounds, was used as a control vehicle. The test vehicle was identical except for having "thin wall" bushings on the left side. The test arms increased the vehicle weight to 78,000 pounds. Both vehicles had Firestone production

T80 tracks and Firestone synthetic rubber bogie tires. Both vehicles were operated for 5500 miles under the following endurance course conditions: heavy mud, hard frozen ground, and snow and ice. Angular deflection measurements were made and recorded on the test arms. Vehicle speed was obtained and recorded by means of a cable attached to the drive sprocket. Measurements were taken on various sections of the endurance course.
DESCRIPTION: The test suspension units differed from the standard in that they incorporated rubber bushings in the bogie arms. The standard bushing thickness was 0.27-inch, and the test bushing thickness 0.22-inch. The thinner bushings were described as having approximately 30% greater torsional rigidity.
CONCLUSIONS: Bogie tire life was considerably decreased by the use of rubber bushed bogie arms and hence, this type of bogie arm, was not recommended. Nine tire failures occurred with the test vehicle, compared with two failures on the standard vehicle. The chief cause of tire failure was guide cutting and gouging which was apparently aggravated by the additional flexibility of the suspension with rubber bushed bogie arms. Deflections were as high as 5° to 6° from the center position, compared to normal deflections of 2° to 4°. The track center guides and wheel rims showed somewhat greater wear on the test vehicle than on the control vehicle. Handling and riding performance of the two vehicles was comparable. Increasing the torque from 250 to 300 lb.-ft. on bogie attaching cap screws decreased loosening.
GENERAL: This 95-page report contains 55 photographs of the test and standard suspension units installed, the test unit assembled and disassembled, and all of the failed bogie tires.

SUBJECT: Suspensions PG-2.1651
TITLE: High Speed Motion Picture Study of U.S. Rubber Bogie Tires Equipped with Special Shock Rings
IDENTIFICATION: Report No. PG-2.1651; Project No. 34-619
DATE OF REPORT: 14 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To obtain high speed motion pictures of the shock ring and the No. 1 bogie tire on an M4 Medium Tank at the instant of striking an obstacle
METHOD: The shock rings were installed at the No. 1 bogie position on an M4A3E8 Medium Tank equipped with a T66 Track. A mirror and one lighting unit were mounted on a long bracket bolted to one of the final drive housing bolts. The mirror was located between the front bogie and sprocket. Two other lighting units were mounted to give the proper lighting effect. With the camera mounted on a shelf extending 18 inches from the vehicle side and 10 inches below the top track line, pictures were taken when the tank hit an obstacle. The obstacle was a 3x6 piece of wood, and vehicle speed was 15 mph.
DESCRIPTION: The shock rings were of two diameters, 19.55 inches and 19.13 inches, and were designed to take the impact loads occurring at the front bogie position.
CONCLUSIONS: The shock rings could interfere with the sprockets if clearances were not accurately maintained. Upon impact, the bogie rubber would fill about half the space between the large diameter ring and the tire, and practically the entire space between the small diameter shock ring and the tire. Further tests were recommended to determine positively whether the shock rings had a tendency to slip off the track edge. It was also recommended that the tests be conducted at higher frame rates than 1000 frames per second.
GENERAL: This nine-page report contains one photograph showing interference between the shock ring and the sprocket.

SUBJECT: Suspensions PG-2.1691
TITLE: Heavier Section Bogie Suspension Parts for Half-Track M2A1 — Autocar Company
IDENTIFICATION: Report No. PG-2.1691; Project No. 372
DATE OF REPORT: 12 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the durability of Autocar heavier section bogie crabs, side arms bogie frames, and frame shafts as compared with standard production parts
METHOD: The test heavier section suspension parts were installed and tested on two Half-Track M2A1 vehicles. The vehicles were operated a total of 4971 and 4720 miles over both muddy and good roads.
DESCRIPTION: The test Autocar suspension parts differed from the standard production suspension parts in that the former incorporated heavier sections in the bogie crabs, side arms, bogie frames, and frame shafts.
CONCLUSIONS: During the total testing time, none of the test suspension parts failed in the heavier sections. Five bogie frames were replaced, (average mileage 4166) because the oil pan seats were grooved or otherwise damaged from bearing failures. Two bogie frame shafts failed at an average of 4538 miles, because of wear at the frame attaching points. The 16 bogie arms and four crabs operated without incident. (Previously 36 standard bogie arm failures occurred at an average of 4971 miles, while eight bogie crab failures averaged 3902 miles. Other standard suspension parts had often operated 5000 miles without failure.) Because of insufficient testing time, it was recommended that additional testing be conducted to determine the life expectancy of the heavier test suspension. It was further recommended that work be done to improve the bogie hub bearing life.
GENERAL: This 28-page report contains 11 photographs illustrating the test parts before and after operation, the vehicle installation, and damaged parts.

SUBJECT: Suspensions PG-60705.4
TITLE: Half-Track Personnel Carrier M5, Standard versus Flame Hardened Bogie Flanges
IDENTIFICATION: Report No. PG-60705.4; T.A.

P.G. Project No. 71
DATE OF REPORT: 26 November 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the wear and endurance characteristics of standard and flame hardened bogie flanges
METHOD: Personnel Carrier M5 was equipped with standard bogie wheels on the left side and the test bogie wheels on the right and operated over endurance courses for 2258 miles. Wear measurements were made periodically during the test.
DESCRIPTION: The test bogie wheels were the same as standard bogie wheels except the flanges of the test wheels were flame hardened. Both standard and flame hardened bogie wheel flanges used on the test were manufactured by the International Harvester Company.
CONCLUSIONS: The test flanges showed 14% better wearing qualities than the standard flanges: the test flanges averaged 3/16-inch wear for the 2258 miles compared to 7/32-inch wear of standard flanges. The use of flame hardened bogie wheel flanges on the M5 Personnel Carrier was recommended.
GENERAL: This 14-page report contains one photograph showing the condition of the test and standard flanges after the test. Two graphs of comparative wear rate are included.

SUBJECT: Suspensions PG-60803
TITLE: Ice Scrapers, Light Tanks M3 and M5 (KG-20-3)
IDENTIFICATION: Report No. PG-60803; Project No. 60
DATE OF REPORT: 22 January 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the practicability of installing scrapers on the trailing idler wheels to prevent ice build-up
METHOD: A pair of ice scrapers were installed on the idler arms of an M5 Light Tank, which was then operated 212 miles over the Proving Ground endurance test route. Although course conditions prevented testing in actual mud and ice conditions, sufficient information was obtained in the mileage completed.
DESCRIPTION: The scrapers were 1/4-inch steel, formed to clamp on the idler arms ahead of the idler wheel, and present a blade to the part of the wheel, below the idler arms. The blade portion was mounted 1/8-inch from the periphery of the wheel. The scrapers were held in place by clamp plates with three bolts on either side of the wheel.
CONCLUSIONS: Although ice and mud performance could not be evaluated, the durability of the scrapers proved inadequate. Stones and gravel, and the track end connectors, hit the scrapers repeatedly and did considerable damage. The mounting was not secure enough, allowing the scrapers to shift under impact and rub against the wheel. After 212 miles one scraper blade was completely worn through and the other well on the way. It was recommended that the scrapers be made of heavier material and mounted, more securely, where the track could not hit them.
GENERAL: This 13-page report contains three photographs of the scraper, installation, and failures.

SUBJECT: Suspensions PG-60803-01
TITLE: Ice Scrapers, Light Tanks, M3 and M5 (KG-20-3), Supplementary Report
IDENTIFICATION: Report No. PG-60803-01; Project No. 60
DATE OF REPORT: 27 May 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the merits of a revised ice scraper and installation after unsatisfactory test results with the original version
METHOD: The revised ice scraper installation was made on an M5 Light Tank and subjected to 54 miles of mud operation, at which time it was felt that sufficient information had been obtained.
DESCRIPTION: The ice scrapers were formed of 1/4-inch, steel plate into a flat-bottomed "U" shape and clamped to the trailing idler arms of the vehicle, below the arms and ahead of the wheel. The flat bottom of the "U" shape formed a scraper blade which was mounted about 1/8-inch from the periphery of the wheel. In the early version, the extensions of the scraper blocks were clamped on the outside of the idler arms and the blade was 10 inches wide. The modification consisted of cutting 3-1/2 inches out of the blade width so that the extensions would fit thside the idler arms. As in the early version, the scraper extensions were secured to the idler arms with a clamp plate and three bolts on each side of each wheel.
CONCLUSIONS: The location of the scrapers below the arms was unsatisfactory as the build-up of mud occurred on the top of the arms where the scrapers had no effect. Wooden blocks were run over to simulate rough terrain operation and it was found that the end connectors of the track interfered with the scrapers as the idler wheel approached the blocks. The necessity for ice scrapers was considered dubious, particularly with rubber tired idlers, and abandonment of the project was recommended.
GENERAL: This 18-page report contains five photographs of the installation and operation of the scrapers as well as detail and assembly drawings and a bill of material.

SUBJECT: Suspensions PG-61505.21
TITLE: Endurance Test of Medium Tank M4A2E4, Preliminary Report
IDENTIFICATION: Report No. PG-61505.21; Project No. 215
DATE OF REPORT: 22 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the suspension of the Medium Tank M4A2E4 with that of the first pilot Medium Tank M4A3E8
METHOD: The test tank was operated for three miles and then returned to the manufacturer for

modifications. Proving Ground efforts to correct the suspension shortcomings proved unsatisfactory.
DESCRIPTION: The test vehicle was a Medium Tank M4A2E4, (Fisher Tank Division) equipped with a GM-6046 diesel engine and an experimental torsion bar suspension system. A 24-inch, center guide track with Sheldrick type bushings was used. Total tank weight with ballast and crew allowance was 73,210 pounds.
CONCLUSIONS: The left front bumper bracket bolts sheared, the left front track support roller bracket bolts sheared, and the left front shock absorber lower shaft was broken. The vehicle was returned to the manufacturer for a more satisfactory reinforcement of the attaching bumper stop brackets by welding on stop plates to take the shear load off the attaching bolts.
GENERAL: This 15-page report is a log record of the work performed at Tank Arsenal Proving Ground to correct the suspension deficiencies and was not to be included in the final report on the operation of the vehicle after being returned by the manufacturer. Two photographs show the failed suspension components and a Sheldrick-bushed track shoe with one bushing omitted in one eye.

SUBJECT: Suspensions PG-61505.38
TITLE: Proof Test and Check-up of T23E3 Pilot Medium Tank Torsion Bar Suspension
IDENTIFICATION: Report No. PG-61505.38
DATE OF REPORT: 10 March 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To make a mechanical inspection and check of the T23E3 pilot Medium Tank before and after a 100-mile break-in run; to determine and adjust the weight distribution on the suspension system; to determine certain cooling factors
METHOD: The weight on each of the 12 suspension assemblies was obtained by placing a highway scale under each road wheel. Torsion bar adjustments were made to obtain the desired weight distribution, followed by a 100-mile break-in run. Included in this break-in operation were engine cooling performance tests and cooling system pressure valve operational tests. Laboratory tests of the pressure valve were also made. Water temperature indicating instruments were checked for accuracy. Crew compartment air temperatures were taken at various levels under various conditions.
DESCRIPTION: The T23E3 pilot Medium Tank, built by the Detroit Tank Arsenal, incorporated a Ford GAN engine and an electric generator and motor system manufactured by General Electric. The suspension was of the torsion bar type using a Sheldrick 19-inch center guide track. Four hot water heaters were used to warm the crew compartment.
CONCLUSIONS: During the break-in run, two road wheel arm bumper brackets sheared the mounting cap screws. An analysis of the mounting method was recommended. Track pin nut torque ranged from 20 to 300 lb.-ft.; the engine governor required cleaning after 70 miles; and a turret machine gun support bracket failed at 102 miles. Because of the extreme importance of proper road wheel loading, it was recommended the weight distribution be more carefully controlled during manufacturer's final assembly. The vehicle could be operated at 2000 engine rpm. WOT, in 141°F ambient air without exceeding the boiling point (251°F) of water in the cooling expansion tank. The pressure valve began to open at 16.2 psi in the laboratory test, and at 251° on the vehicle. Restriction to steam flow through the pressure valve was considered excessive. The temperature indicator and warning signal were found to be accurate. Crew compartment heaters were adequate.
GENERAL: This 49-page report contains five photographs of failed or worn components, the test vehicle on the highway scales, and the radiator core inlet connectors. Drawings, sketches, and three curve sheets are also included.

SUBJECT: Suspensions PG-61801.15
TITLE: Redesigned Suspension Volute Spring Medium Tank M3
IDENTIFICATION: Report No. PG-61801.15; Project No. 29
DATE OF REPORT: 3 February 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the life of experimental Medium Tank M3 suspension volute springs and compare it with production springs No. C-73927
METHOD: In the laboratory, load and stress deflection data were obtained on experimental and production springs in accordance with the paper "Characteristics of the Volute Spring" in the June, 1942, issue of SAE Journal. Both types of springs were then subjected to life tests on a constant stress machine, and at the proving ground, were installed in medium tanks and operated over the standard endurance course.
DESCRIPTION: The experimental springs were Medium Tank M3 suspension volute springs manufactured by the Eaton Manufacturing Company of bar stock of the same thickness and material as that used for production springs but 3/8-inch wider.
CONCLUSIONS: In the laboratory, the minimum life of the experimental springs was below the average life of the production springs, thus showing no decisive improvement in spring life. Highest stress of the experimental spring was not lower than that of the production spring. It was also noted that the test springs had a tendency to bottom more frequently because of increased solid height and decreased stored energy. As a result of proving ground tests, it was recommended that no further consideration be given to use of the experimental springs since seven failed at an average mileage of 2034. Standard springs failed during the same period at an average of 3482 miles. Failures at the proving ground were of a different nature than those at the laboratory, being caused more by interference than by stress fatigue. There was no apparent correlation between these failures. It was concluded that laboratory tests were unsatisfactory in indicating spring life and recommended that a method be devised for testing suspension

units rather than individual springs.
GENERAL: This 51-page report contains two photographs of spring failures; two drawings of volute springs; and detailed charts, graphs, and tables constituting results of laboratory investigations.

SUBJECT: Suspensions PG-61801.16
TITLE: Test of Horizontal Suspension with Conventional Idler, Medium Tank M3
IDENTIFICATION: Report No. PG-61801.16; Project No. 1
DATE OF REPORT: 24 May 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effects of hydraulic shocks and higher rate volute springs on firing platform stability of M3 Medium Tanks
METHOD: Tank pitching motion was determined by making a frame by frame analysis of movies taken of the Medium Tank M3 as it traversed a set of test bumps. Pitch versus time was plotted to form curves of "Ride-O-Graph" type showing forced vibrations, ensuing induced vibrations, maximum angularity of pitch, and damping. Visual observation to determine need for shocks on front and rear suspensions was made, and effects of higher rate volute springs installed in rear suspension only were determined.
DESCRIPTION: Materials tested were Medium Tank M3 horizontal suspensions with front and rear units identical and modified to include the independent mounting of all track support rollers on cantilever brackets fastened to the hull. Monroe two-inch horizontal, direct acting, shock absorbers were used in the test units.
CONCLUSIONS: Hydraulic shocks at either end of the vehicle improved firing platform stability, the greater improvement resulting from shocks at the front. Higher rate volute springs with initial rate of 2700, installed in rear suspension units only, did not improve firing platform stability, with or without shocks. Further durability tests to evaluate improvement in life of suspension parts were recommended. Also, it was recommended that front and rear shocks with hydraulic control four to five times greater on rebound than compression be used.
GENERAL: This 53-page report contains two photographs of suspension sketches, 10 pitch-time curve sheets, and two drawings.

SUBJECT: Suspensions PG-61801.18
TITLE: Medium Tank Rear Idler Brackets, Malleable Iron
IDENTIFICATION: Report No. PG-61801.18; TAPG Project No. 32
DATE OF REPORT: 3 March 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the endurance of malleable iron rear idler brackets for use with Medium Tanks
METHOD: Three malleable iron rear idler brackets were installed in Medium Tanks M4A4 and M4A1 for endurance operation with both rubber and steel track. At the end of the test, the brackets were removed, inspected, and their operation records compared with standard production brackets.
DESCRIPTION: The three malleable iron medium tank rear idler brackets No. D-37919 were cast by the National Malleable Castings Company and machined by Wilson Foundry, Pontiac, Michigan. These brackets were designed to conserve critical materials and to reduce machining time.
CONCLUSIONS: The three brackets tested were not satisfactory. Failure was caused by a crack, which started at the upper blocking notch radius. One bracket cracked after 120 miles of operation with steel track, and was removed after 587 miles when the crack opened to 3/32-inch. On the other tank, the left bracket cracked at the upper locking plate notch radius after 2300 miles, of which 747 miles were with steel tracks. The right bracket had the same type of failure after 2846 miles, of which 1297 miles were with steel track. Both brackets were removed after operating 1553 miles with rubber track and 1565 miles with steel track. It was recommended that the brackets be redesigned to correct the condition that caused failure.
GENERAL: This 12-page report includes two photographs of bracket failures.

SUBJECT: Suspensions PG-61801.18-01
TITLE: Medium Tank Rear Idler Brackets — Malleable Iron, Supplementary
IDENTIFICATION: Report No. PG-61801.18-01; Project No. 32
DATE OF REPORT: 30 June 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine endurance characteristics of two malleable iron rear idler brackets incorporating a 1/4-inch radius at the locking plate notch
METHOD: The two test rear idler brackets were installed on Medium Tank M4A4 with T54E1 cuff type steel track and operated over the dirt and concrete general test course. After failure, castings were removed for visual and microscopic inspection and one was sent to Chrysler laboratories for analyses.
DESCRIPTION: Materials tested were two malleable iron rear idler brackets, cast by National Iron Co. and machined by Wilson Foundry Co. These brackets incorporated 1/4-inch radius at the locking notch. The directive stated one bracket was "Zee Metal" and the other "Nalloy" No. 6 casting.
CONCLUSIONS: The brackets tested were unsatisfactory. One failed after 160 miles and the other after 491. As a result of the test and the laboratory analyses it was concluded that the brackets were not cast of the material stated in the directive nor heat treated in accordance with specifications, thus preventing testing of the locking notch radius. It was recommended that no further consideration be given to rear idler brackets cast of this material.
GENERAL: This 14-page report includes two photographs of the broken idler brackets and correspondence concerning the test.

SUBJECT: Suspensions PG-61801.19
TITLE: Bogie Wheels — Motor Wheel Corporation
IDENTIFICATION: Report No. PG-61801.19; Project No. 78
DATE OF REPORT: 27 March 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine durability of Motor Wheel Corporation disc type bogie wheels with SAE 1020 steel outer rims welded to the discs
METHOD: Six all-welded type wheels on medium tanks were tested for an average of 539 miles on Medium Tanks M3, M4A3, M4A4, and M4A1. As each wheel failed, it was removed and inspected.
DESCRIPTION: Materials tested were six all-welded, Motor Wheel Corporation disc type bogie wheels with SAE 1020 steel outer rims replacing standard low alloy steel.
CONCLUSIONS: Wheels tested were unsatisfactory because of hub weld failures on four of the six after an average 539 miles. Failures were the result of improper welding around the hub. One wheel operated for 1256 miles with all welds intact. Therefore, merits of the outer rim welding could not be determined even though no failures occurred at this point. Sunken grease fittings were satisfactory. Additional testing was recommended with a different type hub construction to eliminate typical failures.
GENERAL: This 15-page report contains a detailed drawing of the bogie wheel lubricator grommet and two photographs of failures.

SUBJECT: Suspensions PG-61801.22
TITLE: Medium Tank Horizontal Spring Suspension, 4000-Mile Durability, Preliminary Report
IDENTIFICATION: Report No. PG-61801.22; Project No. 53
DATE OF REPORT: 21 May 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating and durability characteristics of medium tank horizontal spring suspensions equipped with shock absorbers
METHOD: The test suspension units were installed on a Medium Tank M4A4 and operated with steel tracks for 3995 miles on the endurance test course. Eaton volute springs were installed to replace the original volute springs after 518 miles. Load loss in the Eaton springs was measured after 1635, 3189, and 3477 test miles. Four Eaton springs were subjected to a laboratory life test on a converted Toledo press and averaged 193,000 cycles to failure. Shock absorbers failed at an average of about 1000 miles due to seal or weld failure. Suspension arm failure was eliminated by arm reinforcement. Three rebound stop brackets failed, apparently due to insufficient design strength. Steel track support rollers averaged 1809 miles to failure. Careful measurements were taken of spring seat plate and pin wear.
DESCRIPTION: The 2-inch, horizontal, hydraulic shock absorbers were manufactured by the Monroe Auto Equipment Co., Monroe, Mich. They were mounted only on the front and rear suspension units. Track support rollers were attached separately to the side of the hull. The complete suspension system with shock absorbers weighed 7544 pounds, compared to 8160 pounds for the standard M4 suspension.
CONCLUSIONS: The performance of the test suspension was considered superior to that of the standard M4 suspension. The factors limiting durability were listed as: shock absorbers, bogie arms, track support rollers, and rebound stop brackets. Several minor modifications were suggested to improve durability. Further test was recommended.
GENERAL: This 58-page report contains 28 photos of the suspension units and failed suspension components. A drawing of the Monroe shock absorber, a tabulation of spring seat wear measurements, and a complete parts list are also included.

SUBJECT: Suspensions PG-61801.22-01
TITLE: Medium Tank Horizontal Spring Suspension Without Shocks, 2000-Mile Durability
IDENTIFICATION: Report No. PG-61801.22-01; T.A.P.G. Project No. 53
DATE OF REPORT: 15 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability characteristics of medium tank horizontal spring suspension without shock absorbers
METHOD: Test suspension units were installed on a Medium Tank M4A4 with T54E2 steel track and operated 2455 miles on the endurance test route. Durability was compared to that obtained previously with M4A3 suspensions.
DESCRIPTION: The 6966-pound, horizontal volute spring suspension, medium tank type, operated without shock absorbers. The bogie wheels were of an experimental Motor Wheel disc type.
CONCLUSIONS: Durability was considered satisfactory, although one volute spring broke, five bogie wheel hubs broke at an average of 1039 miles, and five track support rollers failed. Production and use of horizontal suspension units without absorbers were not recommended. It was suggested that track support rollers be mounted on separate brackets of the M4A3 type.
GENERAL: This 34-page report contains three photographs of assembled and disassembled suspension units, and several photographs of damaged bogie wheel neoprene grease seals and Timken bearings.

SUBJECT: Suspensions PG-61801.22-02
TITLE: 2000-Mile Durability Test of Second Set of Horizontal Suspension Units Incorporating Reinforced Arms and Latest Revised Shock Absorbers
IDENTIFICATION: Supplementary Report No. PG-61801.22-02; Project No. 53
DATE OF REPORT: 7 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating and dura-

bility characteristics of medium tank horizontal spring suspensions reinforced and equipped with improved shock absorbers and track support rollers
METHOD: Test suspension units were installed on a Medium Tank M4A4 and operated 2000 miles on the endurance test route with T54E2 Tracks.
DESCRIPTION: The test suspension units incorporated the latest production design and featured capped bogie arms and capped main brackets as well as revised Monroe shock absorbers for front and rear units.
CONCLUSIONS: No volute springs failed, but only one shock absorber completed the 2000-mile test. One track support roller failed at 1720 miles, and considerable trouble was experienced with loosening of roller bracket cap screws until replacement by 3/4-inch through-bolts. Longer bolts and extra locknuts were required for the front suspension unit brackets. Seven sets of bogie wheel bearings failed. The use of shock absorbers was recommended for increased spring life and vehicle stability.
GENERAL: This 49-page report contains 15 photographs of the test suspension units and various failed parts or components, as well as a drawing and two specification sheets on the Monroe shock absorbers.

SUBJECT: Suspensions PG-61801.22-03
TITLE: Suspension — Horizontal, 4000 Miles Durability, Medium Tank, Final Report
IDENTIFICATION: Report No. PG-61801.22-03; Project No. 53
DATE OF REPORT: 18 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating and durability characteristics of medium tank horizontal spring suspension units equipped with shock absorbers
METHOD: Production design horizontal suspension units incorporating shock absorbers on front and rear units and with capped bogie arms and main brackets and separately mounted track support rollers were installed for a test on a Medium Tank M4A4 (test weight 70,440 pounds) and operated over the TAPG endurance test course for a total of 3927 miles. All operation was with steel tracks.
DESCRIPTION: The horizontal suspension system consisted of six units, three for each side of the vehicle. The front and rear unit was made of two bogie wheels mounted on brackets having independent pivot points on a common vehicle mounting bracket. Two volute springs were incorporated in each unit and mounted parallel with both ends loading the bogie wheels. A shock absorber was mounted above the springs on special brackets.
CONCLUSIONS: The test horizontal volute spring suspension with shock absorbers was satisfactory from a durability standpoint in comparison to the existing M4 suspension. The chief limiting factor in the durability of this suspension was the low effective life of the shock absorbers used in the test. They averaged approximately 700 miles. The life of the volute springs used in the test was superior to that of standard M4 springs. Fourteen spring failures occurred during the test at an average of 3283 miles as compared to 24 failures at an average of 2030 miles on a Medium Tank M4A3 over the same course. Bogie wheel tire life was comparable to that of the M4 suspension, the average mileage to failure being 825 as compared to 900 with the M4 suspension. It was recommended that the mounting bracket be redesigned to rectify loosening condition, that bottom ledge bolts of suspension brackets be changed in size, quantity, or fit to alleviate bolt loosening, and that capped suspension brackets and bogie arms be considered for Medium Tank M4 suspension.
GENERAL: This 43-page report includes 12 photographs of failed bogie wheels and of the test suspension assembled and disassembled.

SUBJECT: Suspensions PG-61801.22-04
TITLE: Horizontal Spring 200-Mile Durability Test — Medium Tank Final Report
IDENTIFICATION: Report No. PG-61801.22-04; T.A.P.G. Project No. 53
DATE OF REPORT: 12 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine operating and durability characteristics of medium tank horizontal spring suspension equipped with shock absorbers
METHOD: The test horizontal suspension units were operated on an M4A4 Medium Tank 3995 miles over the endurance test course at the Tank Arsenal Proving Ground. These same test units were then installed on another M4A4 Medium Tank and operated for an additional 1978 miles.
DESCRIPTION: The horizontal suspension system consisted of six units, three for each side of the vehicle. The front and rear unit was made up of two bogie wheels mounted on suspension arms with independent pivot points on a common mounting bracket. Two horizontally mounted volute springs were incorporated in each suspension unit. A shock absorber was mounted on special brackets above the volute springs. The center suspension unit differed from the front and rear units in that it did not include a shock absorber or shock absorber mounting brackets.
CONCLUSIONS: The horizontal suspension with shock absorbers was satisfactory from an operational standpoint in comparison with the existing M4 suspension. Chief limiting factors in the durability of the suspension were shock absorbers, shock absorber mounting brackets, shock absorber eye pin locking devices, and bogie tire life. It was recommended that development effort be concentrated on the later, cantilever type, horizontal volute spring suspension rather than on this test suspension.
GENERAL: This 37-page report includes 10 photographs illustrating the test horizontal suspension unit and unit failures.

SUBJECT: Suspensions PG-61801.38
TITLE: Special Bogie Arms and Special Gudgeon Pins

IDENTIFICATION: Report No. PG-61801.38; T.A. P.G. Project No. 64
DATE OF REPORT: 27 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effect on wheel bearing durability of special gudgeon pins and special bogie arms
METHOD: Six special gudgeon pins were installed on the left side of a Medium Tank M4A3 and tightened to 1200 lbs.-ft. torque. Six special gudgeon pins were also installed on the right side of a Medium Tank M4A1 and tightened to 900 lbs.-ft. torque. Standard pins were used on the opposite side in each case. The test gudgeon pins were operated to failure of the bogie wheels. Four sets of special, boxed-in, bogie arms were installed on two medium tanks with new gudgeon pins, bearings, leather seals, and bogie wheels and operated to failure of the bogie wheels.
DESCRIPTION: Three types of special gudgeon pins with 1-1/2-12NF3, 1-3/4-8NC2, and 1-3/4-12NF3 threads were tested. Marsden "Huglock" and castellated nuts were used on the test pins. New bogie wheels with Timken bearings and Ohio Rubber seals were used with the M4A1 vehicle, and new bogie wheels with New Departure bearings and leather seals were used with the M4A3 vehicle. The boxed-in bogie arms were standard arms reinforced with a brace welded between the bogie arms at the gudgeon end.
CONCLUSIONS: No improvement in bogie wheel bearing life resulted from the use of the special gudgeon pins or the boxed-in bogie arms, and the use of these items was not recommended. The average bearing life with standard gudgeon pins was 1230 miles, and only 1165 miles with the special gudgeon pins. Average bearing life with standard bogie arms was 1178 miles, and only 1167 miles with the special arms.
GENERAL: This 59-page report contains 20 photographs of failed gudgeon pins and bearings and the boxed-in bogie arms. Four sketches of the bogie arm reinforcement are included.

SUBJECT: Suspensions PG-61801.48
TITLE: Track Support Roller Brackets, Kelsey-Hayes Wheel Company — Light Tank
IDENTIFICATION: Report No. PG-61801.48; T.A. P.G. Project No. 129
DATE OF REPORT: 8 November 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of the Kelsey-Hayes Wheel Company reinforced light tank track support roller brackets
METHOD: A Light Tank M5A1, equipped with two test roller support brackets, was operated for 2010 miles on the endurance test course.
DESCRIPTION: The test Kelsey-Hayes track support roller bracket differed from the standard type bracket in that it incorporated a support rib and used six attaching screws instead of five.
CONCLUSIONS: No failures occurred in the test brackets during the test. They were therefore recommended to replace the standard brackets if required by field conditions. Bearing lock plug failures occurred in the four rollers employing standard brackets. A more suitable method of locking the bearing in place was recommended. Since no bearing lock failures occurred in the test brackets, it was suggested that a complete set be tested to determine whether the reinforcing rib would eliminate this trouble.
GENERAL: This 14-page report contains two photographs illustrating the test bracket and a typical bearing lock plug failure.

SUBJECT: Suspensions PG-61801.68
TITLE: Hull Bogie Bracket Cap, D47526B — Medium Tank M4
IDENTIFICATION: Report No. PG-61801.68; T.A. P.G. Project No. 162
DATE OF REPORT: 18 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine suitability of bogie bracket caps, D47526B, with extensions welded to both ends, for use on Medium Tank M4; and to determine the ease of removal of the caps.
METHOD: Extensions were welded to two hull bogie bracket caps on front suspension units on an M4 Medium Tank, and on a complete set of caps on an M4A3 Medium Tank. The test vehicles were operated over the durability test course for a maximum of 4042 miles.
DESCRIPTION: The materials tested were hull bogie bracket caps, D47526B, with one-half-inch extensions welded to each end.
CONCLUSIONS: The experimental caps were satisfactory. Removal of the test caps was accomplished easily with a hammer in only one or two minutes after the three stud nuts were removed. Standard caps required 10 to 20 minutes. It was recommended that extended bracket caps be used.
GENERAL: This 14-page report contains one photograph of a test bogie bracket cap with extensions.

SUBJECT: Suspensions PG-61801.69
TITLE: Test of Horizontal Volute Spring Suspension with 23-Inch Center Guide Track, 100-Mile Shakedown Test of Third Pilot Model M4A3E8 Medium Tank
IDENTIFICATION: Report No. PG-61801.69; Project No. 164
DATE OF REPORT: 21 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the performance characteristics of the suspension components on the third pilot model M4A3E8 Medium Tank
METHOD: The test vehicle was operated 100 miles on the inside dirt track of the endurance course, after which all suspension bracket to hull bolts were tightened to torque of 300 pounds.
DESCRIPTION: The test vehicle was the third pilot model of the Medium Tank M4A3E8 which was equipped with horizontal volute spring suspension and 23-inch center guide track.
CONCLUSIONS: One shock absorber failed during

the test. At the end of the test a number of suspension bracket and track support roller mounting bolts were loose. Other parts of the suspension were in good condition and functioning satisfactorily at end of test. It was recommended that changes be made in design of the suspension bracket or the method of attachment to eliminate loosening of bolts. Correction of the faulty workmanship accounting for failure of the shock absorber was recommended.
GENERAL: This 18-page report is not illustrated.

SUBJECT: Suspensions PG-61801.69-01
TITLE: Durability Test of the Cantilever Horizontal Spring Suspension with 23-Inch Center Guide Track (Volume I of II Volumes)
IDENTIFICATION: Report No. PG-61801.69-01; Project No. 164
DATE OF REPORT: 29 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating characteristics and parts durability of medium tank, cantilever, horizontal volute spring suspensions with 23-inch, center guide track
METHOD: Test suspension units were installed on pilot model Medium Tank M4A3E8 and operated on an endurance course for 1182 miles.
DESCRIPTION: The test suspension was a cantilever type, horizontal volute spring suspension with dual bogie wheels. Double-acting horizontal shock absorbers were used on each.
CONCLUSIONS: The test suspension seemed to offer many advantages over the vertical suspension. Tank pitch and bottoming were reduced with the test suspension, and stability and maneuverability were improved. The over-all durability of the suspension units could not be determined in the limited mileage of the test. However, several component parts were found unsatisfactory in design characteristics, and changes were recommended in sprockets, shock absorber bushings, suspension mounting bolts, suspension arms, and axles. It was also recommended that the suspension mounting brackets be cambered so that the bogie wheels would assume a horizontal position under static load.
GENERAL: This 61-page report contains 14 sketches showing wear points, failures, and bracket and hull deflections, and corresponding measurement data. A weight comparison of horizontal and vertical suspensions is also included. Volume II contains 35 photographs.

SUBJECT: Suspensions PG-61801.69-02
TITLE: Durability Test of Cantilever Horizontal Spring Suspension with 23-Inch Center Guide Tracks
IDENTIFICATION: Report No. PG-61801.69-02; T.A.P.G. Project No. 164
DATE OF REPORT: 6 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating and durability characteristics of the second pilot model M4A3E8 spring suspension, its components, and a pair of 23-inch center guide tracks
METHOD: A Medium Tank M4A3E8 was equipped with the horizontal spring suspension and a pair of 23-inch center guide tracks. The vehicle was operated over the regular endurance course, excluding concrete operation, accumulating a total of 4002 miles. Throughout the test, worn or broken components were replaced.
DESCRIPTION: The Medium Tank M4A3E8, equipped with a horizontal suspension system and a pair of 23-inch center guide tracks, weighed a total of 70,810 pounds. Components included track support rollers, suspension spring, road wheel axles and suspension arms, shock absorbers, hubs, tracks, bogie tires, and road wheels.
CONCLUSIONS: Cantilever type horizontal suspension systems were considered satisfactory. Maneuverability and ride characteristics of the medium tank were improved. Average mileage to failure of volute springs was 2715 miles, almost double the mileage of vertical suspension system. Track support rollers operated throughout the test and were considered satisfactory. Hub failures resulted from loose axle caps. Axles were loose and damaged because of loose sheared cap screws. In general, shock absorbers functioned satisfactorily, except for occasional leakage and an excessive accumulation of dirt. Shock absorber eye bushings failed often and were unsatisfactory. Originally installed hubs were unsatisfactory because of lack of clearance between the center guides of the track and the center portion of the hubs. Fabricated hubs were substituted and operated satisfactorily. Vehicle performance was improved because of the increased flotation obtained from the 23-inch wide tracks. These tracks were considered satisfactory except for guide wear and rubber bushing failures. Bogie tires were unsatisfactory, and road wheels were considered satisfactory.
GENERAL: This 93-page report contains 34 photographs illustrating various failures throughout the test. A weight report, dimensions report, and a detailed analysis of the test are included.

SUBJECT: Suspensions PG-61801.69-03
TITLE: Durability Test of Cantilever Horizontal Spring Suspension with 23-Inch Center Guide Tracks
IDENTIFICATION: Report No. PG-61801.69-03; T.A.P.G. Project No. 164
DATE OF REPORT: 11 October 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of a reconditioned cantilever type horizontal suspension system; to determine the durability of a pair of 23-inch wide center guide tracks, a set of experimental sprockets, and two groups of track pins each with different hardness values.
METHOD: The reconditioned suspension system, a pair of the test tracks, and standard experimental sprockets were tested on the endurance course for 1154 miles. The vehicle was loaded to 70,805 pounds.
DESCRIPTION: The vehicle tested was the second pilot model Medium Tank M4A3E8, whose suspension components were reconditioned; worn or

failed parts were replaced. Tracks tested were 23-inch wide center-guide tracks manufactured by the Ford Motor Company. Center guide height was reduced 3/8 inch to allow clearance between the guide and final drive hub. Pins in the left track had a Brinell hardness of 302 to 341 and pins in the right track had a Brinell hardness of 415 to 461. Standard sprockets were used on the right side of the vehicle and experimental sprockets on the left side. The experimental sprockets were made of NE9422 steel, flame-hardened on the tooth face, and had a 0.045-inch increased circular pitch. They were designed to provide better tooth contact and more uniform loading of the sprocket teeth.
CONCLUSIONS: Track pins with a BHN of 302 to 341 were too soft causing excessive pin wear. They were replaced after 990 miles. The pins with a BHN of 415 to 461 were satisfactory. The experimental sprockets being installed on the same side of the vehicle as the soft track pins resulted in an inconclusive test regarding sprocket wear. However, the indications were that the sprocket life was increased. The test tracks failed at the serrated end of the series type bushings after 164 miles. The 150 pounds-feet of torque on the track pin nuts was considered too low. U.S. Rubber Company natural rubber tires failed at 321 miles and Goodyear at 651 miles. A dirt and stone deflector applied to the rear of number six right suspension was too small to be effective. Testing was concluded after 1154 miles because of lack of replacement parts for the three-inch axles and arms. Because of the short duration of the test no conclusions regarding suspension durability were made.
GENERAL: This 43-page report contains eight photographs illustrating component failures. Test data and a discussion are included.

SUBJECT: Suspensions PG-61801.69-04
TITLE: Test of Horizontal Spring Suspension with 23-Inch Center Guide Track
IDENTIFICATION: Report No. PG-61801.69-04; Project No. 164
DATE OF REPORT: 7 December 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of various modifications made on M4A3E8 cantilever-type, horizontal, volute spring suspension units
METHOD: Six horizontal volute spring suspension units, with numerous and frequent modifications, were operated a total of 5551 miles on a single Medium Tank M4A3.
DESCRIPTION: The test suspension system was a cantilever type, horizontal volute spring suspension and was the first pilot model of the M4A3E8 suspension. The modification made either prior to or during the test consisted of keying the suspension mounting bracket to the hull; application of 3/4 degree camber to the suspension bracket; use of 3-1/2-inch axles pressed into solid suspension arms in place of 3-inch axles and capped suspension arms; use of dust tube relief holes on the shock absorber dust tubes; use of a dirt deflector in front of the rear idlers; and the use of a sprocket in place of rubber-tired idlers. Various kinds of bogie tires were tested on the vehicle as well as four types of track and three different final drive sprockets.
CONCLUSIONS: The keyed-type mounting bracket, the 3-1/2-inch pressed-in axles and solid suspension arms, 3/4-degree bracket camber, and the shock absorber dust tube relief holes were considered satisfactory and were recommended for use. Sprocket No. E1058743 with a 25.250-inch pitch diameter proved more durable than either the standard sprocket or a test sprocket with a 25.156-inch pitch diameter. A single-pin steel track with staggered center guides was found unsatisfactory due to guide breakage. A Woolson-designed steel track, with two short pins welded to both ends of the track shoe instead of a single pin, and a Slack-designed, interlocking single-pin, steel track were considered potentially satisfactory; and further development of these tracks was recommended. Use of the sprocket idlers resulted in 20% less dirt being thrown on the rear suspension, and further test of sprocket idlers was recommended. The dirt deflector provided an advantage too small to justify its use. Bogie tire life was critical throughout the test, and further development of bogie tires was recommended.
GENERAL: This 127-page report contains 35 photographs showing the test vehicle, test components, and failures.

SUBJECT: Suspensions PG-61801.70
TITLE: Investigation of Proposed Method of Salvaging Material Rejected by Inspection
IDENTIFICATION: Report No. PG-61801.70; T.A. P.G. Project No. 143
DATE OF REPORT: 2 March 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To investigate the feasibility of salvaging mismachined medium tank suspension parts by spray-weld metalizing
METHOD: Six volute spring suspension units and two idler wheels and shafts, all incorporating parts salvaged by the spray weld process, were installed on several Medium Tanks M4A3 and M4A4 and operated from 640 to 1962 endurance route miles. Representative parts were sectioned and inspected after test.
DESCRIPTION: The suspension unit and/or idler parts metalized were bearing surfaces in the bogie wheel assembly, roller body, shaft, idler wheel assembly, spindle, spring seat bottom, and bogie wheel gudgeon. Some surfaces were prepared for spray weld metalizing by threading 0.030-inch deep. Other part surfaces were prepared by concentric-parallel grooving 1/32-inch deep, or by grit blasting.
CONCLUSIONS: All test parts, with the exception of bogie wheel gudgeons, wore satisfactorily. It was believed the process could be improved so that reclamation of gudgeons, would also be feasible. The use of certified crushed angular coarse steel grit No. 30 to No. 40 was recommended in preference to Metcoloy Carbon Grit C, and concentric parallel grooves with a round bottom were preferred

over either threading or square-bottomed grooves.
GENERAL: This 59-page report contains seven drawings and 16 photographs of test suspension parts, and Chrysler Laboratory report No. T-61801.51 with three photographs of test parts.

SUBJECT: Suspensions PG-61801.74
TITLE: Suspension, Tractor T22 Adaptation to Medium Tank M4A4
IDENTIFICATION: Report No. PG-61801.74; T.A. P.G. Project No. 155
DATE OF REPORT: 1 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operational and performance characteristics of an adaptation of a T22 Tractor suspension on a Medium Tank M4A4
METHOD: A Medium Tank M4A4 was equipped with a T22 Tractor suspension and 22-inch center guide tracks and loaded to a test weight of 77,020 pounds. It was then operated over a standard endurance course for 187 miles. Four failed volute springs were sent to the suspension laboratory for analysis. Motion pictures were taken during the field tests.
DESCRIPTION: The test suspension was a T22 Tractor suspension, made by Allis Chalmers and adapted for use on Medium Tank M4A4. Each suspension unit contained a large and a small volute spring horizontally opposed at the small ends with the large spring toward the front of the vehicle. The large end of the springs was held in place by deep, cup-shaped, cast steel spring seats with a trunnion on each side. The trunnions were rubber bushed and clamped to the upper extension of the bogie arms. The bogie wheels were 16 x 6 cast spoke wheels.
CONCLUSIONS: The test data accumulated in 187 miles of operation were not sufficient to warrant definite recommendations, and the conclusions were based only on the components that failed during the test. The 20 x 6 x 16 bogie tires were considered unsatisfactory. Undercutting, guide cutting, and separation of the base band necessitated the replacement of six tires. Several spokes failed on two of the bogie wheels, and the sealing surface on eight of the axle shaft seals was slightly scored. This scoring condition was considered unsatisfactory because the sealing surface would become pitted, eliminating the seal effect. The bogie wheel shaft nut locking device, as tested, was found to be inadequate since the shaft lock nuts on all the wheels loosened. Continual bottoming and spring settling led to early failure of four of the 12 test springs. The laboratory analysis showed the springs to be over-stressed, improperly heat treated, and not up to metallurgical specifications. The original spring seat guide was considered unsatisfactory due to bending; however, a modified guide incorporating hardened washers, was satisfactory. The chief limiting factor of the spring seat trunnion bushings was rubber deformation on the compression side of the bushing. New bushings required replacement after 138 miles of operation. The use of the 22-inch center guide track resulted in bogie tire cutting by the center guides.
GENERAL: This 44-page report contains nine photographs of the test suspension installed on the Medium Tank M4A4 and of the failed suspension components.

SUBJECT: Suspensions PG-61801.75
TITLE: Test of Dual 5-1/2-Inch Tire and 24-Inch Track on Horizontal Suspension
IDENTIFICATION: Report No. PG-61801.75; Project No. 180
DATE OF REPORT: 19 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of the test suspension, 5-1/2-inch dual bogie wheels, and two types of 24-inch wide tracks
METHOD: Horizontal suspension parts incorporating shock absorbers on the front and rear units, bogie arms modified to accommodate 11-inch bogie tires, and with separately mounted track support rollers, were installed on a Medium Tank M4A3. The suspension brackets were shimmed out with shims tapered from 0.270-inch at the top to 0.020-inch at the bottom in order to equalize the load on the two tires. The shims were removed after 222 miles of operation. Eleven-inch bogie wheels with Timken sleeve-mounted bearing and seal assemblies were used in all positions. The test vehicle was operated over endurance courses for 2199 miles.
DESCRIPTION: The test medium tank suspension was of the horizontal volute spring type and had brackets set out 3-1/2 inches from the hull to accommodate 24-inch wide tracks. Shock absorbers were used on front and rear units and the bogie arms were modified to accommodate dual 5-1/2-inch bogie tires. Two Burgess-Norton, 24-inch, single pin tracks were tested, one of all steel construction and one of rubber and steel construction. A Burgess-Norton T54E1 steel track, modified to accommodate 11-inch bogie wheels, was used after the two test tracks failed. Test bogie tires were made by U. S., Firestone, and Goodyear.
CONCLUSIONS: The test suspension was considered satisfactory with respect to durability. No bracket failures or bracket attaching bolt loosening occurred during the test. Test bogie tires averaged 849 miles to failure compared with 900 miles for standard 9-inch tires, and were not recommended for use. The two test tracks were considered unsatisfactory. The steel track failed at 221 miles, and the rubber and steel track failed at 327 miles. The 11-inch sleeve-mounted bogie wheels were satisfactory and recommended for use.
GENERAL: This 55-page report contains 25 photographs showing the condition of various test components.

SUBJECT: Suspensions PG-61801.76
TITLE: Tests of Gudgeons B208960 and Safety Nuts A345677 — Medium Tank
IDENTIFICATION: Report No. PG-61801.76; Project No. 64-1
DATE OF REPORT: 26 April 1944

TANK AUTOMOTIVE TEST RESUMES

ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and suitability of the test bogie wheel gudgeon and gudgeon safety nuts
METHOD: The first set of special wheel gudgeons and safety nuts was installed on a Medium Tank M4A3. The gudgeons were lubricated before installation, and the safety nuts were tightened according to regular maintenance procedure. The test vehicle was operated over the endurance course for 1997 miles, after which all bogie wheels were removed to install new suspension units. No. 2 left gudgeon pin was found bent on removal and was sent to the laboratory for a metallurgical check. A second set of gudgeons and safety nuts was installed on a Medium Tank M4A1 and the vehicle operated in a similar manner for 3629 miles. Standard bogie wheels were used throughout both tests.
DESCRIPTION: The test gudgeon B208960 was similar to the production type gudgeon except that the thread length and the thread class fit were changed. The thread length, increased by 1/2-inch over the production part, was changed from 1-1/2-12NF-2 to 1-1/2-12NF-3. The safety nut, of 2-3/8-inch commercial hexagon stock, was tapped with a class 3 fit thread. Locking action was accomplished by crimping the 9/16-inch slotted shoulder of the nut sufficiently to provide a class 4 thread fit.
CONCLUSIONS: Installation and removal of the test items were easily performed in each instance, and all gudgeon pin and safety nut threads were in good condition at the conclusion of the test. One bogie wheel bearing failure occurred after 3418 miles of operation with the test items as compared to a total of seven bearing failures, at an average of 1293 miles, during 2000 miles of operation on a Medium Tank M4 tested concurrently. Standard New Departure bearing and Chicago Rawhide seal assemblies were used on both vehicles. The test gudgeon pin and safety nut were recommended for use in view of the resulting improved bogie wheel bearing life. Analysis of the bent gudgeon pin revealed improper heat treating and slightly low hardness. However, this failed pin did not cause a bearing or seal failure.
GENERAL: This 19-page report contains one photograph of the bent gudgeon pin and two drawings of the test items. A laboratory report on the bent pin is also included.

SUBJECT: Suspensions PG-61801.83
TITLE: Accelerometer Test on the Medium Tank T25 and M4 Series with 23-Inch Horizontal Volute Spring Suspension
IDENTIFICATION: Report No. PG-61801.83; Project No. 212
DATE OF REPORT: 5 June 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the ride characteristics of four medium tanks
METHOD: A medium tank, having a crystal pick-up attached to a 150-pound weight placed in the driver's seat, was operated over various terrain. Test apparatus included a crystal pick-up having an output proportional to acceleration, a RCA linear amplifier, a three-inch cathode ray oscilloscope, and a 35-mm continuous moving film camera. The equipment was then installed in two other vehicles and the operation was again conducted.
DESCRIPTION: The test vehicles were the Medium Tanks T25, M4A2E2 having a torsion bar suspension, M4A3, and M4A3E8 incorporating 23-inch center guide tracks.
CONCLUSIONS: Film results of the first vehicle tested showed satisfactory high frequency discrimination. Because of poor film results in the second test, it was planned to stop operations until all the test vehicles were available. A directive cancelled this project before it was completed.
GENERAL: This eight-page report contains four pages of correspondence.

SUBJECT: Suspensions PG-61801.91
TITLE: Fix for Preventing Interference Between Track Guides and Suspension and Idler Arms — Light Tank
IDENTIFICATION: Report No. PG-61801.91; Project No. 228
DATE OF REPORT: 9 August 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To devise a field fix for correcting the interference between track end connector guides and suspension and trailing idler arms on the light tank
METHOD: A Light Tank M3A3 was driven at high speeds over a number of severe bumps on the Proving Ground endurance course to aggravate suspension interference. Disassembly and inspection clearly indicated the points of contact and necessary modifications were made and tested. Operation totaled 141 miles.
DESCRIPTION: The test vehicle had rubber tire rear idlers and new reversible synthetic rubber T16 tracks. Modifications included lengthening of suspension arm links and addition of rear idler shock absorbers. Suspension arm links B145746 and B145544 were elongated 1/2-inch each, and the double-acting shock absorbers were valved to produce a very high compression resistance and a light rebound resistance. These modifications served to lessen or eliminate interference between the suspension arms and end connector guides and to delay the rear idler action by delaying the action of the springs thereby reducing the impact load.
CONCLUSIONS: The modified suspension arm links plus trailing idler shock absorbers, as developed and tested, minimized interference between end connector guides and suspension and trailing idler arms. The modification was therefore recommended for use on light tanks. It was noted that both modified arm links and shock absorbers must be used together to obtain the desired results. The trailing idler shock absorbers also helped reduce vehicle pitch, thereby increasing vehicle stability and maneuverability.
GENERAL: This 27-page report includes three detail drawings of the modifications and five

photographs illustrating the original interference.

SUBJECT: Suspensions PG-61801.109
TITLE: Test of Pilot No. 1 Medium Tank (76-MM) with Horizontal Spring Suspension on 23-Inch Wide Track
IDENTIFICATION: Report No. PG-61801.109; Project No. 600
DATE OF REPORT: 15 January 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general durability and operating characteristics of the first production model M4A3E8 Medium Tank (76-mm gun) having horizontal spring suspension and 23-inch wide steel tracks, with special emphasis on suspension components and tracks
METHOD: The tank was operated for 4000 miles over the endurance test route. Periodic inspections were made to observe performance and durability of the various components of the vehicle.
DESCRIPTION: This M4A3E8 Tank was the first production vehicle equipped with the cantilever type, horizontal spring suspension, and 23-inch wide center guide track.
CONCLUSIONS: The durability and operating characteristics of this vehicle were considered satisfactory. Detailed observations and recommendations covering engine, electrical system, power train, hull and turret, tracks, and suspension elements were made and included in the report.
GENERAL: This 96-page report includes 22 photographs showing wear and failures of various parts.

SUBJECT: Suspensions PG-61801.110
TITLE: Test of Medium Tank, M4A3E8, Having Both Front Suspension Mounting Bracket Mounting Bolt Holes 0.005-inch Oversize
IDENTIFICATION: Report No. PG-61801.110; T.A.P.G. Project No. 615
DATE OF REPORT: 10 January 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a front suspension mount with 0.005-inch oversize bolt holes
METHOD: A Medium Tank M4A3E8 with enlarged mounting holes in the front suspension bracket was operated 4021 miles on a durability schedule.
DESCRIPTION: The suspension units tested were medium tank, cantilever type, horizontal volute spring suspension units. The mounting holes in the suspension bracket normally accommodate a one-inch body fit bolt. On this vehicle the bolt holes in the front suspension brackets were enlarged 0.005-inch to facilitate production.
CONCLUSIONS: At 3262 miles the right front suspension bracket was torn from the hull. The mounting bolts had sheared, and the bolt holes were elongated. Suspension brackets on other M4-A3E8 tanks with body fit bolts had accumulated over 20,000 miles without failure. Use of 0.005-inch oversize bolt holes in the suspension mounting bracket was not recommended.
GENERAL: This 44-page report contains nine photographs of miscellaneous failures occurring during the test. Several other tests were conducted on this vehicle simultaneously with the suspension test, and results of these tests are contained in separate reports.

SUBJECT: Suspensions PG-61801.111
TITLE: Endurance Test of Medium Tank M4A3 (E8)
IDENTIFICATION: Report No. PG-61801.111; Project No. 298
DATE OF REPORT: 31 January 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of suspension components in Medium Tank M4A3
METHOD: A Medium Tank M4A3 equipped with test suspension components was loaded to 75,760 pounds and operated 5744 miles on concrete and dirt track. Firestone natural rubber bogie tires were used exclusively for 4800 miles. A sprocket test was run simultaneously and reported under another project.
DESCRIPTION: Materials tested were components of the cantilever type, horizontal volute spring suspension of a production built Medium Tank M4A3 with Firestone 20-1/2 x 6-1/4-inch natural rubber bogie tires, and T66 steel tracks.
CONCLUSIONS: The cantilever type, horizontal spring suspension was considered satisfactory. Forty-nine bogie tire failures occurred in 4800 miles' operation at an average mileage of 1592 miles. Twenty-three bogie wheel attaching bolts loosened, and reduced clearance between the hub and the wheel was recommended. Seventeen shock absorbers failed at an average of 1729 miles because of oil lost through ineffective seals. Further shock absorber development and testing were recommended. The shock absorber bushings as tested were not recommended since 19 failed at an average of 2372 miles. Failures in 13 volute springs occurred at an average of 3093 miles. Suspension bracket attaching bolts remained tight for 3356 miles. Two sets of T66 steel tracks were operated 3250 and 2289 miles. The rear idler shaft lock plates were not satisfactory and a design change was recommended. The volute springs, T66 tracks, suspension bracket attaching bolts, and Firestone bogie tires were recommended for use as tested.
GENERAL: This 50-page report contains five photographs of suspension component failures.

SUBJECT: Suspensions PG-61801.116
TITLE: Fender Installation on Spaced Suspension with Stamped and Welded Extended End Connectors, Medium Tank
IDENTIFICATION: Report No. PG-61801.116; TAPG Project No. 342
DATE OF REPORT: 28 February 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide information and photographs necessary for preparation of modification work order authorizing installation of side and

rear fenders on Medium Tank M4A3 with suspension units spaced out 4-1/2 inches from the hull
METHOD: Fender assembly was made on right side only of Medium Tank M4A3, equipped with standard M4 suspension spaced 4-1/2 inches from hull. Installation was made and photographs taken in presence of Ordnance representatives.
DESCRIPTION: Materials tested were experimental fenders installed in accordance with drawings D7070212. They were used with standard medium tank track with 4-1/2 inch stamped and welded extended end connectors on Medium Tank M4A3. Suspension units were spaced out 4-1/2 inches from the hull. Experimental fenders consisted of three 68-inch sections.
CONCLUSIONS: Use of the experimental fenders was recommended for vehicles having suspension units spaced out 4-1/2 inches and using track with 4-1/2 inch stamped and welded extended end connectors. It was also recommended that four braces be used with each fender.
GENERAL: This 16-page report contains six photographs of fender installations.

SUBJECT: Suspensions PG-61801.118
TITLE: Medium Tank M4 (105) Equipped with Horizontal Volute Spring Suspension and T80 Track
IDENTIFICATION: Report No. PG-61801.118; Project No. 316
DATE OF REPORT: 15 March 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of standard production horizontal volute spring suspensions and standard production T80 rubber back steel tracks on late production Medium Tank M4 (105)
METHOD: Tests of standard production spring suspension and T80 track were conducted on Medium Tank M4 (105) over the endurance test route for 3998 miles with vehicle loaded to 75,360 pounds.
DESCRIPTION: Materials tested were standard production cantilever type horizontal spring suspension and standard production Firestone T80 rubber-backed steel track on late production Medium Tank M4 (105).
CONCLUSIONS: The spring suspension was satisfactory and was recommended within limitations of the test. Principal failures were shock absorbers; eleven failed at an average of 952 miles. They were not recommended for use. Four standard rubber shock absorber bushings failed at an average of 2721 miles, and were not considered satisfactory. Standard production natural rubber 20-1/2 x 6-1/4-inch bogie tires were satisfactory. Horizontal volute springs operated satisfactorily; four failed at an average of 2774 miles. T80 rubber-backed steel tracks operated satisfactorily during the entire test, and were recommended for continued use; however, it was recommended that grousers be attached with a full weld to avoid loss.
GENERAL: This 22-page report includes four photographs illustrating worn and damaged parts.

SUBJECT: Suspensions PG-61801.119
TITLE: Durability Test of Production Medium Tank M4A3 (E8)
IDENTIFICATION: Report No. PG-61801.119; Project No. 616
DATE OF REPORT: 27 March 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of the horizontal volute spring suspension used on the M4A3 Medium Tank
METHOD: The horizontal volute spring suspension was installed on a Medium Tank M4A3 and operated 6000 miles on the endurance test course. For the first 2000 miles of operation, only standard suspension parts were used; in the following 4000 miles, various experimental components were used in place of standard parts.
DESCRIPTION: The standard test M4A3 Medium Tank horizontal suspension incorporated the use of single-pin, center-guide T66 track. Test bogie tires, sprockets, T-slot shock absorbers, and thin-wall rubber shock absorber bushings were used to replace the standard parts during the last 4000 miles of testing.
CONCLUSIONS: During the first 2000 miles, all of the suspension parts operated satisfactorily except the shock absorbers which averaged 1076 miles to failure. Improved shock absorber seals and rod guide fastening methods were recommended. During the last 4000 miles of operation, the use of T-slot shock absorbers and thin wall bushings increased shock absorber life and was recommended. Although the horizontal volute spring life was greater than that of the vertical suspension, it was recommended that the development of volute springs be continued. Two sets of standard T66 Tracks operated satisfactorily for 3121 and 2931 miles. Two idler lock plates failed in 4647 miles of operation and were not recommended for use. Details of the test parts' performance were covered in separate reports.
GENERAL: This 46-page report contains six photographs showing four views of the test vehicle and parts failed in operation.

SUBJECT: Suspensions PG-61801.121
TITLE: Endurance Test of Suspension Modifications Medium Tank M4A3E2
IDENTIFICATION: Report No. PG-61801.121; Project No. 347
DATE OF REPORT: 13 April 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To compare the durability of modified suspension components with that of similar standard suspension components previously tested for use on Medium Tank M4A3E2
METHOD: A Medium Tank M4A3 was equipped with the modified suspension components and operated over endurance courses at an average speed of 13.3 mph for 470 miles.
DESCRIPTION: The modified suspension system was a vertical volute spring suspension with a pair of concentric helical coil assist springs fitted inside the inner coil of each volute spring. The volute spring seats were modified to increase the spring seat pins from 2-1/2 to 3-1/2 inches in

diameter in order to accommodate the assist springs.
CONCLUSIONS: Five of twelve outer assist springs had failed at the end of 470 miles' operation. Failures occurred in the upper third of the spring and were the result of severe chafing against the inner edges of the volute spring caused by the uncontrolled lateral movement of the volute spring seats. The modified suspension components, as tested, were not recommended for use in the M4A3E2 Medium Tank vertical suspension system. Several of the unfailed springs were chafed around the outer circumference, and several of the inner coils were slightly bent. The following modifications of the original design, to be tested on the T1E4 Mine Exploder under Tank Arsenal Proving Ground Project No. 642, were suggested by the Chrysler Engineering Laboratory: the upper end of the coil springs to be anchored to prevent sliding sideways into contact with the volute springs; the inner end corner of the volute spring to be trimmed at 45° for 1-1/2 inches; and the remaining part of the vertical inner edge as well as the innermost half coil edge to be chamfered to eliminate the sharp corners which had damaged the outer coil spring.
GENERAL: This 27-page report contains seven photographs of failed and worn test suspension components.

SUBJECT: Suspensions PG-61801.128
TITLE: Welded Arms for Horizontal Suspension, Medium Tank
IDENTIFICATION: Report No. PG-61801.128; T.A.P.G. Project No. 354
DATE OF REPORT: 9 May 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of fabricated bogie arms for use on medium tanks; to compare the stress characteristics of fabricated and standard cast bogie arms
METHOD: Four fabricated bogie arms were installed in No. 1 and No. 2 positions on both sides of a Medium Tank M4A1 and operated over standard endurance courses for 4008 miles. At the conclusion of the test, each arm was checked on a surface plate. A fifth fabricated bogie arm was sent to the laboratory for stress analysis. Static stress measurements were obtained using the "Stresscoat" method and electrical strain gauges. A similar stress analysis was made of a redesigned fabricated bogie arm.
DESCRIPTION: The fabricated bogie arms were made by the Fisher Tank Division and were designed as alternates for the standard cast steel arms to alleviate a critical casting situation. They were fabricated from two-inch armor plate with the spring seat pin, gudgeon pin, and bogie wheel shaft bosses cast and welded in place. The test bogie arms were made for use in medium tank horizontal volute spring suspension systems.
CONCLUSIONS: The four fabricated bogie arms operated for 4008 miles without failure and were in excellent condition at the conclusion of the test. Stress analysis of the first arm tested revealed that the section between the gudgeon pin and spring seat pin contained stresses approximately 50% higher than the standard cast steel arms. To improve this condition, it was recommended that the void lightening hole be eliminated and a reinforcing rib be added to the section between the gudgeon pin and spring seat pin. A stress analysis of an arm incorporating these changes showed a 50% reduction in the above mentioned critical stresses. This revised fabricated bogie arm was recommended for use in all positions on the present medium tank horizontal suspension.
GENERAL: This 25-page report contains five photographs of the original and revised fabricated bogie arms showing strain gage and test installation. Sketches are included of the original, revised, and cast designs showing the location of strain gauges and the measured values of stress for each type arm.

SUBJECT: Suspensions PG-61801.132
TITLE: Endurance Test of Medium Tank M4A3 (76) Equipped with Horizontal Suspension and Extra Weight (EB 1686)
IDENTIFICATION: Report No. PG-61801.132; Project No. 337; ODC No. 10
DATE OF REPORT: 9 June 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of standard and modified horizontal suspension parts for use on medium tanks loaded to assault vehicle weights
METHOD: Two 73,000-pound medium tanks, incorporating standard and modified suspension system parts, were loaded to 46 and 51 tons. Both vehicles were operated over a rough frozen endurance test course for 4004 and 3385 miles, respectively.
DESCRIPTION: Both M4A3 (76) tanks were equipped with rubber bushed "whiffletree" suspension arms on one side of each vehicle. The whiffletree arms, allowed a 5° transverse movement of the axle from horizontal, effecting a distribution of load between the inner and outer tires within specific limits. Standard production T80 tracks, bogie wheels, support rollers, sprockets and hubs, and rear idlers were used with both vehicles. Extended end connectors, rubber "thin wall" shock absorber bushings and experimental volute springs were used on the 51-ton vehicle; standard volute springs, end connectors, and neoprene shock absorber bushings were used on the 46-ton vehicle. Goodyear and Goodrich 20-1/2 x 6-1/4-inch natural and synthetic rubber tires were used in alternate positions on both tanks. Ford GAA engines were used in both vehicles.
CONCLUSIONS: The performance of the test vehicles was satisfactory in spite of the increased impact loads caused by the slippery test course. Synthetic or natural rubber tires, standard shock absorbers, and neoprene, thin wall, shock absorber bushings, used on the 46-ton tank, were recommended for use with this weight vehicle; the standard volute springs required improvement. In the

case of the 51-ton vehicle, the synthetic rubber tires, extended end connectors, shock absorbers, and volute springs were unsatisfactory. Natural rubber bogie tires and thin wall neoprene shock absorber bushings were recommended. It was also recommended that all wedge nuts be tightened to 160 lbs.-ft. torque for both vehicles and the bogie and rear idler wheels be improved to reduce wear. The "whiffletree" suspension increased tire and track life, and was recommended. The engine and power train components were considered satisfactory.
GENERAL: This 100-page report contains 16 photographs illustrating test suspension and engine part failures and one metallurgical photo.

SUBJECT: Suspensions PG-61801.136
TITLE: Road Wheel Spindle C102433 Made of 9450 Steel — Heavy Tank T26E3
IDENTIFICATION: Report No. PG-61801.136; T.A.P.G. Project No. 367
DATE OF REPORT: 1 August 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of spindles made from 9450 steel for use with standard road wheel arms of the Heavy Tank T26E3
METHOD: A road wheel arm assembly employing a test spindle was placed in a front wheel position of each of two T26E3 Medium Tanks weighing 102,000 and 92,000 pounds, respectively. The 102,000 pound vehicle was operated for 1658 miles on the endurance test course; 1035 miles of operation were conducted on the 92,000-pound vehicle.
DESCRIPTION: The test C102433 spindles, used with standard production front road wheel arms, were standard except they were made of 9450 steel.
CONCLUSIONS: The test spindle used with the 102,000-pound tank experienced inner bearing surface wear from .002 to .0035-inch in the vertical plane, indicating excessive bearing creep. In the case of the 92,000-pound vehicle, the test spindle had a .0145-inch bend at the inner edge of the outer bearing race; a standard spindle, at the opposite side of the vehicle, had a .0105-inch bend at the same point. Since the durability characteristics satisfactorily met testing requirements, the test spindles were recommended for use.
GENERAL: This 12-page report contains no illustrations.

SUBJECT: Suspensions PG-61801.146
TITLE: Experimental Suspension Components for Heavy Tank T26E3
IDENTIFICATION: Report No. PG-61801.146; T.A.P.G. Project No. 369
DATE OF REPORT: 30 August 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the ride and durability characteristics of improved suspension components used on the Heavy Tank T26E3
METHOD: Test road wheel bearings were subjected to 2386 and 2085 miles of operation on 92,000 and 102,000-pound T26E3 Medium Tanks, respectively. Hydraulic bump stops, redesigned torsion bars, shock absorbers, and front compensating arms were operated up to 1717 miles on the 92,000 pound vehicle. Ride comparisons were made with standard parts used during the first 669 miles of this test. Both motion picture studies and opinions of the test crew were used in assembling ride characteristics data.
DESCRIPTION: The test suspension parts differed from the standard parts in the following manner: the torsion bar was increased from 2.25 to 2.350 inches in diameter; the shock absorber control was increased 50%; the front compensating arm was modified to accommodate two, instead of one, shock absorbers which were each 3-1/4 inches shorter, but having similar valving as the standard shock absorber; Timken No. 749A inner road wheel bearing O.D. was increased from 5.125 to 5.909 inches and the width from 1.4375 to 1.750 inches. Hydraulic bump stops replaced the volute spring bumpers at the front of the vehicle.
CONCLUSIONS: The test inner road wheel bearings showed better endurance life than the standard bearings and were recommended for use. However, the standard hubs, drilled out to accommodate the increased diameter bearings, were considered unsatisfactory and required an adequate replacement. Because improved ride and durability characteristics resulted from their use, the test torsion bars, shock absorbers, hydraulic bump stops, and front compensating arms were also recommended. It was further recommended that the shorter shock absorbers used with the compensating arms be designed to have 50% more control.
GENERAL: This 35-page report contains three photographs illustrating the test parts installed on the vehicle and the indicator used to measure the ride characteristics. Shock absorber data and graph sheets are also included.

SUBJECT: Suspensions T-18206.1
TITLE: Track Support Rear Idler and Volute Wheel Assemblies — Medium Tank
IDENTIFICATION: Report No. T-18206.1
DATE OF REPORT: 5 September 1941
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To expedite the proper design, shop assembly, and manufacture of parts of tank track wheel assemblies
METHOD: Complete layouts were made in accordance with the latest U.S.A. Ordnance blueprint details to determine the conditions of dimensions, tolerances, design, and other possibilities which might lead to misinterpretations during shop assembly of tank track wheel assemblies. Various parts were selected at random from the inspection line and inspected. Verbal orders were issued to foremen, new layouts and proper assembling procedure were established, and specific recommendations were made to effect the objective.
DESCRIPTION: The following parts and assemblies were examined: idler rear wheel, volute

wheel, and track support roller. Special emphasis was placed on bearings and related components.
CONCLUSIONS: Immediate institution of the necessary changes established by this study was recommended. The cost of the changes was considered small in comparison with the results that could be obtained.
GENERAL: This eight-page report contains two drawings and five pages of procedure and discussion. Attached to this report is one drawing and several data sheets on tests of an M3 Medium Tank transmission.

SUBJECT: Suspensions T-61801.1-03
TITLE: Suspension — M4 Medium Tank -- Improvement
IDENTIFICATION: T-61801.1-03; CX Project No. 42
DATE OF REPORT: 4 May 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To improve the stability of medium tank suspension spring seats
METHOD: Motion pictures were taken of the front suspension units of medium tanks operating over wooden blocks shaped to an eight-foot sine wave of nine-inch amplitude. Each of 24 tests consisted of four runs at four, six, eight, and ten mph. The developed film was projected on a screen and measurements made to determine "seat tilt," and the relative motion between the rubbing plates on the front bogie arm and front half of the suspension lever and again between the rubbing plates on the rear bogie arm and rear half of the suspension lever.
DESCRIPTION: The following suspension units were tested: the M3 suspension; the original design M4 suspension with the trunnion center 1-5/8 inches below the spring seat surface; the first production release M4 suspension with the trunnion center 7/8-inch above the spring seat surface and with "low cages" (one-inch high) for the volute springs in the suspension bracket; this M4 suspension with increased cage height effected by welding 1 x 4-inch steel into the suspension bracket; the second release suspension M4 with cage heights increased to 3-3/4 inches and the pin heights on the spring seat increased to 2-1/2 inches; the M4 suspension with an experimental installation of M3 springs; and the M4 suspension with the trunnion center raised two inches.
CONCLUSIONS: The only effective means of materially improving the spring seat stability in the M4 suspension was the raising of the trunnion center. Stability with the trunnion center raised two inches compared favorably with that of the M3 suspension. Spring life was improved considerably by this method, although failures were not completely eliminated. Since failures usually started in the small tapered coil, it was recommended that eliminating the taper or the coil itself be thoroughly explored by laboratory and proving ground tests. It was predicted that volute spring service life of 4000 to 5000 miles could be obtained by improvements in suspension design (trunnion center location), spring design (small coil), and spring manufacture (helix angle, heat treatment, presetting).
GENERAL: This 63-page report contains 18 photographs, 14 drawings and sketches, and 10 pages of tabulated test data.

SUBJECT: Suspensions T-61801.2
TITLE: Elimination of Separation Between Suspension Lever and Rubbing Plates on Bogie Arms
IDENTIFICATION: Report No. T-61801.2
DATE OF REPORT: 25 February 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop a satisfactory means of preventing excessive rebound travel of the bogie arms and separation of the suspension levers and the rubbing plates
METHOD: A dummy suspension was made up to check the geometry of the suspension. Modified suspension components, designed to eliminate excessive rebound travel of bogie arms, were installed and operated on a Medium Tank M3.
DESCRIPTION: Medium Tank M3, production suspension parts were modified to reduce the rebound travel of the bogie arms, and still maintain the compression travel, by changing the shape of the bogie arm stopping nose, raising the four striking surfaces for the suspension levers in the suspension bracket 1/2-inch, and raising the bottom surface of the volute spring seat 1/8-inch. A second standard suspension was modified by providing 3/4-inch higher side flanges on the rubbing plates.
CONCLUSIONS: Both experimental installations operated satisfactorily. Although the installation with 3/4-inch higher side flanges was effective in preventing the suspension levers from being misplaced on top of the flanges, it did not prevent separation between the levers and rubbing plates. It was recommended that bogie arms conforming to the first modification be adopted.
GENERAL: This 13-page report contains two photographs showing the dummy suspension and an M3 bogie arm, and five drawings of the proposed bogie arm.

SUBJECT: Suspensions T-61801.7
TITLE: Gudgeon Pin Cap-Bolt Loads
IDENTIFICATION: Report No. T-61801.7
DATE OF REPORT: 6 May 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine analytically the increase in the tensile load in the gudgeon arm cap bolts of the Medium Tank M4 suspension, upon application of external load
METHOD: For the purpose of analysis, the suspension support, gudgeon pins, caps, and bolts were analyzed as springs with stiffnesses calculated as spring rates. The analysis was carried out with the aid of free-body diagrams in which two bolts, and one gudgeon pin, were assigned values of stiffness comparable to those of the three bolts and two gudgeon pins of the actual suspension unit. Elastic deflections of these parts under load were calculated to determine the increase in load on the

bolts. An external load of 100,000 pounds was used in the study, and the loading conditions were evaluated for two cases as follows: gudgeon pin clamped, clearance between cap and support; and gudgeon pin free (clearance around pin), no clearance between cap and support.
DESCRIPTION: This study dealt with the vertical-volute-sprung suspension of the M4 Medium Tank. The area under consideration was the bottom of the support bracket, where the gudgeon pins carrying the road wheel arms were attached by means of a cap and three bolts.
CONCLUSIONS: The increase in cap bolt tension under the 100,000-pound load was found to be 10.52% with the pin clamped, and 11.76% with the pin free. These values were based on the calculated stiffnesses of the actual parts of the M4 suspension. It was noted that the increase depended on the relative stiffnesses of clamping and clamped parts, and that application of the load toward the cap increased the bolt loads regardless of the clamping arrangement. The analysis was also carried out for 3/4-inch bolts as well as for the standard 1-inch bolts. While the increase in tension under load was reduced almost 50%, the total stress in the 3/4-inch bolts was practically double that in the 1-inch bolts, reaching the value of 105,880 psi for the assumed test load.
GENERAL: This 12-page report is not illustrated except for the free-body diagrams used in the analysis.

SUBJECT: Suspensions T-61801.8
TITLE: Suspension, Horizontal, Development for M3 Medium Tank
IDENTIFICATION: Report No. T-61801.8; Project Nos. 1 and 2
DATE OF REPORT: 18 May 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To analyze and compare the performance of vertical, horizontal, and trailing idler suspension systems on Medium Tanks M3 with and without shock absorbers
METHOD: Maximum bogie wheel compression and rebound were first measured by attaching one end of a vertical rod to a bogie wheel hub. The rod ran through a guide on the hull, and rubber grommets above and below the guide were displaced by rod movement to indicate the maximum bogie deflection during operation. Pitch angle was obtained by photographing a tank at night with three 25 candle power lights attached to the rear, turret center, and front while the tank passed an open-shutter camera at a speed of 23 mph. From two to six tank lengths of travel were included in each photograph. The test course was rough dirt. Amplitudes and pitch angles were calculated from the night photos. To obtain more accurate data, a movie camera was mounted on a tank with its lens focused on a horizontal rail built parallel to the track. Tank speeds up to 14 mph were employed over various sized bumps. Result curves of the "Rideograph" type were drawn and data compared for each type suspension with and without front shock absorbers installed.
DESCRIPTION: The horizontal suspension featured 8-inch volute springs of higher capacity and lower stress than the vertical springs of the standard suspension. The trailing idler suspension was of the horizontal volute type but the 32-inch steel-tired trailing idler wheel had a much lower wheel rate for the same spring rate than the forward units on the same tank. The Ordnance shock absorbers tested in conjunction with both the horizontal and trailing idler type suspension offered resistance on rebound with orifice type control. The Monroe shocks tested with the horizontal suspension featured both orifice and blow-off control for double action.
CONCLUSIONS: From a study of the result curves, it was concluded that the horizontal suspension without shock absorbers was superior to the horizontal suspension with trailing idler. Further development work was recommended for the former. The use of double acting hydraulic shock absorbers was also recommended.
GENERAL: This 38-page report contains 16 photographs or drawings of the suspension tested, three pages of trace line photographs, and seven graphs of tank pitch and bogie deflection.

SUBJECT: Suspensions T-61801.9
TITLE: Adaptation of Type T4 Suspension to the M4 Medium Tank
IDENTIFICATION: Report No. T-61801.9
DATE OF REPORT: 29 May 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To design a suspension of the T4 type for application to Medium Tanks M4
METHOD: Design considerations were guided by two drawings received from the Ordnance Engineering Department, Washington, D.C., in which a T4 type suspension had been sketched on side and front elevation drawings of an M4 Tank. Weights were estimated, stress was analyzed and major suspension components were redesigned for a maximum vertical load of 90,000 pounds per wheel, which was about twice the strength of the original T4 suspension. The proposed suspension units were drawn in detail, with two possible locations for the shock absorbers.
DESCRIPTION: Five individually sprung wheels per side were required. Suspension spring travel was to be eight inches in compression, and six inches in rebound. Spring positions were to be as dictated by hull construction, except that the armor plate between the wheels and springs could be omitted. All arm ratios were to be equal, and shock absorbers were to be improved. Helical coil springs for each suspension unit were designed for vertical installation to act directly on each wheel arm. Each such spring was concentric with a helper spring which in turn enclosed the shock absorber. Dual cast-steel wheels were carried on spindles by tapered roller bearings. The arms were hollow steel castings designed for torsional rigidity. Each was fitted at the fulcrum end with both Bantam and thrust bearings. The modified T4 type suspension was estimated to weigh about 3080 pounds more than the standard M4A4 suspension.

CONCLUSIONS: The T4 type of suspension as described in this report was considered applicable to the Medium Tank M4.
GENERAL: This 37-page report contains three drawings of the Medium Tank T4 suspension, two drawings of the suspension proposed by the Office of the Chief of Ordnance, and five drawings of the suspension design proposed by Chrysler Engineering.

SUBJECT: Suspensions T-61801.11
TITLE: Suspension — Volute Spring — M4 Medium Tanks — Static Tests
IDENTIFICATION: Report No. T-61801.11
DATE OF REPORT: 15 June 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To compare the results of static load tests performed on volute spring suspension employed in M4 Tanks with those on M3 Tanks
METHOD: After a preliminary force analysis, the test suspensions were installed in a special test fixture which was designed and constructed to support either a complete M3 or M4 Tank suspension sub-assembly in an inverted position. Vertical loads, applied to one wheel mounted on the suspension, and horizontal suspension loads, to determine the spring side rate deflection, were applied and deflection measured through a metallurgical laboratory testing machine; the machine had a 155,000-pound loading capacity. Deflection indicators were placed across the vital suspension parts; curves were plotted to show the resultant deflection characteristics.
DESCRIPTION: The material tested was a production M3 suspension unit, used as a comparison, and an M4 unit that was modified at several points as the testing progressed. The standard spring seat was modified to raise the lever trunnion 2-1/2 inches to eliminate tipping action of the seat. Modifications were also made to accommodate 1-inch gudgeon pin cap bolts replacing 3/4-inch bolts.
CONCLUSIONS: All parts of the revised test M4 suspension unit were able to withstand a static load of 155,000 pounds, which represented a load factor of 15.5 provided the static weight per tank suspension unit was 10,000 pounds. The test suspension unit was approximately 80% more rigid in over-all twist than the M3 design. The revised spring seat was considered satisfactory on the basis of the static tests; a dynamic field test was recommended, however. It was also recommended that 1-inch hold-down bolts replace the 3/4-inch bolts used with the gudgeon pin clamp. The side rate deflection of the M4 and M3 springs was comparable.
GENERAL: This 36-page report contains 16 photographs illustrating the installation of the suspension sub-assemblies in the testing machine during vertical and horizontal testing. Data logs, graphs, and suspension load sketches are also included.

SUBJECT: Suspensions T-61801.25
TITLE: Suspension - Horizontal, Installation of Units D-47907 and D-47908
IDENTIFICATION: Report No. T-61801.25; CX Project No. 10
DATE OF REPORT: 31 March 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To install special horizontal volute spring suspension systems on two medium tanks
METHOD: Horizontal suspension D-47907 and D-47908 were installed on the production hulls for Medium Tanks M3 numbered W-305, 005 and W-304, 437, respectively.
DESCRIPTION: The horizontal volute spring suspension systems consisted of three suspension assemblies on each side of the vehicle. On one of the systems each suspension assembly was equipped with two bogie wheels; on the other system, the rear suspension assembly was equipped with one bogie wheel and a trailing idler wheel.
CONCLUSIONS: This report was issued for record purposes only, and no conclusions or recommendations were made.
GENERAL: This 14-page report contains 10 photographs showing installation of the special suspension, and a drawing of each.

SUBJECT: Suspensions T-61802.35
TITLE: Horizontal Spring Suspension of 23-Inch Center Guide Track
IDENTIFICATION: Report No. T-61802.35
DATE OF REPORT: 18 December 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the dynamic loading of a horizontal spring suspension under severe service conditions; to locate and measure high stress points in the experimental suspension; and to conduct stress analysis of several suspension parts
METHOD: Dynamic loading under severe service conditions was determined by first obtaining strain versus load data at four suitable points on the subject assembly under static loading. Strain data were then obtained at the same points with the assembly installed on a Medium Tank M4 and operated over sine wave bumps of nine-inch amplitude and eight-foot wave length. By correlating these strain data with the static loading data, dynamic loading characteristics (load versus speed) were obtained. The location of points of high stress in the assembly was determined by coating the assembly with a brittle lacquer and subjecting it to a 50-ton vertical load. The magnitude of these stresses was measured by electrical strain gages. Such redesigned and original assembly components as the arm cap screw, gudgeon pin, road wheel shaft, bracket, and arms were stress analyzed with a view to determining cause of failure in service and/or improving their functional strength. Standard strain-gage procedures were used in analyzing all parts but the wheel shafts. A polariscopic study was made of the end of the shaft to examine the location and magnitude of stresses.
DESCRIPTION: The subject assembly was a horizontal volute spring suspension for use on a Medium Tank M4 with a 23-inch wide center-guide track.
CONCLUSIONS: Dynamic loads under severe serv-

ice conditions reached 140 tons per suspension unit. (This figure was used as a basis for study and redesign of failed or potentially weak components.) Maximum stress points, located in the spring seat, bracket, arm support, and arms, would probably equal or exceed the yield point (85,000 psi) of the material from which they were made. (This was confirmed by suspension-assembly service tests.) Design changes such as increasing the thickness of the central section of the spring seat were recommended. The lower surface of the cantilever bracket was modified: comparative stress analysis of this redesigned bracket and the original revealed that the extended fillet curve reduced stresses in that area, the over-all stress reduction amounting to 28%. Since the new bracket could not be installed in a test suspension assembly, conclusive results were impossible. The upper flange of the cantilever bracket was also modified: comparative stress analysis of the new and original designs indicated that the new design was an improvement, reducing high stress points and points of failure; however, no prediction was made concerning increase in service life. The analysis of the arm cap screw and gudgeon pin also resulted in design changes. Two steel overload rings replaced the end rubber grommets, decreasing the maximum load 50% and bringing the load within a safe range without overloading the pin. Points of high stress in the arm (No. E-1058755, incorporating a rectangular section between the road wheels) were located in the area near the rectangular section. Design changes in the blended radii of this area were then made. Scoring of the grease seal contact area by sand and dust during field operations was eliminated by incorporating a removable collar on the road shaft that necessitated a shaft diameter reduction. Polariscopic stress analysis showed that the maximum stress on the shaft was reduced 20% by this modification.
GENERAL: This 53-page report contains 11 photographs of the test assembly, test apparatus, and various assembly components showing location of stresses and strain gages. Polariscopic studies of the road wheel shaft, curve sheets, and drawings of brackets and arms are also included.

SUBJECT: Suspensions T-61801.36
TITLE: Suspension, M4 Medium Tank, Bottom Spring Seat and Bogie Lever
IDENTIFICATION: Report No. T-61801.36; CX Project Nos. 119 and 119-1
DATE OF REPORT: 15 July 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine, if possible, a relationship between the physical properties and static load strengths of suspension spring seats and bogie levers made by 12 manufacturers; to develop a method of proof testing castings
METHOD: Each manufacturer submitted five spring seat castings and six lever castings together with keel blocks and information on melting practice and gating. Charpy and tensile tests bars were taken from representative castings, X-rayed, and the physical properties determined. Static loading tests were performed on representative castings at the Case School of Applied Science, Cleveland, Ohio, with a 600,000 pound capacity Baldwin-Southwark machine. The data were tabulated in an effort to correlate the load test results with physical property data. Sample deflection curves were drawn for a spring seat, for a bogie lever arm tested singly, and for a two-armed bogie lever.
DESCRIPTION: The suspension vertical volute spring seat castings were standard parts No. C95289, except for two experimental "boxless" type spring seats manufactured by the Unitcast Corp. The bogie levers were of "old" and "new" styles, Part No. C95288 and Part No. C95288A. All castings subjected to the static load test were fully machined and were tested without bushings.
CONCLUSIONS: The physical properties of the castings were found to be generally below specification but, by lack of correlation with static load test results, were no true index to the actual load carrying ability of the castings. The spring seat castings were concluded to be sufficiently strong to provide a minimum static load safety factor of 6.7 for 30-ton tanks. From this it was inferred that failures in the field must have been caused by imperfect castings or by high impact loadings. The two experimental boxless spring seats broke at an average load of 430,250 pounds compared with 504,000 pounds for the 18 standard springs, but were still considered sufficiently strong. Carbon Molybdenum and Carbon Manganese castings withstood the highest static loads. Impact testing was recommended to supplement the data obtained in static load tests before any attempt was made to incorporate proof testing in production.
GENERAL: This 55-page report contains 10 photographs showing test setups and steel grain structure. Gating sketches and deflection graphs are also included.

SUBJECT: Suspensions T-61801.41
TITLE: Bump Rig Test of Production Unit
IDENTIFICATION: Report No. T-61801.41
DATE OF REPORT: 28 July 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the endurance characteristics of a Medium Tank M4 suspension unit as tested on a bump rig
METHOD: One Medium Tank M4 suspension unit was operated in the bump rig installed on a dynamometer chassis at a drum speed of approximately 50 rpm for 151 hours. The speed was equivalent to a road speed of about 6.5 mph and constituted a run of about 1300 miles with 900,000 bumps. Temperatures were recorded of various test parts and a moving picture was made, at normal camera speed and at slow motion, of certain phases of the operation.
DESCRIPTION: The test unit was a standard production Medium Tank M4 vertical volute suspension unit conforming with assembly No. D-47527, less track support guide, track return roller, and track return roller bracket.
CONCLUSIONS: During the test, seven volute

springs broke or cracked in the small inactive coil, the failures being very similar to the service failures encountered in most M4 springs. Grease leaks from the bogie wheel bearings occurred after 27 hours of operation and continued even after a heavier lubricant was used. Pits developed at the center of the tire faces, apparently due to heating of the rubber in its contact with wood. Temperature readings showed a maximum of 260°F on the spring seat and suspension lever when the room temperature was 80°F. Temperatures dropped about 50°F after fan cooling was started. The moving pictures showed clearly the shifting and tilting of the spring seat, which was the principal cause of the early volute spring failures in the M4 suspension. Further testing of M4 suspension units was recommended to obtain data on the component parts for establishing base lines for other suspensions.
GENERAL: This 18-page report contains four photographs of failed springs and center-worn bogie wheels. A temperature graph and three log sheets are also included.

SUBJECT: Suspensions T-61801.43
TITLE: Suspension — Horizontal, Record of 16 Sets Built
IDENTIFICATION: Report No. T-61801.43; CX Project No. 44
DATE OF REPORT: 17 August 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To provide a record for the manufacture of 16 sets of medium tank horizontal volute spring suspensions for medium tanks
METHOD: The suspension assemblies were manufactured in accordance with Ordnance drawings and specifications.
DESCRIPTION: The suspension assemblies were M4 Medium Tank horizontal volute spring suspensions with a horizontal shock absorber on the front and rear units.
CONCLUSIONS: This report was made solely to record the disposition of the suspension assemblies. It was believed, however, that the horizontal volute spring suspension could be manufactured at less cost than the standard M4 suspension and that the horizontal volute spring suspension would require fewer strategic materials than the standard suspension.
GENERAL: This 37-page report contains 19 photographs showing the suspension units assembled and disassembled.

SUBJECT: Suspensions T-61801.43-01
TITLE: Suspension — Horizontal, Record of Three Sets Built, M4 Medium Tank
IDENTIFICATION: Report No. T-61801.43-01; Project No. 44-2
DATE OF REPORT: 18 January 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To build three complete sets of horizontal suspensions for use with 11-inch wide bogie wheels on Medium Tanks M4A3
METHOD: The suspension assemblies were fabricated by Chrysler Engineering and shipped to the Tank Arsenal Proving Ground. Spring seat pin diameter was increased when eight pins failed in a preliminary trial. Suspension parts for 16-inch and/or 24-inch track were compared for weight.
DESCRIPTION: The suspensions were Medium Tank M4 horizontal volute spring suspensions modified to accommodate 11-inch wide bogie wheels. The spring seat pins in the suspension assemblies were increased from 1-3/4-inch diameter to 2-inch diameter.
CONCLUSIONS: No conclusions or recommendations were made because the report was written only to cover the fabrication and disposition of the suspension units.
GENERAL: This 21-page report contains two drawings of modified suspension brackets and six photographs of the suspension units assembled and disassembled.

SUBJECT: Suspensions T-61801.43-02
TITLE: Horizontal Volute Spring Suspension for 23-Inch Center Guide Track, Medium Tanks
IDENTIFICATION: Report No. T-61801.43-02; CX Project No. 44-5
DATE OF REPORT: 12 April 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To provide a record of the manufacture and installation of four medium tank suspension systems
METHOD: The suspension assemblies were built and installed on three Medium Tanks M4A3 and on Medium Tank T25. All vehicles were shipped to the Tank Arsenal Proving Ground for preliminary run-in. Two of the vehicles were later returned to the Chrysler Tank Laboratory for suspension rebuilding.
DESCRIPTION: The suspension assemblies were Medium Tank M4 horizontal volute spring cantilever suspension with dual bogie wheels for use with a 23-inch, center-guide track.
CONCLUSIONS: This report was made to provide a record of the manufacture and the rebuilding of the suspension assemblies. No conclusions or recommendations were made.
GENERAL: This 38-page report contains 19 photographs showing the suspension units assembled, disassembled, and installed. A detailed parts list, including part weights, is also included.

SUBJECT: Suspensions T-61801.43-03
TITLE: Horizontal Volute Spring Suspension, M4A3E8 Medium Tank, Building and Disposition of Ten Sets
IDENTIFICATION: Report No. T-61801.43-03; Project No. CX-44-5
DATE OF REPORT: 11 December 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To record the building, installation, and disposition of ten sets of horizontal volute spring suspensions
METHOD: Parts for ten sets of horizontal sus-

pension units to be used on M4A3E8 Medium Tanks were procured by the Chrysler Highland Park Engineering Department. The various parts were assembled into units by the Suspension Department and were then shipped to the Chrysler Tank Arsenal for attachment to tanks. The tanks thus equipped, plus spare parts, were sent to various proving grounds throughout the United States.
DESCRIPTION: The ten sets of horizontal volute spring suspensions were for use on M4A3E8 Medium Tanks with 23-inch center-guide tracks. Designated as the "Experimental Production Design," they were to be identical with subsequent production, differing only in that the parts were experimentally produced by special means.
CONCLUSIONS: This report was only a record of the building and installation of the suspension and no conclusions or recommendations were made.
GENERAL: This 32-page report contains 18 photographs of the suspension unit assembled and disassembled, and a Medium Tank equipped with a similar suspension system. A tabulated list of the part numbers and weights of the various components of the suspension is also included.

SUBJECT: Suspensions T-61801.43-04
TITLE: Horizontal Volute Spring for Center-Guide Track
IDENTIFICATION: Report No. T-61801.43-04; CX Project No. 44.5 Supplement
DATE OF REPORT: 18 April 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To provide a record of laboratory testing and other work performed during the development of the medium tank horizontal volute spring suspension
METHOD: A synopsis was written of each of the following phases of the horizontal volute spring suspension development work: weight analysis, study of interference, study of servicing methods, stress analysis of suspension unit, bump rig tests, fatigue life tests on volute springs, development and life test on shock absorber, deflection and rupture tests on individual parts, chemical and metallurgical analysis of parts, photographic work, pitch tests on vehicle to determine optimum control for shocks and desirability of shocks on center units, and obstacle climbing to determine required track and suspension stops. The highlights of life test programs at various proving grounds, including an analysis of bogie tire life, were also recorded.
DESCRIPTION: This report closed the project authorized by CX Project No. 44 and its several sub-projects. The following reports were issued under this project: T-61801.43, T-61801.43-01, T-61801.43-02, T-61801.43-03, T-61802.35, and T-61817.1.
CONCLUSIONS: Since this report was merely a record of the development work done on the horizontal volute spring suspension for M4A3E8 Medium Tanks, no conclusions or recommendations were made.
GENERAL: This 41-page report contains four photographs of a Medium Tank with the subject suspension; one suspension unit, and the unit installed in the bump rig test. A field test parts failure graph is included as well as an 11-page analysis of bogie tire life supplemented by six curve sheets.

SUBJECT: Suspensions T-61801.97-02
TITLE: Rubber Bushed "Whiffletree" Arms for Horizontal Suspension with 23-Inch Center Guide Track, Medium Tank
IDENTIFICATION: Report No. T-61801.97-02; Supplement to CXE Project No. 534
DATE OF REPORT: 14 December 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To record the design modifications, assembly, and disposition of three sets of "Whiffletree" horizontal suspension arms
METHOD: The part drawings of the suspension unit were revised to increase the fillets and radii in critically stressed regions of the arm casting. Parts were ordered accordingly, 41 arm assemblies were built, and one set (14 arms) was shipped to G.M.P.G., one set shipped to A.P.G., and one set (13 arms) shipped to T.A.P.G.
DESCRIPTION: The "Whiffletree" arm was not described. Rubber bushings with a 1/4-inch wall were standard; 3/16-inch-wall rubber bushings were also used.
CONCLUSIONS: Since this report was intended only to record additional work done under CXE Project No. 534, no general conclusions were drawn.
GENERAL: This 12-page report contains a single photo of the Whiffletree horizontal suspension arm as modified, and suspension arm drawings No. 7055893 and 7055895.

SUBJECT: Suspensions T-61801.129
TITLE: Suspension Weights — Medium Tank M4 Series and Heavy Tank T26 Series
IDENTIFICATION: Report No. T-61801.129; CXE Project No. 604
DATE OF REPORT: 21 May 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine and compare the ratio of vehicle weight to suspension weight of a Medium Tank M4 with horizontal volute spring suspension and a Heavy Tank M26 with torsion bar suspension
METHOD: The gross weight of a Medium Tank M4 was determined, and then all suspension components were removed and weighed. This operation was duplicated in the case of a Heavy Tank T26.
DESCRIPTION: The Medium Tank M4, weighing 75,900 pounds, was equipped with a horizontal volute spring suspension weighing 20,898 pounds. The Heavy Tank T26, weighing 92,600 pounds, was equipped with a torsion bar suspension weighing 23,933 pounds.
CONCLUSIONS: A comparison of the M4 and T26 Tanks and suspensions showed that the suspension weight to gross tank weight relationship was more

favorable in the T26 Tank. The T26 suspension weight was 25.8% of the gross tank weight, whereas the M4 suspension weight was 27.5% of the gross tank weight.
GENERAL: This 47-page report contains 30 photographs showing the vehicles and their associated suspension components.

SUBJECT: Suspensions T-61801.134
TITLE: Modification of Suspension for Pilot Medium Tank M4A3E2
IDENTIFICATION: Report No. T-61801.134; CXE Project No. 553
DATE OF REPORT: 2 July 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the suitability of modified vertical volute and helical spring suspensions for use with vehicles weighing 20% more than M4 Medium Tanks
METHOD: Various volute and helical spring assembly designs were subjected to laboratory life tests on a constant stress machine. After a suitable spring design was obtained, a vehicle installation was made; 474 miles of operation was conducted at Tank Arsenal Proving Ground.
DESCRIPTION: Each vehicle test suspension installation consisted of two volute springs which were set on ring spring seats located about the two cylindrical extensions of a cast steel bottoming spring plate. Two helical springs, one inside the other, were fixed to the bottoming plate extension located inside the respective volute springs. The 3-3/4 active coil, Eaton Mfg. volute spring (No. 483-194) varied from the standard M4 springs in that the inner coil was eliminated, resulting in an increase of the initial rate from 2460 to 2760 pounds/inch, and the nominal free height was reduced from 13-1/8 to 12-7/8 inches. The outer helical springs (No. 483-253) were made of 9260 steel; the inner helical springs (No. 483-524) were made of pretempered chrome-silicon wire.
CONCLUSIONS: The test spring assembly satisfactorily completed the 20% overload laboratory tests; fatigue life was equivalent to that of production M4 springs. Because of 12 outer helical spring failures caused by a chafing action against volute springs during vehicle operation, a coil spring plug was designed for installation to the suspension bracket to prevent the top of the spring from sliding on the seat. Vehicle tests, to determine the suitability of the plug, were recommended. The test suspensions were released by Ordnance for use on the front units of 100 mine exploders T1E4 and T1E6.
GENERAL: This 77-page report contains four photographs illustrating the laboratory test installations of the volute and coil springs, and springs damaged during vehicle operation. Data sheets, calculations, curve sheets, and Ordnance drawings of the test and assemblies are included.

SUBJECT: Suspensions T-61802.22
TITLE: Stress Analysis, Medium Tank M4 Suspension
IDENTIFICATION: Report No. T-61802.22
DATE OF REPORT: 6 November 1943
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine static and dynamic stresses on the suspension, to devise a means of reducing stresses in the spring-seat-trunnion fillet, to determine the effect of various experimental torsional links on the rigidity of the bogie-wheel arm assembly, and to determine the relative strengths of various lever designs
METHOD: Static tests of individual suspension parts were performed in the laboratory using an Olsen Testing Machine with 64,000 pounds as a reference load. The "Stresscoat" technique was employed to determine high stress areas. Dynamic tests were made on an M4 Medium Tank, equipped with the test suspension unit operated over artificial bumps at 10 and 18 mph. Electrical resistance wire strain gages were used as measuring devices. A voltage amplifier, an oscillograph, a film camera, and a photoelectric extensometer were also used to obtain stress readings. Static loading of the complete suspension unit was made using a special test fixture, with the load applied by two Blackhawk 50-ton S-80 hydraulic rams.
DESCRIPTION: Test components were: standard production vertical volute spring seats C-95288, four designs of bogie-wheel arm assemblies, and three designs of spring levers.
CONCLUSIONS: Static stress readings obtained indicated that spring seats and spring levers were the most severely stressed suspension components. Similarly, dynamic tests revealed the spring levers were more highly stressed than the bogie arms. It was found that stresses in the spring-seat-trunnion fillet could be decreased by 27% by adopting a 1/2-inch fillet relief between the bushing and trunnion. The most rigid design of bogie arm assembly incorporated a half-shell torsion link located against a tubular spacer on the section nearest the bogie wheel, and welded (with the tubular spacer) to the bogie wheel arms. A spring lever C-95288, change 4, that was strengthened by the addition of a reinforcing rib in each of the two broad fillets on the upper surface of the lever (adjacent to the bushing-hole section) and by replacing the fillet by a flat surface 4-1/4 inches long, was 30% stronger than the production spring lever. A completely redesigned spring lever C-95288A, of larger cross-sectional area and sweeping curves rather than fillets, was 46% stronger than the production spring lever.
GENERAL: This 77-page report includes 28 photographs of test arrangements and three photoelastic stress patterns of a spring seat model, a comprehensive test analysis, test curves and calculations, and a sketch of bogie arm assembly designs.

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Section 40
TANK RECOVERY VEHICLES

SUMMARY

This summary covers 32 report resumes on the testing and development of tank recovery vehicles. Reports represent the 1942-1954 period and originated at Aberdeen Proving Ground, Maryland; Detroit Arsenal, Center Line, Michigan; Armored Board, Fort Knox, Kentucky; Army Ground Forces Board No. 2, Fort Knox, Kentucky; Desert Warfare Board, Camp Young, California; Tank Automotive Center, Detroit, Michigan; Office, Chief of Ordnance, Detroit, Michigan; General Motors Proving Ground, Milford, Michigan; and the Tank Destroyer Board, Camp Hood, Texas. Tests were conducted primarily to determine the suitability of various recovery vehicles. Suitability depended upon ability to be loaded rapidly, carrying capacity, cross-country mobility, and dependability.

The recovery vehicles were armored, heavy vehicles equipped with winching and raising equipment. Two basic types were evaluated: specially designed tractor-truck and trailer vehicles, and vehicles built up from modified tank hulls. The tractor-truck and trailer units were better suited for transporting tanks for longer distances than were the converted tank recovery vehicles. The converted vehicles were particularly suited for retrieving disabled tanks during combat, especially in rugged terrain.

The following tank recovery vehicles were tested: tank recovery tractor-trailers T3, T21, and M25; and tank recovery vehicles T2, T5, T51, T5E1, T5E2, T5E3, T6, T6E1, T7, M32B1 and M32B3.

These vehicles were generally satisfactory for recovery and transport operation under various conditions.

REPORT RESUMES

SUBJECT: Tank Recovery Vehicles AB-307
TITLE: Suitability of Light Tank, M5, Chassis and Hull as Tank Recovery Vehicle
IDENTIFICATION: Project No. 307
DATE OF REPORT: 20 January 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of the standard M5 Light Tank chassis and hull as a light tank recovery vehicle
METHOD: The test Light Tank M5 was used to tow Light Tank M3A1 cross-country under very muddy conditions. Unsuccessful attempts were made to tow the M3A1 tank up a 20% grade and out of a two-foot ditch.
DESCRIPTION: Both test vehicles were standard production models. The M5 tank weighed 30,000 pounds, and the towed M3A1 vehicle weighed 26,000 pounds.
CONCLUSIONS: Medium Tank M5 was found to be satisfactory as a tank recovery vehicle and was recommended for acceptance provided that the M5 vehicles intended for use as recovery vehicles be equipped with rubber chevron or high traction steel tracks, and that their final drive ratios be reduced to that provided for the latest Light Tank M5A1.
GENERAL: This six-page report is not illustrated.

SUBJECT: Tank Recovery Vehicles AB-312
TITLE: Full-Track Recovery Vehicle, T2
IDENTIFICATION: First Partial and Final Reports; Project No. 312, Vol. I & II
DATE OF REPORT: 25 January 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the tactical suitability of a Recovery Vehicle, T2
METHOD: The vehicle and boom equipment were used to perform the following functions: towing medium tanks; lifting and swinging five tons with free swinging boom; lifting and carrying six tons with boom jack arms fixed to hull; and lifting weights up to 15 tons with boom jack arms on the ground.
DESCRIPTION: The Recovery Vehicle, T2, manufactured by the Baldwin Locomotive Works, was a 60,000 lb., armored, full-track laying vehicle constructed by modifying a Medium Tank M3. The vehicle was powered by a General Motors Twin Diesel, Series 6-71, engine. A 360° traversing turret and a conventional Medium Tank M3A5 power train were installed in the test vehicle. A winch installed on the floor directly below the turret was driven by a chain sprocket built around the universal joint companion flange. The winch cable could be threaded through the floor for winching operation, or out through the turret over a 60,000 lb. capacity boom used for lifting. Two boom jack arms could be attached to the vehicle or placed on the ground, depending on the weight of the load.
CONCLUSIONS: The test vehicle was generally superior to other recovery vehicles used by the Armed Forces. Performance and stowage deficiencies were discovered during testing. With the correction of deficiencies, it was recommended the test vehicle be accepted as a maintenance and recovery vehicle. Only those Medium Tanks M3 which were available for conversion at the writing of the report were to be modified as additional recovery vehicles.

TANK AUTOMOTIVE TEST RESUMES

GENERAL: This 40-page report contains 14 photographs showing various views of the test vehicle, views of the boom and jack arms as used in testing, and views of attempts to tow a Medium Tank M3 up a 45° grade.

SUBJECT: Tank Recovery Vehicles AB 312-1
TITLE: Military Characteristics for Full-Track Recovery Vehicles for Use with Armored Force Units
IDENTIFICATION: Project No. 312-1
DATE OF REPORT: 3 February 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To establish specification requirements for the development of full-track, armored tank recovery vehicles
METHOD: The specification requirements for the tank recovery vehicles were based on the need of providing for the rapid removal of damaged tanks and other armored vehicles from exposed combat positions. In this manner, the damaged vehicles could be rapidly repaired and returned to action.
DESCRIPTION: The proposed vehicles were to be full-tracked vehicles built on the basic chassis of the Light Tank M5A1 and Medium Tanks M4A1 and M4A3. The Medium Tank vehicles were to carry limited repair equipment and a crew of six men; vehicle weight was not to exceed 64,000 lbs. The Light Tank vehicle was to weigh no more than 30,000 lbs.; this weight included a crew of four men and as much essential repair equipment as possible.
CONCLUSIONS: The proposed full-tracked recovery vehicles, in order to be satisfactory, required the use of a basic tank chassis, including the engine with which the standard chassis was equipped. It was recommended work be expedited for developing pilot models of the proposed vehicles. As soon as the vehicles were completed, it was requested they be tested for recovery suitability.
GENERAL: This 11-page report is not illustrated.

AB-409
SUBJECT: Tank Recovery Vehicles AB-411
TITLE: Final Report of Tank Recovery Vehicles, T5E1 and T5E3
IDENTIFICATION: Final Report on Project No. 409 and 411
DATE OF REPORT: 9 June 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the tactical suitability of type T5 Recovery Vehicles
METHOD: Two T5 vehicles and boom equipment were used to perform the following operations: towing medium tanks over all types of terrain; winching light and medium tanks out of mud holes and up grades as high as 75%; removing and replacing vehicle engines and turrets using the vehicle booms; and lifting and carry operations with weights up to 15 tons.
DESCRIPTION: The test Tank Recovery Vehicles T5E1 and T5E3 were standard M4A1 and M4A3 Medium Tank hulls with the following modifications: turrets, baskets, and Homelite engine-generators were removed; a fixed hexagonal shaped turret was added; and a winch, operated through a chain sprocket connected to the front end of the propeller shaft companion flange, was installed on each vehicle crew compartment floor. An "A" frame type boom was mounted on the forward part of the vehicle sponsons. The T5E1 and T5E3 vehicles were powered by Continental R975-C1 and Ford GAA engines, respectively; both vehicles were equipped with an 81mm mortar mounted on the front.
CONCLUSIONS: The test vehicles were considered superior to the Tank Recovery Vehicles T2 and T7. Towing performance of the T5E3 was superior to that of the T5E1. Although not tested as tank recovery vehicles, previous performance of the T5 (R975 engine), T5E2 (GM diesel engine), and the T5E4 (Chrysler engine) as medium tanks M4, M4A2, and M4A3, respectively, indicated the suitability of these vehicles for recovery purposes. With the modifications listed in the report, it was recommended that the T5 Series Recovery Vehicles be accepted for Ordnance use.
GENERAL: This 37-page report contains 21 photographs showing various views of the test vehicles.

SUBJECT: Tank Recovery Vehicles AB-419
TITLE: Test of Tank Recovery Vehicle, T7
IDENTIFICATION: Project No. 419 (1-A-128)
DATE OF REPORT: 16 June 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of the Tank Recovery Vehicle, T7, as a tank recovery and maintenance vehicle for use by the Armored Force
METHOD: The test vehicle was used for winching both Light Tanks of the M5 Series and Medium Tanks of the M4 Series, and towing of the same vehicles. Engines were removed from M4 Medium Tanks and attempts were made to remove the turret as a unit.
DESCRIPTION: The Tank Recovery Vehicle, T7, was the standard M4 hull and power train with several modifications. The turret basket and the 75mm gun and all its operating mechanism were removed. The mantlet was removed and a plate installed in the turret. The boom was mounted on the plate in the turret. A winch was mounted immediately above the propeller shaft directly in the center of the turret. The boom was mounted on the turret to permit 360° rotation and could be used in any position. The boom was adjustable in height, manually operated from inside the turret. The drive for the winch came from a chain sprocket that was built on the front end of the propeller shaft and could be disengaged by a lever which operated a positive jaw clutch. The winch line was threaded out through the bottom of the tank for winching and on up through the turret out over the boom for lifting. A dummy 75mm gun was mounted on the turret opposite the boom.
CONCLUSIONS: The Tank Recovery Vehicle, T7, was considered inferior to the Tank Recovery Vehicles of the T5 series as a maintenance or recovery vehicle in the following respects: simplicity, positioning of winch operator and ability to see and control winching operation, method by

which the cable was fed from vehicle for winching, requisite boom height to handle medium tank turret, and the inability to traverse the boom on the T7 Recovery Vehicle when on slopes. It was recommended that the T7 Recovery Vehicle be considered as unsatisfactory and not be adopted for use by the Armored Force. It was further recommended that development cease on the T7 Recovery Vehicle.
GENERAL: This 21-page report contains nine photographs showing the test vehicle.

SUBJECT: Tank Recovery Vehicles AB-436
TITLE: Test of Recovery Vehicle M25 (Truck-Tractor M26 and Semi-Trailer M15)
IDENTIFICATION: Final Report on Project No. 436
DATE OF REPORT: 10 February 1944
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the mechanical reliability and capabilities of the Recovery Vehicle M25
METHOD: The Recovery Vehicle M25 was operated a total of 228 engine hours, and 1501 miles, over highways, secondary roads, and cross-country. Loading and unloading were carried out with a wide range of equipment. Operation was conducted over varied slopes, ditches, hill-crests, and curves. Mechanical reliability was closely observed throughout all operations.
DESCRIPTION: The Recovery Vehicle M25 (Tank Transporter) consisted of two components: the Truck-Tractor M26 and the Semi-trailer M15. The Truck-Tractor M26, manufactured by Pacific Car and Foundry, was a six-wheeled vehicle with dual tires on the chain-driven four rear wheels, and had an optional front wheel drive. A large cab of 1/4-inch armor plate completely enclosed a 6-cylinder, in-line, liquid-cooled, 230 hp Hall-Scott engine. A caliber .50 machine gun on an anti-aircraft type ring mount was located in the rear of the top. Mounted behind the cab were two variable speed winches to accomplish loading and unloading. A smaller winch was mounted on the front of the cab. The Semitrailer M15, built by Fruehauf Trailer Company, was rated at 40-tons capacity, and constructed with eight wheels mounted on a tandem, walking-beam suspension which permitted nine-inch oscillation.
CONCLUSIONS: The Recovery Vehicle M25 was considered unsatisfactory as a tank recovery vehicle. Cross-country mobility was considered unsatisfactory except under the most favorable circumstances. It was recommended that the Recovery Vehicle M25 be considered an acceptable on-the-highway tank transporter after incorporation of modifications to the suspension system, engine and accessories, power train, frame and body, and stowage arrangement, specified in the report.
GENERAL: This 37-page report contains 16 photographs of the test vehicle during test operation and of failed components.

SUBJECT: Tank Recovery Vehicles AB 620
TITLE: Tank Recovery Vehicle T6E1
IDENTIFICATION: Project No. 620
DATE OF REPORT: 17 February 1945
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of the T6E1 vehicle for tank recovery operations under field conditions
METHOD: The test vehicle was tested during on- and off-highway towing operations of light and medium tanks, by winching light and medium tanks out of bogged-down positions, and by removing M24 light tank engines, power trains, and turrets. All stowage items were tested to determine their adequacy and functional value.
DESCRIPTION: The T6E1 recovery vehicle was based on the M24 light tank chassis, with a fixed hexagonal turret and a boom, pivoted at the front of the vehicle. The boom was of "A" frame construction so that, in the carrying position, the legs laid back on either side of the turret. A 60,000-pound winch with 200 feet of one-inch cable was mounted in the hull in such a way that the cable could be threaded out an opening in the front or over pulleys in the turret to either front or rear. An automatic tow hook, spades for winching operations, and miscellaneous other recovery equipment were also incorporated.
CONCLUSIONS: The T6E1 recovery vehicle was considered unsatisfactory as tested. Drawbar pull and traction were inadequate and the front suspension torsion bars were too weak for lifting operations. Interference with towed vehicles on irregular terrain was occasioned by the low carrying position of the boom and improper location of the towing pintle. Numerous modifications in construction and stowage were recommended.
GENERAL: This 38-page report contains 15 photographs of the T6E1 recovery vehicle in test operations.

SUBJECT: Tank Recovery Vehicles AFF 1242
TITLE: Study of 1946-1947 Winter Test of Vehicle, Tank Recovery, M32B3, by Army Ground Forces Task Force Williwaw
IDENTIFICATION: Project No. 1242
DATE OF REPORT: 18 November 1947
ORIGIN: Army Ground Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine the suitability, maneuverability and mobility of the Tank Recovery Vehicle M32B3 in cold-wet winter conditions
METHOD: The Tank Recovery Vehicle M32B3 was used for first and second-echelon maintenance and scheduled checks in the open. Also the vehicle was used to recover armored equipment under all types of weather and terrain both for cross-country and road operations.
DESCRIPTION: The Tank Recovery Vehicle was a full-track, welded-hull, armored vehicle designed for battlefield recovery of crippled vehicles. The vehicle was equipped with lifting and towing equipment, maintenance tools, and small maintenance shelter hoods for performing field maintenance in the open.
CONCLUSIONS: The Tank Recovery Vehicle M-32B3 was found to be unsatisfactory for operation in cold-wet weather conditions. It was recom-

mended that further tests be made on standard or development vehicles to determine the types best suited for recovery operations.
GENERAL: This 61-page report contains 26 photographs showing construction of the vehicle, operating conditions, and terrain encountered.

SUBJECT: Tank Recovery Vehicles AFF 1386
TITLE: Military Characteristics for Tank Recovery Vehicles
IDENTIFICATION: Project No. 1386
DATE OF REPORT: 21 February 1951
ORIGIN: Army Field Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine the Army requirements for tank recovery vehicles and to establish the military characteristics for new vehicles of this type
METHOD: A study and analysis of combat reports and other documents were made. Various equipment board reports and conferences on armor were reviewed. From the studies, requirements for the tank recovery vehicles were determined.
DESCRIPTION: The vehicles proposed were of the full track-laying, armored type. One vehicle was a light recovery vehicle to perform the rescue and recovery roles for vehicles up to 40 tons and the other was a heavy recovery vehicle to perform these roles for vehicles up to 60 tons. As many standard tank parts as possible were to be used in their construction.
CONCLUSIONS: A detailed list of the requirements for the two vehicles was compiled. It was recommended that pilot models of the vehicles be procured for service tests. Revisions of military characteristics were recommended to be made only by agreement between the user and the development agency.
GENERAL: This 31-page report was not illustrated. The report contained a bibliography, details of study, military characteristics of vehicles, a proposed basis of issue, and a coordination report.

SUBJECT: Tank Recovery Vehicles APG 5538/3
TITLE: First Report on Test of Tank Recovery Unit T3
IDENTIFICATION: Third Report on Ordnance Program No. 5538; APG No. 17-27
DATE OF REPORT: 25 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Tank Recovery Unit T3 as a tractor-trailer combination for the recovery of disabled combat vehicles
METHOD: Loading and unloading operations were conducted using a variety of methods. Road testing was conducted on paved roads and also cross-country.
DESCRIPTION: The Tank Recovery Unit T3 consisted of a Truck Tractor T13 and Trailer T28, and was designed as a means of recovering disabled combat vehicles. The Truck Tractor T13, made by the Dart Truck Company, was a 6x6, wheeled vehicle of 41,500 pounds gross weight. The design of the truck cab provided space for seating one driver and five men. Two rear winches were mounted to the rear of the cab. The tractor was powered with a 250 hp, Waukesha, Model WAK, 6-cylinder gasoline engine. The Trailer T28, made by the Fruehauf Trailer Co., was designed as a low bed trailer onto which a disabled combat unit could be loaded for transportation to a repair base. The running gear consisted of eight 14.00 x 24 combat tires mounted singly onto an axle design which permitted movement of the axles both longitudinally and laterally.
CONCLUSIONS: The Tank Recovery Unit T3 was considered satisfactory with respect to the principle of design. Numerous specific modifications were recommended to improve the vehicle. It was further recommended that consideration be given the development and procurement of a high-speed, full-track-laying unit as a prime mover for operation over difficult terrain.
GENERAL: This 128-page report contains 12 photographs of the recovery unit and failed components.

SUBJECT: Tank Recovery Vehicles APG 5538/4
TITLE: Second Report on Tank Recovery Unit T3 Second Pilot
IDENTIFICATION: Fourth Report on Ordnance Program No. 5538; APG Report No. 17-29
DATE OF REPORT: 1 March 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To study the characteristics of the Tank Recovery Unit T3 with a modified Trailer T28
METHOD: The test vehicle was used as a shop facility vehicle transporting tanks, gun motor carriages, and tractors. The mileage covered was 1402, of which 47 miles was cross-country, and the remainder over concrete and paved roads.
DESCRIPTION: Tank Recovery Unit T3, second pilot, consisted of Tractor T13 and Trailer T28. Tractor T13 was the same as the first pilot except that an armor plated cab and hood, and an overdrive transmission were added, and the spare tire was relocated. Trailer T28 was modified in the following manner: a new set of belly skids, a cable roll at the rear end, a tackle bar and bracket at the front end, and two pockets for carrying hydraulic jacks were installed; a chain loop was added at the rear on each side; the height of the platform skids was reduced; the gooseneck drop plate was moved back; the spare tire carrier was eliminated; and provisions were made for stowing belly skids.
CONCLUSIONS: Recommended for adoption were current traveling position of the belly skids and reinforced ramp channels and pneumatic tires. Among the recommended changes were: that the belly skids be individually fitted and worked for the position they would occupy; larger drainage holes in the trailer bed plate; relocation of the 20-ton jacks; protection of air and electric lines at the gooseneck; improvements for winching and positioning vehicles; addition to the equipment list of cutting torch, bars, hammers; chain, cable, etc.
GENERAL: This 104-page report contains 21 photographs of the vehicle and components and 72 log sheets. The test of the first pilot model of the Tank Recovery Unit T3 is covered by "First Report on

Test of Tank Recovery Unit T3 and Third Report on Ordnance Program No. 5538."

SUBJECT: Tank Recovery Vehicles APG 5568/49
TITLE: First Report on Tank Recovery Vehicle, T5
IDENTIFICATION: Forty-ninth Report on Ordnance Project No. 5568; APG No. 17-33
DATE OF REPORT: 14 September 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Tank Recovery Vehicle, T5
METHOD: Engineering tests were conducted on the test vehicle to determine the center of gravity, load distribution and unit ground pressures, and drawbar pull. Operation of the test vehicle as a crane was checked by lifting a 13-ton load from a trailer. Firing tests were conducted with the 81-mm Mortar. The test vehicle towed a British Cromwell Tank for 19.3 miles. The test vehicle was then operated intermittently for 6 months as a prime mover for the Mine Exploder T1E1. The towing ability of the test vehicle was compared with that of several other vehicles.
DESCRIPTION: The T5 tank recovery vehicle was a Medium Tank M4 manufactured by the Baldwin Locomotive Works and modified by the Lima Locomotive Works. The modifications consisted of a stationary turret, an "A" frame of 15-ton capacity (when stationary), and 10 tons when in motion, and a 60,000-lb. winch located in the center of the fighting compartment. The vehicle was powered by a Wright R975 engine.
CONCLUSIONS: The tank recovery T5 vehicle was not satisfactory for recovery use under combat conditions because of poor towing ability, ineffectiveness of the 81-mm Mortar in laying a smoke screen, limited fields of fire for both the mortar and the cal. .50 machine gun, and lack of protection for the crew. As a mobile shop crane, the test vehicle was considered satisfactory. Further development of this type vehicle was recommended.
GENERAL: This 57-page report contains five photographs of the test vehicle. Appended is a laboratory report on determination of drawbar characteristics.

APG TT2-737/1

SUBJECT: Tank Recovery Vehicles
TITLE: First Partial Report on Engineering and endurance Test of Vehicle, Heavy Recovery, T51
IDENTIFICATION: First Report on Project No. TT2-737
DATE OF REPORT: 17 September 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the engineering characteristics of the T51 vehicle and to determine the suitability of the recovery equipment
METHOD: Engineering tests were conducted to determine center of gravity, load distribution and ground pressure, vertical slope performance, and engine and transmission cooling characteristics. Operational tests were conducted on the recovery equipment to determine ease and accuracy of control, ability to perform rated duties, and reliability. Other tests were conducted regarding crane suitability and the functioning of new type valves for the hydraulic system.
DESCRIPTION: The full-track, lightly-armored vehicle was developed by Chrysler Corporation and had a combat weight of 120,000 pounds and individual torsion bar suspension with 14-dual wheels. The power package consisted of an AVSI-1790-6, 12-cylinder, V-type, air-cooled, supercharged fuel injection engine; and a XT1400-2 cross-drive transmission that combined differential, steering, and final drive in one unit. The recovery equipment consisted of a hydraulic crane, anchor spades, and main and auxiliary winches. Vehicle accessories included an auxiliary generator and engine, fire extinguishers, bilge pump, blower, and heater.
CONCLUSIONS: Major vehicular deficiencies included uneven pressure in the fuel supply line, main engine governor surging, unreliable fuel cut-off mechanism, unsatisfactory parking brake and service brake performance, interference between the oil filter and rear oil cooler, time lag in steering, and excessive effort required to actuate the fire extinguisher mechanism. It was felt that these deficiencies would be corrected in the production model. The recovery equipment was considered satisfactory except for poor level-winding of the winches, insufficient capacity of the boom, sheave bearing, and lack of a safety device to prevent unloading of the extended boom. It was recommended that further testing be conducted to improve engine cooling and to fix the maximum safe relief valve settings on the main winch hydraulic line.
GENERAL: This 162-page report contains 49 photographs showing the test vehicle and component parts.

SUBJECT: Tank Recovery Vehicles DA 1922
TITLE: Heavy Recovery Vehicle, T51, Pilot No. 1, Cooling Characteristics
IDENTIFICATION: Report No. 1922
DATE OF REPORT: 19 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate the general cooling characteristics of the power package as installed
METHOD: Necessary instrumentation was installed, and the engine operated at 2400 engine rpm, low range, and under road load condition until spark plug temperature reached a critical value. Modifications were made during the operation, and the effects noted and recorded.
DESCRIPTION: The T51 recovery vehicle was an armored, full-tracked vehicle, utilizing an AVS-1790-6 engine and a XT-1400-1 transmission. Both the power package and the vehicle were still in the development stage.
CONCLUSIONS: The early test showed that the boom deflected exhaust gases into the horizontal intake grilles. Attempts to prevent this recirculation by closing the susceptible areas failed because insufficient cooling air was supplied to the flywheel end of the engine. The only alternative was the use of the vertical baffles. The two concurrent changes, made in an attempt to prevent the entrance of exhaust gases through the vertical intake grilles, did not significantly improve the cool-

ing of the power package; however, these were indications that exhaust gases had been flowing from each end of the boom. The plate installed to prevent this flow increased the restriction. The temperature of the air through the vertical intake grilles, however, was appreciably reduced. A comprehensive cooling test was not possible because of the 2400 rpm engine speed limitation, and the lack of time. It was recommended that vertical baffles be erected between the horizontal intake and exhaust grilles; that the grilles over the transmission be eliminated; that a well-fitted roof seal completely around the engine, and exhaust grilles and vertical intake grilles, be provided; and that the recess in the boom be extended as far as possible faired into the bottom plate of the boom. It was also recommended that a complete cooling test of the power package be conducted.
GENERAL: This 18-page report includes one photograph of the right side, rear deck of the vehicle, with vertical baffle.

SUBJECT: Tank Recovery Vehicles DWB 94
TITLE: Tractor-Trailer, 40-Ton, Tank Recovery, T21
IDENTIFICATION: Preliminary Report on Project No. 94
DATE OF REPORT: 13 November 1942
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To determine the general suitability of the T21 tank recovery vehicle for battlefield recovery of disabled vehicles, and highway and cross-country transport service
METHOD: The T21 vehicle was service tested on desert maneuvers, in which it was required to perform the same functions as expected in combat. These included loading and evacuating of a disabled vehicle, assisting in field service operations, and general cross-country mobility testing.
DESCRIPTION: The T21 tank recovery vehicle consisted of a T25 tractor truck and a T28 semitrailer. The T25 tractor truck was an armored 6x6 unit, powered by a 250-hp Hall-Scott engine, and equipped with three winches and a fifth wheel. The T28 semitrailer was an eight-wheeled, low-bed unit with loading ramps at the rear.
CONCLUSIONS: Although numerous deficiencies in durability and functioning were discovered, the vehicle was considered worthy of development. It was recommended that the vehicle be adopted, subject to several modifications, and that a modified vehicle be procured for further testing.
GENERAL: This 18-page report contains 12 photographs illustrating deficiencies of the test vehicle.

SUBJECT: Tank Recovery Vehicles DWB 94 (F)
TITLE: Tractor-Trailer, 40-Ton, Tank Recovery T21
IDENTIFICATION: Final Report on Project No. 94
DATE OF REPORT: 2 February 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To determine the suitability of the T21 recovery vehicle for battlefield recovery of disabled vehicles and on-and off-highway transporter service
METHOD: Service tests were conducted on the T21 vehicle under simulated combat conditions. A total of 635 miles of operation with the trailer carrying a medium tank were accumulated. Desert cross-country mobility, in steep washes and sand dunes, was evaluated.
DESCRIPTION: The T21 recovery vehicle consisted of a T25 tractor truck and a T28 semitrailer. The T25 tractor was an armored 6x6 unit, powered by a 250-hp Hall-Scott engine, and equipped with three winches and a fifth wheel. The T28 semitrailer was an eight-wheeled, low-bed trailer with loading ramps at the rear. Since previous testing, covered under the preliminary report, this vehicle had been equipped with a redesigned front axle (in the T25 tractor) as a result of inadequate strength and failure of the original axle.
CONCLUSIONS: The modified front axle proved satisfactory, but numerous deficiencies in function and durability of other components were noted. Nevertheless, the vehicle was considered basically sound and was recommended for adoption, subject to extensive modifications.
GENERAL: This 19-page report contains 10 photographs showing vehicle operation and construction details.

SUBJECT: Tank Recovery Vehicles DWB 94-1 (1)
TITLE: Service Test of Truck Trailer, 40-Ton, Tank Recovery, M25
IDENTIFICATION: First Partial Report on Project 94-1
DATE OF REPORT: 20 August 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To determine the performance characteristics, adequacy of stowage provisions and OVM, and the general suitability of the M25 vehicle for battlefield recovery of disabled vehicles, and on and off-highway transporter service
METHOD: The test vehicle was operated on and off highways for a total of 2137 miles. An M4 medium tank was used as a test payload throughout most of the tests. The scheduled service test, including a 5000-mile run on highways and secondary roads, was interrupted by failures.
DESCRIPTION: The M25 recovery vehicle comprised an armored 6x6 tractor truck, M26, and an eight-wheeled semitrailer with loading ramps at the rear. The tractor was powered by a 275-hp Hall-Scott engine and equipped with three winches. The trailer featured an oscillating-axle, walking beam suspension system.
CONCLUSIONS: The front wheel loading of the M26 tractor was considered excessive and responsible for poor sand and mud flotation. The need for an armored cab was questioned in an effort to find a way to reduce the weight of the tractor. Several deficiencies in component durability were noted and corrective redesign recommended.
GENERAL: This 22-page report contains 13 photographs illustrating test operations and parts failures.

SUBJECT: Tank Recovery Vehicles DWB 94-1 (2)
TITLE: Truck-Trailer, 40-Ton, Tank Recovery, M25
IDENTIFICATION: Second Partial Report on Project No. 94-1
DATE OF REPORT: 20 September 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To continue service testing of the M25 Tank Recovery Vehicle
METHOD: The operation covered in this report consisted of 562 miles of desert secondary road and mountain operation with a medium tank loaded on the trailer. Sand, dust, deep washes, and numerous chuckholes were encountered.
DESCRIPTION: The M25 recovery vehicle consisted of an M26 tractor truck and an eight-wheeled semitrailer. The M26 tractor truck was an armored 6x6, powered by a 275-hp Hall-Scott engine. The trailer employed an oscillating-axle, walking beam suspension system and loading ramps at the rear.
CONCLUSIONS: Minor deficiencies were discovered in addition to those previously noted and their correction was recommended.
GENERAL: This eight-page report contains seven photographs illustrating test operations.

SUBJECT: Tank Recovery Vehicles DWB 94-1 (3)
TITLE: 40-Ton Tank Recovery Vehicle, M25 (Rear Winch Failures)
IDENTIFICATION: Third Partial Report on Project 94-1
DATE OF REPORT: 4 October 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To continue service testing of the M25 Tank Recovery Vehicle
METHOD: This portion of the service test dealt with the winches on the M26 tractor truck. Test operations included winching a M4A1 Medium Tank onto the trailer, and up a 70% slope.
DESCRIPTION: The M25 recovery vehicle was a tractor-semitrailer combination of 40-ton capacity. The tractor was a 6x6 truck with armored cab, powered by a 275-hp Hall-Scott engine. Three Gar Wood winches were mounted, one on the front end, two on the rear.
CONCLUSIONS: The clutches of the rear winches failed on test at approximately 27,000 pounds load, with double and triple lines. The teeth of these face-type jaw clutches were rounded off due to the inability of the clutch control mechanism to hold them fully engaged. A Gar Wood representative who was present attributed the failure solely to flexibility of the control mechanism.
GENERAL: This four-page report contains three photographs of test operations and failures.

SUBJECT: Tank Recovery Vehicles DWB 94-1(4)
TITLE: Truck-Trailer 40-Ton, Tank Recovery, M25
IDENTIFICATION: Fourth Partial Report on Project No. 94-1
DATE OF REPORT: 20 October 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To continue service testing of the M25 recovery vehicle
METHOD: During the period covered by this report the vehicle was awaiting parts. The test operations dealt primarily with the modified winches, whose failures were covered under the 3rd partial report. Other modifications and deficiencies were studied and commented on.
DESCRIPTION: The M25 Tank Recovery Vehicle was a tractor-semitrailer combination of 40 tons capacity. The tractor was an armored 6x6 truck equipped with three Gar Wood Winches and powered by a 275-hp Hall-Scott engine. The semitrailer was an eight-wheeled unit with an oscillating-axle, walking beam suspension system. Modified winch controls were installed to maintain full engagement of the winch clutches under load. Baffle plates had been installed around portions of the exhaust system to reduce radiant heating of adjacent components which had caused trouble in previous tests.
CONCLUSIONS: The modified winch controls were satisfactory and the exhaust system baffles prevented overheating of the right fuel tank and auxiliary transmission. The carburetor, front winch drive shaft and the Goodrich 14.00 x 24 desert tires on the vehicle were found unsatisfactory and corrective measures were recommended.
GENERAL: This six-page report contains two photographs illustrating the installation of the exhaust system heat baffles.

SUBJECT: Tank Recovery Vehicles DWB 94-1 (5)
TITLE: Service Test of Truck-Trailer, 40-Ton, Tank Recovery Vehicle M25
IDENTIFICATION: Fifth Partial Report on Project No. 94-1
DATE OF REPORT: 8 November 1943
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To continue service testing of the M25 recovery vehicle
METHOD: The test vehicle was loaded with a full 40-ton payload and operated over desert cross-country terrain and secondary roads.
DESCRIPTION: The M25 recovery vehicle was a tractor-semitrailer combination of 40-ton capacity. The tractor was an armored 6x6 vehicle powered by a 275-hp Hall-Scott engine and equipped with three winches. The semitrailer was an eight-wheeled unit with rear loading ramps, and with an oscillating-axle walking-beam suspension system. Desert and combat type tires of different construction and manufacture were mounted for test.
CONCLUSIONS: Numerous tire failures occurred during the test and an improved cord construction, not described, was considered necessary for desert operations. The durability of wheel rim bolts, jack shaft axles, and parking brake were unsatisfactory. Roughness of engine operation was prevalent, caused partly by sensitivity of the carburetor to deviations from the level position and partly by deficiencies in the crankcase ventilation system.
GENERAL: This 12-page report contains 10 photographs illustrating deficiencies and failures.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Tank Recovery Vehicles DWB 94-1 (6)
TITLE: Service Test of Truck-Trailer, 40-Ton, Tank Recovery, M25
IDENTIFICATION: Sixth Partial Report, Project No. 94-1
DATE OF REPORT: 1 December 1943
ORIGIN: Desert Warfare Board, Camp Young, Indio, California
PURPOSE: To determine the efficiency and weaknesses of the M25 vehicle under desert conditions
METHOD: The vehicle was operated 1705 miles over all types of desert terrain and highways, fully stowed and carrying a full payload of 40 tons (Medium Tank M4A4 plus 175 sand bags).
DESCRIPTION: The total weight of the vehicle, without payload but fully stowed, was 80,260 pounds. The total vehicle weight fully stowed and loaded with Medium Tank, M4A4, and 175 sand bags was 160,440 pounds.
CONCLUSIONS: The bevel drive gear with pinion in the rear axle was not satisfactory, due to excessive failures. The number of bolts used to secure the transfer case to the auxiliary transmission was insufficient to prevent leakage of gear oil between the two cases. Combat tires were unsatisfactory for this vehicle because of poor flotation qualities in off-road operation.
GENERAL: This five-page report contains four photographs of the test vehicle and parts failures.

SUBJECT: Tank Recovery Vehicles DWB 94-1 (9)
TITLE: Service Test of Truck-Trailer, 40-Ton, Tank Transporter, M25
IDENTIFICATION: Ninth Partial Report on Project No. 94-1
DATE OF REPORT: 22 January 1944
ORIGIN: Desert Warfare Board, Camp Young, California
PURPOSE: To continue service testing of the M25 tank recovery-transporter vehicle
METHOD: Operation of the test vehicle during the period covered by this report totaled 491 miles on highways and secondary roads, during which routine observations were made.
DESCRIPTION: The M25 vehicle was a tractor-semitrailer combination of 40-ton capacity. The tractor was an armored 6x6 powered by a 275-hp Hall-Scott engine and mounting three winches. The semitrailer was equipped with an eight-wheel, oscillating-axle, walking-beam suspension system and loading ramps at the rear.
CONCLUSIONS: Failures of wheel rim bolts, as noted in previous testing, continued throughout this period. No recommendations were made.
GENERAL: This five-page report is not illustrated. The report proper occupies only one page, the remaining four being devoted to letters of transmittal.

OCO KG 369, 354, 370
OCO KG 355, 371

SUBJECT: Tank Recovery Vehicles
TITLE: Tank Recovery Vehicles T5 Series (T5, T5E1, T5E2, T5E3, and T5E4)
IDENTIFICATION: Project Nos. KG-369, 354, 370, 355 and 371
DATE OF REPORT: 20 March 1944
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To develop an adequately armored vehicle for recovering disabled medium tanks and other vehicles, and for removing such tank components as the turret by means of an "A" frame boom
METHOD: The Armored Board at Fort Knox conducted various service tests with Tank Recovery Vehicles T5E1 and T5E3. These operations included towing of medium tanks over highways and cross-country terrain, winching light and medium tanks out of mud holes and creek bottoms and up slopes with grades as high as 75%, and handling, by boom, turrets, engines, and weights to 15 tons.
DESCRIPTION: The test vehicles were full-tracked, armored vehicles with fixed turrets and were based on Medium Tank M4 series chassis. (Tank Recovery Vehicles T5, T5E1, T5E2, T5E3, and T5E4 were based on Medium Tanks M4, M4A1, M4A2, M4A3, and M4A4, respectively.) Armament consisted of two .50 caliber machine guns and an 81-mm Mortar tube. A 60,000-pound, single-line, pull winch with two speeds forward and one reverse was provided as well as a boom of the fixed "A" frame type.
CONCLUSIONS: Tank Recovery Vehicles of the T5 series were considered superior to Tank Recovery Vehicles T2 and T7, and were recommended for standardization and production. Certain minor modifications and rearrangement of stowage were recommended. Tank Recovery Vehicle T5E3 with a Ford V-8 engine was found superior in towing performance to the Tank Recovery Vehicle T5E1 with a R975 engine. Although vehicles based on Medium Tanks with other types of engines had not been tested, it was recommended that the Tank Recovery Vehicles of the T5 series be produced with all types of Medium Tank engines in order that armored units might have uniformity of power plants throughout units.
GENERAL: This 30-page report contains four photographs of test vehicle T5E3, and of the winch and stowage arrangement.

SUBJECT: Tank Recovery Vehicles OCO KG-414
TITLE: Tank Recovery Vehicle T6E1
IDENTIFICATION: Project No. KG-414
DATE OF REPORT: 27 September 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To develop a vehicle capable of recovering light tanks and similar vehicles, lifting, by means of a boom, components such as turrets and engines, and carrying tools for performing second and third echelon field maintenance
METHOD: One pilot model of the Tank Recovery Vehicle T6E1 was manufactured by Cadillac and shipped to Fort Knox for service testing. (Results of the test were recorded in the Armored Board Report on Project No. 620 dated 17 February 1945.) Due to the cancellation of requirement for such a vehicle, it was subsequently shipped to Aberdeen for record purposes in the historical museum.
DESCRIPTION: The test vehicle, Tank Recovery Vehicle T6E1, was based on the Light Tank M24

chassis and contained a fixed turret with a .50 caliber MG in an M49 ring mount; a 60,000-pound capacity winch; an "A" frame boom, pivoted near the front end of the vehicle; and was stowed with first and second echelon spare parts and repair tools.
CONCLUSIONS: In view of the Army Ground Forces decision to standardize on the heavier type Tank Recovery Vehicle M32 to function for recovery of both light and medium class tanks, it was recommended that no further development work be done on this vehicle and that the project be closed.
GENERAL: This 60-page report contains seven photographs showing the vehicle and stowage arrangement, a characteristic sheet, and 40 pages of related correspondence.

OTAC KG-356

SUBJECT: Tank Recovery Vehicles
TITLE: Tank Recovery Vehicle, T6
IDENTIFICATION: Project No. KG-356
DATE OF REPORT: 14 February 1944
ORIGIN: Ordnance Tank Automotive Center, Detroit, Michigan
PURPOSE: To develop and test a vehicle based on the light tank M5A1 suitable for rapid removal of tanks and other damaged material from the battlefield
METHOD: A laboratory setup of the winch, engines and transmission was made to test the suitability of the unit.
DESCRIPTION: A Gar Wood 60,000-lb. power winch with lifting and towing equipment was used. The equipment was designed for mounting in a Light Tank M5A1 chassis.
CONCLUSIONS: From laboratory tests of the winch and preliminary drafting layouts it was recommended that further development of the Tank Recovery Vehicle T6 be cancelled.
GENERAL: This 16-page report contains three photographs of the laboratory setup of the winch. Also included is a summary of previous developments and related correspondence.

SUBJECT: Tank Recovery Vehicles PG-2.1197
TITLE: Test of Power Take-Off Clutch Sprocket and Engine Clutch Equalizer Kit, Tank Recovery Vehicle T2
IDENTIFICATION: Report No. PG-2.1197; GMPG Project No. 298
DATE OF REPORT: 13 May 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of a power take-off clutch sprocket and engine clutch equalizer kit for use on Tank Recovery Vehicle T2
METHOD: Due to the fact that considerable difficulty was encountered in the installation of the power take-off clutch sprocket, a durability test was not conducted. The engine clutch equalizer, on the other hand, was installed with little difficulty and was left on the vehicle since it operated satisfactorily.
DESCRIPTION: The test kit contained an engine clutch equalizer similar to the one used on a Medium Tank M4A2 but adapted to the test vehicle which had idler levers spaced farther apart, and a power take-off clutch sprocket. The kit assembly was designed because the power take-off operated while the vehicle was moving, causing considerable wear and repeated failures in the drive chain. The clutch sprocket was thus designed to eliminate the rotation of the take-off assembly.
CONCLUSIONS: The test kit was considered unsatisfactory because it was difficult to install and did not operate satisfactorily. If the engine clutch equalizer was issued as a field fix kit, it was felt that appropriate auxiliary controls should be furnished. It was recommended that the power take-off clutch be redesigned and further tests conducted.
GENERAL: This 19-page report contains six photographs of kit components and power take-off parts.

SUBJECT: Tank Recovery Vehicles PG-2.1491
TITLE: Standard Inspection Control Test, Tank Recovery Vehicle M32B1, Pressed Steel Car Company
IDENTIFICATION: Report No. PG-2.1491; GMPG Project No. 206-100
DATE OF REPORT: 26 January 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the operating characteristics of the production Tank Recovery Vehicle, M32B1, with the specifications for this vehicle
METHOD: Operating tests were conducted on the engine and engine electrical system, clutch, transmission, brake system, suspension system, winch, and radio suppression. Performance characteristics of the test vehicle were also determined. Approximately 800 miles of operation were accumulated during the test period.
DESCRIPTION: The Tank Recovery Vehicle M32B1 was built on an M4 tank chassis, with a fixed turret and an "A" frame boom. The test vehicle, manufactured by Pressed Steel Car Co., was equipped with an R975-C1 Continental engine and a Caterpillar power train.
CONCLUSIONS: Only very minor engine and clutch deficiencies were noted. The transmission had apparently been rebuilt, and hard shifting developed after 695 test miles because of poorly repaired synchronizer clutch gears. It was recommended that when transmissions were rebuilt, the synchronizer and clutch gears be replaced rather than repaired. Heavy ignition noise was prevalent during the radio suppression tests, the cause of which was not determined. The brakes failed to hold on slopes above 38% although 50% was specified. Leakage of the vehicle on the fording test was seriously above the specified minimum. Removal of the top engine compartment cover to inspect the engine was difficult, because of the large amount of stowage which had to be moved, but, without deleting necessary stowage items, no solution could be seen. The winch did not meet specifications in terms of effective length of cable, and braking power on lowering of weight. The method of raising and lowering the boom was not considered satisfactory be-

cause it lacked controllability.
GENERAL: This 19-page report contains one photograph of the test vehicle, and a memo report (No. PG-19.520) on the test of winch operation.

SUBJECT: Tank Recovery Vehicles PG-2.1599
TITLE: Standard Inspection Control Test, Tank Recovery Vehicle M32B1
IDENTIFICATION: Report No. PG-2.1599; Project No. 206-119
DATE OF REPORT: 25 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the operating characteristics of the production Tank Recovery Vehicle M32B1 with the specifications for this vehicle
METHOD: The vehicle was operated 908 miles. Performance tests were conducted on the M32B1 vehicle. The vehicle was thoroughly checked to determine compliance with specifications. Test weight of the vehicle was 66,000 pounds.
DESCRIPTION: The Tank Recovery Vehicle, M32 B1, was built on an M4 tank chassis, with a fixed turret and an "A" frame boom. The test vehicle, manufactured by Federal Machine and Welder Company, was equipped with a Continental R975-C1 engine and an Iowa transmission.
CONCLUSIONS: The major difficulty experienced was high engine oil consumption. Some trouble was also encountered with broken shear pins during the winch test; with frequent loosening of the mounting cap screws on two track support rollers; and with radio interference. The driver's seat was of the telescoping type, and was considered undesirable because of wobbling and undependability of the height adjustment. It was recommended that a special pantograph seat be designed; that a slip clutch instead of a shear pin be used with the winch drive sprocket; and that a solid rear pintle hook be used.
GENERAL: This 26-page report contains nine photographs of the test vehicle, winch drive sprocket parts, engine, oil temperature control valve, damaged pintle hooks, and winch brake band assembly.

SUBJECT: Tank Recovery Vehicles PG-2.1679
TITLE: Standard Inspection Control Test, Tank Recovery Vehicle M32B1 — Federal
IDENTIFICATION: Report No. PG-2.1679; GMPG Project No. 206-154
DATE OF REPORT: 16 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare the operating characteristics of the production Tank Recovery Vehicle M32B1, with the applicable specifications
METHOD: The test vehicle was operated 44 miles, at which time the test was terminated by directive. The vehicle was ballasted to 68,000 pounds for the test.
DESCRIPTION: The Tank Recovery Vehicle M32 B1, manufactured by Federal Machine Company, was powered by a R975-C1 Continental Engine. The vehicle was built on an M4 tank chassis, and was equipped with a fixed turret and an A-frame boom. A Gar Wood Winch transmission was employed.
CONCLUSIONS: The magneto had not been properly timed by the manufacturer since the point gap was much greater than the standard, and the timing was 11° BTC. It was recommended that the manufacturer exercise closer inspection over the magnetos to insure that the timing marks be properly stamped on both sides of the case flange, and that the magnetos be properly timed.
GENERAL: This six-page report contains two photographs of the test vehicle.

SUBJECT: Tank Recovery Vehicles TDB-193
TITLE: Report of Test of Tank Recovery Vehicle T5E2
IDENTIFICATION: Project No. 193
DATE OF REPORT: 6 April 1944
ORIGIN: Tank Destroyer Board, Camp Hood, Texas
PURPOSE: To determine suitability of Tank Recovery Vehicle T5E2
METHOD: Tests were conducted on the towing, winching and hoisting capacities of the test vehicle. The test vehicle towed GMC's T70 and M10 over varied terrain; the GMC's T70 and M10 were winched out of creeks, ground holes, ditches and up various grade slopes. The hoist was used to remove and replace the turrets of the M10 and T70, and an attempt was made to lift the T70 off the ground. Mobility of the vehicle was ascertained during tactical problems. Adequacy of stowage and the comfort and safety of crew were determined. Firing tests were conducted to determine adequacy of the vehicular weapons.
DESCRIPTION: The test vehicle had an M4A2 Medium Tank hull and power train. However, the turret, turret basket, ammunition racks, and traversing mechanism were replaced by a hexagon-shaped fixed turret. The vehicle was also equipped with a 600-lb. winch, located on the floor slightly forward of the turret center, and an "A" frame boom of 4-1/2-inch seamless tubing. Armament included one cal. .50 and one cal. .30 machine gun, and one 81-mm mortar.
CONCLUSIONS: The Tank Recovery Vehicle T5E2 was considered satisfactory for use with tank destroyer units equipped with 3-inch GMC M10 (diesel engine), the T5E3 for units equipped with GMC M10A1, and T5E1 for units equipped with GMC T70 (radial engine) vehicles. All three of the T5 series vehicles, with modifications listed in the appendixes of the report, were recommended for issue to tank destroyer units. It was also recommended that cutting and welding equipment be added to the basic vehicular equipment of the T5 series tank recovery vehicle.
GENERAL: This 35-page report contains 14 photographs of the T5E2 showing winching, towing, and hoisting operation.

SUBJECT: Tank Recovery Vehicles TDB-219
TITLE: Service Test of Tank Recovery Vehicle M32B1
IDENTIFICATION: Project No. 219

DATE OF REPORT: 21 April 1944
ORIGIN: Tank Destroyer Board, Camp Hood, Texas
PURPOSE: To determine the suitability of the Tank Recovery Vehicle, M32B1, for consideration in the Maintenance Platoon, Hq and Hq Co, TD Bn; or in the Maintenance Section, TD Co., (Self-Propelled)
METHOD: The vehicle was operated for 500 miles on secondary roads, highways, and cross-country with a 76-mm Gun Motor Carriage M18. Typical recovery missions of the vehicle, both simulated and actual, were performed on the Gun Motor Carriage.
DESCRIPTION: The vehicle was a heavy wrecker constructed on the M4A1 Medium Tank hull, was powered by a radial engine (R975-C1), and weighed 35 tons. It was equipped with an "A" frame boom, and a 60-ton mechanical winch.
CONCLUSIONS: The Tank Recovery Vehicle M32 B1 had the same armor and met all technical requirements as a recovery vehicle for the M18, but lacked equal mobility and roadability. That factor would prevent its efficient employment as an integral part of the tank recovery company. It weighed 15 tons more than the M18 therefore routes would be limited by the recovery vehicle. It was recommended that the vehicle, with some minor modifications, be considered a satisfactory expedient and issued to 76-mm Gun Motor Carriage M18 tank destroyer battalions until such time as a recovery vehicle capable of tactical operations with the M18 was developed.
GENERAL: This 18-page report includes six photographs of the vehicle.

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Section 41
TANKS (COMBAT)

SUMMARY

This summary covers 427 report resumes on the testing and development of combat tanks during the years from 1932 to 1955. The majority of the reports originated at Aberdeen Proving Ground, Maryland; Armored Board, Fort Knox, Kentucky; General Motors Proving Ground, Milford, Michigan; and the Tank Arsenal Proving Ground, Utica, Michigan. Other test locations included: The Armored Force Board, Fort Knox, Kentucky; Army Field Forces Board No. 2, Fort Knox, Kentucky; Armored Medical Research Laboratory, Fort Knox, Kentucky; Arctic Test Branch, Big Delta, Alaska; Detroit Arsenal, Center Line, Michigan; Desert Warfare Board, Desert Training Center, Camp Young, California; Military Intelligence Division, Washington, D.C.; Office, Chief of Ordnance, Detroit, Michigan; General Motors Proving Ground and Laboratory, Phoenix, Arizona; Chrysler Corporation, Detroit, Michigan; and the General Motors Corporation, Cleveland Tank Plant.

Data were almost entirely concerned with performance operations of light, medium, and heavy tanks. Tests were conducted with the complete vehicle and results tabulated with respect to adequacy of design and manufacturing, turrets, primary and secondary armament, fire control equipment, engine, transmission suspension, tracks, armor, desert tests, and adequacy of crew and stowage facilities. Because the primary purpose of these investigations was to determine the acceptability of tank vehicles for military use, no outstanding trends can be described. However, results concerning tanks which were particularly emphasized will be discussed. Generally, the testing program was a continuous operation in which the vehicle was constantly improved to develop a tank of high military value. After each testing and with the proper authority, the recommendations suggested were incorporated in the production vehicles. Most of the report resumes were related to light and medium tanks; approximately 300 of these studies represent the 1942 to 1945 span. For this reason summary information is concerned mainly with tests during this period.

An especially large number of light tank performance evaluations were devoted to vehicles of the M3, M5, and M24 series. Additional tests with experimental and production light tanks included the following identification: T2, T2E1, T3, T9E1, T9E2, T23, T24, T24E1, T37, and T7E2. Data were also recorded for M2A2E2, M2A2E3, M2A3, M2A4, and M24E1 light tanks.

M3 LIGHT TANKS

Production M3 light tanks under test were manufactured by the American Car and Foundry Company, and powered by either 7-cylinder Continental or 9-cylinder Guiberson engines. Armament consisted of a 37mm M5 gun and a cal. .30 machine gun in a combination turret mount and one bow cal. .30 machine gun. Final results for the M3 medium tanks indicated satisfactory development. Deficiencies encountered included faulty engine design and manufacturing defects. An M3 tank with twin Cadillac engines and dual Hydramatic transmissions was also satisfactory.

A light tank M3E2 was superior to the M3 light tank with regard to stability of firing platform and was considered a better fighting vehicle than any other light tank. The M3A1 and M3A3 light tanks were tested until satisfactory performance was demonstrated.

M5 LIGHT TANKS

M5 light tanks manufactured by the Massey-Harris Company were 32,000-pound vehicles with a 37mm gun installed as a primary weapon. Power was supplied by two rear-mounted V-8 Cadillac engines. Test M5 tanks were also manufactured by the Cadillac Division of the General Motors Corporation. Satisfactory results were obtained with these vehicles. Inadequacies were noted concerning manufacturing defects in the suspension components, transmission durability, and fuel tank weld fractures. Recommendations were made after a desert endurance test with relation to improper cooling, dust seepage in certain components, crew compartment dust, and excessive oil consumption.

M24 LIGHT TANKS

Light M24 tanks subjected to test operations were manufactured by Cadillac and were powered by two Cadillac V-8 engines. Primary armament consisted of a 75mm gun M6. The light tank M24 was considered superior to other light tanks used by armored units. Ease of maintenance tests revealed a need for revision of technical manual procedure in the replacement of certain items. Durability, reliability, parts mortality, oil consumption, and method of test development were among the aspects of the M24 light tank which were found to be highly satisfactory.

Investigation concerning the suitability of medium tanks emphasized vehicles of the M3 and M4 series. Test course and facility operation were utilized and appropriate data recorded.

M3 MEDIUM TANKS

Tank operation in the evaluation of medium tanks of the M3 series included the following vehicle designations: M3, M3A1, M3A3, M3A4,

M3A5, and M3A5E1 medium tanks. The various power plants utilized General Motors twin diesel engines, and Continental R975-EC2 and R97-EL engines. Among the tank manufacturers represented were the Baldwin Locomotive Works, the American Car and Foundry Company, and the Chrysler Corporation. In general, armament included one 75mm gun, one 37mm gun, and three cal. .30 machine guns. Difficulties experienced included lack of engine power and insufficient space for engine and accessories. However, satisfactory performance was achieved and manufacturing of production vehicles was considered to be at a high quality level. One test indicated that crew compartment accommodations had been developed which were "safe and comfortable". Trouble-free desert operation for M3 medium tanks was found to be 900 to 1000 miles. The M3A5E1, a modified M3 production tank, was superior to M3, M3A1, M3A2, M3A3, and M3A5 medium tanks with respect to acceleration, driver comfort, firing platform stability, and mobility. A Canadian medium tank M3 was identical in mechanical performance to U.S. M3 medium tank.

M4 MEDIUM TANKS

Medium tanks in the M4 series subjected to test evaluation included these identifications: M4, M4A, M4A1, M4A2, M4A2E4, M4A3, M4A3E, M4A3E2, M4A3E3, M4A3E8, M4AEW, M4A4, M4A6, M4E1, M4E6, and M4E8. Approximately 85 reports were devoted to the M4A1, M4A2, and M4A3 medium tanks. Performance studies of these three vehicles will be emphasized for summary purposes.

M4A1 TANKS

Test M4A1 medium tanks were manufactured by the Pressed Steel Corporation, Pacific Car and Foundry Company, and the Lima Locomotive Works. Several tanks were remanufactured by the Evansville Ordnance Plant. Power plants utilized Continental R975-EC2, Continental R975-C, and Ford GAA V-8 gasoline engines. M4A1 armament included a 75mm gun M3 and cal. .30 machine gun in a combination mount M34 controlled by a gyrostabilizer.

Adequate M4A1 performance was obtained and high manufacturing quality for production vehicle was achieved. Difficulties encountered during the various tests pertained to the transmission, engine, clutch, gyrostabilizer, exhaust system, electrical components, suspension, cooling, oil consumption, and general durability. The M4A1 medium tank was considered satisfactory for desert operation only until a medium tank with improved suspension and a more efficient engine could be developed.

M4A2 MEDIUM TANKS

Manufacturers of test M4A2 medium tanks included the Pullman Standard Car Manufacturing Company, Fisher Tank Division of the General Motors Corporation, Baldwin Locomotive Works, and the Federal Machine Company. Power plants utilized twin GM diesel engines of both the 6046 and 6-71 series. Armament included a 75mm gun, one cal. .50 AA machine gun, and two cal. .30 machine guns. Test development was successful, although deficiencies similar to those for the M4A1 medium tank were encountered.

M4A3 MEDIUM TANKS

Manufacturers of test M4A3 medium tanks were the Ford Motor Company, Fisher Body Division of the General Motors Corporation, and the Chrysler Corporation. One M4A3 vehicle was remanufactured by the Montreal Locomotive Works. Operating characteristics and durability of the M4A3 medium tank were satisfactory, although several inadequacies were recorded during desert endurance tests.

HEAVY TANKS

A comparatively small number of reports were devoted to heavy tanks. These included the following: M6, M6A1, M26, M47, T1E1, T1E2, T26, T26E1, T26E3, T28, T29, T30, and T32. Development of these vehicles was successful in most cases; no particular heavy tank was emphasized.

Fifty-seven reports were written from 1951 to 1955. Tests were similar to those previously discussed. The following are typical of the more recent investigations.

M48 TANK WITH BULLDOZER KIT, T18E1

In May, 1955, a test was conducted to determine the effects of a bulldozer installation on the M48 tank, a 49-ton vehicle utilizing a four-man crew and characterized by an elliptical armor configuration, low ground pressure, and a remote-controlled commander's machine gun mount and commander-operated rangefinder. The T18E1 bulldozer kit was a heavy-duty, hydraulically-operated unit especially designed for mounting on the M48 tank. Operation of the M48 tank as a bulldozer was satisfactory, but the certified final drives of the spur gear, single-reduction type, manufactured by the Fisher Tank Division, were not sufficiently durable to withstand more than 100 hours of dozer operation. It was recommended that the certified final drives be limited to 100 hours of dozer operation.

HULL REINFORCEMENTS FOR VIBRATION REDUCTION

A test to determine the effectiveness of hull reinforcements for the reduction of tank vibration in the T41E1 No. 1 pilot tank was conducted in April, 1952. The reinforced vehicle and the No. 66 vehicle, each manufactured by the Cleveland Tank Plant, General Motors Corporation, were operated for comparison of vibration characteristics. The total weight of the reinforcement added to the hull was 245 pounds. The hull reinforcements caused a definite reduction in the vibration of the T41E1 No. 1 pilot tank. It was observed that noticeable vibration periods on vehicle No. 66 were reduced or were nonexistent in vehicle No. 1.

T43E1 TANK, 120MM GUN

An engineering and endurance test of this tank was conducted in April, 1955, to determine the performance characteristics, with special emphasis on suspension modifications. The test modified tank was a heavily armored, full tracklaying,

combat vehicle, mounting a 120mm gun, T123E1. Secondary armament consisted of one cal. .50 and two cal. .30 machine guns. The combat weight of the vehicle was 125,000 pounds and it had a five-man crew complement. The vehicle performance and mechanical reliability were satisfactory and reflected an improvement over previously tested vehicles of the T43 series. Engineering performance tests revealed satisfactory results. It was recommended that the tank, T43E1, be considered satisfactory from an automotive standpoint; that testing of future T43E1 production vehicles be considered to determine whether these results were representative.

REPORT RESUMES

NOTE

A number of tank (combat) report resumes are classified. These resumes appear in Section 41, Volume XI.

SUBJECT: Tanks (Combat) AB 236-1(2)
TITLE: Armored Force Board, Second Partial Report on M4A1 Medium Tank Powered by L972-EC2
IDENTIFICATION: Second Partial Report; Project No. 236-1
DATE OF REPORT: 25 April 1942
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of Medium Tank M4A1, with particular attention to changes in design and operation of all units not included in the Medium Tank M3
METHOD: During service operation of the vehicle, particular attention was paid to the crew compartment, and ease and use of controls, the fuel system, turret and fighting compartment, and accessories.
DESCRIPTION: The test M4A1 Medium Tank was manufactured by the Pressed Steel Car Corporation, and was powered by a Continental R975-EC2 gasoline engine.
CONCLUSIONS: Modifications to improve the direct vision port, the driver's and assistant driver's seats, the periscope heads, the fire screens and fuel tank filler holes, the location of the firing mechanism fuse, the siren, and the "Ration Box" were recommended. Additional drain holes in the front of the crew compartment, and a check valve for the fuel filler cap were also recommended.
GENERAL: This six-page report is not illustrated.

SUBJECT: Tanks (Combat) AB 236-1(F)
TITLE: Final Report of Service Test of Medium Tank, M4A1
IDENTIFICATION: Final Report; Project No. 236-1
DATE OF REPORT: 11 January 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of the M4A1 Medium Tank
METHOD: The vehicle was operated for 2278 miles (247 hours) over varied terrain.
DESCRIPTION: The test M4A1 Medium Tank was manufactured by the Pressed Steel Car Corporation and was equipped with a Continental R975-C1, radial, air-cooled, gasoline engine.
CONCLUSIONS: Modifications were suggested to improve the driver's and assistant driver's seats, the turret hatch cover lock, the muffler support bracket, and the clutch pedal. It was recommended that the siren button be located where it could be operated by the left foot and that the siren be located in a more protected position. A sturdier mount was recommended to eliminate headlight vibration. The latest type synchromesh devices were recommended for use in the transmission. It was further recommended that more effective bogie wheel grease seals be developed and that idler bracket rivets be replaced by through-bolts.
GENERAL: This 28-page report contains two photographs showing muffler breakage and interference between driver's foot and hull bolts.

SUBJECT: Tanks (Combat) AB-243 (1-A-63)
TITLE: Test of Light Tank, M5
IDENTIFICATION: Project No. 243 (1-A-63)
DATE OF REPORT: 27 August 1942
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To perform a complete service test on the Light Tank M5
METHOD: The vehicle was operated for a total of 229 hours (3370 miles). Test runs included highway and cross-country operation. Approximately one-third of the test runs were cross-country. Fording capability of the vehicle was determined by operation in four feet of water.
DESCRIPTION: The test Light Tank M5 was powered by two Cadillac, V-8, gasoline engines and weighed 32,750 pounds. It was equipped with hydramatic transmissions, vertical volute spring suspension, integrated type fighting compartment, power turret traverse, and a gyrostabilizer.
CONCLUSIONS: The vehicle was found to have the following advantages over other light tanks in use at the time: minimum operator training required, greater speed, lower cost, increased cruising range, less driver fatigue, quieter operation, dual controls, and two separate power units and trains (either of which could operate the vehicle in an emergency). Extensive training of personnel to insure maintenance of the power unit and power train and increased ground pressure were the principal disadvantages of the test tank. It was recommended that the Light Tank M5 be considered satisfactory for Armored Force use. It was further recommended that the mechanical deficiencies noted during the test be corrected in production and all tanks in

the field at the earliest possible date.
GENERAL: This 19-page report is not illustrated.

SUBJECT: Tanks (Combat) AB-243 (1-A-64)
TITLE: Test of Light Tank, M5
IDENTIFICATION: Project No. 243 (1-A-64)
DATE OF REPORT: 1 December 1942
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To perform a complete service test on the Light Tank M5
METHOD: The vehicle was given a complete service test including operation under simulated combat conditions on the firing range and in convoy.
DESCRIPTION: The test vehicle was a Light Tank M5. No detailed description was included in the report.
CONCLUSIONS: The one tank tested was considered a generally satisfactory vehicle with the exception of deficiencies in the turret. It was recommended that the deficiencies and failures noted during the course of the test be corrected in all production tanks and wherever possible in existing vehicles. It was further recommended that final recommendations as to suitability, maintenance, operating difficulties, and similar details be incorporated in the report of Project 243-2(1-A-113) "Special Test of 17 Light Tanks, M5A1."
GENERAL: This 20-page report contains two photographs of the tank.

SUBJECT: Tanks (Combat) AB-243-2
TITLE: Service Test of Three Light Tanks, Two M3A1 and One M3A3
IDENTIFICATION: Project No. 243-2; Second Partial Report
DATE OF REPORT: 11 June 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the general durability of M3A1 and M3A3 Light Tanks and to determine the durability of the power-driven turret
METHOD: The test tanks were operated 24 hours a day in convoy and under simulated combat conditions. Particular attention was given to the engine and power train during the test. The test vehicles were operated an average of 531 miles on highways, 632 miles on secondary roads, and 2036 miles cross-country.
DESCRIPTION: The Light Tank M3A1 was a 28,514-pound light tank powered with a Continental, air-cooled, radial engine and armed with a 37-mm gun and three caliber .30 machine guns. The Light Tank M3A3 was slightly larger and weighed approximately 5000 pounds more than the M3A1.
CONCLUSIONS: The general durability of the Light Tanks, M3A3, and, M3A1, was considered satisfactory. No serious difficulty was encountered with the power-driven turret. The oil consumption of the Continental W-670 engine was found to be excessive, and the clutches, clutch operating linkages, and tail light sealed beam units were considered unsatisfactory. An excessive number of failures caused by faulty or careless manufacture was experienced during test operation. Since the Light Tank, M5A1, was being standardized and production of Light Tank, M3A3, discontinued, it was recommended only that the manufacturer be required to improve the quality of the remaining Light Tanks, M3A3, to be built and that defects noted during the test be corrected on existing tanks.
GENERAL: This 17-page report contains three photographs of the test tanks.

SUBJECT: Tanks (Combat) AB-243-2(1-A-113)
TITLE: Service Test of 17 Light Tanks M5A1
IDENTIFICATION: Project No. 243-2 (1-A-113); First Partial Report
DATE OF REPORT: 1 June 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the general durability of the M5A1 Light Tank with particular attention to the engine and power train
METHOD: Seventeen test tanks were operated 24 hours per day for a period of 71 days in convoy on roads and under simulated combat cross-country operation. The average hours and miles per tank at the end of the test for the various types of operations were: 120:42 hours and 1891 miles on highways; 56:11 hours and 667 miles on secondary roads; and 276:51 hours and 2077 miles cross-country. The average total for each tank was 4635 miles and 453:46 hours.
DESCRIPTION: The Light Tanks, M5A1, as tested, were improved versions of the Light Tank, M5. The test tanks had a turret which included a radio bulge and had larger turret hatch openings than the M5. The test tanks were powered by two eight-cylinder Cadillac engines located in the rear of the hull, the flywheel of each engine being connected to a hydramatic transmission. The propeller shaft for each power plant ran forward through the fighting compartment to a transfer unit located to the right of the driver's seat. This transfer unit was also hydramatic and, with the transmissions, provided six forward speeds and one reverse speed. The transfer unit was mounted on the final drive and controlled differential housing.
CONCLUSIONS: The Light Tank, M5A1, was considered an excellent vehicle from the standpoint of durability and maintenance. The power plants were capable of 400 hours of almost continuous service operation before requiring a major overhauling or removal from the tank. Recommendations were made to improve the service life of the flywheel cover assembly, transmission oil seals, transfer unit, idler wheels, and volute springs.
GENERAL: This 59-page report contains 15 photographs showing the condition of various components after testing.

SUBJECT: Tanks (Combat) AB-243-3
TITLE: Test of Two (2) Light Tanks, M5A1 (Modified)
IDENTIFICATION: Final Report on Project No. 243-3
DATE OF REPORT: 25 October 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of two modified power trains in Light Tanks, M5A1
METHOD: The modified tanks were operated 24

hours per day for an average test service of 4020 miles (2477 miles cross-country), 444 engine hours, and 408.5 vehicle hours.
DESCRIPTION: Two Light Tanks, M5A1, which had completed the test under Project No. 243-2 were rebuilt with completely new power trains embodying numerous modifications. These modifications were made in the internal mechanisms of the power train units and few alterations could be discerned without complete disassembly of the units.
CONCLUSIONS: All the modifications incorporated in the test tanks were found to be satisfactory and were recommended for incorporation in future models. The average life of the production volute springs was unsatisfactory, especially in the front bogie assemblies. The special test volute springs provided from two to three times the service life of production type volute springs; however, complete test data have not been obtained.
GENERAL: This 25-page report contains seven photographs showing the condition of failed components.

SUBJECT: Tanks (Combat) AB-267-2
TITLE: Test of Medium Tank M4A3 (76-MM)
IDENTIFICATION: Project No. 267-2
DATE OF REPORT: 4 October 1944
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the stowage adequacy, combat efficiency of the fighting compartment, and the general suitability of present modifications of the test Medium Tank M4A3
METHOD: The vehicle was completely stowed, and a detailed check was made of the adequacy of the stowage. After being stowed with 76mm ammunition, the vehicle was operated cross-country for 48 hours. Tests were made to determine the length of the time required to load the vehicle with full load of 76mm ammunition (71 rounds) and then unload it. Firing tests were conducted to determine the adequacy of the primary and secondary armament and related components. Radio and interphone equipment were checked for static interference and general suitability.
DESCRIPTION: The test Medium Tank M4A3 (76-mm) was a production vehicle incorporating the M4A3 hull and T23 type turret and characterized by a reinforced front end, a vision cupola, water stowage of ammunition, and loader's hatch.
CONCLUSIONS: The vehicle was considered generally satisfactory with respect to stowage, fighting compartment, combat efficiency, and general over-all suitability. However, certain deficiencies in stowage space and location were noted and recommendations were made for relocating or modifying those items found deficient or adding items to improve stowage conditions. Several modifications were recommended to increase combat efficiency. These modifications included such items as removing the partial floor under the tank gunner and commander's positions, re-positioning the power traverse lever and turret lock, reinforcing the elevating rack, and improving the vision blocks. (Complete lists of all recommended modifications were included in the report.)
GENERAL: This 24-page report contains nine photographs of the vehicle.

SUBJECT: Tanks (Combat) AB-293
TITLE: Final Report of Medium Tank, M4A4, with Chrysler Multi-Bank Engine
IDENTIFICATION: Final Report on Project No. 293
DATE OF REPORT: 16 December 1942
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the serviceability of Medium Tank M4A4 with a Chrysler Multi-bank engine
METHOD: Two engines were used in the vehicle. One failed at 917 miles. The second operated 1804 miles before test termination. The vehicle was operated in convoy with another tank under extremely dusty conditions for 24 hours.
DESCRIPTION: The test Medium Tank M4A4, Ordnance Serial No. 4872, was equipped with a Chrysler multi-bank engine. The original engine had five individual water pumps. The second one, a later model, had a single shaft-driven water pump. A modified, radial-thrust, clutch throw-out bearing with steel contact shoes was installed during the test.
CONCLUSIONS: The Chrysler multi-bank engine was considered unsatisfactory for medium tanks. Its discontinuance at the earliest possible date was recommended. The experimental, radial-thrust, clutch throw-out bearing was recommended for adoption both for future production and replacement in the field. The air cleaners were considered inadequate for dusty operation. Dust protection for engine and tank was generally inadequate.
GENERAL: This 32-page report includes 12 photographs of the tank and failed components.

SUBJECT: Tanks (Combat) AB-326-1
TITLE: Final Report on Test of Ten (10) Medium Tanks M4A6
IDENTIFICATION: Project No. 326-1
DATE OF REPORT: 23 September 1944
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the performance, economy, and durability characteristics of Medium Tank M4A6, with special emphasis on determining the suitability of RD 1820, 1820-X, 1820-N, and 1820-XN tank engines
METHOD: Thirteen Medium Tanks M4A6 with the different test engines were operated continuously over the endurance, cross-country courses until the engines failed.
DESCRIPTION: Medium Tank M4A6 was based on Medium Tank M4A4. It utilized the late production hull, incorporated recent modifications, and was altered to accommodate RD 1820 series engines. Engine RD 1820 was a 9-cylinder, radial, diesel engine based on Caterpiller engine D200A. It differed primarily from the D200A engine in that it had cast-steel, induction-hardened, electrolytically-etched cylinder barrels. The RD 1820-X was an improved RD 1820 engine. The improvement consisted of better cylinder electrolytic-etch penetration control and pistons with increased thrust-

load skirt area. The RD 1820-N and RD 1820-XN engines were modified RD 1820 and RD 1820-X engines respectively. This modification included the installation of a forged steel and nitrided cylinder barret in the No. 1 (master rod) position only.
CONCLUSIONS: The RD 1820-N and RD 1820-XN engines were the only ones considered satisfactory, although some modifications were recommended. Medium Tanks M4A6 exhibited better performance, economy and cruising range characteristics than any other standard tanks of the M4 series. An appreciably higher rate of failure was experienced with the one-piece power train assembly than with the older type three-piece power trains. Deficiencies in various engine accessories, clutch, and power train components were recommended for improvement.
GENERAL: This 115-page report includes 29 photographs of the M4A6 tanks and their components; an operations chart and a comparative hill-climbing chart were also included.

SUBJECT: Tanks (Combat) AB-367 (1)
TITLE: Test of Light Tank, T9E1
IDENTIFICATION: First Partial Report; Project No. 367
DATE OF REPORT: 28 September 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the general suitability of the Light Tank T9E1 as an airborne vehicle; adaptability to landing; gun and turret efficiency; suitability of stowage arrangements; and extent of crew safety and comfort
METHOD: Five T9E1 Light Tanks were operated on highways and cross-country terrain 24 hours a day for a total of 3932 miles. These operations included initial inspection, stowage check, flotation tests, and a comprehensive firing test.
DESCRIPTION: The vehicle, designed for airborne operations, weighed 15,000 pounds net, and was equipped with a Lycoming, 162-hp, air-cooled engine. It had a top speed of 40 mph on the highway and 20 mph cross-country. Armor ranged from 3/8 inch on the hull to one inch on the turret. Armament consisted of a 37mm gun and one cal. .30 machine gun coaxially mounted in the turret, which had 360° traverse.
CONCLUSIONS: The Light Tank T9E1 was not considered a satisfactory combat vehicle in the present stage of development due to inadequate reliability and durability. Performance in adverse terrain was unsatisfactory; the vehicle could not operate in heavy mud in first gear without stalling. Since the power-to-weight-ratio was superior to that of the Light Tank M5A1, it was concluded that the test vehicle was overgeared. This factor together with a 37-inch deep fording depth indicated that the vehicle could not be successfully used for landing purposes. Although the turret and gun could be operated efficiently, certain modifications were felt desirable and listed in the report. Modifications to improve crew comfort and safety as well, as stowage arrangements, were also included.
GENERAL: This 54-page report contains 30 photographs of the test vehicle and the condition of various components.

SUBJECT: Tanks (Combat) AB-367 (F)
TITLE: Test of Light Tank, T9E1
IDENTIFICATION: Final Report; Project No. 367
DATE OF REPORT: 31 January 1944
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the general suitability of the Light Tank T9E1 as an airborne vehicle; adaptability to landing; gun and turret efficiency; suitability of stowage arrangements; and extent of crew safety and comfort
METHOD: Five T9E1 Light Tanks were operated on highways and cross-country terrain for an approximate total of 4000 miles. This operation included initial inspection, stowage check, flotation test, and comprehensive firing tests.
DESCRIPTION: The vehicle, designed for airborne operations, weighed 15,000 pounds net and was equipped with a Lycoming, 162-hp, air-cooled engine. It had a top speed of 40 mph on the highway and 20 mph cross-country. Armor ranged from 3/8 inch on the hull to one inch on the turret. Armament consisted of a 37mm gun and one caliber .30 machine gun coaxially mounted in the turret, which had 360° traverse.
CONCLUSIONS: The Armored Board concluded that the Light Tank T9E1 was mechanically reliable up to 100 hours of operation, the minimum limit considered satisfactory. Certain modifications and improvements were deemed necessary before the test vehicle could be considered satisfactory for training or combat. A list of 28 recommended modifications, ranging from the incorporation of heavier sprockets to the replacement of the Airmaze air cleaners with a Vortox type, were included in the report. A list of eight modifications considered urgent included such items as a 20-tooth sprocket, turret head rest, and instrument panel labels. Particular emphasis was placed on the need for an increased final drive ratio.
GENERAL: This 36-page report contains 21 photographs showing the condition of various failed components. Deficiency and modifications lists are included as well as a maintenance record.

SUBJECT: Tanks (Combat) AB-378
TITLE: Final Report on Special Test of 40 Medium Tanks (10 Each M4A1, M4A2, M4A3, and M4A4)
IDENTIFICATION: Final Report on Project No. 378
DATE OF REPORT: 2 August 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine adequacy of Medium Tanks M4A1, M4A2, M4A3, and M4A4
METHOD: Forty medium tanks (10 each M4A1, M4A2, M4A3, and M4A4) were endurance tested by continuous operation over varied terrain
DESCRIPTION: Tanks tested were new, standard production vehicles of the M4 series. They incorporated all changes up to 15 March 1943.
CONCLUSIONS: The Ford GAA engine (recorded in the first report of Project 378) was recommended for acceptance for all tanks of the M4 series. The suspension system of the test M4 tanks was very unsatisfactory. The T48 rubber chevron track was the most satisfactory track tested; the T54E1 track

was unsatisfactory. The auxiliary generator and electrical system were unsatisfactory. It was recommended that these and other defective components listed in the report be corrected.
GENERAL: This 310-page report includes 95 photographs of the test components and performance curves, test tank description, and general discussions.

SUBJECT: Tanks (Combat) AB-383(F)
TITLE: Final Report, Test of Heavy Tanks, M6 and M6A1
IDENTIFICATION: Final Report; Project No. 383
DATE OF REPORT: 12 July 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the serviceability of Heavy Tanks, M6 and M6A1, for use by the Armored Force
METHOD: Two Heavy Tanks, M6 and M6A1, were operated 326 miles and 70:38 engine hours and 71 miles and 15:01 engine hours, respectively, over varied terrain.
DESCRIPTION: The M6 and M6A1 Heavy Tanks were manufactured by Baldwin Locomotive Works and Fisher Body Works, respectively, and were powered with Wright Cyclone G-200 engines. The test vehicles had horizontal volute spring suspension systems, and rubber-backed steel tracks.
CONCLUSIONS: The test tanks were not considered satisfactory because of inadequate and obsolete fire control equipment; insufficient ventilation for the fighting compartment; an unsatisfactory transmission; and poor positioning of controls, crew, and seats.
GENERAL: This 59-page report contains 29 photographs of the vehicles, and torque converter parts.

SUBJECT: Tanks (Combat) AB-417(1)
TITLE: First Partial Report on Medium Tank, T23
IDENTIFICATION: First Partial Report; Project No. 417
DATE OF REPORT: 1 July 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the over-all suitability of Medium Tank T23
METHOD: The vehicle was operated on a 24-hour per day basis for a total of 1587 miles (191:30 engine hours) over cross-country and highway courses.
DESCRIPTION: The test T23 Medium Tank was powered by a Ford GAN gasoline engine and equipped with an electric drive. It mounted a 75mm Gun M1, a coaxial .30 caliber machine gun, a .30 caliber bow machine gun, and a .30 caliber AA machine gun. The vehicle was designed by Ordnance to give increased armor protection, low silhouette, and increased speed and firepower over the Medium Tank M4.
CONCLUSIONS: The head room in the driver's compartment was very limited; only 25% of the Armed Force personnel could sit erect without helmets, and only 40% with helmets. Modifications were suggested to correct this deficiency. Many other deficiences were noted and corrections were suggested to improve engine parts and stowage equipment. (The list of deficiencies noted in the test numbered 53.)
GENERAL: This 65-page report contains one photograph showing the restricted dimension of hatchway; and appended are the redesign of tank parts, physical characteristics of the tank, and discussions of hatchways, vision devices, and structural limitations.

SUBJECT: Tanks (Combat) AB-417 (F)
TITLE: Final Report of Test of Medium Tank, T23 (Pilot Model)
IDENTIFICATION: Final Report on Project No. 417
DATE OF REPORT: 1 December 1943
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the overall suitability of Medium Tank, T23, for use by the Armored Command
METHOD: The vehicle was operated over cross-country and highway courses for a total of 3934 miles (352:58 hours).
DESCRIPTION: The test T23 Medium Tank was powered by a Ford GAN engine and incorporated an electric drive. It mounted a 76mm Gun M1, a coaxial .30 caliber machine gun, a .30 caliber bow machine gun, and a .30 caliber AA machine gun. The vehicle was designed by Ordnance to give increased armor protection, low silhouette, and increased speed and fire control over the M4 Medium Tank.
CONCLUSIONS: The tank was not recommended for production. Additional service testing was recommended to further ascertain the merits of the electric drive. (A list of the advantages and disadvantages of the electric drive is contained in the conclusions sections of the report.) Inadequate engine cooling, excessive ground pressures, and those deficiencies listed in the First Partial Report, Project No. 417, made further tank production undesirable.
GENERAL: This 69-page report contains 13 photographs of the test tank and damaged parts. Included also are comparative characteristics of the test tank and the M4 Tank.

SUBJECT: Tanks (Combat) AB-417-1 (1)
TITLE: Service Test of Ten Production Models, Medium Tank T23
IDENTIFICATION: First Partial Report; Project No. 417-1
DATE OF REPORT: 22 August 1944
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine the suitability of early production models of the Medium Tank, T23, for use by the Armored Command
METHOD: Five of the tanks were operated 24 hours per day and accumulated an average of 953 miles each during the testing.
DESCRIPTION: The Medium Tank, T23, was a 75,311-pound (loaded), gasoline-electric propelled vehicle with driving sprockets mounted in the rear. The welded hull was of a simple box-type construction. The cast turret mounted a caliber .30 machine

gun coaxially with the 76-mm, M1, gun. A caliber .50 AA machine gun was mounted on the loader's hatch ring, or stowed on the rear of the turret. A flexible caliber .30 machine gun was ball-mounted in the bow in front of the assistant driver. The T23 was powered with a Ford, GAN, engine governed at 2600 rpm. Maximum vehicle speed was 35 mph.
CONCLUSIONS: It was recommended that the Medium Tank, T23, be considered unsatisfactory because of numerous defects in the engine, fuel system, cooling group, electrical group, tracks, and suspension system. It was further recommended that all defects found during the test be corrected without delay.
GENERAL: This 64-page report contains 20 photographs showing over-all views of the tanks tested and the condition of failed components.

SUBJECT: Tanks (Combat) AB-417-1 (F)
TITLE: Service Test of Ten Production Models, Medium Tank T23
IDENTIFICATION: Final; Project No. 417-1
DATE OF REPORT: 4 November 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of five late production models of the Medium Tank T23 for use by the Armored Command
METHOD: The five test tanks were operated on a 24-hour a day basis for an average of 1271 miles each.
DESCRIPTION: The Medium Tank, T23, was a full track vehicle having a driving sprocket mounted in the rear. This tank was gasoline-electric propelled, with a maximum vehicle speed of 35 mph. The T23 tank was powered by a Ford GAN engine governed at 2600 rpm. The welded hull was of box-type construction.
CONCLUSIONS: The Medium Tank, T23, had certain advantageous features, but the defects noted and the modifications required to make the tank usable were sufficient to make the tanks tested unsatisfactory. It was recommended that the Medium Tank, T23, be considered usable only after all deficiencies were corrected and the numerous modifications suggested incorporated.
GENERAL: This 173-page report contains 29 photographs showing the tank and the condition of failed components.

SUBJECT: Tanks (Combat) AB-426(1)
TITLE: Test of Medium Tanks, M4A1
IDENTIFICATION: First Partial Report; Project No. 426
DATE OF REPORT: 25 September 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of several modifications on the M4A1 Medium Tank including a fuel tank venting kit
METHOD: Two tanks incorporating the modifications were each operated about 600 miles cross-country and on highways. All modifications were closely inspected for durability and suitability during and after tank operation.
DESCRIPTION: The modifications consisted of changes in the tanks' hatches, splash plates, drivers' controls, clutches, lighting systems, suspensions, power plants, gun mounts, sights, turret baskets, fire control systems, and numerous small components. The two M4A1 Medium Tanks on which the modifications were made were identified as Nos. W3036871 and W3036973.
CONCLUSIONS: The majority of the modifications and their installation on the M4 (series) Medium Tanks were considered satisfactory, although a large number of additional changes were believed necessary. It was recommended that the fuel tank venting kit tested be installed on all Medium Tank M4 series, in the field and in the intermediate tank depots.
GENERAL: This 48-page report contains 15 photographs showing the tank and various modifications.

SUBJECT: Tanks (Combat) AB-456
TITLE: Test of Medium Tank, M4E6
IDENTIFICATION: Project No. 456
DATE OF REPORT: 13 October 1943
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the effectiveness of turret, combination gun mount, gun telescope and ammunition rack modifications on the Medium Tank, M4E6, and to determine the operation and engine performance to be expected from the M4E6
METHOD: Extensive firing tests were conducted to determine the combat efficiency of the fighting compartment, the effectiveness of gun sighting equipment, whether the 76-mm ammunition racks were satisfactory and if empty shell cases were properly ejected. The accuracy of the gun, mount, and sighting equipment was established in firing conducted from 600 yards to 3500 yards. Comparative tests of cross-country mobility and slope-climbing ability were conducted in comparison with Medium Tanks, M4A3, M4E1, and M4A1 (C-4 Engine). Fuel and oil economy checks were made.
DESCRIPTION: The Medium Tank, M4E6, was a modified Medium Tank, M4A1, with the latest type M4 hull and front end, an early model T23 Turret, a T80 Combination Gun Mount, an M1 76-mm gun, a T92 Telescope and T82 Mount, and ammunition racks surrounded by water to minimize danger from fire.
CONCLUSIONS: The tests of the Medium Tank, M4E6, disclosed numerous deficiencies correctable by modifications which were recommended. The Medium Tank, M4E6, with the necessary modifications was recommended for immediate production and adoption for use in Armored Units in the Armored Command. It was further recommended that the Medium Tank, M4E6, with the recommended modifications be used in lieu of the Medium Tank, M4 Series, with the 75-mm gun, in those units where the additional anti-armor firepower of the 76-mm gun would be required.
GENERAL: This 45-page report contains six photographs of the interior and exterior views of the test tank.

SUBJECT: Tanks (Combat) AB-482-1
TITLE: Test of Light Tank M24, Serial No. 14
IDENTIFICATION: Final; Project No. 482-1
DATE OF REPORT: 30 December 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the durability, reliability, and field-worthiness of a production Light Tank M24
METHOD: The vehicle was operated for 309.5 engine hours (2526 miles), the majority consisting of operation over cross-country terrain. Firing tests were conducted.
DESCRIPTION: The Light Tank M24 was a low-silhouette vehicle powered by two Cadillac V-8 engines. Power train components included two hydramatic transmissions with four speeds, a transfer unit containing two forward and one reverse speed range, a controlled differential, and two final drives. The suspension system was of the torsion bar type. Primary armament consisted of a lightweight 75 mm Gun, M6 (with concentric recoil mechanism) mounted in a 360° traverse turret.
CONCLUSIONS: The Light Tank M24 was considered superior to all other light tanks used by armored units. The vehicle consistently out-performed both light and medium tanks during the test operation. Although the combat efficiency was considered satisfactory, it was felt that the incorporation of certain modifications would materially improve the efficiency. Many deficiencies were listed together with the recommended modifications. The bulk of maintenance time (47%) was devoted to the suspension system.
GENERAL: This 62-page report contains 22 photographs of the vehicle and various component failures.

SUBJECT: Tanks (Combat) AB-482 (1)
TITLE: Test of Light Tank T24 (Automotive Phase)
IDENTIFICATION: First Partial Report; Project No. 482
DATE OF REPORT: 11 April 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the mechanical reliability, over-all fighting efficiency, and ease of maintenance of the test vehicle
METHOD: The Light Tank T24, ballasted to full combat weight, was operated on highways for 138:40 engine hours, 2268 miles, and cross-country for 187:34 engine hours, 1729 miles. These operations included a hill climb test, grade ascending ability test, and firing tests of the anti-aircraft and bow machine guns.
DESCRIPTION: The test vehicle, Light Tank T24, was a low-silhouette, armored, full track-laying vehicle, powered by two Cadillac V-8 gasoline engines and employed Hydramatic transmissions. The suspension system was of the torsion bar type, and the primary armament consisted of a 75-mm gun mounted in the turret.
CONCLUSIONS: The design of the Light Tank T24 provided accessibility for, and ease of, servicing and maintenance superior to that of the Light Tank M5A1. Various deficiencies were noted and recommendations made for modifying the vehicle to eliminate the deficiencies. (Most of these modifications were incorporated in production.) With the incorporation of these modifications, the Light Tank T24 was considered superior in all respects to the Light Tank M5A1 and immediate conversion of light tank production to the T24 was recommended. NOTE: Since the 75-mm gun and mount were not available for the test, the over-all recommendations could not include these units.
GENERAL: This 48-page report contains 18 photographs of various failed components, two maintenance record graphs, and various test data. Comparative dimensions of the Light Tank M5A1 and Light Tank T24 are also included.

SUBJECT: Tanks (Combat) AB-482-2
TITLE: Test of Five (5) Production Model Light Tanks, M24
IDENTIFICATON: Final Report; Project No. 482-2
DATE OF REPORT: 17 February 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the durability, reliability, and general efficiency of production Light Tank M24
METHOD: Four vehicles were operated for a combined total of 1715:53 engine hours (13,457 miles), the majority of which was over cross-country terrain under simulated combat conditions. Firing tests were conducted and included accuracy firing tests of the 75 mm gun and .30 caliber coaxial machine gun, moving target tests, and durability firing of the 75 mm gun. Turret torque requirements, stowage facilities, and communication equipment were also studied and checked during the operation.
DESCRIPTION: The test Light Tank M24 was a low-silhouette vehicle powered by two Cadillac V-8 engines. The power train included two Hydramatic transmissions with four speeds, a transfer unit containing two forward and one reverse speed ranges, a controlled differential, and two final drives. The suspension was of the torsion bar type. Primary armament consisted of a lightweight 75 mm Gun M6 (with a concentric recoil mechanism) mounted in a 360° traverse turret.
CONCLUSIONS: The vehicle was considered combat-worthy and an improvement over all other types of light tanks used by armored units. Although the combat efficiency was considered satisfactory, there still was room for improvement. Recommended modifications for eliminating deficiencies included such items as increased engine horsepower, improved power train, decreased ground pressure, etc. Of all maintenance time required during the test, 47% of it was attributable to the suspension system.
GENERAL: This 79-page report contains 29 photographs of the vehicle and various component failures.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Tanks (Combat) AB 482 (F)
TITLE: Final Report, Test of Light Tank, T24 (Firing Phase)
IDENTIFICATION: Final Report; Project No. 482
DATE OF REPORT: 14 July 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the over-all fighting efficiency of the test vehicle
METHOD: Various tests were conducted to determine the suitability of the fighting compartment and the over-all fighting efficiency of the vehicle under simulated combat conditions. Routine accuracy firing tests were conducted to establish the accuracy characteristics of the gun and mount. Stowage was studied to determine the suitability of the stowage arrangement. Communication facilities were also checked.
DESCRIPTION: The test vehicle, Light Tank T24, was a low-silhouette, armored, full tracklaying vehicle, powered by two Cadillac V-8 gasoline engines and employed Hydramatic transmissions. The suspension system was of the torsion bar type. and the primary armament consisted of a 75-mm Gun, T13E1, in Gun Mount T90.
CONCLUSIONS: Test results indicated that the Light Tank T24 represented great advancement in tank design and should be standardized and placed in production immediately. Certain stowage deficiencies were listed together with recommendations for their elimination.
GENERAL: This 43-page report contains 20 photographs showing the condition and arrangement of various components.

SUBJECT: Tanks (Combat) AB-510
TITLE: Test of Medium Tank M4A3E8
IDENTIFICATION: Project No. 510
DATE OF REPORT: 14 July 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the efficiency and durability of the Medium Tank M4A3E8
METHOD: Five identical vehicles participated in the testing. Four were operated an average of 1818 miles over varied terrain while the fifth was used for firing tests.
DESCRIPTION: The test Medium Tank M4A3E8 was equipped with a horizontal volute spring suspension, horizontal hydraulic shock absorbers and 20-1/2x6-1/4-inch dual bogie wheels. Single pin, center guide, cast steel, Tracks T66 were used during most of the test. Later in the testing double pin, rubber backed, Tracks T90 were installed on two vehicles in an attempt to reduce vibration.
CONCLUSIONS: The test of the tanks was terminated because of total suspension failure at an average of 1818 miles. It was concluded that the vehicle was incapable of operating 4000 miles over cross-country terrain and under severe dust conditions. Serious vibrations that affected firing operations were encountered, and development of a new track to give better performance and less vibration was recommended. Development of an improved bogie wheel bearing grease seal was also recommended.
GENERAL: This 85-page report includes 29 photographs of the vehicles and components.

SUBJECT: Tanks (Combat) AB-545
TITLE: Test of Medium Tank, T25E1
IDENTIFICATION: Project No. 545
DATE OF REPORT: 17 March 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of the Medium Tank T25E1 for use in Armored Divisions or separate tank battalions
METHOD: Five pilot tanks were operated over varied terrain for a combined total of 4848 miles (696 engine hours). Complete stowage checks were performed on these vehicles, and simulated combat firing tests were conducted.
DESCRIPTION: The test Medium Tanks T25E1 were manufactured by the Fisher Tank Arsenal and were powered by Ford GAF, V-8, gasoline engines. The vehicles were equipped with a 90 mm gun, .50 and .30 caliber machine guns, torsion bar suspension, mechanical drum brakes, torqumatic transmission, and controlled differential.
CONCLUSIONS: The vehicle was not considered battle-worthy or worthy of further development, since the Heavy Tank T26E3 had all the advantages of the Medium Tank T25E1, plus advantages in armor protection and increased performance.
GENERAL: This 86-page report contains 24 photographs of the test vehicles and failed parts.

SUBJECT: Tanks (Combat) AB-546(1)
TITLE: Test of Heavy Tank, T26E1
IDENTIFICATION: First Partial Report; Project No. 546
DATE OF REPORT: 14 July 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of Heavy Tank T26E1 for use in armored divisions or separate tank battalions
METHOD: The test T26E1 tank was subjected to firing tests and a 514-mile endurance run over cross-country terrain.
DESCRIPTION: Heavy Tank, T26E1, weighed 87,350 pounds (gross) and was powered by a V-8 Ford GAF engine rated at 500 bhp at 2600 rpm. Power was transmitted by a torqumatic transmission. A torsion bar suspension system and single-pin, center-guide, steel tracks were used. A 90 mm gun was the primary weapon.
CONCLUSIONS: The T26E1 tank in its current condition was unsuitable for military use. It was recommended that the following modifications be incorporated as soon as possible to make the Heavy Tank T26E1 acceptable: a more rigid system of inspection control; a blast deflector and special propellant for the 90 mm gun ammunition; improved vulnerability characteristics for the air inlet and exhaust grilles, driver's hatches, turret race, and 90 mm gun port; improved turret ventilation; 90 mm ammunition, re-stowage of 70 rounds; and elimination of many defects of the turret, hull, power train, and suspension.

GENERAL: This 89-page report includes 39 photographs of the test tank and failed components.

SUBJECT: Tanks (Combat) AB 546 (F)
TITLE: Test of Heavy Tank, T26E1
IDENTIFICATION: Final Report; Project No. 546
DATE OF REPORT: 2 February 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of Heavy Tank T26E1 for use in armored divisions or separate tank battalions
METHOD: Three vehicles were tested. They were operated 2398, 2236, and 1577 miles, respectively, over cross-country terrain exclusively.
DESCRIPTION: Heavy Tank T26E1 weighed 87,350 pounds (gross). It was powered by a V-8, Ford GAF gasoline engine rated at 500 bhp at 2600 rpm. Power was transmitted by a torqumatic transmission. A torsion bar suspension system and single-pin, center-guide steel tracks were used. A 90 mm gun was the primary weapon.
CONCLUSIONS: The vehicles were considered unsuitable for military use. The following deficiencies were considered to be of major importance: inadequate cooling, mechanical unreliability, inadequate armor protection afforded by the gun shield, inadequate grousers and insufficient life of single-pin, Sheldrick bushed track, and unsatisfactory stowage of the SCR-508 radio. It was recommended that these defects be eliminated on the production T26E3 heavy tanks.
GENERAL: This 175-page report includes 14 photographs of failed components.

SUBJECT: Tanks (Combat) AB 546-4
TITLE: Final Report on Test of Two Heavy Tanks M26
IDENTIFICATION: Project No. 546-4
DATE OF REPORT: 24 September 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of the Heavy Tank, M26, for combat use
METHOD: Two M26 Heavy Tanks were operated over varied terrain for a total of 4063 miles, 663 engine hours. Each vehicle operated approximately one-half of the total mileage. Special component tests were conducted throughout the operation.
DESCRIPTION: The heavy tank, M26, was powered by a Ford GAF engine and weighed, completely stowed, 92,355 pounds. Armor thickness ranged from 1/2 inch (rear floor plate) to four inches (upper glacis plate). Primary armament consisted of a 90-mm gun with muzzle brake. A .30 cal. coaxial machine gun, .50 cal. anti-aircraft, and .30 cal. BAR machine gun comprised the secondary armament. One vehicle was equipped with heavy torsion bars, hydraulic bump stops, and heavy duty bearings on No. 1 road wheels and idlers. The other vehicle was equipped with test rubber chevron tracks, T84E1, and later with a set of T80E1 tracks with a grouser of 1-1/16 inch additional height.
CONCLUSIONS: The heavy tank, M26, was considered suitable for combat use. However, maintenance was excessive on the production T80E1 track and on the cooling system. To correct this condition, it was recommended that: an agressive grouser be considered for the T81 single pin track, modified to use octagonal pins and bushings in lieu of the present round pins and serrated steel bushings; and that the use of a tapered roller bearing, adjustable by means of shims between the front road wheel arm spindle outer bearing retainer and hull, be considered. (The present outer bearing, straight roller type, could not withstand end thrust.) It was also recommended that a press fit, threaded steel sleeve be installed in the aluminum shroud to prevent dowel loosening, that wire-braid-reinforced transmission oil cooler hoses with screw fittings be considered, and that a study be conducted with a view to redesigning the fan shroud to improve bushing life.
GENERAL: This 38-page report contains 11 pages of photographs showing the condition of various failed components. A maintenance record, a list of defects corrected, and test details are also included.

SUBJECT: Tanks (Combat) AB-563
TITLE: Test of Medium Tank M4A3W
IDENTIFICATION: Project No. 563
DATE OF REPORT: 7 October 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the combat efficiency of the fighting compartment and stowage adequacy of a modified M4A3 Medium Tank
METHOD: The vehicle was completely stowed, and tests were conducted to determine the efficiency of ammunition stowage. Gun dispersion at various ranges was determined by firing, and simulated combat firing at ranges from 400 to 2000 yards was conducted.
DESCRIPTION: The test modified M4A3 Medium Tank was manufactured by the Ford Motor Company and powered with a Ford, V-8, 60°, gasoline engine. The modifications were: a vision cupola, a loader's hatch, reinforced front armor, and water-protected ammunition stowage.
CONCLUSIONS: The vehicle was considered generally satisfactory. Modification to improve the combat efficiency and stowage adequacy was recommended.
GENERAL: This 56-page report contains 27 photographs of the vehicle and stowage methods, and interferences.

SUBJECT: Tanks (Combat) AB-581
TITLE: Final Report on Test of Medium Tank M4A3E2
IDENTIFICATION: Project No. 581
DATE OF REPORT: 29 December 1944
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the performance, maneuverability, flotation, and general suitability of a Medium Tank M4A3E2
METHOD: The vehicle was service-operated 78

engine hours (580 miles) over varied terrain. Firing tests for dispersion of both the 75 mm Gun M3 and the coaxial caliber .30 machine gun were performed. Simulated combat firing of all armament was conducted.
DESCRIPTION: The vehicle was a standard Medium Tank M4A3E2, except that 1-1/2-inches of armor were added to the front slope plate and sides of the hull above the sponsons, and the turret and power train housing were of different type castings.
CONCLUSIONS: The tank was considered satisfactory with certain limitations: inadequate armor protection on the hull sides; maximum reverse speed of only 2.9 mph; an inadequate suspension system; and excessive ground pressures. Corrective action was recommended.
GENERAL: This 50-page report contains 18 photographs of the vehicle and failed transmission parts.

SUBJECT: Tanks (Combat) AB-595
TITLE: Final Report of Test of Medium Tank T25
IDENTIFICATION: Project No. 595
DATE OF REPORT: 14 August 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of the Medium Tank T25
METHOD: The vehicle was operated over highways and various cross-country terrain for 1936 miles (277 engine hours). A new engine was installed after 172 hours (1294 miles). Firing and other tests were conducted under simulated battle conditions.
DESCRIPTION: The test Medium Tank T25 weighed 81,500 pounds, unstowed, and mounted a 90 mm gun in a 360° traverse T25E1 Turret (with a test ammunition stowage arrangement). A horizontal volute suspension was used with a 23-inch T80 Track. The T25 also incorporated a T23 hull, power train without modification, a Ford GAN gasoline engine, and electric drive.
CONCLUSIONS: The vehicle was not considered suitable. It was felt that there was no need for the T25 since the Heavy Tank M26 was superior in the following respects: (1) more reliable control, (2) more heavily armored, (3) more durable and smoother riding with respect to the suspension, and (4) easier to repair and service. It was recommended that no further consideration be given the T25.
GENERAL: This 12-page report contains five photographs of the vehicle, a deficiency-modification list, and a characteristics sheet.

SUBJECT: Tanks (Combat) AB-625
TITLE: Final Report on Test of Medium Tank, M4 with 76-mm Gun (WET)
IDENTIFICATION: Project No. 625
DATE OF REPORT: 19 March 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine the suitability of a modified M4 Medium Tank
METHOD: Simulated combat firing tests were performed to determine the effect of removing the turret basket. A stowage study was made of the items affected by removal of the turret basket. Final drives with reduction ratios of 3:36 to 1 and 2:84 to 1 were operated for 690 miles (114 engine hours) and 312 miles (49 engine hours), respectively.
DESCRIPTION: The test vehicle was a M4 Medium Tank with water-protected ammunition stowage. The turret basket was eliminated. A final drive of 3:36 to 1 gear reduction was installed in place of the 2:84 to 1, although the latter was operated for comparison. The transmission was modified to enable the tank to use all five normally forward speeds in reverse operation. The bow machine gun was connected to the vision periscope by a parallelogram linkage. The vehicle was manufactured by Pullman Std. Mfg. Co., and was powered by a Continental R975 engine.
CONCLUSIONS: The M4 Medium Tanks with water-protected ammunition racks, less the turret basket, were considered superior to those tanks equipped with turret baskets. This change was recommended for production. The high-speed-reverse transmission was considered superior to the standard. The 3:36 to 1 gear reduction was considered superior to the 2:84 to 1 reduction except for the M4A3 Medium Tank. The parallelogram periscope linkage between the cal. .30 bow machine gun and the gunner's periscope was considered essential. Corrective action was recommended for the numerous deficiencies appended in the report.
GENERAL: This 48-page report contains 18 photographs of the test tank, the turret, ammunition racks, the transmission, and periscope linkage.

SUBJECT: Tanks (Combat) AB-636
TITLE: Final Report on Comparative Test of Heavy Tank, T26 and Heavy Tank, T26E1
IDENTIFICATION: Project No. 636
DATE OF REPORT: 28 September 1945
ORIGIN: The Armored Board, Fort Knox, Kentucky
PURPOSE: To determine which was more suitable, the Heavy Tank, T26, with electric transmission, or the Heavy Tank, T26E1, with torqumatic transmission
METHOD: The Heavy Tank, T26, was operated on a one shift, eight hours per day basis during the test. Operation was over highways and cross-country under all types of weather conditions. The Heavy Tank, T26, was operated in conjunction with the Heavy Tank, T26E1, and its later model, Heavy Tank, T26E3, in practically all tests.
DESCRIPTION: The Heavy Tank, T26, was a full track-laying armored vehicle, weighing 99,200 pounds, equipped with a 90 mm gun having a caliber .30 machine gun mounted coaxially with it in the turret. The suspension system was of the individually sprung torsion bar type with a 24-inch center guided track. The vehicle was powered by a 500-horsepower, V, 8-cylinder engine, driving through an electric transmission. Vehicle

carried a five man crew. The Heavy Tank, T26E1, was the same tank except that it utilized a torqumatic transmission and weighed 87,350 pounds.
CONCLUSIONS: The Heavy Tank, T26, as tested, was considered unsatisfactory for use in combat. The fast forward and reverse speeds, quick acceleration and maneuverability of the Heavy Tank, T26, over normal terrain, were superior to that of the Heavy Tanks, T26E1, or T26E3, but the control of the T26 on steep grades (45% and up) was inferior to that of the T26E1 or T26E3. The electric drive in the T26 tested was considered inferior to the T26E1 torqumatic transmission, being too complicated for the average mechanic to understand, while an excessive amount of maintenance was necessary to keep it functioning. It was recommended that no further consideration be given the electric transmission as tested. However, further research was suggested to develop an electric power train of simple, reliable, positive control, and light-weight design.
GENERAL: This 23-page report contains 15 photographs of the tanks and of failed and worn parts.

SUBJECT: Tanks (Combat) AFF 1131
TITLE: Ease of Maintenance Test of Light Tank M24
IDENTIFICATION: Project No. 1131
DATE OF REPORT: 13 January 1948
ORIGIN: Army Field Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine the ease of maintenance of Light Tank M24
METHOD: Time and tool studies were made with tools and equipment authorized for field maintenance units. Selected maintenance operations consisted of removal, installation, and adjustment of the following major assemblies: radiator, engine, transmission, transfer unit, controlled differential, track, final drive, track support roller, shock absorber, suspension arm cushion stop, road wheel, bearings and seals, torsion bar, suspension arm, compensating wheel, compensating arm, and lever. The test of each major assembly was divided into the following phases: time, tools, and crew studies according to procedure and sequence prescribed in TM 9-729; revised procedure; and preparation and testing of such experimental modifications as local facilities permitted.
DESCRIPTION: The Light Tank M24 was a low silhouette, full-tracked, armored vehicle, equipped with twin Cadillac engines, and weighed 40,090 pounds. Suspension system was of the torsion bar type. Primary armament consisted of a 75 mm Gun M6 and Mount M64.
CONCLUSIONS: For the assemblies tested, revision of technical manual procedure was warranted in the replacement of the following items: radiators, engines, transmissions, transfer units, tracks, and final drives. Tank redesign was recommended to reduce man-hours required to replace the transfer unit. A crew of two men was the most economical for removal and installation of the assemblies tested. Use of two power plants was undesirable because of increased maintenance and service requirements and the necessity of using a transfer unit. Specific deficiencies found in the various components were listed together with recommended modifications for incorporation in the event the Light Tank M24 was again produced in quantity.
GENERAL: This 170-page report contains eight photographs showing tanks and suggested modifications, and two drawings.

SUBJECT: Tanks (Combat) AFF 1287
TITLE: Desert Operation of Medium Tank, M26
IDENTIFICATION: Project No. 1287
DATE OF REPORT: 23 June 1948
ORIGIN: Army Field Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine whether the Medium Tank M26 was suitable for operation under desert conditions
METHOD: Three M26 Medium Tanks were operated and tested under typical desert conditions in an average ambient temperature of 107°F.
DESCRIPTION: The standard Medium Tank, M26, was powered by a Ford GAA engine and weighed 92,000 pounds loaded. Its main armament was a 90mm gun mounted in a 360° traverse turret.
CONCLUSIONS: The Medium Tank M26 was considered suitable for operation under desert (hot-dry) conditions. Crew maintenance time, principally in the engine compartment, was increased due to excessive dust accumulations. It was recommended that modification be made to eliminate this dust condition in any future production or remanufactured M26 Medium Tanks.
GENERAL: This 49-page report contains 10 photographs, 14 graph sheets, and five pages of tabulated data.

SUBJECT: Tanks (Combat) AFF 1316
TITLE: Test of Air Transportability of Medium Tank, M26
IDENTIFICATION: Project No. 1316
DATE OF REPORT: 2 May 1949
ORIGIN: Army Field Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine the requirements for disassembly, loading, unloading, and reassembly of the Medium Tank, M26, for transport in heavy, cargo-type aircraft (detachable cargo compartment)
METHOD: Seven references (catalogs, reports, letters) pertaining to different phases of the subject were studied. A Medium Tank (M26) was disassembled, and the components crated, weighed and measured. A mock-up of the detachable cargo compartment was made. Loading of the practical grouping of assemblies was accomplished. Preliminary requirements of the proposed aircraft were worked out. Future conferences on the subject were arranged.
DESCRIPTION: A standard Medium Tank (M26) was used. The mock-up of the detachable cargo compartment, with essential inside dimensions, was evidently constructed of light material.
CONCLUSIONS: The most practical number of

loads was two. One load consisted of the power unit and cooling unit assembly, turret assembly, engine compartment doors and tracks. The other load consisted of the balance of the tank intact. These two loads weighed 37,921 pounds and 48,504 pounds. Replacement of the turret and gun assembly required hoisting facilities capable of handling ten tons with precise control. Further studies and conferences were recommended.
GENERAL: This 34-page report contains three photographs showing the detachable cargo compartment mock-up, empty and loaded. This material is mostly details from which preliminary descriptions and conclusions were drawn.

SUBJECT: Tanks (Combat) AFF 1324
TITLE: Automotive Test of Heavy Tanks, T29 and T30
IDENTIFICATION: First Partial Report; Project No. 1324
DATE OF REPORT: 28 June 1948
ORIGIN: Army Field Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To determine the automotive suitability, durability and maintenance requirements of Heavy Tanks T29 and T30
METHOD: Two vehicles were inspected, proof-fired, and combat stowed. Both vehicles were then operated over highways and cross-country for a total of 171 miles for the Heavy Tank T29, and 95 miles for the Heavy Tank T30. Special tests to determine hill climbing ability, cross-country speed, and mobility in deep mud were also conducted. In the special performance tests a Medium Tank M26 was operated in conjunction with the heavy tanks for comparison purposes.
DESCRIPTION: The Heavy Tank T29 weighed approximately 70 tons, mounted a 105 mm gun T5E2 as primary armament, and was powered by a Ford, 12-cylinder, liquid-cooled, V-type engine, Model GAC, directly connected to a CD-850-1 cross-drive transmission. The Heavy Tank T30 weighed approximately 70 tons, mounted a 155 mm Gun T7 as primary armament, and was powered by a Continental, 12-cylinder, air-cooled, V-type engine, Model AV-1790-3, directly connected to a CD-850-1 cross-drive transmission.
CONCLUSIONS: Heavy Tanks T29 and T30 were considered automotively unsatisfactory for military use due to excessive overheating of the transmissions. Modification or redesign of the CD-850-1 cross-drive transmission was recommended to correct this condition.
GENERAL: This 30-page report contains 18 photographs of the vehicles.

SUBJECT: Tanks (Combat) AFF 1327
TITLE: Ease of Maintenance Tests of Tanks, Heavy T29 and T30
IDENTIFICATION: First Partial Report of Project No. 1327
DATE OF REPORT: 25 June 1948
ORIGIN: Army Field Forces Board No. 2, at Fort Knox, Kentucky
PURPOSE: To evaluate the design features which affect maintenance, and to submit recommendations for changes in design or modifications which will simplify and speed up field maintenance operations
METHOD: Detailed data on sequence, time, tools, and crew requirements were omitted and emphasis was placed on deficiencies observed during maintenance of the vehicles during the automotive test (AFF Board No. 2, Project No. 1324). Maintenance performed was limited to that required through necessity and during normal check periods. Greatest attention was devoted to the engine compartment, and little to other components of the vehicle.
DESCRIPTION: The Heavy Tank, T29, weighed approximately 70 tons, and was powered by a Ford, 12-cylinder, liquid-cooled, V-type engine, Model GAC, directly connected to a CD-850 cross-drive transmission. The Heavy Tank, T30, weighed approximately 70 tons, and was powered by a Continental, AV 1790-3, 12-cylinder, V-type, air-cooled engine directly connected to a CD-850 cross-drive transmission. Both vehicles employed torsion bar suspension, and center guide tracks.
CONCLUSIONS: Ease of maintenance features were not incorporated in the vehicle to the extent desired. Further study of the assemblies and sub-assemblies was recommended to achieve ease of removal and installation of the main power plant, auxiliary engine, and track and suspension system. Modifications suggested were recommended for consideration in further development and/or manufacture of the Heavy Tanks, T29 and T30.
GENERAL: This 26-page report contains 10 photographs of maintenance deficiencies and other features of the test vehicle.

SUBJECT: Tanks (Combat) AFF 1327(F)
TITLE: Ease of Maintenance Test of Heavy Tanks, T29 and T30
IDENTIFICATION: Final Report on Project No. 1327
DATE OF REPORT: 17 February 1950
ORIGIN: Army Field Forces Board No. 2, Fort Knox, Kentucky
PURPOSE: To evaluate the design features which affect maintenance and to submit recommendations for changes in design or modifications which would simplify and speed up field maintenance operations
METHOD: Ease of maintenance studies of the top armor, main power plant, and auxiliary engine were made. Time, crew, and tool studies were limited to one trial. A brief study was made to determine the extent to which the track and suspension tools of the Medium Tank, M26, could be used on the test vehicles.
DESCRIPTION: The Heavy Tanks, T29 and T30, were similar with the exception of engines and armament. Each tank weighed approximately 70 tons, and employed a cross-drive transmission, torsion bar suspension, and center-guide tracks. The Heavy Tank, T29, was powered with a 770 gross horsepower, V-12 Ford, Model GAC, liquid-cooled, gasoline engine, and was armed with the 105-mm gun, T5E2. The Heavy Tank, T30, was powered with an 810 gross horsepower, V-12, Continental, Model AV 1790-3, air-cooled, gasoline

engine and was armed with the 155-mm gun, T7.
CONCLUSIONS: Although desirable design features were built into the Heavy Tanks, T29 and T30, it was recommended that both tanks be considered unsatisfactory from an ease of maintenance viewpoint. The replacement of the main power plant and auxiliary engine in the Heavy Tank, T30, was considerably more difficult than in the Heavy Tank, T29. It was recommended that deficiencies and modifications, listed in Appendix C of the report, be incorporated in the proposed designs of Medium Tank, T42, and Heavy Tank, T43.
GENERAL: This 95-page report contains 26 pages of photographs showing desirable and undesirable features of the test vehicles.

SUBJECT: Tanks (Combat) AFF 1413
TITLE: Automotive Test of Medium Tank, T40
IDENTIFICATION: Project No. 1413
DATE OF REPORT: 27 June 1950
ORIGIN: Army Field Forces Board No. 2 at Fort Knox, Kentucky
PURPOSE: To determine the reliability, suitability, and maintenance requirements of the Medium Tank, T40
METHOD: Four Medium Tanks, T40, were subjected to automotive service tests. The vehicles were given a technical inspection and loaded to a combat weight of 96,000 pounds. They were operated, primarily, cross-country for a total of 3805 miles. Special hill-climbing, maximum sustained speed, and shallow fording-ability tests were also conducted.
DESCRIPTION: The Medium Tank, T40, weighed approximately 48 tons, and was powered by a Continental, 12-cylinder, 810-horsepower, air-cooled, V-type engine, Model AV-1790-3, directly connected to a CD-850-2 cross-drive transmission. It mounted a modified 90mm Gun, M3, as primary armament.
CONCLUSIONS: The Medium Tank, T40, was considered automotively unsatisfactory for military use due to lack of mechanical reliability, inadequacy of steering control, and excessive maintenance requirements. Critical investigation was recommended to determine methods of eliminating the deficiencies encountered during the automotive test. It was further recommended that the vehicle, incorporating all suggested modifications, be thoroughly tested to determine its suitability for military use.
GENERAL: This 122-page report contains 78 photographs of the test vehicles and various component failures and deficiencies.

SUBJECT: Tanks (Combat) AMRL 44
TITLE: Physiological and Operational Characteristics of M24 Tank
IDENTIFICATION: Final Report; Project No. 44
DATE OF REPORT: 8 November 1944
ORIGIN: Armored Medical Research Laboratory, Fort Knox, Kentucky
PURPOSE: To determine the physiological and operating characteristics of the M24 Tank
METHOD: Standard gun fume tests were conducted with the ventilation system varied in operation as regularly provided for in the tank. In addition, tests were conducted with an auxiliary fan of 1000 cfm installed in the bow. The over-all limits of close-in ground vision from the various crew positions were determined and put into diagram form. Studies were also made of the adequacy of fire control, hatchways, seats, lighting, and engine and gun controls.
DESCRIPTION: The test vehicle was an M24 Tank. (No further description was included in the report.)
CONCLUSIONS: The two major deficiencies found were the hazard of drawing heater air from the engine compartment for crew compartment winter heating, and the lack of provision for installation of an M10 periscope in the fire control arrangement. It was recommended that these deficiencies be corrected without interrupting the production of the vehicle. Improvement of the vision cupola and driver's vision was recommended; however, it was emphasized that vision should not be improved at the expense of armor protection. Deficiencies were also found in the hatch locks and recommendations made for this correction.
GENERAL: This 13-page report contains two vision limit diagrams and a page of tabulated fume test data.

SUBJECT: Tanks (Combat) AMRL 45(1)
TITLE: Physiological and Operational Characteristics of T26E3 Tank
IDENTIFICATION: First Partial Report; Project No. 45
DATE OF REPORT: 28 February 1945
ORIGIN: Armored Medical Research Laboratory, Fort Knox, Kentucky
PURPOSE: To determine the physiological and operational characteristics of the T26E3 Tanks
METHOD: The test vehicle was operated and checked with respect to the suitability of fire control, seating, hatchways, vision, and ventilation. The latter item included gun fume tests.
DESCRIPTION: The test vehicle was a T26E3 Tank. (No other description available in the report.)
CONCLUSIONS: Test results indicated that the following essential changes and improvements were necessary: (1) improve and replace as much of the elevating mechanism as necessary to secure easy and positive control; (2) improve performance of traverse mechanism to reduce lost motion, over-run, and slip in the manual traverse control and to eliminate excessive lost motion in the power traverse control; (3) change hull casting to permit field installation of 1000 cfm fan and provide better ventilation and fume control. Changes of lesser importance, a total of 45, were also recommended for incorporation as swiftly as possible in accordance with production schedules.
GENERAL: This 14-page report contains tabulated fume test data and is not illustrated.

SUBJECT: Tanks (Combat) APG 2-24-3
TITLE: Determination of Drawbar, Fuel Consumption, Tractive Resistance, Acceleration, and

Slope Operation Characteristics of Modified Medium Tank M4A2, U.S. Reg. No. 30119820
IDENTIFICATION: Project No. 2-24-3; APG 44-75
DATE OF REPORT: 14 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance and operating characteristics of the Medium Tank, M4A2
METHOD: Data were obtained by standard methods while the test vehicle was operated on dry, level concrete.
DESCRIPTION: Test Medium Tank, M4A2, No. 30119820, weighed 69,200 pounds and was powered by an experimental General Motors V-8, two-cycle, diesel engine rated at 575 bhp at 1800 rpm and 1240 lbs.-ft. at 1050 rpm. The engine drove through a standard Medium Tank M4 transmission and power train. This tank was equipped with T51 non-reversible flat rubber block tracks.
CONCLUSIONS: The test vehicle had a maximum drawbar horsepower of 259.6 at 8.1 mph in second gear. The tractive resistance was 73 lbs. per ton at a speed of 16 mph. Acceleration in 5th gear from five to 28 mph took 20 seconds. Specific fuel consumption ranged from 0.531 to 0.676 pounds per drawbar horsepower hour in second gear between 2.5-6.5 mph road speeds. The vehicle negotiated 30, 40, and 50 percent slopes in second gear and 60 percent slope in first gear.
GENERAL: This 25-page report includes seven pages of performance curves and 12 pages of test data.

SUBJECT: Tanks (Combat) APG 3-2-25
TITLE: Drawbar Pull, Drawbar Horsepower, Tractive Resistance, Braking, Acceleration, and Deceleration Characteristics of Medium Tank M4E8 No. 059
IDENTIFICATION: Project No. 3-2-25; APG 44-78
DATE OF REPORT: 28 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the Medium Tank, M4E8
METHOD: Data were obtained by standard methods while the test vehicle was operated on dry, level concrete.
DESCRIPTION: Test Medium Tank, M4E8, No. 059, weighed 75,500 pounds and was powered by a Ford, GAA, 90° V-8 engine rated at 500 bhp at 2600 rpm and 1050 lbs.-ft. torque at 2200 rpm. The engine drove through a standard synchromesh transmission with five speeds forward and one reverse. Medium Tank, M4E8, was equipped with a T66 center guide track, dual bogie wheels, and a horizontal volute spring suspension.
CONCLUSIONS: The tractive resistance was 92 pounds per ton at a road speed of 16 mph. A maximum drawbar horsepower of 290 was developed in second gear at 5.9 mph. An average of 41 feet was required to bring the vehicle to rest from a road speed of 20 mph with full application of the steering brakes. Forty-eight seconds were required to accelerate from eight to 27.5 mph in fifth gear. Thirty seconds were required to decelerate from 27.5 to 3.25 mph.
GENERAL: This 18-page report includes five pages of performance curves and nine pages of test data.

SUBJECT: Tanks (Combat) APG 3-20-1
TITLE: Medium Tank M3A2 #1040 Welded Hull (Baldwin)
IDENTIFICATION: Project No. 3-20-1; APG 10-70
DATE OF REPORT: 19 May 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of welding of the hull of the Medium Tank M3
METHOD: A Medium Tank M3 with a welded hull instead of a riveted one, was operated a total of 425 miles, of which 111 miles were on paved road and 314 miles in the Hopkins Area. Inspection of all welds was made before and after operation, and angular measurements were taken at the welds.
DESCRIPTION: The test vehicle was a Medium Tank M3 with hull of welded armor plate instead of riveted plate. The hull was fabricated by the Baldwin Locomotive Works.
CONCLUSIONS: Maximum difference in angular measurement before and after operation was 2°. It was recommended that the welded hull be accepted and that production be initiated by the Baldwin Locomotive Works.
GENERAL: This 22-page report contains eight photographs of the Medium Tank M3 and three sheets of sketches showing angular measurements.

SUBJECT: Tanks (Combat) APG 3-25-4-1
TITLE: Tractive Resistance, Drawbar, Acceleration, and Slope Performance Characteristics of Medium Tank M4A3E3 No. 600
IDENTIFICATION: Project No. 3-25-4-1; APG 45-31
DATE OF REPORT: 17 March 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of Medium Tank, M4A3E3
METHOD: Tractive resistance was measured with an M6 Field Dynamometer at towed speeds between 3.0 and 17.5 mph. For fuel consumption and drawbar tests, four power absorption trailers were hitched to the tank through the dynamometer and towed in 1st, 2nd, and 3rd gears at speeds varying from 1.7 to 29.6 mph. All tests were made on dry, level concrete, or on slopes.
DESCRIPTION: The test Medium Tank, M4A3E3, weighed 69,515 pounds, was powered with a Ford, GAA, V-8, liquid-cooled engine, and was equipped with a General Motors, Model 900T, Torqumatic transmission. It was equipped with T48, 16-1/2-inch, rubber chevron tracks.
CONCLUSIONS: Tractive resistance varied from 73 pounds per ton at 3.5 mph to 113.0 pounds per ton at 17.5 mph. Maximum drawbar pull in first gear was 40,000 pounds at 1.7 mph, 22,340 pounds in second gear (2.2 mph) and 11,400 pounds in third gear (3.8 mph). Stall pull (0.0 mph) was 51,000 pounds in first gear, 22,200 pounds in second gear and 10,200 pounds in third gear. Fuel consumption

in pounds per drawbar horsepower-hour bore an inverse relationship to drawbar horsepower developed. In 1st gear, the vehicle speed for best engine efficiency was 8 mph; for 2nd gear, about 7 mph; for 3rd gear, 14 mph. Fuel consumption rates per db/hp were maximum, for 1st, 2nd and 3rd gears, at about 2 mph and at the highest recorded speed for each gear. Acceleration time from rest to a maximum of 30.0 mph was 118 seconds in 3rd gear at full throttle. Maximum possible sustained speeds on 15%, 20%, and 30% grades were found highest in 1st gear. For 20% and 30% slopes, 3rd gear was found impractical.
GENERAL: This 17-page report contains eight pages of tabulated data and four detailed graphs of drawbar pull, acceleration characteristics, tractive resistance, and fuel consumption.

SUBJECT: Tanks (Combat) APG 3-43-1
TITLE: Determination of Drawbar, Fuel Consumption, Tractive Resistance, Acceleration, and Braking Characteristics of Medium Tank T26E1 #2
IDENTIFICATION: Report No. 44-59 (Project No. 3-43-1)
DATE OF REPORT: 17 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance and operating characteristics of the test tank
METHOD: Test data were obtained by standard methods while the test vehicle was operated on dry, level concrete.
DESCRIPTION: Test vehicle Medium Tank T26E1 #2 weighed 84,700 pounds. It was powered by a Ford GAF 90° V-8 cylinder engine rated at 500 bhp at 2600 rpm and 1050 lbs.-ft. torque at 2200 rpm. The engine drove through a torque converter and a three-speed manually operated gear transmission. The tracks were cast steel with center guide, single pin, rubber bushed blocks 24-inches wide.
CONCLUSIONS: The maximum tractive resistance was 77.2 pounds per ton at a road speed of 16 mph. The specific fuel consumption ranged from approximately 0.95 to 3.8 pounds per drawbar-horsepower hour in second gear between 2 and 19 mph. Acceleration through the three gears to the maximum speed of 27.5 mph took 64 seconds. The average stopping distance at a road speed of 20 mph with full brake application was 53 feet.
GENERAL: This 20-page report includes seven pages of performance curves and ten pages of test data.

SUBJECT: Tanks (Combat) APG 34-20
TITLE: Winter Tests 1951-1952 Arctic Test Branch, AFF, Big Delta, Alaska
IDENTIFICATION: APG 34-20
DATE OF REPORT: May 1952
ORIGIN: Arctic Test Branch, Big Delta, Alaska
PURPOSE: To test certain materiel under extreme weather conditions of the Arctic interior
METHOD: Three trucks were operated an average of 2000 miles, loaded to maximum capacity, and towed loads up to 9000 pounds. Two tanks were operated an average of 420 miles under simulated field conditions. Three other tanks were tested for short distances. An amphibious vehicle was run 1200 miles and towed loads up to 7000 pounds. Mortars, recoilless weapons, and rocket launchers were also field-tested.
DESCRIPTION: Materiel tested was: 2 1/2-ton, 6x6 Truck M34; 76mm Gun Tank T41E1; 90mm Gun Tank M47; Amphibious Cargo Carrier T46E1; 4.2-inch mortar in Mount M24; 57, 75, and 105mm recoilless rifles; 3.5-inch and 4.5-inch rocket launchers; and M1 Rifles.
CONCLUSIONS: The tanks T41E1 and M47 were considered unsatisfactory, and the Amphibious Cargo Carrier T46E1 and Truck M34 were considered highly satisfactory for Arctic operation. Use of mortars under Arctic conditions was unsatisfactory. It was recommended that a redesigned trigger for the M1 Rifle, and redesigned fuzes be furnished for Arctic operation; and consideration be given to a set of Arctic range tables for all weapons.
GENERAL: This 65-page report contains 10 photographs showing maps of the test site, failed engine parts, and frozen gear parts of turret traversing mechanism.

SUBJECT: Tanks (Combat) APG 42-36A
TITLE: Determination of Drawbar Pull, Drawbar Horsepower, Acceleration, and Stopping Distance of Medium Tank M3A3 No. 28 (GM Twin Diesel) Equipped with Step-up Gear Ratio of 1.37 to 1.0 and Chrysler Long Lever Steering Mechanism
IDENTIFICATION: APG 42-36A
DATE OF REPORT: 20 February 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance characteristics of the Medium Tank, M3A3
METHOD: Drawbar pull and horsepower were determined by towing a Dynamometer, M5. The vehicle was operated at 100% throttle, and the engine speed was controlled by the towed load connected through a hydraulic drawbar. Acceleration characteristics were determined by starting the test vehicle in third gear, and shifting through fourth gear into fifth gear to maximum speed. Acceleration was measured by a Time-Distance Recorder. To determine stopping distance, road speed was stabilized at 30 mph, the vehicle was shifted to neutral, the brakes were applied, and distance-to-stop measured with a pousometer driven by a fifth wheel. Two to seven runs were completed on concrete for each type test.
DESCRIPTION: The test vehicle was a Medium Tank, M3A3, with General Motors Twin Diesel engines. It was tested with three different step-up gear ratios: 1.194:1, 1.37:1, and 1.69:1.
CONCLUSIONS: A maximum of 306 dbhp was developed in second gear at 2080 rpm with a step-up ratio of 1.371 to 1. This compared with 300 dbhp at 2000 rpm with the 1.194 step-up gear ratio, and 285 dbhp at 1800 rpm with the 1.69 ratio. Acceleration to 30.5 mph required 30 seconds with 1.690:1 and 1.371:1 gear ratios. With the 1.194:1 gear ratio, acceleration was slower. A distance of 39.0 feet was required to stop from a speed of 30 mph.

TANK AUTOMOTIVE TEST RESUMES

GENERAL: This 21-page report contains four graphs of test results; two photographs of copper-lead main bearing after 299:51 engine hours; and a resume of suspension failures on a Medium Tank, M3A5.

SUBJECT: Tanks (Combat) APG 44-62
TITLE: Determination of Tractive Resistance, Drawbar, Acceleration, and Braking Characteristics of the Medium Tank T25E1 #6
IDENTIFICATION: APG 44-62
DATE OF REPORT: 13 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance characteristics of the Medium Tank, T25E1
METHOD: Data were obtained by standard methods while the test vehicle was operated on dry, level concrete.
DESCRIPTION: The test Medium Tank, T26E1, #6 weighed 75,300 pounds and was powered by a Ford, GAF, 90°, V-8 engine rated at 500 bhp at 2600 rpm and 1050 lbs.-ft. torque at 2200 rpm. The torqumatic transmission consisted of a torque converter and two sets of planetary gears which gave three speeds forward and one reverse. The 19-inch tracks employed cast steel, center-guide, single-pin blocks.
CONCLUSIONS: Maximum drawbar horsepower in second gear was 255 at a road speed of 8.0 mph. The tractive resistance was 74 pounds per ton at a speed of 16 mph. Acceleration through the three gears to the maximum speed of 34.5 mph took 64 seconds. The average stopping distance at a road speed of 20 mph with full-brake application was 57 feet.
GENERAL: This 22-page report includes six pages of performance curves.

SUBJECT: Tanks (Combat) APG 5014/2-22/1
TITLE: Field Engineering Tests of Light Tank T24E1, No. 1
IDENTIFICATION: Project No. 5014/2-22-1; APG 44-124
DATE OF REPORT: 31 January 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the Light Tank, T24E1, and to compare them with Light Tank M24, and 76mm Gun Motor Carriage, T70
METHOD: Drawbar pull and fuel consumption were obtained simultaneously by towing the field dynamometer and three power absorption tractors and using a metered quantity of fuel. Tractive resistance was obtained by towing a field dynamometer at speeds of three to 23 mph. Maximum speed was determined by use of a trailing fifth wheel and an electric speedometer. Acceleration rates were determined by starting the vehicle from rest with full throttle and accelerating until the governor operation occurred. Deceleration rates were determined by operating at maximum speed placing the transmission in neutral, and decelerating to zero, without using the brake. Braking distances were determined by measuring the distance to stop the vehicle by application of the steering brakes.
DESCRIPTION: The test Light Tank, T24E1, No. 1, had a Continental R975-C4, 9-cylinder, radial engine which developed 395 bhp at 2600 rpm and had a maximum torque of 944 lbs.-ft., at 1800 rpm. The power train consisted of a Spicer automatic torque converter transmission with three-speed ranges.
CONCLUSIONS: The drawbar pull was from 17,000 pounds at five mph in low range to 2900 pounds at 21.6 mph in high range. The test vehicle averaged 33% more drawbar pull than the Light Tank, M24, and 20% more than the Gun Motor Carriage, T70. Specific fuel consumption varied from 1.057 lbs. per bhp at 5.1 mph to 1.9 lbs. at 10.1 mph in low range. In high range the rates were 2.587 lbs. per bhp at 1.9 mph to 1.62 lbs. at 20.5 mph. Maximun speed was 45 mph as compared to 36.3 mph for the Light Tank, M24, and 50.6 mph for the Gun Motor Carriage, T70. Acceleration rates from 0 to 34 mph were 27.2 seconds, as compared to 36.4 for the M24 and 24.8 for the T70. A distance of 40.5 feet was required to stop the vehicle from 20 mph, and a distance of 172 feet was required from 30 mph.
GENERAL: The bulk of this 29-page report consists of data sheets and graphs of the test results.

SUBJECT: Tanks (Combat) APG 5136/1P
TITLE: First Partial Report on Combat Car T2
IDENTIFICATION: Ordnance Program No. 5136; APG 11-0
DATE OF REPORT: 16 February 1932
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and suitability of Combat Car T2
METHOD: The vehicle was operated cross-country and on hard surfaced roads, with and without tracks, and at various speeds.
DESCRIPTION: The convertible Combat Car T2 was designed to operate on wheels on hard roads, or with removable track over the wheels to operate as a track-laying vehicle. It was powered by a Continental A-70, radial, 7-cylinder, air-cooled, gasoline engine. Armament consisted of a cal. .50 and a cal. .30 machine gun, mounted in a revolving turret, and a cal. .30 antiaircraft machine gun. The vehicle carried a crew of three men.
CONCLUSIONS: The tests resulted in 34 conclusions pertaining to mechanical durability and performance. It was recommended that ground clearance be increased, front idlers be reinstalled to decrease ground pressure, steering wheel be raised, a more powerful engine be installed, and additional tests be conducted.
GENERAL: This 45-page report includes five photographs of the vehicle and three engineering drawings.

SUBJECT: Tanks (Combat) APG 5136/2P
TITLE: Second Partial Report on Combat Car T2
IDENTIFICATION: Ordnance Program No. 5136; APG 11-00
DATE OF REPORT: 10 May 1932
ORIGIN: Aberdeen Proving Ground, Maryland

PURPOSE: To determine vehicle performance and suitability with water-cooled engine as compared with an air-cooled engine
METHOD: The vehicle was operated 81 miles on wheels and 12 miles on tracks.
DESCRIPTION: For this test the convertible Combat Car T2 carried the same description as that given in report APG 11-0, except that a water-cooled engine replaced the air-cooled.
CONCLUSIONS: This brief test tended to show the performance of the vehicle equipped with the water-cooled engine was practically identical to that with the air-cooled engine. It was recommended that a new engine be installed with adequate torque characteristics and 50% more power; that a new transmission be installed of a weight in keeping with the rest of the vehicle; that steering be manually controlled; and that efforts be made to make the engine accessible for adjustments and repairs by use of hand plates in sides and bottom of hull.
GENERAL: This 32-page report includes eight photographs of the vehicle and failed parts, and three sheets of engineering drawings.

SUBJECT: Tanks (Combat) APG 5136/4
TITLE: Third Partial Report on Combat Car T2E1
IDENTIFICATION: Fourth Report on Ordnance Program 5136
DATE OF REPORT: 30 November 1932
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of combat car T2E1 for military use
METHOD: The combat car was operated approximately 2000 miles using wheels or tracks over highways and cross-country courses.
DESCRIPTION: Combat car T2E1 was unique in that it operated on both wheels and tracks. The tracks were installed over the wheels for cross-country and were removed for improved road operation. The power plant was a Continental R-670, static radial air-cooled engine, rated at 210 horsepower at 2000 rpm. The running gear consisted of six load-carrying wheels, two drive sprockets each for track and wheel operation in rear. The two front wheels were mounted on steering knuckles on individually suspended arms, sprung to the frame by a transverse spring. The four rear wheels were sprung by eight semielliptic springs, four to each side mounted on pivot brackets on the hull. Two springs on each side were mounted outside the wheels and two between the wheels and the hull. The combat car incorporated several modifications in the hull and in the running gear.
CONCLUSIONS: Due to numerous deficiencies covering almost the entire vehicle, and because of the vehicle's unique design, it was recommended that testing be discontinued and that the combat car be placed in the museum.
GENERAL: This 68-page report includes 14 photographs showing the T2E1 combat car and several component failures.

SUBJECT: Tanks (Combat) APG 5234
TITLE: Combat Car T4
IDENTIFICATION: Ordnance Program No. 5234; APG 11-1
DATE OF REPORT: 1934
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To summarize development and testing of the T4 Combat Car
METHOD: A summary of the development process was prepared showing the factors contributing to the major design decisions. All test data and related correspondence were compiled under the First, Second, and Third Partial Reports on Ordnance No. 5234, which are bound with this summary.
DESCRIPTION: The T4 Combat Car was a convertible light tank, capable of operating with or without tracks. It was similar to the T3 Medium and T1 Light Tanks (Christie). The Christie suspension system was employed, using four large, rubber-tired independently-suspended road wheels on each side. Coil springs were employed because the pneumatic-hydraulic struts originally specified for the vehicle were not yet available. For road operation, the tracks were stowed on the fenders, the front wheels were steered, the intermediate road wheels were raised and the rear road wheels were clutched to the final drive, making the tank, in effect, a 4x2 wheeled vehicle. A Continental 7-cylinder radial engine of 264 hp, 4-speed constant-mesh transmission, and controlled differential final drive were combined into a unit power package.
CONCLUSIONS: The T4 Combat Car was considered a generally satisfactory vehicle. Deficiencies were corrected throughout the development program, and the design evolved into what was considered the first truly reliable tank.
GENERAL: This 466-page report contains 125 photographs illustrating the design, operation, and parts failures of the test vehicle. This summary covers reports APG 2434/1 (which is not available), APG 2434/2 (APG 11-2), and APG 2434/3 (APG 11-2A).

SUBJECT: Tanks (Combat) APG 5234/2P
TITLE: Second Partial Report on Test of Combat Car T4
IDENTIFICATION: Ordnance Program No. 5234; APG 11-2
DATE OF REPORT: 7 May 1934
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive and military suitability of the combat car T4 pilot model
METHOD: During the period covered by this report, 1726 miles of operation were accumulated, in addition to 1549 miles covered under the first partial report. This operation included service testing at Fort Knox, concerned largely with cross-country mobility, and overland operation between APG and Fort Knox. Various experimental components were studied and mock-ups of stowage facilities and the radio installation were prepared.
DESCRIPTION: The T4 Combat Car was a convertible light tank, capable of operation with or without tracks. For road operation the tracks were stowed on the fenders above the road wheels and the intermediate road wheels were lifted. The

rear road wheels are clutched into the final drive and the front wheels were provided with a conventional automotive steering system. The suspension was of the Christie independent type, coil sprung in the test vehicle although pneumatic-hydraulic struts were called for in the specifications and were to be installed when procured. A unit power package was employed, comprising a 264-hp, 7-cylinder Continental radial engine, a 4-speed constant-mesh transmission, and a controlled differential.
CONCLUSIONS: The experimental features of the T4 Combat Car, including the independent suspension, the convertible feature, the unit power package, and sloping of armor, were considered desirable for incorporation into all future vehicles. Numerous mechanical modifications were recommended, as well as testing of various experimental features and components not included in the pilot vehicle.
GENERAL: This 91-page report contains 23 photographs of the various components of the test vehicle.

SUBJECT: Tanks (Combat) APG 5234/3P
TITLE: Third Partial Report on the Test of the Combat Car T4
IDENTIFICATION: Ordnance Program No. 5234; APG 11-2A
DATE OF REPORT: 17 October 1934
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive and military suitability of the pilot model Combat Car T4
METHOD: This report covers operation, on maneuvers with the Cavalry at Fort Riley, Kansas, for 1100 miles, of which 550 were accumulated on a strategic run, (on wheels). The test vehicle was then shipped to Rock Island Arsenal where numerous modifications were made, followed by a 407-mile track test. After this the vehicle was operated an additional 471 miles at APG.
DESCRIPTION: The T4 Combat Car was a convertible light tank capable of operation as a full-tracked or wheeled vehicle. It employed a Christie-type independent suspension (with coil springs in the test vehicle although pneumatic-hydraulic struts were to be installed when available). Provisions were made for steering the front road wheels, driving the rear wheels, raising the intermediate wheels, and stowing the tracks for highway operation. A unit power package was employed comprising a 264-hp, 7-cylinder, Continental radial engine, a four-speed constant-mesh transmission and a controlled differential final drive.
CONCLUSIONS: Performance of the vehicle was generally satisfactory but numerous mechanical modifications were recommended. It was further recommended that a 325-hp Wright Whirlwind engine be installed and tested, as the low-speed torque characteristic of the Continental engine was inadequate.
GENERAL: This 121-page report contains 11 photographs illustrating the construction and interior arrangement of the test vehicle. Also included are 10 drawings of modified components.

SUBJECT: Tanks (Combat) APG 5235/3
TITLE: First Partial Report on Test of Light Tank T3
IDENTIFICATION: Third Report on Ordnance Program No. 5235; APG 10-5
DATE OF REPORT: 24 June 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether Light Tank T3 fulfilled the specifications of O.C.M. Item 11864
METHOD: The vehicle was operated 1016 miles at Rock Island Arsenal and 1727 miles at Aberdeen Proving Ground. Drawbar pull, acceleration, fuel consumption, resistance to traction, and firing tests were made.
DESCRIPTION: The test Light Tank T3 was a 7080-lb., full track-laying vehicle powered by a Ford, liquid-cooled, gasoline engine rated 83 bhp at 3800 rpm. The vehicle was equipped with a four-speed, selective sliding transmission, and a single plate clutch. Primary armament consisted of a .30 cal. machine gun mounted in a ball turret.
CONCLUSIONS: The vehicle fulfilled the general requirements specified by O.C.M. Item 11864. Advantages of the test vehicle, compared to other tanks were: light construction, making it cheaper to build; low silhouette, offering a small target to the enemy; and the commercial engine and transmission, which were easily procurable. The main disadvantage was a lack of fire power and limited field of fire. Because of slippage occurring in the rubber torsion suspension, it was recommended that a softer rubber be used.
GENERAL: This 374-page report contains 28 photographs of the vehicle and component parts damaged in operation.

SUBJECT: Tanks (Combat) APG 5251/1
TITLE: First Partial Report on Test of Light Tank T2
IDENTIFICATION: Ordnance Program No. 5251; APG 10-000
DATE OF REPORT: 29 May 1934
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the operating characteristics of the Light Tank T2
METHOD: The vehicle was operated for 60 miles over miscellaneous proving ground terrain.
DESCRIPTION: The test Light Tank T2 was powered by a Continental R-670, radial, gasoline engine rated 264 bhp at 2400 rpm, and weighed 12,705 pounds. It was equipped with a mechanical, five-speed, transmission and armed with two cal. .30 and one cal. .50 machine guns. The armor plate hull of this non-convertible vehicle formed the body and frame. Its hull and power plant were identical with those of Combat Car T5 except for heavier armor.
CONCLUSIONS: Specific conclusions and recommendations were not made because of limited testing. Generally, operation was unimpressive, cooling was inadequate, power train components were not readily accessible, and the bogies were not strong enough.
GENERAL: This 33-page report includes 14 photographs of the vehicle and its components.

SUBJECT: Tanks (Combat) APG 5251/1P
TITLE: First Partial Report on Test of Light Tank T2
IDENTIFICATION: First Partial Report on Ordnance Program No. 5251
DATE OF REPORT: 29 May 1934
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine engineering and performance characteristics of the test vehicle
METHOD: A new engine shrouding was installed on the vehicle and a preliminary inspection was made. Testing included operations over the demonstration course, over the bridging device, through shell holes, over a 31-inch vertical wall, and on the cross-country loop. The tank was tested in standard low and high wire entanglements. Thermocouple equipment was installed, and an attempt was made to take temperature readings under high engine load. Test operations were suspended due to the destruction of two track roller tires. The test vehicle was operated a total of 60 miles.
DESCRIPTION: The full track-laying vehicle was manufactured by the Rock Island Arsenal and weighed 12,705 pounds unloaded. The armor plate hull and power plant were similar to that of combat car T5 and the rubber jointed track was identical to that of combat car T4. A Continental R-670, 7-cylinder, radial, air-cooled, gasoline engine developing 264 hp at 2400 rpm was used. Double leaf spring suspension, as in tank T1E6, and controlled differential steering were used.
CONCLUSIONS: Due to limited testing operations, no recommendations were made. The tank was considered mechanically unreliable; major installations of the power train were inaccessible for servicing and maintenance, and the bogie was too weak for ordinary use. The use of rubber joints in high speed tracks was found questionable, and it was felt that further study of the engine cooling system was needed.
GENERAL: This 36-page report contains 18 photographs of the test vehicle and components parts.

SUBJECT: Tanks (Combat) APG 5251/2
TITLE: First Partial Report on the Test of Light Tank T2E1
IDENTIFICATION: Second Report on Ordnance Program No. 5251; APG 10-0
DATE OF REPORT: 30 January 1935
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics and durability of Light Tank T2E1
METHOD: The vehicle was operated for a total of 3808 miles, primarily over good roads. Tests were made as directed in T.S.T.P. 1931-627.
DESCRIPTION: The test Light Tank T2E1 was powered by a Continental R-670, 7-cylinder, radial, air-cooled, gasoline engine rated 264 bhp at 2400 rpm. It was equipped with vertical volute spring suspension and rubber block T16 Tracks. Armament included two cal. .30 and one cal. .50 machine guns.
CONCLUSIONS: The vehicle was generally satisfactory. However, numerous deficiencies and their recommended modifications were included in this report.
GENERAL: This 152-page report includes 47 photographs of the tank and its components.

SUBJECT: Tanks (Combat) APG 5251/4
TITLE: Third Partial Report on the Test of the Pilot Light Tank T2E1
IDENTIFICATION: Fourth Report on Ordnance Program No. 5251; APG 10-1
DATE OF REPORT: 30 March 1936
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the T2E1 vehicle
METHOD: The vehicle was tested in accordance with TSTP 1935-709 and accumulated 7729 miles of test operation.
DESCRIPTION: The test Light Tank T2E1 was equipped successively with three Continental R670 engines, a rebuilt Continental, and finally with a Wright Whirlwind. A Timken D305-16 Transmission was substituted for the original unit during the test. Suspension was the double articulating lever type with volute springs and incorporating two bogie units on each side. Rubber block and rubber-bushed T16 Tracks were used. Other tested components included an experimental Stromberg NAR6 Carburetor, Perfection T85 Air Washer, and steel tracks. The tank had soft steel armor plate and mounted one cal. .50 and two cal. .30 machine guns.
CONCLUSIONS: Mobility of the vehicle was satisfactory. The Continental engine was satisfactory and indicated a life expectancy of 4000 miles. Performance was better with the Wright due to automatic rocker arm lubrication and automatic spark control. The Stromberg carburetor and Perfection air washer proved efficient. The original transmission and differential presented cooling difficulties. A more satisfactory performance was experienced with the Timken transmission. Engine braking was ineffective, and test of asbestos-type lining in the controlled differential indicated the need for improvement. Rubber tires failed due to peening of the metal rims by the track guides. Steel-tired bogie wheels were more reliable, but shortened the life of the rubber blocked track. It was recommended that a production Light Tank T2E1 incorporating suggested modifications and a Young transmission cooler be completely tested under TSTP 1935-709.
GENERAL: This 270-page report includes 71 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) APG 5251/5
TITLE: Fourth Partial and Final Report on the Test of the Pilot Light Tank T2E1
IDENTIFICATION: Fifth Report on Ordnance Program No. 5251; APG 10-2
DATE OF REPORT: 6 August 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the T2E1 tank
METHOD: The Wright and Continental engines were operated for 756 hours in the test tank. The Timken transmission was used for 10,000 miles of operation and the Millman clutch plates for 255

hours. Asbestos and Scandinavia N1L brake linings and Wellman bimetallic brake bands were tested for a total of 8275 miles. Five sets of suspension system guides and gudgeons were subjected to varying load increases, and sprocket idlers replaced rubber idlers after 2359 miles.
DESCRIPTION: There were no major changes in design of the test pilot vehicle, from the standard production Light Tank T2E1, although gross weight had been increased to 19,000 pounds and the volute springs redesigned accordingly. The vehicle incorporated Timken transmission, double articulating volute spring and lever-type suspension, and Rubber-Block, Rubber-Bushed Tracks T16. The test engines were supplied by Wright and Continental.
CONCLUSIONS: The Wright engine gave more satisfactory performance, although it was considered that the Continental engine could be improved with automatic lubrication of the rocker arms and a more satisfactory priming system. The Timken transmission was satisfactory. The grooved Wellman brake linings were satisfactory for about 1670 miles, and the Scandinavia N1L lining gave better service than the regular Scandinavia lining. The Wellman bimetallic clutch plates were satisfactory after 255 hours of operation. The .010-inch undersized bogie gudgeon showed less wear than keyed gudgeons, but the sprocket idler was not as satisfactory as the rubber-tired or steel idler. The Eclipse direct electric starter permitted faster starting. Goodyear tires proved superior to Firestone tires, and the T16 tracks were satisfactory.
GENERAL: This 295-page report includes 28 photographs and test data.

SUBJECT: Tanks (Combat) APG 5251/9
TITLE: Fourth Partial and Final Report on the Test of the Pilot Light Tank T2E1
IDENTIFICATION: Ninth Report on Ordnance Program No. 5251
DATE OF REPORT: 6 August 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate numerous interchangeable components for the light tank T2E1
METHOD: The complete pilot vehicle and component parts were inspected and tested. Interchangeable units and components covering almost the entire vehicle were installed during various stages of the test and inspected on removal. Observations of performance characteristics of all components were recorded.
DESCRIPTION: The pilot tank T2E1 was a full track-laying vehicle with a double-articulating volute spring and lever-type suspension, rubber block track T16, and a gross weight of 19,400 pounds. Continental engines No. 753, No. 740, No. 820, and Wright Whirlwind engine No. 14225 and various power train components were tested. Suspension and track components were interchanged and compared, and Goodyear and Firestone production tires and Wellman bimetallic brake linings were also tested.
CONCLUSIONS: Numerous conclusions and recommendations were contained in the report. The vehicle unit ground pressure was too high. Continental engine life expectancy was 300 hours. The Wright engine performance was considered very satisfactory, and the Eclipse direct electric starter performance was better than the inertia starter. After 10,000 miles of operation, the Timken transmission and differential unit were considered satisfactory. The suspension springs installed during the latter part of the test were satisfactory. After 2754 miles, the special Goodyear tires were in excellent condition and the T16E1 track was most satisfactory. It was recommended that engine modifications include: automatic rocker arm lubrication for all engines, better priming system for cold starting, protection covers for clutch openings, and accelerator pump. It was also recommended that Wellman bimetallic clutch plates and grooved brake linings be further tested.
GENERAL: This 295-page report includes 27 photographs of the test components; also included are characteristic sheets and performance curves.

SUBJECT: Tanks (Combat) APG 5298/63
TITLE: First and Final Report on a Study of the Turning Characteristics and Steering Mechanisms of Track-Laying Vehicles
IDENTIFICATION: Sixty-third Report on Ordnance Program No. 5298: APG 21-49
DATE OF REPORT: 30 September 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To present the theory involved in:

1. Torque and power requirements for turning a track-laying vehicle
2. Steering studies of Heavy Tanks, T1E1; Medium Tanks, M3; British Infantry Tanks, Churchill, Mark IV; and Light Tanks, M-3
3. Steering mechanisms of track-laying vehicles
4. The moment of resistance to turning of track-laying vehicles
5. Horsepower losses in steering brakes of a controlled differential

METHOD: A comprehensive study of various phases of track-laying vehicle turning and steering was conducted. Eight separate reports, briefed below, were made and combined as one report. The information was obtained from various sources, particularly from "The Steering Mechanisms of High Speed Track-Laying Vehicles, with Special Attention Being Given to Their Application in Tank or Combat Car Design," by J.M. Colby.
DESCRIPTION: A brief summary is included for each sub-topic of this report:
Torque and Power Requirements for Turning a Tracklayer
The basic theory presented by Colby is reviewed, further developed, and discussed here. It is shown that the theoretical limit to turning of a tracklayer is reached when the ratio of the length of track on the ground to the tread of the vehicle, l/t, is equal to two (2) units. The effect of $\underline{l}$ and $\underline{t}$, and the frictional coefficients of the tracks on the ground in both a lateral and a longitudinal direction, upon the torque and power required to turn a tracklayer, is shown in report equations. In addition, the effect of rolling resistance, diameter, and speed of turn

upon torque and power requirements are covered.

Steering Study, Heavy Tank T1E1

The gas-electric propelled Heavy Tank T1E1 is selected as a source of field dynamometer data on steering characteristics. Particularly friction coefficients f and f^o, longitudinal and lateral to the track length, are calculated for steel tracks on concrete. Mean values of f = 0.21 and f^o = 0.17 with a relationship f^o/f = 0.81 are obtained. This f^o/f ratio of less than unity explains why this tank with an 1/t ratio of 2.06 is still able to turn, in view of the more exact limit to steering where $1/t = 2\ f/f^o$. The extremely low friction coefficients for steel on concrete result in a relatively low rotational power loss in steering this tank.

Steering Study, Medium Tank M3

Calculations are presented showing the gear torques in the controlled differential of the Medium Tank M3 as a function of the lateral friction coefficient f^o. It is shown that the high friction coefficient of rubber tracks on concrete (approximately 0.7) prevents Medium Tanks M3 from maintaining a steady turn in any gear above third.

Steering Study, British Infantry Tank, Churchill Mark IV

Experimental and calculated data on the steering characteristics of the Merritt-Brown gearbox in the subject tank, are presented. Calculations show the required drive torques of Medium Tanks M3 to be almost twice as great as those for Light Tanks M3, which weigh approximately one-half as much as Medium Tanks M3 (60,000 pounds gross to 28,000 pounds gross). By comparison, Churchill Tanks Mark IV, weight 78,000 pounds, need brake and output shaft torques roughly equivalent to those for our Light Tanks M3, and a much lower ring gear torque. The size of the Merritt-Brown transmission and steering system, although considerably more efficient than ours, is only as large as the power train of the Light Tank M3, including transmission, differential and final drives. This economy in size and weight in the British design, is achieved by a logical combination of the change-speed and steering mechanisms, as well as by the use of a high (7.1:1) final drive reduction to keep the torques low until power reaches sprockets.

Steering Study, Light Tank M3

This study parallels the calculations on the Medium Tank M3.

Steering Mechanisms

Equations are developed relating the external variables involved in a tank traversing a curved path to torques that the steering mechanisms must supply. Five mechanical types of steering mechanisms, Merritt-Brown, Clutch-Epicyclic, Controlled Differential, Clutch Brake and Standard Differential, are analyzed. The order of merit of these units, from a functional viewpoint, is in the descending order listed above. In addition, schematic layouts for electrical and hydraulic transmission and steering systems are presented.

Moment of Resistance to Turning of Track-laying Vehicles

A critical anaylsis is made here of all factors affecting the magnitude of the moment of resisting the turning of a track-laying vehicle. The approximation for the turning arm, 1/4, in the equation $Mr = Wf^o 1/4$ is shown to be not more than 4% in error of the exact mathematical solution for the Medium Tank M3. Also, certain friction coefficient data are presented, and an experimental program for measuring the static moment of resistance is proposed as a practical solution for the problem.

Horsepower Losses in the Steering Brakes of a Controlled Differential

Drawing upon equations and data developed in preceding portions of this report, power losses in the controlled differential for turns at other than the minimum steering ratio are calculated for Light and Medium Tanks M3. A chart of horsepower loss in the controlled differential of the Medium Tank M3, as a function of ground friction coefficient, speed and diameter of turn, is presented. It is shown hypothetically, that for a Medium Tank M3 to execute a turn at 20 mph on the vehicle centerline, a 422-horsepower engine would be required. With the controlled differential, 168 horsepower, or nearly 40%, would be lost in the slipping brake.

CONCLUSIONS: Closer attention to external variables, such as track length to vehicle tread ratio (1/4), shoe design and composition as affecting power required to turn a tracklayer, would result in improved and more efficient vehicle performance.

A ratio of effective lateral to longitudinal friction coefficients less than unity ($f^\circ/f - 1$) has been demonstrated with limited data. As a corollary to $f^\circ/f - 1$, the theoretical limit to the steering ability of tracklayers is at a 1/t ratio greater than the two (2). The more exact limit is $1/t = 2\ f/f^\circ$.

Gear torques in the Merritt-Brown gearbox of the Churchill Tank Mark IV were remarkably low in comparison to Light and Medium Tanks M3. This gearbox represented a notable advance in the design of a transmission and steering mechanism for a track laying vehicle.

It was recommended that: (1) a program be instituted to determine effective longitudinal and lateral friction coefficients for various track compositions and designs on different ground surfaces and at various vehicle speeds, (2) the Merritt-Brown gearbox be installed and tested on a tank horsepower/weight equivalent to U.S. Ordnance practice, (3) an existing experimental program (Rep. No. T61905.1, 3-23-42) on the effect of varying the 1/t ratio in Medium Tanks be continued and expedited, (4) the U.S. Ordnance controlled differential be studied for operating improvements.

GENERAL: This 78-page report contains pertinent equations, their derivations, and some applications. Also, associated schematic diagrams, tabulated data and graphs, are included.

SUBJECT: Tanks (Combat) APG 5312/2
TITLE: First Partial and Final Report on Test of Production Units for Medium Tank T4 in Combat Car T4E2
IDENTIFICATION: Second Report on Ordnance Program No. 5312; APG 10-6
DATE OF REPORT: 7 September 1937

TANK AUTOMOTIVE TEST RESUMES

ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of various components for use on Medium Tank T4
METHOD: A Combat Car, T4E2, was used for testing components to be employed on Medium Tank, M4. The test vehicle was operated over all types of terrain while weighing 22,200 and 26,400 pounds for 443 and 1157 miles, respectively. Specific observations were made with reference to the engine and power train. Upon receipt of a pilot model Medium Tank, T4, tests on the combat car were discontinued.
DESCRIPTION: The test vehicle, manufactured by Rock Island Arsenal, was modified to alternately employ wheels and tracks. It was equipped with the following Medium Tank T4, test components: a Continental R-670, seven-cylinder, radial, air-cooled gasoline engine rated 250 bhp at 2400 rpm; and a power train employing a constant mesh transmission, a two-plate, dry clutch, a controlled differential, and a herringbone final drive. Test vehicle weight, to correspond with the Medium Tank, T4, was 26,400 lbs.
CONCLUSIONS: The test engine (except for its shroud) and power train (when modified) were considered satisfactory. Provisions for cooling the transmission and differential lubricants were inadequate. Additional cooler capacity was to be used on test of Medium Tank T4.
GENERAL: This 103-page report contains 17 photographs of failed components of the test vehicle and photographs of failed components of the Medium Tank, T4, (which was apparently tested at a later date).

SUBJECT: Tanks (Combat) APG 5326/1
TITLE: First Partial Report on the Test of the Medium Tank T4
IDENTIFICATION: First Report on Ordnance Program No. 5326; APG 10-7
DATE OF REPORT: 17 September 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Medium Tank T4 and to determine whether it met general requirements as specified by the Technical Staff
METHOD: Tests were conducted to determine the center of gravity, limits of vision, lubricant requirements, maximum and minimum speeds, braking characteristics, and cooling characteristics. The vehicle was operated for 753 miles prior to a 14-hour run.
DESCRIPTION: The test Medium Tank T4 was a convertible (wheel or track operation) 13-ton vehicle mounting one cal. .50 and two cal. .30 machine guns. The 350-hp, Continental, radial, air-cooled, engine, together with the clutch, transmission and controlled differential could be removed as a unit. The vehicle had eight individually suspended wheels on which could be mounted steel tracks for track-laying operation.
CONCLUSIONS: The tank operated satisfactorily in general. However, many minor modifications were recommended.
GENERAL: This 206-page report includes 26 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) APG 5327/1
TITLE: First Partial Report and Addendum Number 1 on the Combat Car M1
IDENTIFICATION: First Partial and Addendum Report on Program No. 5327; APG 11-3-11-3 (1)
DATE OF REPORT: 29 July 1937 and 20 May 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Combat Car M1
METHOD: For the first test the vehicle accumulated 677 miles of operation over various terrain. Physical characteristics were measured and dynamometer tests run. The second test covered load distribution, ground pressure, acceleration, speed, braking distances, drawbar pull, tractive resistance, fuel consumption, and cooling performance.
DESCRIPTION: The Combat Car M1 was developed from, and was very similar to, Light Tank T2. It was powered by a Continental Series 670, radial, 7-cylinder, 250-hp, gasoline engine. The power train, manufactured by the Wisconsin Axle Company, incorporated a Spicer five-speed transmission and a Cletrac controlled differential. Changes made since the first report were not described.
CONCLUSIONS: The vehicle was generally satisfactory although the engine was considered inadequate in low-speed torque. No recommendations were made.
GENERAL: The first report of 129 pages contains 10 photographs of the vehicles and component failures. The addendum report of 58 pages is illustrated only with laboratory curve sheets.

SUBJECT: Tanks (Combat) APG 5327/2
TITLE: First and Final Report on the Combat Car M1E2
IDENTIFICATION: Second and Final Report on Ordnance Program No. 5327; APG 11-4
DATE OF REPORT: 25 October 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive suitability of a Combat Car, M1E2
METHOD: The vehicle was operated for 1282 miles over various types of terrain. Testing was conducted according to the automotive requirements of Specification T.S.T.P, 1935-709.
DESCRIPTION: The test combat car M1E2, was a 19,530 lb., full-tracked, front sprocket driven vehicle powered by a Continental W670, 7-cylinder, radial, air cooled, gasoline engine rated 268 bhp at 2400 rpm. The vehicle was equipped with a vertical volute spring suspension. The vehicle components were identical to those of the Combat Car M1 except for the following modifications: a slightly revised suspension system; the addition of an engine compartment door permitting ready access to the rear of the engine; a simplified louvered engine compartment hood; increased rear plate thickness; larger fuel tank; and the substitution of a hexagonal turret for a round one as used on the M1.
CONCLUSIONS: It was considered the test vehicle was satisfactory for manufacture. Riding qualities and stability were found more suitable than those of the Combat Car, M1.
GENERAL: This 117-page report contains four

photographs showing various views of the test vehicle.

SUBJECT: Tanks (Combat) APG 5350/2P
TITLE: Second Partial Report on the Light Tank M2A2E2
IDENTIFICATION: Second Partial Report on Ordnance Program No. 5350; APG 10-4
DATE OF REPORT: 26 May 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the suspension transmission and steering units of the Light Tank M2A2E2
METHOD: The vehicle was subjected to 3040 miles of extensive operation on the endurance test course.
DESCRIPTION: The 21,500-pound test vehicle was manufactured by Rock Island Arsenal and was powered by a Continental W670, seven-cylinder radial, air-cooled, gasoline engine rated 250 bhp at 2400 rpm. A constant mesh transmission and a multiple dry disc clutch were used in the power train. Primary armament consisted of a .50 caliber and two .30 caliber machine guns. The suspension used was of the vertical volute spring type. Bendix "Duo Servo" and Timken brakes and various brake linings were evaluated for use with the vehicle.
CONCLUSIONS: Numerous part failures and inadequacies were noted, and the Bendix brakes were unsatisfactory. In general, however, the steering (when employing Timken brakes), transmission, and suspension (except for poor wall climbing ability) were satisfactory. In further testing, it was recommended the following observations be made: the effect on the driver of heat generated by the transmission, brakes and final drive; and the effect of using an improved Wellman metallic lining or a type of lining used with grooved brakes for reducing Timken brake drum wear.
GENERAL: This 297-page report contains 33 photographs showing the test vehicle and parts damaged in operation.

SUBJECT: Tanks (Combat) APG 5366/1P
TITLE: First Partial Report of the Pilot Medium Tank T5, Phase I
IDENTIFICATION: First Partial Report on Ordnance Program No. 5366; APG 10-9
DATE OF REPORT: 21 March 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the mechanical reliability of the Pilot Medium Tank, T5
METHOD: Following minor repairs and modifications the vehicle was given a mechanical inspection and then subjected to limited testing.
DESCRIPTION: The Medium Tank T5 was in many ways an enlarged Light Tank, M2, as it employed the same engine, steering, track, suspension, front drive, etc. It differed primarily (except in size) in having heavier armament. The vehicle was powered by a standard 270-hp, Continental, radial, air-cooled, engine. The engine drove through a multiple disc clutch, and a constant mesh transmission with five forward speeds and one reverse speed.
CONCLUSIONS: Based on a short test of 305 miles running in 15 days, the Medium Tank T5 proved to be an excellent combat vehicle except for excessive weight, height, and minor deficiencies. It was recommended that many modifications be made to the vehicle and further testing be done at the Proving Ground.
GENERAL: This 164-page report includes three photographs of test vehicle and 17 photographs of vehicle components.

SUBJECT: Tanks (Combat) APG 5366/2P
TITLE: First Partial Report of the Pilot Model Medium Tank T5, Phase III
IDENTIFICATION: Second Partial Report on Ordnance Program No. 5366; APG 10-10
DATE OF REPORT: 19 January 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To check the mechanical reliability of the pilot Medium Tank T5 and make improvement changes
METHOD: The vehicle was subjected to a mechanical inspection, and tests were conducted to determine center of gravity, load distribution and ground pressure, limits of vision, ranges and areas of fire, starting characteristics, and turning characteristics. It was operated 444 miles over a period of 30 days.
DESCRIPTION: The test Medium Tank T5 was in many ways an enlarged Light Tank M2 as it employed the same steering, track, suspension, front drive, etc. It differed primarily (except in size) in having heavier armament. Also, the vehicle was powered by a Wright Whirlwind engine rated at 400 hp at 2400 rpm. The engine drove through a multiple-disc, dry clutch, and a constant mesh transmission with five forward speeds and one reverse speed.
CONCLUSIONS: In general, the tank was excellent mechanically and as a combat vehicle. It was recommended that it be further tested at APG after completion of service test at Fort Benning. Further tests were to develop improvements in transmission cooling, transmission gear engagement, differential housing design, track and drive sprocket life, and gun sight attachments.
GENERAL: This 173-page report includes nine photographs of the vehicle and components.

SUBJECT: Tanks (Combat) APG 5366/3P
TITLE: Second Partial Report of the Pilot Medium Tank T5, Phase I
IDENTIFICATION: Third Partial Report on Ordnance Program No. 5366; APG 10-9.1
DATE OF REPORT: 22 March 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To discover defects affecting durability and mechanical reliability of test vehicle; to determine whether vehicle fulfilled required military characteristics; also, to test new items and modifications added after previous test
METHOD: Test vehicle was subjected to tests of starting characteristics, obstacle crossing ability, determination of maximum and minimum speeds, braking characteristics, determination of drawbar pull, acceleration, fuel consumption, and cooling.
DESCRIPTION: The Medium Tank T5 was in many ways an enlarged Light Tank M2 as it employed the same engine, steering, track, suspension, front

drive, etc. It differed primarily (except in size) in having heavier armament. The vehicle was powered by a standard, 270-horsepower, Continental, radial, air-cooled engine. The engine drive through a two-plate, dry clutch and a constant mesh transmission with five forward speeds and one reverse speed.
CONCLUSIONS: In general, the Medium Tank T5 was an excellent combat vehicle. The Medium Tank T5 met the approved military characteristics for Medium Tanks except for minor suggested modifications. It was recommended the steering brakes on production vehicles be installed in the final drive housing with cooling fins on the brake housing.
GENERAL: This 168-page report includes three photographs of test vehicle and 20 photographs of vehicle components.

SUBJECT: Tanks (Combat) APG 5371/3P
TITLE: First Partial Report on Test of Pilot Light Tank M2A3
IDENTIFICATION: Third Partial Report on Ordnance Program No. 5371; APG 10-13
DATE OF REPORT: 25 July 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive suitability of the Light Tank M2A3
METHOD: During 5628 miles of operation, the test vehicle was subjected to a series of performance tests over-all types of terrain. Deficiencies were noted; in some instances corrections were attempted.
DESCRIPTION: The test Light Tank M2A3, somewhat resembling Light Tank M2A2 in construction, was a 19,460-pound, front-sprocket-driven vehicle powered by a Continental W670, seven-cylinder, radial, air-cooled, gasoline engine. The engine was rated 268 bhp at 2400 rpm and developed a maximum torque of 610 lb./ft. at 2000 rpm. An Ordnance synchromesh transmission, a multiple-disc clutch, and a controlled differential made up the major components of the power train. A vertical volute spring suspension, utilizing standard perlitonized gudgeons and guides and test type nitrided gudgeon rollers and guides, was employed on the vehicle.
CONCLUSIONS: Since equivalent mobility and power, and superior riding characteristics were demonstrated by the test vehicle, it was recommended the test Light Tank M2A3 be approved for manufacture in preference to the Light Tank M2A2. The Ordnance synchromesh transmission and its oil cooler were found unsatisfactory in spite of attempted modifications on both; future studies were recommended. Other recommendations included: nitrided gudgeon rollers and guides to replace the standard perlitonized units; battery ignition to replace the magneto ignition; and bogie tire and suspension clearance be increased to alleviate the bogie tire wear caused by mud and stones trapped in the insufficient clearance.
GENERAL: This 208-page report contains 24 photographs showing the vehicle, its component parts, and parts damaged and worn in operation.

SUBJECT: Tanks (Combat) APG 5372/1
TITLE: First Partial Report on Convertible Combat Car T7
IDENTIFICATION: First Report on Ordnance Program 5372; APG 11-5
DATE OF REPORT: 27 April 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive suitability of a Convertible Combat Car T7
METHOD: The test vehicle, equipped with and without tracks, was operated over various types of terrain for 466 miles. Testing was conducted according to the automotive requirements listed in Specification T.S.T.P. 1935-709.
DESCRIPTION: The Convertible Combat Car T7 could be operated with or without tracks by virtue of six tires over which track could be placed. The armored, 21,070-lb. combat car was a front sprocket-driven (rear axle driven, if wheeled) vehicle powered by a Continental W670, 7-cylinder, radial engine rated 268 bhp at 2400 rpm. Vehicle armament consisted of three cal. .30 machine guns and a cal. .50 machine gun. The suspension system of the vehicle consisted of two coiled springs for each front wheel and semi-eliptical leaf springs for the middle and rear wheels.
CONCLUSIONS: The test vehicle was considered generally satisfactory. However, numerous inherent weaknesses were discovered. Among other items, it was recommended that the front suspension of the vehicle be modified and that additional tests be conducted on the vehicle before any production of the combat car T7 was considered.
GENERAL: This 239-page report contains 23 photographs showing various views of the test vehicle and components damaged in operation. Drawings showing various required vehicle changes are also included.

SUBJECT: Tanks (Combat) APG 5391/1
TITLE: First Report on Test of the Pilot Light Tank M2A4
IDENTIFICATION: First Report on Ordnance Program No. 5391; APG 10-17
DATE OF REPORT: November 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the Pilot Light Tank M2A4
METHOD: The test vehicle having the same engine, transmission, suspension, and track as the M2A3, did not require complete tests, but only tests to determine speed, acceleration, hill-climbing, cross-country mobility, braking and steering, insofar as these features were affected by the increased gross weight without any corresponding increase in horsepower. It was operated 3762 miles on paved and gravel roads and cross-country.
DESCRIPTION: The test vehicle was an improved model of the Light Tank M2A3, having a Continental engine, Series 9, equipped with a Pierce overspeed governor. Modifications included one-inch armor plate on all vertical and rear vertical surfaces, single turret mounting a combination of a 37 mm M3 gun and cal. .30 machine gun, and a change in the shape of the rear of the engine compartment. Gross weight was 23,000 pounds.
CONCLUSIONS: The vehicle was superior to the M2A3, the increase in weight not being a handicap. There was increased wear on tracks, bogie tires, and wheel bearings. The turret combination gun

mount was unsatisfactory in that turret positioning bearings failed, and the 37 mm tube was subject to injury. Sponson machine gun mounts were unsatisfactory because of difficulty in adjustment of fire. The transmission oil cooler remained inoperative through most of the test. Aside from driver discomfort resulting from location of steering lever and excess height of seat, and need of protection of oil lines, wiring, and controls in the bottom of the hull, all other features were satisfactory. It was recommended that the width of track be increased to compensate for the extra weight, that rapid and positive means of adjusting fire be provided in gun mounts, that transmission oil coolers be corrected with by-pass valve springs of not less than 50 pounds release pressure, and that driver comfort and protection of oil lines, wiring, and controls be improved.
GENERAL: This 194-page report contains 50 photographs of the vehicle and failed parts.

SUBJECT: Tanks (Combat) APG 5391/3P
TITLE: First Report on Light Tank M2A4, No. 322
IDENTIFICATION: Third Partial Report on Ordnance Program No. 5391; APG 10-23
DATE OF REPORT: 28 September 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive suitability of the Light Tank M2A4
METHOD: The vehicle was subjected to 1173 miles of operation over all types of terrain; some modifications were made on component parts during the testing period.
DESCRIPTION: The test Light Tank M2A4, manufactured by the American Machine and Foundry Company, was a 24,125-pound, front sprocket-driven vehicle powered by a Continental W-670, 7-cylinder, radial, air-cooled, gasoline engine rated 250 bhp at 2400 rpm. A synchromesh transmission, a multi-disc clutch, and a controlled differential made up the primary components of the power train. The vehicle was also equipped with a vertical volute spring suspension. Primary armament consisted of one 37 mm gun and three cal. .30 machine guns.
CONCLUSIONS: With the exception of the suspension system, the general performance and ease of handling the vehicle were satisfactory. On the basis of noted deficiencies, the following corrections were recommended: the suspension be modified in the manner outlined in the report; a more efficient air cleaner be designed for the engine; the accessibility of the engine and transmission be improved; and armor and armament efficiency be increased. It was also recommended the armament of the tank not be decreased and that the gun, utilizing a periscopic sight instead of the direct sight, be provided with greater elevation.
GENERAL: This 118-page report contains 36 photographs of the vehicle, damaged suspension components, and other parts damaged during operation.

SUBJECT: Tanks (Combat) APG 5391/4
TITLE: First Report on Light Tanks M2A4 Ordnance Serial Numbers 382 and 580
IDENTIFICATION: Fourth Report on Ordnance Program No. 5391; APG 10-40
DATE OF REPORT: 7 February 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the components of Light Tank M2A4 when operating at Light Tank M3 weight; and to determine the suitability of the Guiberson engine for use in a standard weight Light Tank M2A4
METHOD: The test Light Tanks, M2A4, No. 382 (loaded to 27,100 pounds and employing standard component parts), and No. 580, a standard weight vehicle employing a test engine, were subjected to 2593 and 659 miles of operation, respectively, over all types of terrain.
DESCRIPTION: The vehicles utilized a power train consisting of a synchromesh transmission, a multi-disc clutch, and a controlled differential. A vertical volute spring suspension was employed on each vehicle. Light Tank No. 382, normally a 24,125-pound vehicle, was powered by a Continental W-670, 7-cylinder, radial, air-cooled, gasoline engine rated 250 bhp at 2400 rpm. Light Tank No. 580 was a 22,960-pound vehicle powered by a Guiberson T-1020-4, 9-cylinder, radial, air-cooled, diesel engine rated 265 bhp at 2250 rpm.
CONCLUSIONS: The component parts of the light tank No. 382 were generally unsatisfactory under the test vehicle weight; primary troubles were encountered with the overtaxed power train and the failure of the suspension volute springs and track. Except for high fuel consumption, the Continental engine gave satisfactory performance. Vehicle No. 580 appeared satisfactory after the short testing period. With the correction of an oil foaming condition and the improvement of starting characteristics of the Guiberson engine, it was recommended vehicle No. 580 be loaded to 27,000 pounds and subjected to tests similar to those conducted on vehicle No. 382. For future light tank development it was recommended that the power train assemblies be redesigned and strengthened, and that heavier volute springs be used in the suspensions.
GENERAL: This 185-page report contains 28 photographs showing views of the test vehicle and condition of component parts during and after operation.

SUBJECT: Tanks (Combat) APG 5396/2
TITLE: First Partial Report on Test of Combat Car M1E3 with Series 11 Engine and Low Tunnel Power Train
IDENTIFICATION: Second Report on Ordnance Program 5396; APG 11-6
DATE OF REPORT: 4 December 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the components used in Combat Car M1E3
METHOD: The test vehicle was operated for 1776 miles over various types of terrain. Testing was conducted according to a few of the automotive requirements listed in Specification T.S.T.P. 1935-709.
DESCRIPTION: The test Combat Car M1E3 was an 18,130-pound full-tracked, front sprocket-driven

vehicle powered by a Continental, Series 11, 7-cylinder, radial engine. A 12-volt battery with coil ignition system was used in place of the standard magneto. The vehicle, similar to the Combat Car M1, was equipped with a vertical volute spring suspension, an experimental low tunnel power train which increased the crew compartment space as compared to the Combat Car M1, and a six speed forward and two speed reverse transmission assembly.
CONCLUSIONS: The engine performed satisfactorily during 92 hours of operation. The starting characteristics were equivalent to those of the Series 9A engines used in the Combat Car M1. Because of unsatisfactory performance, it was recommended the transmission gear ratios be modified to more closely agree with those of the transmission used in the Light Tank M2A4.
GENERAL: This 120-page report contains nine photographs showing various views of the test vehicle and components damaged in operation. Drawings showing the space required for the low tunnel power train, compared to the standard power train of the Combat Car M1, are also included.

SUBJECT: Tanks (Combat) APG 5397/1
TITLE: First Partial Report on Test of Light Tank M2A2E3
IDENTIFICATION: First Report on Ordnance Program No. 5397; APG 10-14
DATE OF REPORT: 5 September 1939
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine power performance of the Light Tank M2A2E3
METHOD: The test vehicle was subjected to the Field dynamometer test. Resistance to traction was determined on level concrete at road speeds of 5-25 mph. Maximum drawbar pull was determined on the same course in low-first, low-second, low-third, low-fourth, and high-second gears over an engine speed range from 1200-1800 rpm. Comparison was made with Light Tank M2A4 and T4E5.
DESCRIPTION: The test vehicle, weighing 21,800 pounds, was powered by a GMC 6-71 diesel engine with fluid flywheel and automatic transmission.
CONCLUSIONS: Resistance to traction was comparable to that of other vehicles of the same type and higher than that of the T4E5. Drawbar horsepower performance was satisfactory, considering the limited horsepower of the engine. The percentage of power delivered at the drawbar was substantially the same as for the M2A4, but drawbar horsepower performance was inferior because of the great difference in engine power. It was found that the slip of the fluid flywheel increased as the gear ratio increased and also as the engine speed decreased under open throttle conditions.
GENERAL: This 14-page report contains five curves showing traction resistance and drawbar pull.

SUBJECT: Tanks (Combat) APG 5397/2
TITLE: Second Report on Test of Light Tank M2A2E3 with General Motors 6-71 Two-Cycle Diesel Engine and Automatic Transmission
IDENTIFICATION: Second Report on Ordnance Program No. 5397; APG 10-20
DATE OF REPORT: 14 May 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the automotive-type diesel power plant and automatic transmission with fluid flywheel for combat vehicles; and to determine the operating characteristics and life of the trailing idler with rubber torsion units
METHOD: The subject vehicle was operated a total of 4676 miles or 258 hours operating time during tests in accordance with features of TSTP 1935-709 relating to power plant, transmission, and suspension.
DESCRIPTION: The M2A2E3 vehicle was made up from the Light Tank M2A2E2 with modifications to remove the engine bulkhead, lengthen the tank hull by 15 inches, add a trailing idler to carry additional weight in the rear and increase the track length, to replace the five-speed mechanical transmission with the automatic bus transmission and to install a new propeller shaft to withstand the higher torque. The engine was a General Motors, two-cycle, 6-17, diesel engine, designed for bus operation. The transmission was an automatic, hydraulically operated, mechanical planetary gear type with four forward speeds, and incorporating a fluid coupling. The suspension had a sliding bar-type bogie with a rubber bushed trailing idler.
CONCLUSIONS: The automotive-type diesel power plant was considered suitable for propelling tanks and combat vehicles, although it had greater weight, less horsepower, and occupied more space than the standard gasoline engine. High torque characteristics gave the vehicle good cross-country mobility. It was recommended this engine be redesigned for use in the light tank, and that horsepower be increased by a change in fuel injection and an increase in governed engine speed. The automatic transmission reduced power plant noise and was considered desirable, although the test unit was unsatisfactory because of slope limitations. Modification to correct this condition was considered possible and was recommended. The trailing idler reduced pitch, making the gun platform more stable, but the bushings tested were not satisfactory as to uniformity or length of life.
GENERAL: This 236-page report contains 25 photographs showing details and failed parts; a sketch and nine drawings showing engine and automatic transmission.

SUBJECT: Tanks (Combat) APG 5402/1
TITLE: First Partial Report on Test of Medium Tanks M2
IDENTIFICATION: First Report on Ordnance Program No. 5402; APG 10-21
DATE OF REPORT: 5 June 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the Medium Tank M2
METHOD: A production model and shop pilot model of the vehicle were subjected to a continuous operating test and to 17 of the 28 features of T.S.T.P. 1935-709. Tests included 1116 miles of

operation on the production model, and 2400 miles on the shop pilot model.
DESCRIPTION: Both tank models were modified Medium Tanks T5, and were powered by Wright R975-EC3 engines of 370 bhp at 2400 rpm. The shop pilot was made of soft carbon steel plate and had a horizontal volute spring suspension. The production model differed mainly in its vertical volute spring suspension and hull of armor plate. Armament consisted of a 37 mm gun in the turret, four cal. .30 flexible machine guns mounted in the sponsons, two cal. .30 fixed machine guns in the bow, and two spare cal. .30 machine guns for use on ground or in AA mounts.
CONCLUSIONS: The vehicles were considered mechanically sound and generally of a satisfactory design. Strategic and tactical mobility were satisfactory, except that ability to negotiate vertical obstacles was poor. Many difficulties in operation were attributed to inadequate manufacturing and assembly inspection. Five sets of recommendations were submitted for modifications in the engine, suspension system, transmission and power train, tracks, and hull. It was also recommended that the armor be increased and that the vehicle incorporate a 75 mm gun or howitzer.
GENERAL: This 400-page report includes 47 photographs of the vehicle, interior details, and failed parts.

SUBJECT: Tanks (Combat) APG 5402/2
TITLE: Second Report on Medium Tank M2
IDENTIFICATION: Second Report on Ordnance Program No. 5402; APG 10-29
DATE OF REPORT: 25 November 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance characteristics of the Medium Tank M2
METHOD: A production and a shop pilot model of Medium Tank, M2, were tested according to T.S.T. P. 1935-709 procedures for determination of load distribution and ground pressure, slope operation, maximum and minimum speed, firing, and operation. Other features of the test were covered in the First Partial Report. Test operation involved 3383 miles on the production model and 3239 miles on a shop pilot model. A 1745-mile test was also conducted on the production model to determine the adequacy of the M2A1 power train with the vehicle loaded to a gross weight of 25 tons.
DESCRIPTION: The two vehicles, each weighing 38,000 pounds gross, were powered by Wright R975-EC-3 engines rated at 350 bhp at 2250 rpm. The shop pilot model was made of soft carbon steel plate and was equipped with a horizontal spring suspension, which was replaced during the test with an experimental suspension incorporating a trailing idler. The production model was equipped with a vertical volute spring suspension and hull of armor plate. Armament consisted of one 37-mm gun mounted in the turret; four cal. .30 flexible machine guns mounted in the sponsons; two cal. .30 fixed machine guns mounted in the bow; and two spare cal. .30 machine guns for use on ground or anti-aircraft mounts.
CONCLUSIONS: In addition to the conclusions of the First Partial Report, it was concluded that the power train was of ample capacity for propelling a 25-ton load, although the suspension was considered inadequate. Most of the difficulties experienced in earlier transmissions had been overcome in the M2A1 transmission. Numerous recommendations were made in a list of five subdivisions covering the engine, suspension, transmission and power train, tracks, bogie wheel tires, and hull.
GENERAL: This 211-page report includes 28 photographs showing details and failed parts of the vehicle and sketches showing the venting of the engine lubricating system, and the modified steering linkage.

SUBJECT: Tanks (Combat) APG 5402/6
TITLE: Third and Final Report on Test of Medium Tank M2
IDENTIFICATION: Sixth Report on Ordnance Program No. 5402; APG 10-53
DATE OF REPORT: 29 September 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of the Medium Tank M2
METHOD: A shop pilot model of the Medium Tank M2 and a production model of the same vehicle were operated a total of 4138 and 7274 miles, respectively.
DESCRIPTION: Both models were standardizations of the Medium Tank T5, Phase III, with modifications. Gross weight of each vehicle was 38,000 pounds. The tanks were powered by Wright Whirlwind R975-EC3 engines converted during tests to R975-EC2 engines. The shop pilot was made of soft carbon steel plate and had a horizontal volute spring suspension incorporating a trailing idler. The production model was equipped with a vertical volute spring suspension and was made of armor plate. Armament consisted of a 37 mm turret gun; four cal. .30 flexible machine guns mounted in the sponsons; two cal. .30 bow machine guns; and two spare cal. .30 machine guns.
CONCLUSIONS: The vehicles were considered mechanically sound and generally satisfactory. The power train was of ample capacity, but the suspension was inadequate. The vehicle had satisfactory strategic and tactical mobility except for a deficiency in obstacle crossing ability. Armament was considered deficient, and a 75 mm gun or howitzer was recommended. The addition of an air expansion tank and an oil temperature regulator eliminated oil foaming. The principle of a cast armor front end assembly was considered practicable. Flat steering brake drums with mating brake bands proved satisfactory. Detailed recommendations were made for improving the engine, suspension, transmission and power train, tracks and hull.
GENERAL: This 159-page report contains 56 photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) APG 5459/3
TITLE: First Report on the Test of the British Infantry Tank (Churchill MK IV)
IDENTIFICATION: Third Report on Ordnance

TANK AUTOMOTIVE TEST RESUMES

Program No. 5459; APG 10-115
DATE OF REPORT: 17 March 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine any advantages of the British tank that could be considered for American tank use
METHOD: The test tank was subjected to standard tests including 87 miles of operation on paved and cross-country courses at the proving ground.
DESCRIPTION: The test British Infantry Tank, Churchill MK IV, was powered by a Bedford, 12-cylinder, horizontally-opposed, L-head, water-cooled engine rated at 350 bhp at 2200 rpm. The vehicle utilized coil springs for the individually suspended bogies. Turret armament consisted of a two-pounder MK IX or X; a Besa Medium Machine Gun, cal. 0.311, MK II; a Bomb Thrower, 2-inch MK I; a Bren Machine Gun, cal. 0.303, MK I; and a Thompson sub-machine gun. Armament in the driver's compartment included a 3-inch Howitzer MK I or a Besa Medium Machine Gun cal. 0.311, MK II; and a Thompson Sub-machine Gun.
CONCLUSIONS: The Merritt-Brown gear box, which took the place of both the transmission and the controlled differential in American tanks, provided an excellent means of steering. The chief advantage of the system was that large radius turns could be made without slipping the steering brake, thus eliminating power loss through the brake. Also, since less torque was required, the British tank could travel in a sustained curve in any gear. It was recommended that the Merritt-Brown type of gear box be considered in the design of any new power train for American tanks.
GENERAL: This 138-page report contains 15 photographs and six drawings of the British Infantry Tank, Churchill MK IV.

SUBJECT: Tanks (Combat) APG 5463/1
TITLE: Report on Test of Light Tank M1A1
IDENTIFICATION: First Report on Ordnance Program No. 5463; APG 10-118
DATE OF REPORT: 26 April 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Light Tank M1A1
METHOD: The M1A1 vehicle was tested in accordance with T.S.T.P. 1935-705 during 7352 miles of operation over paved, gravel, and cross-country courses.
DESCRIPTION: Light Tank M1A1, an armored full track laying vehicle, had formerly been classified as Combat Car M2. It was similar to Combat Car M1A1 except that it was powered by a Guiberson, T-1020, series 4, diesel engine rated at 250 hp at 2200 rpm with a maximum torque of 650 lbs.ft at 1900 rpm. It was equipped with a trailing idler incorporating rubber torsion units. Armament consisted of three .30 and one .50 caliber machine guns.
CONCLUSIONS: Although the test vehicle was mechanically sound and performed satisfactorily, it was considered deficient as a fighting machine because of inadequate fire power and light armor. It was recommended that testing of this vehicle be discontinued, but operation be continued for testing of the engine and components. It was also recommended that the 34 Light Tanks M1A1 in existence be used as training vehicles without being modified as described in the report.
GENERAL: This 206-page report includes 67 photographs of the tank and its components, an analysis of different lubricating oils, a piston hardness analysis, and a test discussion.

SUBJECT: Tanks (Combat) APG 5464/10
TITLE: Tenth Partial Study of Component Parts for Medium Tank M3
IDENTIFICATION: Tenth Report on Ordnance Program No. 5464; APG 10-39
DATE OF REPORT: 15 January 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the adequacy of crew accommodations in Medium Tank M3
METHOD: A fully equipped crew was placed in position in wooden mock-up of an M3 Tank. Studies of crew convenience were made as crew performed duties of combat operation.
DESCRIPTION: The interior of the mock-up contained complete field equipment, radio, ammunition, and personnel gear.
CONCLUSIONS: Except for minor inconveniences, it was concluded that the accommodations for the crew in Medium Tank M3 were safe and comfortable as far as could be determined by a static test.
GENERAL: This 15-page report includes 11 photographs of tank mock-up and crew.

SUBJECT: Tanks (Combat) APG 5464/19Min.
TITLE: First Minor Report on Medium Tank M3A1 No. 1966--Acceptance Test
IDENTIFICATION: Nineteenth Minor Report on Ordnance Program No. 5464; APG 10-76
DATE OF REPORT: 12 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the faults in the Medium Tank, M3A1, No. 1966, which might be attributed to poor design, manufacture, or inspection
METHOD: The vehicle was first given a mechanical inspection for compliance with specifications and quality of workmanship. Test runs to determine adequacy of the braking mechanism and transmission cooling were made. Operation included a total of 600 test miles on concrete and gravel roads at various throttle settings with gyrostabilizers operating continuously.
DESCRIPTION: The test vehicle, powered by a Continental R975-EC2 engine, was basically the same as the Medium Tank M3, except that it had a cast upper hull. Weight loaded was 62,250 pounds.
CONCLUSIONS: In general, the Medium Tank, M3A1, was considered satisfactory. However, some serious deficiencies were noted. The installation of the 37 mm and 75 mm guns was considered poor. Binding was experienced in the mount between the rotor and front plate with the 37 mm gun. Serious binding in the trunnions and leakage of the stabilizer hydraulic system were experienced with the 75 mm gun. The engine installation was good, except for an error in the installation of the

rubber connection on the air intake system and sticking of the oil dilution valve. There were no recommendations.
GENERAL: This 38-page report is not illustrated.

SUBJECT: Tanks (Combat) APG 5464/20Min
TITLE: First Minor Report on Medium Tank M3 No. 2302--Acceptance Test
IDENTIFICATION: Twentieth Minor Report on Ordnance Program No. 5464; APG-10-74
DATE OF REPORT: 12 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the faults of the Medium Tank M3 No. 2302 which might be attributed to poor design, manufacture, or inspection
METHOD: Mechanical inspection for compliance with specifications, quality of workmanship, and setting of adjustments was made before tests, and a final inspection was made to determine failures and excess wear of parts during road tests. The guns were proof-fired according to standard procedure, and were later fired with ammunition carried during the tests to check effects of road operation. The vehicle was loaded to fighting weight, and tests of road drift made to check alignment of suspension, driving sprockets, and rear idler. Operation was over hard surface roads for 280 miles and over gravel roads for seven hours with gyrostabilizers in continuous operation. Runs were made to determine the efficiency of the braking system and transmission cooling.
DESCRIPTION: The test vehicle was a Medium Tank weighing 60,000 pounds loaded, and was powered by a Continental R975-EC2 engine.
CONCLUSIONS: Except for the 37 mm and 75 mm armament, the test vehicle was considered satisfactory. There was excess friction in the trunnions of the 75 mm gun; the stabilizer pump of the 75 mm gun was not serviceable; and a stabilizer bearing was loose on the 37 mm gun. No operational failures or difficulties were experienced. No recommendations were made.
GENERAL: This 33-page report is not illustrated.

SUBJECT: Tanks (Combat) APG 5464/22Min
TITLE: First Minor Report on Medium Tank M3 No. 2322--Acceptance Test
IDENTIFICATION: Twenty-Second Minor Report on Ordnance Program No. 5464; APG 10-81
DATE OF REPORT: 12 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the quality level at which the Medium Tank M3 had been manufactured
METHOD: The vehicle was subjected to mechanical inspection, proof firings, braking tests, misalignment tests, and a strategic run. Total operations amounted to 485 miles; 242 of which was on concrete and the remainder on gravel.
DESCRIPTION: The test production Medium Tank M3, Serial No. 2322, was powered by a Continental R975-EC2, radial, air-cooled, gasoline engine. Modifications, not found in previous production models, included air cleaners mounted at the rear of the engine compartment; no side doors in the hull; short fishtails on the engine exhaust pipes in place of mufflers; a mushroom type ventilator installed in the turret over the 37 mm gun; and, except for those on the hull bottom, all rivets were seal welded.
CONCLUSIONS: Except for the gyrostabilizer elements and a number of minor items, the vehicle was manufactured at a high quality level.
GENERAL: This 38-page report is unillustrated.

SUBJECT: Tanks (Combat) APG 5464/30
TITLE: First Report on Canadian Medium Tank M3
IDENTIFICATION: Thirtieth Report on Ordnance Program Number 5464; APG 10-60
DATE OF REPORT: 18 November 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the Canadian Medium Tank M3 with the U.S. Medium Tank M3 in accordance with T.S.T.P. 1935-709
METHOD: Various tests, to determine characteristics of test tank, were conducted. Included were tests to determine center of gravity, security from observation, obstacle crossing ability, fording ability, turning characteristics, and slope operation. The vehicle operated for a total of 599 test miles.
DESCRIPTION: The Canadian Medium Tank M3 was manufactured by the Montreal Locomotive Works, Montreal, Canada. It was similar to the U.S. Medium Tank M3 in that it had the same lower hull, engine, transmission, differential and final drives, track and suspension systems. It differed from the U. S. Medium Tank M3 only in the upper hull and the location of steering system and controls.
CONCLUSIONS: The mechanical performance of the vehicle was almost identical to that of the U.S. Medium Tank M3. It was considered to be more vulnerable to enemy fire because of the turret and lower cupola design. It was recommended that the fuel tank cowling be modified to duplicate the U.S. M3 and that the power train be equipped with an oil cooling system. It was also recommended that the brake lever be redesigned, a bucket-type seat be adopted, lock screws be used for the muffler assembly, the hull be redesigned for turret ring and lower cupola protection, a method be provided to open the driver's window from the inside, and the air cleaners be made more accessible.
GENERAL: This 149-page report includes 27 photographs of Canadian M3 Medium Tank and its components and two photographs illustrating the U.S. M3 Medium Tank.

SUBJECT: Tanks (Combat) APG 5464/31
TITLE: First Report on Design and Test of Medium Tank M3
IDENTIFICATION: Thirty-first Report on Ordnance Program No. 5464; APG 10-57
DATE OF REPORT: 14 January 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the Medium Tank M3
METHOD: Nine Medium Tanks M3, all made to the same specifications but by different manufacturers,

were tested in accordance with T.S.T.P. 1935-709, revision of 1937, except for features four and nine. The nine vehicles operated a combined total of 11,805 miles, approximately 50% of which was on hard-surfaced roads and 50% on cross-country.
DESCRIPTION: The subject vehicle was a full track laying tank weighing 60,000 pounds. It was powered by a Wright 975-EC2, radial, air-cooled engine rated at 400 bhp at 2400 rpm. Other features included a synchromesh transmission and a vertical volute spring-type suspension. The hull was of riveted construction and the turret, with power traversing unit, was made of a single-piece casting on which was mounted a cast cupola. The armament consisted of one 75-mm gun mounted in the right sponson, and one 37-mm and one cal. .30 machine gun mounted in the turret, one cal. .30 machine gun mounted in the cupola, two cal. .30 machine guns mounted in the bow, and two cal. .45 sub-machine guns carried inside the vehicle.
CONCLUSIONS: The engine was underpowered, and design did not permit sufficient space either for engine and accessories or for cooling. Design features of air cleaners, air intake system, and engine shrouding were also unsatisfactory. The suspension was considered inadequate in capacity for load and not sufficiently flexible for good track action. Tracks were of insufficient pin strength, bushing capacity, and guide and end connector strength. The riveted structures of the hull were unsatisfactory, and protection against bullet splash was insufficient. Location of the main weapon on on the side limited traverse and independent operation. Recommendations were grouped into five subdivisions covering engine, suspension, transmission and power train, tracks, and hull.
GENERAL: This 701-page report, bound in two volumes, contains 81 photographs showing full views, details, and failed parts of the M3.

SUBJECT: Tanks (Combat) APG 5464/32
TITLE: Report on Mojave Desert Test of Medium Tank M3
IDENTIFICATION: Thirty-second Report on Ordnance Program No. 5464; APG 10-62
DATE OF REPORT: 19 February 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the desert operating performance characteristics of the Medium Tank M3
METHOD: Three test vehicles were subjected to 2614, 1937, and 2257 miles, respectively, of desert operation in the Calico Dry Lake area of the Mojave Desert in California.
DESCRIPTION: The test Medium Tank M3 employed vertical volute spring suspension and a power traverse turret. Vehicle power was supplied by a Continental-Wright R975-EC2 engine; two of the vehicle engines incorporated test McQuay-Norris piston rings, which afforded increased ring pressure against the cylinder walls, while the third vehicle engine employed standard rings. Test high-tensile, stock-rubber tracks, supplied by Firestone and Goodyear, were compared with standard production tracks. Fighting compartment ventilators, vehicle sand shields, Donaldson engine air precleaners, and grooved brake band linings were also tested.
CONCLUSIONS: Trouble-free test vehicle operation was determined to be 900 to 1000 miles; after this period, the most likely point of failure would be the suspension. Changes were recommended to improve various suspension components. On the basis of satisfactory results, it was recommended the test piston rings, fighting compartment ventilators (with a filter employed), vehicle sand shields (during desert operation), and grooved brake band linings, be accepted for use. The test track (having less service life than the standard production type), engine air intake precleaners, and power traverse mechanism were found unsatisfactory and were not recommended. Other recommendations were made to improve the carburetor, electrical system, transmission and power train, guns, turret, vision devices, pistol ports and hull.
GENERAL: This 251-page report contains 55 photographs of the vehicle and component parts during and after operation. Automotive Laboratory Report No. 42-14, covering the analysis of two dust samples from the Mojave desert, is also included.

SUBJECT: Tanks (Combat) APG 5464/36
TITLE: First Report on Test of Medium Tank M3A5
IDENTIFICATION: Thirty-Sixth Report on Ordnance Program No. 5464; APG 10-71
DATE OF REPORT: 1 June 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Medium Tank M3 with diesel engines
METHOD: The tank was tested in accordance with features of T.S.T.P. 1935-709 applicable to determining performance characteristics of the engines. In addition an endurance run of 2707 miles (100 hours) was made over hard-surfaced and gravel roads. Total operation was 4201 miles.
DESCRIPTION: The test vehicle was a production Medium Tank M3 with the engine and fighting compartment modified to permit replacement of the Continental R975-EC2 gasoline engine by twin General Motors 6-71 diesel engines (375 hp total).
CONCLUSIONS: Engine, transmission and differential operation was satisfactory with the 25 and 30 mph gears, but not with the 35 mph gears. The engine installation was considered desirable. Unsatisfactory features included overloading of the engine idler gear hub, excessive helix angle on the gears in the engine gear train, clutch wear aggravated by unequal engine speeds, abnormal brake drum scoring, misalignment of differential covers, and inadequate ventilation of the fighting compartment. The increased weight of the power plant placed severe stress on the volute springs of the suspension, and track stretch at high speeds was appreciable. It was recommended that deficiencies be corrected and further testing be given the modified vehicle.
GENERAL: This 330-page report includes 65 photographs of the vehicle, components and failed parts.

SUBJECT: Tanks (Combat) APG 5464/37
TITLE: Medium Tank M3 No. 1871--Acceptance Test
IDENTIFICATION: Thirty-seventh Report on Ordnance Program No. 5464; APG 10-68
DATE OF REPORT: 27 April 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To perform an acceptance test on the vehicle to determine its suitability for military purposes
METHOD: The vehicle was equipped with full armament and live ammunition. It was operated a total of 2011 miles; 1023 miles on paved and smooth gravel roads, and 988 miles over cross-country terrain.
DESCRIPTION: The test production Medium Tank M3 was powered by a Wright R975-EC2 engine.
CONCLUSIONS: Throughout the test, no unusual failures occurred. Those failures that did occur were caused primarily because of weakness in design or normal wear, which may be expected of this vehicle.
GENERAL: This 48-page report contains six photographs of vehicle components that had failed during the test.

SUBJECT: Tanks (Combat) APG 5464/42
TITLE: First Report on Medium Tank M4A2 No. 908--Acceptance Test
IDENTIFICATION: Forty-Second Report on Ordnance Program No. 5464; APG 10-92
DATE OF REPORT: 28 October 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the manufacturing and design suitability of the Medium Tank, M4A2
METHOD: The test vehicle was operated 602 miles on a standard acceptance test.
DESCRIPTION: The Medium Tank, M4A2, No. 908, was manufactured by the Pullman Standard Car Manufacturing Company of Hammond, Indiana, and was powered by a General Motors, Series 6046, twin diesel engine.
CONCLUSIONS: The test vehicle successfully completed the test operation; but numerous accessories and stowage items were missing, improperly located, or inoperative. It was recommended that the manufacturer make closer check of the vehicles to insure proper manufacture and installation of equipment. It was also recommended the engine be equipped with higher dirt capacity air cleaners and that engine oil indicators be redesigned to indicate correct oil level.
GENERAL: This 55-page report contains no illustrations.

SUBJECT: Tanks (Combat) APG 5464/47
TITLE: Second Report on Medium Tank, M3A5, No. 1465--Acceptance Test
IDENTIFICATION: Forty-seventh Report on Ordnance Program No. 5464; APG 10-107
DATE OF REPORT: 15 January 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the quality level and inherent design weaknesses of the Medium Tank M3A5
METHOD: The vehicle was given mechanical inspection and operated 233 miles over various test courses.
DESCRIPTION: The test Medium Tank M3A5 was manufactured by the Baldwin Locomotive Works, and was equipped with a 75mm and a 37mm gun with gyrostabilizers.
CONCLUSIONS: It was concluded that the vehicle was not manufactured to acceptable automotive and military standards. The gun mount and the gyrostabilizers were defective. It was recommended that proper action be taken to have the manufacturer and the Army Inspector of Ordnance closely check various components found unsatisfactory.
GENERAL: This 52-page report includes seven photographs of the vehicle and worn components.

SUBJECT: Tanks (Combat) APG 5464/48
TITLE: First Report on Comparison of Second Gear Drawbar Pull and Horsepower Characteristics of Medium Tanks
IDENTIFICATION: Forty-eighth Report on Ordnance Program No. 5464
DATE OF REPORT: 2 January 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the second gear drawbar pull and drawbar horsepower characteristics of medium tanks
METHOD: The data used to compile this report were extracted from different reports containing drawbar characteristics of specific vehicles, and discussion of all phases of numerous engineering tests conducted on the vehicles at Aberdeen Proving Ground.
DESCRIPTION: The test vehicles were: M4A2 and M3A3 tanks with dual G.M. diesel 6-71 Model 6046 engines and with a 1.194 to 1 step-up gear ratio; a M4A3 tank with a Ford, V8, Model GAA engine; a M3A4 tank with the Chrysler multibank engine and with a 1.19 to 1 reduction gear ratio; a M3A3 tank with dual 6046 engines and with a 1.371 to 1 step-up gear ratio; a M3 tank with a Wright R975-C1 engine and incorporating redesign shroud and engine combustion air intake pipes, modified carburetor, and relocated air cleaners and mufflers; a M4A1 with Wright R975-EC2 engine and same modifications as the M3 tank above; and an M3 tank with Wright R975-EC2 engine and standard installation.
CONCLUSIONS: The drawbar pull and horsepower values of the medium tanks tested were rated in descending order as follows: M4A2, M4A3, M3A3 (1.194 to 1 step-up gear ratio), M3A4, M3A3 (1.371 to 1 step-up gear ratio), M3 (Wright R975-C1 engine), M4A1 (Wright R975-EC2 modified engine), M3(R975-EC2 standard engine).
GENERAL: This 37-page report is not illustrated.

SUBJECT: Tanks (Combat) APG 5514/1
TITLE: First Report on Assembly of Medium Tank T6
IDENTIFICATION: First Report on Ordnance Program No. 5514; APG 10-54
DATE OF REPORT: 9 December 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of design

features of the Medium Tank M3
METHOD: After modification of the tank, tests were made of the traversing mechanism, the 75mm gun, and for shot splash on the driver's direct-vision door and slots, and on the assistant driver's direct-vision door and sighting device.
DESCRIPTION: The principal differences in construction between the test vehicle and the M3 were: the location of the 75mm gun in the turret instead of the upper hull, and provision made for turning of the gun breech 90° from the vertical; provision of a larger bracket of 69-inch diameter; location of the driver's seat to the left of the transmission rather than over it, and provision of a driver's door equipped with both a periscope and direct vision slot; installation of the mechanical "long lever" steering control; elimination of right and left-hand side doors and provision of an escape door in the floor of the lower hull; elimination of the cupola and replacement with a combination antiaircraft machine gun mount. The component parts of the shell were a lower hull of riveted construction, a cast upper hull, and a cast turret. The vehicle was powered by a Wright Whirlwind R975-EC2 Engine. Armament included a 75mm gun, five cal. .30 machine guns, one cal. .50 machine gun, and one cal. .40 Thompson submachine gun.
CONCLUSIONS: The design features of the test vehicle were generally satisfactory. Additional protection against small arms was necessary for the direct vision doors and the assistant driver's sighting device was vulnerable to jamming. It was recommended that the Medium Tank T6 be accepted, subject to standardization, and that it be retained for further development and testing. It was further recommended that the T8 gun be tested in place of the 75mm gun, and that the capacity of the traversing mechanism oil pump be increased.
GENERAL: This 286-page report contains 99 photographs of the tank and details.

SUBJECT: Tanks (Combat) APG 5514/2
TITLE: First Report on Development of Medium Tank M4A1 (Project No. 3-2)
IDENTIFICATION: Second Report on Ordnance Program No. 5514; APG 10-73
DATE OF REPORT: 2 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To design, develop, and test various components and assemblies in conjunction with development of Medium Tank M4A1
METHOD: Components were tested on the shop pilot which had been the Medium Tank T6. Development work was done on 75mm Combination Gun Mount M34, traversing mechanisms, gyrostabilizer, radio and interphone installation, turret, periscope, machine gun mounts, etc.
DESCRIPTION: The vehicle covered by this report was a shop pilot Medium Tank T6, later designated Medium Tank M4A1. It was equipped with a 75mm Gun M3 in an M34 Combination Mount.
CONCLUSIONS: The Medium Tank M4 was considered a satisfactory fighting vehicle. The M34 gun mount and the cal. .50 antiaircraft mount were considered satisfactory. Relocated air cleaners, mufflers, and carburetor changes gave an increase in power of 70 hp at 2300 rpm with a Wright R975 engine. The Oilgear power traverse was considered superior to the Westinghouse electric traverse and the Logansport power traverse. Continued development work was recommended on the gyrostabilizer, armored air intake, and on other traversing systems to supplement the Oilgear production. It was also recommended that direct vision slots and doors be eliminated.
GENERAL: This 803-page report is compiled in three volumes. The report includes a list of drawings, a list of spare parts, a list of stowage containers, and 67 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) APG 5521/5
TITLE: Third Report on Development and Test of Light Tank M3
IDENTIFICATION: Fifth Report on Ordnance Program No. 5521; APG 10-102
DATE OF REPORT: 1 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To perform acceptance tests on production Light Tanks M3
METHOD: Approximately every 200th production vehicle was subjected to an Acceptance Test according to T.S.T.P. 1935-709. Test operation per vehicle varied from 30 to 3729 miles.
DESCRIPTION: The test vehicles were production Light Tanks M3 manufactured by the American Car and Foundry Company. They were powered by either 7-cylinder Continental or 9-cylinder Guiberson engines. The Continental was rated 250 hp at 2400 rpm, and the Guiberson diesel, 250 hp at 2200 rpm. Both were aircraft-type air-cooled, radial engines. Power was transmitted through a disc-type clutch, forward to a synchromesh transmission which provided five forward speeds and one reverse. Volute type spring suspension was utilized for both the bogie supports and the trailing idlers. The combat weight of the vehicle was 28,000 pounds. Armament consisted of a 37mm M5 Gun and a cal. .30 machine gun in a combination turret mount, one bow cal. .30 machine gun, two sponson mounted cal. .30 machine guns, and one cal. .45 Thompson sub-machine gun.
CONCLUSIONS: Numerous conclusions and recommendations were compiled throughout the entire program. After each testing, and with the proper authority, the recommendations suggested were incorporated in the production vehicles. Generally, the testing program was a continuous operation in which the Light Tank M3 was constantly improved to develop a vehicle of high military value.
GENERAL: This 904-page report contains 142 photographs of the vehicle and components. Also included are drawings, specification requirements, a stowage list, and an Automotive Laboratory Report No. 41-113 entitled "Field Dynamometer Test of Light Tank M3 No. 324."

SUBJECT: Tanks (Combat) APG 5521/6
TITLE: First Report on Pilot Model Light Tank M3A1

IDENTIFICATION: Sixth Report on Ordnance Program No. 5521; APG 10-87
DATE OF REPORT: 24 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the design efficiency of Pilot Light Tank, M3A1, with emphasis on the integrated fighting compartment
METHOD: Firing tests were conducted and tests to determine traverse mechanism power consumption were made. Spring deflection was measured, and the gun stabilizer operation was tested. The vehicle accumulated 502 miles during the testing.
DESCRIPTION: The test vehicle was a Light Tank M3 equipped with an integrated fighting compartment with power traverse and gun stabilizer. The vehicle was designated Pilot M3A1 and weighed 28,000 pounds.
CONCLUSIONS: The integrated fighting compartment of Light Tank M3A1 was found satisfactory only as an expedient to incorporate the turret basket with power turret traverse and gun stabilization to the Light Tank M3. Recommendations for redesign of tank included modifications to increase crew space and redesign of the gun mount to improve stabilizer operation.
GENERAL: This 85-page report contains 21 photographs of the test vehicle and components.

SUBJECT: Tanks (Combat) APG 5521/10
TITLE: First Report on Light Tanks M3, Nos. 2704, 3722, 4321, 4727, 5727, 5243, and Light Tank M2A4, No. 652
IDENTIFICATION: Tenth Report on Ordnance Program No. 5521; APG 10-98
DATE OF REPORT: 17 December 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of six light tanks M3 and one M2A4
METHOD: The test vehicles were given standard acceptance tests. The tests consisted of a mechanical inspection, loading and drift tests before and after operation, 100 miles of operation on concrete and on aviation courses with engines at part throttle, tests for braking and cooling, seven-hour continuous operation test on hard-surface roads and functional firing tests. The gyrostabilizers were operated continuously on those vehicles equipped with them.
DESCRIPTION: The test vehicles were powered by radial, gasoline, aircraft engines or by radial, diesel, aircraft engines located in the rear of the hull. Armament consisted of a 37mm gun and a cal. .30 machine gun mounted in the turret; four cal. .30 machine guns mounted in the bow, on the outside of the turret, and in each sponson; and one cal. .45 Thompson sub-machine gun. The weight of the vehicle stowed was 28,000 pounds.
CONCLUSIONS: The principal manufacturing deficiencies encountered in the test vehicles were: leakage in the engine air-intake system, fuel system, and hull joints; failure of the injector stud; incorrect size of cover on the terminal box of the starter; interference of the decompression cable with the engine bulkhead; loose valve pushrod housing; blowby past pistons; binding of the brake linkage; misalignment of rear idlers; and mismatching of the generators and regulators. Faulty design was credited with the burning of the carburetor intake tube connector of one engine, failure of one engine to idle when hot, interference between grounding stud and exhaust manifold, overheating of transmissions provided with Spicer pumps and Harrison AV-30 coolers, inaccessibility of transmission oil filter, inoperative condition of hull drainage valves, and generally unsatisfactory arrangement of Combination Mount, 37mm, M23. It was recommended that closer inspection be given to the manufacturing deficiencies found, and that studies be made to correct the faults in design.
GENERAL: This 308-page report contains six photographs showing some of the unsatisfactory parts and features encountered.

SUBJECT: Tanks (Combat) APG 5535/1
TITLE: First Report on Heavy Tank T1E2
IDENTIFICATION: First Report on Ordnance Program No. 5535; APG 10-86
DATE OF REPORT: 25 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the cooling and braking characteristics of the test Heavy Tank, T1E2, and to evaluate the tank design
METHOD: Tests were conducted on the vehicle for general characteristics, with emphasis on cooling and braking. Operation was on concrete and cross-country courses. A continual operation test under load was given and cooling characteristics noted.
DESCRIPTION: The test vehicle was the Heavy Tank T1E2, weighing 55 tons less dual .50 caliber machine guns, ammunition, and crew. The vehicle was powered by a Wright, 1820-cubic inch, nine-cylinder, radial, G200, air-cooled, gasoline engine rated at 960 hp at 2300 rpm. The transmission was a Twin-Disc torque converter with a Timken-Detroit Axle Co. two-speed gear box. Armament consisted of a three-inch A.A. gun, T12, and a 37mm gun, M6, mounted coaxially in the turret; twin .50 caliber machine guns in the front plate; two .30 caliber machine guns in the bow; one .50 caliber machine gun in the rear of the turret roof; and a .30 caliber machine gun in the cupola. In addition, facilities were available for carrying two .45 caliber sub-machine guns in the turret.
CONCLUSIONS: The test vehicle did not have sufficient cooling properties for continual operation under load. With the hand brakes, the stopping distances on concrete and cross-country courses from road speed of 20 mph were found to be 54 feet and 56 feet five inches. It was recommended that the fan be redesigned to improve cooling, and detailed recommendations were made to improve tank design.
GENERAL: This 297-page report included one photograph of a wooden model and 37 photographs of the test vehicle and components.

SUBJECT: Tanks (Combat) APG 5535/2
TITLE: First Report on Heavy Tank M6A2 Loaded to 76.5 Tons

IDENTIFICATION: Second Report on Ordnance Program No. 5535; APG 10-182
DATE OF REPORT: 3 October 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance and reliability of the Heavy Tank M6A2 when loaded to 76.5 tons
METHOD: The tank, first loaded to 143,800 pounds and later to 153,100 pounds, was given 273 miles of test operation, most of which was on gravel.
DESCRIPTION: The test vehicle was a standard Heavy Tank, M6A2, (Serial No. 24) powered by a 700-hp engine.
CONCLUSIONS: The over-all performance and reliability of the vehicle were not considered satisfactory. Reasonable performance and reliability could only be attained on improved surface roads having grades not in excess of 2%. Power and suspension were not adequate for good performance on rough terrain, and the high unit ground pressure on the track prevented good performance on soft terrain. It was recommended that no further consideration be given to any modification that would increase the gross weight of the Heavy Tank M6.
GENERAL: This seven-page report contains four photographs showing the test vehicle and damaged track guides and bogie wheels.

SUBJECT: Tanks (Combat) APG 5535/3
TITLE: First Report on Test of Heavy Tank T1E1
IDENTIFICATION: Third Report on Ordnance Program No. 5535 — APG 10-136
DATE OF REPORT: 17 November 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop and test a pilot model of the T1E1 Heavy Tank with electric drive
METHOD: Final assembly and installation of the engine and electric drive were done by General Electric, under the supervision of Aberdeen personnel. Much of the development work carried over into the test program, at Aberdeen, in which 1132 miles of varied operation and 255 engine hours, were logged. Comprehensive studies were made of the drive system and of the durability and performance characteristics of the tank itself.
DESCRIPTION: The T1 Heavy Tank series was the experimental form of the M6 Heavy (60 ton) Tank. The T1E1 was unique in that it incorporated an electric drive. A Wright Cyclone (G-200), 775-horsepower, radial, gasoline engine of 1823 cubic-inch displacement was used in all the T1 (M6) series. In the T1E1, the engine served to drive a 500-volt generator, which, in turn, supplied power to two traction motors geared to the final drive sprockets. These motors were arranged at right angles to the sprockets in the rear of the engine compartment. The generator was mounted on the rear of the engine and, when installed, was positioned above and between the motors. Three Amplidyne exciters, driven from the generator shaft provided sensitive field control for the generator and motor fields. The T1 Tank suspension was of the horizontal volute spring type, shielded by a skirt of one-inch armor.
CONCLUSIONS: The T1 series heavy tanks were not reliable mechanically, and ballistic protection was not adequate for the type of combat vehicle. The mobility and maneuverability furnished by the electric drive system were satisfactory. One of the chief sources of failure was the suspension system. The armor skirt interfered with maintenance and prevented the normal escape of the dirt thrown into the suspension components. This trapped dirt caused excessive wear and track throwing.
GENERAL: This 579-page report contains 112 photographs of the test vehicle components and failures.

SUBJECT: Tanks (Combat) APG 5560/1
TITLE: First Report on Pilot Light Tank M3E2 (Light Tank M3 Serial Number 752)
IDENTIFICATION: First Report on Ordnance Program Number 5560; APG 10-58
DATE OF REPORT: 18 December 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the pilot model Light Tank, M3E2, with a view to adapting the power train to similar light tanks
METHOD: The test vehicle was operated for a total of 3120 miles at General Motors Proving Ground on acceleration, noise, general performance, and durability tests. The vehicle was then driven over-land 561 miles to Aberdeen, where subsequent tests included 75 miles of cross-country and 125 miles of operation on hard surfaced roads. About 70% of mileage at Aberdeen was for cooling tests and was done at full load, full throttle, at speeds varying from three to 18 miles per hour. All tests were made in accordance with T.S.T.P. 1935-709.
DESCRIPTION: The test vehicle weighed 30,500 pounds, was powered by twin Cadillac engines and equipped with dual hydramatic transmissions.
CONCLUSIONS: In general, the performance of the Light Tank, M3E2, was satisfactory, and in several respects, performance was superior to that of the Light Tanks M2A4 and M3 with either Continental or Guiberson Engines. It was recommended that 6500-pound springs for the trailing idlers be considered standard for Light Tanks having the twin Cadillac installation and that the trailing idler arm and flange on the idler wheel be strengthened. It was further recommended that consideration be given to the use of heavier brake drums, to larger generator capacity to accommodate additional electrical equipment necessary for a proposed integrated fighting compartment, and to a positive lock-up on the fluid drive to facilitate crossing vertical obstacles. Further development and testing were recommended on the front air inlet and on the radio equipment.
GENERAL: This 127-page report contains 22 photographs, a sketch of the vertical air cleaner, and two automotive laboratory reports, including a sketch of the engine water-cooling and hydramatic oil-cooling system.

SUBJECT: Tanks (Combat) APG 5560/2
TITLE: First Addendum to First Report on Test of Pilot Light Tank M3E2 (New Designation —

Light Tank M3E3)
IDENTIFICATION: Second Report on Ordnance Program No. 5560; APG 10-58-1
DATE OF REPORT: 4 April 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the integrated fighting compartment installed in the Light Tank M3E3
METHOD: Firing tests were conducted in accordance with Feature 22 of TSTP 1935-709, which had been omitted from the tests covered in the First Report, on an approximately straight-in course of 150 to 900 yards. The target used was a stationary wooden silhouette of the light tank. Vehicle speed ranged from eight to 15 mph, and a total of 47 rounds was fired.
DESCRIPTION: The test Light Tank M3E3 contained the chassis and parts of the upper hull of the Light Tank M3E2. Equipment similar to that of the Light Tank M3A1, but relocated, included: Oilgear power and hand traverse gear box at the rear of the turret; a different mounting arrangement of the Oilgear and stabilizer pumps and driving motors; the elimination of the rear basket support strut, and relocation of a 13-round, 37mm ammunition rack. The turret was fitted with the combination Gun Mount M23 mounting the 37mm Gun M6 and a cal. .30 machine gun.
CONCLUSIONS: The test vehicle was considered superior to the Light Tank M3 with regard to stability of firing platform, and superior as a fighting vehicle to other light tanks. The armament was satisfactory except for interference between the gun mount recoil guard and the hand traverse crank, awkward arrangement for shifting from hand to power traverse, and the unsatisfactory sighting linkage between gun mount and periscope. Recommendations were made for correcting these conditions as well as for providing an independent electrical gun-firing circuit; enlargement of turret top hatches; an armored, controlled ventilator; protective armored louvers for the engine cooling air intake; and more adequate lighting in the hull and turret. It was recommended that the following be considered: determination of the danger to ammunition of heat produced by the auxiliary power unit; the elimination of the hand traverse control; shock tests of generator voltage and current regulators; the redesign of the direct vision device for maximum protection; and redesign of front fenders for greater protection of the driver from dust, sand, and mud.
GENERAL: This 21-page report contains 18 photographs of the vehicle with details of the turret and mount.

SUBJECT: Tanks (Combat) APG 5562/1
TITLE: First Partial Report on British Cruiser Tank Mark VIA
IDENTIFICATION: First Report on Ordnance Program No. 5562; APG 10-65
DATE OF REPORT: 6 March 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance and to obtain design data of British Tank Mark VIA
METHOD: The British Mark VIA Tank was test-operated in accordance with T.S.T.P. 1935-709. Detailed observations of individual tank components were made and listed.
DESCRIPTION: Cruiser Tank Mark VIA was a full, track laying, armored vehicle weighing 40,000 pounds. This vehicle was powered by a rear-mounted, V-12, Nufield engine rated at 340 hp at 1550 rpm. Power was transmitted through a short propeller shaft to a constant-mesh Wilson transmission, and then through an epicyclic train to the final drive and sprockets. A Christie-type suspension with five wheels on each side was used. Armament consisted of one 40mm cannon, one 2-inch smoke mortar, two B.E.S.A. 7.92mm machine guns, and a Bren .303 machine gun.
CONCLUSIONS: The general performance of the test vehicle was good. The automotive-type engine merited consideration as a tank power plant. The transmission was considered inadequate because it lacked synchromesh equipment. The large, single, track guide warranted consideration for possible use on American tanks. It was recommended that the low silhouette, and turret design, the placement of driver's controls, and periscope and sighting devices be studied for possible adaption to American tanks.
GENERAL: This 300-page report includes 37 photographs of the Mark VIA tank and a complete 140-page manufacturer's description and maintenance manual.

SUBJECT: Tanks (Combat) APG 5568/3
TITLE: First Report on Medium Tank M4A2, No. 2420 — Acceptance Test
IDENTIFICATION: Third Report on Ordnance Program No. 5568; APG 10-90
DATE OF REPORT: 29 October 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of Medium Tank M4A2
METHOD: The vehicle was given a standard acceptance test consisting of a mechanical inspection, 443 miles of operation, and functional firing tests.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 2420, was manufactured by the Fisher Tank Division of General Motors Corporation. It was powered by a General Motors 6046 twin diesel engine. Armament consisted of a 75mm gun, one .50 cal. AA machine gun, and two .30 cal. machine guns.
CONCLUSIONS: The manufacturing quality of the vehicle was found to be of low quality. Numerous items of stowage and equipment were either omitted, poorly made, or improperly located. It was recommended that deficiencies be corrected and that the manufacturer check the vehicles more closely. Design studies were recommended to improve the oil level indicator, the bow machine gun sights, the turret hatch lock, and the throttle and siren controls.
GENERAL: This 46-page report is not illustrated.

SUBJECT: Tanks (Combat) APG 5568/10
TITLE: First Report on Test of Medium Tank M4A2

TANK AUTOMOTIVE TEST RESUMES

IDENTIFICATION: Report No. 10 on Ordnance Program No. 5568; APG 10-96
DATE OF REPORT: 24 November 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine and evaluate the military and automotive characteristics of a pilot model of Medium Tank M4A2
METHOD: The vehicle was operated 1138 miles over various test courses at Aberdeen Proving Ground. Ballistics tests on the armored intake air louvers and engine splash shield were conducted, and a performance test was made of the Delco-Remy Voltage Regulator.
DESCRIPTION: The test vehicle was the Medium Tank, M3A4, which was similar to the Medium Tank, M3A5, with the exception of the hull construction and armament location. The M4A2 hull was welded instead of riveted and its principal weapon was a 76mm gun, M3, located in a cast turret permitting 360° traverse for the gun. The vehicle was equipped with a gyrostabilizer and a power traversing system. The power plant was a General Motors model 6046 twin diesel engine.
CONCLUSIONS: It was concluded that the test vehicle was superior to the Medium Tanks M3 and M3A5 and that the GM Model 6046 engine was as reliable as the Wright R975-C1 engines. The voltage regulator, air cleaners, intake air louvers, and the engine cooling system were unsatisfactory. It was recommended that Donaldson B-1000 and AC A21024 air cleaners be used on the model 6046 engine, a thorough engine cooling test be conducted, and an attempt be made to simplify engine removal.
GENERAL: This 199-page report includes 24 photographs of the vehicle, components, and voltage regulator test setup.

SUBJECT: Tanks (Combat) APG 5568/15
TITLE: First Report on Medium Tank M4A2, No. 1407, Acceptance Test
IDENTIFICATION: Fifteenth Report on Ordnance Program No. 5568; APG 10-104
DATE OF REPORT: 9 January 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of Medium Tank M4A2
METHOD: The vehicle was given a standard acceptance test consisting of an initial mechanical inspection, approximately 500 miles of operation on gravel and concrete roads, a functional firing test of the armament, and a final mechanical inspection.
DESCRIPTION: The test production Medium Tank M4A2, Serial No. 1407, was powered by a General Motors 6046, twin diesel engine and weighed 66,650 pounds. It was equipped with a one-piece caterpillar tractor power train. The tank mounted a 75mm Gun, M3, in Combination Mount M34 and incorporated a gyrostabilizer and a Westinghouse electric traversing mechanism. Secondary armament included a cal. .50 antiaircraft machine gun.
CONCLUSIONS: The vehicle was a whole met satisfactory automotive standards, although it was pointed out that insufficient consideration had been given to the military characteristics, particularly to care in installing of the gyrostabilizers, assembling of the traversing mechanism, and making proper stowage arrangements. Design weaknesses were considered of a minor nature, indicating chiefly the need for reinforcement of the traveling lock clevis on the Combination Mount M34, changing the location of the antiaircraft machine gun, and eliminating the sub-floor behind the assistant driver's seat and over the escape hatch. It was recommended that greater care be exercised by the manufacturer in future production to correct the manufacturing defects, and that changes be made to improve the weaknesses noted in design.
GENERAL: This 56-page report contains nine photographs showing unsatisfactory features of the vehicle.

SUBJECT: Tanks (Combat) APG 5568/16
TITLE: First Report on Medium Tank, M4A1 #25901 (Lima Locomotive Company) Acceptance Test
IDENTIFICATION: Sixteenth Report on Ordnance Program No. 5568; APG 10-101
DATE OF REPORT: 23 December 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine manufacturing and design discrepancies in the Medium Tank, M4A1
METHOD: The test vehicle was operated 575 miles during routine acceptance tests. These tests included mechanical inspection, proof firing, and alignment tests before and after road tests, runs to test braking and cooling, a strategic 80-mile run, and a seven-hour continuous run.
DESCRIPTION: The test vehicle, weighing 60,000 pounds, was a Medium Tank M4A1, powered by a Continental R975-C1 engine, and incorporating a three-piece transmission. Armament consisted of a 75mm Gun M3 and a cal. .30 machine gun, in Combination Mount M34 controlled by a gyrostabilizer.
CONCLUSIONS: The manufacturing quality of the vehicle was high. However, discrepancies were noted as follows: straps for the machine gun, tripod bracket and windshield brackets were missing, and inferior material and workmanship were noted in many locations. Design weaknesses were interference between the parking brake lever and the cal. .30 ammunition storage box and inadequate braces of the engine manifold and muffler supports. It was recommended that the manufacturer check more closely to eliminate manufacturing discrepancies and that studies be made to correct design faults.
GENERAL: This 57-page report contains four photographs showing misalignment of the exhaust manifolds and mufflers and unsatisfactory parts.

SUBJECT: Tanks (Combat) APG 5568/18
TITLE: First Report on Test of Medium Tank M4A1, No. 3005 (Pacific Car and Foundry) with Continental R975-C1 Engine
IDENTIFICATION: Eighteenth Report on Ordnance Program No. 5568; APG 10-112 (Project No. 3-23-4)
DATE OF REPORT: 5 February 1943

ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine any manufacturing deficiencies in the Medium Tank M4A1, No. 3005, and to determine its airflow cooling characteristics
METHOD: The usual mechanical inspection of new vehicles was made, and the vehicle checked against drawings for manufacturing discrepancies. Airflow tests were made with various types of air intake louvers and with varied cooling air exit conditions to determine the effects on the quantity of cooling air circulated. Additional tests were made using a DeBothezat steel fan. Standard, full-load, cooling tests were made with the R975-C2 engine as originally installed in the vehicle and were repeated with a low compression R975-C1 engine.
DESCRIPTION: The test vehicle was a pilot Medium Tank, M4A1, which differed from other tanks of the M4 series in having a cast hull and an R975, radial, air-cooled, tank engine. The DeBothezat fan consisted of sheet steel plates welded to a ring which bolted to the flywheel; it produced 7400 cfm.
CONCLUSIONS: The general construction and assembly of the vehicle were considered good. Manufacturing deficiencies noted consisted mainly of omission of stowage items or brackets. The production air intake louvers proved as efficient as any other type tested. The DeBothezat fan gave superior performance, producing 10% more cooling air and lowering the maximum head temperature 25°F. Full-load cooling tests on the C1 and C2 engines showed them to have similar cooling characteristics. It was recommended that no change be made in the present air inlet opening to increase airflow, that either the C1 or C2 engine might be used in the vehicle, and that the DeBothezat fan be adopted for use.
GENERAL: This 94-page report contains seven photographs of the test vehicle and an Automotive Laboratory Report on the determination of cooling.

SUBJECT: Tanks (Combat) APG 5568/21
TITLE: First Report on Medium Tank M4A1, No. 6905
IDENTIFICATION: Twenty-first Report on Ordnance Program No. 5568; APG 10-113
DATE OF REPORT: 25 February 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine any manufacturing deficiencies and design weaknesses in the Medium Tank M4A1, No. 6905
METHOD: The tank was given a standard acceptance test, which consisted of an initial mechanical inspection, approximately 500 miles of operation on gravel and concrete roads, a functional test of the armament, and a final mechanical inspection.
DESCRIPTION: The test vehicle was a standard production Medium Tank M4A1 powered by a Continental R975-C1 engine and used a Caterpillar transmission and final drive. The vehicle mounted a 75mm Gun M3, was equipped with a gyrostabilizer, a hydraulic traversing mechanism, and an auxiliary generator.
CONCLUSIONS: The test Medium Tank M4A1 met automotive and military standards. However, there were major failures of the transmission and gyrostabilizer, which were attributed to various component manufacturers, and numerous minor discrepancies resulting from carelessness of the vehicle manufacturer. Unsatisfactory design features were encountered in the fuel pump, auxiliary generator motor, and various hatch locks. It was recommended that in future production, more critical inspection be made of component parts and assemblies of other manufacturers, and that more rigid care be taken by the vehicle manufacturer and Army Inspector in control of quality and compliance to specifications.
GENERAL: This 52-page report contains five photographs of failed parts and unsatisfactory features of the test vehicle.

SUBJECT: Tanks (Combat) APG 5568/22
TITLE: First Report on Test of Medium Tank M4A4, Pilot
IDENTIFICATION: Twenty-second Report on Ordnance Program No. 5568; APG 10-111 (Project No. 3-26-1)
DATE OF REPORT: 18 February 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a Chrysler multi-bank engine in the Medium Tank M4A4
METHOD: The vehicle was tested in accordance with nine features of TSTP 1935-709 relating to engine operation and adaptability. In addition it was given the standard mechanical inspection and a 1000-mile operation for a test of the suspension.
DESCRIPTION: The test pilot Medium Tank M4A4, No. 3, was powered by a Chrysler multi-bank engine and weighed 63,875 pounds. It was equipped with a five-speed transmission and vertical volute spring suspension. Armament consisted of a 75mm gun and a cal. .30 machine gun in the turret, a cal. .30 machine gun in the bow, a cal. .50 machine gun in the turret cupola, and a cal. .45 submachine gun.
CONCLUSIONS: The operation of the vehicle in general was satisfactory. The engine furnished adequate power, but continued failures required constant attention. Maintenance was made difficult by the crowded engine compartment, complexity of the ignition system, the necessity of removing the entire power plant to replace cylinder head gaskets, and the inaccessibility of the engine radiator for cleaning. The overloaded condition of the water pumps and drive belts and clogging of the engine cooling radiator with dirt interfered with cooling. The suspension was considered more desirable than that of the Medium Tank, M3, because components were more easily replaceable. It was recommended that redesign be made which would correct the maintenance difficulties and reduce failures, and that redesign also be made in an effort to reduce the weight of the power plant.
GENERAL: This 122-page report contains 13 photographs of the tank and unsatisfactory features, and one Automotive Laboratory Report on the determination of drawbar pull, acceleration, and cooling characteristics.

TANK AUTOMOTIVE TEST RESUMES

SUBJECT: Tanks (Combat) APG 5568/23
TITLE: First Report on Medium Tank M4A2, No. 1906 Acceptance Test
IDENTIFICATION: Twenty-third Report on Ordnance Program No. 5568; APG 10-109
DATE OF REPORT: 18 February 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine quality level and inherent design weaknesses of test vehicle and its components
METHOD: The acceptance test consisted of an initial mechanical inspection, approximately 500 miles of test operation on gravel and concrete roads, a functional test of armament, and a final mechanical inspection.
DESCRIPTION: The test vehicle was a Medium Tank M4A2 manufactured by the Baldwin Locomotive Works, Eddystone, Pennsylvania. It was powered by a General Motors 6-71 Twin Diesel engine, had a Caterpillar Tractor Company transmission and final drive, a Westinghouse Electric Gyrostabilizer and Traversing Assembly. The armament included a 75mm Gun, M3.
CONCLUSIONS: The test vehicle was not built to satisfactory automotive or military standards. Major discrepancies attributed to component manufacturers included; faulty transmission gears, faulty pump in the gyrostabilizer mechanism, poor rubber moulding in track shoes, and careless assembly of oil pressure gages in panels. Various minor discrepancies attributed to poor workmanship were: poor welding, peeling of paint, and poor adjustments. Six design discrepancies were also noted including inadequate turret traveling lock and hatch locks, troublesome wiring arrangement to battery, inaccessible master switches, inadequate suspension bushings, confusing oil and fuel gages, and uncomfortable driver's seat. Recommendations included measures to correct all conditions causing discrepancies.
GENERAL: This 73-page report includes 12 photographs of failed components.

SUBJECT: Tanks (Combat) APG 5568/24
TITLE: First Report on Medium Tank, M4A2, No. 1915, Acceptance Test
IDENTIFICATION: Twenty-fourth Report on Ordnance Program No. 5568; APG 10-108
DATE OF REPORT: 12 February 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the quality level and inherent design weaknesses of the Medium Tank M4A2
METHOD: The vehicle was given a mechanical inspection and operated 450 miles on various test courses.
DESCRIPTION: The test Medium Tank M4A2 was manufactured by the Baldwin Locomotive Works. It was equipped with a GM 6-71 twin diesel engine. Caterpillar Tractor Company transmission, Westinghouse gyrostabilizer, and a 75mm Gun M3.
CONCLUSIONS: It was concluded that, except for an alarming condition of the gyrostabilizer which would not support the gun in the elevated position, the vehicle was built to a high standard of manufacture. However, a number of minor manufacturing discrepancies and design weaknesses were noted. It was recommended that the manufacturer and the Army Inspector of Ordnance more closely inspect the vehicles during manufacture and assembly.
GENERAL: This 46-page report includes three photographs of the worn and damaged vehicle components.

SUBJECT: Tanks (Combat) APG 5568/27
TITLE: First Report on Medium Tank M4, 105 MM Howitzer Installation Development and Test of
IDENTIFICATION: Twenty-seventh Report on Ordnance Program No. 5568; APG 10-121
DATE OF REPORT: 17 June 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitabiliy of the installation of a 105mm howitzer in the Medium Tank M4
METHOD: After installation of a 105mm howitzer in the Medium Tank M4A4, No. 5868, an endurance firing program of 308 rounds was conducted to determine brinelling of the turret race. A jump firing program of 44 rounds was also conducted. Tests were performed with the howitzer mounted two inches to the left of the center of the turret and comparative tests made with the gun mounted on the center line. A 200-mile cross-country test was made to determine structural weaknesses; proof firing was conducted to determine the maximum elevation at which the gun would return to battery; and tests were made to determine the torque requirement to traverse the turret on a 30% slope.
DESCRIPTION: The test vehicle was a Medium Tank M4A4 modified for ammunition and stowage, and mounted a 105mm Howitzer M2A1 in Combination Mount T70 as its principal weapon in the turret.
CONCLUSIONS: The howitzer could be served under combat conditions, but the size of the weapon and ammunition cramped the crew. Need was indicated for fire control equipment and an adequate telescopic sight on the combination mount. Results of firing indicated there was no great danger of brinelling in the turret race. The gyrostabilizer proved unnecessary and the elevating mechanism was not strong enough to withstand continuous cross-country operation. A torque of 2000 pounds-feet would not traverse the turret 360° on a 30% slope, and neither the standard nor modified electric traversing mechanism had sufficient power. Moving the howitzer two inches to the left of center of the turret would provide no advantage. The howitzer would return to battery satisfactorily at elevations up to 51-1/2 degrees. It was recommended that after modifications to correct the inadequacies noted, the vehicle be considered suitable for service.
GENERAL: This 159-page report includes three photographs of the equipment tested.

SUBJECT: Tanks (Combat) APG 5568/31
TITLE: Second Report on Temperature Reduction of Three-Piece Medium Tank Power Train
IDENTIFICATION: Thirty-first Report on Ordnance Program No. 5568; APG 10-125

DATE OF REPORT: 12 July 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine a means of eliminating high operating temperatures from medium tank power trains
METHOD: A Medium Tank M3A1, utilizing a modified three-piece power train, was given 1843 miles of test operation over cross-country, gravel and paved roads.
DESCRIPTION: The test Medium Tank M3A1 power train consisted of a standard three-piece power train modified to operate with a single oil sump, and a reduced oil level; and with a jet oil stream directed to the brake drums, differential needle bearings, and at the intersection of the bevel ring and pinion gears.
CONCLUSIONS: It was recommended that the single oil sump, reduced oil level, and the jet lubricating system be utilized in Medium Tank, three-piece, power trains already in the field. Further observation and investigation were suggested to determine whether slightly greater clearances between the differential compensating pinion gear shaft needle bearings and their housings would permit sufficient self-alignment to prevent failures when the housing misalignment became excessive.
GENERAL: This 193-page report contains 16 photographs and Automotive Laboratory Report No. 43-96 entitled "Braking Characteristics of Medium Tank M3A1 No. 1962 with Power Train Jet Lubrication and Low Oil Level."

SUBJECT: Tanks (Combat) APG 5568/32
TITLE: First Report on Medium Tank M4, Improvement of Combat Efficiency
IDENTIFICATION: Thirty-second Report on Ordnance Program No. 5568; APG 10-128
DATE OF REPORT: 11 August 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To improve the combat effectiveness of Medium Tank M4 through relocation of components within the tank
METHOD: Experimental changes were made in the location of components in the tank, and functional firing tests were made to determine interference.
DESCRIPTION: The test vehicle was Medium Tank M4A1, Ordnance Serial No. 7066.
CONCLUSIONS: Elimination of the turret basket provided additional room for the crew and was recommended. Seats, foot rests, and hand-holds were also recommended for crew members. Relocation of numerous stowage items was recommended. Attempts to install a 76mm gun in the M4A1 Turret were unsuccessful, and further development of this installation was recommended.
GENERAL: This 100-page report contains 26 photographs of component modifications and stowage arrangement.

SUBJECT: Tanks (Combat) APG 5568/42
TITLE: First Report on British Centaur and Cromwell Tanks, Medium Tank M4A3 Comparative Test of
IDENTIFICATION: Forty-second Report on Ordnance Program No. 5568; APG 10-141
DATE OF REPORT: 24 March 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the relative performance and mechanical reliability of the British Cromwell, British Centaur, and U.S. Medium Tank M4A3
METHOD: The three tanks were tested according to 13 features of T.S.T.P. 1935-709, second revision, including continuous operation and firing tests.
DESCRIPTION: The British Centaur tank was a full track laying vehicle incorporating a Christie-type coil spring suspension, Merritt-Brown transmission, and a 500-hp Ford GAY, V-8, water-cooled engine. A six-pounder gun was mounted in a 360° traverse turret, and supplemental armament consisted of two 7.92 mm Besa Machine guns. The Cromwell tank was essentially the same vehicle except that it used a 600-hp Rolls Royce, V-12, water-cooled engine. The Medium Tank, M4A3, was a standard production vehicle.
CONCLUSIONS: Although the Rolls Royce engine in the Cromwell tank delivered more power, and the Merritt-Brown transmission permitted greater maneuverability in some circumstances, it was concluded that, in general, both of the British tanks were inferior to the Medium Tank M4A3, particularly in the lack of mechanical reliability. A theoretical comparison indicated that the British system of fire control might be superior to that of the M4. It was recommended that the Medium Tank, M4A3, be considered suprior to the British Centaur and Cromwell tanks without further testing.
GENERAL: This 163-page report contains 22 photographs of the engine and components, showing details and failed parts, and 14 photostats of schematic diagrams of the British Cromwell tank components.

SUBJECT: Tanks (Combat) APG 5621/1
TITLE: First Report on Assault Tank T14
IDENTIFICATION: First Report on Ordnance Program No. 5621; APG 10-139
DATE OF REPORT: 28 February 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a pilot model of the Assault Tank T14
METHOD: The first pilot was tested according to 13 features of TSTP 1935-709. The test of the second pilot consisted of operating the vehicle approximately 500 miles to determine its reliability. During the test, several modifications were made, primarily in the accessibility of parts and accessories within the engine compartment and the location of the air intake openings.
DESCRIPTION: The test vehicle was heavily armored, weighed approximately 47 tons, and was powered by a liquid-cooled, Ford V-8 engine rated at 500 hp at 2600 rpm. Its power train was identical to that of the Medium Tank M4. Armament consisted of a 75mm gun and a cal. .30 machine gun mounted in the bow, and a cal. .50 machine gun mounted on top of the turret. Tracks and suspension were similar to those of Heavy Tank, M5, with three bogie assemblies on each side.
CONCLUSIONS: The Assault Tank, T14, was considered unsatisfactory. A series of 64 deficiencies

was encountered embracing ten major components of the tank as well as stowage, tractive resistance, drawbar characteristics, comfort and safety of the crew, maneuverability, and operation. It was recommended that the T14 be given no further consideration in its present stage of development, and that the modification of all deficiencies noted be incorporated in another test vehicle if further consideration was to be given.
GENERAL: This 173-page report contains 32 photographs of the tank, and damaged and failed parts, a photostat of a drawing of a steering improvement used in tests, and one Automotive Laboratory Report.

SUBJECT: Tanks (Combat) APG 5633/1
TITLE: First Report on Test of Pilot Medium Tank M3A5E1
IDENTIFICATION: First Report on Ordnance Program No. 5633; APG 10-67
DATE OF REPORT: 27 March 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of a pilot model Medium Tank, M3A5E1, equipped with a Hydramatic Transmission
METHOD: Performance tests conducted on the test vehicle included slope operation, maximum and minimum speeds, drawbar pull, acceleration, fuel consumption, and resistance to traction. In addition, the vehicle was operated for 1377 miles over various types of terrain on an endurance test schedule.
DESCRIPTION: The Medium Tank, M3A5E1, was a modified M3 production vehicle. Modifications included the installation of two GMC 6-71 diesel engines and two, five-speed Hydramatic transmissions. Both engines were left-hand and were rated at 375 hp at 2500 rpm. The two side plates and rear plate of the hull were extended downward to provide armor protection.
CONCLUSIONS: The test vehicle performance, including acceleration, driver comfort, firing platform stability, and mobility, was superior to Medium Tanks M3, M3A1, M3A2, and M3A5. The basic modifications to the test tank and the design of the heavy-duty Hydramatic transmissions were considered sound, but further studies of the transmission and other automatic transmission systems were recommended before acceptance for use.
GENERAL: This 138-page report contains 25 photographs of the test vehicle and its component parts.

SUBJECT: Tanks (Combat) APG 5639/1
TITLE: First Report on Light Tank, M3A1, #5260 (Diesel) Acceptance Test
IDENTIFICATION: First Report on Ordnance Program No. 5639; APG 10-100
DATE OF REPORT: 11 December 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine any manufacturing and design discrepancies, or defects of the Light Tank, M3A1, No. 5260
METHOD: The test vehicle was given routine acceptance tests, which included two 100-mile runs at part throttle, an 80-mile operation over hard-surface road, a seven-hour continuous operation test, and functional and proof firing tests.
DESCRIPTION: The test vehicle consisted essentially of a Light Tank, M3, with an integrated fighting compartment and a radial, diesel engine. Fully stowed, the vehicle weighed 28,400 pounds. Armament consisted of a 37mm gun in the turret, one cal. .30 coaxial machine gun, a cal. .30 machine gun in the bow, a cal. .30 antiaircraft machine gun, and a cal. .45 submachine gun.
CONCLUSIONS: The test Light Tank, M3A1, was not manufactured to acceptable automotive and military standards. Among the most undesirable features were insufficient stowage space, unsatisfactory engine operation, and improper setting of the voltage regulators. Design was defective especially in 37mm fire control and provision for the proper charging rate of the engine generator and the auxiliary generator. It was recommended that in future production, closer manufacturing and military inspection be given to insure satisfactory performance and that studies be undertaken to correct a series of 15 design defects.
GENERAL: This 105-page report contains four photographs of the vehicle and a schematic diagram of the muffler installation.

SUBJECT: Tanks (Combat) APG 5639/2Min
TITLE: First Minor Report on Light Tank M3A1
IDENTIFICATION: Second Minor Report on Ordnance Program No. 5639; APG 10-80
DATE OF REPORT: 15 August 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop a suitable mechanism that would open the assistant driver's door for the purpose of an emergency escape
METHOD: A pilot design, developed by the Ordnance Office, was installed in a Light Tank M3A1. The mechanism was tested for speed, effort required for operation and simplicity of installation.
DESCRIPTION: The assistant driver's door opening mechanism, developed by the Ordnance Office, consisted of a hand-operated linkage assembly, one end of which was welded to the right side of the assistant driver's door. The linkage could be locked in escape position with a pin.
CONCLUSIONS: The test door opening mechanism, although requiring more effort than was desirable, was recommended as the best with respect to simplicity, speed, and convenience. The mechanism was recommended for installation on all Light Tanks M3A1.
GENERAL: This 17-page report contains four photographs of the test door opening linkage.

SUBJECT: Tanks (Combat) APG 5639/2
TITLE: First Report on Light Tank, M3A1 Nos. 5998, 6111, 6128, 6164, and 6230, Acceptance Test
IDENTIFICATION: Second Report on Ordnance Program No. 5639; APG 10-99
DATE OF REPORT: 12 December 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of five Light Tanks M3A1

METHOD: Five test vehicles made by the same manufacturer were operated on routine acceptance tests including a 600-mile road test and proof and functional firing tests.
DESCRIPTION: The test vehicle consisted of a Light Tank M3 with an integrated fighting compartment. The vehicle fully stowed and with crew weighed 28,400 pounds. Armament consisted of one 37mm gun in the turret, one cal. .30 coaxial machine gun, one cal. .30 machine gun in the bow, one cal. .30 antiaircraft machine gun.
CONCLUSIONS: The test Light Tank, M3A1, did not meet automotive and military standards. Many deficiencies in manufacture and design relating to the hull, suspension, armament, engine, and electrical system were reported. It was recommended that closer inspection be applied to future production vehicles, that attention be directed to all defects noted, and that studies be undertaken to correct design faults.
GENERAL: This 255-page report contains three photographs showing broken parts from a damaged generator and a schematic drawing of the muffler installation.

SUBJECT: Tanks (Combat) APG 5639/3
TITLE: Final Report on Light Tank M3A1 No. 9032
IDENTIFICATION: Third Report on Ordnance Program No. 5639; APG 10-103
DATE OF REPORT: 6 January 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine manufacturing deficiencies and design weaknesses in the Light Tank M3A1, No. 9032
METHOD: The test vehicle was given a standard acceptance test, which consisted of 500 miles of operation and proof and functional firing tests, with mechanical inspection before and after road operation.
DESCRIPTION: The test vehicle consisted essentially of a Light Tank M3 with an integrated fighting compartment and a radial, gasoline engine. The vehicle stowed and with crew weighed 28,000 pounds. Armament consisted of one 37mm gun in the turret, one cal. .30 coaxial machine gun, one cal. .30 machine gun in the bow, one cal. .30 antiaircraft machine gun, and one cal. .45 submachine gun.
CONCLUSIONS: Closer inspection of vehicles in production to eliminate poor assembly and adjustment of components was recommended. Design studies were recommended to provide better locations for components such as: drainage valves, 37mm gun sight, engine compartment fire extinguisher horn, binocular bracket, and grenade box. More clearance was required between the main armament guns and other nearby components to provide for ease of operation and gun recoil protection. An improved manual traversing mechanism and improved fire control items were also recommended.
GENERAL: This 45-page report is not illustrated.

SUBJECT: Tanks (Combat) APG 5639/4
TITLE: Final Report on Light Tank M3A1 No. 8873
IDENTIFICATION: Fourth Report on Ordnance Program No. 5639; APG 10-105
DATE OF REPORT: 13 January 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine any manufacturing deficiencies and design weaknesses in the Light Tank, M3A1, No. 8873
METHOD: The test vehicle was given the standard acceptance test, which consisted of 500 miles of operation and proof and functional firing tests, with mechanical inspection before and after road operation.
DESCRIPTION: The test vehicle consisted essentially of a Light Tank, M3, with an integrated fighting compartment and a Continental W-670 9A, gasoline engine. Armament consisted of a 37mm Gun, M3, in Combination Mount, M23.
CONCLUSIONS: It was recommended that a closer inspection be made of vehicles in future production to eliminate poor assembly and adjustments. It was further recommended that design studies be undertaken to provide better location of rear hull drainage valves, direct sight for the 37mm gun, engine compartment fire extinguisher horn, and binocular mounting bracket; to provide more clearance between the cal. .30 coaxial machine gun and gyrostabilizer unit, and between the manual traversing mechanism and the recoil guard of the 37mm gun; and to provide better protection from the recoil of the 37mm gun for the gunner and loader, smoother operating manual traverse for the turret, better parallel linkage from the periscopic sight to the 37mm gun, and a power traverse with a finer control adjustment.
GENERAL: This is a 36-page report without photographs.

SUBJECT: Tanks (Combat) APG 5663/1
TITLE: First Report on Test of Air-Borne Light Tank T9E1
IDENTIFICATION: First Report on Ordnance Program No. 5663; APG 10-116
DATE OF REPORT: 20 March 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine deficiencies in the second pilot model of Light Tank T9E1
METHOD: The vehicle was tested in accordance with TSTP 1935-709. Also, the firing mechanism and the hand traversing and elevating mechanisms were examined, and the combination mount was tested by firing the 37mm gun
DESCRIPTION: The test vehicle was the second pilot model of a Marmon-Herrington built, light, airborne tank. It weighed 16,400 pounds and was designed to accommodate a crew of three. This armored, full tracklaying vehicle was equipped with brackets, located above and to the rear of the bogie suspension, for attachment to a C-54 airplane. The T9E1 Tank was powered by a Lycoming O-435T, six-cylinder, air-cooled, horizontally opposed, gasoline engine rated at 168 hp at 2800 rpm. It had a fixed ratio transfer case, a four-speed transmission and a controlled differential. The armament consisted of a 37mm Gun M6 and one .30 caliber M1919A4 machine gun attached to Combination Mount T55.

CONCLUSIONS: A series of 16 conclusions were made concerning the durability and mechanical reliability of the vehicle, and six regarding installation and maintenance. Numerous design deficiencies were noted and recommendations made to correct them. These recommendations included: replacing button-type firing switches with electrically-operated, pistol grip, trigger switches, elimination of traversing over-running clutch, and modification of the gun mount.
GENERAL: This 403-page report includes 43 photographs of test vehicle components and German Light Tank PZKW1 handwheel mechanism and base ring. It also includes a detailed analysis of defective tank components.

SUBJECT: Tanks (Combat) APG 5663/2
TITLE: Second Report on Test of Air Borne Light Tank T9E1
IDENTIFICATION: Second Report on Ordnance Program No. 5663; APG 10-132
DATE OF REPORT: 9 December 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the acceptability of a production model of Air Borne Light Tank T9E1
METHOD: The vehicle was operated 2227 miles over various test courses.
DESCRIPTION: The test Light Tank, T9E1, weighed 16,200 pounds, was designed for transportation by air, and manufactured by the Marmon-Herrington Company. It was powered by a Lycoming O-435-T, air-cooled, 6-cylinder, horizontally opposed engine rated 168 hp at 2800 rpm. Armament consisted of a 37mm gun and a coaxial cal. .30 machine gun mounted in a rotating turret. The vehicle was front-sprocket driven and had a vertical volute spring suspension.
CONCLUSIONS: The test vehicle did not meet durability and maintenance standards and was considered unsatisfactory. However, with modifications, the vehicle would be satisfactory for limited use and limited mileage.
GENERAL: This 294-page report contains 50 photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) APG 5663/3
TITLE: Third Report on Ordnance Program No. 5663; APG 10-140
DATE OF REPORT: 10 March 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether a revised first gear ratio and final drive gear ratio would aid over-all performance of the Airborne Light Tank T9E1, and to determine whether the 37mm gun could be safely fired utilizing only the locking pins to secure the turret
METHOD: The test vehicle, equipped with the gears of revised ratio, was given 326 miles of operation over various terrain. Power characteristics were determined by slope operation and dynamometer tests. A firing program was conducted with the cap screws removed that secured the turret casting to the ball race ring.
DESCRIPTION: The test Light Tank T9E1 had the final drive gear ratio changed from 2.23:1 to 2.5:1 and the first gear ratio changed from 1.857:1 to 2.157:1.
CONCLUSIONS: With the revised gear ratios, the vehicle could negotiate slopes up to 60% when in forward or reverse gears. The revised gear ratios reduced maximum speed from 41.8 to 39.5 mph and increased the drawbar pull in second gear by 10%. It was found that the 37mm gun could be safely fired immediately upon assembly of the turret utilizing only the locking pins to secure the turret to the ball race ring. It was recommended that the revised gear ratios be considered satisfactory.
GENERAL: This 52-page report contains one photograph of the test vehicle.

SUBJECT: Tanks (Combat) APG 5680/1
TITLE: German Tank, Panther PzKpfw V, Test of
IDENTIFICATION: First Report on Ordnance Program No. 5680; APG 10-217
DATE OF REPORT: 26 March 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the characteristics of various components of the German, Panther, PzKpfw V tank for possible application in our future tank designs
METHOD: Limited operational and firing tests were conducted on the vehicle, before the tests were terminated by directive.
DESCRIPTION: The test vehicle, a German Panther tank, PzKpfw V, weighed 98,000 pounds stowed. It was powered by a Maybach, V-12, HL 230 P30 engine rated at 700 hp at 3000 rpm, and had synchromesh transmission and a controlled epicyclic differential. The vehicle had a front sprocket drive, and torsion bar suspension with eight interlaced road wheels on each side. The main armament was a 7.5 cm Tank Gun KwK42, with a hydropneumatic equilibrator.
CONCLUSIONS: Construction and mounting of the turret race offered characteristics favorable to reduce turret drift and ease of movement. The method of connecting the sight and gun was considered suitable for stabilized gun operation, and the equilibrator was considered to have excellent qualities. It was recommended that further firing tests be conducted on a stabilized gun having ballistic characteristics of the German 7.5 cm KwK42 Gun and ammunition to determine the desirability of using features of the telescope T2F12A in future sight development; that design, steel analysis, and heat-treatment methods used in German 7.5 cm APC, BC and HE projectiles be investigated; that the equilibrator design used on the 7.5 KwK42 Gun be further developed and tested on our tank guns; and that further study and comparison be conducted on the German Panther PzKpfw turret race for incorporation of desirable features in future tank turret designs.
GENERAL: This 190-page report contains 76 photographs of the German Panther Tank PzKpfw V, components, and projectiles, and drawings of the track tension and torsion bar spring adjustment. Drawings of the gun scavenger unit valve, intake-exhaust air system, cooling and ventilating systems,

turret compound thrust bearing, muzzle brake, and gun tube are included.

SUBJECT: Tanks (Combat) APG 5698/1
TITLE: First Report on Marmon-Herrington 3-Man Dutch Tank, Model CTMS-ITBI
IDENTIFICATION: First Report on Ordnance Program No. 5698; APG 10-144
DATE OF REPORT: 5 November 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a three-man Dutch tank for military use by the forces of the United States
METHOD: The test vehicle was subjected to a complete appraisal in order to help determine the disposition of several Dutch tanks, the contracts for which were purchased from the Netherlands Government.
DESCRIPTION: The test vehicle was fabricated by the Marmon-Herrington Company from 1/2-inch bolted armor plate. The power plant consisted of a six-cylinder Hercules RXLD gasoline engine, and the power train consisted of a conventional five-speed transmission, controlled differential, and final drive units. The suspension was the vertical volute spring type. Armament consisted of two cal. .30 machine guns mounted in the bow, and a 37mm gun and coaxial cal. .30 machine gun mounted in the turret. The turret was manually operated and had a traverse of 360°.
CONCLUSIONS: It was concluded that the vehicle was thoroughly unreliable, mechanically and structurally unsound, under-powered, and equipped with unsatisfactory armament. It was recommended that the vehicle be considered unsatisfactory for use by any Armed Force of the United States.
GENERAL: This 98-page report includes three photographs of the vehicle, one of a broken bogie arm face plate, and one Automotive Laboratory Report.

SUBJECT: Tanks (Combat) APG 5698/2
TITLE: First Report on Four-Man Dutch Tank, Model MTLS-1G14
IDENTIFICATION: Second Report on Ordnance Program No. 5698; APG 10-150 (Project No. 500/2-16-1)
DATE OF REPORT: 3 July 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Four-Man Dutch Tank MTLS-1G14 for military use by the U. S. Armed Forces
METHOD: The test vehicle was operated 362 miles over concrete, sand, gravel, cross-country, and obstacle courses.
DESCRIPTION: The 42,000-pound tank, powered by a 6-cylinder, liquid-cooled, 240-hp Hercules engine, was manufactured by the Marmon-Herrington Company. It had a five-speed transmission, controlled differential, and was front sprocket driven. Vertical volute spring suspension, with two bogie assemblies on each side, was used. Hull and turret consisted of flat plates bolted together. Armament included two 37mm guns and two cal. .30 machine guns mounted in the turret, and three cal. .30 machine guns mounted in the front of the hull.
CONCLUSIONS: The test vehicle was not suitable for military use by the U. S. Armored Forces. It was considered thoroughly unreliable, mechanically and structurally unsound and underpowered; and no further testing or development was recommended.
GENERAL: This 71-page report contains nine photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) APG 5709/1
TITLE: First Report on Light Tanks M3A3, M3A3E1, and M3A3E2
IDENTIFICATION: First Report on Ordnance Program No. 5709; APG 10-157
DATE OF REPORT: 13 September 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the performance characteristics of the three test tanks, special attention being given to the transmissions and engines
METHOD: The three test vehicles were similarly tested according to T.S.T.P. 1939-709. Light Tanks M3A3, M3A3E1, and M3A3E2 were operated for 215, 1427, and 2823 miles, respectively, over paved, gravel, and cross-country courses.
DESCRIPTION: With the exception of having a 1/16-inch thicker fighting compartment bulkhead to support a drop gear box, the hulls and suspensions of test Light Tanks M3A3, M3A3E1, and M3A3E2 were the same as those of standard production Light Tank M3A3. Light Tanks M3A3 and M3A3E1 were powered by 7-cylinder, radial, air-cooled, Continental W-670-9A engines; and Light Tank M3A3E2 was powered by a 9-cylinder, radial, air-cooled, Continental R950-1 engine with a net torque and power output 39.15% and 20.8%, respectively, greater than the W-670 series engine. All three tanks were equipped with a drop gear box between the engine and propeller shaft. The M3A3 utilized a synchro-mesh transmission, and the M3A3E1 and E2 vehicles used Spicer automatic torque converter transmissions. In addition, the M3A3E2 had improved steering brake shafts, dual steering and throttle controls, a transverse muffler across the cooling air outlet bustle, and an automotive-type starter and generator. The gear ratios of the drop gear boxes for the M3A3, M3A3E1, and M3A3E2 tanks were 1:1.000, 1:1.068, and 1:1.134, respectively.
CONCLUSIONS: The full-load performance of the M3A3E1 was better than that of the M3A3 and considerably poorer than that of the M3A1E2. The M3A1E1 and M3A1E2 were also easier to operate. All three vehicles exhibited unsatisfactory full-load engine cooling characteristics. The R950-1 engine was superior to the W-670-9A engine. The Spicer transmission was unsatisfactory. It was recommended that a transmission unit similar to the one tested but having a hydraulic, semi-automatic, shifting system be considered, as well as the adoption of the Continental R975-C4 engine.
GENERAL: This comprehensive 350-page report

contains 79 photographs of test components, numerous performance curves, and design prints.

SUBJECT: Tanks (Combat) APG 5717/1
TITLE: First Report on Medium Tank T23, First Production Pilot
IDENTIFICATION: First Report on Ordnance Program No. 5717; APG 10-152
DATE OF REPORT: 2 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the production pilot model of an electric drive Medium Tank T23
METHOD: The test vehicle was operated 3791 miles over various test courses.
DESCRIPTION: The test Medium Tank T23, manufactured by the Chrysler Corporation, was a 73,900-pound, rear sprocket driven vehicle with vertical volute spring suspension. Power was supplied by a Ford GAN, V-8, gasoline engine rated 500 hp at 2600 rpm. An "electrical power train" was used instead of conventional mechanical power train. The electrical power train consisted of a General Electric direct current power generator, driven by the vehicle engine, and two General Electric propulsion motors located at the drive sprockets. The propulsion motors could drive or brake the tracks individually over a full range of speed. The test vehicle armament consisted of a 76mm gun, two .30 cal. machine guns, and a .50 cal. AA machine gun.
CONCLUSIONS: The performance characteristics of the vehicle were generally satisfactory, and in many instances superior to standard vehicles. However, in its present stage of development, the vehicle was unsatisfactory for combat purpose because of an inadequate suspension system. Further study of the maintenance and durability of the electric power train was recommended.
GENERAL: This 279-page report contains 31 photographs of the vehicle and the condition of component parts after operation. Eight drawings of various vehicle parts and Automotive Laboratory Reports No. 44-22, 44-28, and 44-47 are included.

SUBJECT: Tanks (Combat) APG 5717/3
TITLE: First Report on Medium Tank T23 Laboratory Test to Determine Power Train Output and Efficiency and Investigation of Resistance to Traction and Resistance to Propulsion
IDENTIFICATION: Third Report on Ordnance Program No. 5717; APG 10-201
DATE OF REPORT: 6 February 1946
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the power train output and efficiency of an electric drive Medium Tank T23; and to determine the resistance to both traction and propulsion of the test vehicle under various operating conditions
METHOD: The test vehicle was installed on a laboratory sprocket dynamometer and the sprocket horsepower and torque were determined. Following the laboratory testing, the vehicle was operated on hard-surfaced road to determine resistance to propulsion and resistance to traction.
DESCRIPTION: The test vehicle weighed 74,500 pounds, had vertical volute spring suspension, and was powered by a Ford GAN-C, V-8, liquid-cooled, gasoline engine rated at 500 bhp at 2600 rpm. This engine operated a General Electric generator which supplied electrical power to a propulsion motor mounted at each drive sprocket.
CONCLUSIONS: At an equivalent vehicle speed of 8.5 to 18 mph, the following maximum laboratory results were obtained; observed sprocket power was 337 to 340 horsepower; power train efficiency was 82 to 83.2% and over-all efficiency (observed sprocket hp/observed gross engine hp) was from 75.5 to 76.7%. The laboratory tests were made to secure engineering data only, and no recommendations were made regarding those tests. Because of inadequate instrumentation, the road tests were inconclusive. It was recommended that more satisfactory test procedures be established and appropriate instrumentation be employed in making traction studies.
GENERAL: This 84-page report contains three photographs of the test vehicle and the sprocket dynamometer installation.

SUBJECT: Tanks (Combat) APG 5735/1
TITLE: First Report on Medium Tank T22, First Pilot
IDENTIFICATION: First Report on Ordnance Program, No. 5735; APG 10-154
DATE OF REPORT: 21 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a pilot model Medium Tank T22
METHOD: The vehicle was operated 424 miles over various types of terrain.
DESCRIPTION: The test pilot model Medium Tank T22, manufactured by the Chrysler Corporation, was a 66,705 pound, rear sprocket driven vehicle employing a vertical spring suspension. Power was supplied by a Ford GANC, V-8, gasoline engine rated at 500 hp at 2600 rpm. A standard five-speed, synchromesh transmission and a controlled differential were assembled to the engine to form a single unit. Armament consisted of a 75mm gun, two .30 cal. machine guns, and a .50 caliber AA machine gun.
CONCLUSIONS: The power unit of the tank was mechanically unreliable, and the combination of engine and transmission in a single unit was considered unsatisfactory for a combat vehicle. Second and third echelon maintenance of the power unit was considered too difficult. It was recommended no further consideration be given to the engineering development or testing of the vehicle since the over-all design of the power unit did not permit efficient field maintenance.
GENERAL: This 82-page report contains 14 photographs of the vehicle and components damaged in operation. Automotive Laboratory Report No. 44-12 on drawbar pull and fuel consumption of the test vehicle is also included.

SUBJECT: Tanks (Combat) APG 5739/2
TITLE: First Report on Light Tank, M24, En-

durance Test of
IDENTIFICATION: Second Report on Ordnance Program No. 5739; APG 10-166
DATE OF REPORT: 22 January 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine endurance characteristics, maintenance requirements, parts mortality, and operating economy of the Light Tank, M24, under field conditions and to determine adequacy of preventive maintenance and service procedure recommended by Technical Manual 9-729
METHOD: Two test tanks were operated for 2967 and 3297 miles respectively.
DESCRIPTION: The Light Tank, M24, manufactured by the Cadillac Motor Company, was powered by two, Cadillac, eight-cylinder, V-8, 110-hp gasoline engines. They were equipped with Model 225-T Hydramatic Transmission, and a Pontiac Motor Car Company differential.
CONCLUSIONS: Endurance characteristics, maintenance requirements, and parts mortality of test vehicles were not satisfactory, although the quality of manufacture was excellent. The design of the components was not considered to be fully developed. It was recommended that modifications found necessary during test be placed into production, that TM9-729 be revised, and that two new vehicles complete with modifications be placed on endurance test.
GENERAL: This 267-page report includes 51 photographs of the test vehicle and worn components.

SUBJECT: Tanks (Combat) APG 5739/7
TITLE: Second Report on Light Tank M24, Endurance Test of
IDENTIFICATION: Seventh Report on Ordnance Program No. 5739; APG 10-197 (Project No. 4-34-5)
DATE OF REPORT: 7 December 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the endurance of the Light Tank M24
METHOD: Two test vehicles were operated over cross-country, sand, and highway courses for a total of 4008 miles and 4000 miles, respectively.
DESCRIPTION: The Light Tank, M24, powered by twin, Cadillac, 8-cylinder, liquid-cooled engines rated at 110 hp each at 3400 rpm. The vehicle was equipped with hydramatic transmission and torsion bar suspension system. Armament consisted of a turret-mounted 75mm Gun M6, two cal. .30 machine guns, one cal. .50 machine gun, and four cal. .45 submachine guns.
CONCLUSIONS: Durability, reliability, parts mortality and oil consumption of the tanks were superior to those of any other combat vehicle operated on the endurance course. Fuel consumption of the test vehicles compared favorably with that of the most economical gasoline powered combat vehicles. Modifications made to the Light Tank, M24, previous to the test were generally satisfactory. It was recommended that the method of test development used to improve the Light Tank, M24, be used in all Ordnance automotive equipment development.
GENERAL: This 376-page report contains 86 photographs of the test vehicle and components.

SUBJECT: Tanks (Combat) APG 5739/8
TITLE: First Report on Heavy Tank M26, Endurance Test of
IDENTIFICATION: Eighth Report on Ordnance Program No. 5739; APG 10-199
DATE OF REPORT: 28 January 1946
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Heavy Tank, M26, as a replacement for the Medium Tank M4
METHOD: Two vehicles were tested in accordance with Vehicle Endurance Test Procedure for reliability, endurance, quality, operating economy, maintenance requirements, and parts mortality. Tests included an initial inspection, a 372-mile operation over cross-country, highway, gravel, and sand courses, firing, power determination, and final inspection. The auxiliary generator was used for at least one hour each day.
DESCRIPTION: The Heavy Tank, M26, weighing 92,500 pounds gross, was powered by a Ford GAF, V-8 engine, rated at 500 hp at 2600 rpm. It was equipped with a torqumatic transmission and torsion bar suspension. Armament consisted of a 90-mm Gun, M3, two cal. .30 machine guns, one cal. .50 machine gun, and five cal. .45 submachine guns.
CONCLUSIONS: The durability of the Heavy Tank M26, was not considered satisfactory in relation to other combat vehicles tested. Its reliability was considered only fair in view of 14 immobilizing failures. Parts mortality and maintenance requirements were considered excessive, the maintenance requirement being 4-1/2 times that of the M24. Fuel and oil consumption were considered satisfactory, but at 92,500 pounds the vehicle was underpowered. It was recommended that corrective action be taken on all deficiencies listed.
GENERAL: This 182-page report contains 34 photographs of the tank, components, and failed parts.

SUBJECT: Tanks (Combat) APG 6000/1
TITLE: First Report on Test of the Light Tank T24
IDENTIFICATION: First Report on Ordnance Program No. 6000
DATE OF REPORT: 28 February 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the first pilot model light tank M24 for use as a combat and reconnaissance vehicle
METHOD: Two pilot models were tested. Tests conducted on the first vehicle were performed in order to determine the following: endurance and functional reliability of the vehicle gun mount, fire control system, and armament during an endurance firing program; vehicle hop characteristics during the vehicle firing program; and field dynamometer, TSTP, and automotive endurance characteristics. Fire control and armament functional firing tests and a gun mount endurance test were then performed on the second pilot vehicle

to check modifications which were found desirable during firing tests with the first vehicle.
DESCRIPTION: Both pilot model light tanks M24, manufactured by the Cadillac Motor Car Division, were identical full-tracked, front-sprocket-driven vehicles equipped with torsion bar suspension systems. The vehicles were powered by twin, Cadillac, V8, liquid-cooled, gasoline engines; power was transmitted to the vehicle final drives through two Hydramatic transmissions, a transfer unit, a single propeller shaft, and a controlled differential. Vehicle armament consisted of the following: a new lightweight aircraft-type 75mm gun M5 (T13E1) and a new design concentric recoil mechanism T33; an axial and a ball-mounted cal. .30 machine gun; and a pintle-mounted cal. .50 machine gun.
CONCLUSIONS: The test vehicles were considered suitable for combat and reconnaissance purposes. They were considerably improved over other light tanks tested. Acceptance was recommended provided the noted deficiencies were eliminated; and that the first production model of the vehicle be submitted for test to check the suitability of all modifications made.
GENERAL: This 318-page report contains 64 pages of photographs showing the test vehicle and related components.

SUBJECT: Tanks (Combat) APG 6000/3
TITLE: First Report on Test of Light Tank M24 (T24) No. 2 Production Vehicle
IDENTIFICATION: Third Report on Ordnance Program No. 6000
DATE OF REPORT: 2 April 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance and mechanical reliability of the production light tank M24, No. 2
METHOD: The test vehicle was operated for a total of 2212 miles over varied terrain. A series of engineering and firing tests were conducted on the vehicle during test.
DESCRIPTION: The test light tank M24, No. 2, was a full tracked, front sprocket driven, all welded hull vehicle equipped with a torsion bar suspension system. The vehicle power train included: twin Cadillac, 44-T24, 8-cylinder, liquid-cooled, gasoline engines, each rated 110 hp at 3400 rpm; a four speed forward Hydra-Matic transmission for each engine; a transfer unit which combined the power output of the two engines and at the same time provided, through manual selection, two speed ranges forward and one in reverse; a controlled differential; and two final drive units. Primary vehicle armament included: a 75mm gun, M6; two cal. .30 machine guns, M1919A4; and a cal. .50 machine gun M2, HB.
CONCLUSIONS: General performance of the M24 light tank was considered satisfactory, but mechanical reliability was inadequate. Several deficiencies were noted in the vehicle power train, suspension system, and light primary armament. It was recommended that these deficiencies be corrected and that consideration be given to testing the vehicle as modified in production.
GENERAL: This 256-page report contains 47 photographs showing the test vehicle and related components.

SUBJECT: Tanks (Combat) APG 6000/9
TITLE: First Report on Light Tank T24E1, Pilot Model
IDENTIFICATION: Ninth Report on Ordnance Program No. 6000; APG 10-211
DATE OF REPORT: The report is undated. Inclusive dates of test were 10 October 1944 to 16 November 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the reliability of the Light Tank, T24E1, for the purposes of comparison with the Light Tank, M24, and the 76mm Gun Motor Carriage, T70
METHOD: The vehicle, tested in accordance with 18 features of TSTP 1935-709, accumulated 1665 miles of operation over gravel, concrete, and cross-country courses.
DESCRIPTION: The pilot Light Tank, T24E1 consisted of a standard Light Tank, M24, chassis, suspension, and fighting compartment. The Cadillac engines and power trains had been replaced by a Continental R975-C1 engine with a Spicer Automatic Torque Converter Transmission, and the deck of the engine compartment was raised to accommodate the new engine. All other components of the test vehicle were standard M24 parts.
CONCLUSIONS: The general performance characteristics of the Light Tank, T24E1, were more satisfactory than those of the Light Tank, M24. Reliability of the components required for automatic functioning of the Spicer Automatic Torque Converter Transmission was unsatisfactory, as was the transmission direct drive shaft in resisting torsional vibration. All stabilized engine temperatures in ambient temperatures ranging from 54°F to 75°F were below the recommended maximum allowable, although stabilized drop gear case, transmission, and differential temperatures appeared to be satisfactory. It was recommended that no further testing be done on the Spicer Transmission until redesign of the components had been made to improve reliability, that the Continental R975-C4 engine be considered for further testing in the M24, and that consideration be given to horizontal installation of this engine.
GENERAL: This 243-page report contains 18 photographs of the test Tank, T24E1.

SUBJECT: Tanks (Combat) APG 6001/2
TITLE: First Report on Medium Tank T25, First Pilot, Test of
IDENTIFICATION: Second Report on Ordnance Program No. 6001; APG 10-161
DATE OF REPORT: 21 November 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the test vehicle for combat use
METHOD: The tank was subjected to tests in accordance with T.S.T.P. 1935-709. The vehicle was operated a total of 933 miles while testing over various terrain.

DESCRIPTION: The test Medium Tank T25 was of a low silhouette design equipped with a horizontal volute spring suspension system and 23-inch, center-guided, steel tracks. It was powered by a Ford, GAN, V-8, liquid-cooled engine rated at 500 hp at 2600 rpm. The power train consisted of the engine, a power generator, and propulsion motors attached to each drive sprocket.
CONCLUSIONS: The test vehicle was generally satisfactory and superior to those vehicles before the T20 series. It was recommended that the maintenance requirements and reliability of the electrical distribution system be further studied before standardizing the vehicle for combat use.
GENERAL: This 227-page report contains 35 photographs of the test vehicle and its components.

SUBJECT: Tanks (Combat) APG 6002/1
TITLE: First Report on Test of Medium Tank T25E1
IDENTIFICATION: First Report on Ordnance Program No. 6002; APG 10-165
DATE OF REPORT: 1 January 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Medium Tank T25E1 for combat use
METHOD: The T25E1 tank was extensively tested on paved, gravel, and cross-country test courses and in the laboratory. Design features, cooling, endurance, mobility, gun firing, and power output characteristics were determined. These features were compared to similar features of Medium Tank M4.
DESCRIPTION: Medium Tank T25E1 was designed to provide a combat vehicle of improved design over the Medium Tank M4 series. Superior features of this 76,500-pound vehicle over previous tanks included a hull with thicker armor protection and a lower silhouette, more firepower provided by a 90mm Gun M3, a torqumatic transmission, and a 500 hp V-8 Ford GAF engine. The test vehicle was equipped with a steel, center guide, 19-inch track, and torsion bar suspension. The maximum tractive effort of this vehicle was 57,500 pounds, and its maximum speed was 30 mph.
CONCLUSIONS: In general, the design characteristics of Medium Tank T25E1 were sound, and the vehicle was considered superior to the M4 tank. However, the following deficiencies were noted: the engine compartment grilles and the turret bulge offered insufficient protection against small arms fire; the engine and differential overheated; suspension components, especially the bogie tires, were inadequate; grouser action was poor; gun muzzle blast was excessive. Many minor deficiencies were also noted. It was recommended that these deficiencies be corrected and the vehicle equipped with a 24-inch track. It was further recommended that the modified tank be considered in future development of combat vehicles where a well armored, highly manueverable, high fire powered vehicle was desired.
GENERAL: This two-volume, 510-page report contains 85 pages of photographs, detailed testing procedures, two laboratory reports, and test result data.

SUBJECT: Tanks (Combat) APG 6004/1
TITLE: First Report on Test of Heavy Tank T26E1
IDENTIFICATION: First Report on Ordnance Program No. 6004; APG 10-148
DATE OF REPORT: 26 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of Heavy Tank T26E1
METHOD: The first pilot model of Heavy Tank T26E1 was operated 1572 miles over various test courses. The second pilot was operated 552 miles.
DESCRIPTION: The test vehicles were pilot models of the Heavy Tank T26E1. The hull of the vehicle supported a revolving turret having a 360° traverse and carried a 90mm Gun M3, a coaxial cal. .30 machine gun, and a cal. .50 antiaircraft machine gun. A bow machine gun was also provided for the assistant driver. The combat weight of the vehicle was 86,500 pounds. It was powered by a 500-horsepower Ford GAF engine driving through a three-speed torqumatic transmission, controlled differential, and rear-mounted drive sprockets. The vehicle was supported on a torsion bar suspension with six road wheels on each side.
CONCLUSIONS: The design of the vehicle was considered basically sound. Steering brakes, cooling and stowage were considered unsatisfactory. It was considered that with the correction of these and a number of minor defects that the vehicle would be satisfactory for combat use, and full production of modified vehicles was recommended.
GENERAL: This 269-page report contains 33 pages of photographs of the vehicle, failed components, test targets, and operation on standard military bridges.

SUBJECT: Tanks (Combat) APG 6004/4
TITLE: Second Report on Test of Heavy Tank T26E1
IDENTIFICATION: Fourth Report on Ordnance Program No. 6004; APG 10-158
DATE OF REPORT: 18 October 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the general operating characteristics of a modified pilot model Heavy Tank T26E1
METHOD: Two pilot models of the vehicle were tested in accordance with the Ordnance Proof Manual. They were given a total of 2387 and 1226 miles, respectively, of operation over various terrain and roads.
DESCRIPTION: The test vehicles were pilot models of the Heavy Tank T26E1 which were modified to eliminate deficiencies found in previous tests. These changes consisted mainly of a modification in the differential to promote better steering and longer brake life, modification of the engine and flywheel housing to prevent failure of the connection, and modification of the transmission for better operation. The vehicles were equipped with a Ford GAF V-8 engine and an auxiliary engine and generator. Weight of the T26E2 was 83,300 pounds
CONCLUSIONS: Modifications incorporated in the test vehicle improved operation. However, many additional deficiencies of the entire tank were

noted and it was recommended that these deficiencies be eliminated before the vehicle was released for production.
GENERAL: This 206-page report contains 43 photographs of the test vehicle, failed parts, and unsatisfactory features.

SUBJECT: Tanks (Combat) APG 6004/9
TITLE: First Report on Test of Heavy Tank M26, First Production Vehicle
IDENTIFICATION: Ninth Report on Ordnance Program No. 6004; APG 10-180
DATE OF REPORT: 27 September 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether this first production Heavy Tank M26, as modified after pilot model tests, was capable of satisfactory performance and endurance
METHOD: The vehicle was operated almost continuously for 4010 miles, of which 1752 miles were on highways and 2258 miles were cross-country. A functional firing test of all tank armament was performed.
DESCRIPTION: The test Heavy Tank M26 was powered by a Ford GAF, V-8, gasoline engine rated 500 hp at 2600 rpm. It was equipped with torqumatic transmission, controlled differential steering, torsion bar suspension and cast steel, rubber-backed T80E1 Tracks. The vehicle was rear sprocket driven and weighed 92,500 pounds. Armament included a 90mm Gun M3, two cal..30, and one cal. .50 machine guns.
CONCLUSIONS: In its test state, the vehicle was unsatisfactory. It was considered underpowered even though the engine durability was excellent. The cruising range was adequate, and engineering features of the low silhouette design produced various shortcomings in fording, cooling, stowage and crew comfort. Durability of the torqumatic transmission was poor, and the electrical generating system was unreliable. The front suspension was not strong enough, and the T80E1 track was inadequate in traction. Elevating and traversing mechanisms were lacking in strength and accuracy. Corrective action was recommended.
GENERAL: This 308-page report includes 92 pages of photographs of tank and components and four drawings of shock absorber and floor plate modifications.

SUBJECT: Tanks (Combat) APG 6004/14
TITLE: First Report on Engineering Tests of Heavy Tank M26
IDENTIFICATION: Fourteenth Report on Ordnance Program No. 6004
DATE OF REPORT: 5 December 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the performance and cooling characteristics of a production M26 heavy tank with those of a pilot model T26E1 heavy tank
METHOD: The vehicles were subjected to numerous comparative tests on various types of terrain. Slope operation, drawbar pull, maximum speeds and acceleration, and cooling characteristics were determined. Measurements of airflow were also made.
DESCRIPTION: The heavy tanks M26 and T26E1 were manufactured by the Fisher Tank Division of the General Motors Corporation. The M26 tank was the second production vehicle; it varied slightly from the proposed standard production vehicle. The T26E1 was a second version of the original pilot model; this vehicle was identical to the first pilot model except that the cooling characteristics were improved. Both vehicles weighed 90,500 pounds. Installation of the cooling fans in both vehicles varied greatly. There were several differences in other components of the test vehicles.
CONCLUSIONS: Cross-country performance, drawbar horsepower, and cooling characteristics of the T26E1 tank were superior to those of the M26 tank. Cooling improvements of production vehicles were accomplished, but only with a sacrifice of available drawbar horsepower. Maximum tractive effort of the two vehicles was approximately equal. Vehicular power was sufficient to permit vehicle operation on 60% paved slopes. Transmission cooling was inadequate. It was recommended that the production heavy tank T26 be modified to provide the satisfactory engine cooling and vehicular performance characteristics demonstrated by the heavy tank T26E1.
GENERAL: This 244-page report contains 15 photographs of the test vehicles and components.

SUBJECT: Tanks (Combat) APG 6111/1
TITLE: First Report on Test of the Light Tank T24
IDENTIFICATION: First Report on Ordnance Program No. 6111; APG 10-138
DATE OF REPORT: 28 February 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the first Pilot Light Tank, T24, as a combat and reconnaissance vehicle
METHOD: Tests were conducted on two vehicles. The test work on the first model consisted of an endurance test of the 75mm gun mount, fire control and armament functional firing tests, field dynamometer tests, jump firing tests, T.S.T.P. characteristic tests, and an automotive endurance test. A fire control and armament functional firing test and an endurance test of the 75mm gun mount were conducted on the second Light Tank, T24, to check modifications which had been found desirable during the testing of the first tank. A firing test was also conducted using the production design, blanket-type, water-protected ammunition racks for the Light Tank T24.
DESCRIPTION: The test vehicle was an experimental combat and reconnaissance vehicle driven by two V-8 engines through two hydramatic transmissions, a transfer unit, a single propeller shaft, a controlled differential, and final drives. The transfer unit, of new design, transmitted power from two transmissions to a single propeller shaft and had high, low, and reverse speeds, all with synchromesh gears. Armament consisted of a 75mm Gun M5 with Recoil Mechanism T33, a coaxial cal. .30 machine gun, a cal. .30 machine gun in the bow, and an anti-aircraft cal. .50 Machine Gun M2 on the right rear top of the turret.

Fire control equipment included a power traverse, gyrostabilizer, direct-fire telescope, and an azimuth indicator. The suspension system was the torsion bar-type with five individually sprung road wheels on each side.
CONCLUSIONS: The test vehicle was found to be very satisfactory as a combat and reconnaissance vehicle, and was considered superior to any previous vehicle of its type. Numerous modifications were found desirable, particularly in the Recoil Mechanism T33, in the functioning and durability of the 75mm gun firing mechanism, and in the location of various components of the armament and fire control equipment. Engines, power train, suspension, instruments and controls, ammunition stowage, and hull and turret, all were considered generally satisfactory, requiring only minor modifications. It was recommended that the test vehicle be accepted as a combat and reconnaissance vehicle if corrective modifications were made.
GENERAL: This 247-page report contains 62 photographs of the test vehicle and failed parts. Three sketches and an Automotive Laboratory Report on the Determination of Drawbar Characteristics are also included.

SUBJECT: Tanks (Combat) APG IT2-673/1
TITLE: Engineering and Endurance Test of Tank, 120mm Gun, T43E1
IDENTIFICATION: First Report on Project No. IT2-673
DATE OF REPORT: 8 April 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of tank, 120mm gun, T43E1, with special emphasis on suspension modifications
METHOD: Two modified T43E1 tanks were placed on accelerated engineering and endurance tests with periodic fire control checks. Preliminary and extended operation testing was accelerated to determine if deficiencies had been alleviated or improvements made. One vehicle was operated 4397 miles over cross-country and rough hill courses and over secondary roads to evaluate endurance and reliability; the other vehicle was given extended turret and fire control tests (Fifteenth Report on Project No. TT2-673). Special tests were performed to evaluate vehicle final drives, T107 tracks, friction snubber performance, and vehicle mobility in wet sand.
DESCRIPTION: The test modified tank, 120mm gun, T43E1 was a heavily armored, full tracklaying, combat vehicle, mounting a 120mm gun, T123E1. Secondary armament consisted of one cal. .50 and two cal. .30 machine guns. The combat weight of the vehicle was 125,000 pounds and it had a five-man crew complement. It was powered by a Continental AV-1790-5B, 12-cylinder, 90°V air-cooled engine rated for 810 hp at 2800 rpm, through an Allison transmission, Model CD-850-4B. The vehicle was equipped with a torsion bar suspension modified to use heavy forged road wheel arms at front and rear, double bump springs for the front road wheel arms, and friction snubbers.
CONCLUSIONS: The vehicle performance and mechanical reliability were satisfactory and reflected an improvement over previously tested vehicles of the T43 series. Engineering performance tests revealed satisfactory results. It was recommended that the tank, T43E1 be considered satisfactory from an automotive standpoint; however, continuation of testing on future T43E1 production vehicles be considered to determine if these results were representative. It was also recommended that troublesome discrepancies noted be investigated and, where feasible, corrected.
GENERAL: This 288-page report includes 17 photographs of the test vehicle and failed components.

APG POT-24041/6/1P
SUBJECT: Tanks (Combat)
TITLE: Engineering and Endurance Tests of Two Medium Tanks M46 Production Models
IDENTIFICATION: First Partial Report on POT-24041/6; APG 10-232
DATE OF REPORT: 12 June 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability of components on the Medium Tank M46
METHOD: Two Medium Tanks M46 were operated for a total of 4224 and 4423 miles, respectively, over hard-surface, cross-country, and hilly-type terrain. Firing tests were conducted on one tank and engineering tests were conducted on both.
DESCRIPTION: The Medium Tank M46 was a heavily armored vehicle mounting a 90mm Gun, M3A1, in a 360° traversing turret. It was powered by a Continental AV 1790-5A, air-cooled engine and an Allison CD 850-3 cross-drive transmission. The weight of the vehicle was approximately 46 tons.
CONCLUSIONS: Vehicle speed, driver ease, and power and durability of the engine were considered outstanding. However, the Allison transmission was not considered dependable. The hull, turret, tracks, suspension, and related components were satisfactory. The engine and transmission oil cooler fan assemblies were modified during tests and further development was considered necessary. It was recommended that action be taken to insure extensive field testing of future pilot models before standardization, that all major failures should be corrected in the Medium Tank M46 before issue of the tank to troops, and that more consideration be given to ease of maintenance studies.
GENERAL: This 365-page report in two volumes contains 79 photographs of the Medium Tank M46, components, and unsatisfactory features; a 156-page Ease of Maintenance Report with 31 illustrative photographs and diagrams; and eight Laboratory Reports.

APG POT-24041/6/3P
SUBJECT: Tanks (Combat)
TITLE: Engineering and Endurance Tests of Six Medium Tanks M46 (Production Models)
IDENTIFICATION: Third Partial Report on OCO Project No. POT-24041/6; APG 10-239
DATE OF REPORT: 12 March 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability of Medium Tank, M46, with particular regard to the power package

METHOD: Six production tanks were given endurance tests. Two of the test tanks had previously completed 4300 miles each, and each was operated approximately 1000 additional miles on this test. The other four tanks were operated a total of 1868 miles. Test operation was over gravel and hard surfaces, hilly terrain, and cross-country.
DESCRIPTION: Medium Tank, M46, was a heavily armored, vehicle mounting a 90mm Gun, M3A1. It was equipped with a Continental, 810-hp, 12-cylinder, air-cooled, AV 1790-5 and 5A engines, and an Allison CD 850-3 cross-drive transmission. Medium Tank, M46, was evolved from a modified Medium Tank, M26, and was very similar to it, differing in that it was equipped with a different power package, auxiliary track tension idler, and a bore evacuator. During testing, the CD 850-3 transmission was replaced by a CD 850-4 transmission, which gave turning ability not dependent upon engine speed.
CONCLUSIONS: Endurance of the AV 1790-5A engine was satisfactory with the exception of the fan assemblies. During testing, the two older test tanks experienced 19 major and 31 minor failures, and the four newer tanks had 18 major failures. Elimination of brake plate and input gearing failures in the transmission, and electrical failures in the oil cooler fan drives was considered necessary. It was recommended that the failures listed here and those detailed in this report be corrected as soon as possible.
GENERAL: This 100-page report includes 23 photographs of the test tanks and components.

APG POT-24041/6/5

SUBJECT: Tanks (Combat)
TITLE: First Report on Test of Four Production Model Medium Tanks M46
IDENTIFICATION: Fifth and Final Report on Project POT-24041/6; APG 10-249
DATE OF REPORT: 23 November 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the endurance and suitability of the Medium Tank, M46
METHOD: Four test vehicles were operated for a total of 11,327 miles. Three of the vehicles, subjected to endurance operation over all types of terrain, were specifically tested to determine the endurance characteristics of the service brakes of the CD 850-4 transmission. The remaining vehicle was used in engineering tests primarily to compare the effect of standard and experimental camshafts on drawbar pull and engine fuel consumption.
DESCRIPTION: Each of the four test Medium Tanks M46 had torsion bar suspension, a CD-850-4 cross-drive transmission, and was armed with a 90mm gun, M3A1, mounted in a 360° traversing turret. Power was furnished by a Continental, AV 1790 series, 810 hp, V-12 engine. The engine of the engineering tested vehicle first employed a standard 60° overlap cam with 50° intake valve timing; the second was a 40° overlap cam with 40° intake valve timing; the third was a 40° overlap cam with 50° intake valve timing. Wire-damped and scalloped-brake plates were compared for use in the endurance tested vehicle transmissions. The primary vehicle weapon was a 90mm Gun, M3A1, mounted in a 360° traversing turret.
CONCLUSIONS: The endurance of the test vehicles proved satisfactory with the exception of several components, particularly oil cooler fan clutches. Because of deficiencies, the following was recommended: studies be conducted to eliminate the excessive wear rate of the AV 1790-5A engines; a more practical exhaust muffler system devised; a more efficient power package be developed for future track laying vehicles; oil cooler clutches be replaced with more reliable units; life of the final drive output shafts be improved; and minor body deficiencies be remedied. The test 40° overlap camshaft, with 50° intake valve timing gave increased engine performance in the lower speed ranges, and also improved fuel economy. The wire damped transmission brake plates were recommended for use with the test vehicle as an interim measure until satisfactory solid plates were designed.
GENERAL: This 203-page report contains 42 photographs showing various views of the test vehicle, component parts, and parts damaged in operation. Laboratory Reports 51-38 and 51-80 are also included.

APG POT 24800/D

SUBJECT: Tanks (Combat) Memo 2, 3, 7, and 32
TITLE: Inspection Control Tests of M47
IDENTIFICATION: Project No. POT 24800/D; Memo 2, 3, 7, and 32
DATE OF REPORT: 29 April 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate the performance phase of tank, 90mm gun, M47 during inspection control tests
METHOD: The M47 tank was operated for 441 miles over gravel, paved, and cross-country courses. During this operation observational data were taken of the vehicle's ability for speed, acceleration, braking, climbing, turning, fording, trench crossing, vertical obstacle, turret and traversing mechanism operation. The vehicle was then subjected to a final examination and all deficiencies were noted.
DESCRIPTION: The test vehicle was a tank, 90mm gun, M47 powered by a 12-cylinder, air-cooled Continental AV-1790-5B engine No. 9072 with a CD 850-4A transmission No. 7909. The vehicle weighed 97,000 pounds.
CONCLUSIONS: Examination of four road wheel arm spindle bearings from the No. 2 and 6 positions of the vehicle revealed that dirt was entering the bearing through the grease seals. The inner bearings and the inner bearing oil seals required replacement in both auxiliary idlers as a result of muddy cross-country operation.
GENERAL: This 18-page report includes eight photographs of test failures. This test was currently in progress.

APG TB5-1401/Y4/190

SUBJECT: Tanks (Combat)
TITLE: Desert Test 1954 Tank, 120mm Gun, T43E1
IDENTIFICATION: One Hundred Ninetieth Report on Project No. TB5-1401/Y4
DATE OF REPORT: 16 February 1955

ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the cooling characteristics of the main and auxiliary engines of a T43E1 tank during high ambient temperature conditions
METHOD: Full throttle cooling tests were performed on the test vehicle. During these tests, a standard muffler and five experimental mufflers were tested on the engine in order to determine if any of the installations would improve vehicle cooling characteristics. Hot and cold engine compartment cooling tests were also conducted on the auxiliary generator unit using a modified duct, which drew air from the turret compartment. The vehicle was operated on a hard level surface during the tests which were all conducted at Yuma, Arizona.
DESCRIPTION: The test T43E1 tank was a heavily armored, full tracklaying 120,000-pound vehicle powered by an Ordnance, Model AV-1790, 12-cylinder, V-type, air-cooled gasoline engine, which was rated at 810 hp at 2800 rpm. The vehicle was also equipped with the following: a Model CD-850 cross-drive transmission; a torsion bar-type suspension system with dual roadwheels; T97 rubber chevron track; and a Model A-41-1 auxiliary engine-generator unit. The five experimental mufflers tested were of the center-type.
CONCLUSIONS: The vehicle cooling characteristics were satisfactory in ambient temperatures up to 125°F, except for the transmission oil temperatures. The various muffler installations tested had no effect on vehicle cooling characteristics. The cooling air duct modifications for the auxiliary engine-generator unit provided satisfactory cooling and were recommended for use with the auxiliary engine in the test-type tank. Variation of cooling air distribution among the main power plant cylinders was excessive, and it was recommended that this deficiency be corrected. It was also recommended that transmission malfunction observed be investigated.
GENERAL: This 166-page report contains 12 photographs of vehicle components.

SUBJECT: Tanks (Combat) APG TB5-1401/6
TITLE: Winter Test 1951-1952 of Tank, 76MM Gun, T41E1, Devils Lake, North Dakota
IDENTIFICATION: Sixth Report on OCO Project No. TB5-1401; APG 34-39A
DATE OF REPORT: 22 April 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the operating characteristics of the 76mm Gun Tank T41E1 under low ambient temperature conditions
METHOD: Two test vehicles were operated over cross-country, rough-hill, and secondary road courses. Cold starting and warmup tests were also conducted.
DESCRIPTION: The 76mm Gun Tank T41E1 was designed to operate in ambient temperatures ranging from -65°F to 125°F, and capable of being transported by air. It was powered by a Continental AOS-895-3, six-cylinder, horizontally-opposed, supercharged, air-cooled engine rated 500 hp at 2800 rpm. Engine and power train were located in a rear compartment. The tank carried a crew of four, weighed (ready for action) 50,789 pounds, and was armed with a 76mm gun and two caliber .50 machine guns.
CONCLUSIONS: The endurance and reliability of the vehicle were considered unsatisfactory. Many of the failures and deficiencies which occurred could not be attributed to cold weather operation. Numerous recommendations for redesign and modification were made to improve the over-all characteristics of the vehicle.
GENERAL: This 41-page report is not illustrated.

SUBJECT: Tanks (Combat) APG TB5-1401/10
TITLE: Winter Test 1951-1952 of Tank, 90MM Gun, M47, Devils Lake, North Dakota
IDENTIFICATION: Tenth Report on OCO Project No. TB5-1401; APG 34-38
DATE OF REPORT: 22 May 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the reliability and suitability of the Tank, 90mm Gun, M47, under low ambient temperatures
METHOD: Two test vehicles were operated over cross-country and secondary road courses for a combined total of 3799 miles. Cold starting and warm-up tests were also conducted.
DESCRIPTION: The heavily armored Tank, 90mm Gun, M47 was powered by a Continental AV-1790-5B, air-cooled, V-12, gasoline engine. It was equipped with an Allison CD-850-4 cross-drive transmission which combined an automatic transmission, a steering unit, and a braking mechanism.
CONCLUSIONS: A great many deficiencies affecting practically all tank components were disclosed by the cold weather tests and specific recommendations were made to effect corrections.
GENERAL: This 174-page report contains 25 photographs of the vehicles, test operations, and component deficiencies.

SUBJECT: Tanks (Combat) APG TB5-1401/64
TITLE: Arctic Tests (1952-1953) of Tank, 90mm Gun, M47, Fort Churchill, Manitoba, Canada
IDENTIFICATION: Sixty-fourth Report on Project No. TB5-1401
DATE OF REPORT: 9 October 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the over-all characteristics of the test vehicle under arctic conditions
METHOD: The vehicle was operated on a snow-packed, frozen, muskeg road. Observations were made and data were obtained with respect to the test objectives during the operations. Tests also were performed to determine the suitability and effectiveness of the fire control equipment. No special tests were made on the experimental items which, however, were observed over a 55-day period for proper functioning.
DESCRIPTION: The M47 tank was a heavily armored, full tracklaying, low-silhouette combat vehicle mounting a 90mm gun, T119E1. It was powered by a Continental Model AV-1790-513, 12-cylinder, V-type, air-cooled, gasoline engine. The

vehicle under test was a current production model that had been winterized at Detroit Arsenal. It also included the following experimental components: a gunner's periscope defroster; engine oil temperature control thermostat, 48 psi, 160°F; 6.4-ohm, 200-watt resistor in shunt field circuit of auxiliary generator; oil cooling fans incorporating a centrifugal-type clutch; and choke and throttle controls on the auxiliary generator.
CONCLUSIONS: Arctic mittens and parkas were awkward and made the operation of controls difficult. Frozen throttle linkage occurred in the carburetors at sub-zero temperature, and the air induction system was unsuitable for arctic operation. The primer pump was not reliable for low ambient temperatures. The discrepancies noted on the experimental items were of such a nature to warrant a modification or redesign. It was recommended that a new induction system be designed to eliminate icing of the air cleaner screens and oil reservoir pans. It was also recommended that the hand primer be redesigned and relocated for improved cold starting characteristics, that consideration be given to eliminating the frozen linkage within the carburetor, and that a separate vehicle be used for testing the experimental items so that a more thorough evaluation of these components could be made.
GENERAL: This 174-page report includes 12 photographs of the test tank and component parts, charts of weather data, and two views (one aerial) of Fort Churchill.

SUBJECT: Tanks (Combat) APG TB5-1401/95
TITLE: Winter Test, 1952-1953, of Tank, 90MM Gun, T48 Devils Lake, North Dakota
IDENTIFICATION: Ninety-fifth Report on Project No. TB5-1401
DATE OF REPORT: 26 August 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the T48 tank for use under low ambient temperature conditions
METHOD: The test vehicle was initially inspected and then operated in temperatures ranging from -13° to 30°F for 1500 miles over flat cross-country terrain at Devils Lake. During operation, tests were conducted to determine the suitability of the following: vehicle operating characteristics; fuels and lubricants used with the vehicle; and vehicle winterization equipment.
DESCRIPTION: The test T48 tank was a full tracklaying, rear sprocket driven vehicle equipped with the following: a Continental AV-1790-5B, 12-cylinder, V-type, air-cooled, gasoline engine rated at 810 hp; an Allison Model CD-850-4A cross-drive transmission; a torsion bar suspension system; T97 track consisting of rubber links with integral steel track pins; and a General Motors A-41-1 auxiliary generator driven by a 1-cylinder air-cooled engine. Two Stewart-Warner, Model 978-M-R-24, gasoline fired heaters served to heat the engine and crew compartments. Vehicle weight when combat loaded was 49.2 tons.
CONCLUSIONS: Cold starting, warmup, and mobility characteristics of the test vehicle were considered satisfactory. However, several deficiencies were observed in other respects. These deficiencies included: standard shock absorbers were unsatisfactory during cold weather operation; personnel heater installation was entirely unsatisfactory; arctic clothing was bulky, and restricted crew activity; engine life was not satisfactory due to excessive oil ring wear and piston failures; large quantities of dust and dirt were drawn into the engine compartment; etc. It was recommended that the observed deficiencies be corrected; and that additional cold starting tests be conducted on the main and auxiliary vehicle engines at temperatures below -13°F.
GENERAL: This 139-page report contains 30 photographs showing the test vehicle and components.

SUBJECT: Tanks (Combat) APG TB5-1401/112
TITLE: Desert Test (1953) Tank, 90MM Gun, T48
IDENTIFICATION: One Hundred Twelfth Report on Project No. TB5-1401
DATE OF REPORT: 17 December 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the cooling and vapor lock characteristics, using specification fuel, under desert conditions; and to evaluate performance, durability, and reliability factors
METHOD: Tests were conducted to obtain data on full-throttle cooling, vapor lock, road load and cross-country cooling, cross-country mobility, personnel compartment temperatures, and auxiliary engine cooling.
DESCRIPTION: Standard-production tank, T48, was a heavily armored, full-tracklaying combat vehicle mounting a 90mm gun, T139. The vehicle was operated by a crew of four; commander, gunner, loader, and driver.
CONCLUSIONS: The test vehicle did not cool satisfactorily when operating under full load at an ambient temperature of 125°F. Cylinder head and engine oil temperatures were borderline, and transmission oil temperatures limited the maximum speed to 2 mph in low range at 115°F. Vapor lock occurred at 125°F using 8 psi RVP fuel, and incipient knock was encountered at 100°F. High concentrations of dust required frequent cleaning of components. The auxiliary engine-generator unit did not attain minimum required output of 7 kw. However, modifications made to the unit during the test increased the output. Pancake mufflers reduced cylinder head and engine oil temperatures slightly. Personnel compartment temperatures were satisfactory. It was recommended that development work be done to attain the following: satisfactory engine oil and transmission oil temperatures, determine the cause and correct vapor lock, and provide an auxiliary engine-generator unit that would deliver rated output at elevated temperatures.
GENERAL: This 91-page report includes six photographs of component parts.

SUBJECT: Tanks (Combat) APG TB5-1401/113
TITLE: Desert Test (1953) Tank, 90MM Gun, T42

IDENTIFICATION: One Hundred Thirteenth Report on Ordnance Project TB5-1401; Tenth Report on Project TT2-672
DATE OF REPORT: 14 October 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effect of high ambient temperatures and desert terrain on the operating characteristics of the T42 tank, with particular emphasis given to the engine, transmission, and suspension components
METHOD: Full-throttle, full-load, and road-load cooling tests on paved surfaces were conducted to evaluate vehicle cooling characteristics. The octane requirement of the engine was determined, but vapor lock tests were not conducted. Cross-country operation was limited. The effect of dust on the general operation and on crew efficiency was observed. Full-throttle cooling tests on the auxiliary engine-generator were conducted.
DESCRIPTION: The test tank was a heavily armored full tracklaying combat vehicle mounting a 90mm gun, T119. It carried a crew of four.
CONCLUSIONS: Full-throttle, full-load cooling characteristics of the engine and fuel injection system were satisfactory at 100°F ambient temperature. The vehicle would not operate satisfactorily on low octane fuel allowed by MIL-G-3056. Road-load and cross-country cooling characteristics were satisfactory. Dust was a problem. Cross-country desert mobility was generally unsatisfactory. Full-throttle cooling of the auxiliary engine-generator was satisfactory, although the output of the unit was below its rated capacity. It was recommended that further investigation be conducted to reduce the octane requirements of this engine and fuel injection system, to determine the full-throttle and cross-country cooling characteristics of the fuel injection engine; to investigate vapor lock characteristics; and to determine the desert durability and reliability of the AOSI-895 engine and the XT-500 transmission in a vehicle of this weight class.
GENERAL: This 80-page report includes eight photographs of vehicle component parts.

SUBJECT: Tanks (Combat) APG TB5-1401/156
TITLE: Winter Test (1953-54) Howitzer, 155MM, Self-Propelled, T194
IDENTIFICATION: One Hundred Fifty-sixth Report on Project No. TB5-1401
DATE OF REPORT: 6 August 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the performance characteristics of a self-propelled, 155mm howitzer, T194, under Arctic conditions
METHOD: Cold starts of both the main and auxiliary engines of the test vehicle were performed. Performance characteristics of the crew compartment heater installations were determined. Observations were made as to the effect of environmental factors on the vehicle and components. Limited vehicle operation was conducted over varied terrain. Testing was conducted at Fort Churchill, Manitoba, Canada.
DESCRIPTION: The self-propelled, 155mm howitzer, T194, was a lightly armored, front sprocket driven, full tracklaying vehicle equipped with the following: a Continental, Model AOS-895-3, 6-cylinder, air-cooled, horizontally-opposed, supercharged, gasoline engine, which developed 500 hp at 2800 rpm; an Allison, Model CD-500-3 transmission; and a torsion bar suspension system and individually sprung road wheels. A Delco-Remy, Model GM-A8585 generator and a Detroit Diesel GMC Type A-41-2 auxiliary engine provided auxiliary electrical power. An experimental heater kit carried heated air from the auxiliary unit to the main engine oil pan, intake manifolds, and vehicle batteries. Two Perfection Model E-500 personnel heaters provided localized heating in the driver's and commander's areas. The T194 was developed from the T199E1 howitzer and incorporated several design changes.
CONCLUSIONS: Numerous vehicle deficiencies, not attributable to Arctic conditions, limited an accurate evaluation of the over-all endurance characteristics of the test vehicle. The main engine could be started, without cold-starting aids other than the primer, within 60 seconds at temperatures as low as -25°F. The auxiliary generator unit started within 30 seconds at temperatures down to -30°F. The personnel heaters were inadequate, although their mechanical operation was satisfactory. It was recommended that the numerous deficiencies observed be corrected; and that the modified vehicle be resubmitted for further testing under Arctic conditions.
GENERAL: This 134-page report contains 10 photographs of the test vehicle.

SUBJECT: Tanks (Combat) APG TB5-1401/195
TITLE: Desert Test (1954) Tank, 90MM Gun, M48
IDENTIFICATION: One Hundred Ninety-fifth Report on Project No. TB5-1401
DATE OF REPORT: 31 January 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of main and auxiliary engine modifications for use on the M48 tank during high ambient temperature operation; and to determine the suitability of the fire control system of the vehicle under similar conditions when using two types of hydraulic oils
METHOD: Vapor lock, full throttle cooling, and road load cooling characteristics of the modified main engine of the test vehicle were determined during 1462 miles of operation over varied terrain at Yuma, Arizona. Vapor lock and cooling characteristics of the auxiliary engine with and without modification were also checked. Fire control system performance was determined under high temperature conditions when using two types of hydraulic fluids.
DESCRIPTION: The test M48 tank was a heavily armored, full tracklaying, combat vehicle powered by an Ordnance, Model AV-1790, 12-cylinder, V-type, air-cooled, gasoline engine rated at 810 hp at 2800 rpm. A Model CD-850 cross-drive transmission, a torsion bar suspension system, dual roadwheels, and T97 rubber chevron track were additional vehicle components. Special installations tested on the main engine of the vehicle

included a fuel system modification involving two separate fuel filters, carburetor degassers with closing points adjusted at 17 inches of mercury, and Hollywood and Firestone type mufflers. A fuel by-pass modification was tested with the auxiliary engine, MIL-O-5606 and OH-2-79B hydraulic fluids were tested in the fire control system of the vehicle.
CONCLUSIONS: Cooling characteristics of the main vehicle engine were poor, although vapor lock characteristics were satisfactory. Transmission oil temperatures were satisfactory when using standard and test mufflers; however, the torching characteristics of the mufflers were excessive. Vapor lock and cooling characteristics of the auxilieary engine-generator unit under the test conditions were poor. Turret performance was slightly improved when using OH-2-79B hydraulic fluid in the fire control system. Correction of deficiencies and further tests to determine the effects of temperature on the fire control system of the vehicle were recommended.
GENERAL: This 170-page report contains 18 photographs of vehicle components.

SUBJECT: Tanks (Combat) APG TB5-1401/229
TITLE: Installation of Test Material and Preparation of Tank 90MM Gun M47 for Arctic Operation at Fort Churchill, Canada, 1954-1955
IDENTIFICATION: Two Hundred Twenty-ninth Report on Project No. TB5-1401
DATE OF REPORT: 13 September 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether an M47 tank equipped with modified components would be suitable for use in tests under Arctic conditions at Fort Churchill, Manitoba, Canada
METHOD: The test vehicle was inspected and then equipped with experimental components, including a modified engine which was operated on a power check run. After installing necessary instrumentation, a coldroom check was made of vehicle components following an 18-hour soaking period at 25°F.
DESCRIPTION: The test M47 tank was a heavily armored full tracklaying, low silhouette combat vehicle. Experimental vehicle equipment included: a modified, Ordnance Model AB-1790-7B, 12-cylinder, V-type, air-cooled gasoline engine; a Model CD-850-4B cross-drive transmission equipped with modified low and reverse bands; suspension components consisting of a titanium spindle in one road wheel arm, snow and ice displacer tires for the sprocket hubs, and titanium T80E6 track shoes; and an M3E1 bulldozer kit. Modified engine components included: an experimental hot-spot kit equipped with a velocity control valve and cast iron hot-spot housing; lean carburetors; magnetos with an additional 10° spark advance provided by a vacuum control; booster coils with a vibrator in the circuit; austerity spark plugs; an experimental breather system; and a Cuno, self-cleaning, oil filter.
CONCLUSIONS: The following deficiencies were observed during the power check run of the vehicle engine; experimental intake manifolds were found to loosen, tapped holes in the experimental hot-spot mounting flange on the exhaust manifold were unsatisfactory, and welds on the experimental hot-spot butterfly valve failed. During installation of the engine in the vehicle, it was noted that interferences between test engine items and the engine compartment were not considered in design changes. Following the temporary correction of the observed deficiencies by Aberdeen personnel, it was recommended that the test vehicle be considered suitable for use in Arctic tests at Fort Churchill, Manitoba, Canada. It was further recommended that methods of permanently correcting observed deficiencies be developed.
GENERAL: This 107-page report contains 24 photographs of test components.

SUBJECT: Tanks (Combat) APG TB5-1401/233
TITLE: Winter Test 1954-1955, Test of Tank, 90MM Gun, M47
IDENTIFICATION: Two Hundred Thirty-third Report on Project No. TB5-1401
DATE OF REPORT: 30 March 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a modified Model AV-1790-7B engine and other experimental vehicle components for use with an M47 tank operating under arctic conditions
METHOD: An M47 tank equipped with a modified engine and experimental components was operated for 3640 miles over cross-country terrain at Fort Churchill, Manitoba, Canada, in temperatures ranging from -49° to 20°F. Engine performance characteristics were closely observed. Performance suitability of various experimental vehicle components and personnel and engine compartment heaters was determined.
DESCRIPTION: The modified Model AV-1790-7B engine was equipped with an experimental hot-spot kit with a velocity control valve and cast iron hot-spot housing, lean carburetors, magnetos with an additional 10° sprak advance provided by a vacuum control, booster coils with a vibrator in the circuit, austerity spark plugs, an improved breather system, and a Cuno self-cleaning oil filter. Experimental vehicle components included: a modified CD-850-4 transmission; four, T80E6, titanium alloy track shoe assemblies; a titanium alloy road wheel arm; sponge and foam rubber filled drive-sprocket hub ice displacer tires; an experimental air induction heater kit for the main engine carburetor; T84E1 grouser tracks with ice cleats; and a modified M3E1 bulldozer kit.
CONCLUSIONS: Performance characteristics of the test engine were considered satisfactory. Better fuel economy was noted and was attributed to the experimental components used in the engine. Test titanium alloy components, ice displacer tires, the induction heater kit for the main engine carburetor, and T84E1 grouser tracks with ice cleats were unsatisfactory. The original modified transmission failed after 1600 miles of operation. Only limited tests were conducted with the bulldozer kit before a component of the kit was damaged beyond repair. Frozen engine control linkages and increased engine air cleaner restriction char-

acteristics were deficiencies caused by the entrance of snow into the vehicle hull. The personnel heater performed satisfactorily, but performance characteristics of the engine compartment heater were unsatisfactory. There were numerous recommendations with regard to the suitability of various test components for military use and in reference to the correction of certain vehicle design deficiencies.
GENERAL: This 206-page report contains 52 photographs of test components.

SUBJECT: Tanks (Combat) APG TT1-617/1
TITLE: German Tank, PzKpfw--IV and Panther F, Comparison and Test of Power Trains
IDENTIFICATION: First Report on Project No. TT1-617; APG 10-219
DATE OF REPORT: 30 October 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the characteristics of the gun elevating and traversing mechanisms, and the power train on German Tank, PzKpfw IV
METHOD: The tank was examined and a test run to determine the ability of a gunner to track a moving target using the hydraulic elevating and traversing mechanism. The Panther Tank, Model F, was not available for test.
DESCRIPTION: The PzKpfw IV was found to be a PzKpfw Hull with a Thoma oil drive transmission system. The power train consisted of two wobble plate oil pumps assembled into a single unit and driven by an H1-120, V-12, Maybach Engine. Oil was piped from the pumps to two separate oil motors connected to the rear sprockets. Engine and power train were mounted on the rear of the vehicle.
CONCLUSIONS: Examination showed the German Tank, PzKpfw IV, used two wobble plate pumps, assembled into a single unit, controlled by the operator and supplying various torques for steering and driving the vehicle. The hydraulically operated turret traversing and gun elevating and depressing system used a unique hydraulic slip ring. It was recommended that further tests and development work be continued on German Tank, PzKpfw IV, to explore the possibility of incorporating the oil drive feature on our own vehicles.
GENERAL: This 115-page report includes two photographs of Maybach Engine Model 228, 29 photographs of German Tank PzKpfw IV power train component parts, a steering system sketch, and a schematic diagram of the hydraulic slip ring.

SUBJECT: Tanks (Combat) APG TT1-649/33
TITLE: Final Report on Component Test of Tank, 90MM Gun, T42 Pilot No. 66
IDENTIFICATION: Thirty-third Report on Project No. TT1-649
DATE OF REPORT: 11 August 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate experimental tank components and obtain data for design purposes
METHOD: Noise level studies of the crew's compartment of the tank were made, both with and without insulation between the engine and turret compartment. Road arm deflection tests were also conducted to obtain design data. A set of composite rubber and steel road arm bumper stops were operated on a T42 tank for 770 miles to determine suitability and endurance.
DESCRIPTION: The T42 tank tested was a medium weight, full-track, armored combat vehicle. The sound proofing insulation was a spongy, mastic material approximately 1-1/2 inches thick and cemented into place on the engine side of the bulkhead. The bumper stop consisted of a center steel shaft bonded to a rubber bushing, which in turn was bonded to the outer shell and bracket, fastened to the hull of the tank.
CONCLUSIONS: The test results in reducing noise were inconclusive. The noise insulating material placed between the engine and turret showed a very slight reduction, in some cases, none at all. The road arm deflection test showed that 20 mph was the critical speed at which maximum deflection occurred. The composite rubber-steel bumper stops performed satisfactorily for 1500 miles with no sign of damage. It was concluded that the mastic insulation was of little value in suppressing noise and that more emphasis be placed in stopping noise at its source, such as the engine and suspension, rather than using a make-shift shield of mastic. Further research into the composite rubber-to-steel bumper stops was recommended.
GENERAL: This 57-page report includes three photographs.

SUBJECT: Tanks (Combat) APG TT1-696/44
TITLE: Extended Operations Tests of Tank, 90MM Gun, M47
IDENTIFICATION: Forty-fourth Report on Project TT1-696
DATE OF REPORT: 12 March 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance, operational, and durability characteristics of the M47 tank
METHOD: Five production model vehicles were operated under simulated field conditions for a total 5412 miles over pavement and cross-country, and during changeable weather conditions. Test data were recorded and reports submitted as required. The test was terminated before completion due to a lack of personnel.
DESCRIPTION: The M47 tank was a heavily-armored, full-track-laying, low-silhoutte, combat vehicle mounting a 90mm gun and carrying a crew of five men. The power package consisted of a Continental, 12-cylinder, air-cooled engine developing 810 hp and a cross-drive transmission. Other features of the tank included: a 90mm gun with both hydraulic and manual control, cast and welded armor plate, a torsion bar suspension system, auxiliary engine and generator, fixed and portable fire extinguishing systems, bilge pumps, electric ventilating system, and a gasoline type heater in the crew compartment.
CONCLUSIONS: Various difficulties were encountered in the field tests of the M47 tank. A frequent failure was the shearing of the compensating idler arm retaining bolts, and the road wheel arm spindle bearings often broke down due to high

loads. Some maintenance problems were encountered in tightening the track tension lock nuts, requiring a specially-made thin wrench for proper adjustment. The traversing pilot valve plunger would bind and stick, causing a lack of complete control of the gun turret, and the shock absorbers were not heavy enough to withstand continuous rough operation. The M47 tank performed satisfactorily in general, and it was recommended that its use as a combat vehicle, in the medium tank class, be continued. It was also recommended that steps be taken to correct the above shortcomings.
GENERAL: This 352-page report includes 98 pages of photographs showing failed parts.

SUBJECT: Tanks (Combat) APG TT1-696/46
TITLE: Extended Operations Tests of Tank, Light, M24
IDENTIFICATION: Forty-sixth Report on Project No. TT1-696
DATE OF REPORT: 16 March 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To obtain data concerning vehicle performance under severe field conditions
METHOD: Four M24 tanks were tested during extended operations on severe hills and cross-country courses. Emphasis was placed upon rapid-mileage accumulation with only necessary maintenance being performed. Weather conditions ranged through the year-round cycle and included snow and heavy rain. Data were acquired pertaining to design and performance, frequency and type of failures, parts mortality, and maintenance requirements.
DESCRIPTION: The test vehicle was an armored, full-track laying combat vehicle powered by two 8-cylinder, 90°, V-type liquid-cooled engines; engine torque was delivered through two hydramatic transmissions. The hull was a completely welded structure with a fighting compartment at the front and an engine compartment at the rear. The vehicle's fire power was supplied by a turret-mounted 75mm gun and a coaxial machine gun.
CONCLUSIONS: Significant chronic failures were cracked road wheel rims and disks, bent rear brake band struts, and glazed brake bands. Over-all fuel consumption averaged 0.70 mpg; oil consumption averaged 123.8 mpq. Failure frequency rates remained approximately constant throughout the 4889 test miles. The vehicle's average operating efficiency was 80.9%; it was felt that severe weather conditions accelerated many of the minor failures. A final inspection at the end of the test disclosed no chronic deficiencies.
GENERAL: This 242-page report includes 52 photographs showing various component failures. Also included are parts mortality lists, inspection data, and characteristic sheets.

SUBJECT: Tanks (Combat) APG TT1-696/52
TITLE: Extended Operation Tests of Tank, 90MM Gun, M48
IDENTIFICATION: Fifty-second Report on Project No. TT1-696
DATE OF REPORT: 8 July 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the test tank for general military use
METHOD: Five production model M48 tanks were operated a total of 10,157 miles on various types of terrain and under various weather conditions. The operations covered 3710 miles of hard surface roads, 2431 miles of cross-country roads, and 4016 miles of hill negotiation. The terrain conditions encountered ranged from deep, heavy mud, through dry powdery dust. Weather conditions ranged through the year-round cycle, including snow and heavy rain. Data on all phases of operation and maintenance were recorded.
DESCRIPTION: The M48 tank was a heavily armored, full-tracklaying, low silhouette, combat vehicle, mounting one 90mm gun, T139, and carrying a crew of four. It was powered by a Continental Model AV-1790-5B or AV-1790-7, 12-cylinder, V-type, 4-cycle, air-cooled engine.
CONCLUSIONS: The tank, 90mm gun, M48, did not prove itself suitable for military operations involving ruggedness and durability. It was recommended that the test vehicle be completely modified and retested to ascertain its acceptability, as modified, for field use.
GENERAL: This 206-page report includes 23 photographs of various test tank components and failures.

SUBJECT: Tanks (Combat) APG TT1-699/1
TITLE: Initial Test of the Ride Characteristics of Light Tank M24 and Medium Tank M26
IDENTIFICATION: First Report on Project No. TT1-699
DATE OF REPORT: 24 February 1949
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To investigate shock and vibration characteristics of Light Tank M24 and Medium Tank M26
METHOD: The tanks were equipped with vibration and shock recording instruments and operated over cross-country and obstacle courses.
DESCRIPTION: The test vehicles were a standard Light Tank M24 and a standard Medium Tank M26.
CONCLUSIONS: In general, the vehicles exhibited satisfactory ride characteristics. Pitching was the most objectionable characteristic. Difficulty was encountered in obtaining consistent instrument readings. It was recommended that a variation in the road wheel springing from front to rear be investigated in an effort to reduce pitching, and that an attempt be made to develop more suitable instrumentation for investigating the time-distance factor in ride characteristics.
GENERAL: This 108-page report includes four photographs of the test area and instrumentation, and 73 pages of tabulated data.

APG TT2-479A/2
SUBJECT: Tanks (Combat) APG TT2-479B/1
TITLE: Pilot Model Test of Heavy Tanks T29 and T30
IDENTIFICATION: Second Report on Project TT2-479A; First Report on Project TT2-479B; APG 10-231
DATE OF REPORT: 20 April 1950

ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine reliability, durability, and performance characteristics of the power package components of the Heavy Tanks T29 and T30
METHOD: Three Heavy Tanks T29 and two Heavy Tanks T30 were operated for a total of 7000 miles, with an average of 2000 miles on each of three endurance test vehicles. Complete engineering tests were conducted, including both performance and cooling investigations, and power checks were run on several individual engines. The emphasis during the entire program was placed on the power package, and on the determination of vehicle performance as related to power components.
DESCRIPTION: The Heavy Tank M29 was a heavily armored 70-ton combat vehicle with a Ford GAC, 750-hp, V-12, liquid-cooled engine, driving through an Allison CD850-1 "Cross Drive" transmission (which combined the functions of transmission, steering unit, and vehicle braking). The engine and transmission, together with associated cooling system and electrical wiring, were assembled as a unit to provide a readily removable "power package". The main armament consisted of a 105 mm Gun T5E2 mounted in a fully enclosed, armored turret capable of 360° traverse under hydraulic power. The vehicle suspension was of the torsion bar type with center-guide, double pin, rubber chevron or steel chevron tracks. The basic Heavy Tank T30 was identical to the Heavy Tank T29, except that a Continental air-cooled, 810-hp, V-12, AV1790-3 engine was used, and the turret mounted a 155 mm Gun T7.
CONCLUSIONS: Because of numerous mechanical deficiencies of the power plants and suspensions, the vehicles were considered unsuitable. The performance ability of the T29 was superior to that of the T30. The unit power package idea posed problems of maintenance, since removal and replacement of the package required excessive time. The power package had poor cooling characteristics. It was concluded that the new power components in both vehicles showed considerable promise in both reliability and performance, but needed further development.
GENERAL: This 400-page report is in three volumes and contains 210 photographs of the vehicles, components, and unsatisfactory parts.

SUBJECT: Tanks (Combat) APG TT2-491/1
TITLE: Tank, Super-Heavy T28, Test of
IDENTIFICATION: First Report on Project No. TT2-491; APG 10-222
DATE OF REPORT: 9 October 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Super-Heavy T28 as a combat vehicle in attacking heavy fortifications
METHOD: The test vehicle was tested and the armament was proof-fired in accordance with OATP-1943. Engineering tests included an initial mechanical inspection, operating performance, field tests, and an endurance operation of 541 miles over gravel and paved courses. The test was terminated by directive before completion.
DESCRIPTION: The test vehicle was heavily armored, weighed 194,000 pounds and mounted a 105 mm T5E1 gun in the forward end of the hull. The gun could be traversed a total of 22° and elevated a total of 22-1/2° by two separate manually operated mechanisms. The vehicle was powered by an 8-cylinder, V-type, liquid-cooled, 450 hp gasoline engine driving through a torque converter-type transmission, and a differential. The hull was an all-welded structure of heavy armor steel plates and castings. The suspension was a horizontal volute spring suspension with two parallel suspension systems on each side. The outer tracks and bogies were removable as an assembly with the outer final drives intact and the vehicle was operable on the inner suspension only.
CONCLUSIONS: The increase in armor and weight, without increase in power capacity, critically reduced the mobility of the vehicle. The Super-Heavy Tank T28 was considered unsatisfactory from the standpoints of mobility, reliability, and performance, although the 105 mm Gun T5E1 was found satisfactory. A series of component deficiencies were encountered. It was recommended that no further test work be conducted on this vehicle unless need developed for such heavy vehicles, but that the 105 mm Gun T5E1 be considered satisfactory for use. It was recommended that means of reducing ground pressure on very heavy vehicles be investigated.
GENERAL: This 202-page report contains 61 photographs of the Super-Heavy T28, components, and failed parts.

SUBJECT: Tanks (Combat) APG TT2-533/2
TITLE: Pilot Model Test of Heavy Tank, T32, No. 2
IDENTIFICATION: Second Report on Project TT2-533; APG 10-230
DATE OF REPORT: 15 March 1949
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the physical and operating characteristics of the Heavy Tank T32
METHOD: Performance characteristics were determined by limited operation of the vehicle on various test courses. The tests included a mechanical inspection, slope operation, obstacle crossing and fording ability, mechanical reliability, and cooling studies.
DESCRIPTION: The test Heavy Tank, T32, No. 2, was a 60-ton class vehicle with torsion bar suspension. A Ford GAC, V-12 engine, rated 770 hp at 2800 rpm, supplied power to the final drives through a cross-drive transmission. The transmission was a 3-stage, hydraulic torque converter, Model CD-120. Primary vehicle armament consisted of a 90 mm Gun, T15E2, with a coaxially mounted .30 cal. machine gun, a bow mounted .30 cal. machine gun, and a .50 cal. machine gun mounted on top of the turret.
CONCLUSIONS: The performance characteristics of the test vehicle were considered excellent for its weight class. Operation of the vehicle was limited by poor reliability of the transmission. The following corrections were recommended: the deficiencies experienced with cross-drive transmis-

sion be eliminated; the method of removing the power package be improved; the fuel tanks be redesigned to reduce the required filling time; a high velocity 90 mm gun, with improved equilibration and ammunition handling be employed; and the electrical system controlling the speedometer, tachometer, and sending unit be improved.
GENERAL: This 166-page report contains 19 photographs of the test vehicle, component parts, and parts damaged during testing.

SUBJECT: Tanks (Combat) APG TT2-549/1
TITLE: Bulldozer, Tank Mounting, T9 for Light Tank M24
IDENTIFICATION: First Report on Project TT2-549; APG 15-69
DATE OF REPORT: 8 December 1948
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and effectiveness of the tank-mounted bulldozer and the effect of the bulldozer on the power train and suspension
METHOD: The tank was operated for 100 miles over cross-country at 15 mph to test the moldboard carrying hooks. The performance of the bulldozer and its effect on the tank were tested for 120 hours clearing and grading wooded areas and 80 hours of general earth-moving, for a total of 200 hours.
DESCRIPTION: The Bulldozer, Tank Mounting, T9 was a hydraulically operated unit designed for mounting on the Light Tank M24. It was attached by modified design parallelogram linkage which was the basic feature in the design of the bulldozer. This linkage positioned the bulldozer approximately vertically, for operation, and sloped it back, out of the driver's field of vision, for carrying. It was operated by double-acting hydraulic cylinders mounted on the front of the tank. Carrying hooks and an emergency lifting mechanism were provided for the bulldozer.
CONCLUSIONS: The performance of the vehicle was satisfactory. Maneuverability and mobility of the tank were not affected by the bulldozer and the increase of maintenance was a minimum. It was recommended that the moldboard speed be increased and that a device be developed to reduce the shock pressures in the hydraulic system.
GENERAL: This 53-page report contains nine photographs showing the mounting of the bulldozer on the tank and part failures encountered. Also included in the report are curve sheets showing moldboard velocity vs. engine RPM, and limits of vision for the tank operator.

SUBJECT: Tanks (Combat) APG TT2-645/1P
TITLE: British Centurion II Tank
IDENTIFICATION: First Partial Report on Project TT2-645; APG 10-223A
DATE OF REPORT: 2 December 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the British Centurion, II, Tank
METHOD: The tank was tested according to the second through the sixth, fourteenth, sixteenth nineteenth, and twenty-first features of the Ordnance Automotive Test Program, 1943.
DESCRIPTION: The test British Centurion, II, Tank was a fifty-four ton combat vehicle powered by a 600-hp at 2550 rpm, V-12 engine, driving through a mechanical shift transmission containing a differentially controlled epicyclic steering system. The vehicle had a horizontal helical-spring suspension system and 27-inch steel, center-guided tracks. Armament consisted of an Ordnance Q.F. 17-pounder, Mark 6 Rifle and a coaxial, gas-operated, air-cooled 7.92-mm Besa Machine Gun. The tank was equipped with an electrical power traverse and elevating system.
CONCLUSIONS: In general, the tank proved satisfactory. Major deficiencies encountered in the operation of the tank were high coolant temperatures during continuous operation, and track jumping. It was recommended that various design features be considered for American tank use such as the loader's safety switches and increased working area, automatic turret lock, and automatic disengagement of hand control when changing to power traverse.
GENERAL: This 93-page report contains 21 photographs of the test vehicle and components.

SUBJECT: Tanks (Combat) APG TT2-668/2
TITLE: First Partial Report on Pilot Model Test of Medium Tank T40
IDENTIFICATION: Second Report on Project No. TT2-668; APG 10-233
DATE OF REPORT: 27 June 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the reliability and durability characteristics of the Medium Tank M26E2
METHOD: One Medium Tank M26E2 and one Medium Tank T40 were operated for 2062 miles and 1882 miles, respectively. The tests included an initial mechanical inspection, operation and performance tests over various terrain, and firing tests. Endurance testing was discontinued upon receipt of Medium Tanks M46 with later model engines and transmissions.
DESCRIPTION: The Medium Tank M26E2 was a pilot model vehicle constructed by elongating the rear hull of the standard Medium Tank M26 and replacing the original engine and power train with a new "power package" which consisted mainly of the Continental AV1790-1, 810-hp, air-cooled engine and an Allison CD850-1 cross-drive transmission. The Medium Tank T40 was a pre-production model of the Medium Tank M46, and its characteristics were the same as those of the M26E2.
CONCLUSIONS: Mechanical deficiencies in the engine and transmission were of such frequency and magnitude in both test vehicles that they were considered entirely unsatisfactory from the standpoint of reliability and durability. The Medium Tank T40 was completely unsatisfactory in respect to full throttle cooling ability of the engine and transmission under average temperature conditions. It was concluded that the unit power package provided excellent advantages, but as constituted in the test vehicles, it necessitated excess time and effort for removal or replacement for maintenance of ac-

cessories and components. The durability testing was considered too limited for proper evaluation. It was recommended that corrective action be taken for all deficiencies disclosed in this test, that sufficient reliability and durability tests be conducted for proper evaluation, and that future planning provide for sufficient time for complete testing of vehicles prior to the initiation of production.
GENERAL: This 178-page report contains 72 photographs of the Medium Tank M26E2 and the T40, components, and failed parts.

SUBJECT: Tanks (Combat) APG TT2-668/3
TITLE: Final Report on Pilot Model Test of Medium Tank T40
IDENTIFICATION: Third Report on Project No. TT2-668; APG 10-236
DATE OF REPORT: 3 November 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the Medium Tank T40
METHOD: Tests were conducted on two Medium Tanks, T40. One vehicle was operated on an endurance test and the other was tested for basic field performance characteristics. The latter consisted of field and laboratory dynamometer tests, slope operation and vehicle cooling tests.
DESCRIPTION: The two test Medium Tanks T40 were pilot models of the M46. The vehicles were manufactured from standard M26 tanks and were similar to the M26 except for the following equipment: Continental V-12, air-cooled, 810 hp engine, model AV1790-3; an Allison cross-drive transmission, Ordnance CD850-2; accessories and coolers for the engine and transmission; a 90 mm Gun M3A1; a Telescope T151, Telescope Mount T172; and an auxiliary, spring-loaded, suspension idler on the rear road wheel.
CONCLUSIONS: The performance of the Tanks T40 was superior to that of the M26. However, a full throttle cooling ability was unsatisfactory and a loss of 50% of full throttle gross engine power occurred in the power package before it was delivered to the sprockets. It was recommended that efforts be directed toward reducing power loss.
GENERAL: This 151-page report contains 11 photographs of the vehicles and components.

SUBJECT: Tanks (Combat) APG TT2-672/3
TITLE: Final Report on Test of Medium Tank, T42, Simulated
IDENTIFICATION: Third Report on OCO Project No. TT2-672; APG 10-241
DATE OF REPORT: 13 June 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the operating characteristics of a simulated Medium Tank T42
METHOD: A Medium Tank, T40, modified to simulate Medium Tank, T42, and a Medium Tank, M4E8 (M4A3), were given complete performance tests.
DESCRIPTION: Simulated Medium Tank, T42, consisted of a hull and suspension system from a Medium Tank, T40 (M46), equipped with a power package from a Light Tank, T41, which was an AOS 895-1 engine coupled to a CD 500-1B transmission tank provided with associated oil cooling radiators and engine-driven fans. The test vehicle was loaded to a weight of 36 tons and provided with an over-all final drive gear ratio of 5.84 compared to a final drive gear ratio of 5.92 for the actual T42 vehicle.
CONCLUSIONS: Performance of the test simulated vehicle was comparable to that of the M4E8. A later test of an actual T42 indicated the test results were not applicable to an actual T42 tank. It was recommended that in the future no attempt be made to obtain performance characteristics of a new or incomplete vehicle by use of mock-up or simulated vehicles unless identical power components are available. Also, it was recommended that the AOS-895 engine and CD 500 transmission be fully tested before quantity procurement.
GENERAL: This 56-page report is not illustrated.

SUBJECT: Tanks (Combat) APG TT2-672/5
TITLE: First Report on Test of Tank, 90 MM Gun, T42 Pilot Nos. 1 and 2
IDENTIFICATION: Fifth Report on Project TT2-672; APG 10-251
DATE OF REPORT: 9 April 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance characteristics of the 90 mm Gun Tank T42
METHOD: Pilots No. 1 and No. 2 of 90 mm Gun Tank, T42, were operated over various test courses for 4214 and 886 miles, respectively. Drawbar pull, obstacle crossing, acceleration, cooling, endurance, and firing tests were conducted.
DESCRIPTION: The vehicle weighed 73,500 pounds combat-loaded, and had torsion bar suspension with five road wheels on each side. Its power package consisted of a Continental, AOS-895-3, 6-cylinder horizontally opposed, air-cooled, supercharged, 500-hp, gasoline engine connected directly to an Allison, CD-500-3T, cross-drive transmission. This transmission with a polyphase torque converter, with an automatic lock-up in high range. The vehicle had a 90 mm gun, T119, and concentric recoil mechanism, but was not equipped with power traversing or elevating mechanism, or stabilizer.
CONCLUSIONS: The test vehicles met, and in some instances exceeded specification requirements. Performance of the test T42 exceeded that of the M4A3 and closely approached that of the M46. It was recommended that with modifications to the suspension, final drive pinions, and fire extinguisher system, the vehicle be considered for production.
GENERAL: This 675-page report contains 174 photographs of the test vehicles, components, parts damaged in operation, and condition of Pilot No. 1 after a gasoline fire. Also included are Automotive Laboratory Reports 51-45, 51-45A, 51-63, 51-70, 51-85, 51-91, 51-120, and 51-86.

SUBJECT: Tanks (Combat) APG TT2-672/8
TITLE: Third Report on Test of Tank 90 MM Gun, T42, Pilot No. 2
IDENTIFICATION: Eighth Report on Project No. TT2-672; APG 10-270

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 17 June 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability and performance characteristics of the second pilot model of 90 mm Gun Tank, T42; and to determine the suitability of an experimental, three-speed transmission
METHOD: The test vehicle was operated for 4000 miles over various test courses.
DESCRIPTION: The tank weighed 73,500 pounds and used torsion bar suspension. It was powered by a 500 hp Continental AOS-895-3 engine directly connected to a cross-drive transmission. The test transmission, CD-503-1, provided an intermediate forward speed range with lock-up and an automatic downshift from high to intermediate range. Tests were made with a steering wheel used in place of the wobble stick and with friction snubbers used in place of hydraulic shock absorbers.
CONCLUSIONS: Numerous engine failures occurred on the test, and it was recommended that the manufacturer exercise closer quality control and inspection. The test CD-503-1 transmission did not show significant performance improvement over the standard transmission, and the addition of an intermediate forward speed range was not considered justified. The steering wheel required excessive effort and was considered unsatisfactory; however, further development of steering wheel controls was recommended. The friction snubbers gave satisfactory operation and were considered superior to shock absorbers in durability and maintenance. Modifications to the engine, transmission, and suspension were recommended before further testing.
GENERAL: This 210-page report contains 31 photographs showing the test steering wheel, shift assembly, and parts damaged in operation.

SUBJECT: Tanks (Combat) APG TT2-672/9
TITLE: First Report on Test of Tank, 90MM Gun, T42, Pilot Number Six
IDENTIFICATION: Ninth Report on Project No. TT2-672
DATE OF REPORT: 2 September 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate the test tank
METHOD: The T42 tank was inspected and experimental components were installed. Stowage and radio suppression checks were made and the vehicle was operated 557 miles on endurance and fuel consumption tests.
DESCRIPTION: Tank, 90mm gun, T42, was a medium weight, full-tracked, armored combat vehicle. Main armament consisted of a 90mm, T119 gun in a 360° rotating turret. The power package consisted of an AOS-895-3 engine and CD-500-3 transmission.
CONCLUSIONS: The major deficiencies were in the transmission and suspension, as with previous T42 tank pilot models tested. The road wheel arms, shock absorber brackets and mounting screws, front volute snubber springs, and idler compensating arms were unable to withstand the loads imposed on them during cross-country operation. It was recommended that engineering tests be completed as soon as possible in view of the obvious suspension weaknesses.
GENERAL: This 58-page report includes one photograph showing failed rubber snubber springs.

SUBJECT: Tanks (Combat) APG TT2-672/12
TITLE: Second Report on Test of Tank, 90MM Gun, T42, Pilot No. 6
IDENTIFICATION: Twelfth Report on Project No. TT2-672
DATE OF REPORT: 25 January 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of several modified and experimental components for the T42 tank
METHOD: A T42 vehicle was equipped with experimental bumper stops, bulkhead insulation and a Glowmeter instrument panel. Road arm deflection tests were performed and the noise level in the crew compartment was determined. All test components were inspected periodically to determine their functional reliability. Endurance tests were attempted, but were halted due to a breakdown of the facility vehicle after 207 miles of operation.
DESCRIPTION: The Glowmeter instrument panel was a sealed unit containing instrument mechanism and an optical projection system; it included an outside housing for the exterior screen. The bumper stops were of composite rubber-steel design, and bulkhead insulation was a spongy, mastic type material 1-1/2 inches thick. A hydraulically-operated driver's seat was received with the facility vehicle, but was incomplete and therefore not tested.
CONCLUSIONS: The T42 tank was considered unreliable as a test vehicle due to numerous suspension failures and the unavailability of replacement parts. The accuracy and reliability of the Glowmeter panel were considered unsatisfactory and it was recommended that further testing be conducted using a functionally reliable unit. The bumper stops functioned satisfactorily, but additional endurance testing was recommended for a more thorough evaluation.
GENERAL: This 64-page report includes two photographs showing the experimental driver's seat and bumper stops. A deficiency report is also included.

APG TT2-672/26 Memo
SUBJECT: Tanks (Combat)
TITLE: Twenty-sixth Memorandum Report on Test of Tank, 90MM, T42, Pilot No. 1
IDENTIFICATION: Project TT2-672/26 Memo
DATE OF REPORT: 9 November 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the extent of the damage to the tank, caused by fire, and to make necessary repairs
METHOD: The vehicle was given a complete inspection. The transmission and engine power package were removed. After the wiring, carburetors, and other damaged parts had been replaced, the unit operated satisfactorily on the test stand. The auxiliary generating unit also was put into operating condition by replacing the wiring and other damaged parts referred to in the Twenty-

fifth Memorandum report, dated 29 October 1951.
DESCRIPTION: The damaged vehicle was a tank, 90mm gun, T42, pilot No. 1. The fire occurred 7 October 1951.
CONCLUSIONS: The repaired vehicle was ready for return to the Detroit Arsenal.
GENERAL: This 33-page memorandum includes 31 photographs of the test vehicle and all components damaged by fire.

SUBJECT: Tanks (Combat) APG TT2-673/3
TITLE: First Partial Report on Test of Tank, 120 MM Gun, T43, and Pancake Muffler for AV 1790-5B Engine
IDENTIFICATION: Third Report on Project TT2-673; APG 34-35B
DATE OF REPORT: 15 September 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance, reliability and suitability of the Tank, 120 mm Gun, T43, and to determine the operational characteristics of pancake-type mufflers for use with the AV 1790-5B engine
METHOD: One pilot model test vehicle was operated for 525 miles. Drawbar pull, cooling, acceleration, maximum speed, sustained slope speed, fuel consumption, fording, mobility, and cross-country endurance tests were performed.
DESCRIPTION: The Tank, 120 mm Gun, T43, was a heavily armored vehicle carrying a high-velocity 120 mm gun mounted in a 360° traversing turret. It was powered by a Continental AV 1790-5B engine, used a cross-drive CD 850-4 transmission, and weighed 60 tons.
CONCLUSIONS: Changes considered necessary in the T43 tank were primarily in the front suspension, oil cooler fan clutches, final drive gears, mufflers, engine compartment bulkheads, stowage, ease of maintenance, and safety of the crew. The hull had good armor layout, although several severe re-entrant angles were caused by the turret overhang and the gun shield. The medium tank power package (AV 1790-5B engine and CD 850-4 transmission) provided satisfactory performance for the T43 tank, but with high fuel consumption. Correction of design deficiencies encountered during the test and testing of a pilot vehicle incorporating the changes were recommended. The medium tank power package was recommended for retention in the T43 tank.
GENERAL: This 168-page report contains 37 photographs of the test vehicle and deficient components and design.

SUBJECT: Tanks (Combat) APG TT2-673/8
TITLE: Second Partial Report on Engineering and Endurance Test of Tank, 120MM Gun, T43 (Final Report on Tests of Pilots No. 1 and No. 5 and Final Report on Pancake Muffler for M43 Tank)
IDENTIFICATION: Eighth Report on Project No. TT2-673
DATE OF REPORT: 4 September 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the engineering, mobility, and endurance characteristics of two modified T43 pilot models
METHOD: Engineering tests were conducted to determine low range drawbar pull and drawbar horsepower, heating effects on the turret bustle from engine exhaust, maximum vehicle speed, and fuel consumption. Endurance operations were conducted over paved, gravel, and cross-country courses for a total of 2449 miles. The test vehicles were also operated on slopes, and on vertical walls varying from 18 to 42 inches in height.
DESCRIPTION: The T43 was a heavily-armored, full track-laying, combat vehicle developed by Chrysler Corporation. Combat weight of the vehicle was 6 tons. It was powered by a Continental Model AV 1790-5B, 12-cylinder, V-type, gasoline engine, with an Allison CD-850-4 cross-drive transmission. The turret mounted a 120mm gun T123, and could be traversed 360°. The test vehicles had new-design front road wheel arms, heavier front bump stops, modified front torsion bar housings, and 11-tooth sprockets with modified hubs and final drive gears. Pancake-type mufflers mounted directly on top of each engine fan replaced the original Detroit Arsenal type-V center section muffler.
CONCLUSIONS: The mobility of the T43 tank appeared satisfactory and compared favorably with the M47 tank. The endurance of the vehicle was considered unsatisfactory because of numerous suspension deficiencies. Other deficiencies listed in the report covered almost the entire vehicle. Extensive changes in hull and suspension were required and it was recommended that the deficiencies noted in this report be corrected and that further testing be conducted.
GENERAL: This 263-page report includes 52 photographs showing general views of the test vehicle, several modifications, and vehicle component failures. Laboratory reports and failure summaries are also included.

SUBJECT: Tanks (Combat) APG TT2-673/10
TITLE: Engineering and Endurance Test of Tank, 120MM Gun, T43E1 (Pilot No. 2) Fire Control Phase
IDENTIFICATION: Tenth Report on Project No. TT2-673
DATE OF REPORT: 23 September 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the operating, endurance, and reliability characteristics of the 120mm gun tank T43E1, with special emphasis on the turret and fire control equipment
METHOD: The T43E1 vehicle was placed on extended turret and fire control tests. Automotive deficiencies were noted as encountered. Tests were made in accordance with a master test plan included in the report.
DESCRIPTION: The second, pilot model, T43E1 vehicle incorporated many modifications recommended as a result of previous tests. The major changes in the test vehicle included a new traverse gear box with 2-speed ratios, elimination of the turret control feedback system, installation of a new type cal. .50 commander's cupola mount with remote control features, special electrically and manually operated turret traverse lock, rear-

ranged ammunition stowage, elimination of the commander's T35 periscope, utilization of the T123 gun with 4-cylinder recoil system, and other minor changes in the turret controls. Automotive changes included heavier arms for the front and rear road wheels, repositioned shock absorber brackets, and an 11-tooth drive sprocket in place of the original 13-tooth sprocket.
CONCLUSIONS: Performance of the turret and fire control systems was considered marginal; 120mm gun ammunition stowage, commander's cal. .50 machine gun installation, and coaxially mounted machine gun installation were unsatisfactory. Numerous automotive deficiencies were observed, some of which impaired the combat effectiveness of the tank. It was recommended that future pilot models be given extensive field tests prior to production; that all major deficiencies uncovered by these tests be corrected prior to issue to troops; and that other deficiencies be corrected when feasible.
GENERAL: This 283-page report includes nine photographs showing fire control components and several track components. A complete test log is also included.

SUBJECT: Tanks (Combat) APG TT2-673/14
TITLE: Engineering and Endurance Test of Tank, 120mm Gun, T43E1 (Pilot No. 2)
IDENTIFICATION: Fourteenth Report on Project No. TT2-673
DATE OF REPORT: 7 September 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the operating, endurance, and reliability characteristics of tank, 120mm gun, T43E1, with special emphasis on latest production modifications in suspension and other vehicular components
METHOD: Automotive tests were conducted on tank, 120mm gun, T43E1, Pilot No. 2 to determine if defects reported for earlier pilot models had been corrected. A total of 1843 miles of operation was conducted primarily over hilly cross-country terrain. Tests of electrical loads imposed by vehicle components, turret bustle, floor heating, and operation in sand were conducted.
DESCRIPTION: Modifications to the test vehicle suspension system included heavier road wheel arms in front and rear positions, friction snubbers instead of shock absorbers, repositioned friction snubber brackets to eliminate interference, and an 11-tooth drive sprocket instead of the 13-tooth drive sprocket. In general, the suspension components were the same as used on tank, 90mm gun, T48.
CONCLUSIONS: The maneuverability and mobility of the test vehicle were considered acceptable, but the tracks skipped excessively. Interference between the track and front torsion bar housings and interference between adjacent road wheel arms were the most serious defects noticed. It was recommended that these and other major deficiencies noted in the report be corrected and tested prior to the issue of this vehicle to the using arms.
GENERAL: This 192-page report includes 15 photographs of test components, and a test log.

SUBJECT: Tanks (Combat) APG TT2-673, Memo 21
TITLE: Twenty-first Memorandum Report on Tank, 120mm Gun, T43 (Engineering and Endurance Test)
IDENTIFICATION: Project No. TT2-673; Memo 21
DATE OF REPORT: 16 November 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance and endurance characteristics of the pilot Model T43 vehicle
METHOD: The vehicle was operated for 16 miles over cross-country terrain with approximately 20% of the operation at full throttle and the remainder at part throttle. Subsequent to cross-country operation, the bulkhead and hatch seals in the hull were replaced in preparation for future fording tests.
DESCRIPTION: The test vehicle was designated as tank, 120mm gun, T43.
CONCLUSIONS: During cross-country operations both left and right road wheel arms failed by bending so severely that the road wheels scraped against the arms. This did not completely immobilize the vehicle but rendered further operation impractical. It was recommended that stronger front road wheel arms should be provided for the tank, 120mm gun, T43 pilot model.
GENERAL: This four-page report is not illustrated.

SUBJECT: Tanks (Combat) APG TT2-673, Memo 27
TITLE: Engineering and Endurance Test of Tank, 120mm Gun, T43
IDENTIFICATION: Project No. TT2-673; Memo 27
DATE OF REPORT: 25 March 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance and endurance characteristics of the front track adjusting idler arms of a T43 tank
METHOD: The T43 tank was operated on various types of terrain for 552 miles. Inspections included removal of the two front track adjusting idler arms for examination of the arm bearings and spindles.
DESCRIPTION: The test vehicle was a 120mm gun, T43 tank, vehicle No. 30163674, which weighed 120,000 pounds. Each of the two front track adjusting idler arms utilized a needle bearing (Torrington No. 9612040) nearest the hull and a self-aligning roller bearing (Scirf No. 22316) on the outer part of the spindle. A grease seal and dust shield protected the inner bearing on the right arm; a dust shield was used on the left arm.
CONCLUSIONS: An inspection after 552 miles revealed no evidence of wear on either spindle or any of the bearings or races. It was found that the fiber portion of the grease seal used to protect the inner bearing on the right arm was torn slightly. There was no evidence that water had entered the bearings on either arm.
GENERAL: This two-page report is not illustrated.

APG TT2-674
SUBJECT: Tanks (Combat) Memo 18, 20, 23
TITLE: Tests of Tank, 76mm Gun, T41E1
IDENTIFICATION: Project No. TT2-674; Memo 18, 20, and 23
DATE OF REPORT: 14 January 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine endurance and engineering characteristics of the T41E1 tank
METHOD: Investigations were made to determine the cause for the failure of the engine, Serial No. 21, in a previous test. Dimensional inspection of one of the original front support arms and an experimental rear arm were completed. One of the tanks was subjected to a comparative fuel consumption test on the Churchville course. The front and rear road wheel alignment was checked. Further investigation of the pressure drop through the air cleaner was conducted, and the procedure for removing and installing the engine air cleaners was investigated. Engine, Serial No. 10, was inspected and operated on a test stand. Detailed measurements were made on an experimental right front road wheel arm. A general inspection of the No. 30163739 tank was performed.
DESCRIPTION: The test vehicles were two 76mm gun, T41E1 tanks, US Reg. Nos. 30163738 and 30163739.
CONCLUSIONS: No reason for the failure of the Serial No. 21 engine was discovered. A transmission failure occurred during operation on the Churchville course. It was found that both air cleaners could be completely removed and installed through the engine compartment bulkhead doors without removing the power plant or fuel tanks. A total of 75 track shoes on the No. 30163739 tank was cracked, and the rubber inserts on the inside of the track shoes had started to loosen. Test stand operation of the No. 10 engine was generally satisfactory. Failure summaries for the No. 30163739 tank were presented in the report.
GENERAL: This 49-page report contains 31 photographs showing component wear.

SUBJECT: Tanks (Combat) APG TT2-674/1
TITLE: Test of Light Tank T37
IDENTIFICATION: First Report on OCO Project No. TT2-674; APG 10-238
DATE OF REPORT: 28 December 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the reliability and operating characteristics of the pilot Light Tank T37
METHOD: The test vehicle was given a limited 1174-mile operational and durability test. Fire control tests were made to evaluate Range Finder T37, traversing mechanism and power controls, vision devices, ammunition handling arrangements, and turret space requirements.
DESCRIPTION: Light Tank T37 was a 50,000-pound vehicle powered by an air-cooled, 6-cylinder, horizontally opposed, supercharged, AOS 895-1 Continental engine rated at 500 hp at 2800 rpm and at a maximum torque of 960 lb./ft. at 2400 rpm. Power was transferred by an Allison CD 500-1 cross-drive transmission with torque converter and planetary gear train. The main armament of Tank M26 consisted of 76mm Gun T94 mounted in Combination Gun Mount T137 with Concentric Recoil Mechanism T74. Hydraulic power elevation and traverse were provided. A five-foot stereoscopic Range Finder T37 was used as the primary and secondary sight for the main armament. The track used was single pin, rubber bushed, center-guide, 21-inches wide, and had removable rubber pads for highway use. Torsion bar suspension was used.
CONCLUSIONS: Because of limited endurance testing, no durability characteristics were determined. Over-all operational characteristics were satisfactory. Range Finder T37 was effective in increasing probability of hits. It was recommended that range finders be considered a mandatory component of fire control systems designed for effective fire at ranges of over 1000 yards, and that performance of range Finder T37 be considered a minimum standard for accuracy.
GENERAL: This 127-page report includes 25 photographs of the test tank and components, and three laboratory reports on determination of vehicle physical characteristics.

SUBJECT: Tanks (Combat) APG TT2-674/5
TITLE: First Report on Engineering and Operational Test of Tanks, 76 MM Gun, T41E1, Serial Nos. 6 and 7
IDENTIFICATION: Fifth Report on Project TT2-674; APG 10-246
DATE OF REPORT: 26 March 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the performance, durability, and reliability of the early production T41E1 vehicle
METHOD: Two test tanks were operated 1722 and 2024 miles, respectively, over various test courses.
DESCRIPTION: The lightly armored T41E1 tank (25-ton class) was powered by a Continental, AOS-895-3, horizontally opposed, six-cylinder, supercharged, air-cooled, 500-hp, gasoline engine. It used an Allison CD-500-3 cross-drive transmission and torsion bar suspension. Main armament was a 76 mm gun in a 360° traversing turret.
CONCLUSIONS: Engine life was considered extremely short, part failures were of a serious nature, auxiliary generators were unsatisfactory because of vapor lock, and the cross-drive transmission was inefficient. It was recommended that corrective measures be made to correct these defects and numerous others listed in the report.
GENERAL: This 48-page report contains 91 photographs of the vehicle and its components.

SUBJECT: Tanks (Combat) APG TT2-674/6
TITLE: First Report on Desert Tests of Tank, 76-MM Gun, T41E1 Serial No. 8--Endurance
IDENTIFICATION: Sixth Report on Project No. TT2-674; APG 10-257
DATE OF REPORT: 21 August 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability of the T41E1 Tank during extended operation on desert terrain

METHOD: The vehicle was endurance tested for 652 miles over an extremely rough cross-country course at the Yuma, Arizona, Test Station.
DESCRIPTION: Test Tank, 76-mm Gun, T41E1, was a lightly armored vehicle in the 25-ton class. It was equipped with a 500-hp, supercharged, six-cylinder, air-cooled, Continental, AOS-895-3 engine and a cross-drive transmission. The Track T91E3 was a single-pin, center-guide track.
CONCLUSIONS: The major deficiency in the test vehicle was the suspension system. Performance of the shock absorbers and road wheel bumpers was inadequate, and the self-locking bolts used to secure various suspension components were not of sufficient strength. The life of the AOS-895-3 engine was extremely short. This condition was caused by dust entering the engine through the air cleaners. Separate air cleaner tests were recommended. The T91E3 track performed satisfactorily. It was felt that the vehicle would give good performance over very rough and hilly terrain, if the above mentioned difficulties were corrected.
GENERAL: This 113-page report includes 22 photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) APG TT2-674/13
TITLE: Third and Final Report on Engineering and Operational Test of Tanks, 76mm Gun, M41 and M41A1
IDENTIFICATION: Thirteenth Report on Project No. TT2-674
DATE OF REPORT: 29 January 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine automotive performance characteristics of M41 and M41A1 tanks and to determine characteristics of various test vehicle components, some modified from previous testing
METHOD: Tests were conducted on the entire automotive phase of the test vehicles considering both major and minor components and the complete vehicles. Nine vehicles were operated a total of 30,000 miles; included in the testing were modified engines, austerity engines, fuel injection engines, austerity transmissions, and tracks. Data accumulated included a day-by-day record of component failures and a laboratory study of vibrational characteristics.
DESCRIPTION: The M41 tank was a lightly-armored vehicle, weighing 51,000 pounds loaded, and mounting a 76mm gun with a cal. .30 coaxial machine gun and another cal. .30 machine gun mounted on top of the turret. The power package was a Model AOS-895-3, horizontally opposed, 6-cylinder, air-cooled, supercharged gasoline engine developing 500 hp; the Model CD-500-3 cross-drive transmission embodied a fluid torque converter and planetary gear sets. A differential steering system and mechanical braking were employed in the unit. The M41A1 differed from the M41 in that the traverse and elevating systems were simplified, eliminating separate pulsing relay motor and controls, as well as high-pressure piping.
CONCLUSIONS: Automotive performance and design were satisfactory; fuel economy needed improvement. It was recommended that the reliability of certain components be improved. Recommendations concerning the engine included a redesign of the supercharger assembly and the adoption of seal-type bearings in control linkages. Other recommendations included corrections in the electrical system, transmission, final drive, tracks and suspension, fenders and extensions, and the hull.
GENERAL: This 163-page report includes laboratory reports and 21 photographs of test components.

APG TT2-674/B&C/37 memo
SUBJECT: Tanks (Combat)
TITLE: Test of Tanks, 76mm Gun, T41E1 and T41E2
IDENTIFICATION: Thirty-seventh Memorandum Report on Project No. TT2-674/B&C
DATE OF REPORT: 18 May 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the automotive failures of the test tanks during the general automotive tests conducted from 15 March to 20 April, 1953; and to obtain comparative vibration data on two tanks
METHOD: The tanks were driven over cross-country roads and subjected to track, suspension, modified engine and transmission tests. Vibration characteristics were observed at both high and low speed.
DESCRIPTION: Four T41E1 tanks and one T41E2 tank were used in the automotive test. The T41E1 tanks were USA Nos. 30165360, 30165479, 30165495, and 30165499. The T41E2 tank was USA No. 301651535. The tanks used in the vibration study were a standard tank, USA No. 30165760, and a modified T41E1 tank, USA No. 30165761.
CONCLUSIONS: Automotive failures were shown in the memorandum report for all five tanks engaged in the cross-country test. At the time of this report, the tests were still being continued. Thirty eight curve sheets in the report recorded the vibration characteristics of the two test tanks.
GENERAL: This 57-page report includes 10 photographs of the laboratory vibration study of the two tanks.

SUBJECT: Tanks (Combat) APG TT2-760/7
TITLE: Engineering and Endurance Test of Tank, 90mm Gun, T48, Pilot No. 2 (Automotive Phase)
IDENTIFICATION: Seventh Report on Project No. TT2-760
DATE OF REPORT: 1 January 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the over-all automotive suitability of the T48 tank, Pilot No. 2
METHOD: The test vehicle was operated for 3613 miles over varied terrain. Numerous automotive engineering tests and fire control tests were performed. Testing was expedited since production of the tank was under way and many new vehicle features required testing.
DESCRIPTION: The test 90mm gun, T48 tank, Pilot No. 2, was equipped with a Continental AV-1790-5b engine, a torsion bar suspension, and 28-inch track. Vehicle weight was 49.6 tons. Four men made up the vehicle crew. A total of 60 rounds of 90mm ammunition was carried in the vehicle.

CONCLUSIONS: The test vehicle possessed many satisfactory features, but many components were unreliable and difficult to maintain. Vehicle fuel consumption was high and cruising range was short. It was recommended that future pilot models be extensively tested prior to production approval. This recommendation was made in view of the numerous deficiencies found in the test vehicle. It was further recommended that all major test vehicle deficiencies listed in the report be corrected prior to issuing the vehicle to troops; and that an active program be initiated to reduce test vehicle fuel consumption and increase cruising range.
GENERAL: This 550-page report, included in two volumes, contains 81 photographs showing the test vehicle, vehicle components, and microstructure of a defective component.

SUBJECT: Tanks (Combat) APG TT2-760/14
TITLE: Engineering and Endurance Test of Tank, 90mm Gun T48, Serial Numbers 400 and 401 (Automotive Phase)
IDENTIFICATION: Fourteenth Report on Project No. TT2-760
DATE OF REPORT: 1 October 1954
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine performance and endurance characteristics of two pilot production T48 tanks
METHOD: This evaluation was a continuation of previous tests of the pilot model tanks. The two tanks were operated a total of 4888 miles over various types of terrain. Fuel and oil consumption and deficiencies were noted. Thirty maintenance studies were made, and 32 major vehicular failures were investigated. Engineering performance tests were conducted with respect to component and total electrical load, field performance characteristics, carbon monoxide concentration inside the tank, and hydrostatic lock. Other tests were performed concerning the operation of the personnel heater, cooling characteristics of the tank, and vibration of the Model A-41-1 auxiliary generator set. Vehicular performance was compared using standard T97, 28-inch and experimental T84E1 23-inch tracks.
DESCRIPTION: The pilot production 90mm gun tanks, T48, Serial Nos. 400 and 401, were 50-ton, four-man vehicles, characterized by the unique elliptical armor configuration, low normal ground pressure, remotely controlled commander's machine gun mount, and commander operated range finder. A 16.5 hp per ton ratio was produced by an Ordnance AV-1790-5G engine powering the vehicle through a CD 850-4 transmission, permitting pivot and variable steering. A 60% slope could be climbed by the vehicle, and the maximum speed was 30 mph. High cross-country speed was permitted by the hydraulically damped torsion bar springing and 28-inch, all rubber chevron, rubber bushed, T97 track.
CONCLUSIONS: Maintenance was complicated by the inaccessibility of many components. Performance tests revealed overload of the front suspension and high carbon monoxide concentrations in the crew compartment. Performance characteristics of the 23-inch vs the 28-inch track were approximately equivalent; the 23-inch track endurance life was less than the 28-inch track. Engine torching, oil cooler leakage, and a high mortality of suspension parts were exhibited during the endurance test. Most failures were repetitions of those previously found on the pilot model tests. It was recommended that deficiencies be corrected, and that, when possible, tests and corrective design action precede vehicle production.
GENERAL: This 220-page report contains 45 photographs of the T48 tank and components.

SUBJECT: Tanks (Combat) APG TT2-760/18
TITLE: Test of Tank 90mm Gun M-48 with Bulldozer Kit, T18E1
IDENTIFICATION: Eighteenth Report on Project No. TT2-760
DATE OF REPORT: 6 May 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effects of a bulldozer installation on the M48 tank with major consideration to the durability of the final drives, suspension system, and transmission
METHOD: An M48 tank equipped with the T18E1 bulldozer kit was operated on a cross-country endurance and bulldozing test for approximately 130 hours. Test-certified final drives were installed and operated 100 hours and 130 hours, respectively, for the left and right final drives.
DESCRIPTION: Tank, M48, was a 49-ton vehicle utilizing a four man crew and characterized by an elliptical armor configuration, low ground pressure, and a remote-controlled commander's machine gun mount and commander-operated range finder. It had a 17 hp per ton ratio, which was produced by the Ordnance AV-1790-7 engine through a CD 850-4A transmission. Steering capabilities ranged from pivot to infinite steer. The tank could climb a 60° slope at 2 mph and had a maximum speed of 30 mph on level road. Dampened torsion bar springing coupled with 28-inch rubber chevron, rubber-bushed T97 track permitted high speed cross-country operation. The Fisher certified final drives were of the spur gear, single-reduction type. The T18E1 bulldozer kit was a heavy-duty, hydraulically-operated unit especially designed for mounting on tank M48. The hydraulic system included double-acting hydraulic cylinders, valves, piping and guards. The linkage was of the parallelogram type.
CONCLUSIONS: Operation of the tank, M48, as a bulldozer was satisfactory, but the certified final drives were not sufficiently durable to withstand more than 100 hours of dozer operation. It was recommended that the certified final drives be limited to 100 hours of dozer operation.
GENERAL: This 59-page report includes six photographs of component failures.

SUBJECT: Tanks (Combat) APG TT2-777 Memo 15
TITLE: Engineering and Endurance Test of Tank, 90mm Gun, M47, Serial No. 6
IDENTIFICATION: Project No. TT2-777; Memo 15
DATE OF REPORT: 25 April 1952
ORIGIN: Aberdeen Proving Ground, Maryland

TANK AUTOMOTIVE TEST RESUMES

PURPOSE: To determine endurance and engineering performance characteristics of a tank M47
METHOD: The tank was operated for 550 miles over hard surface and gravel terrain during the period of this test, placing the total mileage on the vehicle at 3229. Failures were noted and recorded. The heat effect of pancake mufflers on the turret bustle with the gun pointing forward was investigated, and the concentration of carbon monoxide inside the turret was measured. A baffle was fabricated to deflect the carbon monoxide in an effort to reduce bustle and stowage box temperatures and carbon monoxide entry through the ventilator. The effectiveness of this baffle was determined. A recheck of the center of gravity was made using the suspension method on a fully stowed vehicle.
DESCRIPTION: The test vehicle was a 90mm gun, M47 tank, vehicle No. 30164213, which weighed 97,000 pounds.
CONCLUSIONS: Four front road wheel arm spindle bearings failed, and shearing of the bolts in the compensating idler arm retainer was observed; the reverse band of the transmission also failed. Excessive wear on the rollers of the input driver gear bearing and on the universal bushing of the tie-rod ends was noted. Bustle and stowage box temperatures and carbon monoxide concentration in the turret were excessive; however, the addition of the baffle reduced the heat and carbon monoxide entry to a point where the use of pancake mufflers was satisfactory. A second fix will be tried on the engine grille itself as a possible alternative to the baffle. The vertical center of gravity was 51-1/8 and 36-1/8 inches from the ground and the bottom of the hull, respectively; the horizontal center of gravity fell 112-3/4 inches from the center line of the rear drive sprocket.
GENERAL: This 16-page report contains three photographs showing component wear.

SUBJECT: Tanks (Combat) APG TT2-777/3
TITLE: Engineering and Endurance Test of Tank, 90 MM Gun, M47, (Pilot)
IDENTIFICATION: Third Report on Project No. TT2-777; APG 10-260
DATE OF REPORT: 17 October 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the operating and engineering characteristics of the Tank, 90 mm Gun, M47
METHOD: The engineering characteristics of the test vehicle were established through instrumented field tests, and performance characteristics were determined in obstacle negotiation, operation over varied terrain, and fording. Endurance operation totaled 3229 miles. Records of parts mortality were maintained on seven M47 tanks undergoing other tests. Special tests were performed to determine the suitability of pancake-type mufflers, solid-tube oil lines for engines and transmission, exhaust pipe clamps, wire damped brake plates, baffled engine oil pan, and steering wheel control. A one-round firing test was conducted to determine the effect of shock on the turret.
DESCRIPTION: The test vehicle was heavily armored and weighed 97,200 pounds. It was powered by a Continental Model AV 1790-5B, 12-cylinder, V-type, four-cycle, air-cooled engine, with CD 850-4 cross-drive transmission. The turret mounted a 90 mm Gun T119E1, and could be traversed 360°.
CONCLUSIONS: Engineering characteristics and field performance were considered satisfactory. It was considered that the operational endurance of the vehicle could be extended by improved design of numerous components. The performance and reliability of the engine were considered good; however, the engine life expectancy from an oil consumption standpoint was not satisfactory. The most serious impediment to continuous vehicle operation was failure of the front road wheel arm spindle bearing. All the special components were considered satisfactory except the baffled engine oil pans and the steering wheel control. A turret base ring modification was suggested to prevent shock from being transferred from the turret to the traversing mechanism.
GENERAL: This 230-page report contains 91 photographs of the Tank M47.

SUBJECT: Tanks (Combat) APG TT2-777/9 Memo
TITLE: Report on Vehicle Durability Test of the M47 Tanks
IDENTIFICATION: Ninth Memorandum Report on Project No. TT2-777
DATE OF REPORT: 19 December 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the durability of five M47 tanks
METHOD: The vehicles were operated on all types of terrain and under various weather conditions. Their failures and deficiencies were observed and recorded. The reporting periods and mileages of the five tanks were No. 30164254, 31 October 1952 (626 miles); No. 30164256, 7 November 1952 (724 miles); No. 30164257, 7 November 1952 (292 miles); No. 30164258, 24 October 1952 (538 miles); No. 30164259, 17 October 1952 (259 miles).
DESCRIPTION: The five test standard production M47 tanks, 90mm gun, were USA Nos. 30164254, 30164256, 30164257, 30164258, and 30164259.
CONCLUSIONS: As of the date of this report, the tests were still in progress. The various deficiencies noted to date were incorporated in this memorandum report.
GENERAL: This 79-page memorandum report includes 21 photographs of various parts failures.

SUBJECT: Tanks (Combat) C-11-12-52
TITLE: 3000 Mile Final Drive Test T99E1
IDENTIFICATION: C-11-12-52
DATE OF REPORT: 12 November 1952
ORIGIN: The Massey-Harris Co., Racine, Wisconsin
PURPOSE: To record vehicle deficiencies for product improvement during a 3000-mile final drive test
METHOD: Test vehicles were combat loaded with 64,000 pounds and driven over a 5-mile test track. Each vehicle was operated one lap in a clockwise direction and one lap in a counter-clockwise di-

rection. At the end of every 10 miles the vehicles were visually checked for failures. Speed of the vehicles for each lap was 6 to 10 mph for 1 mile in low range and 25 to 35 mph for 4 miles in high range. Modifications were made to correct failures as they were encountered.
DESCRIPTION: The test vehicles were T99E1 Tanks. The test track was located at the Massey-Harris Company.
CONCLUSIONS: Transmission brake failures encountered were corrected by using softer metal in all the brake plates. Fuel tank failures were corrected by stress relieving and shock mounting the fuel tank. Hull cracking and failure of track support rollers were still being investigated at the end of the test to determine necessary corrective action. Numerous miscellaneous failures were attributed to vehicle vibration.
GENERAL: This report contains two pages of summaries of vehicle failures and 13 pages of a chronological log. Six photographs are included showing failure of the hulls at the track support rollers. Also included with the report are personal reports on visits by Detroit Arsenal personnel to the Massey-Harris Co. and the Hiel Co.

SUBJECT: Tanks (Combat) DA-991
TITLE: Medium Tank M46, Acceleration Test
IDENTIFICATION: Report No. 991
DATE OF REPORT: 21 June 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of three modifications on the low speed operating characteristics of the AV-1790-5A engine when installed in a Medium Tank, M46
METHOD: Tests were conducted on modified camshafts timed at 40° and 50° ABC (with and without "hot spots"), with variable spark advance from 10° to 25° BTC, and with fixed spark advance of 25° BTC. The standard camshaft was also operated with and without "hot spots", and with a variable and fixed spark advance. All the tests were conducted in low and high range speeds. One and one-half inch diameter tubing was installed from the exhaust manifolds to the intake manifold heater jackets.
DESCRIPTION: The modifications consisted of "hot spots," i.e., the application of heat to the intake manifold heater jackets; the change from a variable spark advance to a fixed spark advance of 25° BTC; and the installation of modified camshafts. These camshafts reduced the overlap of the intake and exhaust valves from 60° to 40° of crankshaft rotation, and were timed at 40° and 50° ABC.
CONCLUSIONS: The modified camshafts, timed at 40° ABC, and used with "hot spots", improved vehicle acceleration at low speeds. These improvements were recommended. No advantage was gained in the modification of the variable spark advance; the fixed spark advance slightly decreased acceleration at low vehicle speeds.
GENERAL: This 14-page report contains one photograph showing the installation of "hot spots" on the heater jacket.

SUBJECT: Tanks (Combat) DA-1717
TITLE: Test of a Proposed Modification for the Commander's Cupola Vision Door Assembly
IDENTIFICATION: Report No. 1717
DATE OF REPORT: 8 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether the proposed modification would decrease the torque required to rotate the door assembly
METHOD: A cupola door using the standard ball arrangement was disassembled, thoroughly cleaned, and reassembled. The torque required to rotate the door was measured. This same door was assembled to include the test modification, and the torque required to rotate the assembly was again measured. This modification was also tested with the single 7/16-inch ball removed.
DESCRIPTION: The proposed modification for the commander's cupola vision door assembly utilized one 7/16-inch and one hundred thirteen 1/2-inch steel balls, Ordnance Nos. A412521-A and B, respectively. The door was used on the M46 medium tank; the standard assembly incorporated sixty-one 7/16-inch steel balls.
CONCLUSIONS: The test modification did not decrease the torque required to rotate the commander's cupola vision door. The torque measurement with the experimental assembly was higher than that used by the standard door and exceeded the specifications by 10 ft.-lbs. Although the torque required to rotate the test door assembly was considerably decreased, it was still higher than the torque required to operate the standard door.
GENERAL: This four-page report is not illustrated.

SUBJECT: Tanks (Combat) DA 1764
TITLE: Failures of Running Gear Parts on Medium Tanks
IDENTIFICATION: Report No. 1764
DATE OF REPORT: 6 June 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To investigate the cause of failures of running gear parts on medium tanks
METHOD: Long mileage runs were made, 30% of the mileage being on the infield over the roughest available terrain and 70% on the track at maximum safe speed. Failed running gear parts were photographed and studied for causes.
DESCRIPTION: None
CONCLUSIONS: A variety of failures included such items as shock absorbers, mounting brackets, tracks, wedge bolts, sprockets and torsion bars. There were three types of shock absorber failures --seal failures, possibly due to overheating, failure of the piston shaft, and failure of the attaching eye. The seal failures occurred most frequently when the vehicle was run on hard ground surfaces. There were two types of track failures--thrown tracks and broken track components. During the test, a high loss of wedge bolts took place. Inspection of the track revealed that some track pins were distorted. The sprocket life was approximately 1500 to 2000 miles. During the test, two torsion bars failed to function properly. All the parts failures were submitted to the materials laboratory for analysis.

GENERAL: This 22-page report includes 17 photographs of the parts failures.

SUBJECT: Tanks (Combat) DA 1953
TITLE: Inspection of Devil's Lake Vehicles
IDENTIFICATION: Report No. 1953; Job No. 6905
DATE OF REPORT: 16 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To visually evaluate the condition of two tanks returned from winter test operation at Devil's Lake, North Dakota
METHOD: The tanks were photographed before and during disassembly and conditions considered significant were recorded.
DESCRIPTION: The two test 90-mm Gun Tanks M47, Nos. 402 and 421, were from winter test operations at Devil's Lake (this inspection took place in April and May of 1952). Winterization kits were still installed. The left side of tank No. 402 and the right side of tank No. 421 were equipped with experimental nylon suspension arm bearings. Tank No. 402 had been operated 2778 miles, and No. 421, 1066 miles.
CONCLUSIONS: The T84E1 rubber chevron track on tank No. 402 showed considerable wear and both tanks showed fender damage and loosening of winterization kit connections. Water was found in several road wheel arm housings, suggesting defective seals. The nylon bearings showed considerable wear, more severe on tank No. 402 than on tank No. 421 as would be expected from the test mileages.
GENERAL: This 15-page report contains 12 photographs showing the general condition of the two vehicles and their components.

SUBJECT: Tanks (Combat) DA 3102 F
TITLE: Investigation of Lateral Movement of the 90mm Gun, Tank M48
IDENTIFICATION: Report No. 3102 (Final)
DATE OF REPORT: 4 November 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the amount of lateral movement due to external loads applied to the hull of the M48 tank in a static position
METHOD: The effect of loading caused by stopping the rotating turret was simulated by applying external loads directly to the hull of the vehicle. The deflections at several locations were recorded as these loads were applied. Two types of lateral movement of the vehicle were measured: the movement of the sprung components in reference to the unsprung components, and the movement of the vehicle road wheels in reference to the ground.
DESCRIPTION: The test vehicle was the 90mm gun tank, M48.
CONCLUSIONS: Lateral movements ranging from 0.011 inch to 0.498 inch were recorded at different positions along the vehicle with a force of 7000 pounds applied to the rear of the vehicle. Lateral movements did not reach 0.5 inch at any of the indicator positions with the load applied at the center of the vehicle. The movement of the sprung components in reference to the unsprung components reached a maximum of 0.246 inch. The movement of the road wheels in reference to the ground, including movement due to elasticity of the track, reached a 0.654-inch maximum.
GENERAL: This 15-page report includes graphs showing the lateral movement at various locations on the vehicle under the test conditions.

SUBJECT: Tanks (Combat) DA 3325
TITLE: Floor Plate Section, Rear, Part No. 7363971; Metallurgical Investigation
IDENTIFICATION: Report No. 3325 Final
DATE OF REPORT: 10 June 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine by metallurgical investigation the causes of failure of section taken from M48 rear floor plate
METHOD: The test floor plate section was subjected to physical, chemical, metallurgical, and hardness studies to determine cause of failure.
DESCRIPTION: The test plate section was designated as M48 rear floor plate Part No. 7363971.
CONCLUSIONS: The test results indicated that the failure of the section of M48 rear floor plate was caused by fatigue. It was recommended that there should be more rigid inspection of rear floor plate armor to minimize slag content; better welding practice to minimize notch effect; and better adherence to dimensional requirements in fabrications.
GENERAL: This 13-page report includes six photomicrographs of the test plate section.

SUBJECT: Tanks (Combat) DA 3370 F
TITLE: Center of Gravity of the 105mm Gun, Tank, T54E2
IDENTIFICATION: Report No. 3370 (Final)
DATE OF REPORT: 11 October 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the center of gravity of a combat loaded 105mm gun tank, T54E2, and a combat loaded turret assembly for this tank
METHOD: The center of gravity of the complete vehicle and of the turret assembly, both combat loaded, was determined by means of a suspension system. The gun was in a forward position at 0° elevation and 0° azimuth during these tests. A target was attached to each side of the vehicle, which was suspended from a single lifting hook by two sets of cables of unequal length. A transit was located so that the vertical plane generated by elevating the line of sight of the transit was perpendicular to the longitudinal axis of the vehicle and also passed through the center of the lifting hook. A projection of the vertical plane was scribed on the target using the vertical cross hair of the transit as a reference. This procedure was repeated with the transit on the other side of the vehicle. The cables were reversed and the procedure repeated. The intersection of the scribed lines located the projection of the center of gravity at each side elevation. Horizontal and vertical dimension taken on both sides of the vehicle from the center line of the cross-drive to the intersection of the scribed lines on each target were designated as the center of gravity. The center of gravity for

the turret assembly was determined by the same method.
DESCRIPTION: The test vehicle was the 105 mm gun tank, T54E2.
CONCLUSIONS: The center of gravity of the complete vehicle was 118 inches forward of and 11 inches above the axial centerline of the cross-drive at either side elevation. The center of gravity for the turret assembly was located 23-1/8 inches above the horizontal reference plane on the centerline of rotation of the turret assembly.
GENERAL: This 13-page report is not illustrated.

SUBJECT: Tanks (Combat) DWB 49
TITLE: Service Test of Light Tank, M5A1
IDENTIFICATION: Final Report Project No. 49
DATE OF REPORT: 24 July 1943
ORIGIN: Desert Warfare Board, Desert Training Center, Camp Young. California
PURPOSE: To service test two Light Tanks, M5A1, and to determine the effectiveness of the latest modifications incorporated in the test vehicles
METHOD: The tanks were operated the entire time under very dusty conditions over rough desert terrain and desert trails. One vehicle was operated for 492 miles and 130 engine hours; and the other vehicle, 608 miles and 124 engine hours.
DESCRIPTION: The Light Tanks, M5A1, were of the latest production type incorporating exhaust and radiator deflectors, larger fans, sealed carburetors, oil bath type crankcase breathers and oil filters. In addition, one tank was equipped with sand shields.
CONCLUSIONS: The test demonstrated that all Light Tanks, M5A1, operating in the desert, should be equipped with exhaust and fan blast deflectors, sealed carburetors, oil bath type crankcase breathers and oil filters, and sand shields. These installations were found to add substantially to engine life and reduce the maintenance time required. The crankcase breathers tested were found to require better inspection in manufacture to insure proper operation. It was recommended that the Light Tank, M5A1, of the latest production type be considered satisfactory for operation in the desert.
GENERAL: This eight-page report contains one photograph of the test vehicle equipped with sand shields and one of the crankcase breather oil bath cups and elements.

SUBJECT: Tanks (Combat) DWB 84-1
TITLE: Service Test of Medium Tank M4A4
IDENTIFICATION: Final Report; Project No. 84-1
DATE OF REPORT: 24 July 1943
ORIGIN: Desert Warfare Board, Camp Young, Indio, California
PURPOSE: To service test the latest production type Medium Tank, M4A4
METHOD: The test vehicles were operated under service conditions by an Armored Force Unit during desert maneuvers. The period of test operation started with small unit problems and concluded with Corps maneuvers.
DESCRIPTION: Medium Tank, M4A4, (of the latest production type), included exhaust deflectors, single water pumps, shaft-driven generators, radiator by-passes, radial throw-out bearings, new crankcase breathers, sealed distributors, and steel tracks.
CONCLUSIONS: Even though the Modified Medium Tank, M4A4, was superior to the old type Medium Tank, M4A4, it was considered unsatisfactory for use in desert operations. The test tank was found to be superior to the former M4A4 Tank in the following respects: operation of clutch release bearings, superiority of steel tracks over rubber tracks for desert operations, generator operation, sealed distributor, and single water pump. Excessive engine weight, multiplicity of power plant parts and accessories, accessibility of engine for maintenance, low fuel economy, rapid engine wear and excessive oil consumption at low engine hours were the undesirable characteristics of the vehicle tested.
GENERAL: This eight-page report contains one photograph of the crankcase breather unit and one of exhaust deflector.

SUBJECT: Tanks (Combat) DWB 85
TITLE: Final Report on Service Test of Medium Tank, M4A1
IDENTIFICATION: Final Report; Project No. 85
DATE OF REPORT: 4 June 1943
ORIGIN: Desert Warfare Board; Camp Young, Indio, California
PURPOSE: To service test the Medium Tank, M4A1
METHOD: Four new tanks were operated for a combined total of 2541 miles over secondary desert trails and cross-country. All were driven with the gyrostabilizer in operation, and frequent use was made of the power traverse.
DESCRIPTION: The Medium Tanks, M4A1, tested were new vehicles with standard equipment and steel-chevron type tracks.
CONCLUSIONS: Maintenance of battery charge was found to be difficult, and frequent use of the auxiliary generator was required. Overheating of one traversing motor was encountered. Suspension failures encountered were broken wheels (disc type), blown bogie tires, cracked track support rollers (welded type), broken support roller axles, and inadequate volute springs. Except for minor control adjustments or replacements, no engine trouble was experienced. Much difficulty was encountered due to dust entering the clutch housings, causing binding. It was recommended that the Medium Tank, M4A1, be considered satisfactory for operation in the desert only until a medium tank with an improved suspension and a more efficient engine could be developed.
GENERAL: This 12-page report is not illustrated.

SUBJECT: Tanks (Combat) DWB 86
TITLE: Medium Tank, M4A2
IDENTIFICATION: Preliminary Report; Project No. 86
DATE OF REPORT: 3 November 1942
ORIGIN: Desert Warfare Board; Camp Young, Indio, California
PURPOSE: To determine the suitability of the

TANK AUTOMOTIVE TEST RESUMES

Medium Tank, M4A2
METHOD: Test vehicles were operated continuously for a period of three weeks for driver and crew instructions and were also used in regular tactical operations.
DESCRIPTION: The Medium Tank, M4A2, tested was a current model powered by a twin GM diesel engine, Model 6046.
CONCLUSIONS: The Medium Tank, M4A2, was not considered a satisfactory combat vehicle due to the faulty engineering design of the power plant with attendant mechanical weaknesses. The suspension system was found to be inadequate for the additional weight imposed on it by the installation of the Model 6046 engine. Further testing of modified Medium Tank, M4A2, was recommended.
GENERAL: This 13-page report contains seven photographs of failed components.

SUBJECT: Tanks (Combat) DWB 86-1
TITLE: Service Test of Medium Tank, M4A2, (Modified) with Steel Tracks
IDENTIFICATION: Seventh and Final Report; Project No. 86-1
DATE OF REPORT: 16 August 1943
ORIGIN: Desert Warfare Board; Camp Young, Indio, California
PURPOSE: To check the effectiveness of all modifications applied to the Medium Tank, M4A2, and to determine any need for further modifications
METHOD: The test vehicles operated on an expedited 1,000-mile test. At the completion of this phase, they were turned over to an armored unit operating in a desert area. During the second phase, they participated in unit and division training problems, with normal service and maintenance.
DESCRIPTION: The six Medium Tanks, M4A2, tested were manufactured by Fisher Body Corporation, and powered with dual GM, six-cylinder, two-cycle diesel engines. Five of the vehicles had engine, power train, and hull improvements as a result of prior tests. The sixth test vehicle included the same improvements and, in addition, an engine lubrication system that eliminated the oil tank and incorporated a wet sump engine base. Oil filters of the regulation military type were eliminated from this installation.
CONCLUSIONS: The Medium Tank, M4A2, was considered satisfactory for desert operations. The wet sump type engine was recommended as preferable to the dry sump type engine from a maintenance standpoint. Every effort to develop a more efficient air cleaner was recommended to overcome excessive engine wear.
GENERAL: This 11-page report is not illustrated.

SUBJECT: Tanks (Combat) DWB 147
TITLE: Service Test of Medium Tank M4A1, with 76 MM Gun
IDENTIFICATION: Final Report on Project No. 147
DATE OF REPORT: 17 June 1943
ORIGIN: Desert Warfare Board, Camp Young, Indio, California
PURPOSE: To determine the operating characteristics of the Medium Tank, M4A1, particularly with respect to turret action, service of gun, and stowage arrangement
METHOD: The test vehicle was operated, during two weeks of normal training, in an average temperature of 110°F. Typical desert terrain was covered, including flat desert, wind blown sand, and rocks.
DESCRIPTION: The Medium Tank, M4A1, with 76 mm gun, was similar to the standard Medium Tank M4A1. The main difference being installation of a 76 mm gun, with heavy recoil guard in a redesigned turret.
CONCLUSIONS: The Medium Tank, M4A1, was unsatisfactory because of the following deficiencies: cramped turret space, erratic gun elevating mechanism, inadequate gun travelling locks, obstructed driver's view with gun in forward traveling position, and poor dust protection for the clutch. It was recommended that if a requirement for a tank armed with a 76 mm gun existed, a new tank be designed with adequate space for gun, crew and stowage.
GENERAL: This eight-page report contains six photographs of the test vehicle.

SUBJECT: Tanks (Combat) FR 44277 British
TITLE: Italian Tanks
IDENTIFICATION: Report No. 44277
DATE OF REPORT: 3 September 1941
ORIGIN: Military Intelligence Division, Washington, D. C.
PURPOSE: To evaluate six types of Italian tanks
METHOD: Specifications, comments, and data regarding six different types of Italian tanks were supplied by the British War Office. This material was submitted by the London Military Attache of the U. S. Military Intelligence Division, War Department General Staff.
DESCRIPTION: The Italian tanks were designated as follows: "L.35-35 Tank, weighing 3.5 tons, with 43-hp gasoline engine and either 8-mm or heavy machine guns; "L.5.21/30 Tank, weighing 5.8 tons, with 60-hp gasoline engine and two 8-mm coaxial machine guns or one 37-mm gun in turret; "L.6-40 Tank, weighing 6.4 tons, with 70-hp gasoline engine, one 20-mm gun, and one 8-mm machine gun; "M.11/39 Tank, weighing 11 tons, with 105-hp diesel engine, one 37/40 gun, and two 8-mm machine guns; "M.13/40 Tank, weighing 13.3 tons, with 105-hp diesel engine, one 47/32 gun, and four 8-mm machine guns; and an unknown prototype of Ansaldo which was a flame thrower or command vehicle.
CONCLUSIONS: The "L.35-35 Tank had been built in large numbers and used as a bridging tank, flame thrower, or armored machine gun carrier and was replaced by the L.6 Tank. The "L.5.21/30 Tank was of the 1917 French Renault design and was obsolete. The "L.6-40 Tank was the then latest light tank but had not been in battle at that time and was considered to be of poor design. The "M.11/39 Tank was built in large quantity but was difficult to fire and was replaced by the "M.13/40 Tank. The "M.13/40 Tank was

the best of the Italian tanks but did not have sufficient armor protection, the antiaircraft mounting was impractical and considerable engine trouble had developed in the Middle East operations. The unknown prototype of Ansaldo had not been seen in action and the report does not contain conclusions regarding it.
GENERAL: This seven-page report includes four photographs of the Italian tanks.

GM-CTP 406-1
SUBJECT: Tanks (Combat) (Preliminary)
TITLE: Installation and Test of Hull Reinforcements for Reduction of Vibration on the T41E1 No. 1 Pilot Tank
IDENTIFICATION: Report No. 406-1 (Preliminary)
DATE OF REPORT: 29 April 1952
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the effectiveness of hull reinforcements for the reduction of tank vibration
METHOD: The reinforced T41E1, No. 1, vehicle and the No. 66 vehicle, which had the same hull construction with no reinforcements, were operated for comparison of vibration characteristics.
DESCRIPTION: The following reinforcements were welded to the T41E1, No. 1 pilot tank: a vertical post from the floor to the front deck of the hull, a torsion bar cover over the No. 2 position torsion bars, gusset plates on the right and left sides at the rear edge of the No. 2 suspension support housings, tubing connecting the sloping side floors to the side walls, and channel sections on the hull floor. Other reinforcements used were angle iron vertical supports on each side of the bulkhead door opening, gusset plates on the right and left sides welded to the rear of the bulkhead and to the walls and sloping floor, and triangular plates on the right and left sides, horizontal at the upper front corners of the engine compartment. The total weight added to the hull was 245 pounds.
CONCLUSIONS: The hull reinforcements caused a definite reduction in the vibration of the tank. It was observed that noticeable vibration periods on vehicle No. 66 were reduced or non-existent in vehicle No. 1.
GENERAL: This seven-page report contains three photographs showing hull reinforcements.

SUBJECT: Tanks (Combat) GM-CTP 905F
TITLE: Hull Durability Test of T141 Vehicle No. 317 Equipped With Latest Cadillac Production Modifications and AC and F Outside Hull Idler Mount Reinforcement Plates
IDENTIFICATION: Report No. 905 (Final)
DATE OF REPORT: 1 July 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine whether hull modifications on a T141 vehicle would eliminate hull armor plate cracking.
METHOD: The vehicle was operated on the production test track for 3000 miles at 20 to 25 mph. An inspection was made after each 100 miles of operation to determine if any armor plate cracks had developed. At the completion of the test track operation, the vehicle was dismantled for inspection. The paint was removed from the surface around the support roller pads and gun mount reinforcement base beam. The Dy-check method was used to determine if cracks were present.
DESCRIPTION: The T141 vehicle, No. 317, incorporated all of the latest Cadillac hull modifications in production at that time. These included: idler mount reinforcing plates on the inside of the hull; gun mount support base beam reinforcing angles; transverse stiffner (3/8-inch) bulkhead reinforcements; and support roller mounting pads tack welded to the hull in two positions. American Car and Foundry idler mount reinforcing plates were added to the outside of the hull.
CONCLUSIONS: It was concluded that the Cadillac modifications in conjunction with AC and F outside idler mount reinforcement plates eliminated hull cracks in the armor plate except in the vicinity of the left front gun mount base beam reinforcement. These cracks were not considered critical.
GENERAL: This 18-page report contains eight photographs showing the effects of testing on the vehicle hull.

SUBJECT: Tanks (Combat) GM-CTP 960F
TITLE: Durability Test on Special T141 Vehicle No. 377 Incorporating 1/2-Inch Hull Side Plate 1-Inch Front Floor Plate One Piece Hull Roof Bolted on Idler Mounts and Engine Access Door
IDENTIFICATION: Report No. 960 (Final)
DATE OF REPORT: 12 November 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the durability characteristics of the drain shield and hull of a modified T141 vehicle
METHOD: The vehicle was subjected to 1415 miles of durability operation at 20 to 25 mph on the production test track, and 1506 miles on cross-country courses at COPG at a maximum safe operating speed.
DESCRIPTION: The T141, No. 377 vehicle used in the test represented current production except for 1/2-inch hull side plates, 1-inch thick front floor plate, bolted on idler mount reinforcements with the bottom edge only welded to the hull, and a one-piece hull roof without center doors. Modifications made prior to testing included new front left and right drain shields and reinforcements installed on the vehicle, gusset reinforcements on the left and right front gun mount basebeam, and three access doors cut in the bottom of the hull.
CONCLUSIONS: The design revisions incorporated in the vehicle eliminated cracks in the drain shield which had been encountered in other vehicles being subjected to similar durability operations. Cracks developed at the bump stop bracket locations; however, these cracks were not detrimental to vehicle operation. It was felt that a later evaluation should be made after the vehicle had been subjected to additional cross-country operation. Cracks of a hair line variety, noted inside the vehicle where the gun mount basebeam reinforcement angle was welded to the hull side armor plate, were not considered critical.

TANK AUTOMOTIVE TEST RESUMES

GENERAL: This 23-page report contains 15 photographs of the test vehicle.

SUBJECT: Tanks (Combat) OCO KG-285
TITLE: Medium Tanks, T23
IDENTIFICATION: Project No. KG-285
DATE OF REPORT: 21 April 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Mich.
PURPOSE: To develop a medium tank with more armor protection, fire power and maneuverability and lower silhouette
METHOD: A Medium Tank, T23, was designed. Pilot models of the tank were built and put through extensive tests at numerous proving grounds.
DESCRIPTION: Medium Tank, T23, was of improved design with a 76 mm gun, electric drive, dual controls and Medium Tank, M4, suspension. The engine was a Ford V-8 Model GAN. A five-man crew operated the tank.
CONCLUSIONS: The final development models of the Medium Tank, T23, were satisfactory. However, it was recommended that further development of the vehicle be discontinued as the Heavy Tank, T26E1, more nearly met the requirements of the Army Ground Forces.
GENERAL: This 216-page report lists 61 photographs of the Medium Tank, T23, and its construction. Also included is a correspondence study of prior related development progress reports. Fourteen photographs and a tank characteristics chart are missing from the report.

SUBJECT: Tanks (Combat) PG-2.360
TITLE: Light Tank M3 Acceptance Test. American Car and Foundry — Continental
IDENTIFICATION: Report No. PG-2.360; GMPG Project No. 24
DATE OF REPORT: 27 July 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a Light Tank, M3, equipped with Rockford clutch and Blood Brothers universal joints
METHOD: The test vehicle was given the usual acceptance tests and operated 2002 miles over the various Proving Ground courses.
DESCRIPTION: The Light Tank, M3, was manufactured by the American Car and Foundry Co. and weighed 25,735 pounds. A Rockford Drilling Machine Co., TCA 2003, 15-1/2-inch double clutch, and Blood Brothers universal joints were installed in the vehicle and tested as substitute components.
CONCLUSIONS: The vehicle was found acceptable. The Rockford clutch and Blood Brothers universal joints operated satisfactorily and were recommended as substitute equipment on Light Tanks, M3.
GENERAL: This 81-page report includes 17 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.361
TITLE: Light Tank M3 Acceptance Test American Car and Foundry — Guiberson
IDENTIFICATION: Report No. PG-2.361; GMPG Project No. 24
DATE OF REPORT: 4 June 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank, M3, Serial No. 2908
METHOD: The vehicle was operated 1,000 miles, including 467 miles on pavement, 97 miles on Belgian Block, and 436 miles on gravel.
DESCRIPTION: The Light Tank, M3, manufactured by American Car and Foundry, was powered by a Guiberson engine, weighed 25,665 pounds and used vertical volute spring suspension.
CONCLUSIONS: The vehicle was considered mechanically sound and of good operating characteristics. It was recommended that: the flexible line from transmission to transmission check valve be redesigned to eliminate failures; that a redesigned parking ratchet on the steering brake be developed to eliminate the hazard of accidental application.
GENERAL: This 59-page report includes 12 photographs of the vehicle and failed parts.

SUBJECT: Tanks (Combat) PG-2.364
TITLE: Engineering Tests of Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.364; GMPG Project No. 5
DATE OF REPORT: 15 June 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability and reliability of the pilot model Light Tank, M5
METHOD: A Light Tank M5 was operated 905 miles in accordance with Test Schedule "A", T.S.T.P. 1935-709.
DESCRIPTION: The Light Tank, M5, No. 1, manufactured by the Cadillac Motor Co., weighed 31,000 pounds. It was powered by Cadillac, Twin V-8, engines and was equipped with Hydramatic transmissions.
CONCLUSIONS: The vehicle gave less mechanical trouble during engineering tests than any of the pilot models of armored vehicles tested to date. It was recommended the transmission be modified to prevent it from jumping from reverse to low when backing, the steering brakes be modified to require less force on the levers, and cooling be improved.
GENERAL: This 119-page report includes 15 photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) PG-2.364B
TITLE: Endurance Test on Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.364B; GMPG Project No. 5
DATE OF REPORT: 1 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine endurance of Light Tank M5
METHOD: The vehicle was operated 2943 miles over the various proving ground courses. Testing procedure TSTP 1935-709, Schedule A was followed.
DESCRIPTION: The test Light Tank M5 was powered by Cadillac, V-8, twin gasoline engines and weighed 31,000 pounds. It was a conversion of

Light Tank M3A2, and had Hydramatic transmissions. The armor plate was of homogeneous welded construction.
CONCLUSIONS: Several major failures occurred during the test; most of these failed parts were already subject to production changes. One engine failed at 905 miles due to overheating. Two transmission failures occurred because of improper servicing. No recommendations were made.
GENERAL: This 203-page report includes 71 photographs of the tank and components.

SUBJECT: Tanks (Combat) PG-2.369
TITLE: Light Tank M5 Acceptance Test — Cadillac
IDENTIFICATION: Report No. PG-2.369; GMPG Project No. 24-4
DATE OF REPORT: 13 June 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank M5
METHOD: The vehicle was operated 506 miles in accordance with "M3 Light Tank Endurance Speed Schedule for Acceptance Test".
DESCRIPTION: The test Light Tank M5 was manufactured by the Cadillac Motor Car Company and powered by two Cadillac, V-8, gasoline engines.
CONCLUSIONS: In general, the vehicle was considered mechanically sound and of good operating characteristics. Welding on the gasoline tanks was unsatisfactory. It was recommended that the A C oil bath air cleaner elements be modified to provide for easier insertion after cleaning. Changes were recommended to prevent the transmission from jumping from reverse into low. It was further recommended that consideration be given to correcting the interference between bogie tires and the suspension system due to stones, soil, etc., collecting.
GENERAL: This 51-page report includes 12 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.370
TITLE: Light Tank M3 Acceptance Test A.C.F. — Guiberson
IDENTIFICATION: Report No. PG-2.370; GMPG Project No. 24-6
DATE OF REPORT: 13 June 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank M3 — A.C.F. — Guiberson, Serial No. 3011
METHOD: Test vehicle was given mechanical inspection and was operated 566 miles at the Proving Ground over varied terrain and at various speeds. The test vehicle was operated in accordance with M3 Light Tank Endurance Speed Schedule for Acceptance Test.
DESCRIPTION: The test vehicle was the Light Tank M3, Serial No. 3011, manufactured by the American Car and Foundry Co., and powered by a Guiberson, radial, diesel engine. The test tank weighed 25,665 pounds and was a full-tracked vehicle armed with a 37 mm gun.
CONCLUSIONS: From the automotive viewpoint, the test vehicle was, in general, mechanically sound and of good operating characteristics. It was recommended that the design, construction, and installation of the flexible line from transmission to transmission oil strainer be changed to eliminate failure at the sweated joint.
GENERAL: This 39-page report includes three photographs of test vehicle and one photograph of failed flexible oil line.

SUBJECT: Tanks (Combat) PG-2.372
TITLE: Light Tank M3 Acceptance Test, American Car and Foundry — Continental
IDENTIFICATION: Report No. PG-2.372; GMPG Project No. 24
DATE OF REPORT: 1 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a production Medium Tank M3
METHOD: The vehicle was given the usual 500 mile production acceptance test over pavement, Belgian Block, and gravel courses.
DESCRIPTION: The test Light Tank M3 was manufactured by the American Car and Foundry Company and weighed 25,625 pounds. Primary armament was a 37 mm gun.
CONCLUSIONS: The vehicle was found to be acceptable. No repairs were required throughout test operation.
GENERAL: This 57-page report includes four photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-2.386
TITLE: Acceptance Test on Light Tank M3 — A.C.F. — Continental
IDENTIFICATION: Report No. PG-2.386; GMPG Project No. 24
DATE OF REPORT: 17 July 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a Light Tank M3; also to test special brake linings, sprockets, and a steel track
METHOD: Special brake linings, sprockets, and steel tracks (Projects 33-1, 33-2, and 34-4) were installed on the test vehicle which was operated 693 miles over pavement, gravel and the Belgian Block course.
DESCRIPTION: The test Light Tank M3 weighed 25,820 pounds. Armament consisted of a 37 mm gun, a cal. .30 coaxial machine gun, two sponson mounted cal. .30 machine guns and one turret mounted cal. .30 machine gun. Fedoro brake linings, Haynes Stellite sprockets, and a Goodrich steel Track T44E1 were installed on the vehicle.
CONCLUSIONS: The vehicle was acceptable. The Fedoro brake linings were satisfactory over a test of 693 miles. The Haynes stellite sprockets wore .004 inch as compared to .011 inch for standard sprockets in 686 miles. Performance characteristics with both rubber and steel tracks were similar. Steel Track T44E1 was weak through the vertical section of the block. The grouser wear was fairly fast with a probable life of 1200-1500 miles.

The steel track caused rapid failures of the trailing idlers. It was recommended that testing be continued on the Fedoro brake linings and Haynes Stellite sprockets, and that the T44E1 or similar tracks be further developed to strengthen the track block and to increase grouser life.
GENERAL: This 85-page report includes 14 photographs of components, two pages of comparative tractive resistance curves with steel and rubber tracks, and two coasting comparison curves.

SUBJECT: Tanks (Combat) PG-2.387
TITLE: Acceptance Test on Light Tank M3 — A.C.F. — Guiberson
IDENTIFICATION: Report No. PG-2.387; GMPG Project No. 24-9
DATE OF REPORT: 15 July 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Light Tank M3
METHOD: A production acceptance test limited to the automotive phase was conducted on the vehicle. Testing included a mechanical inspection and a 500-mile endurance test over pavement, Belgian Block, and gravel.
DESCRIPTION: The test production Light Tank M3, Serial No. 5244, was manufactured by the American Car and Foundry and equipped with a Guiberson Engine, Model T 1020.
CONCLUSIONS: The vehicle was considered to be in good mechanical condition and to have good operating characteristics.
GENERAL: This 43-page report contains five photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-2.388
TITLE: Test of Medium Tank M4A2 — Pullman Standard Car Co.
IDENTIFICATION: Report No. PG-2.388; G.M.P.G. Project No. 27
DATE OF REPORT: 14 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the performance characteristics and durability of the pilot model Medium Tank M4A2
METHOD: The vehicle was operated for a total of 2082 miles over hard-surfaced, improved gravel, and cross-country courses. Testing included a mechanical inspection and an 1138-mile endurance test. Tests were conducted on six special Kelsey-Hayes steel track blocks, a Firestone steel track, T49, and plain and grooved bogie wheels.
DESCRIPTION: The test vehicle was the first pilot model of Medium Tank M4A2. It was built by the Pullman Standard Car Company, and was powered by two GM diesel engines.
CONCLUSIONS: The basic engine gave no trouble in 2011 miles of operation, but the engine installation was considered very poor and gave much trouble. Three failures of copper tubing occurred and the clutch and throttle linkages required constant adjustment. Engine cooling was inadequate and the twin clutches did not prove durable. It was recommended that experimental work be undertaken to improve cooling, and that an investigation be made to improve clutch life without sacrificing its positive disengagement characteristics.
GENERAL: This 248-page report contains 60 photographs of the test vehicle and failed parts.

SUBJECT: Tanks (Combat) PG-2.390
TITLE: Test of Medium Tank M4A3 No. 2 Ford
IDENTIFICATION: PG-2.390; GMPG Project No. 37
DATE OF REPORT: 25 January 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the operating and performance characteristics of a pilot model Medium Tank M4A3
METHOD: The vehicle was operated a total of 3703 miles. Complete engineering tests, which included performance, fuel economy, engine cooling, and endurance, were made.
DESCRIPTION: The test pilot model Medium Tank M4A3, No. 2, was equipped with a Ford GAA, V-8, gasoline engine and a Ford Standard Ordnance Transmission M4. The hull was welded.
CONCLUSIONS: Except for certain engine accessories, the mechanical durability of the M4A3 was considered acceptable. Durability of fan belts and magnetos was not satisfactory; the tracks and bogie tires had relatively short life; brake performance was sub-standard; and power was low enough to preclude cross-country operation in fifth gear on all but level ground and gentle slopes. It was recommended that this type of vehicle be accepted by the Ordnance Department and that further development be undertaken to improve the durability of fan belts, magnetos, tracks, and bogie wheels; and to improve brake performance. Five engines were used in the vehicle during the tests; the last one operated for 2000 miles. It was suggested that consideration be given to a power plant adequate for high mobility over rolling terrain, and it was also recommended that additional operation be performed to evaluate life and durability of engines in future testing.
GENERAL: This 459-page report contains 12 photographs of the M4A3 and components and 138 photographs of failed parts.

SUBJECT: Tanks (Combat) PG-2.425
TITLE: Acceptance Tests of Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.425; GMPG Project No. 25-3
DATE OF REPORT: 24 October 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Medium Tank M3
METHOD: The vehicle was given standard acceptance tests, including mechanical inspection, performance test, and a total operation of 842 miles. In addition, special vapor pressure tests with seal caps on gasoline tanks and modification of the ventilation of the fuel tanks were made in an

attempt to prevent gasoline leakage.
DESCRIPTION: The test Medium Tank M3 weighed 58,885 pounds, and mounted a 75 mm and a 37 mm gun. The experimental Protecto-Seal caps were spring-loaded, two and four-pound release caps. The modification for ventilation of the fuel tanks involved use of sheet metal elbows which drew the intake air for the cleaners from the sponsons, bringing it back from the inside of the fighting compartment and around the fuel tank. This modification was referred to as the "M3 fix".
CONCLUSIONS: There were few mechanical failures during operation. The use of the sealing caps for fuel tanks was ineffective, but the "M3 fix" was considered successful in preventing the loss of fuel through cap vents. It was recommended that the "M3 fix" be used on all M3 tanks currently equipped otherwise and that the Medium Tank M3 be considered acceptable from the automotive standpoint.
GENERAL: This 91-page report contains nine photographs showing the vehicle, the "M3 fix", and failed parts.

SUBJECT: Tanks (Combat) PG-2.432
TITLE: Acceptance Test on Medium Tank M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.432; GMPG Project No. 25
DATE OF REPORT: 10 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a production Medium Tank M4A2
METHOD: The vehicle was given a standard 500-mile endurance test over the hard-surfaced, gravel, and cross-country courses.
DESCRIPTION: The test Medium Tank M4A2 was manufactured by the Fisher Body Division of General Motors and weighed 60,722 pounds. Primary armament was a 75 mm gun. A non-reversible rubber Track T51 was used throughout the test.
CONCLUSIONS: The vehicle was considered of satisfactory design and in good mechanical condition. The rubber bushings in three track blocks failed.
GENERAL: This 47-page report includes four photographs of the tank.

SUBJECT: Tanks (Combat) PG-2.433
TITLE: Acceptance Test on Light Tank M3 — A.C.F.
IDENTIFICATION: Report No. PG-2.433; G.M. P.G. Project No. 24
DATE OF REPORT: 10 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a production Light Tank M3, Serial No. 5391
METHOD: The tank was operated 498 miles: 219 miles over pavement, 48 miles over the Belgian Block course, and 231 miles over gravel. The test was limited to determination of automotive characteristics.
DESCRIPTION: The test Light Tank M3 was manufactured by American Car and Foundry Company, weighed 25,806 pounds, and was armed with a 37 mm gun.
CONCLUSIONS: The tank was considered of good design and sound mechanical condition. There were no important mechanical failures during the test.
GENERAL: This 52-page report includes five photographs of Light Tank M3 and a failed bogie wheel.

SUBJECT: Tanks (Combat) PG-2.434
TITLE: Endurance Tests on Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.434; G.M. P.G. Project No. 38
DATE OF REPORT: 22 December 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the endurance of Light Tank M5, Serial No. 10, Cadillac, equipped with latest production engines
METHOD: An endurance test of 3222 miles was performed on the test vehicle. Both initial and final mechanical inspections were made.
DESCRIPTION: The Cadillac engines of the test Light Tank M5 were of the latest production design, were made of improved material, and had larger water-cooling passages than standard engines. Carburetors, starting motors, generators, fan assemblies, fan and generator belts, and fuel pumps were retained from the old engines, as was the transmission, including the flywheel housing.
CONCLUSIONS: Light Tank M5 operated throughout the endurance test with few failures. The only serious repetitive failures were weld fractures in the fuel tanks. There was evidence on the teardown inspection that the transfer box and Hydramatic transmission were almost worn out. However, it was recommended that the vehicle be accepted as satisfactory.
GENERAL: This 104-page report contains 69 photographs of failed test parts.

SUBJECT: Tanks (Combat) PG 2.450
TITLE: Acceptance Test of Light Tank M5 — Massey-Harris Co.
IDENTIFICATION: Report No. PG-2.450; G.M.P.G. Project No. 24-13
DATE OF REPORT: 17 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Light Tank M5, Serial No. 3269
METHOD: The test vehicle was given standard acceptance tests, including mechanical inspection, performance tests, and a 500-mile endurance test over hard-surfaced, gravel, and cross-country courses.
DESCRIPTION: The test vehicle was a full track laying light tank weighing 29,485 pounds, and was manufactured by the Massey-Harris Company. It was a two-engined vehicle with Hydramatic transmission; and mounted a 37 mm gun with a coaxially mounted cal. .30 machine gun, a cal. .30 machine gun in the bow, and a cal. .30 antiaircraft gun.

CONCLUSIONS: The operation of the Light Tank M5 was satisfactory, although inferior workmanship was observed in the welds of the gasoline tank. The steering brake linings glazed too rapidly, and the transmission band adjustment showed the possibility of loosening during operation. It was recommended that the manufacture and design of the gasoline tanks be improved with respect to seam strength, and that steering brake linings be used which were less susceptible to glazing.
GENERAL: This 65-page report contains photographs of the faulty gasoline tank seam and glazing of the steering brake shoes and lining.

SUBJECT: Tanks (Combat) PG-2.452
TITLE: Acceptance Tests of Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.452; GMPG Project No. 25-3
DATE OF REPORT: 24 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of Medium Tank M3, Serial No. 4149, for military use; and to determine whether Protecto-Seal gasoline caps, or an "M3 fix", would be suitable for preventing loss of fuel through gasoline cap vents
METHOD: One test vehicle was operated on an acceptability test for 842 miles over varied terrain. Another Medium Tank M3 was used for testing ways of eliminating gasoline cap vent leakage; "Protecto-Seal" gasoline caps and an "M3 fix" installation were tested to determine whether either would remedy this condition.
DESCRIPTION: The test Chrysler manufactured Medium Tank M3, Serial No. 4149, was a full-tracked, front sprocket driven vehicle weighing 58,885 lbs. and was equipped with a vertical volute spring suspension. Vehicle armament consisted of a 75-mm gun and a combination 37-mm gun and cal. .30 machine gun. The "M3 fix" consisted of installing engine air cleaner intake elbows around the gas tank for the purpose of drawing cooling air over the tank surfaces. The "Protecto-Seal" gas caps were spring loaded to permit venting of the gasoline tanks under low pressure.
CONCLUSIONS: Performance of the Medium Tank M3 was satisfactory, and it was recommended the vehicle be considered acceptable for military use. One starting motor, one throttle arm pin, and one steering brake adjustment were the only mechanical deficiencies observed during test. The "Protecto-Seal" gasoline caps did not prevent loss of fuel from the gasoline tanks. There was no loss of gasoline when using the "M3 fix", since fuel tank temperature was reduced by 30° to 40°, resulting in reduced tank pressure. It was recommended the "M3 fix" be used on all Medium Tanks M3.
GENERAL: This 91-page report contains nine photographs showing the test vehicle, "M3-fix" installation, and vehicle components which failed.

SUBJECT: Tanks (Combat) PG-2.454
TITLE: Acceptance Test of Light Tank M3 — ACF-Continental
IDENTIFICATION: Report No. PG-2.454; G.M.P.G. Project No. 24-14
DATE OF REPORT: 18 August 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank M3, Serial No. 5653
METHOD: The tank was given standard acceptance tests including mechanical inspection and 500 miles of endurance operation over hard-surfaced, gravel, and cross-country courses.
DESCRIPTION: The test Light Tank M3, manufactured by the American Car and Foundry Company, was powered with a Continental engine, and weighed 27,755 pounds. It was armed with a 37 mm gun in combination with a cal. .30 machine gun, an antiaircraft gun, and an independently mounted cal. .30 machine gun.
CONCLUSIONS: Very little trouble was experienced during the 500-mile operation, only minor adjustments to the brake and track being necessary. It was concluded that the Light Tank M3, ACF-Continental, was of an acceptable design and of good operating characteristics.
GENERAL: This 57-page report contains four photographs of the Light Tank M3 and two photographs of failed parts.

SUBJECT: Tanks (Combat) PG-2.474
TITLE: Acceptance Test of Medium Tank M4A1 — Pacific Car and Foundry Company
IDENTIFICATION: Report No. PG-2.474; G.M.P.G. Project No. 25-7
DATE OF REPORT: 11 September 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct production acceptance test of Medium Tank M4A1
METHOD: The test tank was given a mechanical inspection, then operated 500 miles and reinspected. Daily logs were kept of performance, cooling, fuel and oil economy, braking characteristics, etc.
DESCRIPTION: The test Medium Tank M4A1 was manufactured by the Pacific Car and Foundry Company and was equipped with a gyrostabilizer. Armament included a 75 mm Gun M3 in Mount T48.
CONCLUSIONS: The Medium Tank M4A1 operated satisfactorily throughout the acceptance test except for the following items: the gun stabilizer failed to operate throughout the test (presumably because of a pump failure), the turret traverse motor could not rotate the turret on a 45% grade, and the muffler supports failed twice.
GENERAL: This 101-page report includes eight photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) PG-2.475
TITLE: Acceptance Test of Medium Tank, M4A2, Fisher
IDENTIFICATION: Report No. PG-2.475; G.M.P.G. Project No. 25-5
DATE OF REPORT: 12 September 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct production acceptance test

of Medium Tank M4A2, Fisher, Serial No. 2418
METHOD: A Medium Tank M4A2 was given a mechanical inspection before and after 500 miles of test operation. Daily logs were maintained of performance characteristics, cooling, braking, fuel and oil economy, slope operation, etc.
DESCRIPTION: The Medium Tank M4A2, manufactured by the Fisher Tank Division was powered by two engines, and was equipped with a gyrostabilizer. It was armed with a 75 mm gun mounted in a M34 Mount.
CONCLUSIONS: The Medium Tank M4A2 operated satisfactorily throughout the test except for the following: cooling was inadequate, and the gun stabilizer seized.
GENERAL: This 109-page report includes three photographs of test vehicle, three photographs of failed parts, and two sheets of route profile.

SUBJECT: Tanks (Combat) PG-2.476
TITLE: Acceptance Test of Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.476; G.M.P. G. Project No. 24-15
DATE OF REPORT: 11 September 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct production acceptance test of Light Tank M5; Cadillac
METHOD: A Light Tank M5 was mechanically inspected before and after 546 miles of test operation. Daily logs were kept pertaining to fuel and oil economy, braking, acceleration, etc. Tests were also conducted to determine cooling characteristics.
DESCRIPTION: The test Light Tank M5, No. 40, manufactured by the Cadillac Motor Car Company, was powered by two Cadillac engines, and weighed 32,000 pounds. It was equipped with a Westinghouse gyrostabilizer. Armament consisted of a 37 mm gun in a M23 Mount, a cal. .30 antiaircraft gun and a bow mounted cal. .30 machine gun.
CONCLUSIONS: The vehicle operated satisfactorily throughout the test. The gun stabilizer operated satisfactorily except that the stabilizer packing gland had to be repacked. The cooling tests showed temperature differentials of 137° to 141° F between outlet water and ambient air on both right and left engines. It was recommended that except for the stowage shortages, Light Tank M5 #40 be considered an acceptable vehicle.
GENERAL: This 90-page report includes four photographs of test vehicle and a stowage report.

SUBJECT: Tanks (Combat) PG 2.477
TITLE: Acceptance Test of Light Tank M5 — Massey-Harris
IDENTIFICATION: Report No. PG-2.477; G.M.P. G. Project No. 24-16
DATE OF REPORT: 12 September 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a production Light Tank M5, Massey-Harris, Serial No. 3268
METHOD: Light Tank M5 was operated 549 miles over the strategical tank route. Performance, fuel and oil economy, brake efficiency, and cooling characteristic data were obtained.
DESCRIPTION: The test Light Tank M5, was manufactured by the Massey-Harris Company and was an armored, 32,000-pound vehicle. Its primary weapon was a 37 mm gun. Power was supplied by two rear-mounted, V-8, water-cooled, Cadillac, gasoline engines developing 242 hp at 3200 rpm.
CONCLUSIONS: The vehicle was acceptable in all respects except the following: inconsistent gear shifting characteristics, erratic gun stabilizer operation, and inadequate cooling.
GENERAL: This 95-page report includes four photographs of the test vehicle.

SUBJECT: Tanks (Combat) PG-2.478
TITLE: Acceptance Test of Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.478; G.M.P. G. Project No. 24-17
DATE OF REPORT: 12 September 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Light Tank M5 Serial No. 53
METHOD: The vehicle was given a standard acceptance test including mechanical inspection, performance tests, and endurance testing over hard-surfaced, gravel, and cross-country courses for a total of 621 miles.
DESCRIPTION: The test Light Tank M5, Serial No. 53, was manufactured by Cadillac. It was powered by twin engines and weighed 32,000 pounds. Armament consisted of a 37 mm Gun M23, a cal. .30 machine gun in the bow, and a cal. .30 antiaircraft gun.
CONCLUSIONS: The engineering tests showed normal operation for an M5 Tank. Significant mechanical failures included cracks in the right trailing idler, failure of an inside turret lock, and failure of three engine instruments.
GENERAL: This 106-page report contains six photographs of failed parts.

SUBJECT: Tanks (Combat) PG-2.497
TITLE: Acceptance Test of Light Tank M5, Massey-Harris
IDENTIFICATION: Report No. PG-2.497; GMPG Project No. 24-18
DATE OF REPORT: 6 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank M5, Serial No. 3282, manufactured by Massey-Harris
METHOD: The vehicle was operated 523 miles on an acceptance test schedule.
DESCRIPTION: The test Light Tank M5 (Serial No. 3282), manufactured by the Massey-Harris Company, incorporated a vertical volute spring suspension with two bogie assemblies and a trailing idler on each side. Its main armament was a 37 mm gun mounted in a 360° traversing turret. An Oilgear traversing mechanism and a Westinghouse

gyrostabilizer were used.
CONCLUSIONS: Performance and cooling of the test vehicle were considered normal for that type of tank. Operation of the gyrostabilizer was erratic, but it continued to operate throughout the test. The vehicle was considered acceptable.
GENERAL: This 90-page report contains six photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.498
TITLE: Acceptance Test of Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.498; G.M.P. G. Project No. 24-19
DATE OF REPORT: 6 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank M5
METHOD: The vehicle was operated 502 miles over the standard acceptance test courses. For a cooling test, the vehicle was driven around the track at constant speed (9 mph, fourth gear, full throttle, 1800 rpm) until temperatures stabilized.
DESCRIPTION: The test Light Tank M5, Serial No. 476, was manufactured by the Cadillac Division of General Motors and weighed 32,000 pounds. Its main armament was a 37 mm gun.
CONCLUSIONS: The vehicle was mechanically satisfactory. The cooling test showed very high temperature differentials between water out of the right and left engines and ambient air of 143° and 155° F, respectively. There were numerous shortages of stowage items. It was recommended that the test tank be considered acceptable and that attention be paid to cooling.
GENERAL: This 86-page report includes four photographs of the test tank.

SUBJECT: Tanks (Combat) PG-2.499
TITLE: Acceptance Test of Medium Tank M4A1 — Pressed Steel
IDENTIFICATION: Report No. PG-2.499; G.M.P. G. Project No. 25-8
DATE OF REPORT: 3 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Medium Tank M4A1
METHOD: The vehicle was operated for 465 miles. During the test period it was mechanically inspected; the stowage list was checked; and general performance tests to determine cooling and braking characteristics were conducted.
DESCRIPTION: The test Medium Tank M4A1, Serial No. 371, was manufactured by the Pressed Steel Car Company and was a 63,500 lb., front sprocket driven vehicle powered by a Continental R975-C1 engine. Primary armament consisted of a 75 mm gun in the turret. The 75 mm gun was equipped with a Westinghouse gyrostabilizer.
CONCLUSIONS: The performance characteristics of the test vehicle, with the exception of the gyrostabilizer, were considered satisfactory. The stabilizer was unsatisfactory, hunting at all positions of the stiffness control. With the correction of the numerous stowage list shortages, and a minor modification in the .30 cal. cartridge case bracket, the test vehicle without gyrostabilizer was recommended as acceptable.
GENERAL: This 94-page report contains four photographs of the test vehicle.

SUBJECT: Tanks (Combat) PG-2.500
TITLE: Acceptance Test of Medium Tank, M4A1, Pressed Steel
IDENTIFICATION: Report No. PG-2.500; G.M.P. G. Project No. 25-9
DATE OF REPORT: 13 November 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M4A1
METHOD: The vehicle was inspected and operated for 494 miles on engineering and endurance tests.
DESCRIPTION: The test Medium Tank M4A1 (Serial No. 385) was manufactured by the Pressed Steel Car Company and weighed 63,600 pounds. It was powered by a Continental R975-C1, 9-cylinder, radial, gasoline engine. Main armament was a 75 mm Gun M34 with a cal. .30 coaxial machine gun. A cal. .50 turret mounted antiaircraft machine gun was included as secondary armament.
CONCLUSIONS: The tank was considered acceptable. It was recommended that an investigation be made into failure of relatively new switches on the turret traverse motor; that the fuel relief valve be modified to withstand vibration or be relocated to lessen vibration.
GENERAL: This 107-page report includes 14 photographs of the test vehicle and component failures.

SUBJECT: Tanks (Combat) PG-2.501
TITLE: Acceptance Test of Medium Tank M4A2, Pullman
IDENTIFICATION: Report No. PG-2.501; G.M.P. G. Project No. 25-10
DATE OF REPORT: 3 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M4A2
METHOD: The vehicle was inspected and operated 499 miles on engineering and endurance tests.
DESCRIPTION: The test Medium Tank M4A2 (Serial No. 1213) was manufactured by the Pullman Standard Car Company and weighed 65,500 pounds. It was powered by two GM diesel engines. Main armament was a 75 mm Gun M34 with a cal. .30 coaxial machine gun. Secondary armament included a cal. .50 turret mounted antiaircraft machine gun.
CONCLUSIONS: The M4A2 Tank was considered acceptable. It was recommended that a revised cooling system, which had been released for production, be installed on this vehicle.
GENERAL: This 95-page report includes four photographs of the vehicle and one photograph of a track block failure.

SUBJECT: Tanks (Combat) PG-2.502
TITLE: Acceptance Test of Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.502; G.M.P. G. Project No. 25-11
DATE OF REPORT: 3 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M4A4
METHOD: The tank was given an acceptance test consisting of 531 miles of operation over the Belgian Block course, improved roads, and cross-country terrain of the Endurance Tank Route.
DESCRIPTION: The test Medium Tank M4A4 (Serial No. 4823) was manufactured by the Chrysler Corporation and weighed 67,800 pounds. It was powered by five, L-head, water-cooled, six-cylinder Chrysler gasoline engines. This multi-bank engine was rated 445 hp at 2400 rpm and 1070 lb./ft. torque at 1200 rpm. Armament included a 75 mm gun, one cal. .50 and two cal. .30 machine guns.
CONCLUSIONS: Poor workmanship, stowage shortages, deficient cooling, faulty turret traverse mechanism operation, and numerous minor troubles developed during the test. It was recommended that the tank be accepted; that special attention be paid to cooling; and that manufacturing inspection be improved.
GENERAL: This 106-page report includes 12 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.503
TITLE: Acceptance Test of Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.503; G.M.P. G. Project No. 25-12
DATE OF REPORT: 6 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M3
METHOD: The vehicle was given a 498-mile revised acceptance test over the 10 mile Endurance Tank Route. Performance, fuel and oil economy, brake efficiency, and cooling data were obtained.
DESCRIPTION: The test Medium Tank M3 (Serial No. 4709) was a Chrysler-built 62,240-pound vehicle. It was powered by a radial R975-C1 Continental engine rated for 485 bhp at 2400 rpm. Armament included one 75 mm and one 37 mm gun, and three .30 caliber machine guns.
CONCLUSIONS: The vehicle was found acceptable. No serious deficiencies were found on the acceptance test.
GENERAL: This 79-page report contains four photographs of the test vehicle.

SUBJECT: Tanks (Combat) PG-2.504
TITLE: Acceptance Test of Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.504; G.M.P. G. Project No. 25-13
DATE OF REPORT: 6 October 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M3
METHOD: The vehicle was given a 490-mile acceptance test over the varied courses of the 10-mile Endurance Tank Route. Performance, fuel and oil economy, brake efficiency, and cooling data were obtained.
DESCRIPTION: The test Medium Tank M3 (Serial No. 4718) was a Chrysler-built, 62,750-pound vehicle. This tank was powered by a radial, air-cooled R975-C1 Continental engine rated for 485 bhp at 2400 rpm. Armament included one 75 mm and one 37 mm gun, and three caliber .30 machine guns.
CONCLUSIONS: Both the 37 mm and 75 mm gun stabilizers tended to hunt slightly, even at zero stiffness setting. Except for the gun stabilizer hunting, the vehicle was considered acceptable.
GENERAL: This 84-page report includes seven photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.512
TITLE: Engineering Test of Light Tank M3A3 — Pilot
IDENTIFICATION: Report No. PG-2.512; G.M.P. G. Project No. 64
DATE OF REPORT: 8 January 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the performance characteristics of Pilot Model Light Tank M3A3 and to suggest modifications to improve this tank
METHOD: The vehicle was operated 727 miles over improved roads and cross-country during engineering and strategical tests. Performance, fuel and oil economy, brake efficiency, drawbar pull and tractive resistance, fording ability, and visibility data were obtained.
DESCRIPTION: The test pilot model Light Tank M3A3 was a 27,485 pound vehicle manufactured by the American Car and Foundry Co. The test Light Tank M3A3 was powered by a Continental W-670, radial, 7-cylinder, air-cooled, rear-mounted engine rated for 450 bhp at 2400 rpm on 80 octane fuel. The primary weapon of this tank was a turret-mounted 37 mm gun.
CONCLUSIONS: Performance of the test M3A3 Tank, brake operation, clutch lever operation, and driver's seat and transmission lever location were unsatisfactory. Visibility in the M3A3 was better than it was in Light Tank M3. It was recommended that the driver's seating arrangement and clutch lever location as well as the other deficiencies be corrected, and that the gear ratios be changed to give better acceleration and performance.
GENERAL: This 121-page report includes 16 photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.512A
TITLE: Endurance and Supplementary Engineering Test of Light Tank M3A3 — Pilot — A. C. F.
IDENTIFICATION: Report No. PG-2.512A; G.M.

TANK AUTOMOTIVE TEST RESUMES

P.G. Project No. 64
DATE OF REPORT: 29 July 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability and to suggest modifications to improve the pilot model Light Tank M3A3
METHOD: This tank was operated 1113 miles over improved roads and cross-country during engineering and endurance tests.
DESCRIPTION: The test Light Tank M3A3 was a pilot model of a modified M3A1. This 27,495-pound vehicle, manufactured by the American Car and Foundry Company, was powered by a Continental W 670, radial, 7-cylinder, air-cooled, rear-mounted, gasoline engine rated at 450 bhp. Main armament was a 37 mm gun.
CONCLUSIONS: The test tank developed no serious trouble. Fuel and oil economy were good. Performance was poor in 5th gear. Brakes required considerable service, and linings had to be replaced frequently; the brakes had a tendency to "tighten up" when system oil was cool. It was recommended that the vehicle be considered acceptable provided that: fuel shut-off valves be plainly marked, fuel gage be replaced, engine and transmission gages be improved and plainly labeled, fuel tank removal be simplified, brakes be improved, and suspension system be modified to prevent bending of the guides.
GENERAL: This 134-page report includes 20 photographs of failed tank components. This vehicle had been previously tested and recorded in Report No. PG-2.512; G.M.P.G. Project No. 64.

SUBJECT: Tanks (Combat) PG-2.523
TITLE: Engineering Test of Medium Tank M4A3, #1, Ford
IDENTIFICATION: Report No. PG-2.523; G.M.P.G. Project No. 59
DATE OF REPORT: 27 February 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the engineering suitability of a Medium Tank M4A3
METHOD: The vehicle was subjected to a series of engineering and performance tests during 482 miles of operation over various types of terrain.
DESCRIPTION: The test Medium Tank M4A3, No. 1, was a 64,000-pound, front sprocket driven, welded-hull vehicle manufactured by the Ford Motor Company. It was equipped with a vertical volute spring suspension, a five-speed transmission, and was powered by a Ford GAA, V-8, liquid-cooled, gasoline engine rated 500 bhp at 2600 rpm.
CONCLUSIONS: The engineering performance of the test vehicle was generally satisfactory. Excessive engine oil consumption, electrical system and instrument failures, poor fifth gear drawbar pull, and poor braking ability were the primary deficiencies noted. Although recommendations were made for the approval of the vehicle and the correction of deficiencies, Ordnance representative considered the recommendations questionable because of the brevity of the test.
GENERAL: This 156-page report contains 17 photographs showing various views of the test vehicle and the condition of component parts after operation.

SUBJECT: Tanks (Combat) PG-2.544
TITLE: Acceptance Test of Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.544; G.M.P.G. Project No. 25-14
DATE OF REPORT: 10 December 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Medium Tank M4A3
METHOD: The vehicle was subjected to standard acceptance tests during 479 miles of operation over the hard-surfaced, improved gravel, and cross-country courses of the strategical tank route. Prior to the acceptance test, the vehicle had been operated 1200 miles.
DESCRIPTION: The test Medium Tank M4A3, Serial No. 2673, was a front sprocket driven, 65,470-pound vehicle manufactured by the Ford Motor Company. It was powered by a Ford engine, and used vertical volute spring suspension. Armament consisted of a 37 mm gun and coaxially-mounted cal. .30 machine gun, a cal. .30 bow machine gun, and a cal. .50 antiaircraft machine gun mounted on the turret.
CONCLUSIONS: The test vehicle performed satisfactorily and was recommended for acceptance. Quality of workmanship and vehicle cooling were found acceptable. The following deficiencies were noted during testing: shortages were discovered in the stowage list; engine oil consumption was excessive; oil leaks were found in the right-hand generator and fan drive quill assembly, and rear end of transmission output shaft; a starter mounting flange failed; and right steering brake seized. It was recommended that additional acceptance tests be conducted on a similar vehicle having the latest production changes.
GENERAL: This 109-page report contains 13 photographs of test vehicle and parts damaged in operation.

SUBJECT: Tanks (Combat) PG-2.545
TITLE: Acceptance Test of Medium Tank M4A1, Pacific
IDENTIFICATION: Report No. PG-2.545; GMPG Project No. 25-15
DATE OF REPORT: 10 December 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M4A1, Serial No. 3011
METHOD: The vehicle was inspected and operated for 547 miles of engineering and endurance tests.
DESCRIPTION: The Medium Tank M4A1, Serial No. 3011, was manufactured by the Pacific Car and Foundry Company and weighed 63,645 pounds. It was powered by a Continental R975-C1, 9-cylinder,

radial, gasoline engine. Armament included a 75 mm Gun M34, a coaxially mounted cal. .30 machine gun and a cal. .50 turret mounted antiaircraft machine gun.
CONCLUSIONS: The test tank was considered acceptable. It was recommended that more attention be paid to final inspection to eliminate a large number of minor faults.
GENERAL: This 115-page report includes 15 photographs of the vehicle and component failures.

SUBJECT: Tanks (Combat) PG-2.571
TITLE: Engineering Test of Heavy Tank T1E2 — Baldwin
IDENTIFICATION: Report No. PG-2.571; G.M.P.G. Project No. 17
DATE OF REPORT: 24 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To evaluate the performance of Heavy Tank T1E2 and to report on the merits of Hycon and vacuum booster steering control system
METHOD: The test vehicle was operated 376 miles on engineering tests, including cooling, hill climbing, obstacle crossing, drawbar pull, and fuel economy tests. Steering characteristics with a Hycon system and vacuum booster steering brake control system were determined.
DESCRIPTION: The test Heavy Tank T1E2, Serial No. 8012, was manufactured by the Baldwin Locomotive Works and weighed 117,775 pounds. It was powered by a Wright G-200, 9-cylinder, radial, 935-hp, gasoline engine. The Twin Disc Clutch Company manufactured the torque converter and planetary gear box. The Hycon steering system was a high pressure hydraulic control. The other steering system tested consisted of mechanical linkage and a vacuum booster.
CONCLUSIONS: Performance of Heavy Tank T1E2 was considered very good. The use of vacuum booster steering system was recommended over the Hycon system, since failure of the hydraulic system would render the Hycon system inoperative. Also recommended were: an engine governor to prevent torque converter overheating; track redesign to prevent jumping; and a change in the ratio of the transmission and final drives to provide higher speed and better cooling.
GENERAL: This 109-page report includes eight photographs.

SUBJECT: Tanks (Combat) PG-2.571A
TITLE: First Report on Development of Heavy Tank T1E2 — Baldwin
IDENTIFICATION: Report No. PG-2.571A; G.M.P.G. Project No. 17
DATE OF REPORT: 15 April 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine deficiencies of the test Heavy Tank T1E2 and to recommend corrections
METHOD: The test tank was operated 3333 miles over hard-surfaced roads and cross-country terrain. After 183 miles of operation, the Hycon hydraulic system was replaced by a vacuum-mechanical system. Revisions were made in cooling, transmissions, brake discs, sprockets and piping. A mechanical shifting mechanism was substituted for the hydraulic mechanism.
DESCRIPTION: The test Heavy Tank T1E2, Serial No. 1 was manufactured by the Baldwin Locomotive Works and weighed 117,775 pounds. It was powered by a Wright G-200, 9-cylinder, radial, 935-hp, gasoline engine. The horizontal volute spring suspension included four bogie assemblies on each side. The vehicle was originally equipped with Budd disc brakes employing a pure hydraulic (Hycon) method of actuation. These brakes were operated on a 1000-pound line pressure.
CONCLUSIONS: Vehicle cooling was satisfactory. Present power train provided adequate power to meet the design requirements as to obstacle ability, speed, reliability. The vacuum-mechanical brake control system was preferable to the hydraulic system; the tank was steerable by mechanical means only. Bogie wheels did not have sufficient strength. Track was not adequately guided to prevent throwing.
GENERAL: This 406-page report includes 183 photographs of components.

SUBJECT: Tanks (Combat) PG-2.571B
TITLE: Engineering and Development Tests of Heavy Tank T1E2 — Baldwin — Final Report
IDENTIFICATION: Report No. PG-2.571B; G.M.P.G. Project No. 17
DATE OF REPORT: 1 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the relative merit of the twin GM 3700 Torqumatic transmission as compared with the original Twin Disc torque converter transmission; and to evaluate a mechanical vacuum booster brake control system, a combination vacuum pump and engine overspeed switch, experimental final drive sprockets, bogie wheels, and track center-guides
METHOD: The test vehicle was operated 736 miles to failure of one of the Torqumatic transmissions.
DESCRIPTION: Heavy Tank T1E2 was a pilot model of a 50-ton tank, manufactured by the Baldwin Locomotive Co., and was powered by a Wright Cyclone, radial, air-cooled, engine. It was equipped with twin GM 3700 Torqumatic transmissions with three-speed gear boxes, replacing the Twin Disc Model No. T-16000 torque converter and two-speed gear box combination originally installed. The test brake control consisted of a mechanical lever system, plus a vacuum booster system developed by collaboration of Timken, Buick, and Bendix. The combination vacuum pump and overspeed switch consisted of a Bendix vacuum pump and General Electric switch. The experimental bogie wheels were manufactured by Motor Wheel Corp. The test final drive sprockets were made of SAE 1015 and SAE 2220 steels.
CONCLUSIONS: The twin GM 3700 Torqumatic transmissions were not recommended unless durability and efficiency were improved. A direct drive for high range, by-passing the converter, was rec-

ommended as the most satisfactory steering arrangement for heavy tanks. The experimental bogie wheels, sprockets, and track center guides were recommended for use. The General Electric engine overspeed switch driven from the vacuum pump proved unsatisfactory.
GENERAL: This 192-page report includes 58 photographs of the test installation and failed components.

SUBJECT: Tanks (Combat) PG-2.591
TITLE: Acceptance Test of Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.591; Project No. 24-21
DATE OF REPORT: 9 February 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Light Tank M5
METHOD: The vehicle was given a 513-mile acceptance test over the hard-surfaced, improved gravel, and cross-country courses of the strategical tank route.
DESCRIPTION: The test Light Tank M5, Serial No. 1312, was a 31,795-pound vehicle manufactured by the Cadillac Division of General Motors. It was powered by two Cadillac, Series 48, V-8 engines, developing a total of 242 horsepower at 3200 rpm. A 37-mm gun was used as primary armament.
CONCLUSIONS: This tank was considered acceptable. Vehicle performance was considered satisfactory. Engine cooling was unsatisfactory; however, it was felt that cooling characteristics would be satisfactory if 15 psi (at 250°F) pressure caps were used.
GENERAL: This 108-page report includes eight photographs of the test tank and failed components.

SUBJECT: Tanks (Combat) PG-2.594
TITLE: Acceptance Test of Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.594; G.M.P.G. Project No. 25-16
DATE OF REPORT: 20 February 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M4A4, Ordnance Serial No. 6127
METHOD: The test vehicle was given standard acceptance tests during 572 miles of operation over the hard surfaced, improved ground, and cross-country courses of the Strategical Tank Route.
DESCRIPTION: The test Medium Tank M4A4 manufactured by the Chrysler Corporation, was a 69,500-pound, front sprocket-driven, full track-laying vehicle powered by a Chrysler multibank engine. The vehicle was equipped with a vertical volute spring suspension and a 360° traversing turret. Armament consisted of a 75-mm gun, two cal. .30 machine guns and a cal. .50 anti-aircraft machine gun.
CONCLUSIONS: The performance characteristics of the test vehicle were generally satisfactory. During operation, the following deficiencies were noted: engine cooling was unsatisfactory and required further attention; vehicle stowage list was incomplete; ammunition boxes and shell cases presented minor annoyances; and the turret traversing mechanism was not operating smoothly. On the basis of the results, the test vehicle was recommended for acceptance.
GENERAL: This 103-page report contains seven photographs showing views of periscopes damaged in operation, and the condition of the radiator, which was fouled with mud and water, after 544 miles of testing.

SUBJECT: Tanks (Combat) PG-2.602
TITLE: Grade Performance Comparisons of Light and Medium Tanks Based on Sprocket Power
IDENTIFICATION: Report No. PG-2.602
DATE OF REPORT: 29 January 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the power plant and transmission combination requirements for satisfactory performance of track laying vehicles over rough terrain
METHOD: The drawbar pull and tractive resistance characteristics of several track laying vehicles were obtained during operation over firm moist sod. From these results, the sprocket horsepower of each vehicle was determined and compared.
DESCRIPTION: The test vehicles were of the Light and Medium Tank M3 and M5 series. Each vehicle was equipped with one of the following standard power plants: Cadillac; Continental, W670; General Motors twin diesels; Continental R975; Ford; and Chrysler Multibank. Synchromesh, Torqumatic, and Hydramatic transmissions and transfer case ratios of 0.73 and 0.84 were used in the various vehicle power trains.
CONCLUSIONS: The power plants and transmission combinations used in the various test vehicles were considered as inadequate for satisfactory tank performance over rough terrain. On the basis of the results, it was determined that the over-all performance of the testing vehicles could be improved in the following manner for better handling and maneuverability: the hp/ton available at the sprockets should be increased by at least 50%; gear ratios should be changed to provide better performance in a lower speed range; and a transmission having only four forward ranges should be used.
GENERAL: This 28-page report contains 15 curve sheets comparing the performance of the various test vehicles and their related components. There are no photographs.

SUBJECT: Tanks (Combat) PG-2.606
TITLE: Test of Light Tank T7E2
IDENTIFICATION: Report No. PG-2.606; Project No. 124
DATE OF REPORT: 3 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of the Light Tank T7E2
METHOD: A mechanical inspection and 14 miles

of operation were conducted on the test vehicle when the project was cancelled by directive.
DESCRIPTION: The test Light Tank T7E2 was a 50,265-pound, front sprocket-driven vehicle, powered by a Continental R975-C1, 9-cylinder, air-cooled, gasoline engine rated at 400 bhp at 2400 rpm. The vehicle was equipped with a vertical volute spring suspension.
CONCLUSIONS: There were no conclusions, since the testing period was of such short duration.
GENERAL: This 59-page report contains 13 photographs showing various views of the test vehicle, component parts, and a track end connector failure after two miles of operation.

SUBJECT: Tanks (Combat) PG-2.609
TITLE: Acceptance Test on Light Tank M3A1 — A.C.F.
IDENTIFICATION: Report No. PG-2.609; Project No. 24-20
DATE OF REPORT: 19 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a production Light Tank M3A1, A.C.F., Serial No. 8000
METHOD: The vehicle was operated 647 miles over the 10-mile Endurance Tank Route during the acceptance test. Performance, fuel and oil economy, brake efficiency, and cooling characteristic data were obtained.
DESCRIPTION: The test Light Tank M3A1 was manufactured by the American Car and Foundry Company and weighed 28,345 pounds. It was powered by a 7-cylinder, radial, air-cooled, Continental W-670 gasoline engine. A 37-mm gun was used as the primary weapon.
CONCLUSIONS: The test Light Tank M3A1 was considered an acceptable vehicle.
GENERAL: This 106-page report includes four photographs of the test vehicle and five photographs of failed parts.

SUBJECT: Tanks (Combat) PG-2.610
TITLE: Acceptance Test of Light Tank M5A1 — Cadillac
IDENTIFICATION: Report No. PG-2.610; Project No. 24-22
DATE OF REPORT: 3 April 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a production Light Tank M5A1, Cadillac, Serial No. 2145
METHOD: The vehicle was operated 617 miles over a standard acceptance test course. Performance, fuel and oil economy, brake efficiency, and cooling characteristic data were obtained.
DESCRIPTION: The test Light Tank M5A1 was manufactured by Cadillac and weighed 32,215 pounds. It was powered by two rear-mounted, 242-hp, V-8, Cadillac engines. Armament consisted of a 37-mm gun and three cal. .30 machine guns.
CONCLUSIONS: It was recommended that the test Light Tank M5A1 be considered acceptable and that attention be paid to cooling. Differential between water-out and ambient temperatures was 150° to 153° F.
GENERAL: This 99-page report includes five photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-2.611
TITLE: Acceptance Tests of Medium Tank M4 — Pressed Steel
IDENTIFICATION: Report No. PG-2.611; Project No. 25-17
DATE OF REPORT: 15 April 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Medium Tank M4 — Pressed Steel, Serial No. 615
METHOD: The vehicle was given standard acceptance tests including mechanical inspection, performance tests, and 604-mile endurance test over hard surface, gravel and cross-country courses.
DESCRIPTION: The test Medium Tank M4 was manufactured by the Pressed Steel Car Company and weighed 64,500 pounds. It was powered by a Continental R975-C1, 9-cylinder, gasoline engine, and equipped with a 75-mm Gun M3 and a Westinghouse gyrostabilizer.
CONCLUSIONS: The test vehicle was not acceptable. A fuel line failure resulted in a fire in the engine compartment; difficulty was experienced with the clutch; the transmission could not be shifted into third gear after 465 miles; track support rollers failed due to broken shafts and failed welds; and the drive sprockets required replacement at 554 miles because of excess wear. The following was recommended: improved fuel lines, improved final inspection and workmanship on clutch and transmission, improved design of track support roller assemblies, and improved sprocket durability.
GENERAL: This 142-page report contains 31 photographs showing the test vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.612
TITLE: Acceptance Test of Medium Tank M4A2 — Pullman
IDENTIFICATION: Report No. PG-2.612; Project No. 25-18
DATE OF REPORT: 2 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Medium Tank M4A2 — Pullman, Serial No. 1331
METHOD: The vehicle was given standard acceptance tests including mechanical inspection, performance tests, and a 524-mile endurance test over hard surface, gravel and cross-country courses.
DESCRIPTION: The test Medium Tank M4A2 was manufactured by the Pullman Standard Car Company and weighed 66,200 pounds. It was powered by two GM, 6-cylinder, diesel engines and was equipped with a 75-mm Gun M3 and a Westinghouse gyrostabilizer.

TANK AUTOMOTIVE TEST RESUMES

CONCLUSIONS: The test tank was considered acceptable. The most serious mechanical trouble during the test was failure of the stabilizer pump shaft at 338 miles. It was recommended that final vehicle inspection be improved to correct a number of minor deficiencies.
GENERAL: This 118-page report contains 14 photographs showing the vehicle and damaged components.

SUBJECT: Tanks (Combat) PG-2.626
TITLE: Test of Heavy Tank M6A1
IDENTIFICATION: Report No. PG-2.626; Project No. 111
DATE OF REPORT: 20 March 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine design suitability of Heavy Tank M6A1
METHOD: The vehicle was endurance operated 245 miles over Proving Ground courses.
DESCRIPTION: The test Heavy Tank M6A1 was manufactured by the Fisher Body Division of General Motors and weighed 117,180 pounds. It was powered by a 9-cylinder, radial, air-cooled, model 781C96-C1 Wright engine rated for 800 bhp at 2300 rpm. Power was transmitted through a torque converter consisting of a centrifugal pump and a three-stage turbine. Primary armament consisted of a 3-inch gun and a 37-mm gun.
CONCLUSIONS: No major deficiency was noted. Numerous minor faults were listed. It was recommended that track center guides be adopted for production, track end connectors be made heavier, the exhaust diffuser be modified, the air cleaner location or shifting linkage be changed to facilitate servicing, the method of adjusting track tension be improved, the turret lock be redesigned, the bogie arms be strengthened, Pollock type exhaust clamps be adopted, idler design be improved, and the master cylinder pedal for the transmission brake mechanism be relocated to allow easier operation.
GENERAL: This 120-page report includes 42 photographs of the test tank and its components.

SUBJECT: Tanks (Combat) PG-2.628
TITLE: Engineering Test of Medium Tank M7 — International Harvester
IDENTIFICATION: Report No. PG-2.628; Project No. 101
DATE OF REPORT: 9 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine operating and design characteristics of Medium Tank M7
METHOD: The vehicle was engineering tested during 457 miles of operation over the Proving Ground course.
DESCRIPTION: The test Medium Tank M7, manufactured by International Harvester Company, weighed 52,500 pounds. It was powered by a 9-cylinder, radial, air-cooled, Continental R975-C1 engine rated at 400 bhp at 2400 rpm. Power was transmitted through an automatic torque converter transmission. Primary armament was a 57-mm gun.
CONCLUSIONS: The vehicle was considered unsatisfactory: torque converter cooling capacity was only 50% of minimum requirement; performance at speeds exceeding 15 mph in direct drive was poor; the braking system was seriously defective. Engine accessibility was good. It was recommended that the braking system be improved, the vehicle performance and torque above 15 mph be improved, torque converter oil cooler capacity be doubled, some modification be made to prevent operation in sub-converter range above 6-8 mph, and that some means be provided for locking vehicle in direct below 17 mph to provide some engine braking.
GENERAL: This 190-page report includes 36 photographs of the test vehicle and its components.

SUBJECT: Tanks (Combat) PG-2.640
TITLE: Desert Test of Light Tank M3A1 — A.C.F.
IDENTIFICATION: Report No. PG-2.640; Project No. 51-7
DATE OF REPORT: 28 June 1943
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the vulnerability of Light Tank M3A1 components to dust and heat in desert operation
METHOD: The test vehicle was given a 924-mile endurance test over desert cross-country terrain at Phoenix, Arizona.
DESCRIPTION: The test Light Tank M3A1 was manufactured by the American Car and Foundry Company and weighed 28,500 pounds. It was powered by a 7-cylinder, radial, air-cooled, Continental W-670 gasoline engine that developed approximately 235 horsepower. The original, standard three-plate clutch was replaced by Rockford two- and three-plate clutches during the test.
CONCLUSIONS: The engine, clutch, and electrical system were most vulnerable to dust-originated failures. The accelerator pump and auxiliary generator were also made inoperative by dust accumulation. The modified Rockford two- and three-plate clutches were considered more satisfactory than the standard clutch for operation in dusty terrain. It was recommended that attention be paid to protecting the accelerator well, starter switch mechanism, and auxiliary generator contact points from dust. Also, it was recommended that the standard clutch be modified to give better dust protection.
GENERAL: This 193-page report has 44 photographs of test components.

SUBJECT: Tanks (Combat) PG-2.655
TITLE: Desert Test of Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.655; GMPG Project No. 51-6
DATE OF REPORT: 22 July 1943
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the endurance characteristics of Medium Tank M3, Ordnance Serial No. 4325, while operated under extremely dusty conditions

METHOD: The test included a mechanical inspection, engineering tests and 2135 miles of endurance operation over a dusty course.
DESCRIPTION: Test Medium Tank M3, manufactured by the Chrysler Tank Arsenal, weighed 62,500-pounds. The engine was an R975-C1 with latest type air cleaners and muffler setup.
CONCLUSIONS: Performance and operation of the vehicle on the whole were very satisfactory. The main difficulties were suspension and engine failures. It was recommended that increased protection from dust be provided for engine and clutch and that the durability of springs and spring seats be improved for desert operation.
GENERAL: This 227-page report includes 34 photographs of component failures.

SUBJECT: Tanks (Combat) PG-2.656
TITLE: Desert Test of Medium Tank, M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.656; Project No. 51-5
DATE OF REPORT: 18 January 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the effect of desert heat and dust on the life of Medium Tank M4A4
METHOD: The test covered mechanical inspection, engineering tests, and 822 miles of desert endurance operation.
DESCRIPTION: The test Medium Tank M4A4, Ordnance Serial No. 4836, was manufactured by the Chrysler Tank Arsenal and weighed 67,900 pounds. The engine was a Model No. W-Ord-46. The tank was provided with sponson and gasoline tank ventilation for vapor lock correction.
CONCLUSIONS: The test tank operated satisfactorily for 822 miles when the engine was declared a failure because of high oil consumption and "blow-by". The standard Lipe two-plate clutch proved unsatisfactory because of dust stickiness and overheating. It was recommended that the solenoid fuel shut-off valve be standardized and that a dust-proofed and ventilated Lipe two-plate clutch be used. Many points of the vehicle were adversely affected by dust including the starter, distributor, governors, clutch, turret bearing race, and periscopes. Excessive dust was also thrown in the driver's face by the tracks and the exhaust air.
GENERAL: This 156-page report includes 18 photographs of component failures.

SUBJECT: Tanks (Combat) PG-2.657
TITLE: Desert Test of Medium Tank M4A1 — Pressed Steel
IDENTIFICATION: Report No. PG-2.657; Project No. 51-1
DATE OF REPORT: 21 February 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the effect of dust and high temperatures on the life of the vehicle
METHOD: The test covered mechanical inspection, engineering tests, and 1919 miles endurance operation.
DESCRIPTION: The test Medium Tank M4A1, Serial No. 148, was manufactured by the Pressed Steel Car Company and weighed 58,485 pounds. Equipment included a Continental engine, Model R975-C1 with the latest type air cleaners, muffler setup, and a production vapor lock fix.
CONCLUSIONS: The first test engine was replaced at 129 miles because of a valve failure. The second test engine operated 1218 miles to failure when No. 1 cylinder and piston broke up. Fuel temperature in the carburetor bowl reached 144° F while operating in 95° F ambient air. Borderline vaporlock occurred at this point. Dust had an adverse effect on various components such as: the Rockford 3-plate clutch, bogie wheel grease retainers, magneto, throttle linkage, fuel cut-off solenoid, turret bearing race, and periscopes. The air at the driver's hatch was too dusty to breathe without a respirator. Suspension springs and gudgeon lock bolts were short-lived. Modifications to prevent entrance of dust, better insulation of fuel lines, and respirators for all crew members were recommended.
GENERAL: This 235-page report includes 40 photographs. Information on propeller shaft and bogie wheel bearing lubrication was reported under Projects 51-13 and 51-8, respectively.

SUBJECT: Tanks (Combat) PG-2.658
TITLE: Acceptance Test of Medium Tank M4A2 — Federal
IDENTIFICATION: Report No. PG-2.658; Project No. 25-19
DATE OF REPORT: 29 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank M4A2 — Federal
METHOD: The vehicle was inspected and operated for 595 miles of engineering and endurance test operation.
DESCRIPTION: The test Medium Tank M4A2, manufactured by the Federal Machine Company, weighed 68,830 pounds. It had a 75 mm gun in a M34 Mount as major armament, and was equipped with a Westinghouse gyro-stabilizer.
CONCLUSIONS: The cooling test showed higher differentials (125°F — right and 120°F — left) than were considered desirable, but the use of pressure caps operating at 14 psi gage may make such differentials permissible. Considerable bogie wheel trouble was experienced. The turret ring bearing showed extremely high friction on the initial traversing tests. The resistance increased until the turret jammed. It was recommended that attention be paid to improving the durability of the bogie wheel tires. It was recommended that more attention be paid to workmanship and final inspection of the turret traversing mechanism.
GENERAL: This 134-page report includes 15 photographs of the vehicle and failed parts.

SUBJECT: Tanks (Combat) PG-2.659
TITLE: Acceptance Test of Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.659; GMPG

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Project No. 25-20
DATE OF REPORT: 8 April 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Medium Tank M4A3 — Ford, Serial No. 11629
METHOD: The vehicle was given standard acceptance tests including mechanical inspection, performance and a 594-mile endurance operation over paved, gravel and cross-country courses.
DESCRIPTION: The test Medium Tank M4A3, manufactured by the Ford Motor Company, weighed 66,790 pounds and was powered by a Ford GAA, V-8, gasoline engine. The vehicle was equipped with a 75 mm Gun M3, and a Westinghouse gyrostabilizer.
CONCLUSIONS: The performance of the vehicle declined during operation. Trouble was experienced in leakage from stabilizer oil reservoir and the motor and pumps ran hot with gyrostabilizer operating. Mechanical troubles were minor except for track and clutch. A clutch-driven disk exploded when suddenly engaged after brake failure. One bogie wheel failed at 298 miles. At 538 miles three track support rollers had shaft scoring and end welds cracked. Bogie tires and track support shoes were badly worn. It was recommended that the engine be improved to give consistent performance; that workmanship and design of suspension system and clutch be improved; and that gyrostabilizer workmanship be improved.
GENERAL: This 117-page report contains 15 photographs of the test vehicle and damaged components.

SUBJECT: Tanks (Combat) PG-2.664
TITLE: Acceptance Test of Light Tank M3A3 — A.C.F.
IDENTIFICATION: Report No. PG-2.664; GMPG Project No. 24-23
DATE OF REPORT: 6 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of the Light Tank M3A3 — A.C.F. Serial No. 10437
METHOD: The vehicle was given standard acceptance tests including mechanical inspection and a 607 mile endurance test over hard surfaced, gravel and cross-country course.
DESCRIPTION: The test Light Tank M3A3, weighing 30,174 pounds, was manufactured by the American Car and Foundry Company. It was powered by a 7-cylinder, 235 hp, Continental engine W-670. The vehicle was equipped with a 37 mm Gun M3, and a Westinghouse gyrostabilizer.
CONCLUSIONS: The engine of the test vehicle was replaced at the end of the test because of excessive oil consumption. Transmission oil pressure and stabilizer operation were unsatisfactory, and considerable sag developed in the rear of the vehicle. It was recommended that attention be paid to final inspection and workmanship of the engine; that further investigation be made of the low transmission oil pressure; and that final inspection of the gyrostabilizer be improved.
GENERAL: This 117-page report contains 11 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-2.668
TITLE: Supplementary Report on Medium Tank M4A2 — Pullman Standard
IDENTIFICATION: Report No. PG-2.668; GMPG Project No. 34
DATE OF REPORT: 9 June 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile test data resulting from operation of a Medium Tank M4A2 from the time it was assigned to Project No. 34, until it was shipped
METHOD: Fourteen test projects were run on the vehicle. Charts, photographs, logs, and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 906, was manufactured by the Pullman Standard Car Company. It was powered by two diesel engines and equipped with a gyrostabilizer.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual project reports and were not included in this supplementary report.
GENERAL: This 356-page report includes 192 photographs of failed components, 55 repair detail sheets, 82 daily log sheets, and five performance curve sheets all compiled from test operations while the vehicle was assigned to Project No. 34 from 24 July 1942 to 26 October 1942.

SUBJECT: Tanks (Combat) PG-2.674
TITLE: Supplementary Report on Medium Tank M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.674; GMPG No. 8021; (Project No. 34)
DATE OF REPORT: 14 June 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile test data resulting from operation of a Medium Tank M4A2 assigned as a test facility vehicle on Project No. 34 from 15 July 1942 to 7 December 1942
METHOD: Twenty test projects were run on the vehicle while assigned to Project No. 34. Endurance operation for testing suspension and tracks covered 2503 miles.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 2312, was manufactured by Fisher Body Division of General Motors Corporation and was powered by two diesel engines.
CONCLUSIONS: Conclusions and recommendations of the individual test projects were included in the reports on those projects and were not incorporated in this supplementary report.
GENERAL: This 297-page report includes 147 photographs of component failures, 50 detail repair sheets, 74 daily log sheets, and eight-page test chronology, repair frequency chart, and cumulative engine fuel and lubricating oil economy curves.

SUBJECT: Tanks (Combat) PG-2.680
TITLE: Engineering Test of Light Tank M5A1 — Cadillac
IDENTIFICATION: Report No. PG-2.680; GMPG Project No. 139
DATE OF REPORT: 18 August 1943

ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the performance and endurance characteristics of Light Tank M5A1 — Cadillac, Serial No. 2145
METHOD: The vehicle was operated for 799 miles on engineering tests. This tank had previously passed a 617-mile endurance test.
DESCRIPTION: The test Light Tank M5A1 was manufactured by the Cadillac Motor Car Company and weighed 34,000 pounds. It was powered by two Cadillac 1942 gasoline engines and was equipped with hydramatic transmissions. Main armament was a 37 mm gun.
CONCLUSIONS: The test vehicle was approved for use by the Ordnance Department. There was only minor engine trouble, and mechanical failure was largely limited to the transmission and brake systems. The hydramatic transfer unit failed at 944 miles, and the right transmission failed due to overheating at 1151 miles. It was concluded that hydramatic was not as rugged as conventional transmissions. The left brake drum broke at 1149 miles; brake performance was considered average. In comparison with the Light Tank M5, there was no significant differences in performance except that the fuel economy of the M5 was better at all speeds than that of the M5A1, and from 10 to 15 mph was better by 1/2 mpg. It was recommended that adjustments of the hydramatic and transfer unit be made more often than specified by the Field Service Bulletin.
GENERAL: This 149-page report contains 22 photographs of the test tank and failed components.

SUBJECT: Tanks (Combat) PG-2.682
TITLE: Test of Medium Tank M4A1 with 76 MM Gun
IDENTIFICATION: Report No. PG-2.682; GMPG Project No. 143
DATE OF REPORT: 31 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the quality and endurance of Medium Tank M4A1
METHOD: The vehicle was given a 1485-mile endurance test over the hard-surfaced, gravel, and cross-country courses of the 10-mile endurance tank route.
DESCRIPTION: The test Medium Tank M4A1 was manufactured by the Pressed Steel Car Corporation and weighed 68,520 pounds. It was powered by a Continental R975-C1, air-cooled, 9-cylinder, gasoline engine rated 485 bhp at 2400 rpm. Armament consisted of a 76 mm gun, one cal. .50 and two cal. .30 machine guns.
CONCLUSIONS: Numerous serious deficiencies were noted in the engine, clutch, and transmission. The clutch release bearing was totally unsatisfactory from an endurance standpoint. Interference caused by a bracket and periscope box welded to the hull floor made transmission removal extremely difficult. It was recommended that these deficiencies be corrected.
GENERAL: This 229-page report includes 76 photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) PG-2.683
TITLE: Supplementary Report on Light Tank M3 — A.C.F. — Continental
IDENTIFICATION: Report No. PG-2.683; GMPG No. 8015 (Project No. 34)
DATE OF REPORT: 22 July 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Light Tank M3, A.C.F. — Continental, assigned as a facility vehicle for Project No. 34
METHOD: Fifteen test projects were run on the vehicle while it was assigned to Project No. 34. The endurance operation covered 7143 miles.
DESCRIPTION: The test Light Tank M3, Ordnance Serial No. 3897, was manufactured by the American Car and Foundry Company and equipped with a Continental W-670 gasoline engine.
CONCLUSIONS: Conclusions and recommendations of the individual test projects were not incorporated in this supplementary report.
GENERAL: This 406-page report includes 139 photographs of component failures, a five-page chronology record, 168 daily log sheets, 70 detail repair sheets, a frequency of failure chart, and cumulative engine fuel and lube oil curves.

SUBJECT: Tanks (Combat) PG-2.684
TITLE: Supplementary Report on Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.684; GMPG Project No. 8020
DATE OF REPORT: 7 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational data of a Medium Tank M3
METHOD: The 346 miles of operation covered in this report was over the special Powder Valley route. All operation and repair logs plus photographs of parts failures were assembled into one report.
DESCRIPTION: The test Medium Tank M3, Ordnance Serial No. 2477, was manufactured by the Chrysler Corporation and powered by a Continental, R975-C1, radial, gasoline engine.
CONCLUSIONS: Conclusions and recommendations were included in reports from which this supplementary report was derived.
GENERAL: This 83-page report includes 37 photographs of failed components.

SUBJECT: Tanks (Combat) PG-2.685
TITLE: Supplementary Report on Medium Tank M4A1 — Pressed Steel
IDENTIFICATION: Report No. PG-2.685; GMPG Project No. 101 (Project No. 34)
DATE OF REPORT: 6 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data accumulated in tests conducted on Medium Tank M4A1 from the time it was assigned to Project 34 until it was shipped
METHOD: All photographs of failed parts, daily

operation log sheets, and repair detail sheets were compiled into one report.
DESCRIPTION: The test Medium Tank M4A1, Ordnance Serial No. 165, was manufactured by the Pressed Steel Car Company and powered by a Continental, R975-C1, radial, gasoline engine.
CONCLUSIONS: All conclusions and recommendations were included in the reports from which this supplementary report was derived.
GENERAL: This 183-page report includes 61 photographs of failed parts, 3 pages of repair detail, and 61 daily operation log sheets.

SUBJECT: Tanks (Combat) PG-2.686
TITLE: Supplementary Report on Light Tank M5 — Massey-Harris
IDENTIFICATION: Report No. PG-2.686; GMPG No. 8066 (Project No. 34)
DATE OF REPORT: 7 July 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Light Tank M5, Massey-Harris, assigned as a facility vehicle for Project No. 34
METHOD: Nine test projects were run on the vehicle while assigned to Project No. 34. The endurance operation covered 3701 miles.
DESCRIPTION: The test Light Tank M5, Serial No. 3268, was manufactured by the Massey-Harris Company and weighed 32,000 pounds. It was powered by twin, Cadillac, V-8, gasoline engines.
CONCLUSIONS: Conclusions and recommendations of the individual test projects were not incorporated in this supplementary report.
GENERAL: This 243-page report includes 106 photographs of component failures, a two-page chronology record, 66 daily log sheets, 44 detail repair sheets, a frequency of failures chart, and cumulative engine fuel and lubricating oil curves.

SUBJECT: Tanks (Combat) PG-2.687
TITLE: Supplementary Report on Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.687; GMPG (Project No. 34)
DATE OF REPORT: 3 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Light Tank M5 from the time it was assigned to Project No. 34, until it was shipped
METHOD: Six different tests were run on the vehicle during the time it was assigned to Project No. 34. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Light Tank M5, Ordnance Serial No. 53, was manufactured by the Cadillac Motor Car Company. It was powered by two, Cadillac, V-8, gasoline engines and equipped with a hydramatic transmission.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual project reports and are not included in this supplementary report.
GENERAL: This 230-page report includes 84 photographs of failed components, 39 repair detail sheets, 75 daily log sheets, two performance curve sheets, and one frequency chart, all compiled from test operations while the vehicle was assigned to Project No. 34 from 24 September 1942 to 22 February 1943.

SUBJECT: Tanks (Combat) PG-2.689
TITLE: Supplementary Report on Light Tank M5 — Cadillac
IDENTIFICATION: Report No. PG-2.689; GMPG No. 8098 (Project No. 34)
DATE OF REPORT: 23 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Light Tank M5, Cadillac, assigned as a facility vehicle for Project No. 34 from 26 September 1942 to 10 February 1943
METHOD: Ten projects were run on the vehicle while assigned to Project 34. The operation covered 4323 miles.
DESCRIPTION: The test Light Tank M5, Serial No. 476 was manufactured by the Cadillac Motor Car Company and equipped with two Cadillac V-8 engines. The test weight of the vehicle was 30,165 pounds.
CONCLUSIONS: Conclusions and recommendations covering the tests were included in individual reports of each test and were not incorporated in this supplementary report.
GENERAL: This 205-page report includes 70 photographs of component failures, two pages of test chronology, 78 daily log sheets, 32 repair sheets, a repair frequency chart, and cumulative engine fuel and lubricating oil economy curves.

SUBJECT: Tanks (Combat) PG-2.690
TITLE: Supplementary Report on Light Tank M5 — Massey-Harris
IDENTIFICATION: Report No. PG-2.690; GMPG No. 8099 (Project No. 34)
DATE OF REPORT: 29 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Light Tank M5 from the time it was assigned to Project No. 34 until it was shipped
METHOD: Eight test projects were run on the vehicle during the time it was assigned to Project No. 34. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Light Tank M5, Serial No. 3282, was manufactured by the Massey-Harris Company. It was powered by two Cadillac, V-8, gasoline engines and equipped with hydramatic transmissions.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this supplementary report.
GENERAL: This 216-page report includes 86 photographs of failed components, 37 repair detail

sheets, 67 daily log sheets and two performance curve sheets all compiled from test operations while the vehicle was assigned to Project No. 34 from 26 September 1942 to 21 February 1943.

SUBJECT: Tanks (Combat) PG-2.710
TITLE: Supplementary Report on Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.710; Project No. 8037, (Project No. 92)
DATE OF REPORT: 15 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A3 from the time it was assigned to Project No. 92, until it was shipped
METHOD: Six test projects were run on the vehicle during the time it was assigned to Project No. 92. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A3 was manufactured by the Ford Motor Company and was powered by a Ford GAA, V-8, gasoline engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this supplementary report. However, an engine replacement was necessary at 575 miles due to operation with insufficient oil.
GENERAL: This 106-page report includes 44 photographs of failed components, 21 repair detail sheets, 20 daily log sheets and two fuel and economy curve sheets all compiled from test operations while test vehicle was assigned to Project No. 92 from 6 November 1942 to 27 January 1943.

SUBJECT: Tanks (Combat) PG-2.711
TITLE: Supplementary Report on Medium Tank M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.711; GMPG No. 8062 (Project No. 84)
DATE OF REPORT: 18 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A2 assigned as a facility vehicle for Project No. 84
METHOD: Nine sub-project tests were run on the vehicle. The endurance tests covered 3252 miles.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 2418, was manufactured by the Fisher Body Division of General Motors Corporation and weighed 64,000 pounds. It was powered by two GM diesel engines, Model No. R-671LA24M and L-671LC24M.
CONCLUSIONS: Conclusions and recommendations of the individual test projects were not incorporated in this supplementary report.
GENERAL: This 372-page report includes 173 photographs of component failures, four-page test chronology record, 89 daily log sheets, 78 detail repair sheets, repair frequency chart, and cumulative engine fuel and lubricating oil economy curves.

SUBJECT: Tanks (Combat) PG-2.712
TITLE: Supplementary Report on Medium Tank M4A1 — Pacific
IDENTIFICATION: Report No. PG-2.712; GMPG Project No. 8065 (Project 70)
DATE OF REPORT: 20 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Medium Tank M4A1 assigned as a facility vehicle to Project No. 70
METHOD: Seven sub-project tests were run on the vehicle. The endurance operation covered 2710 miles.
DESCRIPTION: The test Medium Tank M4A1, Serial No. 3006, was manufactured by the Pacific Car and Foundry Company and weighed 60,000 pounds. It was powered by a Continental R975-C1, radial, gasoline engine.
CONCLUSIONS: Conclusions and recommendations were included in the individual reports of the tests and were not incorporated in this supplementary report.
GENERAL: This 280-page report includes 112 photographs of component failures, three-page test chronology record, 93 daily log sheets, 48 detail repair sheets, repair frequency charts, and cumulative engine fuel and lubricating oil economy curves.

SUBJECT: Tanks (Combat) PG-2.713
TITLE: Supplementary Report on Medium Tank M4 — Pressed Steel — Ordnance Serial No. 296
IDENTIFICATION: Report No. PG-2.713; G.M. P.G. No. 8119 (Project Nos. 70, 128, 34 and 171)
DATE OF REPORT: 30 December 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of Medium Tank M4 assigned successively as a facility vehicle to Project Nos. 70, 128, 34 and 171
METHOD: In addition to the main four projects there were 14 sub-projects assigned to the vehicle. Endurance and engineering test operations covered 4075 miles.
DESCRIPTION: The test Medium Tank M4, Serial No. 296, was manufactured by the Pressed Steel Car Company and weighed approximately 60,000 pounds. It was powered by a Continental R975-C1, 9-cylinder, radial, air-cooled, gasoline engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and were not incorporated in this supplemental report.
GENERAL: This 410-page report includes 145 photographs of component failures, six-page test chronology record, 142 daily log sheets, 83 detail repair sheets, repair frequency chart and cumulative engine fuel and lube oil economy curves.

SUBJECT: Tanks (Combat) PG-2.721
TITLE: Power and Performance Comparisons

of M5A1 and M3A3 Light Tank
IDENTIFICATION: Report No. PG-2.721
DATE OF REPORT: 4 May 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare power output and performance of Light Tanks M5A1 and M3A3
METHOD: Tracks, sprockets and front bogies were removed from both light tanks, and 14.00 x 24 tires were mounted on the hubs. Tires were positioned on chassis dynamometer rolls, and test was conducted in normal manner for wheeled vehicles. Tests were run on the road using spring type torquemeters located in the sprockets. Tank was towed with engine disengaged to determine transmission losses. Full throttle tests were conducted by holding vehicle to desired speed by towed dynamometer trucks.
DESCRIPTION: The M3A3 tank was manufactured by the American Car and Foundry Company and the M5A1 by the Cadillac Motor Car Company.
CONCLUSIONS: The M5A1 tank performed better, had greater acceleration through any speed range, and higher top speed on any given grade than the M3A3 tank. It was recommended that governor speed of M3A3 be increased to 2400 rpm and that the 14-tooth sprocket be changed to a 13-tooth sprocket to improve performance.
GENERAL: This 11-page report includes an engine power comparison (chassis dynamometer) curve sheet, an engine power comparison (sprocket torquemeter) curve sheet, and three drawbar pull comparison curve sheets. The report is not illustrated.

SUBJECT: Tanks (Combat) PG-2.726
TITLE: Engineering and Endurance Test of Light Tank M3A3 — A.C.F.
IDENTIFICATION: Report No. PG-2.726; G.M. P.G. Project No. 142
DATE OF REPORT: 29 July 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the performance and endurance characteristics of Light Tank M3A3
METHOD: The vehicle was operated for 2166 miles on engineering tests, including drawbar pull, slope performance, and endurance tests.
DESCRIPTION: The test Light Tank M3A3, Serial No. 10508, was manufactured by the American Car and Foundry Company and weighed 30,174 pounds. It was powered by a Continental W-670, 7-cylinder, 235-hp, gasoline engine. The vehicle was equipped with Light Tank M5 brakes and drums with Thermoid BX9 linings.
CONCLUSIONS: The vehicle was considered satisfactory. No major failures occurred during the test. The test brakes were unsatisfactory because of heating and seizing. A change in the location of the hand-elevating wheel was recommended because of interference with the gunner. It was also recommended that further tests be made using standard M5 tank brake linings to determine their adaptability for M3 tanks. Modifications were recommended in the calibration of the oil pressure indicating light, in accelerator pedal pressure, gear shift lever length, instrument panel angle, and gasoline shut-off valve location.
GENERAL: This 173-page report contains 32 photographs of the test tank and failed components.

SUBJECT: Tanks (Combat) PG-2.763
TITLE: Desert Test of Medium Tank M3A3
IDENTIFICATION: Report No. PG-2.763; G.M. P.G. Project No. 51-4
DATE OF REPORT: 14 February 1944
ORIGIN: General Motors Phoenix Laboratory, Phoenix, Arizona
PURPOSE: To determine the effect of dust and high temperatures during desert operation of Medium Tank M4A3
METHOD: The vehicle was given 551 miles of desert operation.
DESCRIPTION: The test Medium Tank M3A3 was manufactured by the Baldwin Locomotive Works. It was powered by two GM 6046 diesel engines and equipped with a British turret.
CONCLUSIONS: The clutches frequently came out of adjustment. Three suspension springs and two spring seats failed in the 551 miles of operation. It was recommended that for normal desert operation the radiators be cleaned every 500 miles, and the blower air cleaners be cleaned at 100-mile intervals. Conclusions and recommendations regarding vehicle durability could not be made because of short duration of test.
GENERAL: This 79-page report is not illustrated.

SUBJECT: Tanks (Combat) PG-2.764
TITLE: Desert Endurance Test of Light Tank M5A1 — Cadillac
IDENTIFICATION: Report No. PG-2.764; G.M. P.G. Project No. 51-18
DATE OF REPORT: 9 November 1943
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine effect of desert heat and dust on operation and life of the Light Tank M5
METHOD: The vehicle was operated for 2,000 miles on rough hilly roads, deeply coated with dust.
DESCRIPTION: A special directive substituted Light Tank M5 for Light Tank M5A1 as the test unit. The M5 weighed 32,000 pounds and was manufactured by the Cadillac Motor Car Company. It was powered by two Cadillac V-8 engines and equipped with hydramatic transmissions.
CONCLUSIONS: The durability and performance of the Light Tank M5 was very satisfactory. Excessive water temperature was recorded due to an inadequate cooling system. Other unsatisfactory features were dust seepage in the carburetor air cleaner, crankcase breathers, and the periscope. The bogie brackets were hard to remove and the bogie springs were not durable enough. Recommendations included improved engine cooling and relocation of radiators, improved sealing of air cleaner covers, the use of oil bath crankcase breather air cleaners, welding of bogie bracket nuts, and the periscopes sealed to prevent entry of dust.

GENERAL: Ths 138-page report is not illustrated.

SUBJECT: Tanks (Combat) PG-2.797
TITLE: Engineering and Endurance Tests - Marmon-Herrington Light Tank T9E1
IDENTIFICATION: Report No. PG-2.797; G.M. P.G. Project No. 169
DATE OF REPORT: 14 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the reliability of Airborne Light Tank T9E1
METHOD: The vehicle was given a 2062-mile endurance test; actual running time was 162.6 hours. Operation was over the 10-mile Endurance Tank Route.
DESCRIPTION: Airborne Light Tank T9E1 was lightened to weigh 14,620 pounds. It was powered by a Lycoming O-435-T, six-cylinder, horizontally opposed, 168-bhp, air-cooled engine. Primary armament was a 37-mm gun and a coaxial .30 caliber machine gun.
CONCLUSIONS: The tank was unreliable and was unsuited for extended operational use. The suspension system, including tracks, the transmission shifting forks, and the drive shaft system were inadequate and were recommended for corrective redesign. Also, it was recommended that the gear selector be provided with a positive lock-out for reverse. It was suggested that if an airborne vehicle was needed, a new design should be developed based on a wheeled suspension.
GENERAL: This 411-page report includes 194 photographs of tank components.

SUBJECT: Tanks (Combat) PG-2.807
TITLE: Standard Inspection Control Test on Light Tank M5A1 — Massey-Harris
IDENTIFICATION: Report No. PG-2.807; G.M. P.G. Project No. 204-6
DATE OF REPORT: 27 July 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the quality of inspection control on Light Tank M5A1, Serial No. 9832
METHOD: The vehicle was subjected to 890 miles of testing operation.
DESCRIPTION: The test Light Tank M5A1 was manufactured by the Massey-Harris Company. It was powered by two Cadillac, V-8, gasoline engines and was equipped with two Detroit Transmission Company units. Armament included a 37 mm gun in a M44 Mount.
CONCLUSIONS: There were several performance deficiencies with respect to the 60% hill test, fording test, and gyrostabilizer test. The vehicle would not climb a 60% hill in reverse. On the fording trial (36-inches depth) water came in so fast all leaks could not be observed. During the combat cross-country run, the gyrostabilizer was erratic after the first hour: it would bring the gun into position and then creep.
GENERAL: This 10-page report includes two photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-2.808
TITLE: Standard Inspection Control Test on Light Tank M5A1 — Cadillac
IDENTIFICATION: Report No. PG-2.808; G.M. P.G. Project No. 206-5
DATE OF REPORT: 13 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct standard inspection control test on Light Tank M5A1
METHOD: The vehicle was given 802 miles of test operation.
DESCRIPTION: The test Light Tank M5A1 was manufactured by the Cadillac Motor Car Company. It was powered by two Cadillac, V-8, gasoline engines and equipped with two hydramatic transmissions.
CONCLUSIONS: Serious mechanical deficiencies showed up in the suspension system during the test. Track guides and end connectors were bent and broken causing damage to idler and bogie tires. The tracks were badly worn after the test but were still useable. The vehicle would not climb a 60% hill in reverse because the left engine stalled. Brakes held on 60% hill but required very high pressures. It was recommended that the position of the gasoline valves be changed to permit easy view and access. It was also recommended that the vehicle be equipped with gasoline gages.
GENERAL: This 18-page report includes five photographs of the vehicle and failed parts.

SUBJECT: Tanks (Combat) PG-2.809
TITLE: Standard Inspection Control Test on Light Tank T9E1 — Marmon-Herrington
IDENTIFICATION: Report No. PG-2.809; GMPG Project No. 206-6
DATE OF REPORT: 14 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the quality of manufacture and design of airborne Light Tank T9E1
METHOD: The vehicle was operated for 844 miles to determine performance and operation characteristics and manufacturing and design deficiencies.
DESCRIPTION: The test airborne Light Tank T9E1 was manufactured by the Marmon-Herrington Company of Indianapolis, Indiana. It was powered by a Lycoming engine, was full tracked, and mounted a 37 mm gun in a T55 Mount.
CONCLUSIONS: An exceedingly large number of deficiencies in manufacturing and design developed during the test. Most of the deficiencies were in the suspension system. No recommendations were made.
GENERAL: This 28-page report includes 13 photographs of the vehicle and failed components.

PG-2.834
2.834A
2.834B
SUBJECT: Tanks (Combat)
TITLE: Desert Test of Medium Tanks M4A3
IDENTIFICATION: Report Nos. PG-2.834, PG-2.834A, PG-2.834B: GMPG Project No. 51-15
DATE OF REPORT: 12 February 1944
ORIGIN: General Motors Phoenix Laboratory, Phoenix, Arizona

TANK AUTOMOTIVE TEST RESUMES

PURPOSE: To determine the durability of two Medium Tanks M4A3 and their engines
METHOD: Two M4A3 Medium Tanks were operated to failure over the 5.5 mile dusty cross-country endurance course. Engines failed and were replaced in one vehicle at mileages of 360, 490, and 2778. Two engines operated for 295 and 682 miles in the other vehicle.
DESCRIPTION: The test M4A3 Medium Tanks weighed 68,500 pounds and were 19 feet, 4-1/2 inches long and 8 feet, 7 inches wide. They were rated as being able to sustain a speed of 26 mph on level terrain. Both tanks were equipped with 8-cylinder, liquid-cooled, Ford GAA gasoline engines rated at a maximum of 500 bhp at 2600 rpm and 1100 lb.-ft. torque at 2200 rpm.
CONCLUSIONS: Specific deficiencies and failures were listed and discussed under the following categories: engine, engine electrical system, fuel system, cooling system, instruments, vehicle electrical system, exhaust, clutch, transmission, final drives, hull, brake system, suspension system, fenders, and armament. It was noted that one of the test engines exhibited the best endurance characteristics of any engine thus far tested at the Phoenix Test Area. It operated 2778 miles or 311.7 engine hours. At 2507 miles of 278.8 engine hours the left bank exhaust camshaft bearing retainer and bracket broke, apparently from fatigue. Two valve push rods were found cracked. Failure of the No. 8 exhaust valve push rod in the right head was the probable cause of final engine failure. Deficiencies inherent in all of the test engines included such items as faulty hose connections, leaky valve gaskets, and excessive fan belt wear. Suspension spring failures were frequent. Weaknesses were observed in the bogie wheel bearing grease retainers and welded steel track rollers. Engine cooling, clutches, and magnetos were satisfactory. Recommendations were made to improve the deficiencies found in the various vehicle and engine components.
GENERAL: This three-volume, 420-page report contains 65 photographs of failed tank components; performance and economy curves, and daily log sheets.

SUBJECT: Tanks (Combat) PG-2.835
TITLE: Supplementary Report on Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.835; GMPG Project No. 8124 (Project No. 92)
DATE OF REPORT: 21 August 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from endurance operation of a test Medium Tank M4A3 while assigned to Project No. 92, from 8 November 1942 to 24 June 1943
METHOD: Nine test projects were run on the vehicle during the time it was assigned to Project No. 92. The endurance operation covered 4476 miles.
DESCRIPTION: The test Medium Tank M4A3, Serial No. 2929, was manufactured by the Ford Motor Company and weighed 62,400 pounds. It was powered by a Ford GAA, V-8, gasoline engine.
CONCLUSIONS: Conclusions and recommendations of the individual test projects were incorporated in individual reports, and not included in this supplementary report.
GENERAL: This 384-page report includes 174 photographs of component failures, a four-page test chronology record, 109 daily log sheets, 42 detail repair sheets, repair frequency chart, and cumulative engine fuel and lubricating oil economy curves.

SUBJECT: Tanks (Combat) PG-2.845
TITLE: Supplementary Report on Light Tank M3A1 — A.C.F.
IDENTIFICATION: Report No. PG-2.845; GMPG No. 8145 (Project Nos. 34 and 60)
DATE OF REPORT: 16 October 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile test data on the operation of a Light Tank M3A1 from the time it was assigned to Project Nos. 34 and 60 until it was shipped
METHOD: Six test projects were run on the vehicle during the time it was assigned to Project Nos. 34 and 60. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Light Tank M3A1, Serial No. 8000, manufactured by the American Car and Foundry Company, was powered by a Continental 7-cylinder engine, Model W-670.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this report. It was necessary to install a new motor at 2204 miles and another at 4570 miles because of excessive oil consumption.
GENERAL: This 323-page report includes 129 photographs of failed components, 65 repair detail sheets, 100 daily log sheets, four fuel and economy curve sheets and one repair frequency chart, all compiled from test operations while test vehicle was assigned to Project Nos. 34 and 60 from 9 February 1943 to 9 June 1943.

SUBJECT: Tanks (Combat) PG-2.864
TITLE: Standard Inspection Control Test on Light Tank M5A1 — Massey-Harris
IDENTIFICATION: Report No. PG-2.864; GMPG Project No. 206-13
DATE OF REPORT: 13 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To ascertain manufacturing and design deficiencies of Light Tank M5A1 by the Standard Inspection Control Test
METHOD: The test covered manufacturing, design, and performance deficiencies as disclosed by a 801-mile endurance operation.
DESCRIPTION: The test Light Tank M5A1, Serial No. 9905, manufactured by Massey-Harris Tank Plant, was powered by two Cadillac gasoline engines.
CONCLUSIONS: There were no design deficien-

cies. There were considerably more manufacturing deficiencies in the suspension system than in any other section, including the right track being thrown and idler tires being damaged.
GENERAL: This 14-page report includes four photographs, the Standard Inspection Control Test Chart, and a summary of manufacturing and performance deficiencies.

SUBJECT: Tanks (Combat) PG-2.880
TITLE: Supplementary Report on Medium Tank M4A2 — Pullman
IDENTIFICATION: Report No. PG-2.880; GMPG Project No. 8081 (Project No. 34)
DATE OF REPORT: 30 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data resulting from operation of a test Medium Tank M4A2 from the time it was assigned to Project No. 34, until it was shipped, 11 September 1942 to 29 April 1943
METHOD: Ten project tests were run on the vehicle. Charts, photographs, logs, and repair records covering approximately 4000 miles were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 1213, was manufactured by the Pullman Standard Car Company and powered by two GM, six-cylinder, diesel engines.
CONCLUSIONS: Conclusions and recommendations covering each test were in the individual reports of the tests and are not included in this supplementary report.
GENERAL: This 345-page report includes 153 photographs of failed components, 68 repair detail sheets, 96 daily log sheets, two fuel and oil economy curve sheets, and one repair frequency chart.

SUBJECT: Tanks (Combat) PG-2.886
TITLE: Supplementary Report on Medium Tank M4A — Chrysler
IDENTIFICATION: Report No. PG-2.886: GMPG Project No. 8082 (Project Nos. 34-68, 104, and 51-39)
DATE OF REPORT: 6 October 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data covering operation of a Medium Tank M4A4 from the time it was assigned to Project Nos. 34-68, 104, and 51-39, until it was shipped
METHOD: Five project tests were run on the vehicle. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A4, Serial No. 4823, was manufactured by the Chrysler Corporation and powered by a Chrysler multibank engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this supplementary report.
GENERAL: This 141 -page report includes 31 photographs of failed components, 28 repair detail sheets, 49 daily log sheets, three fuel and oil economy curve sheets, and one repair frequency chart, all compiled from test operations while the vehicle was assigned to Project Nos. 34-68, 104, and 51-39 from 11 September 1942 to 5 September 1943.

SUBJECT: Tanks (Combat) PG-2.887
TITLE: Supplementary Report on Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.887; GMPG Project No. 8122 (Project No. 34)
DATE OF REPORT: 11 December 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile data on the operation of a Medium Tank M4A3 from the time it was assigned to Project No. 34, until it was shipped
METHOD: Eleven project tests were run on the vehicle. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A3, Serial No. 2917, was manufactured by the Ford Motor Company and powered by a Ford GAA, V-8, gasoline engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this supplementary report.
GENERAL: This 414-page report includes 48 photographs of failed components, 95 repair detail sheets, 130 daily log sheets, nine fuel and economy curve sheets and one repair frequency chart, all compiled from test operations while the vehicle was assigned to Project No. 34.

SUBJECT: Tanks (Combat) PG-2.893
TITLE: Standard Inspection Control Test on Light Tank M5A1 — Cadillac
IDENTIFICATION: Report No. PG-2.893; GMPG Project No. 206-18
DATE OF REPORT: 23 September 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine manufacturing and design deficiencies by the Standard Inspection Control Test
METHOD: The test operation covered 812 miles. Components of the vehicle were checked according to the Standard Inspection Control Test sheet.
DESCRIPTION: The test Light Tank M5A1 (USA 3047843) was manufactured by the Cadillac Motor Car Company and was powered by two Cadillac, V-8, gasoline engines. It was equipped with hydramatic transmissions and vertical volute spring suspension with two bogie assemblies on each side.
CONCLUSIONS: There were no design deficiencies. The bulk of the manufacturing deficiencies was in the suspension system. There were 20 broken or bent end connectors. This defect was considered typical of Light Tanks M5A1. The major performance deficiency was failure to climb the 60% grade in reverse which had been the case

with all Light Tanks M5A1 on Inspection Control Tests.
GENERAL: In addition to the Standard Inspection Control Test sheet this 12-page report included four photographs and a descriptive list of manufacturing and performance deficiencies.

SUBJECT: Tanks (Combat) PG-2.907
TITLE: Supplementary Report on Medium Tank M4A2 — Federal Machine Co.
IDENTIFICATION: Report No. PG-2.907; GMPG Project No. 8164 (Project Nos. 34 and D-160)
DATE OF REPORT: 4 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational data of a Medium Tank M4A2 from the time it was assigned to Project Nos. 34 and D-160
METHOD: Eleven sub-project tests were run on the vehicle. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 14804 was manufactured by the Federal Machine Company and powered by two General Motors, 6-cylinder, diesel engines.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this supplementary report.
GENERAL: This 388-page report includes 162 photographs of failed components, 84 repair detail sheets, 104 daily log sheets, four fuel and economy curve sheets, and one repair frequency chart, all compiled from test operations while the vehicle was assigned to Projects Nos. 34 and D-160 from 21 January 1943 to 18 September 1943.

SUBJECT: Tanks (Combat) PG-2.909
TITLE: Engineering Test of Modified Medium Tank M7 — International Harvester
IDENTIFICATION: Report No. PG-2.909; GMPG Project No. 101-1
DATE OF REPORT: 8 April 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct engineering test of modified Medium Tank M4
METHOD: The vehicle was operated 342 miles. Performance and operation characteristics, repairs, and manufacturing deficiencies were noted.
DESCRIPTION: The test Medium Tank M7 was manufactured by the International Harvester Company, and was powered by a Continental R975-C1 engine. Test weight was 56,000 pounds.
CONCLUSIONS: The test Medium Tank M7 was considered unsatisfactory. Deficiencies included the following: the brake system and exhaust system were defective; the high gear engine braking, obtainable only at speeds above 20 mph in direct drive, was inadequate. It was recommended that the Medium Tank M7 be redesigned to provide a more suitable exhaust system, sufficient torque converter cooling, more appropriate gear ratios in the power train, and more satisfactory cooling before further testing.
GENERAL: This 87-page report includes 15 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-2.910
TITLE: Test of Light Tank T7E2, Rock Island Arsenal
IDENTIFICATION: Report No. PG-2.910; GMPG Project No. 124-1
DATE OF REPORT: 11 April 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of a new design Light Tank T7E2
METHOD: The operation covered a mechanical inspection and 341 miles of engineering tests.
DESCRIPTION: The test Light Tank T7E2, Serial No. 1, was manufactured by the Rock Island Arsenal and weighed 50,265 pounds. It was powered by a Continental R975-C1, nine-cylinder, radial, gasoline engine rated 400 bhp at 2400 rpm and 900 lbs -ft. at 2000 rpm.
CONCLUSIONS: Because of the generally unsatisfactory design and performance, the test project was cancelled before completion. The vehicle was not considered worthy of Ordnance acceptance. It was too heavy and too slow to compete with the light tank series such as the M5A1.
GENERAL: This 102-page report includes 18 photographs of the tank and component failures.

SUBJECT: Tanks (Combat) PG-2.939
TITLE: Supplementary Report on Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.939; GMPG Project No. 9001
DATE OF REPORT: 25 November 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M3 from the time it was assigned to the General Motors Proving Ground until it was shipped
METHOD: Nine test projects were run on the vehicle for a total of 2817 miles, during the time the vehicle was assigned to the General Motors Proving Ground. Charts, photographs, logs and repair records of these projects were accumulated into one report.
DESCRIPTION: The test vehicle was a Medium Tank M3, manufactured by the Chrysler Corporation, Serial No. 318, and was a full-tracked vehicle, powered by a Continental nine-cylinder, radial engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not contained in this supplementary report.
GENERAL: This 213-page report includes 62 photographs of failed components, 38 repair detail sheets, 81 daily log sheets, two fuel and economy curve sheets and one repair frequency chart.

SUBJECT: Tanks (Combat) PG-2.940
TITLE: Supplementary Report on Medium Tank

M4A3 — Ford
IDENTIFICATION: Report No. PG-2.940; GMPG Project No. 8089 (Project No. 92)
DATE OF REPORT: 25 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A3 from the time it was assigned to Project No. 92, until it was shipped
METHOD: Eight test projects were run on the vehicle for a total of 2750 miles.
DESCRIPTION: The test Medium Tank M4A3, Serial No. 2660, was manufactured by the Ford Motor Company and was powered by a Ford GAA, V-8, gasoline engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the test and are not contained in this supplementary report.
GENERAL: This 295-page report includes 109 photographs, 53 repair detail sheets, 98 daily log sheets, six fuel and economy curve sheets and one repair frequency chart, all compiled from test operations while test vehicle was assigned to Project No. 92 from 6 November 1942 to 20 May 1943.

SUBJECT: Tanks (Combat) PG-2.959
TITLE: Engineering Tests — Heavy Tank M6 — Baldwin
IDENTIFICATION: Report No. PG-2.959; GMPG Project No. 186
DATE OF REPORT: 29 February 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the performance characteristics of Heavy Tank M6, and to compare the performance of this tank with that of the pilot model T1E2
METHOD: A series of engineering tests were conducted on the vehicle. Tests included determination of minimum turning diameters, maximum and minimum speeds in low and high range, cooling and fording characteristics, drawbar pull, tractive resistance, hill climbing performance, and engine and torque converter performances.
DESCRIPTION: The test Heavy Tank M6 was powered by a Wright Cyclone Engine with a compression ratio of 4.92:1 and rated 800 hp at 2300 rpm. The transmission was a Twin-Disc Model T-16000 hydraulic torque converter.
CONCLUSIONS: Performance of the vehicle was decidedly inferior to the pilot model T1E1. The compression ratio had been changed from 6.3:1 in the T1E1 to 4.92:1 in the test vehicle without changing the gear ratio between the engine and torque converter; and this change resulted in a sacrifice of performance. A gear ratio change from 1.5 to 1.7 to fit the converter capacity to the low compression engine was recommended. This increased ratio would enable the engine to run at higher speeds, develop more horsepower, and improve hill climbing performance. It was recommended that the entire power train be redesigned to reduce losses, which were considered excessive.
GENERAL: This 159-page report contains 16 photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) PG-2.960
TITLE: Engineering Tests Medium Tank, M4E1 — Caterpillar
IDENTIFICATION: Report No. PG-2.960; GMPG Project No. 190
DATE OF REPORT: 3 January 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine suitability and any deficiencies of Medium Tank M4A1
METHOD: The vehicle was operated a total of 958 miles over various terrain.
DESCRIPTION: Test Medium Tank M4E1, Ordnance Serial No. 3, was an experimental model designed by the Caterpillar Company and weighed 70,000 pounds. It was powered by a Caterpillar D-200, four-cycle, 9-cylinder, radial, diesel engine rated 450 bhp at 2000 rpm. The engine and transmission incorporated National Emergency steel. Armament included a 75 mm gun, one cal. .50 machine gun and three cal. .30 machine guns.
CONCLUSIONS: In general, the performance of the M4E1 was similar to that of the M4A2 Tanks tested at General Motors Proving Ground, and superior to the M4A1 and M4A3 vehicles. No failures were charged to the engine and the transmission. Modifications were recommended for the clutch, battery location, fuel system and dip-stick. It was also recommended that starting be improved and that hold-open latches on hatch covers be provided.
GENERAL: This 165-page report includes 27 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-2.970
TITLE: Desert Tests of Light Tank M5A1 — Massey-Harris
IDENTIFICATION: Report No. PG-2.970; GMPG Project No. 51-33
DATE OF REPORT: 1 June 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the effects of dust and high temperatures on the operation and life of Light Tank M5A1
METHOD: The test covered mechanical inspection, engineering tests, 1770 miles of endurance operation over desert terrain, and disassembly and final inspection. Specific observations were made on air cleaner life and engine cooling.
DESCRIPTION: The test Light Tank M5A1, Ordnance Serial No. 3623, was manufactured by the Massey-Harris Company and weighed 31,115 pounds. It was powered by two, Cadillac, V-8, gasoline engines. This M5A1 tank was a production vehicle with the latest modifications on engine cooling.
CONCLUSIONS: Two sets of engines were unsatisfactory because of excessive oil consumption due to piston ring gaps. For this reason, a more rigid factory inspection for engine assembly was recommended. While no overheating developed during the tests, improved cooling for engine coolant, engine oil, transmission oil and transfer case oil was recommended. The following intervals were recommended for servicing of carburetor air cleaners: 100 miles for normal cross-country desert oper-

ation; 50 miles for convoy or extreme desert conditions. Crew compartment dust was severe enough to warrant the use of respirators. Further recommendations were: an optimum service life interval should be set up for the bogie wheel bearing seals and the trailing idler bearing seals and replacement should be made accordingly; and a study undertaken to determine the cause of track guide breakage.
GENERAL: This 217-page report included 29 photographs of component failures.

SUBJECT: Tanks (Combat) PG-2.1004
TITLE: Desert Test of Medium Tank M4A2
IDENTIFICATION: Report No. PG-2.1004; GMPG Project No. 51-25
DATE OF REPORT: 14 August 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the effects of dust and high temperatures on the operation and life of the test Medium Tank M4A2
METHOD: The test consisted of a mechanical inspection, engineering tests, 1998 miles of desert endurance operation, and disassembly and final inspection. Specific observations were made on engine cooling and carburetor air cleaner dust pick-up.
DESCRIPTION: The test Medium Tank M4A2, Ordnance Serial No. 10219, was manufactured by the Pullman Standard Car Company and weighed 64,000 pounds. It was powered by twin, 6-cylinder, in-line, two-cycle, GM, diesel engines that were joined by a junction plate at fan ends and a double-clutch housing. Rating was 375 hp at 2100 rpm.
CONCLUSIONS: Two sets of engines failed because of broken rings and cylinder liners. Dust had an adverse effect on components such as: throttle cross-shaft and all joints in the throttle linkage turret race, bearings and ring gear, periscopes, and blower air cleaners. The clutch linkage equalizer prolonged the satisfactory synchronization of the clutches by eight times; it was recommended that this linkage equalizer be adopted as a standard part. The service life of Raybestos semi-metallic faced discs was found to be about equal to that of the standard discs.
GENERAL: This 288-page report included 57 photographs of component failures.

SUBJECT: Tanks (Combat) PG-2.1005
TITLE: Supplementary Report on Medium Tank M4A2 — Federal
IDENTIFICATION: Report No. PG-2.1005; GMPG No. 8175 (Project No. 34)
DATE OF REPORT: 16 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational data of a Medium Tank M4A2 from the time it was assigned to Project No. 34 until it was shipped
METHOD: Seven project tests were run on the vehicle. Charts, photographs, logs, and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 14803, was powered by two General Motors, six-cylinder, diesel engines.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the test and are not included in this supplementary report.
GENERAL: This 213-page report includes 96 photographs of failed components, 76 repair detail sheets, 17 daily log sheets, four fuel and oil economy curve sheets, and one repair frequency chart, all compiled from test operations while vehicle was assigned to Project No. 34 from 21 April 1943 to 25 October 1943.

SUBJECT: Tanks (Combat) PG-2.1017
TITLE: Supplementary Report on Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.1017; GMPG Project No. 8138 (Project Nos. 110B and 216)
DATE OF REPORT: 27 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational data of a Medium Tank M4A4 from the time it was assigned to Projects No. 110B and 216 until it was shipped
METHOD: Nineteen project tests were run on the vehicle. Charts, photographs, logs, and repair records of these projects were accumulated into one report.
DESCRIPTION: The test Medium Tank M4A4, Serial No. 6127, was manufactured by the Chrysler Corporation. It was powered by a Chrysler multi-bank engine composed of five Chrysler, six-cylinder engines assembled into a single unit.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not included in this supplementary report. Installation of a new engine at 1158 miles was necessary and another at 2305 miles due to burned valves.
GENERAL: This 456-page report includes 201 photographs of failed components, 79 repair detail sheets, 134 daily log sheets, six fuel and lubricating oil economy curve sheets, and one repair frequency chart, all compiled from operations while test vehicle was assigned to Project Nos. 110B and 216 from 20 January 1943 to 13 October 1943.

SUBJECT: Tanks (Combat) PG-2.1057
TITLE: Supplementary Report on Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.1057; G.M. P.G. Project No. 8125 (Project Nos. 92 and 167)
DATE OF REPORT: 10 April 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A3 from the time it was assigned to Projects Nos. 92 and 167, until it was shipped
METHOD: Eighteen test projects were run for a total of 5613 miles on this vehicle during the time it was assigned to Project Nos. 92 and 167. Charts, photographs, logs, and repair records of these projects were accumulated into one report.

DESCRIPTION: The test vehicle was a Medium Tank M4A3, Serial No. 2930, manufactured by the Ford Motor Company and was a full-tracked vehicle, powered by a Ford V8, Model GAA engine.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and were not included in this supplementary report. Engine failure occurred at 1612 miles due to failure of push rods caused by excessive rust.
GENERAL: This 421-page report includes 146 photographs of failed components, 74 repair detail sheets, 158 daily log sheets, six fuel and oil economy curve sheets and one repair frequency chart, all compiled from test operations while test vehicle was assigned to Project Nos. 92 and 167 from 7 November 1942 to 2 December 1943.

SUBJECT: Tanks (Combat) PG-2.1084
TITLE: Supplementary Report on Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.1084; GMPG No. 8203 (Projects No. 159, 161, 233, 247, and 274)
DATE OF REPORT: 8 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A4 from the time it was assigned to the above projects until it was shipped
METHOD: Seven test projects were run for a total of 314 miles on the vehicle.
DESCRIPTION: The test Medium Tank M4A4, Serial No. 18975, manufactured by the Chrysler Corporation, was powered by a Chrysler multi-bank engine. It was equipped with a Westinghouse gyrostabilizer.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and were not included in this supplementary report. Poor locations of the control levers caused an accident to one of the drivers and it was recommended that installation of all such levers be checked and padding be rearranged.
GENERAL: This 67-page report includes four photographs of failed components, 19 repair detail sheets, 22 daily log sheets and one fuel and economy curve sheet, all compiled from test operations while vehicle was assigned to the above projects from 7 March 1943 to 24 November 1943.

SUBJECT: Tanks (Combat) PG-2.1121
TITLE: Supplementary Report on Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-2.1121; Projects No. 34, 96 and 180
DATE OF REPORT: 5 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational data of a Medium Tank M3, Ordnance Serial No. 3727, from the time it was assigned to the above projects until it was shipped 3 June 1942 to 7 December 1943
METHOD: The tank was used for nine different tests, during which time it was operated for a total of 491 miles.
DESCRIPTION: The test Medium Tank M3 was manufactured by the Chrysler Corporation and powered by a Continental R975-EC2, six-cylinder, gasoline engine. It was equipped with a Westinghouse gyrostabilizer.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and are not contained in this supplementary report.
GENERAL: This 110-page report includes four photographs of failed components, 28 repair detail sheets, 46 daily log sheets, two fuel and oil economy curve sheets, and one repair frequency chart all compiled from the operations while the vehicle was assigned to the above projects.

SUBJECT: Tanks (Combat) PG-2.1128
TITLE: Supplementary Report on Medium Tank M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.1128; GMPG Project No. 218
DATE OF REPORT: 17 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data on a Medium Tank M4A2
METHOD: The tank was operated for a total of 214 miles during the time it was assigned to Project No. 218.
DESCRIPTION: The test Medium Tank M4A2, Serial No. 26755, was manufactured by the Fisher Body Company. It was powered by two, General Motors, six-cylinder, diesel engines.
CONCLUSIONS: Conclusions and recommendations covering each test were included in project or reports of the tests and are not included in this supplementary report. The nature of the tests and the small number of miles run resulted in a negligible number of parts failure.
GENERAL: This 31-page report includes two photographs of failed components, nine repair detail sheets, and three daily log sheets, all compiled from test operations while test vehicle was assigned to Project No. 218.

SUBJECT: Tanks (Combat) PG-2.1136
TITLE: Supplementary Report on Medium Tank M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.1136; GMPG Project No. 8195
DATE OF REPORT: 25 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational data of a Medium Tank M4A2 from the time it was assigned to Project No. 160 until it was shipped
METHOD: The project tests were run for a total of 2651 miles on this vehicle. Charts, photographs, logs and repair records were accumulated into one report.
DESCRIPTION: The test Medium Tank, M4A2, Serial No. 9333, was manufactured by the Fisher Body Company of General Motors Corporation and was powered by two, General Motors, six-cylinder,

diesel engines.
CONCLUSIONS: Conclusions and recommendations covering this test were included in the project report of the test and are not contained in this supplementary report.
GENERAL: This 202-page report includes 57 photographs of failed components, 36 repair detail sheets, 76 daily log sheets, two fuel and lubricating oil economy curve sheets, and one repair frequency chart, all compiled from the operations while the vehicle was assigned to Project No. 160, 17 March 1943 to 10 December 1943.

SUBJECT: Tanks (Combat) PG-2.1144
TITLE: Supplementary Report on Medium Tank M4A4 — Chrysler
IDENTIFICATION: Report No. PG-2.1144; GMPG Project No. 8235 (34-90)
DATE OF REPORT: 18 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data on a Medium Tank M4A4 from the time it was assigned to Project 34-90 until it was shipped
METHOD: Six test projects were run on the vehicle for a total of 1112 miles.
DESCRIPTION: The test Medium Tank M4A4, Serial No. 19073, was manufactured by the Chrysler Corporation and weighed 65,650 pounds. It was powered by a Chrysler multi-bank engine and was equipped with special suspension components to accommodate 24-inch tracks.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports on the tests and are not included in this supplementary report.
GENERAL: This 141-page report includes 11 photographs of the vehicle and failed components, 35 repair detail sheets, 44 daily log sheets, two fuel and economy curve sheets and one repair frequency chart, all compiled from test operations while the vehicle was assigned to Project No. 34-90 from 26 April 1943 to 23 February 1944.

SUBJECT: Tanks (Combat) PG-2.1145
TITLE: Supplementary Report on Medium Tank M4A3 — Ford
IDENTIFICATION: Report No. PG-2.1145; GMPG Project No. 8178
DATE OF REPORT: 22 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile test data resulting from operation of a Medium Tank M4A3 from the time it was assigned to Project 34, until it was shipped; 14 June 1943 to 22 February 1944
METHOD: Eleven project tests were run on the vehicle. The operation covered 6588 miles.
DESCRIPTION: The test Medium Tank M4A3, was manufactured by the Ford Motor Company and weighed 66,790 pounds. It was powered by a Ford GAA, V-8, gasoline engine.
CONCLUSIONS: Conclusions and recommendations were included in the individual reports on each test and were not incorporated in this supplementary report.
GENERAL: This 445-page report includes 97 photographs of part failures, seven-page test chronology record, adjustments, and replacements, daily log sheets, repair detail log sheets, and cumulative engine fuel and lubricating oil economy curves.

PG-2.1148
2.1148A
SUBJECT: Tanks (Combat) 2.1148B
TITLE: Desert Endurance Test of M4A1 Medium Tanks and Components
IDENTIFICATION: Report Nos. PG-2.1148; PG-2.1148A, and PG-2.1148B; G.M.P.G. Project No. 51-40
DATE OF REPORT: 3 May 1944
ORIGIN: General Motors Phoenix Laboratory, Phoenix, Arizona
PURPOSE: To compare performance of the two test tanks with the first M4A1 Medium Tank tested and to determine the efficiency of Chrysler modifications; to determine the effect of dust and high temperatures on Medium Tank M4A1
METHOD: One of two test vehicles was operated for 2000 miles and the other for 1932 miles over desert terrain. Inspection for vehicle wear was made and the effects of dust and heat were observed.
DESCRIPTION: The two test vehicles were Medium Tanks M4A1, Serial No. 7310 and No. 7314; manufactured by Lima Locomotive Works and were powered by Continental R975-C1 gasoline engines. The vehicles incorporated modifications and production changes. Test weight was 63,600 pounds.
CONCLUSIONS: Three engines failed during the test. One failure was because of an engine compartment fire. Engine cooling with the Continental steel fan proved satisfactory and its adoption was recommended. Vapor lock tendencies were too high, and further investigation was recommended. The carburetor air cleaners sludged heavily in the air inlet passages because of oil splash back. An air inlet baffle was recommended. In heavy dust conditions 50-mile servicing of air cleaners was advised. Improved dust protection was recommended for the throttle linkage, accelerator pump, clutches, starter hand-crank drive, magnetos, turret races and wheel bearings. Redesign was suggested for the volute suspension springs for heavier loading and longer life. Disc wheels proved superior to the spoke type. The use of bogie arm stiffeners was recommended. The double-anchor brakes had no advantage over the single action brakes. Comparison of subject test vehicle with the first M4A1 Medium Tank tested disclosed the following: superior cooling of the recent project vehicles; fuel and oil consumption and vapor lock tendencies were similar.
GENERAL: This 77-page report includes 101 photographs of component failures.

SUBJECT: Tanks (Combat) PG-2.1159
TITLE: Operation of Standard Medium Tank Loaded to Assault Tank Weight Conditions
IDENTIFICATION: Report No. PG-2.1159; GMPG Project No. 296
DATE OF REPORT: 25 April 1944

ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of a standard Medium Tank M4A3 loaded to assault tank weight
METHOD: The vehicle was loaded to a gross weight of 82,940 pounds and operated for 474 miles. Traverse tests were conducted with 2700 pounds of additional ballast added to the turret.
DESCRIPTION: The test Medium Tank M4A3, Serial No. 2607, was manufactured by the Ford Motor Car Company and powered by a Ford GAA engine. It was equipped with modified final drive gears to change the ratio from 2.804:1 to 3.364:1, and with coil helper springs inside the volute suspension springs.
CONCLUSIONS: The vehicle operated satisfactorily at a gross weight of 82,904 pounds. Six of the twelve helper springs were found to be broken at the end of the test. Both the power and hand-traverse mechanism operated satisfactorily on slopes up to 40% with turret ballasted to 15,567 pounds, center of gravity 5.05 inches ahead of the center of the turret ring. Elimination or redesign of the helper springs was recommended and further test of an assault weight vehicle in the summer was recommended.
GENERAL: This 57-page report includes eight photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) PG-2.1184
TITLE: Standard Inspection Control Test Light Tank T9E1
IDENTIFICATION: Report No. PG-2.1184; GMPG Project No. 206-53
DATE OF REPORT: 17 May 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of Light Tank T9E1, Serial No. 806, for military use
METHOD: The test vehicle was operated over varied terrain for 771 miles. During this operating period, vehicle manufacturing, design, and performance deficiencies were noted. After the test run, an engineering test consisting of only a stopping distance test from 20 mph was conducted.
DESCRIPTION: The test Light Tank T9E1, Serial No. 806, was a full-tracked, front sprocket driven vehicle manufactured by Marmon-Herrington. Vehicle equipment included a Lycoming engine and a Marmon-Herrington transmission.
CONCLUSIONS: Major vehicle deficiencies were confined to the suspension system. Vehicle testing was discontinued after 771 miles because the track was in such poor condition it was not deemed advisable to operate the vehicle at high speeds.
GENERAL: This 16-page report contains two photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-2.1248
TITLE: Supplementary Report on Medium Tank M4A2E4 — Fisher
IDENTIFICATION: Report No. PG-2.1248; GMPG Project No. 8394
DATE OF REPORT: 17 July 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A2E4
METHOD: The vehicle was given a mechanical inspection and a 2000-mile road test. Charts, photographs, logs, and repair records were compiled into one report.
DESCRIPTION: The test Medium Tank M4A2E4, Serial No. 2108, was manufactured by the Fisher Body Company. It was powered by two, General Motors, six-cylinder, diesel engines and equipped with a Westinghouse electric stabilizer unit.
CONCLUSIONS: Conclusions and recommendations on major parts failures were covered by reports already submitted and were not included in this supplementary report. Exceptions were: failure of right engine at 1875 miles of operation, due to poor design of fan drive gear, and failure of transmission at 1834 miles due to wear of component parts.
GENERAL: This 73-page report includes 13 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.1257
TITLE: Supplementary Report on Light Tank M5A1 — Cadillac
IDENTIFICATION: Report No. PG-2.1257; GMPG Project No. 8319 (Projects No. 227 and 262)
DATE OF REPORT: 22 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compile test data covering operation of a Light Tank M5A1 from the time it was assigned to Projects No. 227 and 262 until it was shipped
METHOD: Six test projects were run on the vehicle for a total of 4965 miles, including 4620 miles on a chassis dynamometer.
DESCRIPTION: The test Light Tank M5A1, Serial No. 4301, was manufactured by the Cadillac Motor Car Company, powered by two Cadillac V-8 engines and equipped with hydramatic transmissions.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the test and were not included in this supplementary report. The major failures of standard parts were in engine valves and ignition components. The original engines were replaced at 2799 miles because of defective valves.
GENERAL: This 122-page report includes 36 photographs of failed components, 31 repair detail sheets, 14 daily log sheets, five fuel and oil economy curve sheets, and one repair frequency chart, all compiled from test operations while vehicle was assigned to projects No. 227 and 262 from 6 August 1943 to 4 November 1944.

SUBJECT: Tanks (Combat) PG-2.1261
TITLE: Supplementary Report on Medium Tank M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.1261; GMPG Project No. 8262
DATE OF REPORT: 11 October 1944
ORIGIN: General Motors Proving Ground, Milford,

Michigan
PURPOSE: To compile operational test data of a Medium Tank M4A2 from the time it was assigned to the project until it was shipped 11 June 1943 to 16 February 1944
METHOD: Ten test projects were run on the vehicle for a total of 2066 miles.
DESCRIPTION: The Test Medium Tank M4A2, Serial No. 26583, was manufactured by the Fisher Body Company and powered by two, General Motors, six-cylinder diesel engines.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports of the tests and not included in this supplementary report. The engines failed at 1777 miles due to scoring of cylinder liners caused by poor lubrication and Prestone leakage. New engines were installed and these failed at 260 miles due to poor fuel distribution caused by faulty injectors. Considerable clutch trouble developed due to design deficiency. A transmission failed at 588 miles but the cause was not then determined.
GENERAL: This 196-page report includes 21 photographs of failed components, 54 repair detail sheets, 74 daily log sheets, five fuel and economy curve sheets, and one repair frequency chart, all compiled from the operations while the vehicle was assigned to projects 8262.

SUBJECT: Tanks (Combat) PG-2.1270
TITLE: Endurance Test, Medium Tank M4A3 — 75 MM (W) — Fisher
IDENTIFICATION: Report No. PG-2.1270; Project No. 337
DATE OF REPORT: 7 September 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the endurance characteristics of Medium Tank M4A3, Ordnance Serial No. 49069
METHOD: The vehicle was operated 988 miles over a 10-mile endurance tank route.
DESCRIPTION: Test Medium Tank M4A3 was manufactured by the Fisher Body Division of General Motors Corporation and weighed 71,000 pounds. It was powered by a Ford GAA, V-8, 500-bhp, gasoline engine and was equipped with T48 rubber chevron tracks.
CONCLUSIONS: The test vehicle operated satisfactorily and exhibited satisfactory durability. Turret bearing and trunnion bearing friction was satisfactory. The sump drain valve design was poor, and redesign was recommended. Stowage of 75-mm, cal. .30, and cal. .45 ammunition was unsatisfactory. Driver's seats, hatch cover locking pins, commander's turret hatch cover release push rod, gun barrel traveling lock, and several brackets were improperly located or poorly designed. Fuel and oil economy were below normal for M4A3 Medium Tanks.
GENERAL: This 127-page report includes 32 photographs of the tank and components.

SUBJECT: Tanks (Combat) PG-2.1281
TITLE: Medium Tank T20, No. 1 Pilot Model
IDENTIFICATION: Report No. PG-2.1281; Project No. 194
DATE OF REPORT: 12 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine if the test Medium Tank T20 should be put into production
METHOD: The test covered mechanical inspection, and engineering tests. The vehicle was operated for a total of 106 miles over varied terrain.
DESCRIPTION: The test Medium Tank T20, Ordnance Serial No. 1, was manufactured by the Fisher Body Division of General Motors Corporation and weighed 66,155 pounds. It was powered by a Ford GAN, 500 bhp, V-8, gasoline engine and equipped with a torque converter transmission.
CONCLUSIONS: The vehicle was not recommended for production. Engineering tests were terminated after 106 miles because of numerous defects. Vehicle operation of 12.2 hours involved 578.8 hours of repair. Among the desirable features were: low silhouette, wide tread, ease of range selection, and absence of gear shifting. Among the recommendations listed were: an engine governor be provided, a redesign to overcome transmission shortcomings, and protection of gun from engine exhaust.
GENERAL: This 121-page report includes 27 photographs of the test vehicle with parts failures. Specification characteristics data and cooling test during preliminary operation data were also included. The engineering tests requested in the Directive were not completed.

SUBJECT: Tanks (Combat) PG-2.1284
TITLE: Desert Endurance Test — Medium Tank T25E1 — Fisher
IDENTIFICATION: Report No. PG-2.1284; Project No. 51-52
DATE OF REPORT: 23 August 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the operating characteristics of Medium Tank T25E1 under hot-dusty conditions
METHOD: The vehicle was operated for 111 miles on hard-packed roads under dusty conditions.
DESCRIPTION: Test Medium Tank T25E1, Ordnance Serial No. 8, was powered by a Ford GAF, V-8, 500-bhp, gasoline engine and weighed 78,000 pounds.
CONCLUSIONS: The engine operation of the Medium Tank T25E1 was satisfactory. Slack in the fan belts interefered with proper cooling. Fifteen design features including improved access to fan belts, repositioning and redesign of instrument panel, and improved dust shielding were recommended. Inspection of air cleaners each 50 miles of desert operation was also recommended. Tests and observations were incomplete because of limited vehicle operation.
GENERAL: This 79-page report includes 11 photographs of failed components.

SUBJECT: Tanks (Combat) PG-2.1286
TITLE: Endurance Test, Medium Tank M4A3 —

105 MM
IDENTIFICATION: Report No. PG-2.1286; GMPG Project No. 344
DATE OF REPORT: 17 September 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the endurance of Medium Tank M4A3 and the suitability of the ammunition holders
METHOD: The vehicle was given a 1000-mile endurance test over the 10 mile Endurance Tank Route.
DESCRIPTION: The test Medium Tank M4A3 was manufactured by the Chrysler Corporation and weighed 66,700 pounds net. It was powered by a Ford GAA, V-8, gasoline engine rated 500 bhp at 2600 rpm and 1100 lbs.-ft. maximum torque at 2200 rpm.
CONCLUSIONS: Endurance characteristics of the vehicle and forces required to move gun and turret were satisfactory. Provision for ammunition stowage was unsatisfactory. It was recommended that: the 3'' ammunition racks behind the driver's seat be relocated for more accessibility; stowage racks for cal. .30 ammunition be revised to hold the boxes more securely; and that provision be made for stowage of the 900 rounds of cal. .45 ammunition, three more boxes of cal. .50 ammunition, the periscope holder, and the two spare direct vision turret glasses.
GENERAL: This 91-page report includes 21 photographs of the tank, a curve of turret bearing friction force, and fuel and economy curves.

SUBJECT: Tanks (Combat) PG-2.1314
TITLE: Endurance Test, Medium Tank M4A1 — 76 MM (W)
IDENTIFICATION: Report No. PG-2.1314; GMPG Project No. 338
DATE OF REPORT: 28 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability and endurance of Medium Tank M4A1
METHOD: The vehicle was given a 977-mile endurance test over the 10-mile Endurance Tank Route.
DESCRIPTION: The test Medium Tank M4A1 was manufactured by the Pressed Steel Car Company and weighed 71,000 pounds. It was powered by a Continental R975-C1 gasoline engine rated 485 bhp at 2400 rpm and equipped with rubber chevron Track T48.
CONCLUSIONS: The tank operated satisfactorily with no serious difficulties. For a vehicle of this weight it was considered underpowered, however, average fuel and oil economy were 0.42 mpg and 9.95 mpq, respectively. The driver's seat was uncomfortable. It was recommended that a bracket for support of the exhaust pipes just ahead of the ball and socket joint be designed.
GENERAL: This 115-page report includes 30 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-2.1316
TITLE: Endurance Test, Medium Tank M4A2 — 76 MM (W)
IDENTIFICATION: Report No. PG-2.1316; Project No. 345
DATE OF REPORT: 31 August 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine endurance characteristics of Medium Tank M4A2
METHOD: The vehicle was operated 985 miles in 64.1 hours. Most of the operation was on the 10-mile Endurance Tank Route.
DESCRIPTION: The test Medium Tank M4A2 was manufactured by the Fisher Body Division of General Motors Corporation and weighed 70,500 pounds. It was powered by two GM 671 diesel engines and was equipped with rubber chevron Track T48.
CONCLUSIONS: The vehicle completed its endurance run very successfully. Average fuel and oil economy were 0.91 mpg and 16.6 mpq, respectively. The driver's seat was uncomfortable. It was recommended that: the bogie wheel tires be made more durable, the driver's seat be made less concave, a clearance of one-half to one inch be provided in the racks for the cal. .50 ammunition boxes, the 76 mm shell racks be enlarged, provision be made for storage of commander's cupola periscope holder, and that the rear view mirror mounting brackets be strengthened.
GENERAL: This 92-page report includes 19 photographs of the tank.

SUBJECT: Tanks (Combat) PG-2.1336
TITLE: Desert Endurance Test Medium Tank T23 — Chrysler
IDENTIFICATION: Report No. PG-2.1336; GMPG Project No. 51-55
DATE OF REPORT: 3 October 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the effects of dust and high temperatures on the operation and life of the Medium Tank T23
METHOD: The test covered mechanical inspection, engineering tests and 231 miles of endurance operation over dusty terrain.
DESCRIPTION: The test Medium Tank T23, Ordnance Serial No. 55, was manufactured by the Chrysler Corporation and weighed 68,000 pounds. It was powered by a Ford GAN, V-8, gasoline engine.
CONCLUSIONS: Performance of the vehicle was considered excellent with maneuverability surpassing that of M4 Medium Tanks. Among the deficiencies listed were: vehicle subject to vapor locking; erratic governor operation; parking brakes unreliable down long hills or in tow when the electric brakes were inoperative. Included in the recommendations were: addition of external-band brakes on the vehicle; and an investigation to determine the cause of vapor lock.
GENERAL: This 81-page report includes eight photographs.

SUBJECT: Tanks (Combat) PG-2.1349
TITLE: Desert Ordnance Tests of Medium Tank

TANK AUTOMOTIVE TEST RESUMES

M4A6
IDENTIFICATION: Report No. PG-2.1349; GMPG Project No. 51-51
DATE OF REPORT: 24 October 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the effects of desert heat and dust on the operation and life of Medium Tank M4A6 components
METHOD: The test covered mechanical inspection, engineering tests, 176 miles of desert endurance operation and final inspection.
DESCRIPTION: The test Medium Tank M4A6, Ordnance Serial No. 43479, was manufactured by the Chrysler Tank Arsenal and weighed 68,400 pounds. It was powered by a Caterpillar diesel engine, Model No. RD-1820.
CONCLUSIONS: The first test engine failed at the first mile. The second test engine failed at 176 miles, terminating the project. Because of the limited vehicle operation, conclusions and recommendations were limited or qualified. The RD-1820 engine was not recommended for consideration until No. 5 piston rod failures had been investigated.
GENERAL: This 63-page report includes five photographs of piston rod failures.

SUBJECT: Tanks (Combat) PG-2.1365
TITLE: Desert Endurance Test, Medium Tank M4A3, 75 MM (W)
IDENTIFICATION: Report No. PG-2.1365; Project No. 51-54
DATE OF REPORT: 2 December 1944
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine endurance and performance characteristics of a Medium Tank M4A3 during desert operation
METHOD: The vehicle was operated 1801 miles on the endurance course and 126 miles on the dust course.
DESCRIPTION: The test Medium Tank M4A3 was manufactured by the Fisher Body Division of General Motors Corporation and weighed 63,500 pounds. It was powered by a Ford GAA, V-8, gasoline engine rated 500 bhp at 2600 rpm.
CONCLUSIONS: Two engines failed due to faulty piston rings. Service life of the production Donaldson air cleaners was satisfactory, but efficiency was too low. The high idle mechanism, center clips of the 75 mm shell retainers, and T48 Rubber Tracks were unsatisfactory. It was recommended that these, and other minor failures, be corrected.
GENERAL: This 161-page report includes 55 photographs of tank components.

SUBJECT: Tanks (Combat) PG-2.1406
TITLE: Supplementary Report on Medium Tank M3A3 — Baldwin
IDENTIFICATION: Report No. PG-2.1406; GMPG Project No. 8055 (Project Nos. 51-197 and 51-154-1)
DATE OF REPORT: 20 January 1945
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To compile test data covering desert operation of a Medium Tank M3A3 in use as a facility and track utility vehicle
METHOD: Three test projects for a total of 429 miles were run on the vehicle during the time it was assigned to the projects until it was shipped. A previous project had recorded 576 miles on the vehicle. Charts, logs and repair records of these projects were accumulated into one report. The vehicle was also used for 130 miles in conducting a static interference test of steel tracks.
DESCRIPTION: The test Medium Tank M3A3 was manufactured by the Baldwin Locomotive Works and powered by two General Motors, six-cylinder, diesel engines.
CONCLUSIONS: Conclusions and recommendations were included in the individual reports of each test and were not incorporated in this supplementary report. However, the engine operation of the vehicle was fairly satisfactory until 1099 miles, when one engine locked. No investigation was made. No other major failures occurred.
GENERAL: This 40-page report includes seven operation log sheets, 13 repair detail sheets, two fuel and oil economy sheets, and a repair frequency chart, all compiled from operations while the vehicle was assigned to Project Nos. 51-197 and 51-154-1, 26 January 1943 to 25 August 1943.

SUBJECT: Tanks (Combat) PG-2.1410
TITLE: Supplementary Report on Medium Tank M4A1, 76 MM (W), Pressed Steel
IDENTIFICATION: Report No. PG-2.1410; GMPG Project No. 8587
DATE OF REPORT: 4 April 1945
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To conduct endurance test of Medium Tank M4A1
METHOD: The vehicle was operated almost continuously for 1725 miles on the endurance and dust courses (200 miles) while assigned to Project No. 8587.
DESCRIPTION: The test Medium Tank M4A1 was manufactured by the Pressed Steel Company and powered by a R975-C4 gasoline engine.
CONCLUSIONS: Conclusions and recommendations were included mainly in the individual reports of each test. However, numerous conclusions and recommendations, relating to suitability of vehicle components for desert operation, were incorporated in this particular report.
GENERAL: This 81-page report includes 18 photographs of failed tank components.

SUBJECT: Tanks (Combat) PG-2.1417
TITLE: Supplementary Report on Medium Tanks, M4A2 — Fisher
IDENTIFICATION: Report No. PG-2.1417; GMPG Project No. 332
DATE OF REPORT: 1 May 1945
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the effect of desert heat

and dust primarily on the efficiency of improved air cleaners
METHOD: Two vehicles were subjected to cleaner dust tests. One was given an added test of 1147 miles of endurance operation.
DESCRIPTION: The test Medium Tanks M4A2, Ordnance Serial Nos. 27993 and 27868, were manufactured by the Fisher Body Division of General Motors Corporation and weighed 66,580 and 66,200 pounds, respectively. Each vehicle was powered by two GM 6046 diesel engines. Improved United and Vortox air cleaners were tested.
CONCLUSIONS: The use of United and Vortox air cleaners on vehicle Serial No. 27993 lengthened the engine service life by approximately 50% over present production air cleaners. It was recommended that the air cleaner investigation be continued and that the current production type air cleaners be supplanted as soon as possible.
GENERAL: This 78-page report includes 11 photographs.

SUBJECT: Tanks (Combat) PG-2.1420
TITLE: Supplementary Report on Medium Tank M4 — Chrysler
IDENTIFICATION: Report No. PG-2.1420; GMPG Projects No. 51-47
DATE OF REPORT: 14 April 1945
ORIGIN: General Motors Proving Ground, Phoenix, Arizona
PURPOSE: To determine the durability of Medium Tank M4
METHOD: Two test projects were run on the vehicle. The endurance operation covered 3345 miles, 400 miles of this was on the dust course.
DESCRIPTION: The test Medium Tank M4, Serial No. 59334, was manufactured by the Chrysler Tank Arsenal and weighed 68,400 pounds. Power was supplied by a Continental R975-C1, nine-cylinder, radial, air-cooled, gasoline engine. It was equipped with a Lipe clutch with Ordnance design plate separators for one test and with a Bendix-Scintilla magneto for another.
CONCLUSIONS: Cumulative fuel and oil economy were 0.519 mpg and 4.88 mpq, respectively. The high idler mechanism defeated the purpose of the carburetor degasser by maintaining a cracked throttle on overrun operation and was not recommended. It was recommended that the Bendix-Scintilla magneto point housing be more thoroughly dust proofed to eliminate points failures. The Chrysler double anchor brakes were recommended without changes. Other recommendations were: a redesign of the Chrysler-built transmission to eliminate block out tendencies; a vapor lock investigation on present production R975-C1 engines; the engine oil sump mounting be redesigned to give more support to the sump.
GENERAL: This 115-page report includes nine photographs of component failures.

SUBJECT: Tanks (Combat) PG-2.1478
TITLE: Engineering Test, Light Tank M24 — Cadillac
IDENTIFICATION: Report No. PG-2.1478; Project No. 350
DATE OF REPORT: 8 February 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine engineering and durability characteristics of Light Tank M24
METHOD: The vehicle accumulated 2290 miles of engineering and durability tests as directed by Schedule A of TSTP 1935-709.
DESCRIPTION: The test Light Tank M24, Ordnance Serial No. 4, weighed 40,500 pounds, and was powered by two Cadillac, V-8, gasoline engines with separate transmissions. It was equipped with steel, center-guide tracks. Armament consisted of a 75 mm gun, a cal. .50 antiaircraft machine gun and two cal. .30 machine guns.
CONCLUSIONS: Performance of the vehicle was generally satisfactory. Mechanical difficulties were encountered in the brakes, transmission and engines. Track-pin bushings failed after 1000-1300 miles of operation. It was recommended that the many deficiencies listed be corrected and that the modified tank receive further testing.
GENERAL: This 225-page report includes 57 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-2.1481
TITLE: Endurance Test — Heavy Tank T26E1 (E.S. 1682)
IDENTIFICATION: Report No. PG-2.1481; GMPG Project No. 326
DATE OF REPORT: 3 February 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the endurance characteristics of Heavy Tank T26E1
METHOD: The vehicle was operated a total of 443 miles; the first 150 miles on break-in and special tests and the last 293 miles on endurance operation.
DESCRIPTION: The test Heavy Tank T26E1, Ordnance Serial No. 4, was manufactured by the Fisher Body Division of General Motors Corporation and weighed 84,050 pounds. It was powered by a rear-mounted, Ford GAF, V-8, gasoline engine and was equipped with torqumatic transmission and torsion bar suspension. Armament included a 90 mm gun, one cal. .50 machine gun, and two cal. .30 machine guns.
CONCLUSIONS: The steering brakes were inadequate, and very high engine coolant temperatures were encountered. The carburetors were deficient in that the engine exhaust torched excessively during deceleration, and the engine sputtered and backfired during initial acceleration. The air cleaners were located in an area of high dust concentration. The compensating arms of the suspension system loosened on the pivot hubs. Several cap screws on the inside drive sprockets were sheared off flush with the sprocket face. The average fuel economy was 0.37 mpg, and the oil economy was 7.15 mpq. It was recommended that the deficiencies listed above be corrected.
GENERAL: This 174-page report includes 62 photographs of the tank and its components.

SUBJECT: Tanks (Combat) PG-2.1501
TITLE: Engineering Test of Medium Tank T25E1

TANK AUTOMOTIVE TEST RESUMES

IDENTIFICATION: Report No. PG-2.1501; Project No. 322
DATE OF REPORT: 16 February 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the acceptability of Medium Tank T25E1
METHOD: The test covered engine and vehicle break-in; road tests; and 554 miles of endurance operation.
DESCRIPTION: The test Medium Tank T25E1, Serial No. 4, was manufactured by the Fisher Body Division of General Motors Corporation and weighed 78,000 pounds. It was powered by a Ford GAF, V-8, gasoline engine and equipped with a 90 mm gun.
CONCLUSIONS: The project was terminated at 833 miles; before engineering tests were initiated. The steering brakes were considered inadequate for proper control of the vehicle. Track life proved to be low and carburetors deficient. An improved cooling system was considered necessary for the brakes and differential. Fuel economy was poor, and engine cooling inadequate. During the test, 92 repairs and adjustments were made in addition to routine servicing.
GENERAL: This 260-page report includes 93 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-2.1530
TITLE: Engineering Test — Medium Tank T23
IDENTIFICATION: Report No. PG-21530; Project No. 325
DATE OF REPORT: 24 March 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct engineering tests on a Medium Tank T23
METHOD: The test tank was operated 1494 miles over varied terrain. Tests were conducted on braking, acceleration, slope-climbing and obstacle-climbing ability, and engine cooling. Other tests included drawbar pull, tractive resistance, minimum turning diameters, center of gravity, and fording ability.
DESCRIPTION: The test vehicle was a Medium Tank T23, manufactured by Chrysler Corporation, and powered by a Ford GAN Engine. An electric drive system was used to couple the engine to the drive sprockets. The brakes were electrically operated while the parking brake was mechanically operated.
CONCLUSIONS: The test vehicle was seriously deficient in durability, and was not considered acceptable for use as a combat vehicle. The electric drive provided superior maneuverability and ease of handling over that of the Medium Tank M4A3; other performance characteristics of the two vehicles were approximately equivalent. The disadvantages of the electric system were: highly skilled technicians and skilled drivers required; excessive track wear because of high speeds attained. Further development of the electric system was recommended. More ruggedness and simplicity of control of braking and steering system in the event of electric drive failure and some means of starting the engine by towing or coasting downhill were considered necessary. An improved cooling system was also recommended because the radiators continually clogged with oil.
GENERAL: This 269-page report contains 80 photographs of the test vehicle and various tank parts. Appended memo reports cover carburetors and the turret hatch cover, weight reports, and performance data.

SUBJECT: Tanks (Combat) PG-2.1532
TITLE: Standard Inspection Control Test Light Tank M5A1 — American Car and Foundry Company
IDENTIFICATION: Report No. PG-2.1532; Project No. 206-116
DATE OF REPORT: 15 March 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine manufacturing deficiencies of Light Tank M5A1
METHOD: The test vehicle was operated to failure at 909 miles.
DESCRIPTION: The test Light Tank M5A1 was manufactured by the American Car and Foundry Company, weighed 33,965 pounds, and was powered by two Cadillac, V-8, gasoline engines. It was equipped with two hydramatic transmissions, and synthetic rubber Tracks T16 (12-43) manufactured by the U. S. Rubber Company.
CONCLUSIONS: The right engine water temperature ran 40° higher than the left engine due to a defective thermostat. It was recommended that thermostats receive closer inspection during manufacture and that they begin to open at 146°F and be fully opened at 155°F. The transfer case failed at 909 miles when the two-piece low band broke. It was recommended that these old type bands be replaced by the new type bands (memo Report No. PG-19.597). The performance of the synthetic rubber Track T16 was unsatisfactory, and scrapping of these blocks was suggested, unless a severe shortage of blocks existed.
GENERAL: This 14-page report includes two photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-2.1564
TITLE: Brake Tests of Heavy Tank T26E1 and Medium Tanks T25E1 — Conducted by Buick Motor Car Division at General Motors Proving Ground
IDENTIFICATION: Report No. PG-2.1564; GMPG Project No. 613
DATE OF REPORT: 6 April 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To obtain background data on the type, frequency, reasons-for, and mileages-to-failure of standard parts for a Heavy Tank T26E1 and two Medium Tanks T25E1
METHOD: Buick personnel operated the three test vehicles for 8162 miles during separate development and test of brake and cooling systems. Failed standard parts were submitted by Buick crewmen to the Ordnance stockroom for replacement. The failed standard parts thus accumulated were photographed, and mileage and cause of failure

were recorded.
DESCRIPTION: Since the experimental work on brake and cooling systems by Buick precluded replacement of such parts by the Ordnance stockroom, the failed standard parts covered by this report fell principally under the headings of: Suspension, Engine, Power Train, and Hull.
CONCLUSIONS: Failure of four complete engines was attributed to overheating caused by cooling system failure. The engines thus failed were not inspected, but were returned directly to the Ford Motor Company. Practically all track support roller failures occurred at the rear rollers, No. 5 right and No. 5 left, and redesign was recommended. Difficulty was encountered with overrunning clutches in the generator drive arrangement, and improvement was suggested.
GENERAL: This 67-page report contains 43 photographs of miscellaneous tank parts turned in.

PG-2.1710
2.1710A
2.1710B

SUBJECT: Tanks (Combat)
TITLE: Engineering and Endurance Test, Heavy Tank M26 — Fisher
IDENTIFICATION: Report No. PG-2.1710, PG-2.1710A, and PG-2.1710B; GMPG Project No. 414
DATE OF REPORT: 29 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct engineering and endurance tests on the Heavy Tanks M26
METHOD: The test on vehicle (Serial No. 204) included complete engineering tests and 400 miles of strategic and endurance operation. Total mileage covered was 1007 miles. The test on vehicle Serial No. 209 covered 485 miles of strategic and endurance operation only.
DESCRIPTION: The two test Heavy Tanks M26, Serial No. 204 and Serial No. 209, were manufactured by the Fisher Body Division of General Motors Corporation. Test weight of each was 92,000 pounds. Each vehicle was equipped with a Ford gasoline engine Model GAF and a torque converter and torqumatic transmission combination.
CONCLUSIONS: Test vehicle, Serial No. 209, with only 485 miles endurance operation yielded little information. Conclusions and recommendations were therefore based primarily on vehicle Serial No. 204 with 1007 miles of engineering tests and endurance operation. While the vehicle rode exceptionally well, steering and braking efforts were objectionally high and extremely fatiguing. To overcome this, a servo unit and a major redesign of the brake system were recommended. The engine functioned satisfactorily throughout the test. The effects of lowered differential oil on power losses and on brake lining life were inconclusive; a further study was recommended. Among the deficiencies listed were: checking of the transmission oil level with the engine not running gave erroneous and inconsistent readings; fatigue failures of track pins; and failure of turnbuckle fender braces. Poor acceleration of the vehicle was attributed to the lowered efficiency of the torque converter and torqumatic transmission combination.
GENERAL: These three reports are all part of the same test project. Report No. PG-2.1710 contains 85-pages and no illustrations. Report No. PG-2.1710A covers vehicle Serial No. 204. Its 85 pages include 34 photographs of the vehicle and components. Report No. PG-2.1710B covers vehicle Serial No. 209. Its 54 pages include 11 photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-2.1739
TITLE: Acceptance Test of Light Tanks — Summary Report
IDENTIFICATION: Report No. PG-2.1739; GMPG Project No. 24
DATE OF REPORT: 19 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To conduct acceptance tests on Light Tanks M3 and M5
METHOD: Twenty-two vehicles accumulated a total of 10,515 test miles while assigned to Project 24.
DESCRIPTION: The test Light Tanks M3, M3A1, M3A3, M5, and M5A1 were manufactured by the Cadillac Motor Car Company, the American Car and Foundry Company, and the Massey-Harris Company.
CONCLUSIONS: Conclusions and recommendations covering the tests on this project were contained in individual test reports and were not included in this summary. The project was terminated because Project No. 206 was instituted to cover inspection control tests of all Ordnance vehicles.
GENERAL: This six-page report is not illustrated.

SUBJECT: Tanks (Combat) PG-61505.5
TITLE: 2000 Mile Test of Medium Tank M4A4
IDENTIFICATION: Report No. PG-61505.5; TAPG Project No. 16; Volumes I and II
DATE OF REPORT: 8 December 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general durability, and operating and cooling characteristics of a Medium Tank M4A4
METHOD: The vehicle was given 7000 miles of endurance and performance testing. Comparative cooling tests were made using two different water pump systems.
DESCRIPTION: The test Medium Tank M4A4, Ordnance Serial No. 4807, was manufactured by the Chrysler Corporation and weighed 67,875 pounds. It was powered by a Chrysler multi-bank engine rated 445 hp at 4200 rpm. One cooling system tested used five water pumps, one for each engine; the other system used a single large water pump.
CONCLUSIONS: Engine performance was generally satisfactory; durability was not. Cooling was improved when the single pump was substituted for the original five pumps. Propeller shaft durability was unsatisfactory. Other deficiencies included: radiator core and clutch plugging with dirt;

unsatisfactory clutch release bearings; poor bogie wheel tire life; inadequate track support guides. It was recommended that all deficiencies be corrected.
GENERAL: This 190-page report is in two volumes; the first includes the test discussion and the second includes 45 photographs of tank components.

SUBJECT: Tanks (Combat) PG-61505.6
TITLE: Test of Medium Tank, M4A1 (Pressed Steel)
IDENTIFICATION: Report No. PG-61505.6; TAPG Project No. 9
DATE OF REPORT: 24 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and general performance characteristics of Medium Tank M4A1
METHOD: The vehicle was operated 4968 miles over the Endurance Test Route.
DESCRIPTION: The test Medium Tank M4A1 was manufactured by the Pressed Steel Car Company and weighed 57,640 pounds. It was originally powered with a Continental R975-C2 engine with a compression ratio of 6.3:1. Replacements were R975-C1 engines with a 5.7:1 compression ratio. The suspension was the M3 design with 7-inch volute springs and centrally located support rollers. Tracks T41 and T48 were used.
CONCLUSIONS: The general operation of the vehicle was satisfactory. It was recommended that the poor oil economy of the R975-C1 engines be corrected; that clutch design and operation be improved; and that the electrical system parts such as voltage regulators, light bulbs, fuel gage units and wiring should be strengthened to overcome failures due to vibration.
GENERAL: This 50-page report includes four photographs of the tank's components.

SUBJECT: Tanks (Combat) PG-61505.9
TITLE: Light Tank M5 — Durability Test
IDENTIFICATION: Report No. PG-61505.9; TAPG Project No. 49
DATE OF REPORT: 4 September 1943
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine durability and performance of a Light Tank M5
METHOD: The vehicle was operated 2136 miles (171.3 hours) over the Tank Route at an average speed of 12.45 mph.
DESCRIPTION: The test Light Tank M5, Ordnance Serial No. 1269, was manufactured by the Cadillac Motor Car Company. It was equipped with twin Cadillac, V-8, gasoline engines and two hydramatic transmissions. Rubber-on-steel (T36E6) and steel (T55E1) Tracks, manufactured by The Burgess-Norton Company, were used.
CONCLUSIONS: The general performance of the vehicle was satisfactory. The durability of the transmission, transfer unit, controlled differential, and suspension components was unsatisfactory. It was recommended that the design of the transmission and transfer case be strengthened, the suspension be improved to reduce pitch and strengthen the front springs, the motor mountings be redesigned, a fuel gage be provided, an automatic adjustment be devised for the transmission and transfer case bands, steering effort be reduced, and additional flotation be provided.
GENERAL: This 56-page report includes 12 photographs of failed components.

SUBJECT: Tanks (Combat) PG-61505.10
TITLE: Durability Test of Medium Tank M4A1
IDENTIFICATION: Report No. PG-61505.10 (Vols. I and II); TAPG Project No. 106
DATE OF REPORT: 24 March 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and operating characteristics of the Medium Tank M4A1
METHOD: The vehicle was tested in accordance with the standard acceptance test procedure, and subjected to a 2000 mile durability run over the endurance course.
DESCRIPTION: The test Medium Tank M4A1, was equipped with a Continental R975-C1 engine, and manufactured by the Pressed Steel Car Company. Total weight with ballast and crew allowance was 66,080 pounds.
CONCLUSIONS: The original engine was considered unsatisfactory because of a series of exhaust system failures and was replaced at 1800 miles (179.5 engine hours). Oil leakage of the Cuno oil filter, and failure of various fuel system parts also contributed to general unsatisfactory operation. Clutch operation was unsatisfactory because of dirt accumulation, and release-bearing life was relatively short prior to the installation of radial-type bearings. Operation of the electrical system, power train, hull and attachments was considered satisfactory. The vertical volute suspension system was considered unsatisfactory. Five of the original bogie tires failed at an average of 439 miles. Failure of 13 bogie bearings occurred at an average of 415 miles because of inadequate seals. Eight volute springs failed in or near the inner inactive coil at an average of 1405 miles. Four track support rollers failed after an average of 1000 miles. Both rear idlers failed at 1806 miles. Recommendations were made to eliminate deficiencies found in the engine, clutch, suspension and electrical systems. The vehicle was declared generally acceptable contingent upon incorporation of recommended modifications.
GENERAL: Volume I of this 100-page report contains data and discussion pertinent to the 2000 mile durability test. Volume II contains six photographs of the vehicle and failed parts as well as graphs and tabulated acceptance test data.

SUBJECT: Tanks (Combat) PG-61505.11
TITLE: Durability Test of Medium Tank M4A2
IDENTIFICATION: Report No. PG-61505.11; Project No. 107
DATE OF REPORT: 22 March 1944
ORIGIN: Tank Arsenal Proving Ground, Utica,

Michigan
PURPOSE: To determine the general durability and operating characteristics of the Medium Tank M4A2 and to evaluate a modified clutch equalizer and semi-metallic clutch facings
METHOD: The vehicle was tested in accordance with the standard acceptance test procedure and subjected to a 2000-mile durability test over the endurance course. The clutch equalizer was operated for 1969 miles, and the semi-metallic clutch facings, installed after the original fabric facings had worn out at 571 miles, were operated for 1398 miles.
DESCRIPTION: The test Medium Tank M4A2 was manufactured by the Pullman Car Company, and was equipped with two GM 6-71 diesel engines. The total weight of the vehicle with ballast and crew allowance was 69,990 pounds.
CONCLUSIONS: The over-all vehicular durability was considered satisfactory, though outstanding weaknesses were noted in the suspension and in the clutch arrangement. The engines operated without failure. The vehicle was declared acceptable with the exception of several stowage items. The clutch equalizer and semi-metallic clutch facings provided satisfactory operational and durability characteristics during the test. It was recommended that the possibility of incorporating a fluid coupling in the present clutch arrangement to compensate for normal variations in the speed of the two engines and to reduce clutch slippage be investigated. Some means of lubricating clutch lockout controls to prevent sticky action and seizure was suggested. Improvement of the following components was also recommended: bogie tires, bearings, and seals; suspension springs; final drive sprockets; T54E1 Steel Tracks; and rear idler.
GENERAL: This 80-page report contains eight photographs of the vehicle and of clutch conditions.

SUBJECT: Tanks (Combat) PG-61505.12
TITLE: Durability Test of Medium Tank M4A3
IDENTIFICATION: Report No. PG-61505.12; TA PG Project No. 108
DATE OF REPORT: 24 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of Medium Tank M4A3
METHOD: The vehicle was subjected to 1968 miles of operation on the endurance test route.
DESCRIPTION: The test Medium Tank M4A3, Ordnance Serial No. 11870, weighed 62,800 pounds and was manufactured by the Ford Motor Company. It was powered by a Ford GAA engine and equipped with a Westinghouse gyrostabilizer.
CONCLUSIONS: The general operating characteristics and durability of the vehicle were satisfactory except for the durability of the original engine. The engine failed at 488 miles as a result of a broken accessory drive shaft and again at 881 miles because of a broken connecting rod. Changes in the design of the connecting rods and improved manufacturing methods were recommended. Improvement was also recommended in track pin bushings, bogie tires, volute springs, track support rollers, and final drive sprockets.
GENERAL: This 89-page report contains 10 photographs of the vehicle and the failed engine components.

SUBJECT: Tanks (Combat) PG-61505.13
TITLE: Durability Test of Medium Tank M4A4
IDENTIFICATION: Report No. PG-61505.13; TA PG Project No. 109
DATE OF REPORT: 14 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the acceptability of a production Medium Tank M4A4
METHOD: The vehicle was subjected to 857 miles of acceptance tests and 1273 miles of operation over the endurance test route.
DESCRIPTION: The test Medium Tank M4A4 (W-3,019,375) was manufactured by the Chrysler Tank Arsenal and powered by a Chrysler multi-bank engine. It was equipped with a Westinghouse gyrostabilizer and power traverse system.
CONCLUSIONS: The engine, radiators, clutches, bogie tires, volute springs, and track pins were unsatisfactory. No recommendation was made regarding the engine since the Chrysler multi-bank engine had been removed from production. It was recommended that care be exercised to avoid fouling radiators with oil.
GENERAL: This 96-page report contains 13 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.17
TITLE: 3000-Mile Endurance Tests — Medium Tank M3 — Chrysler
IDENTIFICATION: Report No. PG-61505.17; Project No. 4
DATE OF REPORT: 12 January 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and general operating characteristics of a Medium Tank M3
METHOD: The vehicle was operated on the endurance course for 3039 miles.
DESCRIPTION: The test Medium Tank M3 was manufactured by the Chrysler Tank Arsenal and weighed 59,360 pounds. It was powered by a Wright R975-EC2 gasoline engine with a compression ratio of 6.3:1, and equipped with a Bendix vacuum power shift.
CONCLUSIONS: The durability of the vehicle was far superior to previous M3 Tanks tested. Operation of the Bendix Power Shift was satisfactory, but it was established that the transmission would not stand up under the loads imposed by this unit. Recommendations included further improvement on the clutch; a more powerful engine; and a study to reduce the operating temperature of the power train.
GENERAL: This 47-page report includes four photographs of tank components.

SUBJECT: Tanks (Combat) PG-61505.18
TITLE: Test of Pilot Medium Tank M3A4

TANK AUTOMOTIVE TEST RESUMES

IDENTIFICATION: Report No. PG-61505.18; TA PG Project No. 6
DATE OF REPORT: 22 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the performance and durability characteristics of the Medium Tank M3A4
METHOD: The vehicle was operated over the standard endurance course for 5506 miles.
DESCRIPTION: The test Medium Tank M3A4 was powered with a Chrysler multi-bank gasoline engine and was assembled by the Chrysler Engineering Laboratory. It was equipped with an experimental suspension and weighed 64,000 pounds.
CONCLUSIONS: No conclusions or recommendations were made in this report because many modifications and design changes were incorporated in the Medium Tank since this test was conducted. However, test results indicated that considerable development work was needed on the multi-bank engine and that the experimental suspension and track parts warranted further investigation. Total engine hours for the test was 435.7; average speed 12.7 mph; average fuel and lubricating oil economy were .582 mpg and 124 mpg, respectively.
GENERAL: This 53-page report is not illustrated.

SUBJECT: Tanks (Combat) PG-61505.19
TITLE: Durability Test of Medium Tank M4A1
IDENTIFICATION: Report No. PG-61505.19; TA PG Project No. 94
DATE OF REPORT: 8 March 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a Medium Tank M4A1
METHOD: The vehicle was subjected to 2111 miles (219.6 engine hours) over a standard endurance course at an average speed of 9.61 mph.
DESCRIPTION: The test Medium Tank M4A1 was equipped with a Continental R975-C1, radial, air-cooled, gasoline engine, and was manufactured by the Pressed Steel Car Company. Total weight with ballast and crew allowance was 67,000 pounds.
CONCLUSIONS: The general durability characteristics of the vehicle were unsatisfactory. After 1051 miles, the original engine was replaced. Loss of oil through the debubbler tank breather resulted in insufficient engine lubrication, poor oil economy, and ultimate failure of the original engine. Although only minor failures occurred during the operation of the second unit, the mileage accumulated on each engine was considered insufficient for determining durability characteristics. After 1501 test miles, excessive dirt accumulation and a scored and cracked driving plate resulted in the replacement of the clutch assembly. High clutch pedal pressures and unsatisfactory clutch release bearing life were also noted. Improved clutch ventilation, a redesigned clutch pedal linkage, and continued efforts to increase clutch release bearing life were recommended. Life of such suspension components as bogie wheels and sprockets, was considered average, while the life of the springs and idlers was below average. It was recommended that bogie tire life with steel tracks be improved, improved bearing seals and improved bearing mounting be employed, hardness of sprockets be kept as high as possible withoug inducing brittleness, and a heavier rim flange be used to improve rear idler life with steel tracks. Average fuel and lubricating oil economy were .523 mpg and 20.8 mpg, respectively.
GENERAL: This 64-page report contains five photographs of failed components.

SUBJECT: Tanks (Combat) PG-61505.20
TITLE: Operation of Pilot Medium Tank T25
IDENTIFICATION: Report No. PG-61505.20; TA PG Project No. 206
DATE OF REPORT: 12 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general operating characteristics of an electric drive Medium Tank T25
METHOD: The vehicle was tested for 146 miles. This operation included a determination of hill climbing ability and an acceleration comparison with a Medium Tank M4A3.
DESCRIPTION: The test Medium Tank T25 was manufactured by the Chrysler Corporation and weighed 82,530 pounds. It was powered by a Ford GAA engine and incorporated an electric drive. Mechanically this vehicle was essentially the same as the T23, but incorporated a 90mm gun, a horizontal volute suspension, and a Chrysler-designed 23-inch, center-guide track.
CONCLUSIONS: In the cross-country range, the vehicle climbed a 5.8% concrete grade at 2630 engine rpm, with a generator output of 320 kw at 16 mph. In the highway range, engine speed was 2380 rpm, with 290 kw output at 14.5 mph. A satisfactory hill climbing comparison with the Medium Tank M4A3 was not obtained. The test vehicle accelerated to 18 mph in 10.1 seconds while the M4A3 required 12 seconds. Above 18 mph the test vehicle acceleration declined. Deceleration time from 20 mph to 0.0 mph was 29.4 seconds for the test vehicle and 32.2 seconds for the M4A3. Fuel economy of the test vehicle was not as good as the M4A3. Towing of the test vehicle with a dead engine was difficult because the electrically controlled steering brakes were inoperative. It was recommended that the parking brake be replaced with some form of steering brake for descending a grade with a dead engine, when one electric drive fails, and when towing the vehicle.
GENERAL: This 22-page report contains seven photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.22
TITLE: Endurance Test of Light Tanks M5A1
IDENTIFICATION: Report No. PG-61505.22; TA PG Project No. 145
DATE OF REPORT: 1 March 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general durability and operating characteristics of two Light Tanks

M5A1
METHOD: The vehicles were operated 2065 and 1999 miles respectively as facility vehicles in connection with tests of various components.
DESCRIPTION: The test Light Tanks M5A1 were powered by two Cadillac engines and equipped with hydramatic transmissions.
CONCLUSIONS: Durability of the vehicles was generally satisfactory. No failures of engines or transmissions occurred during the test. One pair of engines consumed six times as much oil as the other pair. Failures occurred in the differential, end connectors, bogie tires, track support rollers, front volute springs, and in the electrical system. Recommendations for corrections were made.
GENERAL: This 65-page report contains two photographs of failed components.

SUBJECT: Tanks (Combat) PG-61505.23
TITLE: Operation of First Pilot Model Medium Tank T23
IDENTIFICATION: Report No. PG-61505.23; TA PG Project No. 165
DATE OF REPORT: 10 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating characteristics of the first pilot model Medium Tank T23
METHOD: Acceleration, hill climbing, and fuel consumption tests were conducted.
DESCRIPTION: The Medium Tank T23 was built by Chrysler Corporation and was equipped with General Electric power train powered by a Ford GAN engine. Test weight was 73,600 pounds.
CONCLUSIONS: Operation of the vehicle was considered satisfactory and the increased maneuverability resulting from the electric drive was considered an important improvement. It was recommended that an independent braking system be provided to assure control of the vehicle with the power train inoperative.
GENERAL: This seven-page report contains one acceleration curve comparing acceleration of the T23 to the average acceleration of Medium Tanks M4A3.

SUBJECT: Tanks (Combat) PG-61505.24
TITLE: Test of Medium Tank T25 Pilot No. 2
IDENTIFICATION: Report No. PG-61505.24; Project No. 240
DATE OF REPORT: 20 April 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the operating characteristics of the second pilot model of Medium Tank T25
METHOD: The vehicle was subjected to 186 miles of operation over the endurance test route.
DESCRIPTION: The test Medium Tank T25 was manufactured by the Chrysler Corporation and powered by a Ford GAN-101 gasoline engine. Primary armament included a 90mm gun.
CONCLUSIONS: This test was inconclusive as the vehicle was given only 186 miles of test operation. Performance was generally satisfactory. However, the following deficiencies were noted: the generator regulator and engine oil pressure sending unit were inoperative, and four bogie wheel tires failed during the testing.
GENERAL: This 15-page report is not illustrated.

SUBJECT: Tanks (Combat) PG-61505.25
TITLE: Durability Test of Medium Tank M4A1 — Lima
IDENTIFICATION: Report No. PG-61505.25; TA PG Project No. 8
DATE OF REPORT: 23 May 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of a Medium Tank M4A1
METHOD: The vehicle was operated 4011 miles on an endurance test course.
DESCRIPTION: The test Medium Tank M4A1, Serial No. 1, was manufactured by the Lima Locomotive Works and was originally powered by a Continental R975-EC2 gasoline engine. This engine was replaced by a R975-C1 after 152.4 hours.
CONCLUSIONS: The general operation of the vehicle was satisfactory. Engines were satisfactory except for frequent failures in the high outlet exhaust system; the tendency to vapor lock; and sticky action of throttle linkage. It was recommended that the cooling of the R975-C1 engine be improved.
GENERAL: This 43-page report includes 16 photographs of the test vehicle and components.

SUBJECT: Tanks (Combat) PG-61505.26
TITLE: Performance of Medium Tank T22
IDENTIFICATION: Report No. PG-61505.26; TA PG Project No. 132
DATE OF REPORT: 1 June 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general operating and performance characteristics of two model T22 Medium Tanks
METHOD: One vehicle was operated 683 miles on an endurance course, while the second received 396 miles of general test operation. The testing also included engine cooling and comparative performance using a 2.86 bevel gear ratio and a 3.53 bevel gear ratio.
DESCRIPTION: The two vehicles were experimental, low silhouette Medium Tanks T22, manufactured by the Engineering Division of Chrysler Corporation. They were powered by Ford GAN tank engines with a rear sprocket drive through a geared power train similar to the M4 power train. Test weight was 67,670 pounds. The suspension was a horizontal volute spring type with three bogie assemblies on each side. The tanks were equipped with Novi Hydraulic governors and electric speedometers.
CONCLUSIONS: In general the operation of the vehicles was satisfactory. Engine performance, cooling, and rear drive were satisfactory. The operation of the Novi Hydraulic governor was very irregular as was that of the electric speedometer. The 2.86:1 gear ratio was considered too high for

cross-country operation, and the 3.53:1 ratio was recommended.
GENERAL: This 43-page report includes 11 photographs of the test Medium Tank T22.

SUBJECT: Tanks (Combat) PG-61505.27
TITLE: Durability Test of Medium Tank T25E1
IDENTIFICATION: Report No. PG-61505.27; TA PG Project No. 224
DATE OF REPORT: 19 June 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a Medium Tank T25E1
METHOD: The vehicle was subjected to 766 miles of endurance testing.
DESCRIPTION: The test Medium Tank T25E1, Serial No. 5, was manufactured by the Fisher Body Division of General Motors Corporation and weighed 78,000 pounds. It was powered by a Ford GAF gasoline engine and equipped with a torqumatic transmission. The vehicle was driven through the rear sprockets and supported on a torsion bar suspension with six road wheels and a compensating idler wheel on each side.
CONCLUSIONS: Durability of the suspension components was unsatisfactory. Only 766 miles of the scheduled 2000 miles were run due to difficulties encountered with the track and suspension. Track failures, road wheel tire life, sprocket wear, and exhaust system failures were considered excessive. The torsion bars gave no trouble, and the transmission functioned satisfactorily throughout the test.
GENERAL: This 64-page report includes 24 photographs of the tank and components.

SUBJECT: Tanks (Combat) PG-61505.27-01
TITLE: Endurance Test of Medium Tank T25E1, Final Report
IDENTIFICATION: Report No. PG-61505.27-01; TAPG Project No. 224
DATE OF REPORT: 20 January 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general durability of Medium Tank T25E1
METHOD: The vehicle was operated 939 miles over an endurance route.
DESCRIPTION: The test Medium Tank T25E1, Ordnance Serial No. 32, was manufactured by the Fisher Tank Division of General Motors Corporation and weighed 78,040 pounds. It was powered by a Ford GAF, V-8, gasoline engine, and equipped with a torqumatic transmission, controlled differential, torsion bar suspension and Sheldrick, center-guide steel tracks. Main armament was a 90mm gun.
CONCLUSIONS: An excessive number of failures occurred during the test. Failures included the carburetor degassers, air cleaners, exhaust manifold, high temperature warning switch, transmission low oil pressure sending unit, radiator, cooling fan belt drive, transmission, differential oil pump assembly, brake linings, brakes, Sheldrick track, road wheel tires, road wheels and hubs, shock absorbers, compensating arm bearings, and gun recoil guard frame. Design changes were recommended to correct these deficiencies and to improve hull design and auxiliary engine installation.
GENERAL: This 122-page report includes 56 photographs of the tank and components.

SUBJECT: Tanks (Combat) PG-61505.28
TITLE: Endurance Test, Medium Tank M4A3 (76) W
IDENTIFICATION: Report No. PG-61505.28; TA PG Project No. 245
DATE OF REPORT: 6 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and performance characteristics of an early production Medium Tank M4A3
METHOD: The vehicle was operated 2000 miles (151 hours) over the endurance route at an average speed of 13.25 mph.
DESCRIPTION: The test Medium Tank M4A3, Ordnance Serial No. 43640, weighed 72,040 pounds. It was powered by a Ford GAA, V-8, gasoline engine rated 500 bhp at 2600 rpm and produced a maximum torque of 1100 lb.-ft. at 2200 rpm. The vehicle was originally equipped with rubber chevron Tracks T48. These were removed to permit testing of Tracks T74 and T62. Main armament was a 76mm gun.
CONCLUSIONS: The durability of the test tank was generally satisfactory. The following components, however, were faulty: original exhaust valves, intake and exhaust manifolds, and low oil pressure gage. Attachment of final drive sprockets to hubs was also unsatisfactory.
GENERAL: This 34-page report includes three photographs of failed tank components.

SUBJECT: Tanks (Combat) PG-61505.29
TITLE: Endurance Test of Medium Tank M4 (105MM)
IDENTIFICATION: Report No. PG-61505.29; TA PG Project No. 248
DATE OF REPORT: 12 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the general operating and durability characteristics of a production Medium Tank M4
METHOD: The vehicle was operated 2002 miles (170.6 hours) over endurance route at an average speed of 12 mph.
DESCRIPTION: The test Medium Tank M4 weighed 69,550 pounds. It was powered by a 9-cylinder, radial, air-cooled, series R975, Continental engine rated 485 bhp at 2400 rpm. The vehicle was originally equipped with rubber chevron Tracks T48. These were replaced at 485 miles by rubber-backed steel Tracks T14. Main armament was a 105mm howitzer.
CONCLUSIONS: The general operating and durability characteristics of the tank were satisfactory

except for the original engine, the T74 tracks, clutch, and sprockets. The engine failed after 979 miles due to metal chips in the oil pressure relief valve. Dust accumulation in the clutch was considered excessive and further test of the clutch cowl was recommended. The T74 Tracks failed after 971 miles due to loss of rubber over the pins. The sprockets were badly worn after 1456 miles, and the sprocket hub and cap screws required frequent tightening.
GENERAL: This 49-page report includes 20 photographs of the tank and failed components.

SUBJECT: Tanks (Combat) PG-61505.30
TITLE: Endurance Test of Medium Tank M4A3 (75) W
IDENTIFICATION: Report No. PG-61505.30; TA PG Project No. 246
DATE OF REPORT: 18 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and performance of a production M4A3 Medium Tank
METHOD: The vehicle accumulated 2013 miles of operation on the endurance course at an average speed of 12.4 mph. The course was rough and muddy during most of the test.
DESCRIPTION: The test production Medium Tank M4A3 was manufactured by the Fisher Tank Division of General Motors Corporation and was powered by a Ford GAA, V-8, gasoline engine. Standard rubber chevron Tracks T48 were replaced with steel Tracks T62 (Chrysler) for the purpose of testing several synthetic bogie tire compounds under another project. This vehicle was one of the first of a series with wet stowed ammunition.
CONCLUSIONS: In general, the durability and operating characteristics of the vehicle were considered satisfactory. However, numerous deficiencies occurred. Engine exhaust valves were replaced after 1577 miles because of burning and cracking. Other engine components and accessories failed. Many suspension components exhibited unsatisfactory characteristics. Initial inspection of the vehicle revealed considerable shell clip breakage in the wet stowed ammunition boxes, and water jacket drain plugs were subject to rusting in place. To overcome this rusting, non-ferrous plugs were recommended. The average fuel and oil economy of the vehicle was .517 mpg and 60.5 mpg, respectively.
GENERAL: This 52-page report contains 15 photographs of the vehicle and component failures.

SUBJECT: Tanks (Combat) PG-61505.32
TITLE: Endurance Test of Medium Tank M4A1 (76) W
IDENTIFICATION: Report No. PG-61505.32; TA PG Project No. 247
DATE OF REPORT: 18 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the performance and durability of a production Medium Tank M4A1
METHOD: The vehicle was operated over an endurance course for 2001 miles at an average speed of 12.6 mph.
DESCRIPTION: The test production Medium Tank M4A1, manufactured by the Pressed Steel Car Company, was powered by a Wright-Continental R975-C1, radial, air-cooled, gasoline engine. It was equipped with a 76mm gun and wet stowed ammunition boxes.
CONCLUSIONS: The performance and durability were generally satisfactory. Average fuel and oil economy was .468 and 24.8 mpg, respectively. Track and suspension were the weakest points. The original T51 Track failed at 638 miles. Five suspension volute springs failed during the test, four of them simultaneously at 1909 miles, and heavier springs were recommended for future production. Difficulty was experienced in removing the ammunition box water jacket drain plugs due to rusting, and a change from cast iron to brass plugs was suggested.
GENERAL: This 33-page report contains five photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-61505.33
TITLE: Test of Medium Tank M4A1 (76MM) Wet and Medium Tank M4A3 (105MM) Dry
IDENTIFICATION: Report No. PG-61505.33; Project No. 201
DATE OF REPORT: 22 August 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the suitability of the performance of Medium Tanks M4A1 and M4A3
METHOD: A Medium Tank M4A1 and a Medium Tank M4A3 were operated for 2000 and 1000 miles, respectively. Performance of special engine and vehicle components and the cooling characteristics of the vehicles were observed.
DESCRIPTION: The test Medium Tank M4A1, weighing 72,040 pounds, was powered by a Continental R975-C1, 9-cylinder, radial, air-cooled gasoline engine. Test equipment mounted on the vehicle included: a new electrical harness, located along the left sponson; Barber Colman after-swirl, diffuser vanes for aiding engine cooling characteristics; a high rpm engine idle control; water jacket enclosed ammunition compartments; and a new type gun elevating mechanism. The Medium Tank M4A3, weighing 69,720 pounds, was powered by a Ford GAA, V-8, liquid cooled, gasoline engine. An electrical harness, identical to that tested on the M4A1, was also tested on this vehicle; the harness was again located under the left sponson.
CONCLUSIONS: The high idle control used on the Medium Tank M4A1 and the electrical harness tested on both vehicles were considered satisfactory. Barber Colman after-swirl diffuser vanes, mounted on the M4A1 vehicle, failed as a result of excessive vibration set up by the failure of the engine cooling fan; because of this failure, no conclusions were drawn with reference to the vanes. The Medium Tank M4A1 water jacket enclosed ammunition compartments were in generally satisfactory condition after test; the new type gun elevating mechanism was difficult to mount in the vehicle, and it was recommended that various changes be made to improve mounting. Cooling characteristics

of both vehicles were satisfactory. Numerous R975 engine failures were observed after test; generally satisfactory performance was obtained with the GAA engines.
GENERAL: This 81-page report contains 22 photographs of the vehicles and related components. A drawing of a water jacket enclosed ammunition compartment is also included.

SUBJECT: Tanks (Combat) PG-61505.35
TITLE: Endurance Test of Medium Tank M4A3E2, 75W
IDENTIFICATION: Report No. PG-61505.35; TA PG Project No. 265
DATE OF REPORT: 30 August 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effect of increased weight on the durability of suspension components; the comparative durability of T48 and T74 Tracks; and the operation of the turret
METHOD: The test vehicle was operated over the standard endurance course for 2001 miles. During the first 162 miles, at 18 mph, the overloaded front suspension springs bottomed on rough terrain. To eliminate this condition, the remainder of the test was limited to 12 mph.
DESCRIPTION: The test Medium Tank M4A3E2, differed from the standard M4A3 in that additional armor was provided for the turret, upper hull, and final drive, bringing the weight to 84,850 pounds. The suspension was modified by the addition of rubber assist springs inside of each vertical volute spring. The original rubber chevron Tracks T48 were replaced at 1132 miles by a set of Tracks T74 which were steel, rubber-backed, with extended end connectors.
CONCLUSIONS: The standard M4 vertical volute suspension was unsatisfactory for use with the vehicle. The rubber assist springs were unsatisfactory and not recommended for future use. Operation of the turret was satisfactory. Although the T74 Track did not operate to failure, inspection indicated that the life was comparable to the T48. Disc bogie wheels used to replace the front spoke-type wheels at 162 miles operated satisfactorily and were recommended for use. Considering the increased vehicle weight, bogie tire life was adequate. Suspension arm and liner rubbing plates exhibited excessive wear, and corrective measures were recommended.
GENERAL: This 50-page report contains 21 photographs of the vehicle and damaged components.

SUBJECT: Tanks (Combat) PG-61505.36
TITLE: Endurance Test of Medium Tank M4A2, (76) W
IDENTIFICATION: Report No. PG-61505.36; TA PG Project No. 249
DATE OF REPORT: 19 September 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and the performance characteristics of the Medium Tank M4A2
METHOD: The vehicle was operated over a standard endurance course for 2000 miles. A performance test was conducted at completion of the endurance operations.
DESCRIPTION: The test Medium Tank M4A2 was manufactured by the Fisher Tank Division of General Motors Corporation and weighed, with ballast and crew allowance, 74,530 pounds. It was powered by two GM 6046 diesel engines which were modified with Buna-S vibration dampers.
CONCLUSIONS: The durability and performance characteristics of the vehicle were considered satisfactory, except for the operation of the right engine. This engine was removed at 375 and at 1374 miles for overhauling. In both cases the compression rings were excessively worn or broken, and cylinder liners scored. The failures were attributed to dirt entering through the air cleaners rather than to faulty engine design. The left engine operated satisfactorily throughout the test.
GENERAL: This 39-page report contains 10 photographs showing the vehicle and the condition of the right front air cleaner, air cleaner seals, and scored piston and sleeve.

SUBJECT: Tanks (Combat) PG-61505.37
TITLE: Inspection Control Test — Medium Tank M4A4
IDENTIFICATION: Report No. PG-61505.37; TA PG Project No. 150-3
DATE OF REPORT: 25 September 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the performance and endurance characteristics of the test vehicle
METHOD: The tank was operated in accordance with Inspection Control Test procedure modified to cover a 2000-mile cross-country endurance run. Various performance characteristics such as acceleration and deceleration, brake stopping distances, drawbar pull, and maximum speed, were checked during the operation.
DESCRIPTION: The test vehicle was a Medium Tank M4A4, remanufactured at the Detroit Tank Arsenal.
CONCLUSIONS: The vehicle completed the 2000-mile endurance test with relatively few deficiencies. The suspension system had the most component failures; however, considering the past performance, the type and rate of failures were considered normal.
GENERAL: This 18-page report contains five photographs of the tank and failed components.

SUBJECT: Tanks (Combat) PG-61505.40
TITLE: Inspection Control Test — M4 Medium Tank
IDENTIFICATION: Report No. PG-61505.40; TA PG Project No. 150-9
DATE OF REPORT: 12 May 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a remanufactured M4 Medium Tank
METHOD: The tank was operated 2000 miles over

the endurance course. Acceleration tests were conducted every 500 miles. Brake stopping distance from 20 mph maximum speed, and drawbar pull in 5th gear (wide open throttle) were determined at start and end of the test. Engine blowby and compression pressures were determined at 1000 mile intervals.
DESCRIPTION: The test vehicle was a Medium Tank M4 remanufactured by the Evansville Ordnance Plant. It was equipped with a Continental R975-C1 engine, T54E1 Tracks, and a vertical volute spring suspension system. Main armament was a 75mm gun.
CONCLUSIONS: The tank was considered unsatisfactory because of failures in the suspension units. Thirty-two track blocks and 14 natural rubber bogie tires failed at an average of 1500 and 1167 miles. The track support roller shafts caused trouble, and two volute springs failed at 1607 test miles.
GENERAL: This 21-page report contains six photographs of the vehicle and failed parts.

SUBJECT: Tanks (Combat) PG-61505.41
TITLE: Inspection Control Test — M4A4 Medium Tank (Remanufactured)
IDENTIFICATION: Report No. PG-61505.41; Project No. 150-7
DATE OF REPORT: 17 November 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a remanufactured M4A4 Medium Tank
METHOD: The vehicle was operated 2000 miles over the endurance course. Acceleration tests were conducted at 500-mile intervals. Brake stopping distance, drawbar pull, and engine compression pressures were measured at the beginning and end of the test. Engine blowby was measured at 1000-mile intervals. Trunnion friction, angle of elevation and traverse of 75mm gun mount, and turret speed with the vehicle level and on a 45% grade were determined.
DESCRIPTION: The test Medium Tank M4A4 was manufactured by the Chrysler Corporation and was powered by a Chrysler multi-bank gasoline engine. It was equipped with a 75mm gun, vertical volute spring suspension, and a double pin, interrupted-parallel grouser, steel Track T49.
CONCLUSIONS: Vehicle performance exceeded all specifications, and the 2000-mile endurance operation was relatively trouble-free except for failures in the suspension system. Eleven natural rubber bogie tires failed at an average of 847 miles; five synthetic tires failed at an average of 818 miles; and five end connectors were replaced at 818 miles.
GENERAL: This 19-page report contains seven photographs of the vehicle and damaged parts.

SUBJECT: Tanks (Combat) PG-61505.42
TITLE: Endurance Test of Light Tank M24
IDENTIFICATION: Report No. PG-61505.42; TA PG Project No. 264
DATE OF REPORT: 13 December 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of an M24 Light Tank
METHOD: The vehicle was operated a total of 3994 miles over an endurance test route.
DESCRIPTION: The test Light Tank M24 was manufactured by the Cadillac Motor Car Company and weighed 40,520 pounds. It was powered by twin Cadillac engines and equipped with hydramatic transmissions.
CONCLUSIONS: The durability and performance of the vehicle in general were satisfactory. Operation of the two Cadillac engines was satisfactory with minor difficulties encountered in the ignition and fuel systems. It was recommended that the distributor cover sealing be improved to prevent dirt from entering and causing misfiring. It was further recommended that a manual or automatic device be provided to shut off the gasoline supply at each carburetor in case of engine stalling. Vibration of the engine firewall to which the generator regulators were mounted was found to cause malfunctioning of the units. There were 10 shock absorber failures, nine track wheel tire failures, and six track wheel failures. Suggestions were made to improve the service life of the shock absorbers, tires, and wheels.
GENERAL: This 79-page report contains 28 photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.43
TITLE: Proof Tests and Check-Up of Medium Tank, T26
IDENTIFICATION: Report No. PG-61505.43; TA PG Project No. 624
DATE OF REPORT: 16 December 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To conduct break-in operational tests and check-up of Medium Tank T26, and to determine the weight and load distribution with the 90mm gun in forward and rear positions
METHOD: The vehicle was operated a total of 108 miles over the endurance test route. Six loadometer scales were used to obtain the basic stowed, and combat weight and load distribution of the tank.
DESCRIPTION: The test pilot Medium Tank T26 was armed with a 90mm gun and equipped with torsion bar suspension and rear sprocket drive.
CONCLUSIONS: The operation of the vehicle was very satisfactory with only two minor failures occurring during the test. The basic weight of the test vehicle was 89,695 pounds; the stowed weight was 94,250 pounds; and the combat weight was 95,110 pounds.
GENERAL: This 23-page report contains eight photographs of the vehicle and weight distribution data.

SUBJECT: Tanks (Combat) PG-61505.44
TITLE: Medium Tank M4 (105) Equipped with Horizontal Volute Spring Suspension and T80 Track (2000 Mile Durability Test)
IDENTIFICATION: Report No. PG-61505.44; TA PG Project No. 316

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 17 January 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To conduct a 2000-mile durability test of a standard production Medium Tank M4 equipped with horizontal volute spring suspension and rubber-backed steel tracks
METHOD: The vehicle was loaded to a gross weight of 75,360 pounds and was operated 2004 miles over the endurance test route.
DESCRIPTION: The test vehicle was a standard production Medium Tank M4 (105mm gun) with the exception of minor changes in the fuel and ignition systems. It was equipped with horizontal volute spring Suspension E8 and rubber-backed, steel, Track T80.
CONCLUSIONS: Generally, the tank operated satisfactorily. Detailed observations and recommendations affecting various components are included in the report. The greatest trouble was encountered with the shock absorbers of the E8 Suspension which had an average life of 590 miles. Further development was recommended in this field.
GENERAL: This 30-page report includes six photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.45
TITLE: Inspection Control Test — Medium Tank M4
IDENTIFICATION: Report No. PG-61505.45; TAPG Project No. 150-12
DATE OF REPORT: 8 February 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a remanufactured Medium Tank M4
METHOD: The vehicle was operated 2000 miles over the endurance route. Engine blowby and engine compression pressures were checked every 1000 miles. Turret speed on level and 45° slope, trunnion friction and angle of elevation of the 75mm gun mount were measured.
DESCRIPTION: The test Medium Tank M4 was manufactured by the International Harvester Company and powered by a Continental R975-C1, radial, air-cooled, gasoline engine. It was equipped with T54E1 Tracks, vertical volute spring suspension and a 75mm gun.
CONCLUSIONS: The vehicle was considered unsatisfactory because of failures of the suspension components, and to a lesser degree, because of failures of engine units. Among the suspension component failures were 53 track blocks, 12 bogie tires, six volute springs and numerous track support rollers. Failures of engine units included the supercharger drive, spark plug terminals, booster coil mounting bracket, engine cowling, fuel gage, and tachometer drive gears.
GENERAL: This 25-page report contains 11 photographs of the vehicle and damaged parts.

SUBJECT: Tanks (Combat) PG-61505.46
TITLE: Inspection Control Test, Medium Tank, M4 (Remanufactured)
IDENTIFICATION: Report No. PG-61505.46; TAPG Project No. 150-12
DATE OF REPORT: 2 February 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a remanufactured M4 Medium Tank
METHOD: The vehicle was operated 2000 miles over the endurance course. Acceleration tests were conducted and engine blowby and compression pressures were measured every 1000 miles. Brake stopping distance from 20 mph maximum speed, and drawbar pull were obtained at start and end of test. Trunnion friction, maximum turret speed on level and 30% slope, and the 75mm gun mount angle of elevation were determined.
DESCRIPTION: The test Medium Tank M4 was remanufactured by the International Harvester Company and powered by a Continental R975-C1, radial, air-cooled, gasoline engine. It was equipped with T54E1 Tracks, vertical volute spring suspension, and a 75mm gun.
CONCLUSIONS: The vehicle was considered unsatisfactory because of numerous suspension failures. Twenty track shoes, 16 natural rubber bogie tires, and four volute suspension springs failed during the 2000-mile test. Difficulty was also experienced with the power train and electrical system.
GENERAL: This 25-page report contains 11 photographs of the vehicle and damaged parts.

SUBJECT: Tanks (Combat) PG-61505.47
TITLE: Inspection Control Test — Medium Tank M4A1
IDENTIFICATION: Report No. PG-61505.47; TAPG Project No. 150-14
DATE OF REPORT: 8 February 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a remanufactured M4A1 Medium Tank
METHOD: The vehicle was operated 2000 miles over the endurance course. Tests were conducted on acceleration every 500 miles; maximum speed, drawbar pull at 1500 rpm, wide open throttle, and brake stopping distance from 20 mph were determined at beginning and end of test: and engine blowby and compression pressures were taken at 1000 mile intervals. Trunnion friction and maximum turret speed on level and 30% grade were measured.
DESCRIPTION: The test Medium Tank M4A1 was remanufactured by the Evansville Ordnance Plant and was powered by a Continental R975-C1, radial, air-cooled, gasoline engine. It was equipped with a 75mm gun, T54E1 Tracks, and vertical volute spring suspension.
CONCLUSIONS: The vehicle was considered unsatisfactory because of recurrent failures in the suspension system during the last 1000 miles. Thirty-four track blocks were replaced at an average of 1696 miles. All but one of the original natural rubber bogie tires failed at an average of 945 miles; five volute springs failed at an average of 1283 miles; and other failures occurred in the track support roller shafts, bogie arm rubbing

plates, and suspension brackets.
GENERAL: This 23-page report contains nine photographs of the vehicle and failed parts.

SUBJECT: Tanks (Combat) PG-61505.49
TITLE: Inspection Control Test — Medium Tank M4A3 (75) Remanufactured
IDENTIFICATION: Report No. PG-61505.49; TAPG Project No. 150-18
DATE OF REPORT: 10 March 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of a remanufactured M4A3 Medium Tank
METHOD: The vehicle was operated 2000 miles over the endurance course. Performance tests were made to determine acceleration characteristics, drawbar pull in fifth gear, and brake stopping distances at the start and the end of the test. Engine blowby and compression pressures were measured every 1000 miles. Trunnion friction and turret speed on level and 30% grade were determined.
DESCRIPTION: The test Medium Tank M4A3 was remanufactured by the Montreal Locomotive Works and powered by a Ford GAA, V-8, gasoline engine. It was equipped with a 76mm gun, T49 Tracks, and vertical volute spring suspension.
CONCLUSIONS: The vehicle operated with an average amount of failures. Twenty-four track blocks and three bogie tires failed at an average of 1522 miles and 1529 miles, respectively. Five volute springs failed at an average of 1400 miles. Minor troubles were also experienced with the power train and engine. The vehicle stopping distance did not meet specifications.
GENERAL: This 21-page report contains six photographs of the tank and failed parts.

SUBJECT: Tanks (Combat) PG-61505.50
TITLE: Inspection Control Test, Medium Tank M4A1 (Remanufactured)
IDENTIFICATION: Report No. PG-61505.50; TAPG Project No. 150-20
DATE OF REPORT: 13 March 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the acceptability of a remanufactured Medium Tank M4A1
METHOD: The vehicle was tested according to standard inspection control test procedure modified to include 2000 miles of endurance testing. The test procedure included the following: a mechanical inspection and determination of performance characteristics, engine blow-by and compression pressures, gun trunnion friction, and turret speed.
DESCRIPTION: Test Medium Tank M4A1, Ordnance Serial No. 7210, was remanufactured by the International Harvester Company and weighed 68,050 pounds. It was powered by a 9-cylinder, radial, air-cooled, Continental R975-C1 engine.
CONCLUSIONS: The vehicle was fairly satisfactory except for the T74 rubber chevron tracks and the loosening of many bolts in the suspension system.
GENERAL: This 19-page report includes four photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.51
TITLE: Inspection Control Test, Light Tank M5A1 (Remanufactured)
IDENTIFICATION: Report No. PG-61505.51; TAPG Project No. 150-19
DATE OF REPORT: 14 March 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the acceptability of a remanufactured Light Tank M5A1
METHOD: The vehicle was tested according to standard inspection control test procedure modified to include 2000 miles of endurance operation. The test procedure included the following: a mechanical inspection and determination of performance characteristics, engine blow-by and compression pressures, gun trunnion friction and turret speed.
DESCRIPTION: The test Light Tank M5A1, Ordnance Serial No. 3773, was remanufactured by the American Car and Foundry Company and weighed 33,920 pounds. It was powered by twin V-8 Cadillac engines and equipped with hydramatic transmissions.
CONCLUSIONS: Except for the suspension system, the vehicle exhibited satisfactory performance and durability characteristics.
GENERAL: This 18-page report includes six photographs of the tank and failed suspension elements.

SUBJECT: Tanks (Combat) PG-61505.53
TITLE: Endurance Test of Light Tank M24 Incorporating Latest Production Changes
IDENTIFICATION: Report No. PG-61505.53; TAPG Project No. 318
DATE OF REPORT: 10 April 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability and performance of a modified Light Tank M24
METHOD: The vehicle was given a mechanical inspection, ballasted to test weight, and operated for 200 hours over the endurance course, covering 3639 miles.
DESCRIPTION: The test production Light Tank M24, Ordnance Serial No. 768, was manufactured by the Cadillac Motor Car Company and weighed 40,510 pounds. It was powered by two Cadillac, V-8, gasoline engines and equipped with hydramatic transmissions and a steel T72 Track. Special equipment included experimental high resistance Monroe shock absorbers, two Zenith fuel filters, and Inland T72 Tracks with special bushings (first 2291 miles).
CONCLUSIONS: The durability and performance of the vehicle proved very satisfactory. There were no failures in the hydramatic transmissions. The Zenith fuel filters were satisfactory, and were recommended for use. The experimental shock absorbers were unsatisfactory and a means of increasing their life was recommended. Improvement was also recommended for the track wheels.

Nine reinforcing rings and nine dust shields broke away from the wheels during the test.
GENERAL: This 67-page report includes seven photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-61505.54
TITLE: Inspection Control Test Medium Tank, M4A1 (Remanufactured)
IDENTIFICATION: Report No. PG-61505.54; TAPG Project No. 150-23
DATE OF REPORT: 14 April 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine any manufacturing and design deficiencies in a remanufactured Medium Tank M4A1
METHOD: The vehicle was tested according to the standard inspection control test procedure modified to include 2000 miles of endurance operation.
DESCRIPTION: The test Medium Tank M4A1, remanufactured by the Evansville Ordnance Plant, was powered by a Continental R975-C1 engine and weighed 71,140 pounds.
CONCLUSIONS: The vehicle was considered satisfactory. No serious failures occurred during the test.
GENERAL: This 16-page report includes four photographs of the vehicle and components.

SUBJECT: Tanks (Combat) PG-61505.55
TITLE: Inspection Control Test Light Tank M5A1 (Remanufactured)
IDENTIFICATION: Report No. PG-61505.55; TAPG Project No. 150-25
DATE OF REPORT: 18 April 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the performance and durability of Light Tank M5A1 (Remanufactured)
METHOD: The vehicle was tested according to the standard inspection control test procedure modified to include 2000 miles endurance operation.
DESCRIPTION: The test Light Tank M5A1 was remanufactured by the American Car and Foundry Company and weighed 33,640 pounds. It was powered by two, Cadillac, V-8, gasoline engines and equipped with hydramatic transmission and a 37mm gun.
CONCLUSIONS: The vehicle was very satisfactory in operation and durability. The most serious discrepancy was the engine unit. It was necessary to rebuild the engine at 762 miles because of a bearing and crankshaft failure. An oversize bearing cap was believed to be the cause. Four volute springs failed in an active coil at an average of 1320 miles.
GENERAL: This 13-page report includes three photographs of the vehicle and a component failure.

SUBJECT: Tanks (Combat) PG-61505.56
TITLE: Facility Vehicle Report M4A1 (76W) Medium Tank
IDENTIFICATION: Report No. PG-61505.56
DATE OF REPORT: 30 April 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of the Medium Tank M4A1 (76W) serial No. 67901, used as a facility vehicle at the Tank Arsenal Proving Ground, during the period from 13 January 1945 to 23 April 1945
METHOD: Ten projects were carried out while the tank was used as a facility vehicle. A log of experimental installations and repairs made on the test vehicle during these ten projects was recorded. A total of 4,045 miles was accumulated on this facility vehicle. Experimental installations for testing were made under the various projects.
DESCRIPTION: The Medium Tank M4A1 (76W), Ordnance Serial No. 67901, manufactured by the Pressed Steel Car Company, was equipped with horizontal volute suspension (E8) and T-80 center guide tracks.
CONCLUSIONS: Conclusions and recommendations were listed under the individual test projects, and not included in this facility report.
GENERAL: This 39-page report includes six photographs of the vehicle and component failures, test facility log sheets, weight report, and mechanical inspection report.

SUBJECT: Tanks (Combat) PG-61505.57
TITLE: Facility Vehicle Report, M4A3 (76W) Medium Tank
IDENTIFICATION: Report No. PG-61505.57
DATE OF REPORT: 16 May 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of a Medium Tank M4A3 while used as a facility vehicle from 22 November 1944 to 5 May 1945
METHOD: Various experimental material was installed and tested on the vehicle during 4508 miles of operation.
DESCRIPTION: The test facility Medium Tank M4A3 was manufactured by the Chrysler Corporation, powered by a Ford GAA, V-8, gasoline engine, and equipped with horizontal volute spring Suspension E8.
CONCLUSIONS: Since this report was written to provide an operation record, no recommendations or conclusions were made. However, the log sheets indicated certain difficulties encountered during the test operation. At 2571 miles, the oil pan was found broken on both sides and the cylinder block cracked. Removal of the oil pan revealed that No. 2 connecting rod was broken and related parts worn or damaged. Bearing liner halves of No. 1 left- and right-rods were completely scored of (silver) bearing metal. A new standard engine was installed. Sprocket wear and tooth breakage, transmission failure, and failure directly related to the various experimental units tested were also noted in the log. More comprehensive data on the experimental material tested were provided in the individual project reports. Average speed during the testing was 14.9 mph; fuel economy, 0.558 mpg; and oil economy, 61.1 mpg.
GENERAL: This 38-page report contains five photographs of failed components.

SUBJECT: Tanks (Combat) PG-61505.58
TITLE: Facility Vehicle Report — M4A3 (74W) Medium Tank
IDENTIFICATION: Report No. PG-61505.58
DATE OF REPORT: 29 May 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of the test vehicle while used as a facility vehicle, 11 February 1945 to 16 May 1945
METHOD: Various experimental material was installed and tested on the facility vehicle during 2638 miles of operation at Tank Arsenal Proving Ground.
DESCRIPTION: The facility vehicle, Medium Tank M4A3, was manufactured by the Fisher Tank Division and was equipped with a Ford GAA engine and a T51 Track. Total weight with ballast and crew allowance was 75,960 pounds.
CONCLUSIONS: Since this report was written as an operation record, no conclusions or recommendations were made. However, the log sheets indicated that certain difficulties were encountered. At 1885 miles, the original engine was replaced because of a crankshaft failure. At 1448 miles left final drive gear and pinion teeth stripped; fine chips apparently worked into the differential. The differential, transmission, and final drive assembly were replaced. Generally, the performance and durability characteristics of the standard components were normal. More comprehensive data on the various experimental material tested was provided in individual project reports. Average speed during the testing was 12.9 mph; fuel economy, 0.490 mpg; oil economy, 36.2 mpg.
GENERAL: This 35-page report contains six photographs of the vehicle and failed components, lubrication record, weight report, specification characteristics data, and three pages of mechanical inspection data.

SUBJECT: Tanks (Combat) PG-61505.62
TITLE: Facility Vehicle Report — M4A3 (76W) Medium Tank
IDENTIFICATION: Report No. PG-61505.62
DATE OF REPORT: 23 July 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of a Medium Tank M4A3 while used as a facility vehicle from 22 March 1945 to 9 July 1945
METHOD: Various experimental material was installed and tested on the vehicle during 3001 miles of operation.
DESCRIPTION: The test facility Medium Tank M4A3 was manufactured by the Chrysler Corporation and powered by a Ford GAA, V-8, gasoline engine. It was equipped with Tracks T80 which had forged extended end connectors.
CONCLUSIONS: Since this report was written to provide an operation record, no recommendations or conclusions were made. However, the log sheets indicated that the performance and durability of the standard components were normal for the type of operation. More comprehensive data on the various experimental material tested were provided in individual project reports. Average speed during the test was 14.5 mph; fuel economy, 0.515 mpg; oil economy, 62.5 mpg.
GENERAL: This 32-page report contains six photographs of the vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.63
TITLE: Facility Vehicle Report — M24 Light Tank
IDENTIFICATION: Report No. PG-61505.63
DATE OF REPORT: 12 July 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of the test vehicle while used as a facility from 25 April 1945 to 22 June 1945
METHOD: A set of T72E1 Tracks with 24-inch grousers was installed on a Light Tank M24 and operated for 1492 miles at Tank Arsenal Proving Ground. The vehicle had been operated 1000 miles prior to this test.
DESCRIPTION: The facility vehicle, Light Tank M25, was manufactured by General Motors and equipped with a dual Cadillac V-8 engine installation. Total weight with ballast and crew allowance was 40,680 pounds.
CONCLUSIONS: Since this report was written to provide an operation record of a facility vehicle, no recommendations or conclusions were made. However, the log sheets indicated certain difficulties encountered during the test operation. At 2348 miles, the left engine was replaced because the No. 6 cylinder exhaust valve head had broken off, damaging the valve seat. At 2493 miles, the right engine failed and the vehicle was overhauled for shipment to another center. Failure was traced to the pounding-out of No. 8 rod bearing. At 2291 miles the transfer case right idler input gear shaft bearing burned out necessitating the replacement of the transfer case. A new set of standard final drive sprockets was installed at 1740 miles due to excessive tooth wear on original sprockets. Certain failures and deficiencies were also noted in the ignition system. During the test operation, average speed was 14.1 mph; fuel economy, 0.591 mpg; and oil economy, 119.5 mpg.
GENERAL: This 28-page report contains nine photographs of the vehicle and failed components, a lubrication record, and a weight report.

SUBJECT: Tanks (Combat) PG-61505.64
TITLE: Facility Vehicle Report — M4A2 (76W) Medium Tank
IDENTIFICATION: Report No. PG-61505.64
DATE OF REPORT: 23 July 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a record of the operation of facility Medium Tank M4A2
METHOD: The vehicle was operated for 3991 miles during the following projects: project No. 346, service test of 8T storage batteries; project No. 350, generator mounting bracket; project Nos. 356-5 and 357-9, shock absorbers; project No. 360, T80 Track block sections; project No. 364, experi-

mental end connectors; and project No. 370, road wheels.
DESCRIPTION: The test Medium Tank M4A2, Ordnance Serial No. 64925, was manufactured by the Fisher Tank Division of General Motors Corporation and weight, with ballast and crew allowance, was 80,450 pounds. It was powered by a GM 6046, dual diesel engine.
CONCLUSIONS: Since this report was written as an operation record, no conclusions or recommendations were made. However, the log indicated that the original engine operated throughout the 3991 miles. Considerable difficulty was encountered during the test with the fuel injection system. At 3887 miles, No. 12 exhaust valve head of the right engine was found bent; the stem scuffed and the lower end of the valve guide broken. After failure was repaired, excessive knocking occurred and an inspection revealed that the No. 4 cylinder liner had dropped down and was broken by the connecting rod. All pistons, cylinder liners, and blower rotors were in various stages of failure. At 3896 miles, the right engine connecting rod bearings were found gritty; the main bearings scored; and the crankshaft journal surfaces wore out due to bearing failure. Average speed during the testing was 15.7 mph; fuel economy, 0.681 mpg; and oil economy 179.4 mpg. The performance and durability characteristics of the other standard components were normal.
GENERAL: This 36-page report contains six photographs of the test vehicle and failed engine components, 19 log sheets, a lubrication record, mechanical inspection data, and a weight report.

SUBJECT: Tanks (Combat) PG-61505.65
TITLE: Facility Vehicle Report: M4A3 (76W) Medium Tank, Reg No. W-3031773, Serial No. 59910
IDENTIFICATION: Report No. PG-61505.65
DATE OF REPORT: 31 July 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation and performance of facility Medium Tank M4A3E8 during several tests of various components.
METHOD: The vehicle was subjected to a total of 1591 miles (112.1 engine hours) of testing at an average speed of 14.2 mph.
DESCRIPTION: The test Medium Tank M4A3E8, Serial No. 59910, was manufactured by the Chrysler Corporation and powered by a Ford GAA, V-8, gasoline engine. It was equipped with a 76mm gun, horizontal volute spring suspension, and wet ammunition stowage. The vehicle was standard except for the following test components: tracks, shock absorbers, pistons, oil rings, valves, final drive (with low level oiling system), and Auto-Lite high capacity batteries.
CONCLUSIONS: Average fuel and oil economy during this period was .483 and 63.6 mpg, respectively. Operation of the vehicle was generally satisfactory with no major failures of the standard components. The test components were reported under projects No. 381, 396, 397 and 655.
GENERAL: This 23-page report is not illustrated. It consists of test and inspection logs covering the above operation.

SUBJECT: Tanks (Combat) PG-61505.67
TITLE: Inspection Control Test, Heavy Tank T26E3
IDENTIFICATION: Report No. PG-61505.67; TAPG Project No. 150-22
DATE OF REPORT: 8 August 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine both design and manufacturing deficiencies (combined engineering-inspection control test) on a developmental Heavy Tank T26E3
METHOD: The vehicle was subjected to 2076 miles (141 engine hours) of testing. Periodic performance tests were made and compared with the results of similar tests of an M4A3 Medium Tank loaded to the weight of the T26E3. Failures were differentiated as resulting from manufacturing or design deficiencies, to meet the dual purpose of this test.
DESCRIPTION: The test vehicle was a T26E3 Heavy (90mm gun) Tank, manufactured by Fisher Tank Division at Grand Blanc, Michigan. The power train comprised a Ford V-8 engine, model GAF, and a Detroit Transmission Division Torqmatic (hydraulic torque converter) transmission. The current combat weight was 92,000 pounds and the vehicle was performance-tested both at this weight and at a proposed combat weight of 102,000 pounds. The M4A3 tank was tested for comparative performance at both these weights. The endurance operation was at the higher weight.
CONCLUSIONS: Average fuel and oil mileages were .402 and 45.5 mpg, respectively. In the performance tests (acceleration, drawbar pull, fuel consumption, top speed and braking distance) the M4 tank was superior in everything except low-speed drawbar pull. Various manufacturing and/or design deficiencies were discovered and tabulated.
GENERAL: This 153-page report contains 20 photographs of the tank and various component failures. Tables of deficiencies and performance data are included.

SUBJECT: Tanks (Combat) PG-61505.68
TITLE: Endurance Test of Two Heavy Tanks T26-E3
IDENTIFICATION: Report No. PG-61505.68; TAPG Project No. 361
DATE OF REPORT: 21 August 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the durability of Heavy Tank T26E3
METHOD: The tank was ballasted to 91,985 pounds and operated 3093 miles on an endurance course. Various component tests were conducted on this vehicle during the endurance operation and were reported separately.
DESCRIPTION: The test Heavy Tank T26E3 was an early experimental model.
CONCLUSIONS: Operation of the vehicle was

generally satisfactory except for the engine oil pressure sending unit, final drive oil seals, sprocket hubs and differential oil pump drive shaft. Difficulty was experienced with clogged radiators, and modification of the shroud was recommended. Relocation of the oil pressure sending unit, modified final drive oil seals, and closer fit of sprocket hubs were recommended. A new differential oil pump drive shaft with splined instead of serrated end was also recommended.
GENERAL: This 69-page report contains 15 photographs of the test vehicle and failed components.

SUBJECT: Tanks (Combat) PG-61505.69
TITLE: Facility Vehicle Report — M4 (75) Medium Tank, Reg. No. W-3,015,0635, Serial No. 307
IDENTIFICATION: Report No. PG-61505.69
DATE OF REPORT: 6 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of Medium Tank M4, Ordnance Serial No. 307, on four test projects
METHOD: This medium Tank was operated 2231 miles at an average speed of 14 mph on the following test projects: Project No. 317 — Modified T74 Rubber Backed Tracks with 1-1/2-inch grousers — Medium Tank M4 Series; Project No. 331 — Carburetor Revisions — Model NAR-9G Stromberg Carburetor, Continental R975 Engine; Project No. 358 — Field Tests of Crude and Synthetic Rubber Motor Mounts — Part No. A-186297; and Project No. 630 — Test of Medium Tank Track Equipped with Extended End Connectors and 37 inch wide Detachable Grousers.
DESCRIPTION: The test Medium Tank M4 was remanufactured by the Chrysler Corporation and weighed 64,560 pounds. It was powered by a 9-cylinder, air-cooled, radial, R975-C1 Continental engine and carried a 75mm gun and two .30 caliber machine guns.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual reports and are not included here. The original tank engine failed after 2235 miles and was replaced.
GENERAL: This 22-page report includes five photographs of the tank and components and seven sheets of operational logs.

SUBJECT: Tanks (Combat) PG-61505.70
TITLE: Facility Vehicle Report, M4A3 (76W) Medium Tank, Registration No. W-3,099,874 Serial No. 43640
IDENTIFICATION: Report No. PG-61505.70
DATE OF REPORT: 10 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the use to which this tank was subjected while used during different test projects
METHOD: The vehicle was operated for a total of 340 miles on the following projects: No. 366 — Experimental Tow Bar Tests; No. 382 — Test of Revised Pintle Adapter L-1193 and L-1196; and No. 653 — Mine Field Gap Marker Equipment.
DESCRIPTION: The test Medium Tank M4A3, Ordnance Serial No. 43640, weighed 69,090 pounds. It was powered by a V-8 Ford engine, carried a 76mm gun, and was equipped with T49 cast steel tracks.
CONCLUSIONS: Conclusions and recommendations covering each test were included in individual reports of the test and were not included in this facility report.
GENERAL: This 18-page report includes two photographs of the tank and 10 log sheets.

SUBJECT: Tanks (Combat) PG-61505.71
TITLE: Facility Vehicle Report M4A1 (76W) Medium Tank, Registration No. W-30, 126,755, Serial No. 88775
IDENTIFICATION: Report No. PG-61505.71
DATE OF REPORT: 19 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of a Medium Tank M4A1 while used on 10 test projects
METHOD: The vehicle accumulated 2528 miles of test operation while on the following projects: Nos. 381 and 669 (tracks); No. 331 (carburetor revisions); No. 358 (rubber motor mounts); No. 377 (bogie wheel bearing seals); No. 387 (shock absorbers); No. 394 (clutch); No. 413 (rear idler and bracket assembly); No. 420 (spark plugs); and No. 655 (batteries).
DESCRIPTION: The test Medium Tank M4A1, Serial No. 88776, was manufactured by the Pressed Steel Car Company and weighed 72,700 pounds. It was powered by a Continental R975-C1 engine and carried a 76mm gun.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual project reports and are not included in this report. No major vehicle failures were encountered during its use.
GENERAL: This 31-page report contains one photograph of the crankcase oil breather and 18 log sheets.

SUBJECT: Tanks (Combat) PG-61505.72
TITLE: Facility Vehicle Report M4A3 (76W) Medium Tank, Registration No. W-30,114,268, Series No. 61246
IDENTIFICATION: Report No. PG-61505.72
DATE OF REPORT: 24 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of facility Tank M4A3 while used on different test projects
METHOD: The vehicle accumulated a total of 6870 miles while on the following projects: Nos. 325, 329, 331, 399, 422, 633, 643, 659, and 663.
DESCRIPTION: The test Medium Tank, Ordnance Serial No. 43640, weighed 71,170 pounds and was manufactured by the Detroit Tank Arsenal. It was powered by a V-8 Ford engine, carried a 76mm gun, and was equipped with T66 Tracks.

CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual project reports and were not included in this report. Major vehicle component failures included broken teeth in the differential, worn out transmission synchronizer cones, broken suspension arms, failed bogie tires, and broken volute springs.
GENERAL: This 50-page report includes four photographs of the tank, a weight report, and 35 log sheets.

SUBJECT: Tanks (Combat) PG-61505.73
TITLE: Facility Vehicle Report M4A3 (76W) Medium Tank, Registration No. 3-30, 123, 328, Serial No. 67592
IDENTIFICATION: Report No. PG-61505.73
DATE OF REPORT: 6 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of facility Medium Tank M4A3 while used on different test projects
METHOD: The vehicle accumulated a total of 656 miles while on the following projects: No. 377 (Various Bogie Wheel Bearing Seals — Medium Tank M4 Series); No. 378 (Redesign Cuno Hand-Operated Oil Strainer); No. 395 (Delco-Remy Battery Test — Glass Separators); and No. 666 (Test of T84 Track with 1-1/2" Chevron).
DESCRIPTION: The test Medium Tank M4A3, Ordnance Serial No. 67592, weighed 72,770 pounds. It was powered by a V-8 Ford engine, carried a 76mm gun and was equipped with T80 center guide tracks.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual project reports and not in this facility report. The vehicle suffered no major failure throughout the individual tests.
GENERAL: This 15-page report includes six pages of logs and is not illustrated.

SUBJECT: Tanks (Combat) PG-61505.74
TITLE: Facility Vehicle Report
IDENTIFICATION: Report No. PG-61505.74
DATE OF REPORT: 17 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of facility Medium Tank M4A3E8 while used on different test projects
METHOD: The vehicle was operated a total of 4752 miles. Thirteen sub-project tests were conducted on various suspension and engine parts.
DESCRIPTION: The test Medium Tank M4A3E8, Serial No. 677666, was manufactured by the Detroit Tank Arsenal. It was equipped with a Ford GAA, V-8, gasoline engine and T66 Tracks.
CONCLUSIONS: Conclusions and recommendations covering each test were included in the individual project reports and not in this facility report. Numerous suspension failures occurred such as bogie tires and volute springs. Trouble was also encountered with the engine overheating because of loss of coolant and a faulty radiator cap.
GENERAL: This 38-page report contains six photographs of the vehicle and damaged parts and a log of repairs.

SUBJECT: Tanks (Combat) PG-61505.75
TITLE: Facility Vehicle Report, M4A3 Medium Tank, Registration No. W-30,123,413
IDENTIFICATION: Report No. PG-61505.75
DATE OF REPORT: 10 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of facility M4A3 Medium Tank while used on different test projects
METHOD: The vehicle was operated a total of 5424 miles. Project tests were conducted on shock absorbers, forged extended end connectors, spark plugs, tracks; and engines with experimental pistons, exhaust valves, oil control rings, and "Heli-Coil" inserts.
DESCRIPTION: The test Medium Tank M4A3E8, Serial No. 67677, was powered by a Ford GAA, V-8, gasoline engine and equipped with T80 Tracks.
CONCLUSIONS: Conclusions and recommendations covering each test were included in individual project reports and not in this facility report. Numerous suspension failures occurred such as volute spring, bogie tires, wheel hub bearings, and track blocks.
GENERAL: This 32-page report contains three photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-61505.76
TITLE: Facility Vehicle Report - M4A3 (76W) Medium Tank
IDENTIFICATION: Report No. PG-61505.76
DATE OF REPORT: 10 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide an operational history of a facility Medium Tank M4A3 while used on different test projects
METHOD: The vehicle was operated a total of 3728 miles. Tests were conducted on seven sub-projects covering the following equipment: shock absorbers, oil strainers, bogie tires, batteries, tracks; and experimental pistons, oil control rings, exhaust valves and inserts in Ford GAA engines.
DESCRIPTION: The test Medium Tank M4A3E8, Serial No. 61492, was manufactured by the Detroit Tank Arsenal and powered by a Ford GAA, V-8, gasoline engine. Test components included; Auto-Lite batteries, T85 Tracks and Heli-Coil inserts.
CONCLUSIONS: Conclusions and recommendations covering each test were included in individual project reports and not in this facility report.
GENERAL: This 26-page report is not illustrated.

SUBJECT: Tanks (Combat) PG-61505.77
TITLE: Facility Vehicle Report, M26 Heavy Tank Reg. No. W-30, 127,481S, Serial No. 735
IDENTIFICATION: Report No. PG-61505.77
DATE OF REPORT: 7 September 1945

ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of a Heavy Tank M26 used as a facility vehicle
METHOD: The vehicle was operated 1988 miles on eight project tests covering experimental cooling fan drive, track support rollers, spark plugs, batteries, steering linkage, differential oil pump, driver's door springs, and water pump.
DESCRIPTION: The test facility Heavy Tank M26, Serial No. 735, was powered by a Ford GAF, V-8, gasoline engine and equipped with torsion bar suspension. Armament included a 90mm gun.
CONCLUSIONS: Conclusions and recommendations covering the tests of experimental items on this vehicle were contained in the individual reports of the projects and were not included in this report. Among the standard parts that failed during the test were the radiators, front road wheel bearings, and the sprocket hub nuts. At 1572 miles the engine overheated because of clogged radiators, and it was necessary to remove the cores for cleaning. There were numerous failures of the standard inner front road wheel bearings, and oversize bearings were installed. Several failures of the left sprocket hub nut locking plate were repaired by welding.
GENERAL: This 27-page report contains two photographs of the vehicle.

SUBJECT: Tanks (Combat) PG-61505.78
TITLE: Facility Vehicle Report, M26 Heavy Tank, Reg. No. W-30, 127,507S, Serial No. 761
IDENTIFICATION: Report No. PG-61505.78
DATE OF REPORT: 17 September 1945
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To provide a history of the operation of Heavy Tank M26, W-30,217,507S, which was used as a facility vehicle at the Tank Arsenal Proving Ground
METHOD: The test vehicle was operated 2427 miles on ten test projects covering experimental fan drives, final drive gear ratio, differential oil pump and reduced oil level, drivers door springs, auxiliary generator, oil cooler lines and fittings, batteries, bogie tires, and shear cushion bogies.
DESCRIPTION: The test vehicle was a Heavy Tank M26 powered by a Ford GAF engine and equipped with a torsion bar suspension and a 90mm gun.
CONCLUSIONS: Conclusions and recommendations covering the tests of experimental items on this vehicle were contained in the individual project reports and were not included in this report. Standard parts that failed during the test included a number of front road wheel bearings, sprocket hub nut locking plates, and radiators. The standard front road wheel bearings were replaced by oversize bearings, and the radiators were removed and cleaned at odometer 1489 and 2061. Failed sprocket hub nut locking plates were replaced by new ones.
GENERAL: This 34-page report contains seven photographs of the test vehicle and failed standard parts.

SUBJECT: Tanks (Combat) T-61505
TITLE: Endurance Operation — M3 Medium Tank — Tank with Serial No. 367
IDENTIFICATION: Report No. T-61505
DATE OF REPORT: 5 January 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To obtain field test data on the general performance and durability of a Medium Tank M3
METHOD: The test procedure consisted chiefly of low-speed operation on heavy, wet, clay soil. This report covers 2695 miles of such operation, accomplished in 371.3 engine hours.
DESCRIPTION: The test vehicle was a Chrysler Medium Tank M3, Ordnance Serial No. 367, equipped with a Wright radial engine. This was a standard production vehicle with no experimental components.
CONCLUSIONS: The vertical volute spring suspension system was the source of the greatest number of failures. Eleven springs were broken or cracked. Track support rollers were susceptible to accumulations of mud, seizing in position and wearing through quickly when in sliding contact with the track. Seizing of nonlubricated suspension parts, due to corrosion, was discovered in several spring failures and was considered a possible contributing factor. Numerous track end connector failures, involving breakage of the integral track guide, were also encountered. Though these connectors were found satisfactory according to metallurgical specifications, it was possible to break them almost at will by making sudden turns in semi-soft dirt. Considerable difficulty was encountered with the clutch, which consistently failed to release properly and failed completely at 2385 miles. High transmission oil temperatures contributed to a serious oil fume problem within the tank. Other unsatisfactory features were failure of exhaust muffler flexible sleeves, brittle latch pins on pistol ports, and failure of head and tail light bulbs due to inadequate voltage control. No cooling trouble was experienced with the engine, possibly due to the low ambient temperature, although considerable dirt, thrown up on the grilles by the tracks, entered the engine compartment and clogged the oil cooling radiator.
GENERAL: This 26-page report contains six photographs of track and suspension failures.

SUBJECT: Tanks (Combat) T-61505.1
TITLE: Performance — M3 Medium Tank, 4000-Mile Endurance Test, Ordnance Vehicle No. 367
IDENTIFICATION: Report No. T-61505.1
DATE OF REPORT: 23 February 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To obtain field test data on the performance and durability of a standard production Medium Tank M3 to serve as a basis for product development
METHOD: The test mileage totaled 4056, chiefly run at low speed over soft and frozen mud but including 25 miles of highway operation. Operation was on a continuous, 24-hour per day, basis.
DESCRIPTION: The vehicle tested was a standard

production Chrysler Medium Tank M3, Ordnance Serial No. 367, equipped with a Wright radial engine.
CONCLUSIONS: The vertical volute spring suspension caused the greatest trouble, with 32 spring failures, seven spring seat failures, five track support roller failures (jammed with mud, seized, and worn through by track), and considerable seizing of unlubricated trunnions and gudgeon pins. Failure of track end connectors (breaking of guides) was frequent, and resulted in considerable track throwing. These connectors were up to standard, metallurgically, but were seriously inadequate in durability. Track, bogie wheel, and drive sprocket wear was considerable. Two clutches failed completely due to unsatisfactory flywheel hub roller bearings. Nauseating oil fumes resulting from high transmission oil temperatures contributed greatly to crew discomfort. Water and dirt leaked into the hull readily and the noise level was high. The engine durability was considered satisfactory although the fact that it did not overheat was attributed partly to low ambient temperatures. From the standpoint of performance, however, the engine was considered inadequate. Lugging ability was poor, necessitating excessive gear shifting on difficult terrain, and a more powerful engine was recommended. Also recommended was a complete design evaluation from the weight and cost economy standpoints as there were many evidences of overdesign in the vehicle.
GENERAL: In this 52-page report are 16 photographs of the various types of failures encountered during the test.

SUBJECT: Tanks (Combat) T-61505-20-01
TITLE: Pilot Tanks T25 Medium Tanks Equipped with 90MM Gun
IDENTIFICATION: Report No. T-61505-20-01; CX Project No. 164
DATE OF REPORT: 23 June 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To design and build two pilot models of a 90mm gun Medium Tank T25, based on the electric drive, Medium Tank T23 with 76mm gun
METHOD: Two pilot model tanks were built in the Tank Laboratory of the Chrysler Engineering Department, and operated an average of 225 miles at the Tank Arsenal Proving Ground.
DESCRIPTION: The test vehicles were pilot models of Medium Tank T25. Each vehicle weighed approximately 85,000 pounds and was equipped with an electric drive system identical to that of Medium Tank T23. Power was furnished by a Ford GAN engine. The main armament consisted of a 90mm gun in a cast turret. The suspension was a horizontal volute spring unit with a 23-inch, centerguide track.
CONCLUSIONS: This report was compiled to provide a record of work performed, and no conclusions or recommendations were made. However, maximum speed was stated to be 34.5 mph on level concrete and it was anticipated that stowage of the .45 caliber sub-machine guns would be inconvenient.
GENERAL: This 102-page report contains 47 photographs of the vehicle, interior arrangements, and exterior stowage.

SUBJECT: Tanks (Combat) T-61505.38-01
TITLE: Pilot Tank, Medium Tank T23E3 with Torsion Bar Suspension
IDENTIFICATION: Report No. T-61505.38-01; Project No. 217
DATE OF REPORT: 14 November 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To design and manufacture an engineering pilot model of Medium Tank T23E3
METHOD: The torsion bar suspension of the T25 E1 Medium Tank was adapted to the basic Medium Tank T23 hull and turret. The completed pilot model was proof tested at the Tank Arsenal Proving Ground and shipped to Fort Knox. The proof test consisted of a 100-mile break-in run, equalization of weight distribution in the suspension, and a cooling test. No load and full load camber measurements were made and recorded.
DESCRIPTION: The pilot T23E3 was a T23 Medium Tank equipped with a T25E1 Suspension and 19-inch, center-guide tracks. Vehicle height was increased from 8 ft. 9 in. to 9 ft. 7/8 in. due to the sub-floor installation. Combat weight was 79,390 pounds. Maximum speed on level concrete was 35 mph (governed).
CONCLUSIONS: To produce pilot Medium Tank T23E3 the following major modifications were made to Medium Tank T23: introduction of a sub-floor (since ground clearance was to be maintained, vehicle height was increased); revision of attachments and mountings supported by, or fastened to, the hull (such as controls, stowage items, bulkhead engine, final drive, etc.); revision of idler attachment and other changes in the hull required for actual attachment of the suspension; rearrangement of hull stowage and 76mm ammunition stowage; removal of turret platform; and revision of the T25E1 Suspension. During the proof testing, camber was noted in most of the road wheels. This was caused by the variation in angle of the slope plates due to the difficulty experienced in hull welding.
GENERAL: This 48-page report contains 18 photographs of the completed pilot model and modifications incorporated. A discussion sheet explaining details of the various changes accompanies each of the photographs.

SUBJECT: Tanks (Combat) T-61905.5
TITLE: Pilot Tank, M4A6 Medium Tank Caterpillar Tractor Company
IDENTIFICATION: Report No. T-61905.5; CX Project No. 140
DATE OF REPORT: 28 January 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To provide a record of the steps involved in the building of a pilot model of the M4A6 Medium Tank
METHOD: This project consisted chiefly of the

installation of the RD-1820 radial engine in the M4A4 tank hull. Initial studies were based on drawings furnished by Caterpillar and dealt with modifications of the engine compartment and wiring. Several additional changes, involving relocation of various items in the vehicle, were requested by OCO-D and incorporated into the pilot tank.
DESCRIPTION: The pilot M4A6 Medium Tank was built mainly from production M4A4 components, but incorporated a RD-1820 Caterpillar engine. This nine-cylinder, radial, air-cooled, four-cycle diesel unit was based on the Wright Cyclone G-200 gasoline engine. Modifications on the basic vehicle included a skeletonized turret basket, altered assistant driver's seat, vented battery boxes, a pressure equalization tube between transfer case and transmission for power train lubrication system, and an emergency engine shut-off control. Minor changes and stowage item relocations, including both those necessitated by the engine installation and those requested by Ordnance, were incorporated.
CONCLUSIONS: Only sixty miles of test operation were possible before the vehicle was shipped to the Ford Motor Company to be prepared for winterization testing. The only trouble encountered was oil leakage from the engine oil tank. This was caused by an ill-fitting clean-out cover and was readily corrected. Some additional leakage occurred in the exhaust system, small amounts of burnt oil escaping from the clamped manifold joints due to imperfect sealing. Otherwise this tank was considered satisfactory.
GENERAL: This 32-page report contains eight photographs of the engine installation and hull layout.

SUBJECT: Tanks (Combat) T-61905.6
TITLE: Medium Tanks — Pilot Vehicles
IDENTIFICATION: Report No. T-61905.6; CXD Project No. 75-25
DATE OF REPORT: 11 March 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To modify seven late production M4 Tanks and standardize the M4 series
METHOD: Seven hulls and four turrets were built for this project. The other three turrets were to be handled under a separate project. During the building of the pilot tanks, a total of 161 mechanical changes, and 79 electrical changes were recorded.
DESCRIPTION: The test vehicles were series M4 Medium Tank pilot models. They were equipped with either a 75mm gun, 76mm gun, or 105mm howitzer. The standard Thompson sub-machine gun was replaced by five M3 cal. .45 sub-machine guns. The tanks were equipped with T48 Tracks, Continental engines, and vertical volute spring suspensions. Combat weights varied from 69,385 to 73,445 pounds.
CONCLUSIONS: The main improvements in the vehicles were the installation of 76mm guns and 105mm howitzers, and water protected stowage for the 75mm and 76mm ammunition; change in location of the electrical equipment to the left-hand sponson; and uniformity of components in the 75mm gun, 76mm gun, and 105mm howitzer Medium Tanks M4.
GENERAL: This 58-page report contains 31 photographs showing fighting compartment stowage, outside stowage, the engine compartment, and the pilot model.

SUBJECT: Tanks (Combat) T-61905.7
TITLE: Weights Centers of Gravity, and Photographs — M4A3E2 Medium Tank
IDENTIFICATION: Report No. T-61905.7; CXE Project No. 545
DATE OF REPORT: 24 June 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To conduct engineering tests on an M4A3E2 Medium Tank
METHOD: The weight and center of gravity of the turret assembly gun mount assembly final drive assembly, vehicle unstowed, and vehicle stowed (less crew and sand shields) were determined.
DESCRIPTION: The test vehicle was an assault M4A3E2 Medium Tank manufactured by Fisher Tank Division. The vehicle was equipped with heavier armor than standard; 1-1/2 inch plates were welded to the sides and front slope plate of the upper hull. The final drive casting was 3000 pounds heavier; an additional plate was welded to the gun shield resulting in a weight increase of 1100 pounds. The standard 76mm gun mount was equipped with a 75mm tube.
CONCLUSIONS: The weight and center of gravity of each assembly are as follows:

Part	Weight (lbs.)	Center of Gravity
Turret Assembly	20,510	0.50'' to rear and 0.58'' to right of centerline of turret race
Gun mount assembly	4,008	0.26'' to rear of trunnions centerline
Final drive assembly	11,275	18.27'' ahead of vertical centerline through the side plate bolts
Vehicle unstowed	79,360	1.65'' ahead of centerline of center bogie
Vehicle stowed	84,240	0.46'' to rear of center bogie centerline and 0.48'' to right of longitudinal centerline

GENERAL: This 32-page report containing 13 photographs of the test tank compartments and a sketch of turret assembly showing locations of the scales and stowed weights.

SUBJECT: Tanks (Combat) T-61905.8
TITLE: T26 Heavy Tank — Pilot Vehicle
IDENTIFICATION: Report No. T-61905.8; CXD

TANK AUTOMOTIVE TEST RESUMES

Project No. 219
DATE OF REPORT: 4 May 1945
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To design and build a pilot model of the Heavy Tank T26
METHOD: Chrysler Engineering executed the design, layout, and built the complete hull assembly. Ordnance furnished a complete turret assembly, and parts from T24 vehicles which could be used. Chrysler Corporation assembled the complete pilot model. It was operated approximately 160 miles at the Tank Arsenal Proving Ground before release to the Ordnance Department.
DESCRIPTION: The test vehicle T26, Registration No. 30, 128, 307, was a pilot model heavy tank adapted from the Medium Tank T23. The principal changes were as follows: The T26 Tank was equipped with a 90mm instead of a 76mm gun; frontal and side armor were increased from 3 to 4 inches and 2 to 3 inches, respectively; a torsion bar suspension was used in place of the vertical volute spring suspension; and the vehicle was equipped with a 24-inch track. The power plant and propulsion equipment consisted of a Ford V-8 model GAN engine with electrical conversion to the sprockets.
CONCLUSIONS: The vehicle weight was 98,700 pounds as received, and 95,100 pounds when loaded for combat. Maximum vehicle speed was 28 miles per hour. The vehicle was shipped to the Tank Arsenal and then to Fort Knox.
GENERAL: This 31-page report contains seven photographs of the vehicle.

SUBJECT: Tanks (Combat) T-62103.7
TITLE: Tank Ventilation, Pressure vs Exhaust System
IDENTIFICATION: Report No. T-62103.7
DATE OF REPORT: 5 November 1951
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the relative merit of a pressure and exhaust-type fan in dispelling gases resulting from firing the tank gun
METHOD: Nine firing tests, using a T34 tank with both functioning and observing members present, were run. Various combinations of the fan, with hatches opened or closed, and w/o ductwork being used were tested. After each trial, the observers filled out a questionnaire which asked each to rate the effectiveness of the test combination in dispelling gases on a scale from 0 to 10 in the order of its estimated merit.
DESCRIPTION: The test equipment consisted of various adapters for use with the Remsel fan in the T34 tank for both pressure and exhaust applications. The fan was a turret ventilating fan manufactured by Remsel Industries of Chicago and designated by Ordnance No. 7770609.
CONCLUSIONS: A pressure system utilizing a duct extending to near the gun breech appears to be the most effective combination. However, an exhaust fan without ducting would do a fair job but would cancel any effect of the bore evacuator and would make the tank more vulnerable to chemical attack since a decontaminating connector could not be used. A small blower near the driver's face to give the driver some needed relief from irritating gases was needed, and would be utilized in the case of the pressure system. The use of the heater fan was recommended for investigation of this application. Further testing should be conducted on the T34 pilot model tank equipped with a pressure fan and ductwork extending to near the breech of the gun and the tank should be equipped with a bore evacuator.
GENERAL: This 69-page report includes nine schematic drawings showing the ventilator during each test. Three photographs of the test fan were also included.

SUBJECT: Tanks (Combat) T-62103.8
TITLE: Tank Ventilation - System Characteristics of the M46 Tank
IDENTIFICATION: Report No. T-62103.8
DATE OF REPORT: 5 December 1951
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To acquire basic ventilating data on a medium (M46) tank, such as tank restriction, leakage, and static pressure maintained with the input of various airflows through the ventilating fan
METHOD: The principal objective was to obtain data and curves showing the leakage of the tank when various pressure differentials were maintained between the inside and outside of the tank. The test plan for obtaining these figures was to pressurize the inside of the tank by blowing air into it with the test blower. Manometers were used to measure the pressure differential across the measuring nozzle and also between the inside of the vehicle and atmospheric. Since a steady static pressure was maintained inside the tank, all the air blown in by the test blower would have to find its way out of the tank as leakage. This meant that the test blower input was equal to the leakage and therefore both values would then be known by measuring the test blower input. Initially a simple leakage or restriction test was made on the tank alone. Later, similar tests were run with the tank engines running and also with the tank fan operating at 24 and 27-1/2 volts. The tank engines for this particular M46 tank drew air for combustion from the inside of the tank, thus making it necessary to consider this factor in any tank fan design. Control of the airflow into the tank was obtained in two ways: (1) the butterfly damper in the duct system and (2) a field rheostat used to control the speed of the test blower.
DESCRIPTION: The test blower used, an Eaton Turret Ventilating Blower Assembly, was one that was regularly used to simulate the relative air velocity over a car mounted on the chassis rolls in the cold test laboratory. This centrifugal type blower was 24 inches in diameter and 14 inches wide, and was powered by a 15 hp d.c. motor operating on 110 or 220 volts. The motor was manufactured by the Bogue Electric Company.
CONCLUSIONS: No conclusions were reached other than the compilation of data which was in-

cluded in the report. The total restriction curve for the tank also was included in the report.
GENERAL: This 38-page report includes three photographs of the leakage test equipment and setup and 10 curve sheets of various tests.

SUBJECT: Tanks (Combat) T-62202.8-01A
TITLE: Weights — Combat Vehicles Determination of the Longitudinal and Transverse Center of Gravity Location
IDENTIFICATION: Report No. T-62202.8-01A; CX Project No. 161
DATE OF REPORT: 26 April 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the longitudinal and transverse center of gravity location of ten medium tanks with both basic and combat weights
METHOD: Four Hi-Way Loadometer Scales (Black and Decker Co.) were placed under the hull of each tank at each corner. Longitudinal and transverse center of gravity locations, with both basic and combat weights, were obtained by taking moments about the weighing points on the tanks. Location of the longitudinal center of gravity was established by the dimension "R", indicating the distance rearward, and the dimension "F", indicating the distance forward of the center line of the ground contact of the track. Location of the transverse center of gravity was established by the dimension "R", indicating the distance to the right, and the dimension "L", indicating the distance to the left of the longitudinal center line of the tank.
DESCRIPTION: Basic weight included the following items: one .30 cal. flexible bow gun mount, one .30 cal. turret gun mount, one Pioneer compass, one Cordomatic reel and handle, two hand fire extinguishers, one traveling lock assembly, one towing pintle, one set of fenders and sand shields, one engine starting crank, fuel, lubricating oil, engine coolant, and full quantities of coolant for ammunition cases. Combat weight included basic weight plus weight of complete stowage and 875 pounds for weight of crew.
CONCLUSIONS: The transverse and longitudinal centers of gravity locations were determined for the following medium tanks: M4 and M4A3 with 76mm gun and with 105mm gun; M4A1, M4A2, T22, T23 with 76mm gun; M4A3 with 75mm gun; T25 with 90mm gun.
GENERAL: This 14-page report includes 10 photographs of the test tanks, and tables of longitudinal and transverse center of gravity locations of the tanks under basic weight and combat weight.

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Section 42
TEST EQUIPMENT

SUMMARY

This summary covers resumes of 98 engineering reports written on test equipment between 1937 and 1956 at Aberdeen Proving Ground, Maryland; Detroit Arsenal, Center Line, Michigan; Frankford Arsenal, Philadelphia; General Motors Corporation, Cleveland Tank Plant; General Motors Proving Ground, Milford, Michigan. Rock Island Arsenal, Illinois; National Bureau of Standards, Washington, D.C.; Chrysler Engineering Division, Detroit, Michigan; Watertown Arsenal, Watertown, Massachusetts; and Standard Steel Spring Company, Coraopolis, Pennsylvania.

The equipment and test methods reported on included: a positional control reference for servo analysis, electronic control and recorder for the bomb tester T4, Weindenhoff generator test bench for use in testing 150-ampere, 24-volt generators, state-of-charge indicator for storage batteries, dwell meters for testing rated pulse and gyro pick-off mechanism, electronic ignition monitor for diagnosing engine troubles, evaluation of performance characteristics and physical properties of test hydrometers, calibration accuracy of a portable thermometer test stand, evaluation of the use of the 15-MEV Betatron for inspection application, development of a method for studying deformation of tensile specimens using high-speed motion pictures, evaluation of an experimental static torsion listing machine, preliminary uses of electron microscopes in Ordnance research, nondestructive hardness testing of small arms bullet cores, granetometer for rapid density measurement of solids, Model LG Scott tester (aluminum aging block), temperature investigation, conformance of the A-2 and D type durometers and the pressor foot and gage, field dynamometers M5 and M6, Lub-Rim-Eter (a device for analyzing the condition of engine lubricating oils), photoelectric device for determining the amount of solid materials in used engine lubricating oils, comparison of dynamometers and establishment of procedures for testing, comparison of timing lights, mechanical dipping apparatus for the production of controlled coating thickness on test panels, qualification tests of hydraulic brake fluids, investigation and design of stroking equipment, stress measurement instruments for automotive development, study of the development of a portable transmission dynamometer, and a bend test device for autographic recording of load deflection diagrams.

Tests results varied with the equipment analyzed. Results, however, were generally satisfactory.

REPORT RESUMES

NOTE

A number of test equipment report resumes are classified. These resumes appear in Section 42, Volume XI.

SUBJECT: Test Equipment APG 225-70A
TITLE: A Method of Measurement of the Angular Velocity and Changes in the Angular Velocity of Power-Driven Gun Carriages
IDENTIFICATION: APG 225-70A
DATE OF REPORT: 8 November 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop a method to measure velocity variation of multiple Cal. .50 M.G. Turrets M45
METHOD: Using a temporary method, an a.c. generator output was recorded via an oscillograph on a tape. The cycles per inch of tape were counted and interpreted in degrees of rotation of the annular gear or gear segment. From the known speed of the tape, the speed of the gear was determined. Also, turret speed was determined by measuring the generator output voltage, since the generator speed voltage was known. The permanent method used a d.c. generator arranged similar to the a.c. generator. The d.c. generator output was connected to a recording milliammeter. After calibrating, the variation from the average velocity was determined from the tape recording.
DESCRIPTION: The method of measurement consisted of generating a voltage by gearing a tachometer generator to the elevating or traversing gear. The voltage produced was measured on a recording voltmeter. Two procedures were outlined, one was a temporary arrangement and the other was permanent. Both used traverse and elevation speed ratio attachments plus additional equipment to record the test results.
CONCLUSIONS: No conclusions were presented.
GENERAL: This 20-page report contains detailed test procedures and methods of interpreting the

test results. Six photographs and five drawings are included which illustrate the test equipment.

SUBJECT: Test Equipment APG 4481
TITLE: Twenty-Second Partial Report on Drawbar Pull of Mobile Artillery Vehicles
IDENTIFICATION: Ordnance Program No. 4481; APG 42-8A
DATE OF REPORT: 10 February 1936
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the drawbar pull, resistance to traction, and other performance data of various vehicles; to develop testing procedures which would yield more accurate drawbar pull and resistance to traction measurements; and to determine the suitability of Field Dynamometers M3 and M4
METHOD: During the period of August 1933 to April 1935, a total of 30 vehicles were tested over various types of terrain. Drawbar pull and resistance to traction measurements were recorded from the instruments of Field Dynamometers M3 and M4. Other vehicle performance data were observed and recorded.
DESCRIPTION: The 30 vehicles subjected to testing included various wheeled, half-track, convertible, and towing load vehicles. Field Dynamometer M3 was a White Co. Truck which weighed 24,000 pounds and had an 8-ton capacity on level, dry concrete; Field Dynamometer M4, based on a Ford truck, weighed 8000 pounds and had a 3500-pound capacity on level, dry concrete. Both vehicles employed the principles of hydraulics in measuring drawbar pull.
CONCLUSIONS: The Field Dynamometers M3 and M4 (in affording smooth and uniform loads, by demonstrating great ease in handling and load flexibility, and by allowing the determination of drawbar pull and tractive resistance all in one vehicle) were considered a decided improvement over the standard Field Dynamometer M2. Rubber painted tracks, where used, improved tractive resistance, and Oilite bushed track increased resistance. Results and conclusions of drawbar pull and tractive resistance tests for each of the numerous vehicles are detailed in the report. Performance of component parts and economy data are included.
GENERAL: This 391-page report contains six photographs showing the Field Dynamometers M3 and M4, the load control units, and a view of the Sperry Recording Dynamometer Mark IV.

SUBJECT: Test Equipment APG 4481/23
TITLE: Final Report on Power Absorption Trailers
IDENTIFICATION: Twenty-Third Report on Ordnance Program No. 4481; APG No. 14-23
DATE OF REPORT: 23 June 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the Power Absorption Trailers as field dynamometer equipment
METHOD: Four trailers were tested. Power absorption characteristics were determined by towing each trailer with the Medium Tank M3A1 on dry, level concrete. Drawbar pull, horsepower absorbed, and tire slippage were determined with the tank traveling 4.4 mph in first gear, 7.7 mph in second, 15.2 mph in third, 24 mph in fourth, and 24 mph in fifth. Cooling characteristics were determined by towing the trailers behind the tank at 4.5 mph in first gear. Ambient air temperature and maximum and stabilized temperatures of the dynamometer water were recorded. Tests were also made with the tank towing two and three trailers. During the tests, the operation of safety devices, insulators, and controls of the trailers were checked.
DESCRIPTION: The four trailers tested were of the same design. They were mounted on tandem axles with single wheels. Power was taken from the axles through a five-speed transmission to a dynamometer. The amount of power absorbed by the dynamometer was regulated by the amount of cooling water flowing through the absorption unit. A 6-volt electrical system operated the controls, relays, stop and tail lights, and overspeed warning signal light. Service air brakes on the wheels and a parking brake on the drive shaft were supplied. Complete description of the trailers may be found in the Mack Maintenance Manual dated April, 1943.
CONCLUSIONS: The power absorption trailers were generally satisfactory. Safety devices operated satisfactorily after adjustments on the overspeed and overload controls were made. It was recommended that the drawbar pull per trailer be limited to 8000 pounds and that multiple units be used for higher values. It was also recommended that the maximum road speed with four vehicles towed in tandem and on no-load operation be limited to 18 mph.
GENERAL: This 28-page report contains two photographs showing three trailers being towed by a Medium Tank M3A1. Descriptions of the trailer and its operations were incomplete.

SUBJECT: Test Equipment APG 4481/24
TITLE: First Report on Field Dynamometers M5 and M6 and Report on Field Dynamometer Testing at Aberdeen Proving Ground
IDENTIFICATION: Twenty-fourth Report on Ordnance Program No. 4481
DATE OF REPORT: 21 February 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of dynamometers M5 and M6 for use as test equipment
METHOD: The vehicles were tested utilizing the medium tank M4A4 for drawbar pull tests and resistance to traction tests, and with power absorption trailers for cooling tests.
DESCRIPTION: The field dynamometer M5 was similar in design to dynamometers M3 and M4 in that the vehicle incorporated absorption apparatus for controlling load and measuring power in drawbar tests and also furnished its own power for tractive-resistance tests. It was based on the Mack Model 8-K-SW, 6x4, chassis, and weighed approximately 30,000 pounds with all equipment. It could carry an additional 20,000-pound load, all of which was effective on the four rear driving wheels for

the purpose of increasing the traction of these wheels. The frame was specially reinforced to withstand a drawbar pull of 50,000 pounds. The vehicle was powered with a Mack Model 19 engine having a 707 cubic-inch displacement, rated at 178 brake horsepower at 2200 rpm, and governed at 2000 rpm. The field dynamometer M6 was the same as the M5 except for a modified Mack 19 engine. The power plant was modified to increase the rated brake horsepower to 195 at 2200 rpm and 188 at the full load governed speed of 2000 mph.
CONCLUSIONS: Both vehicles were considered satisfactory for the purposes for which they were designed. The size and power of newer Ordnance automotive vehicles exceeded the capacity of the standard field dynamometer equipment and it was felt that a larger dynamometer was needed to conduct complete tests of such vehicles. It was recommended that field dynamometer testing of Ordnance automotive vehicles be continued and that a larger capacity field dynamometer be procured in order to conduct tests on vehicles which exceed the capacity of the standard equipment.
GENERAL: This 99-page report includes 12 photographs of the test dynamometers.

SUBJECT: Test Equipment APG 4481/25
TITLE: Second Report on Power Absorption Trailers
IDENTIFICATION: Twenty-Fifth Report on Ordnance Program No. 4481; APG 14-99
DATE OF REPORT: 22 October 1946
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether three years of use had caused a loss in efficiency of Power Absorption Trailers PAT-1; and to determine the over all performance of new Power Absorption Trailers PAT-2
METHOD: Four PAT-1 Trailers and two PAT-2 Trailers were towed by a Field Dynamometer M6. Each trailer was operated through various gear speed ranges at minimum and maximum load in order to determine drawbar pull and drawbar horsepower absorbed by the trailer.
DESCRIPTION: The test Power Absorption Trailers PAT-1 and PAT-2 were each made up of a Taylor, Model No. D-31, hydraulic absorption dynamometer mounted on a chassis equipped with a ten-speed transmission control assembly. Overspeed and torque limiting governors were installed on the trailer; if the dynamometer speed reached 2500 rpm, or the torque increased to 375 lb. feet during any of the transmission speed ratios, the trailer air brakes would be applied automatically through governor-actuated electrical contacts. The two PAT-2 trailers were modifications of the PAT-1 trailers.
CONCLUSIONS: The PAT-1 trailers were as accurate as they were three years previously. The speed and torque-limiting governors were unsatisfactory. Dust covers improved performance of the speed limiting governors. Trailers PAT-2 met all specification requirements. The following recommendations were made: all electrical circuits and controls be dust and waterproofed, a load control mechanism be designed which would provide accurate synchronization of tandem connected trailer loads, a rapid loading and unloading speed range, and a vernier adjustment for minor load variations.
GENERAL: This 76-page report contains four photographs and drawings of vehicle components.

SUBJECT: Test Equipment APG 5179/18
TITLE: First Report on Test of "Lub-Rim-Eter"
IDENTIFICATION: Eighteenth Report on Ordnance Program No. 5179
DATE OF REPORT: 22 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a device for analyzing the condition of engine lubricating oils
METHOD: Various used diesel and mineral engine oils were analyzed to determine the amount of material insoluble in precipitation naphtha. Readings of the same oil samples were then obtained through use of the Lub-Rim-Eter device. The data acquired from these experiments were tabulated and compared.
DESCRIPTION: The Lub-Rim-Eter was manufactured by the Inspection Machinery Company of Cleveland, Ohio, and was a device used to measure the amount of carbonaceous material in mineral oils. It consisted of two glass plates mounted in hinged, synthetic rubber frames. One plate was clear and flat, and the other had a groove approximately 0.010 inches deep across the center of one face. This groove was bounded by four color scales graded from a very light amber to a dark brown. In practice, a drop of oil was placed in the groove, the flat plate was pressed firmly against the grooved plate, and the transparency of the oil was compared to that of the four color scales.
CONCLUSIONS: Mineral oil samples which gave a Lub-Rim-Eter reading of four contained 0.7% or more of materials insoluble in precipitation naphtha. The test instrument successfully indicated the approximate content of naphtha insoluble materials in mineral engine oils. The device was useless for diesel engine oil samples and it was felt that the transparency of an oil sample might not be an indication of the condition of the oil or the engine in which it had been used. It was recommended that the Lub-Rim-Eter be considered unsatisfactory for determining when engine oil should be changed.
GENERAL: This 10-page report includes a photostatic advertising leaflet concerning the test item. Graphs showing a comparison between laboratory analyses and Lub-Rim-Eter readings are also included.

SUBJECT: Test Equipment APG 5179/19
TITLE: First Report on the Development of Photoelectric Device for Determining the Amount of Solid Materials in Used Engine Lubricating Oils
IDENTIFICATION: Nineteenth Report on Ordnance Program No. 5179
DATE OF REPORT: 9 February 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a de-

vice for analyzing the condition of engine lubricating oils
METHOD: The experimental apparatus was calibrated by placing an exposed photographic slide between the light source and a photoelectric cell, and adjusting the microammeter to a predetermined reading. Cells containing either new or used oil samples were placed in the light beam and the corresponding microammeter readings were recorded. The percent by volume of naphtha insolubles present in used samples of mineral and diesel oils was determined by regular laboratory methods, and compared with readings obtained on the subject apparatus.
DESCRIPTION: The test apparatus consisted essentially of a 60-watt, 110-volt lamp; a special cell fabricated of two 1/8-inch thick lucite plates, and a photoelectric cell connected in series with a microammeter. A rheostat, connected in series with the lamp, was used for calibration purposes. One of the plates in each cell had a groove of a given thickness machined on one face to contain the test oil sample. Cells with both 0.006-inch and 0.010-inch grooves were used during the test.
CONCLUSIONS: The test device accurately determined the transparency of the oil samples and a reliable relationship existed between the amount of mineral oil transparency and the percent by volume of naphtha insoluble present in the oil. It was felt that the test apparatus did not convey sufficient information on the condition of the oil or the engine in which it was used. Explanations were offered to clarify this opinion and included the facts that an oil might contain enough abrasive material to ruin an engine and yet appear relatively clear, or that a dirty oil might be contaminated due to its ability to hold dirt and sludges in suspension. It was recommended that the test device be used only for approximating the efficiency of oil filters.
GENERAL: This 11-page report includes a sketch of the test device and several pages of graphs and comparison tables.

SUBJECT: Test Equipment APG 5271
TITLE: First Report on Field Dynamometers M3 and M4 and First Report on Research Problems KG1, KG2, and KG3. Development of a Complete Dynamometer Study of a Wheeled Vehicle, a Tracklaying Vehicle and a Half-Track Vehicle
IDENTIFICATION: Ordnance Program Nos. 5271, 5272, 5273
DATE OF REPORT: 27 April 1937
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare three dynamometers and establish procedures for testing and compiling data
METHOD: The test procedure was outlined for wheel, tracklaying, and half-track vehicles. This study was designed to measure traction resistance for vehicles and trailed loads, drawbar pull and drawbar horsepower, and fuel consumption characteristics of prime movers under drawbar load. The method for measurement and computation of results was described. A representative test report on the T1 tractor was included.
DESCRIPTION: The field dynamometer M3 was a 6-wheel, 4-wheel drive, 8-ton truck powered by a Hercules, Model HXE engine developing 198 hp at 2000 rpm. The design was based on a 6x4 White chassis. Two sensitive drawbars, front and rear, were connected to the pressure recording device (a modified Crosley steam engine indicator) and recording apparatus in the cab. The recording apparatus was manufactured by the Sperry Gyroscope Company. Time and distance recording devices, sprocket revolution counters, and a fuel measuring device were included. The power absorbing mechanism consisted of two high pressure water pumps, supply tanks, and a circulating system with load control valve. The M4 dynamometer was adapted to a Ford, 1-1/2-ton, 4x2 chassis. Its operation was identical to the M3, but construction of the vehicle was designed for testing with light loads and high speeds.
CONCLUSIONS: The M3 and M4 dynamometers were more efficient than the M2 unit. Greater speed possibilities of the M2 and M3 greatly increased the scope of dynamometer testing. It was felt that the time distance method of determining drawbar pull and tractive resistance has been sufficiently developed to take care of light, high speed vehicles. The recently developed method for determining fuel consumption gave more accurate results than the old method.
GENERAL: This 61-page report contains 19 photographs of the test dynamometers. Also included are drawings and graphs which further illustrate these vehicles.

SUBJECT: Test Equipment APG 5309/1
TITLE: First Partial Report on Test of Rubber Blocks for Light Tanks and Combat Cars on Track Testing Course
IDENTIFICATION: First Report on Ordnance Program No. 5309; APG 21-7
DATE OF REPORT: 17 October 1938
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop a track testing machine and course to simulate field conditions for test purposes. These tests were the first on the testing machine, begun shortly after its completion.
METHOD: Various test tracks were installed on the testing machine and loaded first to 7600 pounds, later to 9000 pounds. They were operated on gravel, smooth concrete, and undulating concrete at speeds from 10 to 20 mph. A composite T18 track was operated 417 miles, mainly for the purpose of trouble-shooting the machine. T16E4 tracks were each operated 514 miles. A composite T16, T16E1, and T16E2 track was operated 2161 miles, all but 142 miles on gravel. Hardness, elasticity, and wear were measured in an attempt to find a correlation of factors.
DESCRIPTION: The track testing machine installation consisted of a circular course, carriage, five-ton crane for handling the carriage, and a control house. The course was circular, 1/5 mile in circumference, and banked for speeds of approximately 20 mph. It consisted of a narrow gage railroad track for the carriage with three concentric test surfaces between the rails. The surfaces were smooth concrete, undulating or "bump" concrete with one to two-inch bumps

at six to 15-foot intervals, and washed gravel. The carriage contained a light tank suspension on which the test tracks were mounted and a 220-volt direct-current driving motor. Power was taken from a third rail, concentric with the carriage rails. A 220-volt motor-generator set and the control equipment were located in the control house. Test tracks were a composite T18 track, two T16E4 bonded tracks, and a composite T16 track consisting of shoes of T16, T16E1, and T16E2 designations.
CONCLUSIONS: The machine closely approximated vehicle conditions, permitted accelerated testing, and effected a reduction in testing costs of about $500 per unit tested. It was recommended that all possible future track testing be done on this course and that accurate records be kept of tracks in field service for comparison to machine results. A modification of the machine carriage was recommended to permit testing of half-track tracks.
GENERAL: This 94-page report includes 27 photographs of the installation and test tracks.

SUBJECT: Test Equipment APG 5365/1
TITLE: First Report on Firestone Track T16E4 (Reversible), Purchase Order Number 38-1325, APG No. 29
IDENTIFICATION: First Report on Ordnance Program No. 5365; APG 21-11
DATE OF REPORT: 13 February 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To further develop the Track Testing Machine and test methods; to obtain a correlation between operation on a vehicle and on the machine; and to determine mileage life and other data on the subject track for comparison with T16E3 non-reversible track
METHOD: One set each of T16E3 non-reversible and T16E4 reversible tracks were installed on Combat Cars M1 and operated 706 miles. Speed and type of course are not stated. One track from each set was then removed for machine testing and the mates installed on a Combat Car M1 for further vehicle testing. The T16E4 track was installed on the testing machine, loaded to 9550 pounds, and operated at an average speed of 18 mph over the testing machine gravel course. After 900 miles (total 1606) the track was reversed. Machine operation was then continued for a total of 5300 miles (grand total 6006). The T16E3 track, removed for machine operation, was not tested within the scope of this report, if at all. The tracks remaining on the test vehicle were operated over concrete, gravel, and cross-country courses for a total of 3432 miles, with reversal at 2578.
DESCRIPTION: The tracks tested were conventional, double-pin, rubber, flat block tracks, the only apparent difference being the reversibility of the T16E4 tracks. Both were manufactured by Firestone.
CONCLUSIONS: The machine-tested T16E4 track was worn out at 6006 miles and the vehicle-tested track was in good condition at 3432 miles. From this it was concluded that the wear life of tracks on the testing machine was about equal to the life on a vehicle with equal loading and, therefore, that the vehicle life of T16E4 track would be 4000 to 6000 miles. Comparison between the T16E3 tracks after 3432 miles of vehicle operation showed slightly better wear for the T16E4. It was noted that abrasion was less severe on the testing machine than under vehicle conditions, and the recommendation was made that the machine test course be modified to include concrete as well as gravel. It was also recommended that the machine speed be increased to 25 mph to accelerate testing.
GENERAL: This 72-page report contains 55 photographs showing the test tracks at various mileages. Plots of hardness versus mileage and block thickness versus mileage are also included.

SUBJECT: Test Equipment APG 5365/2
TITLE: First Partial Report on Test of Composite Track on Track Testing Machine
IDENTIFICATION: Second Report on Ordnance Program No. 5365; APG 21-13
DATE OF REPORT: 22 April 1940
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To further develop the Track Testing Machine and test methods; to grade if possible the various types of blocks in order of performance
METHOD: A composite track was installed on the track testing machine on December 7,1939. It was operated for a total of 6254 miles. At this point, a break-down of the testing machine occurred and it was deemed advisable to submit a partial report covering past operations.
DESCRIPTION: The composite track consisted of 13 different types of rubber in groups of five blocks each listed below:

	Goodrich	Firestone
Type	5(A-E)	8(AA-EE) (HH) (7-60D) (Man-Ten)
P. O. No.	39-4588	39-4589 39-5409
Rubber Thickness	3-1/32"	3-1/32" & 3-1/16"
Thickness	2-5/16" & 2-11/32"	2-5/16" & 2-11/32"
Durometer	65-67-86	69-79-80-81

Total weight of assembled track was 1155 pounds, length was 28 ft., 4-5/8 in., and weight per track foot was 40.75 pounds.
CONCLUSIONS: By means of a comparative cost study made on both methods of track testing, i.e., the track testing machine and vehicle operation, it was concluded that tests could be conducted more rapidly and at less expense on the testing machine than utilizing a suitable vehicle even though extensive repairs and modifications were interspersed with test operations. Improvement in the design of the track carrier would effect a substantial reduction in operating cost and time. Since the most important data of a test would be the mileage life of the best type shoe, it was contemplated making a composite track reversal only when necessary to

reverse the best shoes. Results indicated that more than five and preferably 10 shoes should be used, and the best standard shoes should be procured to serve as control. The best types of shoes tested in the composite track were Goodrich Type C and Firestone Types BB, EE, and HH. Wear could possibly be accelerated on the testing machine by using different loads and types of operating surfaces. The best speed of operation was considered to be 21 mph.
GENERAL: This 45-page report contains 77 photographs.

SUBJECT: Test Equipment APG 5365-4
TITLE: Second Partial Report of Goodrich and Firestone Composite Track on Track Testing Machine
IDENTIFICATION: Fourth Report on Ordnance Program No. 5365; APG 21-16-(2)
DATE OF REPORT: 10 January 1941
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To continue testing of a Goodrich and Firestone composite track on the track testing machine (3127 miles had previously been logged on this track, covered in the second report on this program); to improve the testing machine and test setup to better simulate vehicle conditions; and to determine comparative performance of the various types of blocks in the composite track
METHOD: The composite track was installed on the track testing machine and operated 2791 miles, bringing the total mileage on the track to 5918. The testing course at first, was part gravel and part concrete. During the tests, it was changed to 100% concrete, to crushed granite, and finally to a stone hump course, consisting of large stones set in concrete and protruding about one inch. Operation was at 20 mph except on the crushed granite where speeds over 15 mph tended to throw the stone out of the course. The track operated under a total load of 12,800 pounds.
DESCRIPTION: The composite track was made up of 13 types of track blocks of Goodrich and Firestone manufacture. It was a double-pin flat-block, reversible, rubber track of the type then in use on Light Tank M2A3.
CONCLUSIONS: It was thought that the testing machine course, as finally modified, was a good approximation of field conditions if a speed of 20 mph was maintained. Three of the types of blocks tested were considered superior to the others, based on observation and wear measurements. It was recommended that an improved method of determining wear be developed, as measurement was apparently unreliable.
GENERAL: This 109-page report contains 50 photographs showing the different track block types at different mileages. Also included are graphs of track block wear and hardness versus mileage for each of the 13 block types. An appendix contains a list of testing machine breakdowns from 2 November 1938 to 26 August 1940. Mileage data are difficult to check as there is no distinction made between the previous testing (see Report No. 2, Ordnance Program No. 5365) and the work covered in this report.

SUBJECT: Test Equipment APG 5686/2
TITLE: First Report on Test of Shock Mounts for Signal Equipment
IDENTIFICATION: Second Report on Ordnance Program No. 5686; APG 70-41
DATE OF REPORT: 3 January 1946
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of standard and experimental shock mounts for signal and fire control equipment mounted on various Ordnance vehicles, under the operating conditions attainable at the Proving Ground
METHOD: The shock-mounted equipment was installed in the test vehicles with the standard or experimental mounting provisions. Vibration pickups were placed on the equipment so as to measure vibrations in all planes. Various types of amplifying and recording equipment were used to meet individual measurement problems.
DESCRIPTION: The shock-mounted equipment included Signal Corps radio equipment and sighting and fire control optical equipment. The Signal Corps equipment was tested in a 3/4-ton weapons carrier, 1/4-ton truck, 2-1/2-ton 6x6 truck, and an M4A3E8 Medium Tank. Optical instrument vibration tests were conducted on a 40-mm gun carriage, M14 Director Trailer, and M4A3E8 Medium Tank.
CONCLUSIONS: The conclusions drawn from this test dealt primarily with the suitability of the vibration analysis equipment and not with the shock mount performance. Three systems for vibration measurement were considered necessary and the instrumentation used in this study was recommended for future tests. Analysis of the vibration study results was not attempted.
GENERAL: This 33-page report contains 12 photographs and two drawings, illustrating various test setups, construction of equipment, and traces from recording instruments.

SUBJECT: Test Equipment APG 5688/29
TITLE: First Report on Investigation of Spring Testers
IDENTIFICATION: Twenty-Ninth Report on Ordnance Program No. 5688; APG 70-30
DATE OF REPORT: 5 January 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the accuracy and suitability of Rinck-McIlwaine, and P. A. Sturtevant spring testers for use in measuring the compression force of valve and clutch springs
METHOD: The spring testers were used to measure eight accurately calibrated valve and clutch springs. The average percentage of error of 18 Rinck-McIlwaine testers used in measuring the springs as compared to calibrated spring measurements was determined. An identical average was determined with a Sturtevant spring tester.
DESCRIPTION: The test P. A. Sturtevant spring tester, Federal Stock No. 41-T-1601, had a pressure capacity limited only with respect to the size of torque wrench which would be used with the unit. The maximum size spring the tester could handle was 7 inches long and 2-1/2 inches

in diameter. The Rinck-McIlwaine units were standard Ordnance spring testers, Federal Stock No. 41-T-1600, equipped with permanently fixed indicator dials which could only measure compressed spring pressures up to 250 lbs. The maximum size valve or clutch spring size that could be measured was 4-1/2 inches in length and 2-3/8 inches in diameter.
CONCLUSIONS: The accuracy, simplicity of design, and durability characteristics of the Sturtevant spring tester were superior to those of the Rinck-McIlwaine tester. It was recommended that the Sturtevant spring tester replace the Rinck-McIlwaine tester in all Ordnance maintenance operations relating to valve or clutch spring measurements.
GENERAL: This 29-page report contains four photographs showing the test and standard spring testers.

SUBJECT: Test Equipment APG 5688/105
TITLE: First Report on Emergency Refrigeration Apparatus
IDENTIFICATION: One Hundred-Fifth Report on Ordnance Program No. 5688; APG 34-7
DATE OF REPORT: 9 May 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop emergency auxiliary refrigeration equipment to lower cold room temperature from -40° to -70°F
METHOD: After preliminary study an apparatus was constructed in the cold room. During the testing period, modifications to the system included insulating the coolant lines and installing pumps of different types and capacities to increase the coolant flow.
DESCRIPTION: The test apparatus circulated coolant over dry ice in a cooling chamber and then through a heat exchanger in the cold room. The system had a manual temperature control and used trichlorethylene for a coolant. The heat exchanger was a Cadillac radiator assembly with fan and shroud from Light Tank M4.
CONCLUSIONS: After a positive gear pump was installed, desired temperatures under sustained loading and operation were obtained. Trouble was encountered with frost accumulating on the heat exchanger, with circulation stoppages resulting from water condensates precipitated in the trichlorethylene, and with the manual temperature control in maintaining stabilized temperatures. The principle of operation was considered sound and, if further studies indicated a need for an auxiliary unit, the following recommendations were made: that a more suitable heat exchanger be employed, with wider fin spacing and a built-in defroster; that thermostatic control be incorporated; and that methanol be used as a coolant.
GENERAL: This 37-page report includes four sketches and three photographs of the auxiliary unit.

SUBJECT: Test Equipment APG 5731/25
TITLE: First Report of Battery Hydrometers with Less Rubber
IDENTIFICATION: Twenty-Fifth Report on Ordnance Program No. 5731; APG 70-15
DATE OF REPORT: 9 September 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of battery hydrometers substituting neoprene for rubber parts
METHOD: Laboratory tests of two hydrometer models were conducted. Cold test exposures of the test items were made at temperatures as low as -40°F. The hydrometers were tested to determine the reaction from contact with 1300 specific gravity of sulphuric acid at room temperatures for 96 hours and at 140°F for 24 hours. Tests were also made to determine the effect of contact with gasoline.
DESCRIPTION: Two test battery hydrometers were submitted by the Kimble Glass Company and E. Edelmann and Company. The test items had polystyrene barrels in place of the usual glass barrel, and FR neoprene parts were substituted for the usual rubber parts. The test models were experimental and not production models.
CONCLUSIONS: The use of crude rubber in the manufacture of hydrometers could be eliminated by the use of properly colored FR neoprene. The neoprene parts would function satisfactorily at temperatures from -30°F to +140°F. Polystyrene was an acceptable substitute for glass. It was recommended that the test hydrometers be considered acceptable for military use and that production samples be submitted for final approval.
GENERAL: This 32-page report includes six photographs and three drawings of the test equipment.

SUBJECT: Test Equipment APG 5731/39
TITLE: First Report on Investigation of Glass Breakage of Hydrometers
IDENTIFICATION: Thirty-Ninth Report on Ordnance Program No. 5731; APG 70-22
DATE OF REPORT: 18 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the cause of glass breakage of hydrometers and provide corrective measures
METHOD: Tests were conducted with 13 anti-freeze and six battery hydrometers. A polariscope was employed to determine whether the barrels and floats were properly annealed. The shipping containers and types of packaging were observed and containers were tested for ability to protect the instruments in shipment and from weather conditions.
DESCRIPTION: The test instruments included ten Kimble and three Edelmann anti-freeze hydrometers and four Kimble and two Edelmann battery hydrometers. The barrels and floats were of annealed glass in the majority of the instruments. The containers were constructed of light wood and some of cardboard.
CONCLUSIONS: The glass barrels and floats of many of the instruments were not properly annealed. The containers were not adequate to protect the hydrometers in shipment and from weather. It was

recommended that definite annealing standards be established and that more rugged containers and better packaging be developed.
GENERAL: This 31-page report includes seven photographs of the test hydrometers.

SUBJECT: Test Equipment APG 5731/41
TITLE: First Report on Test of Production Samples of Anti-Freeze Hydrometers
IDENTIFICATION: Forty-First Report on Ordnance Program No. 5731; APG Report No. 70-25
DATE OF REPORT: 30 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether the antifreeze hydrometers used by Ordnance complied with the applicable specifications
METHOD: Ten Kimble antifreeze hydrometers were tested for accuracy with antifreeze solutions. The freezing points of these solutions were determined by freezing the solutions and measuring the temperature of the initial crystallization. Ethylene glycol solutions of known specific gravities were mixed and checked with standard hydrometers at each change of solution temperatures from 160°F to the solution freezing point. The rubber parts were examined and tested at each 10°F. temperature interval to determine when the limit of usefulness had been reached in the cold temperature range.
DESCRIPTION: The test hydrometers were identified as Kimble No. 176. The antifreeze used was made by the U.S. Industrial Chemicals Incorporated.
CONCLUSIONS: The test hydrometers did not meet Ordnance Specification ES No. 713A with respect to the ethylene glycol and alcohol floats, rubber bulbs, glass connector, hydrometer container, conversion chart compartment, and thermometer scale. The test hydrometers were considered an advancement over previous antifreeze hydrometers. It was recommended they be improved to overcome the aforementioned deficiencies, and that the use of alcohol floats and conversion charts be discontinued.
GENERAL: This 27-page report contains three photographs of the test equipment.

SUBJECT: Test Equipment APG 5731/45
TITLE: First Report on Test of Burton Rogers Company A.C. Voltmeter
IDENTIFICATION: Forty-Fifth Report on Ordnance Program No. 5731; APG 72-5
DATE OF REPORT: 30 June 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine if the test voltmeter used in conjunction with a standard growler could discriminate between a good and a defective 12-volt automotive generator armature with equalizer connections
METHOD: Several generator armatures with equalizer connections were used for the tests. The armatures were rotated on a Lanagan and Hoke Company growler. The voltage between two adjacent commutator bars was taken with the test prods of the voltmeter held firm and the commutator bars rotated past the prods. Armatures with known open and short circuited coils were tested to determine the effectiveness of the test setup.
DESCRIPTION: The voltmeter under test was a Burton Rogers Company Model 560 voltmeter with a linear 0-2 volt scale. The sample armatures used in the tests were Auto-Lite Company Model Nos. GDJ2065F and GDJ2031F, equipotential, 12-volt, d.c. armatures. These armatures had points of equal voltage on the commutators electrically connected giving an indication of shorted coils when tested by the growler alone.
CONCLUSIONS: The voltmeter and growler method of testing the equipotential armatures was not thoroughly satisfactory. The voltmeter detected short circuits involving three or more turns only. It was recommended that the voltmeter not be considered a method of testing generators and that a d.c. millivoltmeter method of testing be considered.
GENERAL: This 15-page report contains two photographs of the meter and a generator armature test setup.

SUBJECT: Test Equipment APG 5731/49
TITLE: Forty-Ninth Report on Ordnance Program No. 5731; APG 70-27
DATE OF REPORT: 21 August 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether the battery hydrometers used by Ordnance complied with applicable specifications
METHOD: Ten Edelmann and eight Kimble battery hydrometers were tested for accuracy with standard electrolytic solutions ranging in specific gravity from 1.344 to 1.164 at 80°F. The specific gravities of the test solutions were checked with a set of Fisher hydrometers. The solutions and hydrometers were tested before, during, and after the test in 10° increments from 140° to -30°F. The rubber parts were examined and tested in 10° intervals to determine when the limit of usefulness had been reached in the cold temperature range.
DESCRIPTION: The test hydrometers were Edelmann No. 40-9 and Kimble No. 350 battery hydrometers. Each hydrometer consisted of a glass barrel with plug base, bulb and inlet tube for drawing the electrolyte into the float chamber. Temperature correction was indicated on the thermometer scale and the specific gravity of the solution was read directly from the float scale.
CONCLUSIONS: The test hydrometers did not meet specifications because of deficiencies in every part of the hydrometers. The thermometers were not within the specified 4° tolerances, and accurate readings could not be obtained below -10°F. It was recommended that procurement of Edelmann and Kimble hydrometers be discontinued until all the deficiencies were corrected. It was also recommended that certain changes on the float be incorporated into the specifications.
GENERAL: This 58-page report contains three photographs of the test equipment.

SUBJECT: Test Equipment APG 5731/51
TITLE: First Report on Test of Union Manufac-

turing and Gauge Company Thermostat Tester
IDENTIFICATION: Fifty-first Report on Ordnance Program No. 5731; APG 70-29
DATE OF REPORT: 22 November 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of a Union thermostat tester for Ordnance maintenance use
METHOD: The water basin of the thermostat tester was filled with 2180 cc of ethylene glycol solution. The following information was then determined: maximum ethylene glycol temperature which could be obtained with the thermostat tester heater; accuracy of the thermometer provided with the tester; and accuracy of the thermostatic switch settings at which prescribed temperatures were to be maintained. A calibrated thermometer of known accuracy was used for control during these tests.
DESCRIPTION: The Union Manufacturing and Gauge Company thermostat tester consisted primarily of a basin with carrying handles for liquids, a tray for holding thermostats, a Rochester thermometer, and a Fenwal 750-watt, 115-volt, ring type heater element with a 10-ampere, 115-volt thermostatic switch. The thermostatic switch scale was divided in 5° increments from 150° to 200°F.
CONCLUSIONS: The tester provided a convenient method of testing a quantity of radiator thermostats and heat indicators quickly and accurately. The thermostat switch and thermometer used with the tester were considered sufficiently accurate. It was recommended that, after minor modifications, the tester be resubmitted for test before final approval was made.
GENERAL: This 27-page report contains three photographs showing assembled tester and a complete component disassembly of the tester.

SUBJECT: Test Equipment APG 5731/52
TITLE: First Report on Test of Weidenhoff Model 1019 Engine Analyzer
IDENTIFICATION: Fifty-second Report on Ordnance Program No. 5731; APG 73-4
DATE OF REPORT: 28 August 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the adequacy of a Weidenhoff Model 1019 engine analyzer with similar standard Ordnance equipment
METHOD: The analyzer and similar Ordnance equipment were compared for use in the analysis of various wheeled vehicle engines. In order to determine durability, the test analyzer was placed on the floor of a 2-1/2-ton, 6x6, truck which was operated for 1135 miles over various types of terrain.
DESCRIPTION: The test Weidenhoff Engine Analyzer, Model 1019, consisted of a low voltage circuit tester, a high tension tester, and an ohmmeter all contained in one package; accessories included a compression gage, a vacuum gage, and ignition timing light. Standard engine analyzing equipment consisted of the following items each separately packaged: ignition tester, low voltage circuit tester, electric tachometer, compression gage, vacuum gage, and timing light.
CONCLUSIONS: The engine analyzer was not as satisfactory as standard Ordnance equipment. The following analyzer deficiencies were noted: the unit was designed for testing wheeled transport vehicles and was not satisfactory for checking combat vehicles; the unit was not designed for testing magneto ignition systems; and since all checking operations were conducted with the one package the versatility of the separate standard kit components for use in testing several vehicles at once, was lost. The mechanical ruggedness and the electrical performance of the test analyzer were both satisfactory. It was recommended that the analyzer not replace standard Ordnance equipment.
GENERAL: This 17-page report contains two photographs showing the test analyzer and standard analyzer components.

SUBJECT: Test Equipment APG 5731/56
TITLE: First Report on Performance Test of Adapter for Lanagan and Hoke Electrical Test Bench
IDENTIFICATION: Fifty-sixth Report on Ordnance Program No. 5731; APG 72-5A
DATE OF REPORT: 14 April 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of the adapter for use in testing all standard automotive generators on the Lanagan and Hoke model LH-555 test bench
METHOD: The adapter was attached to the Lanagan and Hoke test bench. The adapter was then used for testing several generators with various types of drive shafts. Three types of adapter drive couplings were tested during the operations. The adapter was tested for approximately 186 hours.
DESCRIPTION: The adapter assembly consisted of a main assembly with a mounting bracket, an adjustable arm, a drive pulley, and a drive coupling. Parts supplied with the assembly to allow it to fit any type of drive shaft were a dog clamp, spline coupling, quill center, hexagonal coupling, Allen wrenches and a terminal protector. The unit was attached to the test bench by two bolts. The three types of adapter drive couplings used were all the same except for their compositions which were heavy rubberized fabric, vulcanized fabric and leather discs.
CONCLUSIONS: The adapter assembly was satisfactory and was recommended for use on the test bench provided several modifications were made. These modifications included a better method of securing the drive pulley to the main assembly and a more durable drive coupling. The leather discs were satisfactory for use until a better coupling was designed.
GENERAL: This 25-page report contains eight photographs showing general construction, mounting and defects of the adaptor assembly.

SUBJECT: Test Equipment APG 5731/63
TITLE: First Report on Test of Low Voltage Circuit Tester 17-T-5575
IDENTIFICATION: Sixty-third Report on Ordnance Program No. 5731; APG 70-39

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 28 November 1945
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the adequacy of the 6-12 volt circuit testers for use with 24-volt systems and recommend modifications, if feasible
METHOD: Several low-voltage testers were studied for convenience and adequacy for testing of 24-volt systems. In this study field maintenance and training school reports relating to this problem were used as a basis for evaluation.
DESCRIPTION: The testers under investigation were similar, one-unit testers, consisting basically of a volt-ammeter with several pairs of test leads connected, and selection switches to make the appropriate internal connections for various tests. Each incorporated some form of fixed or variable load resistor for current regulator testing. In operation, several hookups were made simultaneously, using the test leads; and different readings were obtained with the selection switch. Some testers proposed for consideration used fewer test leads, necessitating individual hookups for different tests. The testers considered were manufactured by Meyer, Sun, Hickok, Weidenhoff, and Weston.
CONCLUSIONS: The one unit Ordnance testers were found inadequate for 24-volt circuit testing and were not readily adaptable. A set of instruments in two units, with a volt-ammeter in one and an ohmmeter in the other, was recommended. The use of fewer test leads and separate hookups was considered better from the standpoint of the user's comprehension and was recommended for the development tester.
GENERAL: This 32-page report contains six photographs of the testers considered.

SUBJECT: Test Equipment APG 5981/1
TITLE: First Report on Determination of Recoil Oil Pressures in a 105-MM Howitzer Mount, M52
IDENTIFICATION: First Report on Ordnance Program No. 5981 (Project No. 1666); APG 40-32-1
DATE OF REPORT: 12 September 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the recoil oil pressure of the 105-MM Howitzer Mount, M52
METHOD: Recoil oil pressures were determined by three types of test equipment. The first test arrangement included a magnetic type galvanometer oscillograph with two strain resistance gages. The second arrangement consisted of Bacharach pressure indicator equipment. The third arrangement consisted of a three-beam cathode ray oscillograph with two strain gages. In each method, the equipment was connected to the recoil cylinder and several rounds of ammunition were fired.
DESCRIPTION: The test 105-MM, Howitzer M4, and Mount, M52, were installed in a Medium Tank, M4. Eight ounces of oil were removed from each of the recoil cylinders.
CONCLUSIONS: The maximum recoil oil pressure obtained with each method was as follows: galvanometer oscillograph, 3400 psi; cathode ray oscillograph, 3200 psi; and Bacharach pressure indicator equipment, 6000 psi. Location of the strain resistance gages apparently did not affect the values obtained during the tests. Because of the limited test firing, no comparison was made regarding differences in oil pressure with the recoil cylinders filled and with eight ounces of oil removed. It was recommended that future tests of this type should be made with strain resistance gages or Piezo gages.
GENERAL: This 40-page report contains five photographs of the galvanometer oscillograph records, three photostats of the cathode ray oscillograph records, and 14 photostats of the Bacharach pressure indicator records.

SUBJECT: Test Equipment APG TB5-5000/3
TITLE: Qualification Test on Hydraulic Brake Fluids Investigation and Design of Stroking Equipment
IDENTIFICATION: Third Report on Project No. TB5-5000
DATE OF REPORT: 23 May 1949
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop suitable equipment for use in conducting stroking qualification tests on hydraulic brake fluids
METHOD: Requirements for the proposed equipment, based on the specification stroking test procedures, were outlined. Commercial units were studied; refinements for anticipated research were incorporated in the design. After the unit was constructed and assembled, the equipment was used in conducting hot and cold cycle proof tests on ten fluids which were tentatively approved under U.S. Army Specification 2-111B.
DESCRIPTION: Primary components making up the apparatus for conducting stroking qualifications tests of hydraulic fluids included: a large sub-zero conditioning cabinet with a capacity large enough to hold eight wheel assemblies and four master cylinders of 3/4-ton, 4x4 truck design, an auxiliary refrigerating compressor in conjunction with a heat exchanger for cooling the cabinet; copper coils through which hot water could be circulated for the purpose of heating the cabinet; electric driven circulating air fans; and special push rods which protruded into the cabinet for the purpose of actuating the master cylinders during the stroking cycles. The ends of the push rods protruding outside the cabinet were attached to large air brake cylinders. Air from a surge tank was passed to these cylinders via electric air valves. Stroking rate of the master cylinders was controlled by means of a variable speed device which rotated a small cam in a distributor head; this cam made and broke the electric circuit to the air valves. A control board for the apparatus contained four Brown Instrument, 24-hour, pressure recorders and 1 Brown Instrument, high speed, pressure recorder.
CONCLUSIONS: Performance of the test apparatus was satisfactory. Stroking tests could be conducted at temperature ranges of -50° to 200°F, at pressures varying from 200 to 2000 psi, and at stroking rates ranging from 2 to 40 strokes per minute. It was recommended that the apparatus be considered satisfactory for use in conducting hydraulic brake fluid stroking tests in accordance

with the requirements of U.S. Army Specification 2-111B, and tentative specifications for arctic winter grade brake fluids; and that the apparatus be considered suitable for use in investigating, studying, and formulating new and improved hydraulic brake fluids, and for research and qualification work on rubber components.
GENERAL: This 30-page report contains 18 photographs of the test apparatus and instrumented graphic test results.

SUBJECT: Test Equipment APG TT1-649/22
TITLE: Stress Measurement Instruments for Automotive Development
IDENTIFICATION: Twenty-second Report on Project No. TT1-649
DATE OF REPORT: 14 March 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether suitable methods could be developed for use in measuring shock loads and stresses occurring in automotive components during vehicle operation
METHOD: Strain-gage measuring devices were placed on various components of several types of vehicles. The vehicles were then operated over courses that exhibited severest operating conditions for the particular components being tested. Instruments and meters were used to record the strain which existed in the components as a result of the vehicle operation. Shock loads and stresses on the components were calculated from the strain data.
DESCRIPTION: The strain-gage measuring devices tested were of the resistance wire type. Baldwin Southwark SR-4 bonded wire resistance strain-gages served as the strain-detecting elements, which made up half or full Wheatstone bridges. Grids of the strain-gages were made from either Advance or Iso-elastic type wire. Meters for recording amplified strain-gage bridge outputs included Baldwin SR-4 strain indicator; Glen L. Martin dynamic measurement equipment; Hathaway Type S-8 magnetic-type recording oscillograph; Brush strain analyzer, Model BL-310, with Brush direct inking oscillograph, Model BL-202; and General Electric photoelectric recorder.
CONCLUSIONS: Satisfactory methods were developed for measuring shock loads and stresses in automotive components. The instrumentation used produced reliable data, however, the strain gage method was considered the most satisfactory, especially in dynamic testing. It was recommended that the investigation of various methods for measuring shock loads and stresses in automotive components be continued.
GENERAL: This 66-page report contains 23 pages of photographs showing testing equipment.

SUBJECT: Test Equipment APG TT1-698/8
TITLE: Service Test of Cone Penetrometer
IDENTIFICATION: Eighth Report on Project No. TT1-698; APG 37-9
DATE OF REPORT: 13 February 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the mechanical adequacy and durability of the cone penetrometer
METHOD: The test penetrometer was subjected to such handling as would be encountered in field use. The penetrometer was carried in a truck for approximately 330 miles over cross-country and secondary roads. For approximately 50 of these miles, it lay loose in the truck bed. The meter was often dropped in soil and was forced into soil approximately 900 times. Inspection of penetrometer components was made before and after the test.
DESCRIPTION: The cone penetrometer, designed by the Corps of Engineers, consisted of a circular spring mounted between a handle and a 5/8-inch diameter shaft at the end of which was a conically shaped probe having a 30° apex and one square inch of projected base area. An extensometer was mounted inside the spring. The dial of the indicator was calibrated to indicate deflection of the spring directly in pounds of applied force. Since the base area of the cone was one square inch, the instrument indicated pressure directly in psi.
CONCLUSIONS: The penetrometer showed no adverse effects resulting from the test. It was mechanically adequate, and was considered sufficiently durable for military use. It was recommended that the instrument be made available to the using services for further evaluation of its utility as a means of rating terrain.
GENERAL: This 41-page report contains one photograph showing the cone penetrometer in use, three photographs illustrating test vehicles, a radio-frequency power generator, and a page showing penetrometer and detail drawings.

SUBJECT: Test Equipment APG TT1-700/1
TITLE: Test of Heavy Field Dynamometer
IDENTIFICATION: First Report on Project No. TT1-700
DATE OF REPORT: 11 June 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To report on the design, construction and acceptance tests of a heavy field dynamometer
METHOD: Specification requirements for the dynamometer and instrumentation were drawn up, summarizing the functions the vehicle would have to fulfill. Contracts were negotiated separately for the vehicle and instrumentation. The equipment was delivered to Aberdeen Proving Ground where acceptance tests were conducted.
DESCRIPTION: The dynamometer truck was built by the Knuckey Truck Company and was instrumented by the General Electric Company. The vehicle was approximately 46 feet long, 12 feet wide, and 11 feet, 9 inches high with a wheel base of 26 feet, 6 inches. It employed an electric drive system which consisted primarily of two gasoline engine-driven generators that supplied power to four electric motors that drove the wheels. When used as a power absorption vehicle, the fields of the motors were reversed and the generated power was absorbed by resistance grids mounted on the vehicle. The total weight of the dynamometer truck was 110,800 pounds without ballast. A detailed description of the vehicle and instrumentation is included in the report.

CONCLUSIONS: The heavy field dynamometer met most of the specification requirements regarding general over-all design, power train, electrical controls, instrumentation, maneuverability, and general service. It was recommended that the following modifications be incorporated on the vehicle: installation of larger, heavy-duty drive chains, relocation of rear drawbar, and use of a carrier amplifier system instead of a chopper amplifier system. It was also recommended that future field dynamometers be of the electric-drive type, and that an investigation be made of Tate-Emery hydraulic cells, or other hydraulic drawbar systems, before any additional dynamometers were procured.
GENERAL: This 276-page report includes schematic drawings and 26 photographs of the heavy field dynamometer and associated components.

SUBJECT: Test Equipment APG TT1-700/2
TITLE: Studies for the Development of a Portable Transmission Dynamometer
IDENTIFICATION: Second Report on Project No. TT1-700
DATE OF REPORT: 23 April 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of wire resistance strain gages and a 2000 ft.-lb. impedance-type torquemeter for use in evaluating torque at various points in the power train of Ordnance vehicles
METHOD: Wire resistance strain gages were used to measure the torque in the following vehicle components: medium tank M4E8 final drives; medium tank M26 transmission input shaft during cold starting tests; heavy tank T29 final drive flanges during actual field operations; medium tanks T30 and T40 transmission input shafts; and model CD-500-1 cross-drive transmission, converter drive cross shaft. Attempts were made to measure the torque applied between the engine and propeller shaft of a light tank M24 by using the impedance-type torquemeter.
DESCRIPTION: The wire resistance strain gages were devices which electrically measured the torsional stress of the component on which it was mounted. The 2000 ft.-lb. impedance-type torquemeter was made by the General Motors Corporation and was designed for installation as a coupling between the engine and propeller shaft of a vehicle. An electrical output derived as a result of the deflection of a hub and a rim in the unit was proportional to the torque at the point of unit installation. This output was taken to a meter which directly indicated the torque value.
CONCLUSIONS: Torque measurements made with resistance wire strain gage devices were found to be improved to a point where measurements could fall within ± 5% of the torque values determined by normal dynamometer laboratory methods. The impedance-type torquemeter results were unsatisfactory since torque fluctuations in the propeller shaft made it impossible to read the indicating meter values. The noise level and maintenance of sliprings used with the torque measuring devices were found unsatisfactory. It was recommended that investigations and test be continued toward developing adequate torquemeters for measuring torque at various points in the power trains of Ordnance vehicles; and that development of slipring assemblies be investigated in an effort to reduce maintenance requirements and noise level.
GENERAL: This 41-page report contains 18 photographs showing equipment tested.

SUBJECT: Test Equipment APG TT1-708/1
TITLE: Investigation and Fabrication of Attachment of Track Block Testing on Tire Testing Machine
IDENTIFICATION: First Report on Project No. TT1-708; APG 24-225
DATE OF REPORT: 1 September 1947 (Last Date of Test)
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether a tire test machine without major modification would be suitable for use in testing track blocks
METHOD: A slightly modified tire-testing machine was used for testing a 38-block section of T84 chevron rubber tank track. Block temperatures were recorded during the course of test.
DESCRIPTION: A Bureau of Standards tire-testing machine was modified to test track blocks. The modified machine consisted of a steel drum over which a track section could be mounted; a 25-hp electric motor drove the track drum through a system of V-belts and a 42-inch diameter load wheel.
CONCLUSIONS: The modified machine was unsatisfactory for conducting controlled tests on tracks. The primary deficiency was the inability of the machine motor to drive the track at speeds high enough to cause abnormal track block-operating characteristics and temperatures. It was recommended that no further consideration be given to the use of tire-testing machines for track block testing; and that extensive studies be conducted on the design of a machine on which track blocks could be tested under controlled conditions.
GENERAL: This 17-page report contains one photograph showing the modified tire testing machine.

C-J3-996
Std Stl Spring
SUBJECT: Test Equipment B-1.2
TITLE: Charpy Impact Machine Calibration at Florence Stove Company, Kankakee, Illinois
IDENTIFICATION: Report No. J3-996
DATE OF REPORT: 28 September 1953
ORIGIN: Standard Steel Spring Company
PURPOSE: To calibrate a Charpy impact machine and compare companion test specimens
METHOD: One hundred twenty-five companion Charpy bars were used to compare results at Florence Stove Company with those at Standard Steel Spring Company. Calibrating the impact machine and checking the machining operations of Charpy specimens were also performed. This work was done at Florence Stove Company.
DESCRIPTION: The test equipment was a Sonntag impact machine and an American Instrument Company sub-zero test cabinet. The Charpy specimens

were cooled to the required -40°F in the sub-zero cabinet, using alcohol as the liquid medium and dry ice as the coolant.
CONCLUSIONS: Machining operations and Charpy testing at Florence Stove Company met the requirements of Specification MIL-A-12560 ORD. Impact results were 1.2% higher than those of companion samples tested at Standard Steel Spring Company.
GENERAL: This 12-page report is not illustrated. Included is Report No. J3-1030.

C-J-9368
Std Stl Spring
SUBJECT: Test Equipment B-1.2
TITLE: Standardization of Impact Machines
IDENTIFICATION: Project No. J-9368
DATE OF REPORT: 8 April 1952
ORIGIN: Standard Steel Spring Co., Coraopolis, Pennsylvania
PURPOSE: To standardize impact machines by study of impact results from various testing facilities
METHOD: Impact specimens of three armor plate types were machined by Standard Steel Spring Co. and distributed among laboratories in the program for impact testing at -40°F. Data of the tests were accumulated and studied on a comparative basis.
DESCRIPTION: The 134 standard size V-notch Charpy specimens were from 1/2-inch thick armor plates and were tested by Great Lakes Steel, Jones & Laughlin, U.S. Steel, Watertown Arsenal, and Standard Steel Spring Co. The Sonntag Machine was used as the standard.
CONCLUSIONS: No serious variation in impact level of specimens from the same plate was found on any of the machines. The machines used by Great Lakes Steel, U.S. Steel, and Jones & Laughlin gave higher average impact results on all plates at all hardness levels.
GENERAL: This three-page report includes two pages of impact testing data.

SUBJECT: Test Equipment DA 416A
TITLE: Weindenhoff Model 500 Generator Test Bench
IDENTIFICATION: Report No. 416A
DATE OF REPORT: 12 October 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of a Weindenhoff generator test bench for use in testing 150-ampere, 24-volt generators
METHOD: Attempts were made to test 150-ampere, 24-volt generators while using the generator test bench.
DESCRIPTION: The test Weindenhoff generator test bench was identified as Model 500. A brush shifting-type motor, Serial No. 12757, rated 220 volts, 60 cycle, single phase, 5 hp, was included with the bench.
CONCLUSIONS: The Weindenhoff generator test bench was not suitable for use in testing 150-ampere, 24-volt generators. The brush shifting-type of motor was difficult to adjust to proper speed and load conditions, and did not maintain a constant speed. The motor required more maintenance than constant speed induction motors. The motor was easily overloaded, and would give no immediate indication of being overloaded. It was recommended that the use of the brush shifting-type of motor be discontinued and that constant speed (2, 3, or 4 speed) induction motors with mechanical speed changers, such as the varispeed drive, be substituted.
GENERAL: This 21-page report includes eight photographs of the test equipment.

SUBJECT: Test Equipment DA 696
TITLE: State-of-Charge Indicator for Storage Batteries
IDENTIFICATION: Report No. 696
DATE OF REPORT: 12 February 1956
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the possibilities of the test voltmeter for military use
METHOD: Battery voltages were measured on two 6TN and two 2HN batteries with the test instrument. Separate tests were conducted while the batteries were being charged, overcharged, and discharged. Additional tests were made on high-rate discharges of short intervals on a 6TN battery to simulate starting conditions. Results were shown graphically and on data sheets.
DESCRIPTION: The suppressed zero-type voltmeter was a Model P-60, Hickok Chargicator manufactured by the Hickok Electrical Company for indicating the charge of storage batteries. This unit had a scale reading of 10 to 16 volts and was intended for use with 12-volt batteries.
CONCLUSIONS: The test unit indicated the state-of-charge of tank batteries when it was used under the specified conditions. Suggestions were made concerning the readability of the scale, and the procedure for taking readings. It was believed that the instrument showed some promise; therefore, additional tests with a 24-volt model were recommended. An outline for these tests was included in the report.
GENERAL: This 18-page report contains one photograph of the test instrument.

SUBJECT: Test Equipment DA 1102
TITLE: Dwell Meters
IDENTIFICATION: Report No. 1102
DATE OF REPORT: 17 August 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of dwell meters CL-19506 and CL-18621 for use in testing rated pulse and gyro pickoff mechanisms
METHOD: The two test meters were intended for use in measuring the d.c. pulse length as produced by rated pulse mechanisms, Ordnance Part No. 7380434, and gyro pickoff mechanisms, Ordnance Part No. 7382786.
DESCRIPTION: Dwell meter CL-19506 weighed 8-3/4 pounds and measured 11-1/4x9-1/2x7-1/2 inches. Dwell meter CL-18621 weighed 7 pounds and measured 11-1/4x9-1/2x7-1/2 inches.
CONCLUSIONS: The test meters were not suitable for testing rated pulse or gyro pickoff mechanisms. Pulse length measurements were unsatisfactory because of extreme vibration which occurred in the meter needles. This vibration indicated that the

meters had not been designed to operate at frequencies encountered in the mechanisms tested. It was recommended that the manufacturer of the test meters be advised that the meters would be required to perform at frequencies as low as 12 cycles-per-second.
GENERAL: This four-page report includes two photographs of the dwell meters.

SUBJECT: Test Equipment DA 1439
TITLE: "A" Electronic Ignition Monitor
IDENTIFICATION: Report No. 1439
DATE OF REPORT: 17 December 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of an ignition monitor for diagnosing Ordnance engine troubles
METHOD: Definite ignition troubles were introduced in the ignition systems of a 2-1/2-ton, 6-cylinder, GMC truck, a 1/4-ton, 4x4, 4-cylinder truck, and a V-8 Snowmobile. The effects on the ignition monitor were noted. The ignition malfunctions used included open and short-circuited secondary leads, unsatisfactory condenser size, weak breaker point spring tension, incorrect breaker gap, defective ignition coil, high secondary resistance, and an excessive spark plug gap. An attempt to check the timing on an AV-1790-5 engine was made using the external adaptor for the sealed ignition system. The temperature rise at the transformers, choke, and various places within the instrument was observed after 8 hours of operation. The resistance of the connecting cables to gasoline and oil was determined.
DESCRIPTION: The test unit was an electronic ignition analyzer supplied by the Hastings Manufacturing Company, Hastings, Michigan. The instrument had two circuits to be connected to the ignition system. The spark plug lead of the last cylinder in the firing order was passed through the triggering pickup, and the signal pickup was connected to the primary terminal on the distributor. Three ground clips were connected to the engine block. The monitor weighed 66 pounds and measured 13-1/4x16x24-1/4 inches. The unit operated on 110 volts, a.c., and required 105 watts of power. Accessories were available to adapt the instrument for use on sealed ignition systems.
CONCLUSIONS: The ignition monitor successfully indicated ignition malfunctions and was recommended as a supplement for presently used engine analysis equipment; the instrument could not be used at maintenance levels below the Fifth Echelon. The following design changes were also recommended: shock mounting of the chassis, reduction in size, parade control modification, and adaptation for use on multi-magneto engines.
GENERAL: This 24-page report contains 15 photographs of the ignition monitor.

SUBJECT: Test Equipment DA 1499
TITLE: Evaluation of an Ignition and Vibration Analyzer
IDENTIFICATION: Report No. 1499
DATE OF REPORT: 18 January 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of an ignition and vibration analyzer used in test and maintenance work on Ordnance engines
METHOD: The test unit was studied from the standpoint of usefulness, size, portability, and degree of skill required by the operator. All common ignition malfunctions were simulated on both a test stand and an AV-1790 engine. Definite patterns were observed for each condition.
DESCRIPTION: The test analyzer was a modified three-inch cathode ray tube oscilloscope which displayed patterns directly related to ignition, vibration, torsion, and pressure conditions within an engine. The unit model and manufacturer were not identified.
CONCLUSIONS: The test analyzer was found to be satisfactory in all respects.
GENERAL: This 40-page report includes 30 photographs of the analyzer, scope patterns, and the test arrangements and circuits.

DA 1607
SUBJECT: Test Equipment B-4.10.1
TITLE: Crash Padding for Combat Vehicles
IDENTIFICATION: Report No. 1607
DATE OF REPORT: 13 March 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the arbitrary efficiency rating of crash pad materials; to determine the suitability of testing equipment
METHOD: A sample of the test material was placed between two steel sheets, one of which had an opening 8 inches in diameter. The sample was held in place by spring pressure against the sheet metal. A large pendulum on the apparatus was used to impart a known amount of energy to the exposed test material. The energy imparted to the material caused the large pendulum to rebound and caused a small pendulum, resting against the outside of the other plate, to move away from the pad with an acceleration due to the transmitted energy. These energies were calculated by the use of formulae and graphs.
DESCRIPTION: The test material consisted of eleven types of crash pad material, including expanded plastic hair felt, wool felt, jute felt and sponge types. The test apparatus consisted of two pendulums suspended so that the suspension balls were 1-inch apart. The large pendulum was used to create the impact energy and to measure the energy expended by the pad in resilience. The lighter pendulum was used to measure the amount of energy transmitted through the crash-pad material.
CONCLUSIONS: The total energy absorbed by the test materials varied from 27 to 53%. The apparatus was not considered suitable for determining the relative shock absorption properties of crash pad materials. It was recommended that the pendulum test apparatus be modified so that it would include a means for measuring the rate of force transmission.
GENERAL: This nine-page report includes five pages of test data.

SUBJECT: Test Equipment DA 1731
TITLE: Evaluation of Test Bench, FSN 17B-13990
IDENTIFICATION: Report No. 1731
DATE OF REPORT: 20 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the test bench, FSN 17B-13990, for testing standard Ordnance generators at 2400 watts
METHOD: A standard Ordnance generator delivering 2400 watts, regulated voltage at 28.0 volts was tested at speed ranges of 1/3 and 2/3 of maximum speed. A Weston Model 639 Industrial analyser (a.c.) was used to measure input voltage, current, and wattage of the test bench drive motor. A Weston Model 901 voltmeter, and Model 622 millivoltmeter with shunt, were used to measure generator output. Generator speed was determined with the test bench tachometer.
DESCRIPTION: The test bench, FSN 17B-13990, was designed for testing standard tank generators at an output of 2400 watts.
CONCLUSIONS: The test bench was considered unsatisfactory for testing the standard tank, 2400-watt generator. As preliminary tests indicated that low generator outputs were obtained at test bench speeds, manually controlled rheostat was substituted for the carbon pile voltage regulator. Excessive vibration caused the generator frame to rotate approximately 30° in its clamping device. Other unsatisfactory characteristics of the test bench were its inadequate range of speeds and poor speed regulation.
GENERAL: This five-page report is not illustrated.

SUBJECT: Test Equipment DA 1732
TITLE: Two Types of Antifreeze Hydrometers
IDENTIFICATION: Report No. 1732; Job No. 6923
DATE OF REPORT: 20 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of two FSN-8-H-940 anti-freeze hydrometers
METHOD: The hydrometers were examined in regard to assembly, shape, transparent and soft parts, efficiency of syringe and float, individual diameters, vertical position, thermometer construction, figures, and accuracy in the manner prescribed by the applicable requirements of Specification 56-85-7. The hydrometers were also subjected to accuracy, high and low temperature conditioning, low-temperature flexibility, and blow-off tests.
DESCRIPTION: The test FSN-8-H-940 anti-freeze hydrometers were identified as the AF-1, manufactured by the Kimble Glass Division of Owens-Illinois Glass Co., and the AF-2, manufactured by Edelmann and Co. The ethylene glycol used in the tests conformed to Specification 4-1116, and was diluted with distilled water to obtain solutions of the proper freezing points. The alcohol type anti-freeze was a commercial ethyl-base product.
CONCLUSIONS: Both the AF-1 and the AF-2 hydrometers indicated incorrect freezing point readings, some of which showed considerable discrepancy.
GENERAL: This 10-page report is not illustrated.

SUBJECT: Test Equipment DA 1737
TITLE: Report on Several Electric Leakage Testers
IDENTIFICATION: Report No. 1737
DATE OF REPORT: 22 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate four leakage testers
METHOD: The leakage testers' components were checked for energizing presence while the circuit selector switch was set at the "off" position. Tests were performed on the "test light," "leakage," "high," and "high tension" circuits, the testers themselves being used as the voltage source in lieu of an external test voltage. An ignition harness from a 1790 Continental engine was tested for flaws with two of the testers. These testers were also subjected to a -20°F temperature for 24 hours, and a vibration test. Three of the testers, were exposed to 200 hours of salt fog to determine their resistance to corrosion.
DESCRIPTION: The test material was four leakage testers designated A, B, C, and D. Leakage testers A, C, and D were identified as Part No. FSN 17-T-5536-110, and were manufactured by Nelson Tester Co. Inc., Lanagan and Hoke, and Joseph Weidenhoff Inc., respectively. Leakage tester B was identified as Part No. FSN 17-T-5536-100 and was manufactured by Lanagan and Hoke.
CONCLUSIONS: No energizing presence was detected during the time the circuit selector switches were in the "off" position. The "high tension" circuit of the A and D leakage testers failed to operate properly when the source voltage and the case had a common ground. The outside insulation of the high tension cable of the D tester cracked when it was flexed at -20°F. The "high tension" circuit of the B tester did not become energized with input voltages of 12 and 24 volts, d.c. The "high" and "leakage" circuits of this tester ceased to operate on input voltages of 6, 12, and 24 volts d.c. after the "leakage" circuit was operated for approximately 10 seconds with an input voltage of 24 volts, d.c. The lamp of the C tester "test light" circuit burned out when used continuously for one minute. The A and D testers operated satisfactorily after the vibration test. The A, C, and D tester covers gave a poor performance in the resistance to corrosion tests.
GENERAL: This 29-page report includes 14 pages of photographs and one appendix.

SUBJECT: Test Equipment DA 1769
TITLE: Tire Test Gages and Tire Inflator Gages
IDENTIFICATION: Report No. 1769; Job No. 7118
DATE OF REPORT: 11 July 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the accuracy of tire test gages and tire inflator gages at temperatures of 165°, 74°, -40°, and -65°F
METHOD: Three tire pressure gages were clamped in a well-seated position in the gage holder, which was then connected with the air pressure system. After the inlet and exhaust valves were closed, the pressure in the reservoir was adjusted to the test pressure. The inlet valve was then

opened and the gage readings were recorded. With the inlet valve closed the exhaust valve was opened until the gage indicator bars were returned to the zero position manually, and then the exhaust valve was closed. This procedure was followed for each reading at each test pressure. The tests were conducted in an oven maintained at 165°F, and in a walk-in cold chamber maintained at -40° and -65°F. The precision gage was kept at ambient temperatures of approximately 74°F regardless of the temperature of the sample gages. The inflator gages were tested individually with the pressure reservoir substituted for a pneumatic tire. The tank was filled with nitrogen until the precision gage registered the desired pressure and the pressure was then measured with the inflator gage. The gages were operated manually and by air pressure prior to the start of each test series to assure smooth operation. Three gage readings were taken at each test pressure and temperature, and the results reported as the differential between the precision gage readings and readings of the sample gages.
DESCRIPTION: The tire pressure gages were a general service Type II, manufactured by the Syracuse Gage Manufacturing Company, Syracuse, New York; a general service Type II No. 2379, and a precision Type I No. 4550, both manufactured by A. Schrader's Sons, Brooklyn, New York. The tire inflating tools complete with gages were identified as No. 56, manufactured by Milton Manufacturing Company, Chicago, Illinois; No. 1215G, manufactured by Amseco, Villa Park, Illinois; and No. 715 DRC, manufactured by Druge Brothers Manufacturing Company, Oakland, California.
CONCLUSIONS: The Syracuse tire test gage failed at 165°F. The Schrader No. 2379 tire test gage was unsatisfactory at -65°F. The performance of the Milton and Amseco gages was superior to that of the Druge Brothers gage although errors of all gages were over the limits specified for precision gages (Specification 56-50-5, Amendment 3).
GENERAL: This 14-page report includes four pages of photographs of the test gages and apparatus.

SUBJECT: Test Equipment DA 1778
TITLE: Six Types of Low Voltage Circuit Testers
IDENTIFICATION: Report No. 1778
DATE OF REPORT: 17 June 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To conduct evaluation test of six low voltage testers
METHOD: Sample low voltage testers were checked for over-all dimensions and weight, and for accuracy at 20, 40, 60, 80, and 100% of full scale deflection on all ranges. The testers were also subjected to electrical overload, vibration, and low temperature tests. The tester covers were subjected to corrosion tests and samples of the cables used in the accessories were subjected to oil absorption, high temperature, and cold bend tests.
DESCRIPTION: The test material consisted of six low voltage circuit testers, Federal Stock Number 17-T-5575-50, manufactured by Heyer Products Co., Inc., Belleville, New Jersey; Sun Electric Corporation, Chicago, Illinois; Joseph Weidenhoff, Inc.; Allen Electric and Equipment Co., Kalamazoo, Michigan; King Electric Equipment Co., Cleveland, Ohio; and Electro Products Company.
CONCLUSIONS: Tests on the Sun Electric, King Electric, and Electro Products low voltage circuit testers were either discontinued, or were not conducted, at the request of the project engineer. The low voltage circuit testers manufactured by Joseph Weidenhoff, Inc., gave the best over-all test performance.
GENERAL: This 63-page report includes 16 photographs of equipment tested, 12 tables of test results, and eight sheets of calibration curves.

SUBJECT: Test Equipment DA 1792
TITLE: Weston and Triplett Ohmmeters
IDENTIFICATION: Report No. 1792
DATE OF REPORT: 23 June 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare Weston and Triplett ohmmeter accuracy
METHOD: The accuracy and sensitivity of the two test meters were compared on the 0 to 10 ohms and 0 to 1,000 ohms scales. The exterior and interior of the meters were photographed to record workmanship. The meters were also checked for internal resistance.
DESCRIPTION: Both test meters had three binding posts: one post common, one post for the 0 to 10 ohms scale, and one post for the 0 to 1,000 ohms scale. Both meters housed a single cell battery as a power source. The larger of the two meters was manufactured by the Weston Electrical Instrument Corp. of Newark, New Jersey; the other meter was manufactured by the Triplett Instrument Company of Bluffton, Ohio. Both meters carried No. FSN 17-0-402.
CONCLUSIONS: The ohmmeters were comparable in workmanship. The Weston ohmmeter proved to be superior in accuracy and sensitivity to the Triplett meter.
GENERAL: This 13-page report includes two photographs of each meter, two curve sheets of meter deviation, and a table of meter readings using resistance standards.

SUBJECT: Test Equipment DA 1794
TITLE: Test of Battery Cell Testers
IDENTIFICATION: Report No. 1794
DATE OF REPORT: 23 June 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the battery testers for military use
METHOD: The calibration of the voltmeter on the battery testers was checked at full-scale deflection at temperatures between -10°F and 110°F. The prod arrangements of the testers were checked on various types of batteries including defective and discharged batteries. The testers were then cycled 50 times with two volts across the prods for 10 seconds and then with zero voltage across the prods for 10 seconds. Operation of the testers was checked after a two hour simulated rain test

and 1/2 hour of drying. A separate ammeter and voltmeter were used to check the calibration of the testers.
DESCRIPTION: The various battery testers were manufactured by Meyer, Mercury, Allen, Auto Test, Hoyt, Lanagan, Stuart, and Weidenhoff. The testers consisted basically of two metallic pointed prods mounted on an insulated handle. A -3 volts to +3 volts d.c. voltmeter was connected between the two metal prods. A low resistance load, between the prods, shunted the voltmeter.
CONCLUSIONS: All of the battery testers were unsatisfactory due to their failure on the rain and calibration tests.
GENERAL: This 16-page report contains two photographs showing the testers and the laboratory test setup.

SUBJECT: Test Equipment DA 1807
TITLE: Four Types of Megohmmeters
IDENTIFICATION: Report No. 1807
DATE OF REPORT: 27 June 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate four types of megohmmeters
METHOD: Three of the four submitted megohmmeters were subjected to a voltage-speed characteristics test and the fourth megohmmeter was subjected to a voltage output-ohms scale test. Tests on two of the megohmmeters were discontinued. The two remaining megohmmeters were given a calibration check against resistance standards, were checked for proper guard circuit function, and were given a 0°F 24-hour soak test.
DESCRIPTION: Three of the megohmmeters submitted for the test were hand operated. One was manufactured by the Winslow Company, one by the J. G. Biddle Company of Philadelphia, Pa., and one by the Holtzer-Cabot Company of Boston, Massachusetts. The other megohmmeter was battery operated and was manufactured by Associated Research, Inc. of Chicago, Illinois.
CONCLUSIONS: A table of recorded voltage-speed characteristics and a table of calibration readings were compiled. Three curve sheets were plotted to compare megohmmeter characteristics. The guard circuits of the Winslow and J. G. Biddle megohmmeters operated satisfactorily. Neither the Winslow nor the Biddle megohmmeter could be turned at maximum speed immediately after they were subjected to the cold test, but the Biddle megohmmeter loosened after a few revolutions.
GENERAL: This 15-page report includes five photographs illustrating details of the test megohmmeters. Three curve sheets are also included in this report.

SUBJECT: Test Equipment DA 1888
TITLE: Report on Five Types of Magneto Lights
IDENTIFICATION: Report No. 1888; Job No. 7114
DATE OF REPORT: 28 July 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the conformance of five magneto timing lights to specification requirements
METHOD: The test lights were subjected to weight, field operation, spark plug firing, 2-1/2-hour endurance, 100-cycle intermittent operation, salt spray, low temperature, high temperature, and readings were compiled. Three curve sheets were high humidity tests in accordance with the requirements of Specification MIL-L-7857.
DESCRIPTION: The magneto timing lights were identified as lights MTL1, MTL2, MTL3, MTL4, and MTL5, manufactured by the Aircraft Electronics Assn., Allen Electronic & Equip. Co., Joseph Weidenhoff Inc., Auto-Test Inc., and Standard Electrical Products Co., respectively.
CONCLUSIONS: Lights MTL4 and MTL5 complied with all requirements. Light MTL1 failed to comply with the weight requirement. Light MTL2 became defective during the field operation test. Light MTL3 became defective during the high temperature test.
GENERAL: This nine-page unillustrated report includes five schematics of the timing lights and one table showing test results.

SUBJECT: Test Equipment DA 1900
TITLE: Ozone Content, Exposure Chamber of the Atlas Twin Arc Weather-Ometer
IDENTIFICATION: Report No. 1900
DATE OF REPORT: 27 August 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the ozone content within the exposure chamber of the Weather-Ometer with the ozone content in the general laboratory atmosphere
METHOD: All measurements were made with the absorbing device and according to the procedures outlined in the applicable sections of ASTM-D1149-51T, Accelerated Ozone Cracking of Vulcanized Rubber.
DESCRIPTION: The Atlas Twin-Arc Weather-Ometer was equipped with filters which transmitted only those frequencies of ultra-violet light above 2750 actual Angstrom units, with the region of greatest intensity near 3900 Angstrom units. The pyrox optical filters, in which the carbon arcs operated were air tight, and served to exclude radiations below 2750A°, gases and other impurities from the test chamber. Limited intensity radiations near the destructive range were transmitted by the glass filters and tended to lower the concentration of ozone in the Weather-Ometer, as compared to the laboratory atmosphere.
CONCLUSIONS: The ozone concentration of the air directly in front of the Weather-Ometer was approximately twice as much as the ozone concentration in the instrument itself. The efficiency of the Weather-Ometer in controlling ozone generation within its exposure chamber was responsible for the fact that the ozone concentration was less within the instrument than it was in the surrounding laboratory atmosphere.
GENERAL: This three-page report is not illustrated.

SUBJECT: Test equipment DA 1913
TITLE: Fixture for Testing Battery Vent Caps
IDENTIFICATION: Report No. 1913; Job No. 5698
DATE OF REPORT: 26 August 1952

TANK AUTOMOTIVE TEST RESUMES

ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of a special fixture for use in testing battery vent caps according to the requirements of Specification MIL-B-11188
METHOD: Vent caps were installed in the fixture, the fixture top was secured in place, and pressure, equivalent to a 4-foot column of water, was applied to the upper portion of the fixture and cap leakage checked. Pressure was then released from the upper portion of the fixture and in turn applied to the lower portion so as to permit a check of the venting characteristics of the caps. Fixture suitability was determined on the basis of the vent cap leakage observed.
DESCRIPTION: The battery vent cap testing fixture consisted of a plastic base, upper and lower cylindrical plastic chambers separated by a plastic divider, a plastic top, and a special metal fixture used to hold the assembly together. The top of the upper plastic cylinder and the plastic divider were equipped with special stems through which air pressure could be applied into the upper and lower chambers of the tester. A plastic hose and charging valve were included with the fixture assembly.
CONCLUSIONS: The fixture was considered suitable for use in testing battery vent cap leakage and venting characteristics in accordance with the procedures outlined in Specification MIL-B-11188.
GENERAL: This three-page report contains two photographs showing the fixture assembled and disassembled.

SUBJECT: Test Equipment DA 1914
TITLE: Tests of Seven Power Timing Lights
IDENTIFICATION: Report No. 1914
DATE OF REPORT: 27 August 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of seven timing lights
METHOD: A chalk mark was placed on the flywheel of a vehicle engine. The focusing qualities and visibility ranges of the seven timing lights on the chalk mark were then determined in bright sunlight at vehicle engine speeds ranging from 300 to 2600 rpm. Additional testing was conducted using the timing lights in ambient temperatures of -25° and 160°F; in these tests the lights were used in conjunction with 6, 12, and 24-volt electrical systems with vehicle engines operating at 1500 rpm. The timing lights were given an endurance test and were tested for current input, voltage across the vibrator and flash tube, and circuit breaker operation at -25°F and room temperature. Oscillograms were made of the voltage characteristics of the timing light vibrators in the static and dynamic states.
DESCRIPTION: The test timing lights were manufactured by Sun Electric; Joseph Weidenhoff, Allen Electric, Heyer Products, E. Edelmann, and Auto Test Inc.
CONCLUSIONS: The Joseph Weidenhoff, Allen Electric, and Sun Electric Timing lights were found unsatisfactory. Although the Heyer, Edelmann, and Auto Test timing lights apparently operated satisfactorily, oscillograms revealed some objectionable peak and unstable voltage characteristics across the vibrator contacts.
GENERAL: This 19-page report contains four pages of photographs showing the voltage wave forms of the timing lights as recorded on the oscillograms. Duplicate sheets of the report are also included in the enclosing folder.

SUBJECT: Test Equipment DA 1970
TITLE: Leakage Testing Apparatus for Submersible Storage Batteries
IDENTIFICATION: Report No. 1970
DATE OF REPORT: 22 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of an apparatus for leakage testing of submersible storage batteries
METHOD: The device for leakage testing of submersible storage batteries was constructed and tested in accordance with paragraph 4.5.5.1 of Specification MIL-B-11188.
DESCRIPTION: The leakage apparatus consisted of six tubes having a vent fitting on one end and a quick disconnect fitting on the other for attachment to each vent opening of the battery. The quick disconnect ends of five tubes were placed in a beaker containing one to two inches of water. The remaining tube was attached to a manometer and air supply. The cell being tested was daubed with a solution of water, detergent, and glycerin. An air pressure of four psi was applied, then cut off. Leakage of the cell under test was evidenced by a drop in the manometer reading and emission of bubbles. Intercell leakage was evidenced by a drop in the manometer reading and emission of bubbles from quick disconnect air fittings in the beaker of water.
CONCLUSIONS: The test apparatus operated satisfactorily.
GENERAL: This two-page report includes a photograph of the test apparatus.

SUBJECT: Test Equipment DA 2011
TITLE: Sample Hydrometer, FSN 18-H-1241-20
IDENTIFICATION: Report No. 2011
DATE OF REPORT: 22 October 1956
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To obtain engineering data on the test hydrometer
METHOD: The hydrometer was tested for accuracy, leakage, and shock. Sulphuric acid resistance characteristics of the hydrometer and carrying case were then determined; 1.275 solutions of sulphuric acid were used in these tests.
DESCRIPTION: The test hydrometer was identified only as FSN 18-H-1241-20.
CONCLUSIONS: There was no leakage of water into the hydrometer barrel assembly. When dropped from a height of 2 feet with its longitudinal axis parallel to the floor, the hydrometer components were not damaged. When dropped from 3 feet, the hydrometer fractured in two places. There was no further damage to the hydrometer, or its parts, when dropped from heights of 4 and 5 feet. After

immersion in sulphuric acid for a period of 6 hours, the bulb, float, and barrel group of the hydrometer showed no harmful effects. After a second flushing of the hydrometer carrying case with sulphuric acid, the entire inner surface area of the case hardened and revealed slight blistering. At the end of the fourth cycle, the carton separated along two of its horizontal folds for about 3 inches. After the fifth cycle, approximately 3/4 of the bottom of the case was separated from the body.
GENERAL: This two-page report is not illustrated.

SUBJECT: Test Equipment DA 2190
TITLE: Schrader Type 8G620 Tire Gages for Arctic Use
IDENTIFICATION: Report No. 2190
DATE OF REPORT: 26 January 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To calibrate a tire pressure gage for use in arctic tire endurance tests
METHOD: Four tire gages were conditioned for 4 hours at the test temperature. Pressure determinations were made at 135°F, 80°F, -25°F, and -65°F.
DESCRIPTION: The tire gage tested was the Gage, Air Pressure, Pneumatic Tire, Type 8G620, Manufacturer No. 7188B-H, manufactured by A. Schrader's Sons, Brooklyn, New York.
CONCLUSIONS: Four tables were compiled to record the reading of the four test gages at the four test temperatures. Pressure readings between gages varied the most at -65°F; one gage was completely inoperative at this temperature.
GENERAL: This seven-page report includes four tables of gage readings for the four temperature levels.

SUBJECT: Test Equipment DA 2243
TITLE: Antifreeze Hydrometers "A" and "B", Type FSN 18-H-940
IDENTIFICATION: Report No. 2243
DATE OF REPORT: 26 February 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate two antifreeze hydrometers, Type FSN 18-H-940, designated "A" and "B"
METHOD: Performance tests were conducted with the two test hydrometers, in accordance with the test program. Physical requirements tests were conducted in accordance with USA Specification 56-85-7. The hydrometer floats and thermometers were checked for accuracy, using solutions of ethyl alcohol and ethylene glycol at specified temperatures. The tests were conducted while the hydrometers were maintained at room temperature, and repeated after conditioning the hydrometers for 24 hours at the solution temperature. The freezing points of the various solutions, interpolated from specific gravity readings of the two test hydrometers, were compared with actual freezing points of the solutions, which were determined by using ASTM standard low cloud and pour thermometers that complied with Federal Specification VV-L-791d, and which were accurate within 2°F. Ethylene glycol was used in testing hydrometer "A". The ethylene glycol used in testing hydrometer "B" conformed to Specification MIL-E-11789, superseding USA Specification 4-1116. The ethyl alcohol used in testing both hydrometers complied with Federal Specification O-A-396.
DESCRIPTION: Antifreeze hydrometer "A" was manufactured by the Kimble Glass Company, antifreeze hydrometer "B", by the Edelmann Company.
CONCLUSIONS: Both hydrometers exhibited adequate operating performance when operated at room temperature with solutions of 80°F and 150°F, after having been conditioned at -50°F for 72 hours. Slight blistering was observed in the bottom of each carrying case, after both hydrometer cases had been flushed once each day for 5 days, full strength concentrations of ethyl alcohol and ethylene glycol being used alternately. Polariscope examination revealed no strains or defects in the glass parts of the test hydrometers.
GENERAL: This 17-page report includes four photographs of the test hydrometers and their carrying cases.

SUBJECT: Test Equipment DA 2316
TITLE: Weston Volt-Ohm-Milliammeter Model 697
IDENTIFICATION: Report No. 2316
DATE OF REPORT: 24 March 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the engineering suitability of a Weston volt-ohm-milliammeter, Model 697
METHOD: The electrostatic deflection characteristics of the instrument were tested by rubbing the instrument window with a dry cloth and by applying a potential of 2500 V.D.C. between the window and instrument movement. Accuracy checks were made of the various instrument scales at room temperature and at temperatures of -25°, 0°, 32°, and 125°F; during continuous use cycling tests; after a vibration test; and after being soaked at temperatures of -65° and 165°F (accuracy not being checked until the instrument reached room temperature). In addition, the voltage and milliampere scales were checked to determine the effect of a 100% overload applied for one second in the reverse and forward directions. The meter was dismantled and inspected after the tests.
DESCRIPTION: The test volt-ohm-milliammeter, Model 697, was manufactured by the Weston Electrical Instrument Corp. The following scales were included on the meter: 7.5, 15, 150, and 750 V.D.C.; 7.5 and 75 milliamps D.C.; 7.5, 15, 150, and 750 V.A.C.; and 500, 5000, and 500,000 ohms.
CONCLUSIONS: The movement of the instrument did not deflect as a result of the cloth-rubbing test or 2500 V.D.C. test. Tables made up showing the accuracy of the various meter scales under the various test conditions indicated that all meter ranges were accurate within the specifications of the test outline. The instrument was not damaged by the 100% overload applied to the milliampere and voltage circuits of the meter. The inspection

after testing revealed that the 165°F soaking temperature caused most of the wax surrounding the multiplying resistors to melt.
GENERAL: This 43-page report contains two photographs showing the test instrument.

SUBJECT: Test Equipment DA 2319
TITLE: Weston Ohmmeter Model 698-1F
IDENTIFICATION: Report No. 2319
DATE OF REPORT: 25 March 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of a Weston Ohmmeter Model 698-1F
METHOD: The electrostatic characteristics of the meter were tested by rubbing the instrument window with a dry cloth and by applying a potential of 2500 V.D.C. between the instrument window and movement. Accuracy tests of the meter were made with Shallcross No. 829 resistance boxes that were accurate to within 0.5% of the dial setting of a Wheatstone Bridge. The accuracy tests were made at temperatures of -25°, 0°, 32°, 75°, and 125°F; during continuous use cycling tests; after vibration tests; and after being soaked at temperatures of -65° and 165°F. In the extreme temperature tests, the batteries were removed during the soaking period and the accuracy of the meter was not checked until the instrument reached room temperature. The instrument was dismantled and inspected after the test program and a shatterproof test was conducted on the instrument window.
DESCRIPTION: The test ohmmeter, Model 698-1F, was manufactured by the Weston Electrical Corp. The instrument was a two-range ohmmeter, with the low range designed for measuring resistance values up to 10 ohms and the high range designed for measuring resistance values up to infinity.
CONCLUSIONS: The tests on the electrostatic deflection characteristics of the meter produced no deflection of the instrument movement. Neither the low nor the high range of the ohmmeter could be zeroed when the instrument was checked for accuracy at -25°F; this was thought to be caused by the low efficiency of the battery at low temperatures. The window of the instrument was fractured in the shatterproof test. Test data were incorporated in tables showing the accuracy of the meter under the various test conditions.
GENERAL: This 13-page report contains two photographs of the ohmmeter.

SUBJECT: Test Equipment DA 2231
TITLE: Magneto-Distributor Tester, Federal Stock No. 17-T-5545
IDENTIFICATION: Report No. 2231
DATE OF REPORT: 18 February 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the performance characteristics of two types of magneto-distributor testers
METHOD: Tests were conducted on two types of magneto-distributor testers to determine the following performance characteristics: speed, torque (ft./lbs.), output (hp), current (amperes), power factor, and efficiency (percent). The foregoing tests were determined on the basis of brush shifts varying from 3-1/2 bars to full brush shift of 20 bars.
DESCRIPTION: The two types of testers were designated "A" and "B" with a common Federal stock number, but no information was given as to the manufacturer or manufacturers. More accessories were provided for the "B" than for the "A" tester. The equipment was apparently designed to test generators and voltage regulators as well as magnetos and distributors.
CONCLUSIONS: The generator mounting vises were not adjustable laterally, therefore all types of generators could not be tested due to inability of alignment of drive and driven pulleys. Proper adapters were not provided for driving all types of magnetos and distributors. Considerable vibration was noted at increased speed of the "A" tester. The "B" tester was constructed of heavier metal and was considered superior from this standpoint. The "B" tester had superior driving motor characteristics. The voltage regulator brackets were too small for heavy duty regulators. Trouble was encountered with the shifting mechanism of the "A" tester.
GENERAL: This 11-page report includes four pages of tabular data, four pages of performance curves, and 11 photographs.

SUBJECT: Test Equipment DA 2321
TITLE: Nelson Leakage Testers
IDENTIFICATION: Report No. 2321
DATE OF REPORT: 26 March 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the engineering suitability of Nelson alternating current and direct current leakage testers
METHOD: Testing of the d.c. leakage tester circuits was conducted while using each of the three available d.c. voltage input ranges of 6, 12, and 24-volts. The a.c. leakage tester circuits were tested using 110-volts a.c. input. The "test light," "leakage," "high," "high tension" circuits of the leakage testers were checked for short circuit current, input voltage, no-load output voltage, and resistance in series with test prods that would make the test lamp barely visible for each of the input voltages. In addition, oscillograms were taken showing the output waveforms at various resistance leads for the "leakage," "high," and "high tension" circuits. The "high tension" circuits were subjected to an endurance cycling test. The leakage testers were used to test various ignition components such as magnetos, distributors, ignition harnesses, and coils.
DESCRIPTION: The leakage testers were manufactured by the Nelson Tester Company, Inc. The d.c. and a.c. leakage testers were identified as Federal Stock No. 17-T-5536-100 and Federal Stock No. 17-T-5536-110, respectively.
CONCLUSIONS: The results of the various tests were tabulated. Operation of the "high tension" circuit of the d.c. leakage tester was apparently unsatisfactory. A movable contact on the voltage range selector switch of the d.c. tester would sometimes become lodged on a shoulder separat-

ing the 6 and 12-volt stationary contacts, and thus render the d.c. tester inoperative. The endurance characteristics of the a.c. leakage tester appeared to be unsatisfactory.
GENERAL: This 35-page report contains 21 photographs showing both testers and the voltage wave shapes of the "leakage," "high," and "high tension" circuits of both testers.

SUBJECT: Test Equipment DA 2338
TITLE: Weston A.C. Voltmeter Model 528
IDENTIFICATION: Report No. 2338
DATE OF REPORT: 19 March 1953
PURPOSE: To obtain engineering data on a test voltmeter
METHOD: The test meter was subjected to calibration accuracy, electrostatic effect, overload voltage, cold temperature, high temperature continuous duty, vibration and tear-down inspection tests.
DESCRIPTION: The test meter was a high-low range a-c voltmeter having three binding posts: one common post and a post for each range. The high range was calibrated for 0-150 volt range and the low range was calibrated for 0-15 volt range. The meter carried Federal stock No. 17-V-932 and Weston Electrical Instrument Corp. No. Model 528.
CONCLUSIONS: Results of tests were tabulated in five tables in the report. The instrument movement showed slight deflections in the electrostatic tests. The cycling test apparently did not affect the accuracy of the instrument. The overload test caused no damage. Low and high temperatures did not seem to affect the accuracy of the instrument. The condition of the jewels, pivots, and external circuitry was considered serviceable.
GENERAL: This 20-page report includes one photograph illustrating the test meter.

SUBJECT: Test Equipment DA 2529
TITLE: Triumph Tachometer
IDENTIFICATION: Report No. 2529
DATE OF REPORT: 14 July 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether Triumph tachometers would meet the requirements of Specification MIL-T-10357
METHOD: The test tachometers were inspected and subjected to performance, endurance, and rainproof tests in accordance with the requirements of Specification MIL-T-10357.
DESCRIPTION: The test tachometers were electric portable type, manufactured by the Triumph Manufacturing Company. Three tachometer units were submitted for tests.
CONCLUSIONS: The first tachometer unit tested failed to operate satisfactorily. The second tachometer unit performed satisfactorily with a distributor ignition system but failed to work with a magneto system. The third tachometer unit satisfactorily met the requirements of Specification MIL-T-10357.
GENERAL: This 16-page report contains four photographs of the test tachometer.

SUBJECT: Test Equipment DA 2628
TITLE: Heyer Model HP-2 Distributor Tester
IDENTIFICATION: Report No. 2628; Job No. 8436
DATE OF REPORT: 29 September 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the performance of a distributor tester
METHOD: A Heyer Model HP-2 distributor tester was given a visual examination and tested for performance, instrumentation accuracy, high and low temperature operation, vibration, storage and drive motor endurance, and dust operation in accordance with a test program outlined in this report.
DESCRIPTION: The test Model HP-2 distributor tester was manufactured by Heyer Products Co. of Belleville, New Jersey.
CONCLUSIONS: Instrumentation was accurate within 5% at the start of the test; however, accuracy was difficult to determine during the test because of excessive slippage in the drive coupling. High and low temperature operation was unsatisfactory. After the vibration test, all testing was discontinued because of parts failures, unsatisfactory operation, and coupling slippage.
GENERAL: This 14-page report includes seven photographs of the distributor tester.

SUBJECT: Test Equipment DA 2633
TITLE: Six Types of Timing Lights
IDENTIFICATION: Report No. 2633
DATE OF REPORT: 18 September 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the performance characteristics of the test timing lights
METHOD: The six timing lights were subjected to operational endurance, ambient temperature, storage, short circuit, and shock tests. Accuracy, sensitivity, and voltage characteristics of the lights were also determined.
DESCRIPTION: The timing lights were submitted for test by the Sun Equipment Co., Allen Electric and Equipment, Weidenhoff Co., Auto Test Co., and Edelmann Co. The Auto Test Co. submitted two models, ATL-1X and ATL-2X. All timing lights had a flash duration of about 0.00009 second, or one degree at 1800 rpm.
CONCLUSIONS: The Sun Co. timer performed satisfactorily during all but the shock test. The Allen Co., Weidenhoff Co., and Auto Test Co. ATL-2X timers operated satisfactorily during all tests. The Auto Test Co. ATL-1X timer operated very erratically during all tests. The Edelmann timer performed satisfactorily during the operational, endurance, and temperature tests, after which testing was discontinued and the timer returned to the manufacturer at his request.
GENERAL: This 30-page report includes 15 photographs of the test timers.

SUBJECT: Test Equipment DA 2639
TITLE: Test of Battery Hydrometers, Federal Stock No. 18-H-1241-20
IDENTIFICATION: Report No. 2639
DATE OF REPORT: 25 September 1953

TANK AUTOMOTIVE TEST RESUMES

ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate the physical properties of two makes of hydrometers
METHOD: The hydrometers were subjected to float, thermometer, syringe, thermal shock, cold, and acid resistance tests, according to FSN 18-H-1241-20. Certified A.S.T.M. thermometers ranging from -75°F to +70°F, -40°F to +40°F, and +100°F to +180°F, were employed as standard control thermometers.
DESCRIPTION: Hydrometer "A", KG Model No. 5110-S16, was manufactured by the Kimble Glass Company, of Toledo, Ohio. Hydrometer "B", No. 18-H-1241, was manufactured by the E. Edelmann Company, of Chicago, Illinois.
CONCLUSIONS: In the thermal shock test, the components of the two hydrometers showed no evidence of cracks or signs of strain after testing. In the acid resistance test, the rubber components of hydrometer "A" showed extreme discoloration after immersion, changing from a red rust color to a deep olive drab; hydrometer "B" showed no visible deleterious effects after acid immersion. The physical properties of the hydrometer bulbs were not determined, since the size and structure of the bulb material did not permit accurate testing.
GENERAL: This 11-page report includes two photographs of the test hydrometers.

SUBJECT: Test Equipment DA 2645
TITLE: Two Types of Electrical Leakage Testers
IDENTIFICATION: Report No. 2645
DATE OF REPORT: 23 September 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the Wiedenhoff leakage tester in performance and to spot check the Nelson Tester
METHOD: A characteristic test was conducted in which the values of the "test light," "leakage," "high," and "high tension" circuits were measured. Operational tests included testing on a bench and in a vehicle. The endurance test was performed on the "high tension" circuit.
DESCRIPTION: The leakage testers used in the tests were the FSN 17-T5536-110, Mfr. No. 214-Q, manufactured by the Wiedenhoff Co., Chicago, Illinois; and the FSN 17-T-5536-110, manufactured by the Nelson Tester Co., Waterloo, Iowa. The Packard Company ignition cable used to replace the high tension lead was a Type I, Grade A, Class 2, high-tension, 7-mm ignition cable, with a stainless steel core, rubber insulation, glass inner braid, and neoprene sheath.
CONCLUSIONS: During the "high tension" circuit test of both testers there was evidence of excessive leakage from the units and high-tension leads. There was also electrical discharge from the cable to the tester case or other nearby metal. Testing was discontinued until two sample cables were received to replace the lead supplied with the tester. The same defect was present in the replacement cables. The 7-mm high-tension ignition cable was then used as a replacement for the high-tension lead and evidence of leakage was very slight when the tester was operated.
GENERAL: This 10-page report includes four pages of photographs showing the face and the inside of the leakage testers.

SUBJECT: Test Equipment DA 2688
TITLE: Turret Trouble Shooting Kit for Tank M47
IDENTIFICATION: Report No. 2688; Job No. 9241
DATE OF REPORT: 9 November 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate a sample differential gear train analyzer for the M47 Tank turret
METHOD: The analyzer was checked for conformance to the applicable schematic and wiring diagrams. Workmanship was evaluated for conformance to acceptable standards. An operational check was made using tracking motors known to be defective. Known discrepancies were imposed on gear trains and the operation of the analyzer was noted in determining the defects.
DESCRIPTION: The analyzer was manufactured by the Laboratories Corporation of America and included a rheostat, red and green indicator lamps, sensitrol relay, line and reverse switch, relay and receptacle. This analyzer was part of a preproduction sample turret trouble shooting kit for use with the M47 Tank.
CONCLUSIONS: The analyzer was not built according to the wiring diagram; however, the workmanship of the wiring was of acceptable standards. The accuracy of the sensitrol relay was within the specified 5% error. Sensitivity of the relay did not meet the 5% error requirement; however, this was considered due to large graduations on a small scale. The analyzer successfully detected defects such as armature end play, excessive brush pressure, and a dirty commutator.
GENERAL: This unillustrated 18-page report includes eight pages of test data and two wiring diagrams.

SUBJECT: Test Equipment DA 2988 F
TITLE: Thermometer Test Stand — Calibration Test
IDENTIFICATION: Report No. 2988 (Final)
DATE OF REPORT: 19 July 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the calibration accuracy of a portable thermometer test stand
METHOD: The calibration accuracy of the temperature-indicating system was determined by measuring the oil (heat transferring medium) temperature with a thermocouple and potentiometer; and comparing the readings with those on the temperature indicator of the test stand. A calibration accuracy test was conducted on a standard Ordnance temperature sending unit using the portable test stand and an approved oil circulating bath.
DESCRIPTION: The test unit was a portable thermometer test stand, No. ASK-7557, manufactured by the U.S. Gauge Company.
CONCLUSIONS: Temperature lags up to 70°F between the heated oil and the temperature indicator were recorded. When the calibration of

an Ordnance sending unit was checked on the test stand, resistance values were obtained which indicated temperature errors of up to 80°F as compared with standard calibration test methods. The small quantity of oil in the thermometer well, lack of oil circulation, and the comparatively large mass of the Ordnance temperature switches and sending units accounted for the large errors involved when the portable test stand was used.
GENERAL: This 10-page report is not illustrated.

SUBJECT: Test Equipment DA 3049 F
TITLE: 15 MEV Betatron Radiography
IDENTIFICATION: Report No. 3049 (Final)
DATE OF REPORT: 24 November 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate the use of the 15-mev betatron with respect to Ordnance inspection applications; and to establish standard radiographic testing procedures for Betatron radiography
METHOD: Radiation distribution of the test Betatron was determined in tests conducted on 4 inches of steel at radiation levels of 5, 10, and 15 mev. In radiation intensity tests, the roentgen output of the Betatron was determined at radiation levels of 5, 7.5, 10, 12, 13, 14, 15, and 16 mev. Exposure curves for various commercial X-ray films used in X-raying steel up to 14 inches thick were established at 5, 10, and 15 mev radiation levels; in addition, tests were conducted to determine the lead screen thickness that would provide the greatest film intensification at these radiation levels. Using a medium grain film with a relative speed of 100, the percent penetrameter image located on the source side was determined for steel sections ranging from 2 to 14 inches in thickness.
DESCRIPTION: Test equipment included: General Electric 15 mev Betatron; Victoreen ionization chamber incased in a 1/8-inch lead shield; Ansco Sweet Densitometer; Eastman comparator Densitometer; 12 steel test plates, each measuring 1x18x36 inches; sensitivity penetrameters, sizes 1/2 to 12 inches; various thicknesses of lead intensifying screens; standard metal holders; and General Electric film processing equipment. X-ray films tested included: Ansco Corporation Superay (A) and Superay (B); Eastman Kodak Company Type A and Type M; and E. I. Dupont De Nemours and Company Type 506 and Type 510.
CONCLUSIONS: The test Betatron was satisfactory as a radiographic inspection tool for armor sections ranging from 2 to 20 inches thick. Betatron inspection provided sharply defined radiographs free from secondary radiation effects without the aid of lead shielding, which was necessary with low voltage radiography. Standard operating procedures for betatron inspection were established in the report for production quality control radiography. It was recommended that the Betatron be used for the examination of all armor thicknesses exceeding 3 inches.
GENERAL: This 29-page report contains five photographs of the test apparatus. Graphs of accumulated test data are also included.

SUBJECT: Test Equipment DA 3057/F
TITLE: Development of Laboratory Method for Testing Friction Materials
IDENTIFICATION: Final Report No. 3057
DATE OF REPORT: 20 September 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of SAE brake-lining tests
METHOD: Three types of brake-lining materials were selected for tests in two similar friction materials test machines. Samples of the materials were measured and weighed for initial wear; given base-line, fade, recovery phase, wear, and repeat base-line tests; and measured and weighed for final wear. Test data were used to plot curves which were analyzed to determine the variations in the coefficients of friction and lining wear for each type of material in both machines.
DESCRIPTION: The test material consisted of two Chase Friction Materials Test Machines, and samples of low, medium, and high friction brake-lining materials.
CONCLUSIONS: Temperature gradients were not obtained in the fade tests. The recovery run friction curves showed variations among the same type of lining materials. These variations were believed to be due to variations in starting temperatures. The base-line, wear, and repeat base-line tests were considered satisfactory.
GENERAL: This 25-page report contains six pages of graphs of test data and one photograph of Chase Friction Materials Test Machine.

SUBJECT: Test Equipment DA3192 F
TITLE: Four-Square Final Drive Test Machine Development and Preliminary Tests
IDENTIFICATION: Report No. 3192 (Final)
DATE OF REPORT: 26 January 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To construct and evaluate a laboratory test machine which subjected four final drive assemblies to a continuous program of load and speed combinations
METHOD: A 100 hp hydraulic power package was used with the machine, and the maximum track speed and torque load were measured. The machine was then operated with a 300 hp hydraulic power unit and similar measurements were made. Final drive assemblies were operated on the test machine for 5 hours, and deficiencies and gear wear on the assemblies were noted.
DESCRIPTION: The four-square final drive test machine consisted of four final drive assemblies mounted on a modified tank hull and connected by two cross-shafts and two tracks. A hydraulic motor coupled to the rear cross-shaft through a silent link chain provided the power to drive the tracks. Loading of the final drive assemblies was accomplished when the lower section of the right track was depressed by the loading arm and wheel. The track driving system and the final drive loading system functioned independently of each other. They could also be synchronized to operate in phase. Any predetermined schedule of load and speed combinations, within the physical limits of the machine, could be continuously programmed to the final drive

units under test.
CONCLUSIONS: Approximately 300 hp were required to operate the machine at speeds and torque loads comparable to field conditions. The examination of the final drive assemblies after removal from the test machine revealed defects and gear tooth wear patterns identical to those found in final drive assemblies after field tests. Standard M47 rubber-bushed tracks as components of the final drive loading system were unsatisfactory, and the use of tracks incorporating either nylon or sintered metal track bushings was recommended. It was also recommended that consideration be given to the incorporation of a device which would enable the machine to include both negative and positive loads within each test final drive assembly. Investigations should also be conducted concerning the use of servo-valves employing an electromechanical principle of operation and control, so that conditions recorded under actual field operation could be repeated.
GENERAL: This 98-page report contains 50 photographs showing the test machine and wear on final drive components.

SUBJECT: Test Equipment FAR-948
TITLE: A Study of the Deformation of Tensile Specimens Under High Rates of Strain Employing High-Speed Motion Pictures
IDENTIFICATION: Report No. R-948
DATE OF REPORT: October 1949
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To develop a method for studying deformation of tensile specimens using high-speed motion pictures, and to apply this method to make corrections for the average tensile stress in a specimen after necking has begun
METHOD: This report describes a method for studying the geometry of deformation processes at drawing speeds using high-speed motion pictures. A shadow technique was used which permits measurements of strain and of the shapes of the neck throughout a tensile test at high speeds. The method has been applied to obtain curves of the sharpness of the neck vs strain data similar to that used by Professor P.W. Bridgmen to correct stress-strain curves for the true tensile stress once necking had set in.
DESCRIPTION: The three machines used for tests were a Tinius-Olsen, Denison hydraulic press, and a hand single-action crack press. The two motion picture cameras were Fastax 16mm and 35mm.
CONCLUSIONS: Comparison of results for steel, aluminum and brass with results by Bridgman in "static" tensile tests show that the true uniaxial tensile stress during tests at the speeds used (100 inches and 1000 inches per minute) was on the order of 5% higher than would be calculated from Bridgman's results. The change in formation of the neck as a function of the speeds of test provides an indication of the manner in which strain-hardening varies with strain rate; steel and aluminum showed little change at 100 inches per minute, more at 1000 inches per minute, while brass showed considerable change at the first speed and little more at the faster speed. The strain at which necking occurs tends to increase with increasing speed of test.
GENERAL: This 20-page report includes three photographs of the test components, one drawing showing contours of necking, and two curve sheets of test results.

SUBJECT: Test Equipment FAR 972
TITLE: Stress-Strain Curves in Torsion
IDENTIFICATION: Report No. R-972
DATE OF REPORT: May 1950
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To evaluate an experimental static torsion testing machine
METHOD: A method was developed for determining torque-twist and stress-strain curves, using the newly developed static torsion testing machine. Fractured specimens of a hard steel and a soft nonferrous alloy were obtained with the machine. An arbitrary twist velocity was chosen. Keeping the twist velocity constant, the strain indicator on the machine was read for corresponding twist angles. In this way, the twist-torque curve was obtained. A method outlined in the report was used to compute the stress-strain curve from this torque-twist curve.
DESCRIPTION: The new type static torsion tester, developed by the Mechanical Engineering Branch of the Pitman-Dunn Laboratory, was designed to subject the specimen to shear forces only, so that the specimen would always fracture in shear. The load during testing could be measured to an accuracy of $\pm$ .25 lb.; hence the torque, which was equal to load times the radius of the testing wheel (5 in.) was accurate to $\pm$ 1.25 in.-lb.
CONCLUSIONS: Shear stress-strain data could be obtained using the newly developed static torsion tester. Results with the two specimens used in these tests demonstrated that the range of the machine was considerably greater than the others available at this time. The physical dimensions of the specimens were not changed in any way during the test up to the point of fracture.
GENERAL: This 12-page report contains four photographs of the newly developed torsion test and test specimens. A drawing of the tester with the various components labeled was also included.

SUBJECT: Test Equipment FAR 990
TITLE: Preliminary Uses of Electron Microscopes in Ordnance Research
IDENTIFICATION: Report No. R-990
DATE OF REPORT: January 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To acquaint personnel of the Ordnance Corps with the potentialities of the electron microscope in their respective fields
METHOD: An electron microscope was installed in the physics branch of the Pitman-Dunn Laboratory in May, 1949. The work up to the time of this report was concerned with establishing the necessary facilities and the study of the techniques of specimen preparation. Electron diffraction studies

were made. Here, use was made of the knowledge that any crystalline material will scatter electrons through discrete angles depending only on the lattice spacings of the material and the velocity of the electrons.
DESCRIPTION: The electron microscope was a Type EMU. A list of auxiliary items shown in the report was necessary as minimum essentials for work with the electron microscope.
CONCLUSIONS: The electron microscope could be used to study three major classes of specimens: (1) internal structure of extremely thin specimens; (2) particle size and shape; and (3) surface structures. The first class was largely limited to organic materials. A problem of this type in Ordnance development was the mechanism whereby fungus growth was inhibited. Observations of particle size and shape were helpful in the development of products involving finely granulated substances. Investigations of surface structures appeared to offer the widest range of immediate Ordnance applications.
GENERAL: This 30-page report includes 14 pages of assorted pictures showing enlargements of test specimens.

SUBJECT: Test Equipment FAR-1041
TITLE: Nondestructive Hardness Testing of Small Arms Bullet Cores
IDENTIFICATION: Report No. R-1041
DATE OF REPORT: 19 October 1950
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To develop a device for automatic separation of small arms armor-piercing cores according to a predetermined hardness level to obtain 100% inspection
METHOD: Automatic nondestructive hardness testing equipment was developed and employed in the testing of cal. .50 armor-piercing cores. Over a half-million cores were inspected at rates up to 100 per minute. Various methods for improving the quality control of small arms cores were discussed.
DESCRIPTION: This report was concerned with four different models of an electronic hardness tester for separating small arms armor-piercing cores according to a predetermined hardness level.
CONCLUSIONS: The automatic nondestructive hardness testing equipment was capable of separating small arms armor-piercing cores in a range of Rockwell C scale hardness from 58 to 66. Although the various methods developed were utilized specifically to improve quality control of small arms cores, this type of inspection equipment was considered readily applicable to numerous other inspection processes such as the detection of cracks and flaws. It was recommended that the manufacturing facilities of small armor bullet cores incorporate this type of automatic nondestructive hardness testing equipment to obtain 100% inspection. The hardness acceptance level should be raised to insure the manufacture of higher quality small arms cores.
GENERAL: This 43-page report contains 11 photographs of the electronic hardness testers and components. Also included are detailed drawings of this equipment.

SUBJECT: Test Equipment FAR-1181
TITLE: Gravitometer for Rapid Density Measurement of Solids
IDENTIFICATION: Report No. R-1181
DATE OF REPORT: January 1954
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To develop an apparatus for rapid measurement of the density of solids
METHOD: An apparatus was developed which consisted of a cylinder which contained two immiscible liquids, the lighter liquid floating above the heavier liquid. Mercury and ethyl alcohol were used in this case. A specimen submerged in the alcohol floated on the surface of the mercury. The density of the specimen was calculated from the relative displacements occurring in each liquid.
DESCRIPTION: A schematic illustration and a detailed description of the gravitometer was included in the report.
CONCLUSIONS: The apparatus was sufficiently sensitive to be utilized for quantitative determination of gas in aluminum specimens which had been solidified at reduced pressure. The gravitometer was capable of determining the density of aluminum samples within 30 seconds. The reproducibility of results from this instrument when measuring samples in the density range of aluminum alloys was determined to be ± 0.02g/cc ($\pm 0.7\%$). Under the test conditions considered, variation in test temperature between 20° and 30° would, if uncorrected, introduce an error of about one-third the reproducibility.
GENERAL: This 18-page report includes one photograph of the gravitometer.

SUBJECT: Test Equipment FAR-1190
TITLE: Nondestructive Hardness Testing of Caliber .50 M9 Belt Links
IDENTIFICATION: Report No. R-1190
DATE OF REPORT: March 1954
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To develop equipment for the nondestructive hardness testing of cal. .50 M9 belt links
METHOD: Electronic instrumentation was developed to automatically inspect and segregate cal. .50 M9 belt links according to a predetermined hardness range. Links possessing hardness values above or below this range were rejected.
DESCRIPTION: The operation of the equipment was based upon the magnetic retentivity of steel. During inspection, the links were magnetized and then partially demagnetized. The magnetism retained was a function of the hardness of the link and was measured by electronic instrumentation which discriminated between links of acceptable and unacceptable hardness.
CONCLUSIONS: The developed equipment tested link hardness faster, cheaper and more accurately than the standard pull test. In the event of a national

emergency the belt link inspection equipment would release a substantial number of personnel from the pull test. The equipment made possible a 100% nondestructive inspection during peak production periods, thereby maintaining top quality control at all times. In comparison, the standard pull test may pass links which have been partially or completely fractured during the test. It was recommended that following a field test of the developed equipment, the standard pull test for cal. .50 belt links be replaced by adoption of the new method. It was also recommended that application of this method to other caliber links be considered.
GENERAL: This 21-page report includes 10 photographs of the methods used to determine caliber belt link hardness.

SUBJECT: Test Equipment GM-CTP 1394-1
TITLE: Model LG Scott Tester (Aluminum Aging Block) Temperature Investigation
IDENTIFICATION: Report No. 1394-1
DATE OF REPORT: 4 August 1955
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine whether the tester could control temperatures within the range required by the specifications
METHOD: A Twelve Channel Brown Recording Potentiometer and iron-constantan thermocouples inserted through a third hole drilled into each stopper were used in this operation. Tests were conducted at various temperatures to establish the heat rate curve, temperature control range, temperature variation between stations, amount of temperature drift, distance under stopper vs temperature, time for temperature to stabilize after initially reaching desired point, and the amount of temperature over-shoot.
DESCRIPTION: The test item was a Model LG Scott Tester (aluminum aging block) manufactured by Scott Testers Incorporated of Providence, Rhode Island. The tester consisted of a 24-inch diameter by 15-inch high aluminum cylinder with insulation, electric heaters, a thermoswitch, and holes for the insertion of test tubes and thermometers. The equipment was designed for heat aging of vulcanized, synthetic, or natural rubber by the test tube method. It was intended for use in estimating the relative resistance of rubber to high temperature aging under controlled conditions of air circulation.
CONCLUSIONS: The Model LG Scott was capable of controlling temperatures well within the $\pm 1.8^{\circ}$F tolerance range prescribed by ASTM. Further with a minimum expenditure of effort to compensate for drift, temperature variations could be held to approximately one-half of the tolerance range.
GENERAL: This 19-page report includes three photographs of the test setup, one schematic wiring diagram, and two curve sheets of test results.

SUBJECT: Test Equipment GM-CTP 1394-3
TITLE: Inspection and Calibration of the A-2 and D Type Durometers and the Presser Foot and Gage
IDENTIFICATION: Report No. 1394-3
DATE OF REPORT: 12 October 1955
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the conformance of the A-2 and D type durometers and the presser foot and gage to the ASTM specifications
METHOD: The subject items were calibrated against instruments of known accuracy, in one case a chemical scale and in the other precision gage blocks. Also tested was a buffer which was used to prepare specimens.
DESCRIPTION: The test durometers A-2 and D were manufactured by Shore Instrument and Manufacturing Company. The presser foot and gage were supplied by the American Instrument Company, Silver Spring, Maryland. The buffer tested was supplied by Emerson Apparatus Company.
CONCLUSIONS: The Shore durometer Type A-2 conformed to the requirements of sections 2 of test method ASTM designation D676-49T. Since no calibration curve or physical specifications were available from the ASTM for the Type D durometer, it was not possible to ascertain whether this instrument was acceptable. The presser foot and gage were found to adequately meet all ASTM requirements as stated in D395-52T. The Emerson buffer conformed to the requirements of section 20 of ASTM designation D15-54T, "Preparation for Physical Testing of Rubber Products".
GENERAL: This 14-page report includes four photographs of the test instruments.

GRG 5A 173
NBS
SUBJECT: Test Equipment B-4.12.18
TITLE: The Measurement of Dielectric Properties Over a Wide Range of Temperatures
IDENTIFICATION: Report No. GRG 5A-173
DATE OF REPORT: 15 June 1953
ORIGIN: National Bureau of Standards, Washington, D. C.
PURPOSE: To determine the suitability of equipment used in making electrical measurements of dielectric properties of insulating materials
METHOD: A specially designed high temperature specimen holder and air thermostat were used to measure the electrical properties of samples of boron nitride and teflon. The teflon samples were given a conditioning treatment at 350°C and machined to provide 1/8 x 1-1/2-inch disks. The disk specimens were tested at various temperatures and frequencies in the specially designed test apparatus. Dielectric constant, dissipation factor, and d.c. conductivity were measured by means of a Schering bridge or Q-Meter.
DESCRIPTION: The test apparatus consisted of a two-terminal micrometer sample holder housed in an air thermostat and standard commercial generator, bridge, amplifier, and detector equipment.
CONCLUSIONS: The test equipment seemed to operate properly in measuring the electrical properties of boron nitride at temperatures up to 500°C; however, the electrical properties of the test specimens were not considered sufficiently stable

to warrant extensive measurement. Satisfactory results were obtained in testing teflon at temperatures ranging from room temperature to 314°C at frequencies from 100 to 100,000 cps. In these tests it was found that the dielectric constant decreased with increasing temperature, but was independent of frequency. The values of dissipation factor and d.c. conductivity were low at all temperatures. The sensitivity of the bridge was considered too low to obtain either a qualitative or quantitative factor of the dielectric losses as a function of temperature and frequency. The relation between the thermal expansion coefficient and the temperature coefficient of the dielectric constant was found to be approximately that predicted by the Clausius-Mosotti equation. The high temperature melting transition of the samples at 327°C was easily detected by the dielectric measurements; however, attempts to carry out reproducible measurements through this transition range were abandoned due to serious warping of the test specimens.
GENERAL: This 20-page report contains a photograph of the high temperature sample holder and two graphs of test measurements.

SUBJECT: Test Equipment PG-2.703
TITLE: Detonation Characteristics of Half-Track M3-White
IDENTIFICATION: Report No. PG-2.703; Project No. 39-2
DATE OF REPORT: 15 April 1943
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To compare a bench dynamometer with a chassis dynamometer for detonation testing of low octane fuels
METHOD: The first step was the measurement of the relationship of power output with ignition advance of an engine at constant speed and full throttle. Fuels with various octane ratings were used in this test. The tests were then re-run at speeds from 800-rpm to full throttle with 400-rpm increments. Borderline knock of each fuel, and friction horsepower at each speed were also recorded. The above tests were all made with a chassis dynamometer, and they were compared with bench dynamometer tests made by the Ethyl Corporation on the same engine.
DESCRIPTION: A standard White Half-Track, M3, with a White 160AXS engine was used for the bench dynamometer tests by the Ethyl Corporation and the chassis dynamometer tests. The gasoline fuels tested were 65-, 70-, 75-, and 80-octane U.S. Army Specification 2-103A gasoline.
CONCLUSIONS: The chassis dynamometer tests agreed with the dynamometer bench tests within the normal limits of experimental error, and it was recommended that in lieu of bench tests, the chassis dynamometer be used. The octane requirement of the engine was between 65 and 70 octane number when the ignition timing was adjusted within the limits set by the engine manufacturer.
GENERAL: This 22-page report contains four charts showing test results and comparisons of the two methods.

SUBJECT: Test Equipment PG-2.1092
TITLE: Track Fatigue Test Machine
IDENTIFICATION: Report No. PG-2.1092; Project No. 34
DATE OF REPORT: 13 March 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To develop and evaluate a laboratory method for determining the comparative fatigue life of track components
METHOD: A machine was constructed to apply a cyclic tensile load to a section of test track that would simulate the stress load in the track under field conditions. Numerous test sections were operated to failure on the machine, and the fatigue life of standard components was selected as a basis of comparison. To determine the reliability of the test machine in maintaining constant test conditions, records of cycle pressures were made with a continuous drum indicator. To determine whether both sides of the track section were equally loaded, tests of end connector stress load were made with wire resistance strain gages on each side of the track section.
DESCRIPTION: The laboratory track fatigue testing machine consisted of a lever supported on an upright beam, a base structure, a pneumatic cylinder, and necessary control valves and switches. The test section of three track links was connected to the lever and the base, and the pneumatic cylinder was used to alternately raise and lower the lever to apply a cyclic load to the track section. Controls were provided to set the upper and lower pressure limits and to regulate the cyclic rate. A standard test procedure was established to apply a cyclic tensile load of 3690 to 20,900 pounds at the rate of 70 cycles per minute.
CONCLUSIONS: The track fatigue testing machine was considered a valid means for determining the comparative fatigue life of track components; but it was not considered a valid means of determining actual durability since factors other than fatigue are encountered in field operation. The reliability of the machine in maintaining constant test conditions was found to be good; only slight deviations from the set limits were found. Tests with strain gages indicated that both sides of the test section were equally loaded.
GENERAL: This 26-page report contains six drawings and six photographs of the track test machine.

SUBJECT: Test Equipment PG-2.1534 F
TITLE: Comparative Test of 41-L-1440 Lights; Timing, Neon, and Sun Timing Lights
IDENTIFICATION: Report No. 2.1534 (Final)
DATE OF REPORT: 23 March 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To test standard timing lights in comparison with Sun timing lights
METHOD: The test lights were compared on various installations on 14 different vehicles. Two or more persons observed each test. The lights were tried under various intensities of light. A Weston photographic light meter was used to check

the uniformity of the light intensity.
DESCRIPTION: The standard timing lights were Ordnance lights No. 41-L-1440 and the Sun timing lights, furnished by the Sun Manufacturing Company, included lamps for 6, 12, and 24-volt systems.
CONCLUSIONS: The standard timing light, No. 41-L-1440 could be used on a 6-volt system, but was too dim and the flash too long to be used on 12 or 24-volt systems. The 6-volt Sun light was more satisfactory. The Sun timing lights had a quick, bright flash which made the timing marks appear distinct. The bulk and weight of the Sun lights are a disadvantage. A light having a bright, quick flash, and which could be used on all three voltage systems, would be most desirable. It was suggested that a light be developed having a transformer or resistor controlled by a switch on the handle, which would be universally applicable.
GENERAL: This 14-page report contains one photograph of the four types of timing lights.

RIA 47-375
SUBJECT: Test Equipment B 5.6
TITLE: Addendum to RIA Laboratory Report No. 46-731A, "A," "Rust Preventive Removability Tester"
IDENTIFICATION: Report No. 4 on Project No. TB5-6101; RIA 47-375
DATE OF REPORT: 25 June 1947
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the reliability of a rust preventive removability tester for use in testing the removal resistance of rust preventives from metal surfaces
METHOD: Several groups of steel panels were coated with different types of rust preventives. After a 24-hour drying period, panels from each group were exposed to outdoor weathering for periods of 21 to 84 days and to humidity cabinet-ultra violet cyclic tests. The accuracy of the results secured with the rust preventive removability tester was determined by removing like rust preventives exposed to identical conditions.
DESCRIPTION: The rust preventive removability tester was developed at Rock Island Arsenal. Details of the tester construction and operation were not provided in the report.
CONCLUSIONS: The tester was considered a practical method of testing the removability resistance of rust preventive coatings from metal panels. Removal resistance results of like rust preventives exposed to identical conditions were fairly well duplicated by the rust preventive removability tester.
GENERAL: This 13-page report is not illustrated.

SUBJECT: Test Equipment RIA 54-1989
TITLE: A Mechanical Dipping Apparatus for the Production of Controlled Coating Thickness on Test Panels
IDENTIFICATION: Report No. 54-1989
DATE OF REPORT: 4 June 1954
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To construct and evaluate a mechanical dipping mechanism which would provide uniform coatings of reproducible thickness on test panels
METHOD: The first part of the work involved design and construction of the dipping apparatus to provide the controls desired. An evaluation of the limits of the machine was made. Two sets of basic conditions involving the following were arbitrarily chosen: the time of immersion and the rate of withdrawal; the thickness of the panels and the temperature of application. Tests were then conducted in which each of their four factors were separately investigated while the three remaining basic values were retained at the arbitrary value selected.
DESCRIPTION: The mechanical dipping apparatus consisted basically of an oil bath for heating the compound, a variable speed motor attached to concentric discs for controlling the rate of withdrawal, and an attached rack to support the test panels being dipped.
CONCLUSIONS: Upon selection of the proper variables, the apparatus produced smooth, reproducible coatings on test panels, and its use was recommended. It was also recommended that a comparative evaluation of the commercially available petrolatum-type corrosion preventatives be made to determine which compound, or compounds, would provide the longest protective life under similar test conditions.
GENERAL: This 29-page report contains graphs illustrating the coating thickness obtained as the values of the four variables were increased.

SUBJECT: Test Equipment T-60401.3
TITLE: Equipment — Absorption Trailer for Testing Tanks, Preliminary Investigation
IDENTIFICATION: Report No. T-60401.3
DATE OF REPORT: 28 April 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the possibility of designing an absorption trailer for use in tank testing at Aberdeen Proving Ground
METHOD: Studies were made of an absorption trailer capable of imposing a drawbar load of 12,000 pounds at four mph, and 1600 pounds at 30 mph.
DESCRIPTION: The trailer was to be equipped with a Thornton four-wheel drive, a G.E. 1213D motor used as a generator, power-dissipating resistors, a four-speed transmission, a single speed transfer case, eight tires (8.25 x 20), and a standard Ordnance tow bar connection (lunette and pintle). The frame would be composed of 8-inch channel side rails, and cross-members consisting of dead weight castings at each end. The body would be made from sheet steel.
CONCLUSIONS: It was considered possible to design and build a trailer capable of providing the specified resistance.
GENERAL: This four-page report contains one sketch of the proposed trailer.

SUBJECT: Test Equipment T-60401.21
TITLE: Equipment for L/T Ratio Investigation
IDENTIFICATION: Report No. T-60401.21; CXD

Project No. 18
DATE OF REPORT: 5 February 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To develop an instrumented method for studying the effect of various track design conditions on tank steering and maneuverability by measuring and recording torque and speeds at various points in the drive train. To prepare an instruction book and manual for operating the necessary equipment
METHOD: The following equipment was set up and investigated: output shaft torsiometers, drive shaft torsiometers, brake shaft torsiometers, speed indicators for output and drive shafts, brake shaft rotation indicators, Hathaway oscillograph, amplifying equipment (console), regulated power supply for amplifying equipment, and calibrator for amplifying equipment.
DESCRIPTION: The torsiometers were essentially balanced-resistance bridge circuits that were actuated by strain gages mounted on different power output shafts. These strain gages changed their resistance in direct proportion to the shaft torque. When a torque was applied to the shaft, the bridge was unbalanced and a proportional d.c. voltage was produced at the input terminals of a small d.c. motor (chopper). The chopper closed five microswitches successively during each revolution to produce a small pulsating d.c. voltage at the input terminals of the particular amplifier that served the individual bridge circuit which, in turn, was connected to a shaft whose torque was to be determined. The amplified signal was then passed on to the console and actuated its milliammeter or recorded on a Hathaway oscillograph. Readings thus obtained were interpreted from calibration curves to obtain the shaft torque. Contactors were provided for determining shaft speeds from oscillograph deflections.
CONCLUSIONS: The instrumentation developed here was an effective way to obtain instantaneous torque and speed values while the tank under test was in motion.
GENERAL: This 70-page report includes 15 photographs of the instrumentation, and operational instructions. This report should prove to be of extreme importance to anyone interested in analysing output torque and speed characteristics of any moving vehicle.

SUBJECT: Test Equipment T-60401.26
TITLE: Bench Tests of Battery Hydrometers
IDENTIFICATION: Report No. T-60401.26; CXD Project No. 227-2
DATE OF REPORT: 3 May 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the effect of fuel and lubricants on the barrels of various battery hydrometers, and the cold resistance of the rubber bulbs
METHOD: The barrels of various test hydrometers were wiped with rags containing diesel fuel, motor oil, gear oil, gasoline and aromatic gasoline. The appearance of the barrels after wiping was noted. The hydrometers were then placed in cold boxes at -20°F and -40°F. After five hours, the bulbs were flexed to determine their condition.
DESCRIPTION: Battery hydrometers with glass and polystyrene barrels, and neoprene and reclaimed red and black rubber bulbs were used in the tests. The glass barrel hydrometers were manufactured by the Kimble Glass Company and the E. Edlemann Company. The polystyrene barrel hydrometers were manufactured by the E. Edelmann Company.
CONCLUSIONS: The glass bulbs were unaffected by the fuels and lubricants. Polystyrene barrels were affected by the fuels, and it was recommended that several transparent resins be tested for use in place of the polystyrene. The reclaimed rubber bulbs were satisfactory at -40°F whereas the neoprene bulb was unsatisfactory at -20°F.
GENERAL: This seven-page report contains two photographs showing the effect of gasoline on polystyrene barrels.

SUBJECT: Test Equipment T-60401.26-01
TITLE: Bench Test of Battery Hydrometer
IDENTIFICATION: Report No. T-60401.26-01; CXD Project No. 227-4
DATE OF REPORT: 24 October 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the effect of fuels and lubricants and high and low temperatures on experimental hydrometer barrels, and to check the calibration of the hydrometers
METHOD: The experimental barrels of several hydrometers were wiped with rags saturated with diesel fuel, motor oil, gear oil and gasoline. The appearance of the barrels after wiping was noted. The hydrometers were then subjected to temperatures of -40°F, -20°F, and 160°F. The hydrometers were subjected to alternate hot and cold cycling every 24 hours for a week. A final test for calibration of the hydrometers was made at -15°F, 43°F, 80°F, and 115°F using acid with specific gravities of 1.244 and 1.262.
DESCRIPTION: The hydrometer was a device that measured the specific gravity of the electrolyte in a storage battery by drawing out of the battery a small amount of electrolyte. The electrolyte was held in a transparent barrel which also contained a calibrated float that gave the specific gravity of the electrolyte. An experimental barrel of methyl methacrylate was tested on the hydrometers.
CONCLUSIONS: The experimental barrels were unaffected by the various fuels and oils and the high and low temperatures. The rubber parts of the hydrometers were affected by the temperatures. Calibration of the hydrometers was satisfactory.
GENERAL: This eight-page report contains one page of data results of the calibration tests.

SUBJECT: Test Equipment WAL 110/14
TITLE: Bend Test Device for Autographic Recording of Load-Deflection Diagrams
IDENTIFICATION: Report No. 110/14
DATE OF REPORT: 3 June 1948
ORIGIN: Watertown Arsenal Laboratory, Mass.

PURPOSE: To develop a bend test device which, when used with a standard Baldwin-Southwark hydraulic testing machine, would produce a complete autographically recorded load-deflection diagram
METHOD: A bend test device was developed for use with a standard Baldwin-Southwark hydraulic testing machine. This device was designed to provide full autographic recording of both load and deflection values and to decrease the time for conducting the test. Autographically recorded curves showing yielding characteristics were obtained with the device for materials of low and medium ductility.
DESCRIPTION: The bend test device utilized a standard Templin type extensometer modified to a pivoted lever system which converted compression motion between the heads of the hydraulic testing machine to tension motion of the extensometer. Load deflection recording was accomplished through Selsyn motors attached to the extensometer and a standard O.S. Peters type autographic recorder.
CONCLUSIONS: The bend test device was used successfully to autographically record deflection diagrams at normal, elevated, and low temperatures. The device could be used for the testing of any material where the total deflection of the specimen over the span used did not exceed .75-inch. Normal testing could be accomplished in 3 minutes per specimen. The elastic modulus of a material could be determined within an accuracy of 5% by direct substitution in the standard beam formula of load and deflection values from the autographically recorded curve.
GENERAL: This 16-page report contains five photographs of the load deflection device. Also included are several curves obtained with the device.

SUBJECT: Test Equipment WAL 111.2/16
TITLE: Description of an Automatic Recorder for Tensile Machines
IDENTIFICATION: Report No. WAL 111.2/16
DATE OF REPORT: 29 June 1943
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To describe an apparatus that would automatically record, over a wide range of strain rates and specimen temperatures, the quantities necessary to obtain a true stress-strain curve
METHOD: Performance of tensile test consisted mostly of calibrating the instrument. All recording was done automatically. The equipment automatically recorded load-diameter and load-elongation curves over the range of strain rates obtainable with standard tensile machines. High strain rates to simulate service conditions were obtained by measuring tensile properties at low temperatures.
DESCRIPTION: Essential new features of the automatic recorder were the designs of the gauges which were used to convert load, or diameter, or elongation, into elastic strain of elements upon which electric strain gauges were attached. The use of alternating current permitted unusually high sensitivity. The load deflected the point of light vertically on an oscilloscope screen; the changes in diameter or elongation deflected the same point of light horizontally. A permanent record was obtained by photographing the oscilloscope screen during the test. The method of calibration had been so devised that a direct reading coordinate system and the load-diameter or load-elongation curves were photographed upon the same film. Operation required an operator and two assistants.
CONCLUSIONS: The equipment had ample sensitivity for those measurements for which it was designed.
GENERAL: This 28-page report includes two photographs of test equipment, a calibration curve, and load-diameter and load-elongation curves.

SUBJECT: Test Equipment WAL 310/75-4
TITLE: Cooperative Research with Watertown Arsenal on Fracture Characteristics of Metals
IDENTIFICATION: Report No. WAL 310/75-4
DATE OF REPORT: 31 July 1947
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To establish a testing procedure for determining the fracture characteristics of embrittled and nonembrittled pearlites and tempered martensites
METHOD: Several procedures were studied in an attempt to obtain a method of gripping and cooling a specimen that would provide the most dependable results. Such methods as wooden grips, woods metal cast around each end of the specimen, use of a preformed hook on each end held in a conical countersink in upper and lower grips, and the normal snubbing device, were either tried and proven unsatisfactory or eliminated after consideration as not meeting the overall flexibility desired. The method finally decided upon consisted of welding small washer-like discs on the end of 3-inch specimens of 0.050-inch wire and threading them on the grips designed in the interlocking square frames mounted on the ends of the testing machine. The work on this project was performed by the Pennsylvania State College Division of Metallurgy.
DESCRIPTION: All testing was conducted on a Dillon Model K tensile tester with a Graham Transmission for providing constant head speeds between 0.05 to 0.0005-inch per minute of constant torque. A cooling device was provided for determining fracture stress values at temperatures as low as -190°C after prestraining at room temperature. This cooling device was a simple can arrangement of three sections: insulation, dead air space, and inner area for coolant surrounding the specimen. Temperature was controlled by inserting a thermocouple in the bath directly adjacent to the specimen.
CONCLUSIONS: A description of the test procedure, a drawing of the specimen grip shackles and coolant container were presented.
GENERAL: This eight-page report includes one drawing and two curve sheets.

SUBJECT: Test Equipment WAL 401/68-8
TITLE: Research and Development of Effect of Range of Stress and Prestrain on the Fatigue Properties of Titanium and Its Alloys

IDENTIFICATION: Report No. WAL 401/68-8
DATE OF REPORT: 1 March 1952
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To report on the construction and calibration of two fatigue testing machines
METHOD: Two fatigue machines were constructed and calibrated. Pure tension tests were constructed by applying loads in increments to a total load of 45.5 pounds. Pure bending tests were conducted by applying loads until a total load of 3 pounds was reached. Both calculated and observed functions were plotted. Tests of combined bending and tension were conducted at a constant mean stress level and at varying mean stress levels. Tests were also conducted to determine whether any dynamic effect on the stress existed due to the rotation of the specimen and the vibration of the machine. This research project was conducted by Carnegie Institute of Technology.
DESCRIPTION: The fatigue machines used in this investigation of the effect of range of stress and prestrain on titanium and titanium alloys were of the rotating-beam type and were easily assembled and maintained.
CONCLUSIONS: The machines fulfilled the desired functions and specifications called for in their design and were satisfactory for an investigation on the effect of range of stress and prestrain on the fatigue properties of a metal.
GENERAL: This 33-page report contains 17 pages of test equipment drawings and photographs and test result tables, graphs, and curves.

SUBJECT: Test Equipment WAL 691/17-8
TITLE: Qualification Test for Platers of Chromium
IDENTIFICATION: Report No. WAL 691/17-8
DATE OF REPORT: 31 December 1951
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To develop a qualification test for chromium platers and to develop a test for the evaluation of the quality of the chromium plate
METHOD: Following a survey of literature related to the project, a scratch test was devised to measure the adhesion of chromium plate to the base metal. A blast test was designed to simulate the erosion that occurred close to the chamber in a gun barrel. All tests were made at Rensselaer Polytechnic Institute.
DESCRIPTION: The scratch test apparatus consisted of a tungsten carbide scratching tool and an angle iron guide which was mounted in a vise with the test sample. A microscope with a filar micrometer eyepiece was used to examine the scratch after test. The following operating conditions were recommended and used by the arsenals for electroplating chromium on steel: bath composition, 2.5M chromic acid and 0.025M sulphuric acid; bath temperature, -130°F; current density, -2.1 amps/sq.in. Lead anodes were used, with an anode to cathode separation of approximately 3/4 inch.
CONCLUSIONS: The scratch test presented a quantitative evaluation of adhesion of chromium to base metal, though it did not simulate actual conditions that existed in ordnance applications. The blast test was to be conducted and the results correlated with those of the scratch test. In the future, a correlation of these results and results obtained from actual proof firing of ordnance materials was to be made.
GENERAL: This 36-page report contains five photographs of the test apparatus.

SUBJECT: Test Equipment WAL 732/114
TITLE: Disclosure of Principles and Details of a New Method for the Detection of Flaws in Ferromagnetic Materials
IDENTIFICATION: Report No. WAL 732/114
DATE OF REPORT: 11 January 1946
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To describe a flaw detecting device and the method of operation
METHOD: Two controls were set on the device before inspection. A weak d.c. magnetic flux was provided in the metal under test. The bridge of the device was brought into balance and the required sensitivity obtained. The pick-up coil was scanned over the surface of the metal and deflections of the indicating device noted. Flaws were detected by upsetting the balance of the bridge which occurred when the shunt strip, in contact with the test metal was passed over a flaw.
DESCRIPTION: The flaw detecting device was developed by the Watertown Arsenal and made use of a simple a.c. inductance bridge coupled to an indicating or recording device through a suitable amplifier. One of the inductances was used as a pick-up or detecting coil and the other as an identical compensating coil. These coils were wound on iron cores and equipped with magnetic shunts made of high permeability nickel-iron alloy.
CONCLUSIONS: The operation of the flaw detector was simple and the device was capable of locating and measuring flaws in ferromagnetic materials. Detection of flaws in the bore of tubing and pipe and exterior surfaces was possible.
GENERAL: This 10-page report includes three drawings of the test device.

SUBJECT: Test Equipment WAL 732/114-7
TITLE: Industrial Evaluation and Operation of the Automatic Crack Detector for Tubes, Model II
IDENTIFICATION: Report No. 732/114-7; Project No. TR3-3002
DATE OF REPORT: 1 June 1951
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To compare the results of industrial usage of the test detector with the boroscope
METHOD: Preliminary adjustments of the test detector were made and the gun tubes magnetized. Testing with the detector was done on 54 tubes previously inspected by the boroscope. A graphic tape record of each gun tube examined was produced by the detector identifying flaws and cracks by means of recorded signals. Tube test specimens were cut and given visual examination to verify the accuracy of the results obtained by the detector.
DESCRIPTION: The 75, 76 and 90-mm gun tubes,

in both rough and finished condition, were tested prior to rifling. The automatic Crack Detector Model II for gun tubes consisted of a main console inspection unit, photocell unit, puller unit, and interconnecting cables.

CONCLUSIONS: The automatic crack detector was reliable, expeditious, and had a greater sensitivity than the boroscope. The detector indicated many cracks not detected by the boroscope and did not give false responses as the boroscope did. The detector eliminated most of the human element from the test and did indicate certain subsurface flaws. The test equipment occupied a smaller area, was much faster in operation than the boroscope, and required only one easily trained operator. Heat-treated tubes with a scale layer or in oily and dirty condition could also be tested with the detector.

GENERAL: This 35-page report includes ten photographs of the test equipment and material.

Section 43
TESTS, SPECIAL, MISCELLANEOUS

SUMMARY

This summary covers resumes of 152 engineering reports on special and miscellaneous tests written between 1942 and 1955 at the Detroit Arsenal, Center Line, Michigan; Aberdeen Proving Ground, Maryland; Frankford Arsenal, Philadelphia; Rock Island Arsenal, Illinois; Armored Force Board, Fort Knox, Kentucky; Watertown Arsenal, Massachusetts; Chrysler Engineering Division, Detroit, Michigan; Princeton University, Princeton, New Jersey; General Motors Corporation, Cleveland Tank Plant; General Motors Proving Ground, Milford, Michigan; Tank Arsenal Proving Ground, Utica, Michigan; Ordnance Tank-Automotive Center, Detroit, Michigan; Ordnance Desert Proving Ground, Camp Seeley, California; Ordnance Tire Test Fleet, Normoyle Field, San Antonio, Texas; Office, Chief of Ordnance, Detroit, Michigan; National Bureau of Standards, Washington, D.C.; U.S. Naval Ordnance Laboratory, White Oak, Maryland; Fellows Gear Shaper Company, Springfield, Vermont; Picatinny Arsenal, Raritan, New Jersey; and Armored Medical Research Laboratory, Fort Knox, Kentucky.

The reports cover a wide variety of subjects and tests, all of which cannot be included here. As examples, the subject matter of a handful of reports is listed and summarized: determination of the effects of the July 1946 atomic bomb detonation at Bikini Atoll, Marshall Islands, on certain Ordnance automotive equipment; determination of the amount of error of the untrained eye in estimating the range and speed of moving vehicles; evaluation of a method for predicting the relative corrosiveness of a metal or alloy; metallurgical examination of V-2 components for cause of failure; the determination of the solubility of ferric phosphate in various phosphating solutions; and an evaluation of the storage results on items packaged and stored for a period of approximately 2 years.

AUTOMOTIVE EQUIPMENT IN "OPERATION CROSSROADS"

In June, 1947, a report was released at Aberdeen setting forth the effects of the 1 June 1946 atomic bomb detonation at Bikini Atoll, Marshall Islands, on certain Ordnance automotive equipment. A number of assorted vehicles, ranging in age from brand new to 46 months old, had been placed on ships located about 600 yards from the point of burst of the bomb. One vehicle had been placed on a ship some 1600 yards from the point of the bomb's explosion. It was concluded that no irreparable damage had been inflicted on the automotive equipment by the atomic bomb detonation. A considerable part of the damage sustained by the vehicles was caused by handling during shipment or by corrosion due to weathering. No residual radioactivity was present on the vehicles when they arrived at Aberdeen. Four man-days of work was the maximum required to place the most seriously damaged vehicle in operating condition. The results of subsequent road tests conducted with the repaired vehicles were generally satisfactory. It was recommended that for future tests, the fuel tanks of vehicles be filled with a liquid to determine more accurately the ability of the tanks to withstand blast pressures.

RANGE AND SPEED ESTIMATION

Testing was conducted at Aberdeen in October, 1953, to determine the amount of error of the untrained eye in estimating the range and speed of moving vehicles. Eight hundred ROTC cadets, with and without the aid of binoculars, standing on a platform 70 feet high, made some 7000 speed estimations and 1400 range observations of M135 trucks, which operated at speeds varying from 2 to 29 mph, and at ranges varying from 500 to 1650 yards. Other than for a brief lecture, the cadets had had no previous training on range or speed estimation. A wide variety of estimates were obtained rather than a constant deviation from the true range and speed of the vehicles. The use of binoculars offered no practical advantage. Target speed and target range were factors which affected the variability of speed estimation. It was felt that the systematic error for a group of untrained observers was not serious, but that the reverse might be true for an individual. It was recommended that the results obtained from this test be considered in future investigations with untrained observers.

V-2 COMPONENTS

This test was conducted at the Frankford Arsenal in August, 1953, to examine metallurgically V-2 German rocket components (from the propulsion system) that had failed in service or in tests. Mechanical tests and metallurgical examinations showed the material used in the manufacture of the components to be of acceptable quality as judged by existing commerical standards. There was no evidence that any deleterious aging phenomenon had taken place during component storage which could be responsible for failure. It was postulated that the failures were caused by the unforeseen application of stresses in excess of accepted design stresses for the alloys caused by other V-2 components.

CORROSION RATE OF METALS

Nine different metals were used in a test at the

Detroit Arsenal in September, 1954, to evaluate a method for predicting the relative corrosivity of a metal or alloy. A corrosion cell had been constructed for the test by immersing a test metal panel and a calomel electrode in a one-molal saline solution. It was concluded that metals and alloys having a low rate of corrosion as indicated by weight loss measurements resulted in a test cell with low internal resistance. Metals and alloys shown by weight loss data to have a high corrosion resistance caused the test cell to have a high internal resistance. It was recommended that this test method be utilized as a means of predicting the rate of corrosion of metals and alloys, and that further research be conducted on this project.

EFFECTS OF NATURAL COOLER STORAGE

In a report written at Rock Island Arsenal in April, 1953, the storage results of three different groups of packaged items stored for approximately 2 years in natural cool storage at Atchison, Kansas, were evaluated. The three groups consisted of rubber items, small arms, and optical equipment. Examination of the rubber items (two tires and 144 innertubes) showed the articles to be serviceable, even though the butyl innertubes showed a loss of physical properties. The small arms group (60 carbines, cal. .30 M1, with accompanying slings, oilers, and magazines) showed very light rust deposits in the bores, chambers, and on a very few external surfaces. A thorough cleaning removed these traces of rust and the weapons were considered serviceable. Detailed examination showed slight films of condensate on some of the optical elements (18 telescopes, M69C) and scattered amounts of loose dirt and brass chips. These conditions were of a negligible nature and were not considered detrimental at the time. The degree of corrosion on the small arms indicated that the weapons were approaching a critical point. The rust had formed regardless of the method of packaging employed, which indicated that moisture had not been completely removed by the cleaning process.

SOLUBILITY OF FERRIC PHOSPHATE

Determination of the solubility of ferric phosphate in various phosphating solutions was made in a test conducted at Rock Island Arsenal in June, 1953. Twelve phosphating solutions divided into two groups were used in the test. The first group contained zinc phosphating compound without nitrate; the second group contained a zinc phosphating compound with added nitrate accelerator. The solubility of ferric phosphate in all the test solutions was greater at 70°F than at 200°F. The solubility of the ferric phosphate was greatly enhanced by the addition of the nitrate ion, based on the results of tests conducted at 70°F. The results of the test at 200°F were too erratic to permit a similar conclusion. Solubility of ferric phosphate in phosphoric acid increased inversely with the pH of the solution, although not linearly. A leveling off of the solubility at lower pH values could be attributed to an insufficient excess of solute used. It was recommended that nitrate concentration in a phosphating solution be held between 1.0% and 2.5%, and that automatic temperature control equipment on phosphating baths be throttled to allow for a long heating cycle and a short cooling cycle. It was emphasized that at no time should all of the sludge be removed from a phosphating bath.

REPORT RESUMES

NOTE

A number of tests, special, miscellaneous report resumes are classified. These resumes appear in Section 43, Volume XI.

SUBJECT: Tests, Special, Miscellaneous AB-271
TITLE: Reducing Vulnerability to Chemical Agents of 105-MM Howitzer Motor Carriage, M7
IDENTIFICATION: Project No. 271
DATE OF REPORT: 24 October 1942
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To determine vulnerability of the 105-mm Howitzer Motor Carriage to persistent chemical agents and to test means for decontamination and reduction of vulnerability
METHOD: Two chemical land mines containing one gallon each of simulated mustard were detonated twelve feet from the vehicle to produce the effect of a plane spraying at 300 feet or five 105-mm shells striking the ground at 15 feet from the vehicle. Strips of white paper were placed at various positions within the vehicle. First echelon decontamination was performed using the 1-1/2-quart decontaminating apparatus issued to each of the M7 Motor Carriages.
DESCRIPTION: Equipment tested was the 105-mm Howitzer Motor Carriage M7.
CONCLUSIONS: The Armored Force Board concluded that nothing less than a direct hit was likely to contaminate the interior of a vehicle sufficiently to penetrate compartments and recesses below the floor plates. Contamination of vehicle was considered of minor importance compared with contamination of the crew. The vehicle could be decontaminated with little interruption of normal military activities. Utmost use of available protective and preventive measures to the crew was suggested. The possibility of contamination of recess and compartments below the floor plates was not considered a serious hazard. No further action on this project was recommended.
GENERAL: This three-page report is not illustrated.

SUBJECT: Test, Special, Miscellaneous AB-711
TITLE: Test on Maintenance and Repair of Ar-

mored Vehicles (Removal of Blood and Residue)
IDENTIFICATION: Project No. AB-711
DATE OF REPORT: 29 August 1945
ORIGIN: The Armored Board, Fort Knox, Ky.
PURPOSE: To find a method for complete removal of blood and residue, by use of detergents and deodorants, from disabled but repairable armored vehicles
METHOD: Four Medium Tanks M4 were driven to the test area and three dead goats were placed in each tank. One pound of T.N.T. was placed under each goat and exploded. Five days later an attempt was made to clean and deodorize the tanks. Different solutions were used for cleaning each tank and the results were compared. The best cleaning methods were then combined to determine which combination was superior.
DESCRIPTION: The tanks were cleaned in the following manner: (a) Tank No. 1 was cleaned using G.I. soap, hot water, and stiff brushes. (b) Oakite Penetrant in a water solution was used in Tank No. 2. It was rinsed in clear water, and Oakite Tri-San deodorizing disinfectant was sprayed in the tank. (c) Tank No. 3 was cleaned by West Disinfectant Co.'s Teramine in a water solution with an equal amount of soda ash. (d) Tank No. 4 was cleaned by a Kerrick Kleaner Co.'s steam cleaner using a solution of steam cleaning compound and kerosene.
CONCLUSIONS: Best results would be obtained by use of the Kerrick steam cleaner combined with a solution of West Co.'s Teramine with an equal amount of soda ash. The results of these tests, however, were inconclusive, and it was recommended that the problem of cleaning and disinfecting disabled tanks be given to the National Defense Research Committee.
GENERAL: This three-page report is not illustrated.

AMRL-34
SUBJECT: Tests, Special, Miscellaneous
TITLE: Evaluation of the Gun Fume Hazard in the LVT-A-1
IDENTIFICATION: Project No. 34
DATE OF REPORT: 1 May 1944
ORIGIN: Armored Medical Research Laboratory, Fort Knox, Kentucky
PURPOSE: To determine the extent of the gun fume hazard from firing the 37-mm gun and turret cal. .30 machine gun in the LVT A-1
METHOD: Gun fumes were accumulated by five minute burst firing of the 37-mm gun and 3000 rounds per hour firing of the cal. .30 machine gun. Tests were conducted with hatches open and closed, with and without auxiliary ventilation, and with the engine idling and stopped. Air samples were analyzed for carbon monoxide and ammonia.
DESCRIPTION: The test vehicle was a full-tracked, amphibious tank, LVT A-1. It mounted a 37-mm gun and cal. .30 machine gun and was equipped with a 200 cfm fan. A selective gas analyzer was used to determine fume concentration.
CONCLUSIONS: Positive means of turret ventilation were required due to concentration of fumes in that location. The majority of fumes was the result of machine gun fire. It was recommended that a fan of approximately 200 cfm be installed in the rear of the turret.
GENERAL: This seven-page report includes one chart of fume concentration, and one drawing of fan installation.

AMRL 45(2)
SUBJECT: Tests, Special, Miscellaneous
TITLE: The Physiological Work Rates of the Driver and Loader in the Tank T26E3 in Relation to Fatigue and Efficiency of Performance
IDENTIFICATION: Second Partial Report, Project No. 45
DATE OF REPORT: 19 June 1945
ORIGIN: Armored Medical Research Laboratory, Fort Knox, Kentucky
PURPOSE: To evaluate the physiological work rate of the driver and loader in the Tank T26E3
METHOD: Three crewmen, each approximately 22 years of age, and of average height and weight, were selected for the tests. Each subject breathed through a plastic valve attached to a light helmet, and expired air was collected in 200 liter Douglas bags. Duplicate analysis for O2 and CO2 were performed on each collection. Results were recorded in Cals/hr., Cals/m^2/hr., Cals/kg/hr., and Cals above resting. Each subject drove a buttoned up Tank T26E3 over rolling cross-country terrain. The equivalent of 1.3 right angle turns was made in each minute. The following aspects of the loader's task were selected for study: (1) Loading five rounds at maximum speed from the ready rack; (2) loading 10 rounds at maximum speed from the ready rack; (3) moving 10 rounds from the floor racks to the ready rack; (4) throwing 10 empty shell cases from the floor through the turret hatch. Each test was performed by two or three men. Data from similar tests in M4A3, M5, M24, and T23 Tanks were used for comparison purposes.
DESCRIPTION: The test vehicle was a T26E3 Tank. (No further description was included in the report.)
CONCLUSIONS: The work rate of driving the T26E3 Tank was considered moderate whereas the work rate of loading was high. Impaired loader performance would result from excessive fatigue and reduced tolerance to severe humidity and heat. Efficiency of loading, measured by loading speed, was poor in comparison with previously studied tanks. Higher work rates and reduced loading speeds resulted from increased size and weight of rounds. It was recommended that measures be instituted in the T26E3, by restowage of rounds and/or by mechanical aids, to reduce loading work rates and to promote loading speed. It was further recommended that the effect of stowage of rounds on the work rate, and the marked rise in work rate resulting from increased size and weight of rounds, be carefully considered in future tank development.
GENERAL: This eight-page report contains various tabulated and graphical test data and is not illustrated.

APG 12-14-2
SUBJECT: Tests, Special, Miscellaneous
TITLE: Test of Valve Grinding Compound
IDENTIFICATION: Report No. 44-32; Project No. 12-14-2

TANK AUTOMOTIVE TEST RESUMES

DATE OF REPORT: 6 March 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether water-mixed or grease-mixed valve grinding compounds were best suited for Ordnance use in various temperatures
METHOD: The type and percentage of each abrasive used in the manufacture of the test compounds were determined on a Ro-Top sieving machine. Determination of the work value was made on an Attrition machine. The samples tested for work value were also tested for fineness. All of the compounds were placed under temperatures ranging from 0° to 140°F to determine whether temperature or temperature change affected the properties of the compounds. The effects of the compounds on container lining were investigated to determine whether the lining oxidized or the enamel corroded. All tests were conducted in accordance with the "General Requirements, Inspection and Methods of Sampling and Tests" of the Navy Department Specification 51C22b and Bureau of Ships Specifications 51C22(INT) for Grades A and C compounds.
DESCRIPTION: The test water-mixed and grease-mixed samples of valve grinding compounds were made by the following companies: Pep Manufacturing Company, Inc., New York, New York; The Zip Abrasive Company, Cleveland, Ohio; The Carborundum Company, Niagara Falls, New York; Clover Manufacturing Company, Norwalk, Connecticut. These compounds were standard commercial types. They were similar, differing slightly in fineness. All except those submitted by the Pep Co. employed 100% silicon carbide as the abrasive; the exceptions were 60% silicon carbide and 40% aluminum oxide. Fineness ranged from sieve test grit numbers of 120 to 180.
CONCLUSIONS: All of the grease-mixed compounds were found suitable for use; i.e., of satisfactory work value and impervious to extreme temperatures. None of the water-mixed compounds were found suitable. The Navy specifications were considered positive tests for any type of valve grinding compound.
GENERAL: This 16-page report includes a photograph of several water-mixed compound containers, showing corrosion, two sketches of test setups, and six data sheets.

APG 222-1-2
SUBJECT: Tests, Special, Miscellaneous
TITLE: Study of Power Losses Truck, 2-1/2-Ton, 6x6, Special vs Standard
IDENTIFICATION: Project No. 222-1-2; APG 14-102
DATE OF REPORT: 15 October 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the relative highway operating efficiency of a truck when operating with multi-axle and then single-axle drives
METHOD: A 2-1/2-ton truck was operated as a 6x6, a 6x4, and a 6x2 vehicle for 471.5, 503.7, and 531.1 miles, respectively. All operation was conducted on highways.
DESCRIPTION: The vehicle was a standard 2-1/2-ton, 6x6, truck. During use as a 6x6 truck, the front axle drive was declutched; as a 6x4, the front axle driving mechanism was removed; and in the case of use as a 6x2 vehicle, the transfer case and rear axle driving mechanism were removed. In order to reduce excessive overloads, 8.25 x 20 tires replaced the standard vehicle 7.50 x 20 tires.
CONCLUSIONS: No significant difference in vehicle fuel consumption could be attributed to the difference in multi-axle or single-axle use. Differences in driver habits and climatic or highway and traffic conditions only obscured the results. It was recommended that no further testing be conducted on this type of project, since the cost involved in conducting an adequate test was not considered commensurate with the value of the results obtained.
GENERAL: This 16-page report contains no photographs.

APG 5275/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Report on Automotive Mechanical Laboratory Facilities at Aberdeen Proving Ground
IDENTIFICATION: First Report on Ordnance Program No. 5275
DATE OF REPORT: 11 October 1943
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To evaluate the mechanical laboratory facilities at Aberdeen Proving Ground and to recommend requirements around which a mechanical laboratory should be built
METHOD: This report consisted of a detailed description of Aberdeen Proving Ground's mechanical laboratory facilities, and the history and overall purpose of this laboratory up to October 1943, with recommendations for future development.
DESCRIPTION: There was a serious housing shortage at Aberdeen Proving Grounds, further aggravated by the transfer of all the engineering and development work from the Holabird Ordnance Depot. The buildings were crowded, inadequate in scope, and outmoded in arrangement. Overloaded with wartime developments and test programs, the Ordnance Department was forced to use private industry at excessive costs. Recommendations for new laboratory facilities were based on a careful study of the consolidated opinions of the Tank Automotive Center, Chrysler Corporation, Ethyl Gasoline Corporation, Wright Field, and Aberdeen Proving Ground.
CONCLUSIONS: It was recommended that the acute laboratory problem and future needs for adequate laboratory facilities be recognized and that a mechanical laboratory be constructed as soon as possible to fulfill the requirements outlined in the report. It was felt that an adequate mechanical laboratory could not be built for less than $1,500,000.00.
GENERAL: This 83-page report includes 21 drawings and photographs of the 1943 facilities and the proposed construction program.

APG 5388/1 Min.
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Minor Report on Test to Exclude Auxiliary Engine Exhaust Gases from the Fighting Compartment of the Medium Tank M3
IDENTIFICATION: First Minor Report on Ord-

nance Program No. 5388
DATE OF REPORT: 15 June 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of an extended exhaust pipe for eliminating auxiliary engine exhaust gases from the crew compartment
METHOD: A 200-hour endurance run was made on the auxiliary engine with the unit delivering 1500 watts. A long exhaust line was installed on the unit to determine the effect it had on the operation of the engine. The long exhaust was then installed in a medium tank M3, and carbon monoxide measurements were made in the fighting compartment with the main engine off and the auxiliary set running.
DESCRIPTION: The Homelite auxiliary generator set was a 28-volt, d.c., 1500-watt unit and the gasoline engine which ran the generator was a 2-cycle, 3400 to 3600 rpm, single-cylinder engine. The exhaust extension was a 1-inch, close pitch, seamless steel exhaust hose.
CONCLUSIONS: The extended exhaust system had no effect on the engine operation, and the highest CO concentration measured was .01% with the tank buttoned up and only the auxiliary generator running. It was recommended that the extended exhaust pipe be incorporated on M3 and M4 medium tanks.
GENERAL: This 73-page report includes 15 photographs of the test equipment.

APG 5568/10 Min.
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Minor Report on Armament and Allied Equipment Instruction Plates, Etc.
IDENTIFICATION: Tenth Minor Report on Ordnance Program No. 5568
DATE OF REPORT: 25 July 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of decalcomania transfers for use in combat vehicles for naming items of stowage, for instruction plates, etc.
METHOD: Miscellaneous samples of the standard quality water decalcomania transfers were obtained, applied to test panels and tested for bonding by scratching, rubbing and soaking with oil.
DESCRIPTION: The decalcomania water transfers were of the standard quality of the industry and the miscellaneous samples were obtained from three of the largest manufacturers, Palm Brothers Decalcomania Company, the Mayercord Company, and the Klearfilm Labels Incorporation.
CONCLUSIONS: Standard decalcomania transfers had satisfactory bonding, to most surfaces. To insure a better bond and to protect the decalcomania from abrasion it was recommended that a transparent lacquer be applied over the decalcomania after application.
GENERAL: This 26-page report is not illustrated.

APG 5683/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Report on the Tank Obstacle Course
IDENTIFICATION: First Report on Ordnance Program No. 5683
DATE OF REPORT: 26 December 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the most effective method of reducing tank obstructions to allow the passage of light and medium tanks; to determine any deficiencies in the design of these obstacles or in the design of the tanks
METHOD: Numerous tank obstacles of different sizes, shapes, and constructions were set up on courses at Aberdeen Proving Ground. These obstacles were assaulted by light and medium tanks in an effort to destroy, or partially reduce them with the firepower of the tanks. In some cases, low-angle fire from a 155mm gun was utilized and indirect high-angle fire was simulated by statically detonating 105mm, 155mm, and 8-inch HE shells near or among the obstructions. Whenever necessary, engineer explosives were used.
DESCRIPTION: The large variety of tank obstacles included dragon's teeth, cubes, coffins, eggs, and stars, all constructed of reinforced concrete; concrete-filled round and square pipes; railroad heads with and without concrete cylinders; road blocks; shell holes; log ramps; hedge hogs; tetrahedrons; zigzag and double-row sheet steel piles; timber piles; and triangular and trapezoidal ditches.
CONCLUSIONS: The best means of reducing each obstacle to allow the passage of light and medium tanks were determined and recorded in the report in tabular form. Recommendations concerning changes in configuration of some of the obstacles and the most efficient methods of placing them in the field to obtain the maximum resistance-to-tank negotiation were also listed in the report. It was further recommended that design consideration be given to the elimination of projections on the bottom of all tanks and combat vehicles, and to the strengthening of the bottom plates of light and medium tanks.
GENERAL: This 286-page report contains 260 photographs of the test obstacles.

APG 5688/11
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Report on Firing of Standard Artillery, Self-Propelled Mounts, and Tanks from Landing Craft and Pontoons
IDENTIFICATION: Eleventh Report on Ordnance Program No. 5688
DATE OF REPORT: 24 May 1944
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of firing standard artillery, self-propelled mount weapons, and tank weapons from various amphibious vehicles, landing craft, and Navy pontoon barges normally used in landing operations
METHOD: Amphibious DUKW and LVT vehicles and various landing craft and Navy pontoon barges were loaded with standard artillery, self-propelled mounts, and tanks. The amphibious vehicles, landing craft, and barges were then moved out into relatively calm water where the loaded artillery and tank weapons were fired. After firing tests, unloading tests were conducted on a beach.
DESCRIPTION: Several test devices which would adequately secure the artillery, mounts, and tanks to the amphibious vehicles, landing craft, and barges were tested.
CONCLUSIONS: Standard artillery and self-pro-

pelled mount and tank weapons, when mounted as described in the report, could be satisfactorily fired from amphibious vehicles, landing craft, and Navy pontoon barges operating in relatively calm water, except for the following: 4.2-inch chemical mortar, mounted on a DUKW; 75mm pack howitzer, mounted on an LVT-2; 105mm howitzer carriage M2A2, loaded on an LVT-4; and four 40mm AA gun carriages M2A1, loaded on an LCT-6. It was generally felt that use of the waterborne weapons as artillery support during landing operations would not unduly sacrifice beaching time. It was recommented that the firing of waterborne weapons as outlined be considered technically satisfactory for use in providing artillery support during landing operations; and that further testing under actual invasion conditions be conducted.
GENERAL: This 722-page report, included in two volumes, contains 270 pages of photographs showing the installation of weapons on waterborne equipment and the appearance of both under firing conditions.

APG 5874/6
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Report on Demolition of Combat Vehicles
IDENTIFICATION: Sixth Report on Ordnance Program No. 5874; APG 11-7
DATE OF REPORT: 3 November 1942
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine a rapid, effective way for personnel to destroy vehicles abandoned in combat areas
METHOD: Demolition tests were performed on light and medium tanks, half-tracks, and trucks. Attempts were made to destroy and/or disable the various test vehicles by igniting ammunition and engine oil and fuel; by igniting demolition charges strapped to the fuel tanks and clutch and transmission housings; and by using small arms fire, sledge hammers, picks, or axes on various components.
DESCRIPTION: Thermite Grenades, AN-M14, were used for igniting fires. Fuze-equipped demolition charges of TNT weighing from 1/2 to 3 pounds were used in the demolition tests.
CONCLUSIONS: The most rapid and effective method of destroying light and medium tank and half-track vehicle components was the application of demolition charges. Considerable time and a great degree of uncertainty was involved in destruction by the other methods attempted. Trucks could be easily disabled by any of the methods used. It was recommended that all vehicles be equipped with built-in demolition charges; that a method be devised by which the charges could be readily ignited by personnel; that thermite grenades be provided for use in destroying vehicle tires; and that testing be continued on methods of disabling vehicles.
GENERAL: This 124-page report contains 30 photographs showing the results of thermite bombs on fuel tanks and the effects of ignited demolition charges on vehicle components. Drawings showing the proposed locations of charges on Light Tanks M3A1 and Medium Tanks M4 as well as a proposed charge container are also included.

APG 6012/3
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Report on Examination and Test of Automotive Equipment in "Operation Crossroads"
IDENTIFICATION: Third Report on Ordnance Program No. 6012
DATE OF REPORT: 4 June 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the effects of the 1 July 1946 atomic bomb detonation at Bikini Atoll, Marshall Islands, on certain Ordnance automotive equipment
METHOD: A radioactivity check was made of the automotive material after its arrival at Aberdeen Proving Ground. This examination was followed by a complete physical inspection of all vehicles and equipment; samples of any material which might have undergone a physical change were sent to the Laboratory Services Division. The next step consisted of placing the vehicles in minimum operating condition. After the vehicles were repaired, they were placed on road tests and operated for 500 miles over assorted terrain, with the exception of the light tank, M24, which was operated 300 miles. Following the road test, firing tests were conducted to determine the efficiency of the armament on the combat vehicles.
DESCRIPTION: The material tested consisted of the following motor vehicles: truck, 1/4-ton, 4x4 (Ford); two carriers, cargo, M29C (Studebaker); carriage, multiple gun, M16 (White Motor Co.); car, armored light, M8 (Ford); tank, light, M24 (Massey-Harris Company); and truck 2-1/2-ton, 6x6, GMC. Six of the vehicles had been on ships located about 600 yards from the point of burst of the bomb. The GMC truck had been on a ship some 1600 yards from the point of burst of the bomb. The vehicles ranged in age from brand new to 46 months old.
CONCLUSIONS: No significant irreparable damage was inflicted on the automotive equipment by the atomic bomb detonation. A considerable part of the damage sustained by the vehicles was caused by handling during shipment or by corrosion due to weathering. No residual radioactivity was present on the vehicles when they arrived at Aberdeen Proving Ground. Four man-days of work were the maximum required to place the most seriously damaged vehicle in operating condition. The results of road tests conducted on the repaired vehicles were generally satisfactory. Several recommendations were made concerning modifications to the M16 gun motor carriage, and the M29 cargo carrier. It was also recommended that in future tests the vehicle fuel tanks be filled with a liquid to more accurately determine the ability of the tanks to withstand blast pressures.
GENERAL: This 147-page report includes 30 photographs showing the condition of the vehicles when received at Aberdeen Proving Ground.

APG POT-24615/5
SUBJECT: Tests, Special, Miscellaneous
TITLE: Investigation of Crankcase Dilution on

Truck, Cargo, 2-1/2-Ton, 6x6, M34
IDENTIFICATION: Fifth Report OCO Project No. POT-24615; APG 14-136
DATE OF REPORT: 12 October 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the cause of engine oil dilution with gasoline forced from the fuel tank while the M34 truck stood exposed to the sun
METHOD: A rubber hose was connected to the gas vent line, and the end was submerged into a bottle of water. This gave a check on the operation of the fuel tank pressure relief valve denoted by an air bubble emitted when fuel tank was pressurized. Maintaining air pressures and allowing the tank relief valve to regulate it, line pressures were taken at possible sources of gasoline entry into engine.
DESCRIPTION: The test vehicle was the Truck, Cargo, 2-1/2-ton, 6x6, M34 as manufactured by Reo Motors Inc., Lansing, Michigan. For the test the fuel tank contained approximately 30 gallons of gasoline and was pressurized by using a standard gas tank filler cap fitted with a pressure gage and air valve.
CONCLUSIONS: Engine oil dilution with gasoline could occur on vehicle with pressurized fuel systems if the tank pressure relief valve was inoperative. It was recommended that the necessary action be initiated to emphasize the proper handling of the pressurized fuel system. Instructions should be issued to adjust the fuel tank filler cap to the "Pressure Release Position" when the vehicle was not in use. It was also recommended the main fuel line valve be closed for extended storage.
GENERAL: This 12-page report is not illustrated.

APG TB4-10H/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: Second Report on Development of Ballistic Test for Aircraft Armor and Weldments
IDENTIFICATION: First Report on Project No. TB4-10H; Armor Test Report AD-1133
DATE OF REPORT: 18 May 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether a ballistic fracture test could differentiate between samples of tough and brittle armor, and between weldments employing different electrodes
METHOD: One hundred and forty-five samples of aircraft armor, including both tough and brittle material 1/4, 3/8, and 1/2-inch thick, and 118 welded aircraft armor samples incorporating three different types of welding electrodes were tested to determine the sensitivity of the testing technique and the reproducibility of results.
DESCRIPTION: The test technique involved the following: a suitable method of holding the samples; impacts that could be placed in the desired location; samples that could be stressed, by impact, in an identical manner; differentiation between qualities of armor and between different types of weldments; a suitable projectile as to caliber and hardness; and proper size of samples.
CONCLUSIONS: The test did differentiate between brittle and tough armor. Data were insufficient to determine if the test could differentiate between weldments employing different welding electrodes. It was recommended that additional weldments of two different welding electrodes be furnished to carry out further investigations.
GENERAL: This 61-page report includes two photographs of the method of mounting test samples.

APG TB4-670A/25
SUBJECT: Tests, Special, Miscellaneous
TITLE: First Report on Type II Survey
IDENTIFICATION: Twenty-fifth Report on Project No. APG TB4-670A
DATE OF REPORT: 6 May 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To establish the limits and number of necessary specimens for tensile strength and elongation determinations of strippable protective compounds and to determine the effects of aging on the level of tensile strength and elongation of tensile specimens
METHOD: Three Type 1 and three Type 2 compounds, typical of material used by Ordnance, were prepared in accordance with Specification AXS-1167, Revision 2, with slight deviations in the preparation. Two groups of 48 or more specimens of each compound were placed in a conditioning box at 77°F, 50% relative humidity for 24 hours. One of the groups was identified as initial specimens. The other group was left in the box for an additional 30 days and referred to as aged specimens. Specimens were removed individually from the conditioning box and pulled on a Scott Tensile Machine, Model X-5. The data obtained from these tests were subjected to a statistical analysis.
DESCRIPTION: The three Type 1 test compounds were Seibert 500R, Seibert 525, and DuPont VMT-1141. The three Type 2 test compounds were Nox Rust Peel Film #20, Nox Rust Peel Film #21, and Eronel #900.
CONCLUSIONS: The limits for the experimental error of individual specimens of the test compounds were given as follows: tensile strength, Type 1, $\pm$ 12.9% from the mean average; percent elongation, Type 1, $\pm$ 8.5% from the mean average; tensile strength, Type 2, $\pm$ 14.2% from the mean average; percent elongation, Type 2, $\pm$ 13.8% from the mean average. A minimum of ten specimen results was considered necessary for both types of compounds in order to give a representative tensile strength and elongation value equal to or within 5% error. Aging of the compounds in the conditioning box caused an increase in tensile strength and decrease in elongation. On the basis of this investigation it was thought that the current specification minimum requirements for tensile strength and elongation were satisfactory for the type of compounds tested.
GENERAL: This 73-page report includes 51 pages of tables and graphs.

APG TB4-760D/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: Comparison of 5% and 20% Salt Spray
IDENTIFICATION: First Report on Project No. TB4-760D
DATE OF REPORT: 24 October 1949

TANK AUTOMOTIVE TEST RESUMES

ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine whether a 5% or 20% salt concentration in salt spray testing would be more effective for use in testing specification paint finishes
METHOD: Seven widely different types of paints generally used as protective coatings for U.S. Army materiel were applied to each of two sets of metal and glass panels. One set of glass and and metal panels was exposed to a 5% solution salt spray, and the other set of glass and metal plates was exposed to the standard 20% solution salt spray for metallic coatings. Deterioration rates of the paints under the different sprays were recorded and compared.
DESCRIPTION: One test salt spray for paints contained a 5% salt concentration. The other was 20% concentration of salt used in the standard metallic coating salt spray test.
CONCLUSIONS: Severity and rate of deterioration of the paint were more rapid when using the spray containing a 5% salt concentration. Blistering of the paint and rusting of the substrate were more distinctly observed, occurred within a shorter exposure time, and developed more extensively with the 5% solution than with the 20% solution. It was recommended that a salt spray containing a 5% concentration of salt be used in future salt spray testing of U.S. Army paints.
GENERAL: This 22-page report contains no photographs.

APG TB4-770B/F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Analytical Methods of Fungicides Used in U. S. Army Specification 3-186, Sealer, Wood, Preservative
IDENTIFICATION: Final Report on OCO Project No. TB4-770B
DATE OF REPORT: 30 December 1947
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop satisfactory analytic procedures for wood preservative sealers
METHOD: The methods for extracting and purifying salicyl anilide pentachlophenol, and phenyl mercuric oleate from wood preservatives were determined. Qualitative analysis steps in determining the presence of the compounds were listed. Preparations and calculations for colorimetric analysis of the quantity of the compound present were listed.
DESCRIPTION: The compounds discussed in this report were added to wood preservatives as fungicides. Chemicals used in the analysis were supplied by E. I. DuPont de Nemours and Company, Dow Chemical Company, and Monsanto Chemical Company.
CONCLUSIONS: Existing analytic methods were unsuitable for determining resinous materials used as fungicides. The methods described in this report eliminate the need for decomposing resins and may be simply conducted using standard laboratory equipment.
GENERAL: This 11-page report contains procedures for quantitative and qualitative analyzing the fungicides in wood preservatives.

APG TB4-771/1

SUBJECT: Tests, Special, Miscellaneous
TITLE: Comparison of the Water Immersion and Humidity Tests for Evaluation of Paint Films
IDENTIFICATION: First Report on Project No. TB4-771
DATE OF REPORT: 6 September 1950
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the effectiveness and usefulness of the distilled water immersion test and 100% relative humidity test as specification tests for paint
METHOD: Representative Ordnance paints were exposed to a distilled water immersion test at 100°F and to a 100% relative humidity test at 100°F. The paints were tested over both steel and tin plate panels employing methods applicable to typical specification usage. The comparative advantages and effectiveness of the immersion and humidity tests in measuring water resistance and as accelerated rusting tests were evaluated from the behavior of the paints. The test methods and not the paints were evaluated in this investigation.
DESCRIPTION: The humidity cabinet used in the test was described in U. S. Army Specification 2-122, paragraph H-3. The test panels were suspended vertically in the cabinet by means of insulated hooks and were continuously covered with fine droplets of condensed moisture. Immersion resistance was determined upon panels immersed vertically to a depth 2/3 their height in distilled water maintained at 98 to 102°F. There was no metallic contact between panels.
CONCLUSIONS: Evaluation of the water resistance of a paint film was accomplished with equal effectiveness by either the humidity or immersion test. The immersion test was preferable because of its simplicity. As an accelerated rusting test, the humidity test was more effective than the immersion test, but excessive exposure periods were required with the commonly employed Ordnance paint systems. It was recommended that the water immersion test be retained in preference to a humidity test as the specification test for water resistance of Ordnance paints.
GENERAL: This 17-page report is not illustrated.

APG TB5-1401/53

SUBJECT: Tests, Special, Miscellaneous
TITLE: Over-All Summary Report on Summer Climatic Tests, 1952
IDENTIFICATION: Fifty-third Report on Project TB5-1401; APG 58-4
DATE OF REPORT: 30 October 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the suitability of selected items of Ordnance materiel for operation and functioning under summer desert conditions and summer arctic conditions
METHOD: Thirty-seven vehicle projects and one ammunition project conducted at Yuma, Arizona, during the summer of 1952 were reviewed and summarized. Several vehicle and ammunition projects conducted under summer arctic conditions at Fort Churchill, Canada, were similarly reviewed and summarized.
DESCRIPTION: The transport vehicles tested at

Yuma and/or Fort Churchill were the M34, M35, M37, M38A1, T46E1, M41, M51, M135, T23, and T121. The combat vehicles tested were the M8E2, M47, T48, T59, T59E1, T101, and T108. Ammunition tested was of HE, chemical, and HEAT-FS types for 76-mm and 90-mm Guns or 105-mm Mortars. Submerged type fuel pumps of Bendix, Tokheim, and Stewart-Warner manufacture were also tested. Various aviation fuels, jet fuels, and blends of gasoline were stored under various temperature conditions with corrosion inhibitors, antioxidants, and metal deactivators.
CONCLUSIONS: In the summer arctic tests, no wheeled Ordnance vehicle could operate in muskeg, but the T121 Snow Tractor (Gladden) was satisfactory except for steering and suspension difficulties. In the summer desert tests, the M135, M37, M38A1, and T46E1 transport vehicles cooled satisfactorily, as did the T48 Tank, and M8E2 Cargo Tractor. All transport vehicles were satisfactory in desert mobility except in sand dune areas. All tracked vehicles had satisfactory mobility in sand dune areas except the M8E2 Tractor towing its designated load. The 60% synthetic tire and 9.00 x 20 V.P. Hutchinson safety tube were not satisfactory. Collapsible rubber fuel storage tanks were not satisfactory. Improvement of desert test facilities and stabilization of personnel were recommended.
GENERAL: This 73-page report contains various photographs of the test materiel and test terrain at Yuma and Fort Churchill.

APG TB5-5000/2

SUBJECT: Tests, Special, Miscellaneous
TITLE: Development of Specification for Hydraulic Brake Fluid, Arctic Winter Grade
IDENTIFICATION: Report No. TB5-5000/2
DATE OF REPORT: 8 April 1949
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop suitable specifications for Arctic winter grade hydraulic brake fluid
METHOD: The current Specification USA-2-111B for brake fluids was used to test the Arctic winter grade hydraulic brake fluid. The suitability of this specification for boil and flash point, and viscosity at -65°F tests on the Arctic fluid was checked. A new specification based on USA-2-111B was drafted and sent to various brake fluid manufacturers for comments.
DESCRIPTION: The specification covered one type and grade of non-mineral oil for hydraulic brake systems at atmospheric temperatures from 125°F to -90°F.
CONCLUSIONS: The new specification was a suitable procurement specification and it was recommended that the specification be issued and used to procure Arctic winter grade hydraulic fluid.
GENERAL: This report contains 24 pages. A copy of the new specification was included.

APG TB5-8010A/10

SUBJECT: Tests, Special, Miscellaneous
TITLE: Investigation of the Intensity of the 3.0u Band of Aliphatic Alcohols and Its Analytical Implications
IDENTIFICATION: Tenth Report on Ordnance Project No. TB5-8010A
DATE OF REPORT: 18 February 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To apply infrared measurements to the analysis of the aliphatic alcohol components of hydraulic brake fluids and antifreeze fluids.
METHOD: The intensity of the hydroxide band of the infrared spectra of numerous aliphatic alcohols was evaluated in terms of a difference of percent transmittance of the fundamental CH stretching vibration and that of the 3.0 micron band. Infrared spectra covering the region of 2-16 microns, were obtained with a Model A., Baird Associates Spectrophotometer.
DESCRIPTION: The alcohols were obtained from the center cut of the freshly distilled product. The deviation of the boiling points of the alcohols from the values of the International Critical Tables was not in any case greater than plus or minus 1°C, and it was assumed from this that the alcohols were of a reasonably high degree of purity. The glycols were of C.P. reagent grade taken from freshly opened containers.
CONCLUSIONS: The difference of percent transmittance of the fundamental CH stretching vibration and that of the 3.0 micron hydroxide band was a constant for sample layers thicknesses of the order of 0.006-0.02 mm, and was a characterizing and identifying constant for each aliphatic alcohol. Propylene glycol-1, 2 exhibited anomalous behavior. It was recommended that the qualitative and quantitative applications of the constants developed be explored and developed for use in brake fluids and antifreeze analyses, and that the treatment be extended to carbonyl compounds for the detection and estimation of oxidation products formed during the formation of gum and the process of corrosion in coolant and brake systems.
GENERAL: This 38-page report contains no photographs.

APG TB5-8010A/11

SUBJECT: Tests, Special, Miscellaneous
TITLE: Fundamental Studies on the Galvanic Behavior of Aluminum-Copper, Iron-Copper and Solder-Copper Couples in Antifreeze Environments
IDENTIFICATION: Eleventh Report on Ordnance Project No. TB5-8010A
DATE OF REPORT: 18 March 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine (1) which metals were likely to be more severely corroded due to electrical contact with copper in various antifreeze media; (2) the relative cathodic protection offered copper by aluminum, solder, and iron in these antifreeze environments; (3) the relative amount of corrosion of the anode metals in antifreeze media due to galvanic action under the test conditions
METHOD: Each of the tested couples was immersed in each of the test solutions, and inserted in a zero resistance ammeter circuit. Total coulombs developed were calculated by integration from points on the current-time plot, developed from readings taken over a period of 11 days. The theoretical weight loss, calculated by use of Faraday's equation, was compared with actual weight loss, determined gravimetrically, to calculate the percent of galvanic corrosion in each case.

DESCRIPTION: Aluminum-copper, solder-copper, and iron-copper couples were tested in 50% 4-1116, 50% TX 1923, 50% X-9-1, and 50% uninhibited ethylene glycol solutions.
CONCLUSIONS: Tendency to galvanic corrosion of aluminum, solder, and iron, in the environments of the test, could be based on their relative positions in the electromotive series. Greatest cathodic protection to copper was offered by iron in the 4-1116 and Texaco solutions, aluminum in the X-9-1 solution, and solder in uninhibited ethylene glycol solution. It was recommended that a further study be undertaken to determine the extent of protection the various metals found in the cooling system of a vehicle would offer solder in antifreeze media; that studies of this type be carried out to determine the effect of various known inhibitors in ethylene glycol solutions on the galvanic corrosion current, so that an ideal combination of inhibitors would be found to yield maximum cathodic protection.
GENERAL: This 25-page report is not illustrated.

APG TT1-19/5
SUBJECT: Tests, Special, Miscellaneous
TITLE: Vibration Test of T94 and T91E3 Tracks on Light Tank, 76mm, T41E1
IDENTIFICATION: Fifth Report on Project TT1-19; APG 21-150
DATE OF REPORT: 17 September 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the vibration characteristics of the 76mm Gun Tank T41E1 with T94 Tracks and with T91E3 Tracks; and to determine the resistance to towing with each track
METHOD: A T41E1 Tank was equipped with instrumentation for obtaining vibration data at the front road wheel arm, the No. 3 road wheel arm, and one point on the turret ring. The test vehicle was operated on a paved road at speeds of 5, 15, and 25 mph with T94 Tracks, T91E3 Tracks with pads and T91E3 Tracks without pads. Resistance to towing tests were made with the final drives disconnected and on a level concrete course.
DESCRIPTION: The T94 track was a 21-inch wide, single-octagonal-pin, doughnut-bushed, center-guide, all-rubber track. The T91E3 Track was a 24-1/4-inch wide, single-octagonal pin, doughnut-bushed, center-guide, rubber-backed track with integral steel grousers and detachable rubber grousers.
CONCLUSIONS: The T94 Track imparted less vibration to the road wheel arms and into the turret than the T91E3 Track. The vibration acceleration of both tracks, measured at the turret ring, ranged from 2% to 50% of the vibration at the road wheel arms. At all points, the vibration from the T91E3 Track was severe, and the vibration acceleration reached a value nine times the acceleration due to gravity. Sources of vibration other than the tracks also caused disturbances at the turret ring. The towing resistance of the T94 Track averaged 10% greater than that of the T91E3 Track. The T94 Track was considered better than the T91E3 Track from the standpoint of vibration, but it was not recommended for use on the T41E1 Tank since extensive suspension modifications were necessary to make the installation.
GENERAL: This 37-page report contains two photographs of the track blocks used in the test tracks.

APG TT1-696A/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: Report on Evaluation of Military Wheeled Vehicle Panel Austerity Program
IDENTIFICATION: First Report on Project No. TT1-696A
DATE OF REPORT: 14 May 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine what non-essential items of equipment could be eliminated from wheeled-vehicle standard equipment to realize production cost savings while not impairing the tactical application of the vehicle, and to determine what equipment could be furnished in kit form for special requirements
METHOD: Five types of standard tactical trucks were prepared by individual manufacturers according to their ideas of reducing the cost of the vehicles. The trucks were inspected, evaluated, and the effectiveness and applicability of kits were determined.
DESCRIPTION: The five trucks submitted for test were standard vehicles except for the deletion of equipment which was considered non-essential. Trucks submitted for test included: Willys-Overland Corporation, 1/4-ton, 4x4, M38E2; Dodge Motors, 3/4-ton, 4x4, M37E4; Reo Motors Incorporated, 2-1/2-ton, 6x6, M35E2; General Motors Truck Division, 2-1/2-ton, 6x6, M135E1; and International Harvester Company, 5-ton, 6x6, M41E1. In some cases, manufacturers supplied kits for partially-essential items, which were also eliminated from vehicle design.
CONCLUSIONS: Many items such as instruments, waterproof equipment, and extra accessories could be omitted from military vehicles without seriously impairing their intended tactical use. It was recommended that further studies be conducted to eliminate all the non-essential items and partially-essential items which could be economically supplied in kit form for application only when needed on military vehicles.
GENERAL: This 56-page report contains 32 pages of photographs showing the modified vehicles and components.

APG TT1-701/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: Drawbar Pulls Required in Field Recovery Operations
IDENTIFICATION: First Report on Project No. TT1-701
DATE OF REPORT: 6 January 1948
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the drawbar-pull requirements which could be used as guides in the design of recovery equipment for several types of standard military vehicles
METHOD: The drawbar-pull required to recover each of seven types of vehicles was determined under the following conditions: while winching the vehicles up 60% slopes; while winching the

vehicles through mud and ditch obstacles; and while towing the vehicles through mud with the brakes applied. In order to determine drawbar-pull under shock conditions, the seven vehicles were towed over a cross-country course. Measuring devices used in test included three electric strain gage type drawbars having maximum load capacities of 40,000, 80,000, and 120,000 pounds. A commercial type photoelectric recorder was used as the external meter to record the drawbar-pull values.
DESCRIPTION: Drawbar-pull recovery requirements were determined for the following vehicles: 1/4-ton, 4x4 and 2-1/2-ton, 6x6 trucks; 10-ton heavy wreckers, M1; 6x6, truck-tractors, T30; cargo carriers M29C; light tanks, M24; medium tanks M26; and 240mm howitzer motor carriages, T92. The weight of these vehicles ranged from 2375 to 127,600 pounds.
CONCLUSIONS: The tabulated test results were considered suitable for use as a guide in predicting maximum drawbar-pull requirements for recovery of the vehicles used in test. Peak loads did not exceed the weight of the recovered vehicles, except in cases where the vehicles overran the tow chain. It was recommended that a safety limit be fixed to the design of recovery equipment if the data presented in the report were utilized in the design of such equipment; and that if further data on stresses encountered in vehicle recovery were desired, the data should be obtained by tests conducted during routine recovery operations.
GENERAL: This 17-page report is not illustrated.

APG TT1-702/1
SUBJECT: Tests, Special, Miscellaneous
TITLE: An Examination of the Acceleration Method for Determining the Performance of Track-Laying Vehicles
IDENTIFICATION: First Report on Project No. TT1-702
DATE OF REPORT: 12 March 1952
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To study the acceleration method for determining the performance of track-laying vehicles and to determine factors contributing to the errors of this method
METHOD: An electric-drive Medium Tank T23E3, equipped with test instrumentation, was operated through five consecutive acceleration runs. Instrument readings were obtained and used in conjunction with mathematical analysis to obtain vehicle acceleration force and sprocket force. To determine acceleration force, the kinetic energy of the rotating mass equivalent of tank components was calculated. To determine the kinetic energy of the rotating mass equivalent, kinetic energies of the following components were found and multiplied by two (for two sides of the tank): sprocket and hub assembly, bogie wheels, idler wheels, rollers, final drive gear, armature, and track. Kinetic energy of the track was found by an involved vector analysis of each block, and by assuming that the track was equivalent to a wheel of the same mass with a circumference equal to the track perimeter and using the kinetic energy equation. Track energy results from each of the above methods were compared. Resistance to propulsion under acceleration, the difference between sprocket and acceleration forces, was found and compared to resistance to propulsion at constant speed.
DESCRIPTION: The acceleration method was a system devised to determine resistance to propulsion, drawbar pull, and towing by measuring the ability of a tank to accelerate or decelerate by use of a field dynamometer. This method was unsuccessful.
CONCLUSIONS: The greatest error in the acceleration method resulted from inaccuracy in determining the equivalent mass of the rotating parts. It was therefore concluded that this mass should be calculated analytically, rather than experimentally in the field, by determination of the corresponding kinetic energy. The kinetic energy of the track could be calculated by assuming that it was equivalent to a wheel of the same mass and circumference. Under a steady accelerating sprocket force, the resistance to propulsion approached the value characteristic for a constant speed; however, under a fluctuating force, the resistance was greater. Damping forces opposing the fluctuations increased the resistance to propulsion. Acceleration tests should be run with direct reading accelerometers. It was recommended that track loss studies of the acceleration method for determining vehicle performance be continued.
GENERAL: This 133-page report contains three photographs showing the exterior of the testing vehicle and a view of the oscillograph chart. Complete test calculations are also included. This report is an excellent reference for anyone interested in determining comprehensive tank performance.

APG TT1-702/2
SUBJECT: Tests, Special, Miscellaneous
TITLE: Study of Methods for Determination of Vehicle Acceleration
IDENTIFICATION: Second Report on Project No. TT1-702
DATE OF REPORT: 31 January 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To develop a method for measuring linear acceleration characteristics of Ordnance vehicles with sufficient accuracy to permit qualitative comparisons of vehicles whose difference in power output was small
METHOD: Efforts were made to measure vehicle linear acceleration on the basis of either the acceleration or time-velocity characteristics of a vehicle. Two acceleration and two time-velocity methods were used in the determinations.
DESCRIPTION: The following instrumentation was required for one acceleration method of determining vehicle linear acceleration characteristics: a General Electric dynamometer, Model 5DY83AB1; a Brush Development Company amplifier, Model BL-10, and dual channel oscillograph, Type 202; a filter differentiating network; and a trailing fifth wheel. Instrumentation for the second acceleration method included: a Statham direct reading accelerometer, $\pm$ 2G, Model S-2-120; Glen L. Martin dynamic measurement equipment (amplifier-oscillator); a Hathaway oscillograph, Type S-8-B; and a filter network. The following instru-

mentation was required for one time-velocity method of measuring vehicle linear acceleration: a General Electric tachometer generator, Type CM5, Model 2CM5 and magnetic oscillograph, Type PM-10-B2; and a trailing fifth wheel. Instrumentation for the second time-velocity method included a fifth wheel driven General Electric, Type CM5, Model 2CM5, generator, the output of which was fed directly into an indicating meter calibrated in mph, and a stop watch; in this method, the time required to accelerate from one speed to another could be easily measured.
CONCLUSIONS: The only method giving satisfactory vehicle acceleration results was the one employing a fifth-wheel driven generator, indicating meter calibrated in terms of mph, and a stop watch. This method was recommended.
GENERAL: This 35-page report includes 11 photographs of the test equipment and five photostatic oscillograms.

APG TT1-720E/3
SUBJECT: Tests, Special, Miscellaneous
TITLE: Report on Test of Resilient Shock Mounts Comparing 40 and 70 Durometer
IDENTIFICATION: Third Report on Project No. TT1-720E
DATE OF REPORT: 24 January 1955
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To compare the 40 durometer resilient rubber shock mounts with the standard 70 durometer mounts for track vehicle headlights
METHOD: One headlight with a test mount and one with a standard mount were installed on five M41 light tanks, three M47 and two M48 medium tanks, a tractor M8E2, two M59 and one M76 armored infantry vehicles. The vehicles were operated over various types of terrain for a total of 16,105 miles. Mileage of the failed units was recorded.
DESCRIPTION: The term "durometer" is a measurement of the resiliency of rubber; the higher the durometer number, the harder and less flexible the material. The 40 durometer and 70 durometer units were identical except for the change in resiliency.
CONCLUSIONS: Seven 70 durometer units failed as compared to the failure of three 40 durometer units. It was concluded that the vibration characteristics of the test unit lengthened the life of the lamp and had no adverse effect on the lighting characteristics. It was recommended that the 40 durometer unit be used as a replacement for the standard mount.
GENERAL: This 21-page report contains no illustrations.

APG TT2-672/4
SUBJECT: Tests, Special, Miscellaneous
TITLE: Visual Range Estimation
IDENTIFICATION: Fourth Report on Project No. TT2-672
DATE OF REPORT: 27 December 1951
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the over-all average percentage of error in visual range estimation, without instruments, by 530 R.O.T.C. observers; also, to note the influence of weather conditions on distance judging and the effect of distance increase, intervening landmarks, and prior experience of observer
METHOD: Ten landmark "targets" (at known ranges of 517 to 2017 yards) were observed by 530 R.O.T.C. cadets between the hours of 0800 to 1500 on six successive days. All estimates were made from a central platform. The prior experience, if any, of each observer was noted and error distribution graphs prepared ("histograms").
DESCRIPTION: The targets observed were buildings, water towers, a smoke stack, and other objects located about The Proving Ground.
CONCLUSIONS: The average percentage of error for observers having small previous experience was 32.2%. For median range error for 5300 observations was 28.8%. Most distances were underestimated. The percentage of error in estimating the shorter distances was greater on bright, sunny days. Whether the observer came from city or country had little bearing on ability in this test. Observers with previous ranging experience made smaller errors than did untrained observers.
GENERAL: This 50-page report contains a photograph of each landmark used. A histogram for each of the ten targets, five summary graphs, and a linear trend curve are also included.

APG TT2-689/3
SUBJECT: Tests, Special, Miscellaneous
TITLE: Range and Speed Estimation
IDENTIFICATION: Third Report on Project No. TT2-689
DATE OF REPORT: 23 October 1953
ORIGIN: Aberdeen Proving Ground, Maryland
PURPOSE: To determine the amount of error of the untrained eye in estimating the range and speed of moving vehicles
METHOD: Approximately 7000 speed estimations and 1400 range observations were made of M135 trucks which operated at speeds varying from 3 to 29 mph and at ranges varying from 500 to 1650 yards. Eight hundred ROTC cadets were used in this experiment. Each observational result was tabulated and the average errors in speed and range estimations were determined. The value of binoculars in making speed and range estimations was also determined.
DESCRIPTION: Other than a brief lecture, the cadets had no previous training on range or speed estimation. The binoculars were intended only for use as an instrument of magnification. All observations were made from a platform 70-feet high.
CONCLUSIONS: A wide range of estimates was obtained rather than a constant deviation from the true range and speed of the vehicle. The use of binoculars offered no practical advantage. Target speed and target range were factors which affected the variability of speed estimation. It was felt that the systematic error for a group of observers was not serious, but the reverse might be true for an individual. It was recommended that the results obtained from this test be considered in future investigations with untrained observers.
GENERAL: This 44-page report includes four photographs showing the test courses. Graphs,

and range and speed estimation tables are also included.

SUBJECT: Tests, Special, Miscellaneous C-5V
TITLE: Vapor Blast Liquid Honing Process as Applied to Cutter Tool No. 7537137-4
IDENTIFICATION: Report No. 5V
DATE OF REPORT: 24 April 1952
ORIGIN: Fellows Gear Shaper Co., Springfield, Vermont
PURPOSE: To determine the acceptability of the vapor blast liquid honing process for cutter tools
METHOD: Six cutter tools were liquid honed for use in shaping the gear teeth in lower race turret rings. The liquid honing was done by blasting the surface of the tools with a chemical emulsion and fine abrasive in solution. Each cutter was then used to rough- and finish-shape the teeth in six turret rings; a total of 36 rings being processed in this way.
DESCRIPTION: The type of cutter tool used in this test was designated No. 7537137-4.
CONCLUSIONS: The operation of cutting turret ring teeth without regrinding of the test cutter tool was successful. The cutter tool could be replaced in the machine after vapor blasting and additional turret rings cut without regrinding after each operation. The vapor blast liquid honing method could be applied rapidly and with considerable uniformity regardless of the contour of the cutting face.
GENERAL: This seven-page report includes four photographs of the cutter tool teeth.

SUBJECT: Tests, Special, Miscellaneous DA 340
TITLE: Two Part Batching Stock (For Use in Retreading Cement)
IDENTIFICATION: Report No. 340
DATE OF REPORT: 28 February 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of accelerated aging on a two-part retreading cement batching stock with respect to dissolution and viscosity of the resulting cements
METHOD: The two-part cement batching stock was conditioned in an oven for 72 and 168 hours at 158°F. The stocks were added in the proportion of one-half pound of each part in one gallon of rubber solvent. Two batches were prepared at each aging period, one hand mixed and the other machine mixed. Cements were also mixed using the two-part stock as it was received from the United States Rubber Company. A relative measure of viscosity was obtained from the Stormer Viscosimeter. Viscosities were compared using the weight required for 200 rpm of a standard paddle as a criterion. Samples of retreading cement representative of that supplied to Field Service were used as a control.
DESCRIPTION: The two-part retreading cement batching stock was supplied by the United States Rubber Company. Each part of the stock was compounded to decrease pre-curing tendencies.
CONCLUSIONS: Dissolution of the batching stock became more difficult, and viscosities of the resulting cements increased with aging. Mechanical agitation yielded cements having lower viscosities than those which were hand stirred. Retreading cement prepared from the two-part batching stock, unaged and aged 72 hours at 158°F, had lower viscosities than the control sample. The two-part batching stock that was aged 168 hours at 158°F produced cement with higher viscosities than the control sample. It was recommended that testing be conducted to compare the stabilities of ready mixed cement and cement made from batching stock, both freshly prepared.
GENERAL: This five-page report is not illustrated.

SUBJECT: Tests, Special, Miscellaneous DA 359
TITLE: Heat Rejection of the Personnel Heater and Temperature of Ammunition in Tank, Light, T41E1 No. 3
IDENTIFICATION: Report No. 359
DATE OF REPORT: 23 March 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the maximum temperatures in the ammunition boxes, heater exhaust line, and driver's compartment of a T41E1 light tank when operating the personnel heater under high ambient temperature conditions
METHOD: A light tank T41E1 equipped with a personnel heater and no turret was used in test. With all vehicle hatches open and with the heater operating, temperature measurements were made at various locations in the vehicle; ambient temperature during this phase of test was 65°F. After incorporating various modified components and with the vehicle escape hatch closed and top hatch open, a similar test was conducted at an ambient temperature of 72°F. Both tests were conducted to simulate the worst conditions possible by bypassing the compartment thermostat and the heater overheat switch.
DESCRIPTION: The personnel heater of the T41E1 light tank was a Stewart-Warner, Model 978 M-25, personnel heater.
CONCLUSIONS: The test proved that the maximum temperature encountered with operation of the test vehicle personnel heater at prevailing ambient temperatures without turret and with hatches opened was 121°F, or 29°F below the critical temperature specified for the ammunition boxes. Temperatures at other locations in the vehicle were recorded in the report. It was recommended that similar tests be conducted with all vehicle hatches closed and a turret installed.
GENERAL: This 14-page report is not illustrated.

SUBJECT: Tests, Special, Miscellaneous DA 413
TITLE: Comparison of Several Fungus Resistance Test Procedures
IDENTIFICATION: Report No. 413
DATE OF REPORT: 10 July 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the effectiveness of several methods for conducting fungus resistance tests
METHOD: Samples of various materials were

subjected to several procedures and variations of tests outlined in the applicable specifications. These samples included black Bakelite sections with laminations of the cloth filler, an automotive type low tension cable covered with cotton braid and lacquer, a circular disc of lucite (methyl methacrylate), and treated cotton duck, No. 8 impregnated with copper naphthenate mildew proof compound. Observations of the mold attack were made after 14 and after 28 days.
DESCRIPTION: The procedures for conducting fungus resistance tests which were evaluated were those outlined in USA Specification 60-977-2 and USAF Specification 41065-B with certain variations. Non-nutrient agar tests and tropical room exposure tests were also included. The latter of these were performed after inoculations with single spore suspensions and again after inoculations with mixed spore suspensions.
CONCLUSIONS: The 14 days' incubation time allowed by Specification 60-977-2 was sufficient to promote mold propagation. A longer incubation period in the tropical room was considered necessary for verification of agar test results. The non-nutrient agar test, when employed concurrently with the nutrient agar test, proved applicable both for verification purposes and as a medium for determining the inherent nutrient property of the specimen. The Specification 60-977-2 procedure was not considered a conclusive test for differentiating between the inherent nutrient value or initial fungistasis of a material. Modifications of Specification 60-977-2 relating to the test results were recommended. These included the use of some type of cellulosic destroyer in the agar tests, and further studies to determine optimum exposure time and method of exposure of tropical room samples.
GENERAL: This 53-page report contains 32 photographs of the test results.

SUBJECT: Tests, Special, Miscellaneous DA 562
TITLE: Hydraulic Jack
IDENTIFICATION: Report No. 562
DATE OF REPORT: 10 November 1950
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of a Calnevar jack for use with military vehicles
METHOD: The test jack was used for removing and changing the tires of 1/4-ton, 3/4-ton, and 2-1/2-ton trucks. It was further tested on a compression testing machine and finally tested after exposure to temperatures of -70°, -40°, and -20°F for 24 hours.
DESCRIPTION: The test unit was Calnevar J-77B hydraulic jack with a rated capacity of 2 tons. It consisted of two sections and a base. Its closed height was 5-1/2 inches, the extended height, 12 inches. Forty strokes were necessary to raise it to the maximum height.
CONCLUSIONS: When checked with the compression testing machine, the jack lifted 4000 pounds with one section extended, but only 3000 pounds after the second section began to ascend. A flat tire on a 1/4-ton truck, 4x4, could readily be removed and an inflated tire replaced with the test jack in an upright or in an inverted position. A 5-inch block had to be used for added height with the jack in order to make contact between the jack and the axle of a 3/4-ton truck, 4x4. The jack could not hold the necessary weight on a 2-1/2-ton truck, 6x6, after the second section started to ascend. The test item failed to extend without loading, after having been exposed to -70°F, -40°F, or -20°F for 24 hours. However, it worked satisfactorily again after it had been warmed to a temperature of +70°F. It was recommended that the test jack be considered unsatisfactory for general use on military vehicles.
GENERAL: This two-page report is not illustrated.

DA 637A
SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of Metallurgical Reasons for Chipping of Sledge Hammer
IDENTIFICATION: Report No. 637A
DATE OF REPORT: 19 October 1948
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the cause of chipping of an 8-pound sledge hammer; and to make recommendations to eliminate the condition
METHOD: The test hammer was inspected. Magnetic and micro-examinations and Brinnel hardness measurements were then made of the sledge surfaces.
DESCRIPTION: The test 8-pound sledge hammer was submitted by the U. S. Corps of Engineers. One of the working surfaces of the sledge was chipped during usage.
CONCLUSIONS: The steel used in the test hammer was substantially in conformity with the composition for an AISI C 1064 steel. The hardness exploration and the micro-examination showed a structure consisting of alternate hard and soft zones at the working faces. Particular examination of the chipped zone indicated that failure occurred from shearing or tearing of the metal through a soft region. It was recommended that the sledge head be fabricated from a conventional punch and chisel stock; that flame hardening be eliminated by the employment of a furnace hardening and tempering procedure; that a comparatively soft steel or brass cup, to be mounted on the steel spike cap, be used to reduce the tendency toward "mushrooming" of the working face, and to increase the life of the hammer; that the heat treatment be such as to produce a surface hardness of 55-58 Rockwell C; and that a final tempering temperature of 400°F be employed.
GENERAL: This nine-page report includes three photographs of the test sledge hammer and its failures.

DA 1257
SUBJECT: Tests, Special, Miscellaneous
TITLE: Proposed Revision of Fungus Test Procedures of U.S. Army Specification 60-977-2
IDENTIFICATION: Report No. 1257
DATE OF REPORT: 19 September 1951
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate fungus resistance tests and techniques for determining funginertness and

and fungistatic resistance for incorporation into USA Specification 60-977-2
METHOD: Test methods evaluated included the non-nutrient Petri dish method for determining the fungus susceptibility of small specimens mildly susceptible to fungus growth; the nutrient agar Petri dish method as outlined in the specification; and tropical room exposure methods, with and without direct innoculation. Techniques for inoculation that were evaluated included inoculation in Petri dishes with a sterile air brush and compressed carbon dioxide, and the application of infected nutrient cotton strings to the surfaces of specimens too large for Petri dishes.
DESCRIPTION: A review of USA Specification 60-977-2 revealed that the fungus resistance test outlined therein served to establish only the degree of effectiveness of materials exerting a fungicidal or strongly fungistatic action. It could not be used for an absolute evaluation of nutrient inertness or funginertness.
CONCLUSIONS: The results derived from the nutrient and non-nutrient Petri dish tests conducted on the same material would give the most complete definition of the fungus susceptibility of a material. The non-nutrient Petri dish method of determining the fungus susceptibility of small specimens was readily adapted to correct interpretation of results when testing for possible fungistatic or funginert properties of a material. The nutrient agar Petri dish method was excellent for determining the fungicidal properties of materials. The air brush spray method of applying, or inoculating small and large specimens with cultures, mediums was the most satisfactory method used. It was recommended that paragraphs F6c through F6c4 of USA Specification 60-977-2 be deleted; and that a proposed revision to the specification contained in the report be substituted in place of the deleted paragraphs.
GENERAL: This 70-page report contains 25 photographs showing the condition of specimens after various fungus test conditions.

DA 1483

SUBJECT: Tests, Special, Miscellaneous
TITLE: Insulation Resistance as a Means of Testing Modified Scintilla and Cannon Electrical Connectors
IDENTIFICATION: Report No. 1483
DATE OF REPORT: 4 January 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of using insulation resistance measurements as a means of testing modified electrical connectors for leakage
METHOD: Waterproof and temperature change tests were performed on the test connectors in accordance with Specification AXS-1659. The lowest values of insulation resistance of the connectors for the waterproof and temperature change tests were measured in megohms. The insulation resistance measurements were made with the standard Leeds and Northrup insulation resistance test set using the standard technique of applying 500 volts, direct current, at the terminals of the connector for one minute prior to making the insulation measurement.
DESCRIPTION: The connectors used in the tests were shell size No. 22 with 14 each No. 16 contacts, and shell size No. 28 with 12 each No. 12 contacts, manufactured by Scintilla Magneto Division of Bendix Aviation Corp. and by the Cannon Company.
CONCLUSIONS: The insulation resistance method of checking the modified electrical connectors for leakage was considered satisfactory. However, the connectors did not comply with other requirements of the temperature change test of Specification AXS-1659.
GENERAL: This six-page report includes two pages of photographs showing the plug and receptacle assembly and inserts.

DA 1630

SUBJECT: Tests, Special, Miscellaneous
TITLE: Pneumatic Tire Demounter Comparison Test
IDENTIFICATION: Report No. 1630
DATE OF REPORT: 1 April 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the performance of two tire demounters submitted by different manufacturers
METHOD: The physical characteristics of both demounters as to weight, number of accessories, and storage dimensions, were determined and recorded. The tire demounters were tested in accordance with the manufacturer's instructions for changing various-sized tires, and ease of assembly and operation, ease of adjusting for various size tires, and operating efficiency were determined.
DESCRIPTION: One tire demounter was submitted by Clayborne Manufacturing Company, Chicago. The other tire demounter, Presto Model B-1 was made by Lee Engineering Company, Pawtucket, Rhode Island. Both machines were adjustable and could be used on the bead diameters of from 20 to 24 inches.
CONCLUSIONS: The weight and storage space for both demounters were approximately the same. The performance of both tire demounters was satisfactory. The Clayborne unit required more accessories and greater time for bead adjustment. Both tools required the aid of auxiliary lifting equipment for assembly.
GENERAL: This 13-page report includes five photographs of the test tire demounters.

DA 1642

SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of CO in M-47 Medium Tanks
IDENTIFICATION: Report No. 1642
DATE OF REPORT: 3 April 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the degree of carbon monoxide contamination which existed in the crew compartment of an M47 tank as the result of main and auxiliary engine operation
METHOD: Testing was conducted with all hatches and openings of the test vehicle closed. With the main engine air cleaner inlets set to draw air from the crew compartment of the test vehicle,

carbon monoxide content of the crew compartment air was measured in 3 minute intervals under the following conditions: with only the main engine running at idle (700 to 800 rpm); with the vehicle stationary and indoors; and with and without the crew compartment ventilating blower operating. These tests were conducted with the main engine equipped with three types of mufflers. Similar tests were also conducted with the main engine air cleaner inlets set to draw air from the engine compartment. Following these tests, carbon monoxide content of the crew compartment air was also determined under similar conditions while operating only the auxiliary engine.
DESCRIPTION: The test vehicle was an M47 medium tank. Mufflers tested on the main engine of the vehicle included: pancake, Type VI; eliptical center, Type V; and standard fender-type.
CONCLUSIONS: Carbon monoxide contamination of the crew compartment air of the test vehicle was not excessive when the main vehicle engine was equipped with fender and elliptical center-type mufflers. The pancake-type muffler required the construction of a shroud over the turret ventilator fan inlet for safe operation. Carbon monoxide content of the crew compartment air when operating the auxiliary engine reached the dangerous level. It was recommended that tests be conducted to determine the effects of changing the location of the auxiliary engine exhaust outlet.
GENERAL: This nine-page report includes one drawing showing the relative position of the test vehicle components.

DA 1687(A)

SUBJECT: Tests, Special, Miscellaneous
TITLE: F. W. Stewart Speedometer Shaft
IDENTIFICATION: Report No. 1687(A); Job No. 6874
DATE OF REPORT: 23 April 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the conformance of a speedometer shaft to specification requirements
METHOD: The test speedometer shaft was subjected to waterproofness, wear, and fungus-resistance tests according to the requirements of Specification MIL-I-10215. The fungus-resistance test included 14 days' exposure to Aspergillus niger ATCC 6275 and Penicillium citrinum ATCC 9849.
DESCRIPTION: The test speedometer shaft was manufactured by the F. W. Stewart Manufacturing Company.
CONCLUSIONS: The test speedometer shaft met the test requirements of Specification MIL-I-10215.
GENERAL: This five-page report is not illustrated. The report includes test data for the fungus-resistance tests but not for the waterproofness and wear resistance tests.

DA 1738

SUBJECT: Tests, Special, Miscellaneous
TITLE: Tests of Hoists, Air, Electric
IDENTIFICATION: Report No. 1738
DATE OF REPORT: 23 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To conduct preliminary tests of two air hoists and one electric hoist
METHOD: The two air hoists were mounted on an A-frame sufficiently high to permit a lift of 60 inches. Air pressure was supplied by a mock-up of the T44 cargo truck air system, installed on a 1/4-ton, 4x4, truck. The electric hoist was connected to the slave battery receptacle of a medium tank, M46, which utilized a generator identical to that of the cargo truck. The electric hoist was mounted on the wrecker rail. Tests were conducted with each hoist attempting to lift a 500-pound and a 1000-pound load. Power consumption, hoist speed, and operating characteristics were noted and recorded.
DESCRIPTION: The "A" air hoist was made by the Keller Tool Company; the "C" air hoist, and the "C" electric hoist, were manufactured by the Detroit Hoist and Machine Company.
CONCLUSIONS: The operating speed of the "C" electric hoist was 13.3 fpm, and therefore was below the desired speed of 20 fpm. The power consumption was satisfactory. The "C" air hoist was unable to lift the 1000-pound weight. The hoist lifted the 500-pound weight to a maximum height of 32 inches, after which the air supply was insufficient to sustain further lifting. Operation of the "A" hoist in lifting the 1000-pound weight proved unsatisfactory. All three hoists failed to meet the standards of either the operating speed of 20 fpm, or sustained operation, or both. It was recommended that further investigation of electric hoists was justified to obtain one that would operate at the desired speed of 20 fpm; and that further investigation of the air hoists for this particular application was not justified.
GENERAL: This 14-page report includes five photographs of the test hoists.

DA 1741

SUBJECT: Tests, Special, Miscellaneous
TITLE: Metallurgical Tests of Stud Bolt, Part No. B-296682 and Camshaft, Part No. E-9101
IDENTIFICATION: Report No. 1741
DATE OF REPORT: 26 May 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the metallurgical factors that may have contributed to the failure of the two test parts
METHOD: One fractured stud bolt and two sound stud bolts were subjected to a hardness survey, a microscope examination, and a chemical analysis. A camshaft that had failed in service was tested and examined for case depth estimation. A microhardness survey, microscopic examination (case and core), and chemical analysis were also conducted.
DESCRIPTION: The test stud bolt was identified as Part No. B-296682 and the camshaft was identified as Part No. E-9101.
CONCLUSIONS: Visual examination of the failed stud bolt revealed a ductile type tensile fracture. The surface of the carburized case in the failed camshaft revealed numerous cracks around the oil hole and other areas of the cam lobe. The chemical analysis of all three stud bolts did not conform to print specifications. The hardness results of the failed stud and the sound stud "B" were below the minimum blue print requirements.

The nature of the fracture on the failed stud and the results of the hardness tests indicated that the cause of failure probably was due to low hardness. The results of the tests conducted on the camshaft did not reveal any major metallurgical factors that may have contributed to the failure. However, the sulfide inclusions present in the case micro-structure could have been detrimental to the surface lift of the test part.
GENERAL: This six-page report includes a photomicrograph of the camshaft structure near the surface of the case.

DA 1821

SUBJECT: Tests, Special, Miscellaneous
TITLE: Test of Vinyl Film
IDENTIFICATION: Report No. 1821
DATE OF REPORT: 8 July 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the strength of sewed seams and the low temperature flexibility of the vinyl films
METHOD: One-inch strips of both types of material were sewed to 1-inch strips of canvas with 10-40 thread and five stitches to the inch. These samples were then pulled apart at rates of 12 and 20 inches per minute. One-inch strips of both materials were aged 22 hours at -65°F. The strips were bent 350° around a mandrel for 15 seconds, and the behavior of the materials was noted.
DESCRIPTION: The 0.012-inch, clear vinyl sheet, GEON-103EP, was supplied by the B. F. Goodrich Chemical Company. A second clear vinyl sheet, Vinylite, VT-1928, was 0.022-inch thick and was manufactured by the Bakelite Corporation of America.
CONCLUSIONS: The results of the tensile strength test were recorded and outlined in the report. Both types of materials passed the low temperature flexibility test.
GENERAL: This three-page report is not illustrated.

DA 1944

SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of CO in 90-mm Gun Tank M47
IDENTIFICATION: Report No. 1944; Job No. 7367
DATE OF REPORT: 30 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of the M47 turret bustle stowage box on CO contamination of the crew compartment
METHOD: The test was performed indoors with a stationary M47 Tank, with ventilating blower operating, and the engine running at idle speed and at 1800 rpm. Runs were made with air cleaners drawing from the engine compartment and from the crew compartment, with the bustle stowage box in place. The stowage box was then removed and all runs repeated. CO concentration was measured at three-minute intervals, and considered stabilized when three consecutive readings were alike. A run was also made with only the auxiliary engine operating.
DESCRIPTION: The test 90-mm Gun Tank M47 was equipped with Type VI pancake mufflers. The bustle stowage box on M47 had previously been found deleterious to engine cooling, impeding the flow of exhaust cooling air, hence this investigation.
CONCLUSIONS: Removal of the turret bustle stowage box markedly reduced crew compartment contamination. In all runs with stowage box installed the CO concentration reached 0.04%, while the greatest concentration with stowage box removed was 0.02%. The auxiliary engine alone produced a CO concentration of only 0.01%.
GENERAL: This seven-page report is not illustrated except for a reprint of a graph showing the physiological effects of CO concentration and exposure time.

DA 1972

SUBJECT: Tests, Special, Miscellaneous
TITLE: Evaluation of Nylon Slide Fasteners
IDENTIFICATION: Report No. 1972
DATE OF REPORT: 22 September 1952
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the crosswise breaking strength and individual scoop strength of the slide fasteners
METHOD: Tests were performed according to Specification V-F-106. The crosswise breaking strength of the fasteners was determined. A Scott tensile tester was used to measure the force required to tear an individual scoop from the tape. Two fasteners were submerged in water and subjected to temperatures of -40°F for 24 hours. These fasteners were then dried at room temperature and were again subjected to the preceding tests.
DESCRIPTION: The nylon slide fasteners were submitted by Waldes-Kohinoor, Incorporated.
CONCLUSIONS: The fasteners failed the applicable specification requirements both before and after coldroom exposure. A marked decrease in the crosswise and scoop strength of the slide fasteners was observed after the 24-hour cold aging.
GENERAL: This four-page report is not illustrated.

DA 2122

SUBJECT: Tests, Special, Miscellaneous
TITLE: Measurements of the Shearing Strength of Snap Rings
IDENTIFICATION: Report No. 2122
DATE OF REPORT: 5 January 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the shearing strength of the snap rings
METHOD: A punch and die, with grooves machined to print tolerance specified in drawing No. 7725463, were used to determine the shearing strength of these parts. External shearing was conducted by fitting the rings in the groove of the punch and forcing through the die. Internal shearing was performed by fitting the rings in the groove of the die, and forcing the punch through the die.
DESCRIPTION: The snap rings had 1.250-inch and 1.500-inch inner diameters; these rings were supplied by the Ramsey Corporation, St. Louis, Missouri, and the Waldes-Kohinoor Co. (Tru-Arc).
CONCLUSIONS: External shearing of the Ramsey rings, with 1.250 and 1.500-inch inner diameters,

required 25,500 and 30,000 pounds, respectively; internal shearing of these rings required 25,000 and 29,000 pounds, respectively. External shearing of the Kohinoor rings of identical sizes used 14,500 and 31,000 pounds, respectively; internal shearing of these rings required 15,000 and 32,000 pounds, respectively. The Ramsey rings had a 70% higher shearing strength than the Kohinoor rings. No appreciable difference between externally and internally sheared rings was determined.
GENERAL: This four-page report includes a sketch of the test apparatus.

DA 2139

SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of Friction and Load Performance Properties of Five Swivel Type Casters
IDENTIFICATION: Report No. 2139
DATE OF REPORT: 16 January 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the friction and load performance characteristics of the casters
METHOD: Each set of casters was attached to a flat steel plate to form a dolley. The force necessary to start the dolley (static friction) and the force required to keep it moving (kinetic friction) were measured under various loads with a spring gage. Measurements were taken on both smooth steel and rough cedar block surfaces. A compressive load four times the load rating of the casters was applied to each caster. Damage to the unit was recorded, and the casters were subjected to an out of roundness check before and after the test.
DESCRIPTION: Five sets of swivel type casters, three in each set, were tested. Bassick 6-inch and 4-inch diameter casters, Midwest casters of the same sizes, and a set of unidentified, 6-inch casters were tested.
CONCLUSIONS: The two sets of Bassick casters required the least amount of force to overcome both types of resistance. These casters had fewer rough spots, smoother roller surfaces, and less deformation than the other casters. At the conclusion of the tests, the Midwest, 4-inch casters showed the highest out of round values, the largest permanent deformation, and the poorest bearing condition.
GENERAL: This 16-page report contains one photograph of the casters, and graphs of the static and kinetic friction forces recorded during the tests.

DA 2203

SUBJECT: Tests, Special, Miscellaneous
TITLE: Corrosion of Trailer Plug Contacts
IDENTIFICATION: Report No. 2203
DATE OF REPORT: 4 February 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of electrolytic action on the contacts of an energized trailer plug
METHOD: Lengths of No. 14 AWG cable were connected to three pin contacts of an Ordnance approved receptacle. Two of these cables were connected to the negative terminal of a 24-volt battery and the third cable was connected through a switch to the positive terminal of the same battery. Three lengths of No. 14 AWG cable were attached to contacts of a mating Ordnance approved plug insert. The plug and receptacle were engaged and the assembly was immersed in a salt water solution (NaCl, 5% by weight). Contacts were energized by means of the 24-volt battery. The voltage drop across the plug terminals was measured before immersing and after one and two hours of immersion. Current flow was recorded every 10 minutes.
DESCRIPTION: Both the receptacle and the plug insert were Ordnance approved items designed for three conductor trailer electrical connection.
CONCLUSIONS: Electrolysis of a salt solution at the contacts of an energized trailer receptacle and mating plug insert resulted in rapid corrosion of the positive contact.
GENERAL: This three-page unillustrated report includes one sheet of test data.

DA 2206

SUBJECT: Tests, Special, Miscellaneous
TITLE: Carbon Monoxide Concentration Investigation for the 90-mm Gun Tank M47
IDENTIFICATION: Report No. 2206
DATE OF REPORT: 5 February 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether a lethal carbon monoxide (CO) contamination in the crew compartment of an M47 Tank would result from the operation of various components and to evaluate the effect of extending the auxiliary generator exhaust pipe into the transmission compartment
METHOD: The CO concentration in the vehicle was observed when the auxiliary generator, main engine, ventilating blower, and personnel heater of the 90-mm Gun Tank M47 were operating in various combinations. Checks were made with the hatches opened and closed, and with the main engine air drawn from the engine and crew compartments. The same procedure was used when the auxiliary generator exhaust pipe was extended into the transmission compartment.
DESCRIPTION: The equipment used in the tests included the 90-mm Gun Tank M47, a CO indicator, safety devices, and a modified auxiliary generator exhaust pipe.
CONCLUSIONS: The maximum concentration of CO found in the vehicle after the operation in various combinations was 0.02%. The exhaust pipe directed into the transmission compartment reduced the concentration to one-half or less than that recorded with the standard exhaust, but one recording showed a concentration of 0.02%. No dangerous concentrations of CO were recorded when the vehicle was operating properly.
GENERAL: This 16-page report includes three photographs showing the exhaust system, and one page of curves showing the effects of CO on human beings.

DA 2225

SUBJECT: Tests, Special, Miscellaneous
TITLE: Analyses of Four Samples of Unknown Substances
IDENTIFICATION: Report No. 2225
DATE OF REPORT: 16 February 1953

ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To analyze the test samples
METHOD: Both qualitative and quantitative analyses of the test samples were conducted.
DESCRIPTION: The four test samples included the following: a white powder with black specks; a red brown substance; beige, soft, porous rock with a specific gravity of 2.52; and black, semihard, porous rock with a specific gravity of 2.93.
CONCLUSIONS: The qualitative analysis disclosed no significant data concerning the test samples. However, the quantitative analysis indicated that the beige, soft, porous rock was impure quartz, and the other substances were impure complex silicates. The white powder contained aluminum, silicon, calcium, and traces of iron and magnesium. The red brown substance consisted of aluminum, iron, silicon, calcium, and a trace of magnesium. The beige, soft, porous rock included iron and silicon, as well as traces of aluminum, calcium, and magnesium. The black, semihard, porous rock contained aluminum, iron, silicon, calcium, manganese, and a trace of magnesium. Any additional identification of the silicates would be extremely costly because of their complex structure, and could be accomplished only by X-ray diffraction analysis.
GENERAL: This three-page report is not illustrated.

DA 2588

SUBJECT: Tests, Special, Miscellaneous
TITLE: Carbon Monoxide Contamination in 90-MM Gun Tank M47
IDENTIFICATION: Report No. 2588; Job No. 8256
DATE OF REPORT: 30 September 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the degree of carbon monoxide contamination present in the crew compartment of the tank under various operating conditions
METHOD: Three tanks were placed indoors in relatively still air. A flexible sampling tube was positioned at approximately head level in the turret compartment and led out to an MSA carbon monoxide analyzer. The analyzer was paralleled with a Brown automatic recorder to obtain a permanent record of stabilized readings in hundredths of one percent CO concentration. The ambient, CO concentration around the vehicles as obtained with the analyzer and recorder was rechecked by means of a squeeze bulb colorimeter. The CO concentration was checked with the auxiliary generator, main engine, ventilating blower and personnel heater operating in various combinations. Checks were made with the hatches opened or closed and with the main engine air drawn from the engine or crew compartments. After determining those conditions that yielded the greatest concentration of CO from such trial runs, outdoor runs were made to spot-check similar conditions.
DESCRIPTION: The three test 90-mm Gun Tanks M47 carried Serial Nos. 492, 847, and 6899.
CONCLUSIONS: Maximum contamination of the M47 crew compartment was noted when only the auxiliary engine was operating, especially when in relatively still air with the hatches closed and the gun positioned in the rear. Dangerous concentrations ranging from .052% to 0.14% CO were noted in 21 of the 255 tests made of the crew compartment atmosphere. Approximately 1-1/2 hours of operating time was required before concentration measurements were stabilized. These test results suggested the need for equipment modifications that would lessen CO accumulations.
GENERAL: This 11-page report contains one photograph showing the instrumentation for the CO test setup.

DA 2744

SUBJECT: Tests, Special, Miscellaneous
TITLE: Carbon Monoxide Contamination Tests on Various Vehicles
IDENTIFICATION: Report No. 2744; Job No. 8733
DATE OF REPORT: 18 December 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the degree of CO contamination in the crew compartment of a number of Ordnance vehicles when operated outdoors; to determine the effect of environmental conditions on CO contamination in the crew compartment of a tank when operated outdoors; to determine the feasibility of a standard operating procedure
METHOD: Each Ordnance vehicle was positioned outdoors approximately 100 feet from the nearest building. A flexible sampling tube was set at the commander's head level and connected to an MSA carbon monoxide analyzer, paralleled with an automatic recorder for permanent record of CO concentrations. All hatches were secured. The instrumentation and the crew compartment were purged of any accumulated CO gas before each test. Velocity and direction of the wind with respect to the vehicle were noted and the ambient CO concentration and the wet and dry bulb temperatures were recorded. The auxiliary engine was operated continuously and CO concentrations noted every half-hour when the vehicle was turned to present another aspect to the wind.
DESCRIPTION: The test vehicles were an automobile, two self-propelled howitzers, a cargo tractor, six tanks and a self-propelled twin gun. Test apparatus included an MSA carbon monoxide analyzer, a Brown automatic recorder, an MSA squeeze bulb colorimeter, and a sampling tube.
CONCLUSIONS: Readings were taken after one-half hour of operation although this time was not necessarily a point of stabilization of CO concentration. Environmental factors influenced the percentage of CO contamination in a vehicle for a given period of time. Four of the vehicles tested indicated the production and retention of dangerous CO concentration. A standard operating procedure for duplication of test results was not established because environment was not sufficiently controllable.
GENERAL: This 32-page report includes 23 pages of tabulated test results.

DA 2794

SUBJECT: Tests, Special, Miscellaneous
TITLE: Investigation of Possible Excess Voltage Conditions in the Electrical System of the M75 Vehicle

TANK AUTOMOTIVE TEST RESUMES

IDENTIFICATION: Report No. 2794
DATE OF REPORT: 26 January 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether there was excess voltage in the electrical system of the M75 vehicle
METHOD: The electrical system of eight M75 vehicles was tested at the International Harvesting Company, Chicago, Illinois. A recording voltmeter was connected to the electrical outlet on the instrument panel, and the vehicle started. As soon as the electrical system indicated a stable condition on the recording voltmeter, the value of the voltage was taken with a Weston, Model 901 voltmeter. This test was repeated with the recording voltmeter connected at the slave cable connection and at the radio transmitter-receiver connection.
DESCRIPTION: The eight M75 vehicles were supplied by the International Harvester Company, Chicago, Illinois.
CONCLUSIONS: There was no indication of excess voltage conditions in the electrical systems of the M75 vehicles.
GENERAL: This 12-page report contains eight photographs of calibrated recording voltmeter tracings.

DA 2825

SUBJECT: Tests, Special, Miscellaneous
TITLE: Pressure Drop Across the Exit Grilles on the M75 Personnel Carrier
IDENTIFICATION: Report No. 2825
DATE OF REPORT: 15 February 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of air deflectors on the pressure drop across the exit grilles
METHOD: Comparative tests were conducted at engine speeds of 1000, 1500, 2000, and 2800 rpm, with and without the air deflectors installed at the exit grilles. Static pressure measurements were determined with a direction-finding pilot tube.
DESCRIPTION: The exit grilles were those used on the M75 personnel carrier.
CONCLUSIONS: The air deflectors had no appreciable effect on the pressure drop across the exit grilles.
GENERAL: This six-page report includes two photographs of the air deflectors.

DA 2866

SUBJECT: Tests, Special, Miscellaneous
TITLE: Qualification Oil Sample Test According to Specification MIL-O-10295, Amendment 1
IDENTIFICATION: Report No. 2866
DATE OF REPORT: 26 March 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the quality of a used oil sample with the specification requirements
METHOD: Prior to spectrographic analysis, the test oil was subjected to a qualitative and quantitative chemical analysis, and the findings were recorded.
DESCRIPTION: The oil sample was approximately 12 ounces of used oil submitted by the Wheeled Vehicle Branch, Research and Development Division.
CONCLUSIONS: The oil submitted failed to comply with the flash point temperature and 210°F viscosity requirements. The presence of iron, 43 parts per million, in both the oil and sludge presented the possibility that metallic wear or corrosion took place in the unit which held the oil.
GENERAL: This three-page report is not illustrated.

DA 2920

SUBJECT: Tests, Special, Miscellaneous
TITLE: Daily Concentration of Ozone
IDENTIFICATION: Report No. 2920
DATE OF REPORT: 27 April 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the daily concentration of ozone in the air on the roof of the low temperature laboratory near the time weathering area
METHOD: The ozone concentration of the air on the roof was determined daily using an ozone absorption device. An air intake tube extended through the door to the roof of the low temperature laboratory. A buffered solution of potassium iodine, containing the iodine liberated by ozone was titrated, and the ozone concentration in pp hm was calculated and recorded. The temperature, humidity, wind direction and velocity, barometric pressure, and the time and date of test run were recorded in accordance with ASTM Method D1149-51T.
DESCRIPTION: It was known that ozone was a predominant cause of the weather deterioration of rubber, and that the amounts of atmospheric ozone varied with the weather. Although roof weathering tests have been conducted at equal periods of exposure time, it was felt that, in view of these facts, comparisons might better be made at periods of equivalent ozone exposure.
CONCLUSIONS: Humidity apparently had a direct effect on ozone concentration in the air on the roof. The ozone concentration was highest during the summer months when temperatures were high and humidity was low. The ozone concentration was low during the winter months when low temperatures and high humidity were prevalent. Neither the wind direction and velocity nor the barometric pressure appeared to have any effect on the amount of ozone in the air on the roof.
GENERAL: This 12-page report contains two photographs of the test apparatus.

DA 3027 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Spindle, Compensating Idler; Metallurgical Investigation
IDENTIFICATION: Report No. 3027 (Final)
DATE OF REPORT: 19 August 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether metallurgical factors contributed to the failure of two idler spindles
METHOD: The spindles were visually examined and photographed. Both specimens were subjected to physical tests. One was subjected to metallographic examination and chemical analysis.

DESCRIPTION: The two compensating idler spindles, Ordnance Part No. 7379452, were from an M48 tank, and had failed in an Aberdeen Proving Ground service test after 1960 miles of operation.
CONCLUSIONS: The hardness of the spindle ranged from 36-41 Rockwell "C" in the core areas. The surface hardness of the hardened area ranged from 57-58 Rockwell "C". The surface hardness of the hardened zone was slightly below print specifications. No metallurgical discrepancies were evident in the failure area. The results of the visual examination revealed a nucleus at the edge of the fracture in the fillet sections of the 3.149 diameter, indicating failure originated at this point.
GENERAL: This 13-page report includes two photographs of the failed compensating idler spindles, a macro-cross section of the hardened pattern, and two photomacrographs of the failed area.

DA 3048 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Carbon Monoxide Investigation of Combat Vehicle Closed Compartments
IDENTIFICATION: Report No. 3048 (Final)
DATE OF REPORT: 9 September 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of weather conditions and of the use of a screened enclosure on results of tests for carbon monoxide contamination on combat vehicles
METHOD: A tank, M47, was stationed centrally within a screened enclosure. After the installation of necessary instrumentation, the vehicle hatches and openings were closed, and the auxiliary engine was placed in operation. The following data were recorded in 75, 1/2-hour intervals: time at start and end of 1/2-hour run; wind velocity and direction inside and outside of the enclosure; wet and dry bulb temperatures; carbon monoxide values in the crew compartment; meteorological data; and malfunctions of apparatus, test vehicle, or components.
DESCRIPTION: Test apparatus included: the 90-mm gun, M47 tank, Serial No. 492; a 15-foot high, opened top, canvas walled, or screened, enclosure covering an area 50-feet square; a wind vane on top of the enclosure frame; a velometer; a sling psychrometer; carbon monoxide instrumentation including a carbon monoxide MSA indicator and a Brown recorder, both housed in a special cabinet; a carbon monoxide campling probe; and streamers to indicate wind direction in the enclosure.
CONCLUSIONS: Scrambling of wind currents around a vehicle by placing it within an enclosure permitted a closer control of the wind, one of the major test variables, necessary in establishing a standard operating procedure for carbon monoxide tests on Ordnance vehicles. Meteorological conditions did not materially affect carbon monoxide contamination. It was recommended that additional tests be conducted using an enclosure with walls built of a more durable material than the fabric used in this test; and that a series of tests be conducted using enclosures built in an octagonal or a round form so as to minimize the wind effect experienced with large flat surfaces.
GENERAL: This 17-page report is not illustrated.

DA 3119 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: The Corrosion Rate of Metals as Predicted by Single Electrode Potential Measurements
IDENTIFICATION: Report No. 3119 (Final)
DATE OF REPORT: 28 September 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate a method for predicting the relative corrosivity of a metal or alloy
METHOD: The corrosion rates of nine different metals were evaluated. A corrosion cell was constructed by immersing a test metal panel and a calomel electrode in a one-molal saline solution. A 100,000-ohm resistor was then placed in parallel with the test panel and calomel electrode to provide a uniform load on the cell. The internal resistance of the cell was calculated from the measured values of voltage across the resistor and the open circuit voltage. Weight loss determinations of the panels were made for evaluation purposes.
DESCRIPTION: The laboratory method being tested used a unique test cell for directly measuring the relative corrosivity of a metal immersed in an aqueous electrolyte. This procedure, if adopted, could replace the corrosion tests incorporating visual examinations in specifications such as: AXS-673; MIL-O-5606, MIL-O-10924; and USA 2-126.
CONCLUSIONS: Metals and alloys having a low rate of corrosion as indicated by weight loss measurements resulted in a test cell with low internal resistance. Metals and alloys shown by weight loss data to have a high corrosion resistance caused the test cell to have a high internal resistance. It was recommended that this test method be utilized as a means of predicting the rate of corrosion of metals and alloys, and that further research be conducted on this project.
GENERAL: This 29-page report contains four photographs of the test materials and setup.

DA 3153 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Low Temperature Test of Launcher, 762MM Rocket, Truck Mounted, XM289
IDENTIFICATION: Report No. 3153 (Final)
DATE OF REPORT: 8 December 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the suitability of the launcher under extreme low-temperature conditions
METHOD: Following proper preparation, the launcher was placed in a cold room at -42°F. All tests were conducted at -40°F ± 3°. A sheet metal fairing was installed on the dummy rocket to provide a contact surface for the blanket thermostats. The detailed outline of the test procedure was furnished by the Rock Island Arsenal and is incorporated in the report as Appendix A.
DESCRIPTION: In addition to the launcher, 762mm rocket, truck mounted, XM 289, other material and apparatus used in the test included a power plant heater kit, Ordnance No. 735527, standard for the M139 truck; and engine primer kit, Ordnance No. 7358662; a slave receptacle kit, Ordnance No. 7358646; a personnel heater kit, Ordnance No.

7355525; and low-temperature lubricants, engine oil, sub-zero, MIL-O-10295, Type OES, and universal gear lubricant, sub-zero, MIL-L-10324.
CONCLUSIONS: The test launcher was considered suitable for low-temperature operation, although the auxiliary equipment required further improvement to operate satisfactorily. It was recommended that the pillow bearings and the firing cables of the launcher be subjected to further testing at low temperatures. It was also recommended that additional cold room investigations be made with the electric blanket, circuit tester, micro switches, gunner's switch, and electric cables.
GENERAL: This 28-page report contains two photographs of a rocket mounted on the truck, XM-289, and eight photographs of various truck components.

DA 3173 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Compatibility of Fungicides and Antiozodants
IDENTIFICATION: Report No. 3173 (Final)
DATE OF REPORT: 5 January 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the effect of two antiozodants on the fungus resistance of GRS and Buna N standard rubber, each of which contained a fungicide; and to determine the effect a fungicide had on the ozone resistance of GRS and a Buna N rubber, each of which contained one of two antiozodants
METHOD: Six sample compounds of GRS and Buna N rubber were prepared with the following variations added: (1) vancide 89 commercial fungicide, (2) antiozodant 2237-290, (3) antiozodant 2008-94, (4) vancide 89 and antiozodant 2237-290, (5) vancide 89 and antiozodant 2008-94, and (6) controls without either fungicide or antiozodant. Specimens from each sample were cured for 5 minutes then cut out and investigated for resistance to both ozone and fungus attack. A fresh batch of compounds was mixed using the same variations, except that antiozodants 2237-290 and 2008-94 were increased from 1 part to 3 parts. The rubber was then cured, specimens die cut, and new fungus and ozone resistance tests started. The same routine was carried out with Buna N and divided into six equal parts. One part was kept intact as a control sample.
DESCRIPTION: The test material consisted of: antiozodants 2237-290 and 2008-294 manufactured by Universal Oil Products Company; vancide 89 commercial fungicide made by R. T. Vanderbilt Company, New York; and Hycar OR-15 (1001) manufactured by B. F. Goodrich Chemical Company.
CONCLUSIONS: The Buna N compounds tested resisted ozone attack better than GRS compounds. The Buna N compound samples with 1 part of additive resisted ozone attack better than the same compounds with 3 parts of antiozodants added. However, the antiozodants aided ozone attack instead of repelling it. The addition of one part of either antiozodants or fungicide to GRS rubber did very little to aid the compound to resist ozone attack. The addition of antiozodants or fungicide into Buna N, either separately or in combinations with each other, or parts, hastened fungus attack instead of repelling it.
GENERAL: This 38-page report includes 12 photographs of the test samples.

DA 3223 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Static Ozone Test on GRS 1500 Compounds
IDENTIFICATION: Report No. 3223 (Final)
DATE OF REPORT: 1 March 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate the effectiveness of a wax and two antiozodants on the ozone resistance of GRS compounds
METHOD: Three sets of specimens were mounted, one set using a clamp-screw device, one with ASTM Method D-518 bent loop-type, and one with rubber process T-50 holders. The specimens were then exposed in the ozone chamber according to ASTM Method D-1149, for 30 days at a ozone concentration of 25 ± 5 pphm, and an additional 30 days at 50 ± 5 pphm ozone. The specimens were observed for earliest cracking at 18X magnification and by the naked eye and results were recorded.
DESCRIPTION: The test units consisted of tensile sheets of GRS-1500 compound and either wax, BRC-100 antiozodant, or UOP-2237-290 antiozodant, in varying amounts. The GRS-1500 compound and antiozodant BRC-100 were furnished by Burke Research, Incorporated, Van Dyke, Michigan; the test wax was santoflex AW, submitted by Monsanto Chemical Company of St. Louis, Missouri; and antiozodant UOP-2237-290 was furnished by Universal Oil Products, of Chicago, Illinois.
CONCLUSIONS: Two or more parts of the test wax, 1.5 or more parts of either antiozodants conferred considerable ozone resistance on the GRS compounds used.
GENERAL: This 16-page report includes four photographs of the test specimens.

DA 3254 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Washer, Gland, Stock No. G244-7527641, and Socket, Stock No. G244-7716527
IDENTIFICATION: Report No. 3254 (Final)
DATE OF REPORT: 8 April 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To compare the material composition and dimensions of the subject items to Ordnance drawings
METHOD: The test washer, gland, No. G244-7527641 and socket No. G244-7716527 were compared to Ordnance drawings C-7716711 and 7716527, respectively, by applicable tests for hardness, plating thickness, engaging, and disengaging forces, contact resistance, chemical composition and dimension compliance.
DESCRIPTION: The test washer, gland, stock No. G244-7527641 and socket, Stock No. G244-7716527 were both manufactured by the General Electric Company.
CONCLUSIONS: The results as detailed in the report represented the evaluation of the items submitted by General Electric Company because

no Ordnance standard parts were available for comparison and testing had been discontinued by the project engineer.
GENERAL: This 12-page report is not illustrated.

DA 3255 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Effects of Preservative Oil (MIL-L-21260) on Zinc Chromate Lacquer (MIL-L-6047)
IDENTIFICATION: Report No. 3255 (Final)
DATE OF REPORT: 8 April 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the deleterious effect of preservative oil (MIL-L-2160) on zinc chromate lacquer (MIL-L-6047) through various laboratory tests
METHOD: Six steel panels coated with zinc chromate lacquer (MIL-L-6047) were weighed, subjected to the accelerated oxidation test at 150°F for 200 hours, and submerged in preservative oil (MIL-L-21260). The panels were then checked for weight loss and physical change of lacquer film and the oil was inspected for contaminations. Three of the panels were then subjected to the humidity test for 100 hours. The panels were then inspected for removal of oil film and physical changes of lacquer coating.
DESCRIPTION: Six steel panels, each 3x6x20 inches gage thick, and coated with zinc chromate lacquer (MIL-L-6047), were used on the tests.
CONCLUSIONS: The test results showed no deleterious effect of oil preservative (MIL-L-21260) on zinc chromate lacquer (MIL-L-6047).
GENERAL: This six-page report is not illustrated.

DA 3270 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Torsion Bar, Ordnance Part No. 7035900; Metallurgical Investigation
IDENTIFICATION: Report No. 3270 (Final)
DATE OF REPORT: 25 April 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether metallurgical factors contributed to the failure of the test bar
METHOD: The failed torsion bar was given a magnetic particle inspection. A macroscopic evaluation of the quality of the steel was made. Metallographic examination was conducted of samples taken from the vicinity of the fracture origin. The bar was subjected to a chemical analysis.
DESCRIPTION: The test torsion bar, Ordnance Part No. 7035900, failed while undergoing endurance tests on a fatigue test machine at the Detroit Arsenal. The bar had been subjected to a 5° to 50° twist for approximately 10,000 cycles, prior to failure.
CONCLUSIONS: The torsion bar showed a uniform microstructure, with some bonding evident at the center. The hardness was uniform throughout, with the exception of a very hard, untempered area at the outside surface adjacent to the point of failure. Foreign metal was present on the outside surface of the hardened area. The cause of the locally hardened area could not be definitely ascertained. The results of the metallurgical investigation revealed that the failure was caused by the untempered, hardened area at the outside surface of the bar. This detrimental factor, together with the extreme differential in hardness, created a stress concentration or nucleus from which the failure originated.
GENERAL: This 10-page report includes two photographs of the failed torsion bar and two photomicrographs.

DA 3277 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Air Conditioning Unit in the Air Cleaner Laboratory — Acceptance Test
IDENTIFICATION: Report No. 3277 (Final)
DATE OF REPORT: 3 May 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether the air conditioning unit met the requirements of the Detroit Arsenal Purchase Description
METHOD: The unit was operated, and the following characteristics determined: control of dry bulb temperature in the range of 80 to 90°F; control of relative humidity in the range of 20 to 90%; air cleanliness; control of room air pressure; stabilization of air conditions; and defrosting time. The results were compared with the requirements of the purchase description.
DESCRIPTION: The air conditioning unit was intended for use in conducting air cleaner performance and development tests under controlled conditions of temperature, humidity, and air cleanliness. The unit was manufactured by Sogaard & Debo, Inc., Detroit, Michigan.
CONCLUSIONS: The unit controlled dry bulb temperature within ±4°F, and relative humidity within ±8%, as against purchase description requirements of ±3°F and ±5%, respectively. It failed to maintain room air pressure at 2 inches of water, as specified. The air conditioning unit failed to meet the contract specifications. However, its performance was acceptable for conducting air cleaner performance tests.
GENERAL: This 23-page report includes seven photographs of the system and its components.

DA 3278 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Chromized Coatings on Mild Steel; Evaluation of Corrosion Resistance
IDENTIFICATION: Report No. 3278 (Final)
DATE OF REPORT: 3 May 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To evaluate the corrosion resistance characteristics of chromized steel samples by comparison with other type steel samples
METHOD: One sample of each of the submitted steel materials was subjected to salt fog exposure, elevated temperature exposure, and thermal shock.
DESCRIPTION: The test materials consisted of: steel pieces of 1010 and 1020 chromized steel, with chromium penetration range .001 to .005-inch; six pieces of etched samples of chromized steel showing depth of penetrations; and four pieces of steel 1010 aluminized. The comparison materials were steel, stainless, type 430; steel, stainless, 18-8 stabilized grade; steel, aluminized, diffused; and steel, carbon, FS 1010.

CONCLUSIONS: The corrosion resistance of the chromized steel samples after exposure to salt fog was similar to that of the stainless steel samples and superior to the resistance of aluminized steel and untreated FS 1010 steel sample. The corrosion resistance of the chromized steel samples after the elevated temperature exposure was superior to the stainless steel and untreated FS 1010 steel samples. The aluminized steel samples showed the best corrosion resistance of all materials tested. After the effects of thermal shock, the corrosion resistance of the chromized steel was comparable to both stainless steel samples, superior to the FS 1010 steel, and slightly less than the aluminized steel samples.
GENERAL: This eight-page report is not illustrated.

DA 3280 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Flexible Tube Test
IDENTIFICATION: Report No. 3280 (Final)
DATE OF REPORT: 4 May 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether or not two types of corrugated metallic tubes were the equivalent of standard tube Ordnance No. 8723835
METHOD: Specimens of each type of metallic tube were subjected to endurance, deflection, thermal, and flexibility tests.
DESCRIPTION: The three types of tubes tested were: (1) standard flexible tube with 59 annular corrugations per foot (Ordnance No. 8723835) manufactured by Flexonics Corporation of Maywood, Illinois; (2) flexible tube with 33 helical corrugations per foot manufactured by Atlantic Metal Hose Co., Inc. of New York; and (3) flexible tube with 28 annular corrugations per foot made by American Brass Company of Waterbury, Connecticut.
CONCLUSIONS: Specimens of each type of flexible tube satisfactorily completed the endurance and thermal shock tests. Deflection rate of Atlantic and American tubes failed to satisfactorily meet that of the standard Flexonics (Ordnance No. 8723335). The Atlantic tube design (helical corrugations) introduced a twist which was evident throughout the test apparatus.
GENERAL: This 12-page report includes one photograph of the endurance test setup and one curve sheet of test results.

DA 3298 F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Three-Sided Splines
IDENTIFICATION: Report No. 3298 (Final)
DATE OF REPORT: 17 May 1955
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine whether the performance of the proposed three-sided splines was comparable to that of standard involute splines
METHOD: Two involute splines, "V", and six specimens of each of the types of the three-sided splines, "A", "B", and "C", were tested with minimum clearance between mating parts. The torsional loads were applied at the same rate on all specimens until failure occurred. Load rate for all the tests was maintained at 2° per minute. The torsion machine range was adjusted to 100,000 in.-lbs. full scale for the spline types "A" and "B", and 500,000 in.-lbs. scale for spline types "C" and "V". The test specimens were inspected and photographed after failure.
DESCRIPTION: The involute splines were fabricated as per Layout No. LD-1246, Sheet 2 of 2. The three-sided splines, as per Layout No. LD-1246, Sheet 1 of 2. AISI-4140 steel was used to fabricate the three-sided splines.
CONCLUSIONS: The total strength of specimens 1 and 2 of splines "A", "B", and "V", was not obtainable. The maximum torque, before yielding occurred, was obtined with involute spline "V-2". This torque value was 65,000 in.-lbs. The maximum torque obtained on any three-sided spline was 55,000 in.-lbs. with "C-3", and that occurred after increasing the spline engagement length 1-inch. The effect obtained by cutting grooves in shafts (specimens 4, 5 and 6, of types "A", "B", and "C") between spline and shank of external spline was favorable. Splines remained engaged throughout the test and greater loads were obtained with splines 4, 5 and 6, or in the order of increasing groove diameter. All of the three types of three-sided splines failed to equal the torque-carrying capacity of standard involute splines. Modification of specimens to reduce the extent of the axial disengagement of the splines was only partially successful.
GENERAL: This 20-page report includes seven photographs of the various types of test splines after failure.

DA 7827

SUBJECT: Tests, Special, Miscellaneous
TITLE: Infrared Transmission and Index of Refraction of Various Types of Safety and Plate Glass
IDENTIFICATION: Report No. 7827
DATE OF REPORT: 30 October 1953
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To determine the infrared transmission and index of refraction of various types of safety and plate glass
METHOD: Nine types of glass were placed in the beam of a spectrometer. Percent of transmission was recorded between the frequencies of .55 and 3.50 microns. An optical bench micrometer was used to measure the index of refraction. A monochromatic light source of 5890 Angstroms was used. Snell's law of refraction was used to compute the indexes.
DESCRIPTION: The test material consisted of four laminated safety glass samples ranging from 1/4 to 1-1/16-inch in thickness and five commercial plate glass samples of 7/8-inch thickness supplied by the Pittsburgh Plate Glass Company. A model 21 Perkin-Elmer double beam-double pass spectrometer with a calcium fluoride prism was used to determine the percent of transmission.
CONCLUSIONS: It was found that the transmission properties of the test glass did not become inversely proportional to glass thickness except near the threshold region of 2.5 to 2.8 microns. The compositions of the test glasses were considered to affect their transmission qualities; for example, medium to light flint glass exhibited higher

transmission than other types of optical glass.
GENERAL: This report is six-pages long.

DA 36881/1
B-4.9.25

SUBJECT: Tests, Special, Miscellaneous
TITLE: Self-Energizing Hydraulic Fluid
IDENTIFICATION: Report No. 36881/1
DATE OF REPORT: 28 February 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To prepare colloidal suspensions which show dilatant properties, and to evaluate such suspensions as hydraulic fluids for power transmission
METHOD: Test apparatus was designed and built to evaluate various dilatant suspensions. A test program was planned wherein it was proposed to test concentrations of resin from 30 to 65% (on a solids basis) in polybutenes of commercially available molecular weight ranges. The test program was set up by the Burke Research Co. of Van Dyke, Michigan.
DESCRIPTION: Test equipment was manufactured by Door-Paterson Engineering Company, Inc. of Detroit, Michigan. The apparatus consisted basically of a cylinder containing a rotor driven by an electric motor. Instrumentation was provided to determine the degree of rotation imparted to the cylinder by the reaction of the dilatant suspension to the agitation of the motor-driven rotor.
CONCLUSIONS: Since this report was of a preliminary nature, no conclusions were offered. However, a discussion of the dilatant properties of certain colloidal suspensions was presented.
GENERAL: This six-page report contains two photographs of the test equipment.

DA 36881/2
B-4.9.25

SUBJECT: Tests, Special, Miscellaneous
TITLE: Self-Energizing Hydraulic Fluid
IDENTIFICATION: Report No. 36881/2
DATE OF REPORT: 31 March 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To develop a hydraulic fluid with a viscosity proportional to agitation
METHOD: Equipment for testing the fluids was tested and calibrated. Three resins were made in a 15-gallon stainless steel reactor with agitation by tumbling. Nitrogen flushing of the reactor was made before charging with raw materials. Polymerization was run at 80°C for 16 hours. Various mixtures of the resins and liquid carriers were made and tested.
DESCRIPTION: The three resins prepared were Oronite 32, Indopol L-10, and Propylene Glycol. They contained organic acid groups, neutral groups, and organic basic groups, respectively. All were cross-linked, infusible, and insoluble in all solvents. Particles were extremely fine and uniformly spherical. Tests were conducted by the Burke Research Company of Van Dyke, Michigan.
CONCLUSIONS: Promising results were obtained with a dried resin propylene glycol compound. Further work was recommended on the compounds and the test equipment.
GENERAL: This 10-page progress report contains three graphs.

DA 36881/3
B-4.9.25

SUBJECT: Tests, Special, Miscellaneous
TITLE: Self-Energizing Hydraulic Fluid
IDENTIFICATION: Report No. 36881/3
DATE OF REPORT: 30 April 1954
ORIGIN: Detroit Arsenal, Center Line, Michigan
PURPOSE: To develop a self-energizing hydraulic fluid with power transmission characteristics dependent on the rate of shear
METHOD: Colloidal suspensions were prepared and their dilatant properties evaluated in a special hydraulic apparatus. A Stormer viscosimeter was used to check the flow characteristics of several compounds under conditions of lower varying rates of shear. This research was performed by the Burke Research Company, Van Dyke, Michigan.
DESCRIPTION: The resins which were employed were described in Report No. 2 of this project. These dry resins were blended in varying amounts with three different vehicles: propylene glycol, hydraulic oil (MIL-O-5606), and subzero engine oil (MIL-O-10295). Viscasil 100,000, which was also evaluated, was made by General Electric; this material was a heavy silicone fluid. The hydraulic apparatus used to evaluate the colloidal suspensions tested was described in Report No. 1 of this project.
CONCLUSIONS: Several of the compounds tested appeared promising as hydraulic fluids for transmission of power. The resin-loaded propylene glycol (55 to 60%) and Viscasil showed 95 to 100% efficiency. The high rpm efficiency with Viscasil was considered to be of special interest, but it was not known, as yet, whether this was due to dilatancy of the fluid or to extreme viscosity. The suspensions made with acid resin and hydraulic oil and with acid resin and engine oil were not found to be dilatant in the range of shear rates tested. It was thought that this might be advantageous for the purpose of power transmission.
GENERAL: This 33-page report contains 27 pages of tables and graphs.

FA MR 470/1

SUBJECT: Tests, Special, Miscellaneous
TITLE: Comparison of Organically Finished HAE Treated and Dichromate Treated Magnesium Panels
IDENTIFICATION: First Report on MR-470
DATE OF REPORT: September 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To compare the salt spray resistance of HAE treated magnesium panels and dichromate treated magnesium panels which have been organically finished
METHOD: One coat of TT-E-485b, Type II, rust inhibiting olive drab enamel was sprayed on one set of panels. The other panels were sprayed with one coat of USA Specification 3-201 zinc chromate primer plus a coat of USA Specification 3-173 lustreless olive drab enamel. All of the panels were air dried for 30 minutes at room temperature after the application of each coat of paint. Two panels from each set were scribed to the metal surface below the pretreatment. The edges of all the panels were waxed, and the panels were then

exposed to a 20% salt spray at 95°F and at -3°F. The results of the tests were compared.
DESCRIPTION: The test items were two groups of HAE treated and dichromate treated magnesium panels to which two different organic finishing systems were applied.
CONCLUSIONS: The HAE treated panels had a much better salt spray resistance than the dichromate treated panels.
GENERAL: This 12-page report contains four photographs showing the effects of the salt spray test on the panels. Also included are tabular results of the test.

FA MR-568

SUBJECT: Tests, Special, Miscellaneous
TITLE: Examination of V-2 Components
IDENTIFICATION: Report No. MR-568
DATE OF REPORT: August 1953
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To metallurgically examine V-2 components for cause of failure
METHOD: The components were subjected to an as-received visual examination followed by applicable chemical and spectrographic analyses, mechanical tests, and metallographic and radiographic examinations.
DESCRIPTION: The V-2 German Rocket components were parts of the propulsion system which failed in service or in tests.
CONCLUSIONS: Mechanical tests and metallographic examinations showed the material used in the manufacture of the components to be of acceptable quality as judged by present commercial standards. There was no evidence that any deleterious aging phenomenon had taken place during storage of the components which could be responsible for failure. It was postulated that failures were caused by the unforeseen application of stresses in excess of accepted design stresses for the alloys, which might be explained on the basis of malfunction and failure of other components in the V-2 which caused excess loads on the examined parts.
GENERAL: This 20-page report includes eight photographs of the V-2 components.

FA MR-589

SUBJECT: Tests, Special, Miscellaneous
TITLE: A Comparison of Asphaltic Formulations and the Adherence of Slate Granules
IDENTIFICATION: Report No. MR-589
DATE OF REPORT: June 1954
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To compare the weathering characteristics of films made from homogeneous asphalts and gilsonite-modified heterogeneous asphalts, and to determine the relative retentivity or adherence of slate granules to such films
METHOD: Films of heterogeneous and homogeneous asphaltic compounds, with and without natural or synthetic gilsonite, with and without slate granule coatings, were subjected to accelerated weathering conditions for 5000 hours. The panels were examined periodically, and photographed.
DESCRIPTION: The tested formulations were various combinations of homogeneous asphalt, heterogeneous asphalt, gilsonite, synthetic gilsonite, slate granules, Fuller's earth, asbestos, Hercolyn 200, VM and P naphtha, and Sun Spirits. All of the bituminous materials, with the exception of synthetic gilsonite, were supplied by the Insul-Mastic Corporation of America. The synthetic gilsonite was obtained from the American Refining Company.
CONCLUSIONS: Homogeneous or gilsonite modified homogeneous asphalt may be used as a base for a slate granule coating. Homogeneous asphalt need not be modified with gilsonite to attain good resistance to accelerated weathering. Sprayable mastic compounds could be formulated which would permit a lapse of 4 to 6 hours between applications of the mastic and granule coatings without affecting the granule-mastic bond.
GENERAL: This 12-page report includes four photographs of the subject panels.

FAR-742
B-5.6

SUBJECT: Tests, Special, Miscellaneous
TITLE: Weather at the Panama Canal Zone Tropical Testing Station
IDENTIFICATION: Report No. R-742; Project 4/63
DATE OF REPORT: October 1946
ORIGIN: Frankford Arsenal, Pennsylvania
PURPOSE: To determine the suitability of a tropical station for field testing of materiel
METHOD: The test area weather data from May 1945 to November 1945 were recorded. Meteorological measurements of rainfall, temperature, and relative humidity were made. Additional information was obtained from the Section of Meteorology and Hydrography of the Panama Canal. Rainfall was measured each morning and temperature and relative humidity were taken from a rotating drum recording hygrothermograph. Recordings were taken at various times in the jungle. The bi-hourly means of temperature and relative humidity were recorded. Daily maximum and minimum temperatures were also taken.
DESCRIPTION: The tropical testing station was located in the Fort Sherman Military Reservation of the Panama Canal Zone. The test area included a cleared space, forest, and jungle. The tropical weather conditions were severe.
CONCLUSIONS: The testing station had a wet tropical climate with an annual four-month dry season. In 1945 the total rainfall was about 130 inches. The rainy season average temperature was 79°F and the average relative humidity was over 90%. The daily range in relative humidity and temperature was less in the forested area than in the cleared area. It was recommended that because of the wet tropical conditions which prevailed in this area and which would cause severe deterioration of materiel that the area be used for field tests.
GENERAL: This 29-page report includes seven charts of test data and one map of the Canal Zone area.

FAR-992

SUBJECT: Test, Special, Miscellaneous
TITLE: Preparation of Ortho-Nitrobenzoic Acid

and Certain Esters on Mononitrobenzoic Acids-Vapor Pressure Data of the Esters
IDENTIFICATION: Report No. R-992
DATE OF REPORT: January 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To synthesize certain organic compounds required for the program relating chemical structure to fungicidal activity
METHOD:. o-Nitrobenzoic acid and 10 of its lower alkyl esters were prepared for inclusion in a series of aromatic nitro compounds evaluated for fungistatic activity as part of the program of developing fungicides for Ordnance usage.
DESCRIPTION: Eleven compounds, listed in the report, were included in a series of nitro-organic compounds evaluated for fungistatic activity. Of the methods available for the oxidation of alkyl groups attached to an aryl unit, the alkali-permanganate and acid-dichromate were employed.
CONCLUSIONS: Preparation of o-Nitrobenzoic acid by the oxidation of o-nitrotoluene proceeded more rapidly and more efficiently in the alkali-permanganate medium than in the acid-dichromate medium, although the literature did not indicate that difficulty would be experienced with the acid-dichromate medium. Esterification of mononitrobenzoic acids, as discussed in this report, was indicated to proceed more effectively when catalyzed with HCl rather than H_2SO_4. Boiling points of most of the mononitrobenzoates were difficult or impossible to measure at atmospheric pressure because of decomposition at elevated temperatures. Decomposition was not prevented by a nitrogen atmosphere, indicating that nitroesters underwent thermal breakdown.
GENERAL: This 18-page report is not illustrated.

FAR-1002

SUBJECT: Tests, Special, Miscellaneous
TITLE: Agar Gels in Plaster-Bonded Investment
IDENTIFICATION: Report No. R-1002
DATE OF REPORT: February 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To determine the usefulness of agar additions to nonferrous investment mixes for improving the investment with respect to dipping, for use as a nonferrous precoat, and for the elimination of casting defects caused by the separation of the mixing water from the slurry
METHOD: A suitable refractory precoat was needed in order to utilize a moist foamed-type investment previously developed for aluminum alloys.
DESCRIPTION: None.
CONCLUSIONS: Agar additions to investment mixes in the concentrations of 0.0-0.2% agar by weight in the mixing water were effective in arresting the mobility of the investment when used as a dipping precoat, and in suppressing the collection of free water on the under side of the patterns when used as a single-coat investment. A precoat was one containing 0.2% agar in a water-mixed solution with the standard 70:30 silica-gypsum investment. The effect of the agar was to thicken the slurry so that a dipped pattern was completely covered without appreciable loss by drainage. It was recommended that 0.2% agar additions be made to the mixing water used for the precoat slurry; and, that future investment practice require the addition of between 0.1-0.2% agar in the mixing water to reduce surface defects caused by the separation of free water during the investment setting process.
GENERAL: This 12-page report includes three photographs of the precoated dipped patterns, castings obtained with mold, and a test pattern.

FAR-1016

SUBJECT: Tests, Special, Miscellaneous
TITLE: Biological Effects of Ionizing Radiations from Radium and Polonium on Fungi
IDENTIFICATION: Report No. R-1016
DATE OF REPORT: July 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To determine the effect of emanations from radio-active materials on the germination of fungus spores, on vegetative growth, and on the sporulation of fungi
METHOD: Experiments were conducted concerning the effects on fungi of radioactive emanation from a radioactive gold foil containing radium, from a free emanating radium salt, from a lacquer containing radium, and from nickel foils plated with polonium.
DESCRIPTION: Not applicable.
CONCLUSIONS: It was concluded that, with the radioactive sources used, the alpha particles were primarily responsible for the biological effects observed. Alpha radiation from radium and polonium in low dosage inhibited the sporulation of fungi grown on a good culture medium. Higher dosages of alpha radiation were inhibitory to cell division or mycelium proliferation. Continuous bombardment of a culture of Aspergillus Niger with alpha particles resulted in injury mutants. It was also found that alpha radiation could produce mutation in fungi. The biological effect of the irradiation of dry Aspergillus Niger spores with alpha particles was dependent on the dose.
GENERAL: This 90-page report contains 28 photographs showing examples of irradiated cultures.

FAR-1021

SUBJECT: Tests, Special, Miscellaneous
TITLE: Deformation Characteristics of Copper and Alpha Brasses
IDENTIFICATION: Report No. R-1021
DATE OF REPORT: August 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To investigate the effects of grain size and composition on the compression flow curves of OFHC copper and three alpha brasses of various grain sizes
METHOD: Strain measurements were taken by means of an extensometer, utilizing wire resistance strain gages, with the application to the data of an accepted factor to correct for the effects of barreling. Correlated studies also were made of the effects of various end lubricants as well as diameter: length ratios.
DESCRIPTION: The high purity, oxygen-free (OF HC) copper and the three alpha brasses, all in the

form of fully annealed 3/4-inch diameter rods 36 inches long, used in the test, were manufactured by the Chase Brass and Copper Company. The brasses selected were commercial bronze 90%, low brass 80% and cartridge brass 70%.
CONCLUSIONS: The compressive properties of copper and the three alpha brasses investigated were sensitive to grain size over the ranges of grain size and stress tested. In general, not only the initial flow stresses but the entire compressive stress decreased with increasing grain size. The existence of an initial yielding or yield point in some grain sizes of both low brass and cartridge brass was indicative of initial homogenous flow causing plastic deformation. For the copper and brasses tested, the compressive stress did not vary as a linear function of the strain raised to a fractional power over any range of strain investigated. For these metals, the logarithm of the stress was actually a curvilinear function of the logarithm of the strain. The derived true stress natural strain curves did not follow the empirical relationship $O = Ke^n$.
GENERAL: This 32-page report includes three photographs showing the compression extensometer and the test setup.

FAR-1043

SUBJECT: Tests, Special, Miscellaneous
TITLE: Analysis of the HAE Electrolytic Bath
IDENTIFICATION: Report No. R-1043
DATE OF REPORT: October 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To develop methods of analysis for the major constituents of the HAE electrolytic bath and to determine the state of oxidation of the manganese in the bath
METHOD: Quantitative methods of analysis were developed for the major constituents of the HAE electrolytic bath. Each procedure was tested for accuracy and precision. The state of oxidation of the soluble manganese in the bath was determined.
DESCRIPTION: Major constituents of the HAE electrolytic bath were manganese, phosphate, aluminum, fluoride, free alkali, nitrite, and nitrate.
CONCLUSIONS: The manganese was found to be present solely as the manganate. The methods of analyses developed for the major constituents of the HAE electrolytic bath were listed in this report.
GENERAL: This 25-page report is not illustrated.

FAR-1044

SUBJECT: Tests, Special, Miscellaneous
TITLE: Evidence of Internal Fracture
IDENTIFICATION: Report No. R-1044
DATE OF REPORT: October 1951
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To compile data concerning internal fracture in a ductile metal under tension
METHOD: A modified standard oxygen-free high-conductivity copper tensile specimen was subjected to static tensile loading in a 120,000-pound capacity Baldwin-Southwark hydraulic machine which was "stopped down" to a minimum value of oil input to the loading cylinder. Diameter measurements of the minimum area were taken with a hand micrometer and correlated with visual observations of time and load readings. After instability occurred, the test was halted at regular intervals and the specimen removed for the purpose of radiographing. Two mutually perpendicular photos were taken for each specimen state.
DESCRIPTION: The modified standard oxygen-free high-conductivity (OFHC) copper tensile specimen was 0.5052 inch in diameter at center of gauge length and 0.035-mm grain size and slightly tapered from the ends to the center. The purpose of such a taper was to ensure central formation of the neck.
CONCLUSIONS: By use of radiography, a standard tensile specimen of OFHC copper was found, under "static" testing conditions, to start fracturing internally in the central region of the minimum area of the necked portion. All fracture surfaces were inclined to the longitudinal axis, indicating a shear mechanism. The crack direction underwent several reversals, thereby restricting the fissure to the central region of the neck. Indications of the internal specimen behavior were also provided by the anomalous behavior of the time curves (load, area, and calculated stress) and of the logarithmic true-stress natural-strain (total) curve.
GENERAL: This 13-page report includes four curve sheets of test results

FAR-1056

SUBJECT: Tests, Special, Miscellaneous
TITLE: A Detail Description of Internal Fracture
IDENTIFICATION: Report No. R-1056
DATE OF REPORT: January 1952
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To give a detail description of the internal crack propagation in a ductile tensile specimen
METHOD: A set of radiographs showing internal fracture and magnified photographs of the fracture surfaces of a previously tested standard (OFHC) copper tensile specimen was carefully studied to obtain a detail description of the crack propagation for one particular ductile tensile specimen.
DESCRIPTION: The set of radiographs were Neg. No. 220 10-1, (A and B), and the magnified photographs were Neg. No. 220 10-2. The item tested was a modified standard oxygen-free high-conductivity copper tensile specimen. Report No. R-1044.
CONCLUSIONS: The study of the radiographs of the cracked profiles and the photographs of the cracked surfaces provided a detailed picture of the propagation of internal fissure in a ductile tensile specimen. The propagation resulted in a series of cups and cones which ostensibly spiral about the longitudinal axis. However, the true state for this specimen was the formation of two sets of cup-cone type fractures oriented around two different focal points, interspersed with periods of plastic deformation in the supporting ring of metal.
GENERAL: This 12-page report includes the set of radiographs, the magnified photographs, and a schematic drawing of the necked region.

FAR-1074

SUBJECT: Tests, Special, Miscellaneous
TITLE: Radiographic Evidence and Other In-

dications of Internal Fracture
IDENTIFICATION: Report No. R-1074
DATE OF REPORT: May 1952
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To compile data on the internal fracture propagation in a ductile copper tensile specimen, and the reflection of this phenomenon in the external geometry
METHOD: A standard copper tensile specimen was tested under continuous "static" conditions. After instability occurred the test was halted at regular intervals and the specimen removed for the purpose of radiographing. In addition to these X-ray pictures, other information obtained included the logarithmic true-stress natural-strain (total) relationship, the development of an eccentricity in the minimum cross section, the variation with strain (plastic) of the a/R term, and a series of photographs showing the external appearance of the necked region at a time very close to complete rupture. Internal fracture was in evidence with all the forms of information except the variation of neck-contour stress-correction term with strain.
DESCRIPTION: This report was based upon the test results of Reports No. R-1044 and No. R-1056.
CONCLUSIONS: The radiographic series provided a discontinuous picture of the internal fracture propagation. The internal cracking caused the specimen to develop a diameter eccentricity about the region of minimum cross section. The degree of eccentricity fluctuated as a function of the relative extent of cracking in different directions. Neither of these indications of internal fracture was so sensitive to the phenomenon as the behavior of the logarithmic true-stress natural-strain (total) relationship. On the other hand, the variation of a/R with strain (plastic) generally remained uninfluenced, and what minor fluctuations occurred were uninterpretable. The crack first appears on the periphery at diametrically opposite positions. These were connected by a combination of single and double lines which seemed to anticipate the subsequent external crack location. As was evident from the pictures, plastic deformation after incipient fracture rendered useless the concept of radius of curvature of the root of the neck.
GENERAL: This 16-page report includes one set of radiographs and one photograph magnification 9X of the standard copper tensile specimen used on the test. Also included are four curve sheets of test results.

FAR-1098

SUBJECT: Tests, Special, Miscellaneous
TITLE: Tensile Deformation Characteristics of Copper and Alpha Brasses
IDENTIFICATION: Report No. R-1098
DATE OF REPORT: August 1952
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To investigate the true stress-strain curves of oxygen free, high conductivity (OFHC) copper and three alpha brasses in tension; to determine the effects of grain size and composition
METHOD: Tension stress-strain data on the (OFHC) copper and the three alpha brasses were obtained by means of systematic measurements of the minimum diameters of the specimen while under load with hand-held ball micrometer calipers. These data were partially substantiated by direct use of a new type wire resistance strain gage which enabled strain measurements to be taken through the initial plastic range. A 120,000-pound capacity hydraulic machine was used to conduct these slow (static) tension tests at practically constant strain rates.
DESCRIPTION: High purity oxygen free (OFHC) copper and three alpha brasses of various grain sizes, all in the form of fully annealed 3/4-inch diameter rods 36 inches long, were supplied by the Chase Brass and Copper Company. The brasses used were 90% commercial bronze, 80% low brass, and 70% cartridge brass. The compositions, including impurities, were within the range of commercial tolerances set forth by the Copper and Brass Research Association. Except for a closer tolerance at the diameter, the specimens were identical with Type 1 of Federal Specification QQ-M-51a (15).
CONCLUSIONS: The results indicated that copper and brass tensile properties were sensitive to grain size; stress decreased with increasing grain size. An increase in zinc content increased the stress values, especially at higher strains. Results also indicated the existence of inhomogenous initial plastic yielding which appeared to be more evident with greater zinc content and larger grain sizes.
GENERAL: This 15-page report contains graphs showing various strain curves obtained.

FAR-1132

SUBJECT: Tests, Special, Miscellaneous
TITLE: Stress Corrosion Cracking of 70/30 Brass by Smokeless Powders and High Explosives
IDENTIFICATION: Report No. R-1132
DATE OF REPORT: June 1953
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To determine whether various smokeless powders and high explosives in the presence of air and water vapor could cause stress corrosion cracking of 70/30 brass
METHOD: Diphenylamine and various smokeless powders and high explosives containing diphenylamine were tested for their ability to cause season cracking in three types of stressed 70/30 brass specimens. Corrosion experiments on cups and draw pieces were conducted in a three-component gaseous system containing a powder vapor, air, and water vapor at a temperature of 50°C. Tests on cartridge cases were carried out with no water vapor added to that normally present in the powder or explosive being tested.
DESCRIPTION: Three types of stressed 70/30 brass specimens were tested. The first samples were unannealed 70/30 brass cups formed from a .04-inch thick sheet; the height of the cups was 1-3/8 inches and the diameter was 1-7/8 inches. The second samples were unannealed cal. .50 first draw pieces of 70/30 brass. The third test specimens were 70/30 brass, 37mm, M16 cartridge cases, without stress relief anneal. The various smokeless powders and high explosives tested were

listed in the report.
CONCLUSIONS: Brass cups and draw pieces cracked under the test conditions with all of the powders except commercial diphenylamine and pyrocellulose, multiperforated, 15-inch gun powder in stick form. Pyrocellulose and 7/8-inch stick powders caused the greatest incidence of cracking. The effect of diphenylamine on cracking was negligible. One 37mm cartridge case containing PETN cracked after 36 months storage.
GENERAL: This 31-page report contains one photograph and nine photomicrographs showing the effects of testing on the samples.

FAR 1136
B-4.11.19

SUBJECT: Tests, Special, Miscellaneous
TITLE: Tensile Strength Testing of Spray-Formed and Cast Vinyl Films
IDENTIFICATION: Report No. R-1136
DATE OF REPORT: May 1953
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To determine the effects of variables on the tensile strength of vinyl films
METHOD: In preparing cast and sprayed vinyl films on glass plates, the effects of variations in operator, film thickness, drying time, formulation, and preparative technique were determined by making tensile tests on various film specimens.
DESCRIPTION: The test material consisted of two vinyl plastics made up of various amounts of 90/10 vinyl chloride-vinyl acetate copolymer, dioctyl phthalate, methyl ethyl ketone, and, in the case of one of the plastics, low temperature lubricating oil.
CONCLUSIONS: The variations in the time of room temperature aging, spray operator, and formulation caused significant changes in the tensile strength of spray-formed vinyl films. The tensile strength of cast vinyl films decreased with increasing specimen thickness. It was thought that vinyl films must be sprayed or cast on different days to compensate for uncontrolled day-to-day variations in spraying and casting techniques, and that in order to obtain reproducible strength results within a laboratory, it was necessary to sample from three films, each prepared on a different day and by a different operator.
GENERAL: This 30-page report contains 10 graphs and 13 tables of test data.

FAR-1172

SUBJECT: Tests, Special, Miscellaneous
TITLE: A Technique for Anodizing Hollow or Deeply Recessed Articles
IDENTIFICATION: Report No. R-1172
DATE OF REPORT: October 1953
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To determine the suitability of a bipolar-type electrode for anodic treatment of hollow or deeply recessed articles
METHOD: Specimens treated by the bipolar electrode technique included 3/4-inch bars of FS magnesium alloy, drilled lengthwise to a depth of approximately 3-1/2-inches; magnesium tubes, 4-1/2 inches long, 1-inch ID, and closed at one end; and 6-inch cubical boxes, constructed of 0.10-inch FS-1 alloy magnesium sheet, welded on the seams with two holes totaling 2-1/2 sq.-in. cut into each box. Tests were conducted with different electrode arrangements and with electrodes of copper, steel, and magnesium. The technique was tested in HAE and Cr-22 treatment of magnesium and sulfuric acid anodizing of aluminum.
DESCRIPTION: The technique consisted of substituting a metallic conductor wherever the passage of electric current through the electrolyte would result in a large enough voltage drop to produce a poor coating on internal surfaces.
CONCLUSIONS: A technique embodying a bipolar-type electrode was developed to facilitate the anodic treatment of hollow or deeply recessed articles. It was recommended that detailed voltage studies of the HAE and Cr-22 treatments on various magnesium alloys be made.
GENERAL: This 16-page report includes three photographs of drilled magnesium bars, HAE treated; untreated magnesium boxes; and HAE treated magnesium boxes.

FAR-1175

SUBJECT: Tests, Special, Miscellaneous
TITLE: Nondestructive Testing of Sintered Brass Booster Rotors
IDENTIFICATION: Report No. R-1175
DATE OF REPORT: December 1953
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To investigate techniques for the nondestructive testing of sintered brass booster rotors
METHOD: Test specimens of rotors with various crush strength ratings were tested. All the samples of the 275-pound grade were inserted in the work coil to test their homogeneity as a function of frequency deviation. The test was repeated on all samples in the lots rated at 500, 825, 1000 and 1200-pound crush ratings. A second test was made to determine the actual measured difference between grades in terms of heat frequency in cycles per second. A 275-pound reference specimen was inserted in the work coil and the standard oscillator was set at zero beat with respect to the test oscillator. The average deviation of each lot was plotted against crush strength ratings with indications of a linear relation up to approximately 1000-pound crush strength.
DESCRIPTION: The technique developed was a system for testing sintered brass rotors that evaluated the crush strength rating of a particular lot as a function of the electrical conductivity of the specimen.
CONCLUSIONS: There was a definite correlation between the crush strength and the electrical conductivity of a particular lot of sintered brass booster rotors. There were many factors affecting the mechanical and physical properties of brass rotors. Studies were initiated to determine the relative importance of these factors. Since there was a definite correlation between the electrical conductivity and many mechanical properties of metals, it was considered that the method used to test sintered brass rotors could be applicable to other types of sintered brass products. It was rec-

ommended that a compact single unit capable of providing a manual test of sintered brass rotors be developed; and that further research be conducted to determine the effects of various manufacturing processes on the fundamental mechanical properties of brass rotors and other powder metallurgical products and the correlation of these properties with electrical conductivity.
GENERAL: This 17-page report includes three photographs of the sintered brass booster rotor and the test setup.

FAR-1191

SUBJECT: Tests, Special, Miscellaneous
TITLE: Chromate Electrolytes for Anodizing Magnesium
IDENTIFICATION: Report No. R-1191
DATE OF REPORT: March 1954
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To investigate chromate electrolytes for anodizing magnesium
METHOD: A series of chromate electrolytes for magnesium were investigated. In the preliminary study, chemical composition and operating conditions were varied. When improved deposits were obtained, the variation thought responsible was incorporated into the next bath prepared. A standard set of operating conditions was selected from the results of the preliminary study, and keeping these fixed for all tests, each chemical component was varied from low to high limits while the other components were held constant. Each series of panels representing the range of variation for one component was tested for corrosion resistance and dielectric strength. These values were plotted against concentration and compared with a similar plot of voltage needed to form the coating at each of the concentrations studied. The panels were coated in both freshly prepared and much used baths containing the same amount of added materials to determine whether changes in coating properties were due to changes in concentration of the component being studied or to bath depletions.
DESCRIPTION: The various compositions were listed in the body of this report.
CONCLUSIONS: Excellent protective coatings for magnesium could be obtained with ammoniacal electrolytes containing chromate, phosphate, and fluoride. The best results were obtained using baths from which alkali metal ions were excluded. Organic bases such as choline and hexamethylenetetramie could be substituted for ammonia in baths of this type. It was recommended that the operating conditions of the Cr-22 bath be further investigated and the industrial practicablility of the Cr-22 bath be studied.
GENERAL: This 32-page report includes curve sheets of the test results.

FAR-1201

SUBJECT: Tests, Special, Miscellaneous
TITLE: Chemical Studies Relative to the HAE Process
IDENTIFICATION: Report No. R-1201
DATE OF REPORT: April 1954
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To develop the most suitable method of preparing potassium manganate to be incorporated in the HAE electrolytic bath; to devise methods of analysis for various components in potassium manganate prepared commercially; to determine the state of oxidation of the manganese in the coating
METHOD: Suitable potassium manganate for use in the HAE electrolytic bath was prepared. Quantitative methods of analysis were devised for the following constituents in the prepared potassium manganate: chloride, sulfate, insoluble material, and potassium manganate. A qualitative test for the presence of potassium permanganate was also developed. The average valence of the manganese in the HAE coating was determined.
DESCRIPTION: Detailed descriptions of the various methods developed were contained in the body of this report.
CONCLUSIONS: A suitable method of preparing potassium manganate by reducing potassium permanganate in the presence of potassium hydroxide has been established. Methods of analysis for various components in potassium manganate have been devised. The average valence of the manganate in the HAE coating was found to be 2.18.
GENERAL: This 25-page report includes one drawing of the apparatus for determination of average oxidation state of manganese.

FAR-1204

SUBJECT: Tests, Special, Miscellaneous
TITLE: Studies of the Physical Properties of Materials by Use of a Reluctance Coil
IDENTIFICATION: Report No. R-1204
DATE OF REPORT: May 1954
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To evaluate results obtained by magnetic reluctance measurements as applied to the field of nondestructive testing
METHOD: An experimental device was developed which was capable of detecting the presence of flaws in round stock and cylindrical specimens. Specimens were concentrically rotated between the poles of the coils. Those specimens containing flaws produced defined meter indications during rotation.
DESCRIPTION: The experimental device consisted of four coils radially displaced to 90° and with their axis on the same plane. The coils were energized by a 500-cycle source of voltage.
CONCLUSIONS: The four-coil reluctance test system was capable of detecting the presence of flaws in round stock and cylindrical specimens. It had the advantage of greater sensitivity and better stability over that of the three-coil reluctance test system. It was recommended that further development be conducted on the four-coil reluctance test for rapid production line inspection. Investigations should also be conducted to evaluate the flaw detection sensitivity of the four-coil reluctance system.
GENERAL: This 20-page report includes 3 photographs of the four-coil reluctance test system and four schematic drawings of the three and four-coil system.

TANK AUTOMOTIVE TEST RESUMES

FAR-1263

SUBJECT: Tests, Special, Miscellaneous
TITLE: Activation of Nonmetallic Surfaces with Palladium Salts for Electroless Nickel Deposition
IDENTIFICATION: Report No. R-1263
DATE OF REPORT: May 1955
ORIGIN: Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To produce a film of palladium on nonmetallic materials for the purpose of initiating electroless nickel deposition
METHOD: Polystyrene panels were immersed in $SnCl_2$ solution, rinsed, and immersed in $PdCl_2$ solutions of varying pH. After a $SnCl_2$ dip, the polystyrene panels were rinsed and immersed in dilutions of a stock solution of 0.5 gm/ℓ $PdCl_2$ and 5 cc/ℓ HCl. Polystyrene panels were dipped in various concentrations of $SnCl_2$ made from a stock solution of 100 gm/ℓ $SnCl_2$ and 50 cc/ℓ HCl, followed by rinsing and 1-minute immersion in a $PdCl_2$ solution. Nonmetallic materials, other than polystyrene, were treated with the solutions and techniques that were found to be satisfactory for applying palladium films to polystyrene. In every case, after immersion in $PdCl_2$ solution, the specimen was rinsed and immersed in the electroless nickel solution. The effectiveness of the treatment was determined by the approximate percentage of the area that was found to have been coated with nickel.
DESCRIPTION: The films formed by immersion of nonmetallic materials in $PdCl_2$ solutions were invisible. The presence of an activating film was ascertained by its ability to initiate nickel deposition from the electroless nickel solution.
CONCLUSIONS: A satisfactory treatment for polystyrene consisted of a 2-minute immersion in 0.1 gm/ℓ $PdCl_2$ at 125°F within the pH range of 3.8 to 4.8. When polystyrene was given a predip in $SnCl_2$ solution, the $PdCl_2$ solution could be used at room temperature within the minimum pH range of 0.9 to 4.2. Certain other nonmetallic materials could be successfully treated in the same manner as polystyrene.
GENERAL: This 10-page report includes a sample of nickel coated polystyrene.

FA TB4-21E/R-1116

SUBJECT: Tests, Special, Miscellaneous
TITLE: Selection of Color Compensating Filters in Metallographic Color Photomicrography
IDENTIFICATION: Report No. R-1116 of Project No. TB4-21E
DATE OF REPORT: March 1953
ORIGIN: Pitman-Dunn Laboratories, Frankford Arsenal, Philadelphia, Pennsylvania
PURPOSE: To describe a method of selecting color filters to improve color reproduction in metallographic color photography
METHOD: Experiments and discussions were conducted to evaluate: sources of errors in color reproduction and evaluation, the preparation of color transparencies for the selection of color compensating filters and the method of their selection, and a simplified method of construction of color compensating filters.
DESCRIPTION: Not applicable here.
CONCLUSIONS: For the particular optical system of Bausch and Lomb Research Model Metallograph, Serial No. 9059, fitted with the 8X objective and 5X eyepiece in the camera and illuminated with a carbon arc, the following filters were selected for best color balance: filter UV16P for Kodak Ektachrome color film (emulsion C6102-4633), filters UV16P and CC.05Y for Ansco tungsten-type color film (emulsion 427), and filters UV16P and CC.10Y for Printon (emulsion M630-1796-4-A1) exposed in photomicroscope. These same color compensating filters could also generally be used in other B and L microscopes with different combination of eyefields and objectives. Color compensating filters mounted with waterproof cement between two glass slides were convenient to use but could not be held immersed in water of the cooling cell of the photomicroscope for periods of more than two hours.
GENERAL: This 13-page report includes three pages of color spectrum strips showing the effect of different filters on color reproduction.

GM-CTP 550F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Metered Oil Puddles
IDENTIFICATION: Report No. 550 (Final)
DATE OF REPORT: 29 July 1952
ORIGIN: General Motors Corp., Cleveland Tank Plant, Cleveland, Ohio
PURPOSE: To provide a visual guide for Cadillac and Ordnance inspection to determine the approximate size spot resulting from the leakage of a given amount of oil
METHOD: Three tests were made of metered 1cc and 5cc of oil of concrete, paper, and glass. Level surfaces were used so that an extraordinary pattern would not be made. Each test observed and reported was allowed to set for 15 minutes after being metered on the material.
DESCRIPTION: The oil used in the test was M11-O-2104, SAE No. 10 oil which was utilized at this time for the lubrication of vehicle suspension systems. One cc of oil was equivalent to a 7/16-inch diameter tube filled to a 3/8-inch level; five cc were equivalent to the same 7/16-inch diameter tube filled to 1-7/8-inch.
CONCLUSIONS: The maximum dimensions of the puddles after 15 minutes were listed in the report. Comparison of the various metered oil puddle tests indicated a definite trend in each trail. The result of the metered oil puddle on concrete depended greatly on the top surface finish of the cement. The oil followed any lines and unevenness in the concrete. In the paper test the metered oil was more subject to enlargement over a period of time (3 to 4 hours) due to the rag content of the paper. In the glass test the metered oil did not tend to enlarge itself greatly over a period of 5 hours because the oil surface tension was maintained by the glass smoothness.
GENERAL: This 10-page report contains five photographs of the metered oil puddles.

GM-CTP 563-3

SUBJECT: Tests, Special, Miscellaneous
TITLE: Comparison of T141 Hull Vibration Between Duplicate Runs
IDENTIFICATION: Report No. 563-3

DATE OF REPORT: 20 January 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant, Cleveland, Ohio
PURPOSE: To determine the difference of recorded hull vibration, if any, between duplicate runs
METHOD: The necessary instrumentation was installed on the T141 vehicle and test recordings were made of duplicate runs, one within minutes of the other in which there was no change in vehicle or road conditions.
DESCRIPTION: The test vehicle was a standard production T141 vehicle.
CONCLUSIONS: The greatest average acceleration difference between any two similar points and conditions on duplicate runs was 24.2% as recorded on displacement pickups, and 5% as recorded on accelerometers. The average acceleration difference, all conditions combined, between duplicate runs was 9.4% as recorded on displacement pickups and 1.64% as recorded on accelerometers. Correlations seemed more consistent and much better when read on accelerometers. More than two duplicate runs should be made before a reliable correlation factor can be determined. The inconsistency of duplications when using displacement meters should be investigated.
GENERAL: This seven-page report is not illustrated.

GM-CTP 736F

SUBJECT: Tests, Special, Miscellaneous
TITLE: Tensile Test of Experimental Volute Spring Tappet Assembly Part No. SK-1579
IDENTIFICATION: Report No. 736 (Final)
DATE OF REPORT: 19 January 1953
ORIGIN: General Motors Corporation, Cleveland Tank Plant
PURPOSE: To determine the load required to cause failure of an experimental tappet assembly
METHOD: The tappet assembly was installed on a Baldwin testing machine, and the load was applied and increased until the maximum load was recorded. The lifting action on the shaft was continued until the shaft was pulled free of the flange. In the first trial a new assembly with cadmium plated pins was used; in this assembly the rod had been pressed into the flange and the pins fitted into place. The second trial used the original assembly with stainless steel pins. The third trial was run with stainless steel pins in newly drilled holes of the same assembly. The fourth trial was made using a new assembly with cadmium plated pins; this assembly differed from the first in that the rod was not pressed into the flange but was a loose fit.
DESCRIPTION: The test unit was an experimental volute spring tappet assembly, Part No. SK-1579, which was designed to retain the volute spring and plate to the mounting bracket without welding. A split, hollow, cadmium plated steel pin and a split, hollow, stainless steel pin were both tested.
CONCLUSIONS: In all four trials the failure occurred in the split hollow pins. The cadmium plated pins failed in shear, but without bending. The stainless steel pins failed in shear but were also bent in the direction of the applied load. The cadmium plated pins in two trials needed an average of 12,600 pounds to produce failure. During two trials, the stainless steel pins needed an average load of 10,500 pounds to produce failures.
GENERAL: This seven-page report contains one photograph of the experimental tappet assembly. Also included is a drawing of the test setup.

GRG 5A-118

SUBJECT: Tests, Special, Miscellaneous
TITLE: Evaluation of Tests for Cermets as Components of Heat Resistant Materials
IDENTIFICATION: GRG-5A-118, NBS
DATE OF REPORT: 9 May 1952
ORIGIN: National Bureau of Standards, Washington, D.C.
PURPOSE: To compile an index of classified reports relating to cermets and to abstract the significant reports
METHOD: Each reference was assigned a number, and the references were indexed by research organizations according to subject and material.
DESCRIPTION: The subject index covered the following topics: Abrasion, Adherence, Bonding, Ceramic Coatings, Ceramic Material Uses, Ceramic Material Properties, Cermet Coatings, Cermet Uses, Cermets, Corrosion, Crystal Structure, Density, Electrical Resistance, Erosion, Fabrication, Flame Spraying, Fusion, Furnaces, Grain Size, Hardness, Heat Resistance, Heat Transfer, Homogeneity, Machining, Microscope, Milling, Modulus of Elasticity, Modulus of Rupture, Oxidation, Particle Size, Porosity, Refractoriness, Shrinkage, Strength, Strength in Compression, Strength in Flexure, Strength in Shear, Strength in Tension, Thermal Conductivity, Thermal Expansion, Thermal Shock, and Thermal Spalling. The main research organizations were Ohio State University Research Foundation, Batelle Memorial Institute, Pennsylvania State College, New York College of Ceramics, University of Illinois, and Armour Research Foundation.
CONCLUSIONS: The information contained in these reports indicated that for cermets: (1) the geometry of the specimens affected the values obtained for strength, (2) the loading rate used in the transverse test affected the values obtained for strength, (3) particle size distribution affected the resistances to thermal shock, oxidation and erosion, (4) the erosion characteristics differed from those of metals, and (5) resistance to erosion when tested as nozzles for recoilless rifles was less than the resistance to erosion of certain metals.
GENERAL: This 51-page report contains no illustrations.

GRG 2666

SUBJECT: Tests, Special, Miscellaneous
TITLE: Gamma Ray Sources and Techniques for Gamma Ray Radiography
IDENTIFICATION: Report No. GRG 2666
DATE OF REPORT: 26 February 1953
ORIGIN: U.S. Naval Ordnance Laboratory, White Oak, Maryland
PURPOSE: To review data on radioisotopes used as radiation sources for industrial radiography
METHOD: Data were presented on radiographic

gamma ray sources as the result of laboratory investigation of optimum techniques. General information such as physical properties, shipment, storage, and handling procedure was presented.
DESCRIPTION: The report was arranged in six divisions with appropriate subdivisions. The main divisions were Abstract, Introduction, Handling and Radiation Safety, Exposure Factors, Storage and Shipping, and Conclusions.
CONCLUSIONS: The recent increase in the use of isotopes with the promise of continued expansion warrants the familiarization by radiographers with gamma ray techniques, including exposure and handling.
GENERAL: This 81-page report contains 12 pages of test data and 39 illustrations.

N-526(S)

SUBJECT: Tests, Special, Miscellaneous
TITLE: Information and Data on Drivers' Run-Flat Detection
IDENTIFICATION: Supplemental Report; Test N-526
DATE OF REPORT: 19 January 1945
ORIGIN: Ordnance Tires Test Fleet, Normoyle Field, San Antonio, Texas
PURPOSE: To determine whether drivers could detect low inflated or flat tire conditions when operating a vehicle
METHOD: A 1/4-ton, 4x4, Ford reconnaissance car and a 3/4-ton, 4x4, Dodge weapons carrier were operated by civilian drivers who had no realization that run-flat tests were being conducted. After a ten mile tire warm-up period at 45 mph, vehicle speed was reduced to 35 mph, and the right front and rear tires were deflated automatically. Driver reaction was observed. The distance traveled before the driver definitely identified the low inflation or flat tire condition was recorded in the logs.
DESCRIPTION: The 1/4-ton Ford vehicle was equipped with 6.00x16 tires; front and rear tire loads were 650 and 1065 lbs. The Dodge vehicle was equipped with 9.00x16 tires; front and rear tire loads were 1525 and 2200 lbs. Tire pressures at the beginning of test were 35 psi.
CONCLUSIONS: Drivers were able to detect a soft or flat tire satisfactorily by means of the erratic weaving and instability and loss of speed of a vehicle. On a straight paved highway it was more difficult to identify a flat front tire than a flat rear tire. A soft or flat tire could be more readily identified by a driver when operating the vehicle on highways and gravel road with curves than could be detected when operating in a straight line on paved highways or cross-country.
GENERAL: This seven-page report contains a graph showing the deflation rates used with the two sizes of tires during test.

OCO 1-1945
B-4.15.2

SUBJECT: Tests, Special, Miscellaneous
TITLE: The Prevention of Deterioration of Material by Mold
IDENTIFICATION: OCO 1-1945
DATE OF REPORT: January 1945
ORIGIN: Office, Chief of Ordnance, Detroit, Michigan
PURPOSE: To summarize suitable methods of mold prevention
METHOD: A presentation was made of established facts and data regarding fungi growth and the prevention of deterioration of material by mold. The material was compiled by the Materials Branch of the Office, Chief of Ordnance.
DESCRIPTION: The review included: the factors that produce tropical deterioration of service materials; history of mold preventive treatments of service materials; evaluation of compounds used as mold-preventive agents; microbiological test methods used for evaluation of mold-preventive agents; chemical test methods used for determining retention of mold preventive agents; materials, uses, and recommended treatments for Ordnance materials; and development of field treatment methods for mold-prevention.
CONCLUSIONS: Moisture, fungi, mold, bacteria actinomycetes, ultraviolet radiation, and chemicals cause deterioration of service materials. The most effective method of protecting materials in storage was to reduce the relative humidity by increasing the temperature. Copper, zinc and mercury compounds and phenols and phenol derivatives were the best mold-preventives. Three types of methods for the evaluation of mold-preventive agents were detailed and included controlled laboratory procedures, soil burial procedures, and natural exposure procedures.
GENERAL: This 25-page report includes a one page illustration of various fungi and one drawing of leaching apparatus.

ODPG KG-382

SUBJECT: Tests, Special, Miscellaneous
TITLE: Effect of Altitude on Performance of Military Motor Vehicles
IDENTIFICATION: Project No. KG-382
DATE OF REPORT: 9 September 1943
ORIGIN: Ordnance Desert Proving Ground, Camp Seeley, California
PURPOSE: To determine the effect of high altitude on production military vehicles in common use
METHOD: The test operation was conducted on grades of up to 32% at elevations from 170 to 10,000 feet above sea level. Operation was with and without rated payloads and towed loads, and with double the rated payload. Performance was evaluated in terms of gradeability with comparable loads, at each altitude. Changes in ignition timing and carburetion were studied.
DESCRIPTION: The test vehicles included 1/4- to 6-ton trucks, the M3 Half-Track Personnel Carrier, M5A1 Light Tank, and M4A1 Medium Tank. All engines were new or in excellent condition, and incorporated the latest production features.
CONCLUSIONS: The loss in performance, indicated by decreased speed on grades, was found to be about 40% at 10,000 feet as compared to sea level. Recommendations for carburetor and governor adjustments were made and certain shortcomings of the various test vehicles were discovered. Further testing was recommended to study cross-country performance at high altitudes.

GENERAL: This 125-page report contains 12 photographs of test operations and 41 curve sheets based on test data.

ODPG 11-13-42

SUBJECT: Tests, Special, Miscellaneous
TITLE: Sand Flotation Engineering Guide
IDENTIFICATION: None
DATE OF REPORT: 13 November 1942
ORIGIN: Ordnance Desert Proving Ground, Camp Seeley, California
PURPOSE: To establish an empirical basis for predicting sand flotation and mobility of Ordnance wheeled vehicles
METHOD: Data obtained from five months of desert testing, of vehicles grossing from 3000 to 54,000 pounds, under various conditions, were studied to determine the factors influencing vehicle performance in sand. Rating methods were established to evaluate these factors in different vehicles so that an over-all vehicle rating could be arrived at.
DESCRIPTION: Not applicable
CONCLUSIONS: A series of empirical rating factors and equations, and graphs of various sand mobility relationships, were compiled. It was felt that these permitted reasonably accurate prediction of wheeled vehicle performance in sand to serve as a basis for design work.
GENERAL: This 28-page report contains no illustrations. It includes nine curve sheets plus methods for estimating and determining sand ability of vehicles.

OTAC KG 60-2

SUBJECT: Test, Special, Miscellaneous
TITLE: Tire Paints and Preservatives
IDENTIFICATION: Project Number KG 60-2
DATE OF REPORT: 6 January 1943
ORIGIN: Ordnance Tank Automotive Center, Detroit, Michigan
PURPOSE: To determine whether tire paints and preservatives would reduce the deleterious effects of weather on tires during storage and vehicle operation
METHOD: One-half of the sidewalls of several tires were coated with the paints and preservatives submitted. One group of tires was stored in the open and a second group of tires was tested on vehicles for a period of 60 days.
DESCRIPTION: The paints and preservatives submitted were not described.
CONCLUSIONS: At the end of the 60-day period, no reduction in weather checking was noted, though some of the test tires showed a slight improvement in appearance. There was no material value to the use of paints and preservatives. It was recommended that the test materials be declared unsatisfactory for military use.
GENERAL: This eight-page report is not illustrated.

PA 1960

SUBJECT: Tests, Special, Miscellaneous
TITLE: Material for Plug, Closing T22E1 for 155mm Howitzer Ammunition
IDENTIFICATION: Report No. 1960
DATE OF REPORT: September 1953
ORIGIN: Picatinny Arsenal, Raritan, N. J.
PURPOSE: To determine suitable material and construction for the T22E1 closing plug
METHOD: Closing plugs incorporating two design modifications and made of either a rubber modified fabric filled phenolic or a macerated fabric filled phenolic were subjected to a laboratory drop test devised to simulate the ramming action of the 155mm howitzer T97. Each plug was subjected to a drop from a preselected height, and the effect was noted and recorded. This procedure was carried out until the closing plug fractured. A third modified closing plug was drop tested and the ft.-lb. required for rupture of the different designs were compared. Ammunition assembled with plugs of test material incorporating the first two design modifications were fired from the 155mm howitzer for closing plug fragmentation test.
DESCRIPTION: The test units were plastic closing plugs for the 155mm howitzer T97, and identified as closing plugs T22E1. It was required that the plugs be able to withstand the ramming action of the T68E1 Massey Harris Rammer #7525000, and, in addition, to fragment into small harmless pieces when the round was fired.
CONCLUSIONS: A successful combination of material and structural design was developed resulting in an acceptable closing plug. It was recommended that plastic closing plugs incorporating the first two tested design modifications and made from either rubber modified, fabric reinforced phenolic or from an unmodified, fabric reinforced phenolic molding material be subjected to whatever additional tests were required to lead to standardization. It was also recommended that the third modification tested be incorporated in the design of experimental closing plugs.
GENERAL: This 34-page report includes six photographs of the test setup and closing plugs and one drawing showing ramming action of 155mm howitzer.

PA 2060

SUBJECT: Tests, Special, Miscellaneous
TITLE: Survey of the Methods Used to Determine the Dynamic Mechanical Properties of Polymers
IDENTIFICATION: Report No. 2060
DATE OF REPORT: September 1954
ORIGIN: Picatinny Arsenal, Dover, N. J.
PURPOSE: To study test methods used to determine the dynamic properties of polymers
METHOD: A literature survey was conducted on the best methods used in determining the dynamic mechanical behavior of polymers.
DESCRIPTION: A list of the references used was included in the report.
CONCLUSIONS: A general theoretical treatment of the information found was given in the report by classifying the test methods so that they could be more conveniently discussed and compared. The best methods were grouped into three major divisions-attenuation methods, resonance methods, and direct stress-strain methods. Each division was further broken down into subgroups. Brief comments on the various test methods were included

with respect to ease of operation, degree of accuracy and precision, and cost of instrumentation. It was recommended that this survey be used as a starting point for studies of dynamic methods of testing polymeric materials.
GENERAL: This 40-page report contains several diagrams of equipment used in dynamic testing.

PG-2.405
SUBJECT: Tests, Special, Miscellaneous
TITLE: Electrical Resistance of Tracks - TEO 1021 JO
IDENTIFICATION: Report No. PG-2.405
DATE OF REPORT: 25 July 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the electrical resistance between the pin and binocular of various track blocks with and without grounding devices
METHOD: Various types of tracks on both medium and light tanks were used for the test. Twenty blocks from each of 16 tracks were subjected to a resistance test.
DESCRIPTION: Phosphor-bronze grounding springs were built into several track blocks. These springs were used to transmit electrical charges from the track binocular to the track pin for the purpose of grounding.
CONCLUSIONS: From a total of 32 blocks tested, 30 had more than 0.1 ohm resistance. Of these 30, 21 had more than 1,000,000 ohms resistance. The resistance of the other nine varied from 0.2 ohm to 200 ohms. Tests made on a track not equipped with grounding springs revealed the blocks to be in an open circuit condition.
GENERAL: This five-page report is not illustrated.

PG-2.520
SUBJECT: Tests, Special, Miscellaneous
TITLE: Test of Medium Tank M4 with Fort Knox Drivers
IDENTIFICATION: Report No. PG-2.520; G.M. P.G. Project No. 69
DATE OF REPORT: 14 December 1942
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the ability of personnel, classified as "average tank drivers," to operate and maintain medium tanks
METHOD: Six men were chosen at random to operate and maintain each of five medium tanks of the M4 series. Vehicle operation was conducted over a prepared seven mile course; test driver behavior and their vehicle maintenance ability, with no aid from experienced proving ground personnel prior to testing, were observed.
DESCRIPTION: The six men used in testing were sent from Fort Knox, Kentucky, to the General Motors Proving Ground. Each man was classified as an "average tank driver." The following medium tanks were used in testing: one each of the M4A1, M4A2, and M4A4 series, and two of the M4A3 series.
CONCLUSIONS: The men used in the test were unable to fulfill the requirements of a "tank driver" satisfactorily. Through questioning the men, it was discovered that each man had very little experience in the actual driving of tanks prior to testing. Primary deficiencies were found in their lack of interest, inability to identify the importance of vehicle instruments, and poor ability to shift gears properly; a number of maintenance requirements were either not observed or just ignored. It was recommended that in future instruction courses the importance of vehicle instruments and the proper manipulation of controls be stressed to a greater degree.
GENERAL: This 168-page report contains 16 photographs showing various views of vehicle components damaged in operation.

PG-2.1077
SUBJECT: Tests, Special, Miscellaneous
TITLE: Impact Test and Metallurgical Analysis of Medium Tank Track Wedges
IDENTIFICATION: Report No. PG-2.1077; GMPG Project No. 261
DATE OF REPORT: 12 February 1944
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the comparative impact characteristics and chemical composition of three wedge bolts forged from resulphurized steel and three wedge bolts forged from standard steel
METHOD: One standard Charpy impact bar was machined from each of the six bolt wedges. One test bar from each set was tested at room temperature (76°F), and two bars from each set were tested at -40°F. Chemical and spectrographic analyses were made of one test bar of each set.
DESCRIPTION: Three test wedge bolts were forged from resulphurized X-1345 steel, and three test bolts were forged from standard NE-1345 steel. Both sets of test bolts were forged by the Columbus Bolt Works from Carnegie-Illinois steel.
CONCLUSIONS: The test data secured from the limited number of specimens provided were considered insufficient to warrant any conclusions. The resulphurized steel test bars fractured at 36 foot-pounds at 76°F and at 37 and 43 foot-pounds at 76°F and at 19 and 20 foot-pounds at -40°F. Hardness of the resulphurized steel wedges was from 31 to 33 Rockwell C; hardness of the standard steel wedges was from 33 to 35 Rockwell C. Chemical analysis of the two types of steel indicated the sulphur, silicon, and chromium content of the resulphurized steel was slightly higher than the standard steel. Spectrographic analysis indicated 0.07 percent aluminum in each type steel.
GENERAL: This seven page report is not illustrated.

PG-2.1554
SUBJECT: Tests, Special, Miscellaneous
TITLE: Pitch, Roll, and Yaw Tests of Heavy Tank T26E3
IDENTIFICATION: Report No. PG-2.1554; Project No. 628
DATE OF REPORT: 23 March 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the pitch, roll, and yaw characteristics of Heavy Tank T26E3

METHOD: The instrumentation used to measure the above characteristics consisted of two spring retained gyrostabilizer controls with variable ratio transformers excited by 120 volt, 60 cycle inverters. The voltage output from the transformers was fed to amplifiers and recorded on an oscillograph. The amplitude of the 60 cycle wave was directly proportional to the gyro-displacement.
DESCRIPTION: The test vehicle was a Heavy Tank T26E3.
CONCLUSIONS: No conclusions were drawn since results of the test were not published at the time. However, preliminary checks indicated that maximum yaw was approximately 25 to 30 degrees per second; that maximum roll velocity was approximately 10 degrees per second; that pitch velocities were seldom in excess of 30 degrees per second; and that pitch accelerations may be in excess of 80°/sec/sec. The suspension system exhibited a natural pitch frequency of nearly one cycle per second.
GENERAL: This 19-page report contains 11 photographs of the testing grounds, the instrumentation installation, the gyro assembly, and a sample of the oscillograph record.

PG-2.1620
SUBJECT: Tests, Special, Miscellaneous
TITLE: Interchangeability Test of 4-Ton and 6-Ton Truck Axle Assemblies
IDENTIFICATION: Report No. PG-2.1620; GMPG Project No. 367-6
DATE OF REPORT: 29 May 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of interchanging truck axle components of different manufacture
METHOD: The front axles of 1/4-ton, 4x4 trucks were assembled from the components of front axle assemblies supplied by different manufacturers. Identical interchangeability tests were executed with the following respective axle assemblies: the rear axles of a 4-ton, 6x6, truck; and the front and intermediate axle assemblies of a 6-ton, 6x6, truck.
DESCRIPTION: The 4-ton, 6x6, front axle interchangeability assembly was made from front axle assembly components manufactured by the Standard Steel Spring Co. and Reo Motor Co.; the rear axle assembly components were supplied by the same two manufacturers and the Bradford Machine Tool Co. Front axle assembly components manufactured by Timken Axle Co., Standard Steel Spring Co., and C. L. Gougler Machine Co. were interchanged for use on 6-ton, 6x6, trucks; intermediate axle assemblies were assembled from components furnished by the first two manufacturers.
CONCLUSIONS: The respective axle components furnished for use with the front and rear axles of the 4-ton, 6x6, truck and the intermediate axle components of the 6-ton, 6x6 truck were satisfactorily interchanged in the final axle assemblies. However, the Gougler and Standard Steel Spring pinions could not be interchanged with a Timken pinion used in the 6-ton, 6x6, truck front axle. It was recommended that a comparison be made of Gougler, Standard Steel Spring, and Timken prints in order to determine which front axle pinions were off size; and, because of foreign material found in the axle housings, that a more thorough final inspection be made of 6-ton, 6x6, truck intermediate axles before being submitted for military use.
GENERAL: This 29-page report contains 11 photographs showing the vehicle axle components.

PG-2.1690
SUBJECT: Tests, Special, Miscellaneous
TITLE: Interchangeability Test — 1/4-Ton Command Reconnaissance Trucks Willys Overland Co. and Ford Motor Co.
IDENTIFICATION: Report PG-2.1690; GMPG Project No. 367-7
DATE OF REPORT: 9 June 1945
ORIGIN: General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the suitability of interchanging component parts of Willys and Ford command reconnaissance trucks
METHOD: Attempts were made to interchange all of the components of a Willys manufactured reconnaissance truck with the components of a similar-type vehicle manufactured by Ford. The time allotted for the test did not permit the exchange of individual engine and transmission components. After the interchange, the vehicles were given trial runs.
DESCRIPTION: The test 1/4-ton, 4x4 reconnaissance trucks used in the component interchange operation were standard Willys, GMPG No. 8769, and Ford, GMPG No. 8784, vehicles.
CONCLUSIONS: Either vehicle frame could be used with all parts and components of the other vehicle except for the following: the short muffler and exhaust pipe assembly manufactured by Ford could be used on either vehicle, while the longer Willys exhaust assembly required special brackets and clamps before being suitable for installation on the Ford frame; and, when the Ford frame was used with Willys components, it was found necessary to use a Ford battery support bracket. Operation of both vehicles when using interchanged components was satisfactory. Minor recommendations were included with reference to the need for Ford components to be more thoroughly cleaned before being painted, and the requirement for Willys to inspect their transfer cases more closely for foreign matter accumulation before submission for military use.
GENERAL: This 26-page report contains four photographs showing each test vehicle chassis, a comparison in the difference of design of each vehicle transmission shield, and a view of foreign matter found in the bottom cover of the Willys transfer case during inspection.

PG-2.1715
SUBJECT: Tests, Special, Miscellaneous
TITLE: Engine Fan Belt Creep Investigation
IDENTIFICATION: Report No. PG-2.1715; G.M. P.G. Project No. 420
DATE OF REPORT: 25 June 1945
ORIGIN: General Motors Proving Ground, Mil-

ford, Michigan
PURPOSE: To determine if creep (difference in speed) existed between similar belts in multiple V-belt drives in fan and generator driving installations and to devise a method of eliminating this creep if it existed
METHOD: Tests were made on the multiple V-belt drives on four Ordnance vehicles, a Half-Track Car M2A1, a Light Tank M24, a Medium Tank M4A3, and a Heavy Tank T25A3. A line was marked across all the belts of a group, the engine was operated, and the time for each belt to make one revolution was determined by use of a stroboscope.
DESCRIPTION: The fan drive arrangement of Heavy Tank T26E3 utilized a four-belt, engine-driven pulley driving four fans, two above and two below, with four double-belt fan pulleys for power transfer. The belts were 40-1/2-inches long. The Medium Tank M4A3 fan drive utilized two double belt drive pulleys and two double-driven pulleys. The belts were 57 inches long. The fan belt drive installation of the Light Tank M24 had three belt pulleys for each engine. The drive pulley was mounted to the crankshaft and drove both the water pump and generator through three belts. The fan was driven by a shaft knuckle connected to the generator shaft. The fan belt drive installation of the Half-Track Car M2A1 was a two-belt drive with a pulley on the crankshaft driving both a generator and a fan.
CONCLUSIONS: Differences of speed between the fastest and slowest belt in the various multiple V-belt drives were all less than 0.476%. Speed Differences were attributed to variations in the belts and not to differences of sheave dimensions. It was recommended that a research program be instituted to evaluate the effect of matching tolerances of each belt of a group, to check power distribution, and to establish rational limits for selection of matched groups. It was felt that V-belt manufacturers of the rubber industry should undertake the project.
GENERAL: This 31-page report includes four sketches illustrating the respective drive installations.

PG-2.1719
SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of Requirement for Support Bracket Under Transmission — M4 Series Medium Tanks
IDENTIFICATION: Report No. PG-2.1719; GMPG Project No. 425
DATE OF REPORT: 11 June 1945
ORIGIN: Ordnance Department Operation at General Motors Proving Ground, Milford, Michigan
PURPOSE: To determine the need for a bracket and support pad, between the floor and rear end of the M4 Medium Tank Transmissions
METHOD: A transmission load-deflection test was conducted by applying known loads with a hydraulic jack placed between the hull roof and the rear of the transmission case. Strain gages, cemented to the transmission case, and dial indicators were used to measure strains and deflections at various loads. Measurements were made with and without the support pad. Data were also obtained from tanks operating with and without the support pad.
DESCRIPTION: The support pads were rubber and fabric pads designed to reinforce or support the transmission.
CONCLUSIONS: The support bracket and pad did not reinforce the transmission sufficiently to warrant their use. The rubber pad once compressed, became loose, and no longer served its purpose. No mounting flange or attaching bolts failures occurred on two medium tanks which operated without support pads 3065 and 2811 miles over the endurance course.
GENERAL: This 22-page report contains three photographs of the static test setup and two graphs on the transmission load-deflection test.

PG-61505.31
SUBJECT: Tests, Special, Miscellaneous
TITLE: Investigation of Performance of Light Tank M5A1 with Simulated Increased Frontal, Turret and Hull Armor
IDENTIFICATION: Report No. PG-61505.31; Project No. 271
DATE OF REPORT: 12 July 1944
ORIGIN: Tank Arsenal Proving Ground, Utica, Michigan
PURPOSE: To determine the effect of additional weight on the performance and durability of the M5A1 tank
METHOD: The vehicle, with 4090 lbs. of ballast to simulate a proposed increased armor weight, was operated 1001 miles over the proving ground endurance course. Comparative acceleration tests were made with and without the ballast weight. Speeds were limited to 30 mph on concrete and 20 mph on dirt because of the increased suspension loads.
DESCRIPTION: A new production Cadillac M5A1 Light Tank, with Cadillac twin V-8 engine and hydramatic transmission was used for the test. The ballast weight was distributed on the front of the hull and on the turret to obtain the same center of gravity as the proposed vehicle. The weight of the vehicle, with ballast, was 36,900 pounds, as against 32,310 pounds net. Comparative acceleration tests were run at these weights. Bogie arm links lengthened 1/2 inch, which had proved successful in correcting end-connector interference on standard vehicles, were installed on the test vehicle to check the tendency toward interference under the increased load.
CONCLUSIONS: The comparative performance tests showed only 7% less in acceleration to 32 mph for the weighted vehicle. Suspension durability, at the reduced test speeds, was considered satisfactory. Only eight end connectors were damaged by interference, and this was considered an improvement over results obtained with standard suspensions. The front volute springs bottomed frequently under the heavier loads and substitution of heavier springs was recommended. No adverse effects on riding or steering qualities were detected.
GENERAL: This 27-page report contains five photographs of the tank and the damaged end connectors.

RIA 47-351
B 5.2

SUBJECT: Tests, Special, Miscellaneous
TITLE: Vapor Blast Cleaning of Ball Bearings
IDENTIFICATION: Report No. 47-351
DATE OF REPORT: 17 June 1947
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the effect of vapor blast cleaning on the endurance life of ball bearings
METHOD: Three groups of five new, single row ball bearings were vapor blasted with No. 325, 1250, and 2500 mesh grit, respectively. After blasting, the dimensional characteristics and expected reduction of life of the bearings in each group were determined.
DESCRIPTION: The vapor blast cleaning process consisted of ejecting, at a high velocity, a mixture of abrasive particles, water, and rust inhibitor against the object being treated. Ejection rate of the vapor blast from a spray gun was 10 to 15 pounds per minute.
CONCLUSIONS: The vapor blast process did not affect the physical dimensions or normal operational life of the ball bearings. Abrasive remaining in the bearings after vapor blasting was found to be negligible. It was recommended that bearings be rotated during blasting operations to insure effective cleaning of the balls and raceways.
GENERAL: This 14-page report contains no illustrations.

RIA 48-68
B-5.6

SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of Specimen Surface Cleanliness by Use of a "Falling Drop" Method
IDENTIFICATION: Report No. 48-68; Project No. TB5-6101
DATE OF REPORT: 16 February 1948
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine a reproducible and fast method for accurately measuring surface cleanliness of test panels
METHOD: Various methods of determining the surface cleanliness were investigated. A simple "falling drop" method was devised using standard laboratory equipment. Numerous tests were conducted on test panels with clean and contaminated surfaces using the falling drop method. Photographs of the results were taken for comparison.
DESCRIPTION: Equipment used in the simple falling drop method were a 50-ml burette with an average delivery of two drops per .10 ml., a 50-ml beaker, a petri dish, distilled water, a tripod stand, and a burette holder.
CONCLUSIONS: The falling drop test, under controlled conditions was found to be superior over the currently used methods with regard to sensitivity, simplicity, and reproducibility.
GENERAL: This 25-page report contains a bibliography on the various methods tested. Also included are test data and photographs on the tests of the falling drop method.

RIA 48-238

SUBJECT: Tests, Special, Miscellaneous
TITLE: Fingerprint Neutralizing Compounds
IDENTIFICATION: Report No. 48-238
DATE OF REPORT: 9 April 1948
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To explore the problem of fingerprint removal, and to investigate the effectiveness of the synthetic fingerprint solution of USA Tentative Specification AXS-1719 compared with natural fingerprints and other synthetic solutions
METHOD: Twenty male members of the laboratory staff were investigated to find two or three subjects with the most corrosive fingerprints. The fingerprints of these subjects then were compared with the synthetic solution specified in Specification AXS-1719. The comparison was made by means of a corrosiveness test and an ease of removal test. The specified solution also was compared with several other synthetic solutions used by other investigators.
DESCRIPTION: Five commercial products used in the test with their designations and manufacturers were named in the report.
CONCLUSIONS: The synthetic print was more difficult to remove than the most active natural print encountered, apparently due to the greater amount of corrosive material deposited. In no instance did a compound, effective in removing the synthetic print, fail to remove natural prints. The AXS-1719 synthetic fingerprint solution and other synthetics investigated, despite moderate differences of concentration and constituency, were equally effective in evaluating fingerprint removing compounds. On the basis on the limited evidence available, the AXS-1719 synthetic fingerprint solution corresponded more closely to the concentration and pH of hand secretions normally encountered than did the other synthetic solutions, which, in the main, were based on analysis of general body sweat. Because of these factors, and the large body of data already accumulated by use of the AXS-1719 solution, its continued use was recommended.
GENERAL: This 41-page report includes 10 pages of photographs showing comparative results of the compounds with natural and synthetic fingerprints.

RIA 48-726

SUBJECT: Tests, Special, Miscellaneous
TITLE: Colorimetric Determination of Nitrate in Phosphate Coating Solutions
IDENTIFICATION: Report No. 48-726
DATE OF REPORT: 18 June 1948
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To develop a method for the determination of nitrate and nitrite in phosphating solutions
METHOD: A direct adaptation of the brown ring test for nitrate was investigated for the purpose of developing a rapid, accurate method for the determination of nitrate in phosphating solutions.
DESCRIPTION: The procedure developed for the determination of nitrate in a phosphating solution was carried out as follows: a 10% ferrous sulfate solution was added to a dilution of the phosphating solution; with the solution in a beaker, concentrated sulfuric acid was slowly added to the beaker from a pipette; the solution was mixed well and a transmittance was obtained at 520 millimicrons wavelength, using distilled water in the comparison cell;

the percent of nitrate (as NO_3) was determined from the standard transmittance-concentration curve.
CONCLUSIONS: A method for colorimetric determination of nitrate provided both speed and accuracy and was developed using a modified brown ring test. Volumes prescribed for the sample, ferrous sulfate, and sulfuric acid were critical in obtaining successful results.
GENERAL: This 11-page report contains two graphs showing spectral transmittance.

RIA 49-28
B-4.12.14

SUBJECT: Tests, Special, Miscellaneous
TITLE: Test Methods for Elastomers at Extreme Low Temperatures
IDENTIFICATION: Report No. 49-28; Thirteenth Report on Project No. TB4-520A
DATE OF REPORT: 14 January 1949
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate test methods used for elastomers at low temperatures
METHOD: An analysis of previous test methods was made by means of a library survey; an analysis was made of the test methods used at the Rock Island Arsenal.
DESCRIPTION: The library survey covered brittleness test methods, hardness test methods, structural test methods, and modulus or stiffness test methods. The Rock Island Arsenal test methods consisted of bent loop, and Izod and Charpy pendulum brittleness tests; Rex gage and Shore A and D durometer hardness tests; T-50 retraction, tension creep, and compression set, stress decay, and fatigue cell elastic recovery tests; linear contraction structural test; torsion flexing and bending beam stiffness tests; and Gasket-Bomb apparatus, brake cup stroking tester, and recoil and O-ring packing gymnasticator service tests.
CONCLUSIONS: A bibliography and brief resume of the library survey were given. Analysis of the survey and of Rock Island Arsenal methods resulted in the following general conclusions: laboratory tests should simulate service conditions as much as possible; the bent loop brittleness test currently covered in Government specifications was not considered sufficiently reproducible; elastic recovery tests were considered more practical than brittleness tests for articles used as packings or gaskets; modulus or stiffness tests were considered to have more value than brittleness tests for hose, tires, tubes, and mechanical applications where stiffness detracts from serviceability; Shore D hardness test correlated well with brittleness, stiffness, and elastic recovery tests.
GENERAL: This 48-page report includes 17 pages of photographs of testing equipment.

RIA 49-1296

SUBJECT: Tests, Special, Miscellaneous
TITLE: Proposed Draft of a Unified Military Specification for Thin Film Rust Preventive
IDENTIFICATION: Report No. 49-1296
DATE OF REPORT: 25 January 1950
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To develop a water stability test combining water displacement and water stability
METHOD: A water stability test was developed for the testing of rust preventive compounds. Rust preventives were diluted to observe the effect of dilution on water displacing performance. Materials qualified under the Bureau of Ships Specification 52C18, which employed rusted cylinders in its water displacement test, were compared to materials qualified under Army Specification AXS-1759, which used unrusted panels.
DESCRIPTION: Three unrusted panels were prepared, which were dipped in water momentarily and drained in a vertical position for not more than 5 seconds with the bottom edge in contact with absorbent paper. The panels were immersed horizontally for 15 seconds without agitation in a petri dish containing the rust preventive compound. After momentary draining, the panels were placed in a static humidity cabinet for 1 hour at 75°F. If upon removal of the rust preventive coating with naphtha, the panels showed no evidence of rust or surface stain, the compound was considered satisfactory.
CONCLUSIONS: The water stability test was considered satisfactory and was recommended as a replacement for the then current AXS-1759 water displacement test. Dilution of rust preventatives proved important in determining the factor of safety provided by manufacturers in insuring water displacement action and as a reflection of the amount of additive used in their product. It was recommended that a dilution test be incorporated in the next specification revision. The water displacement test recommended was found to be more selective than one employing rusted surfaces, since poor or borderline materials could not be detected on rusted specimens. Water displacing rust preventatives apparently displaced water and arrested further rusting dependent on the inherent protective characteristics of the compound.
GENERAL: This 49-page report contains 11 photographs showing test panels.

RIA 50-1613

SUBJECT: Tests, Special, Miscellaneous
TITLE: A Method for Revealing Imbedded Abrasive Particles in Sandblasted Steel Surfaces
IDENTIFICATION: Report No. 50-1613
DATE OF REPORT: 1 August 1950
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate a dye technique as a convenient means for making imbedded silica or alumina particles microscopically visible
METHOD: Clean sandblasted panels were immersed in 0.5% solution of various dyes in distilled water for 30 minutes at room temperature. The panels were cold water rinsed and dried by clean compressed air. The panels were given a microscopic examination for uniform and continuous film. The panels showing the best results were further studied to determine where the greatest absorption and continuity occurred.
DESCRIPTION: The test dyes were: chrysordine R; methylene blue; methyl violet 2B; nigrosine black WS; alizarin red R; congo red; AZO carmine B; biebrech scarlet.
CONCLUSIONS: This method provides a means of determining the degree of contamination of boned, lapped, or polished surfaces of cylinders, rods,

etc. The results proved that the more prolonged the blasting treatment the finer the imbedded particles become. The suspected but heretofore unproven existence of contamination on sandblasted or alundum abrasive blasted surfaces may be the cause of numerous cases on non-reproducibility encountered in corrosion testing procedures using sandblasted steel panels.
GENERAL: This 11-page report includes two photomicrographs showing imbedded silica particles.

RIA 51-1036
SUBJECT: Tests, Special, Miscellaneous
TITLE: Friction Studies of Packing Materials, Cylinder Materials and Lubricants Applicable to 90/mm A.A. Recoil Mechanisms
IDENTIFICATION: Report No. 51-1036
DATE OF REPORT: 29 June 1951
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To compare the coefficients of friction of various packing materials, cylinder materials, and lubricants used in recoil mechanisms
METHOD: Base plates were prepared from the cylinder materials, and the upper contacts or strips were prepared from the packing material under test. The specified base plate and holder with strips of pad made of the specified packing material were mounted in a reciprocating plate machine. The sleigh reservoir was filled with the specified oil, or the specified grease was applied to the base plate. After completing the "wearing in" process, the dynamic and static frictional forces were recorded on a Brush Strain Analysis and Pen recorder. Coefficients of friction were calculated from a formula given in the report.
DESCRIPTION: The recoil cylinder materials tested were WD144D steel and two different copper-nickel alloys. Test recoil mechanism packings used were annealed silver, unfilled leather, an Alcoa aluminum alloy, Teflon plastic produced by E. I. duPont de Nemours and Company, and an antifriction metal. Army-Navy Aeronautical Specification AN-O-366 oil, the same oil with several different additives, and US Army Tentative Specification AXS-808 recoil oil were used in the test. Greases tested conformed to US Army Specification 2-134, 2-39D, and Army Tentative Specification AXS-1169, respectively.
CONCLUSIONS: It was concluded that the antifriction properties of steel were superior to copper-nickel alloys. The antifriction properties of Specification AXS-808 recoil oil, at normal temperatures, were superior to all other recoil oils tested. The use of antifriction additives in Specification AN-O-366 hydraulic oil decreased friction when used in conjunction with silver, but had little or no effect on aluminum, leather, and teflon. The coefficient of friction of leather was not appreciably affected by the type of lubrication of cylinder material.
GENERAL: This 38-page report contains four photographs showing test apparatus and several test samples. Also included are sample brush friction records and graphs showing the coefficients of friction with the various lubricants.

RIA 51-1107
SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of Sulfate Concentration in Chromium Plating Baths by Use of Radiobarium
IDENTIFICATION: Report No. 51-1107
DATE OF REPORT: 4 April 1951
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate an experimental method for the determination of sulfate concentration in chromium plating bath
METHOD: Comparative tests using the new method and the then current gravimetric method were conducted using plating tank samples. Similar tests were conducted using a known sulfate concentration.
DESCRIPTION: The experimental procedure utilized radiobarium in the precipitating agent for the determination of sulfate concentration. The sulfate was precipitated as barium sulfate by adding 15 ml of 10% $BaC/_2$ containing radiobarium as a tracer. After filtration, the filtrate was made up to 200 ml; a 1-ml aliquot of the solution was pipetted into a stainless steel cup, dried under an infrared lamp, and counted. It was assumed that this counting rate would be proportional to the excess amount of barium not used for the precipitation and inversely proportional to the amount used and to the amount of sulfate ion in the original sample.
CONCLUSIONS: The results of both types of tests were in fair agreement. However, comparative tests using a known sulfate concentration indicated that better results could be obtained by the radiometric method. The radiometric method would provide results which, it was believed, would be free of the inaccuracies of the gravimetric method, although the analysis time was not reduced. It was recommended that the radiometric method be explored further to determine its degree of accuracy. The method could be used to determine sulfate concentration either alone or in conjunction with the gravimetric test.
GENERAL: This 24-page report contains a graph illustrating the use of the standard curve method. Also included are tables showing counting rates obtained during testing.

RIA 51-1145
SUBJECT: Tests, Special, Miscellaneous
TITLE: Six Year Storage Program Tests, Packaged Items
IDENTIFICATION: Report No. 51-1145
DATE OF REPORT: 28 March 1951
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the effectiveness of various packaging methods and materials
METHOD: This inspection was conducted after a year of storage, the entire duration of which was to be 6 years. A total of 18 boxes were opened and their contents examined. As each box was opened, its exterior condition and liners were carefully observed. Packaged items were opened and evaluated with respect to: exterior of the unit pack, wrapping or barrier materials, rust preventive or preservative compounds used, and the usability of the packaged item.
DESCRIPTION: Three types of storage were used: open, shed, and warehouse. The exposure sites

were: Rock Island Arsenal, Illinois; Red River Arsenal, Texarkana, Texas; and the San Jacinto Ordnance Depot, Houston, Texas. Two boxes from each type of storage were supplied by the three storage sites.
CONCLUSIONS: The warehouse and shed stored boxes were satisfactory; the items in these boxes were in good condition. With respect to the boxes which had been in open storage, a need was indicated for stronger, tougher, more water-resistant box liners, impervious to mold and fungus growth; the liners that did not develop fungi or mold growth under the box lid provided fair protection during this type of storage.
GENERAL: This 161-page report contains 42 photographs of the boxes, packaging materials, and stored items. Also included are tabular results of the inspections and a copy of the packaging instructions used.

RIA 51-5429
SUBJECT: Tests, Special, Miscellaneous
TITLE: Examination and Evaluation of Miscellaneous Items for Natural Cooler Storage
IDENTIFICATION: Report No. 51-5429
DATE OF REPORT: 11 January 1952
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the effectiveness of natural cooler storage on packaged items
METHOD: Evaluation of the natural cooler storage method was made by examination of rubber items, small arms weapons, and fire control equipment after 1 year of storage. Observations were noted of rust deposits, pitting, corrosion, condition of paint surfaces, condensation, dirt, fungus growth, and cement separation.
DESCRIPTION: The examined items were: two Goodyear 8.25 x 20 mud and snow type tires; 144 inner tubes 6.00 x 16 for trucks and buses; 60 carbines cal. .30, M1 with sling and oiler; and, 18 telescopes M69C W/E.
CONCLUSIONS: Examination of the tires, inner tubes, and telescopes showed them to be in excellent condition. The light rust deposits found in the carbine bores indicated the presence of moisture in the bores at the time of packaging, resulting from improper or careless cleaning methods. These rust deposits were found in the majority of all carbine bores, irrespective of the type of packaging material used. It was recommended that the remaining portion of this lot of carbines be withdrawn from underground storage test and reprocessed before the weapons become unserviceable from bore rusting.
GENERAL: This 30-page report includes 14 photographs of test results.

RIA 51-5430
SUBJECT: Tests, Special, Miscellaneous
TITLE: Radiocobalt Gage for Determining Liquid Level
IDENTIFICATION: Report No. 51-5430
DATE OF REPORT: 30 January 1952
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To devise a method for measuring a liquid level in the closed system of a Pfaudler vacuum evaporator
METHOD: A liquid level gage which employed a radiocobalt source and a count rate meter for detection was designed, constructed, and tested.
DESCRIPTION: The subject radioactive gage employed a source on one side of the tank and a detector on the other side, both mounted on the outside of the tank. The source consisted of a piece of cobalt wire 1/2-inch long and 1 mm in diameter, irradiated to possess an activity of approximately 36 millicuries. The detector was a Keleket K-900 radiation monitor which used a 30 mg./cm.^{2} aluminum wall Geiger-Muller tube.
CONCLUSIONS: The test results prove that the water level in the evaporator could be located within 1/2-inch very readily, and within 1/4-inch after taking a few additional readings. The accuracy of the determinations noted was well above the accuracy required for this particular installation.
GENERAL: This 16-page report includes one photograph of the test gage installed.

RIA 52-502
SUBJECT: Tests, Special, Miscellaneous
TITLE: Six Year Storage Program Tests Packaged Items
IDENTIFICATION: Report No. 52-502
DATE OF REPORT: 14 March 1952
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the effectiveness of the various packaging methods and materials, and the economy of the system
METHOD: Three boxes from each, open, shed, and warehouse storage, were removed and the contents examined. The following conditions were noted; the exterior of the box as regards to weathering, rough usage, the box liner leakage in relation to respective items, the exterior of the unit pack, various wrapping or barrier materials, rust preventive or preservative compounds, and the items from protection afforded. The packaged items were evaluated as ready for issue, unusable but reclaimable, scrap, or salvage.
DESCRIPTION: The boxes of packaged items had been stored for 1 year and 6 months at Rock Island, Red River, and San Jacinto storage sites. The test was to continue for 6 years. This report covers the first year and a half of the test.
CONCLUSIONS: The condition of packaged items after 1 year and 6 months storage indicated the need for a stronger, tougher, absolutely water-resistant case liner, impervious to mold or fungi growth. The liners that did not develop fungi or mold growth under the box lid provided good protection during the period in open storage. Warehouse and shed stored boxes were satisfactory, no failures of liner or packed items were observed.
GENERAL: This 129-page report includes 17 photographs of the packaged items.

RIA 52-1586
SUBJECT: Tests, Special, Miscellaneous
TITLE: Polyethylene Packages in Contact with Petroleum Preservatives
IDENTIFICATION: Report No. 52-1586
DATE OF REPORT: 1 May 1952
ORIGIN: Rock Island Arsenal, Illinois

PURPOSE: To determine the resistance of polyethylene containers to the action of petroleum based lubricants and preservatives over the temperature range of 70° to 158°F
METHOD: The resistance of injection molded polyethylene containers, both "as molded" and "stress relieve", to various lubricants, greases and preservatives was determined after 5 days' immersion at temperatures of 70°, 120°, and 158°F. Properties determined were tensile strength, percent elongation, hardness, volume change, stiffness, water absorption, and moisture vapor transmission.
DESCRIPTION: The polyethylene containers used in these tests were of Rock Island Arsenal design and were purchased from Industrial Plastic Company (brown container) and the Republic Molding Corporation (black container), both of Chicago.
CONCLUSIONS: Changes in physical properties of polyethylene were found to be dependent on the temperature and the type of preservative employed. It was recommended that polyethylene containers be used for packaging of precision parts when petroleum lubricants, greases and preservatives do not come in direct contact with the polyethylene and whenever the metal parts could be protected by vapor corrosion inhibitors only. It was further recommended that precision parts of Ordnance material be packaged in the manner prescribed in RIA laboratory Report No. 50-2187, page 3.
GENERAL: This 24-page report includes three photographs of the test specimens.

RIA 52-3201

SUBJECT: Tests, Special, Miscellaneous
TITLE: Radiometric Study of the Chromium Sulfate Complex Formed in Chromium Plating Baths
IDENTIFICATION: Report No. 52-3201
DATE OF REPORT: 10 September 1952
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the ionic nature of the coordination complex formed from sulfate and trivalent chromium ions during electrolysis
METHOD: Tests were conducted on a solution which was compounded to simulate an actual chromium plating bath. Radio-sulfur was added to this solution in the form of sulfuric acid. This solution was then electrolyzed under conditions favorable to the formation of trivalent chromium. The electrolyzed solution was subjected to a cationic resin column designed to remove all positive ions. The column was then regenerated with hydrochloric acid to remove the exchanged ions. Sulfate and trivalent chromium analyses were made on the original solution, and the regenerating acid solution.
DESCRIPTION: A radiometric method for determining small substances, described by Friedlander and Kennedy — "Introduction to Radio-chemistry", John Wiley & Sons, Incorporated 1949 — was adopted and modified for the determination of sulfate concentrations in chromic acid baths. This method was described in Rock Island Arsenal Report No. 51-3780.
CONCLUSIONS: The chromium sulfate complex formed was cationic in behavior and could be removed from the plating solution by employing the appropriate ion exchange media. Approximately 7% of the available sulfate concentration was tied up as a chromium sulfate complex. The efficiency of the resin column in removing trivalent chromium from the solution was over 90%. The formation of a large complex ion was indicated by the fact that the per cent of sulfate regained from the resin column was considerably less than and independent of the amount of trivalent chromium regained.
GENERAL: This 25-page report is not illustrated.

RIA 52-5318

SUBJECT: Tests, Special, Miscellaneous
TITLE: Carbon Removal from Machine Gun Parts
IDENTIFICATION: Report No. 52-5318
DATE OF REPORT: 3 April 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate, improve and/or develop cleaning materials for Ordnance applications, obtain performance limits and improve or develop test methods
METHOD: Several commercial cleaners and carbon removers were tested and the best ones analyzed. Several formulations were made and tested for cleaning efficiency. Various modifications of the booster and/or plating were then tested for the removal of the carbon deposits.
DESCRIPTION: The machine gun used was a cal. .30 M2 converted to a cal. .30 T9 trainer.
CONCLUSIONS: Although several good commercial cleaners were available none was considered satisfactory. It was found that certain coatings were beneficial in inhibiting soiling of booster parts. Further investigation of the design and material for fabrication should be conducted.
GENERAL: This 14-page report includes one photograph of the dirty component parts of a standard booster and one page of booster designs.

RIA 52-5396

SUBJECT: Tests, Special, Miscellaneous
TITLE: Examination and Evaluation of Miscellaneous Items from Natural Cooler Storage
IDENTIFICATION: Report No. 52-5396
DATE OF REPORT: 9 April 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate the storage results on items packaged and stored for a period of approximately 2 years in Natural Cooler Storage at Atchison, Kansas
METHOD: Samples of each of the three groups, rubber items, small arms, and optical equipment, were removed and inspected for signs of deterioration. A comparison of the methods and materials used in preparing the items for storage was also made.
DESCRIPTION: The three groups of items were: rubber items, consisting of two tires and 144 inner tubes; small arms, consisting of 60 carbines, cal. .30 M1, with accompanying slings, oilers, and magazines; optical equipment, consisting of 18 telescopes, M69C, W/E.
CONCLUSIONS: Examination of the rubber items showed the articles to be serviceable even though the butyl inner tubes showed a loss of physical properties. The small arms group showed very light rust deposits in the bores, chambers and on a very few external surfaces. A thorough cleaning removed these traces of rust and the weapons

were considered serviceable. Detailed examination showed slight films of condensate on some of the optical elements, and scattered amounts of loose dirt and brass chips. These conditions were of a negligible nature and were not considered detrimental at the time. The degree of corrosion on the small arms indicated that the weapons were approaching a critical point. The rust had formed regardless of the method of packaging employed, which indicated that moisture was not completely removed by the cleaning process. It was recommended that the remaining portions of this lot of carbines be removed from underground storage test and reprocessed.
GENERAL: This 35-page report includes 15 photographs of the storage items.

RIA 53-638
SUBJECT: Tests, Special, Miscellaneous
TITLE: Determination of the Solubility of Ferric Phosphate in Phosphating Solutions Using Radioiron
IDENTIFICATION: Report No. 53-638
DATE OF REPORT: 17 June 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the solubility of ferric phosphate in various phosphating solutions
METHOD: Several tests were conducted to determine the solubility of ferric phosphate in various strengths of phosphating solutions, with and without added nitrate as an accelerator. Radioactive iron was used to prepare the precipitates of ferric phosphate which were then allowed to come to equilibrium with the various test solutions. Aliquot portions of the test solutions, after removal of the undissolved ferric phosphate, were dried and counted for comparison with controls containing known amounts of radioiron dissolved in similar solutions. Based on the results of the counting determinations, the solubility of ferric phosphate in the various test solutions was calculated.
DESCRIPTION: Twelve phosphating solutions were used for the solubility tests. These solutions were divided into two groups; the first group contained zinc phosphating compound without nitrate, while the second contained a zinc phosphating compound with added nitrate accelerator.
CONCLUSIONS: The solubility of ferric phosphate in all the test solutions was greater at 70°F than at 200°F. The solubility of the ferric phosphate was greatly enhanced by the addition of the nitrate ion, based on the results of tests conducted at 70°F. The results of the tests at 200°F were too low and erratic to permit a similar conclusion. Solubility of ferric phosphate in phosphoric acid increased inversely with the pH of the solution, although not linearly. A leveling off of the solubility at lower pH values could be attributed to an insufficient excess of solute used. It was recommended that nitrate concentration in a phosphating be held between 1.0% and 2.5%. It was also recommended that automatic temperature control equipment on phosphating baths be throttled to allow for a long heating cycle and a short cooling cycle. At no time should all of the sludge be removed from a phosphating bath.
GENERAL: This 25-page report contains one photograph of equipment used in saturating solutions with radioactive ferric phosphate.

RIA 53-2670
SUBJECT: Tests, Special, Miscellaneous
TITLE: An Evaluation of Analytical Methods for Volatile Corrosion Inhibitors
IDENTIFICATION: Report No. 53-2670
DATE OF REPORT: 22 September 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To evaluate chemical methods for the quantitative determination of total nitrite and urea in volatile corrosion inhibitors
METHOD: Two methods for the quantitative chemical determination of volatile corrosion inhibitors were evaluated. An attempt was made to utilize the Nox-Rust Chemical Corporation method in a Beckman Model DU spectrophotometer and a Coleman spectrophotometer. The Shell method for nitrite determination plus several adaptations were utilized as outlined in the report. The possibility of the interference of urea in the determination of sodium nitrite by the Shell method was studied. The validity of random selection of samples of a coated carrier was determined by systematic selection of samples from a roll of the carrier followed by a qualitative chemical analysis of these samples.
DESCRIPTION: The Nox-Rust Chemical Corporation method for the quantitative chemical determination of volatile corrosion inhibitors was based on a diazotization and coupling reaction between sodium nitrite, sulfanilic acid, and alpha-napthylamine. The Shell method was based on the same reactions; however, sulfanilamide and N-(1-naphthyl)-ethylene diamine dihydrochloride were employed as the diazotizing and coupling reagents.
CONCLUSIONS: The method suggested by the Nox-Rust Chemical Corporation for the determination of total nitrite and urea was unsatisfactory. However, the Shell method was considered adequate for the determination of inorganic and organic nitrite salts which have been commonly used as volatile corrosion inhibitor chemicals. Urea did not interfere with nitrite determination by the Shell method. It was shown that some coated carriers do tend to vary considerably in inhibitor content as one proceeds across the roll. Little variation was found by advancing into the roll.
GENERAL: This 42-page report is not illustrated.

RIA 53-4519
SUBJECT: Tests, Special, Miscellaneous
TITLE: High Energy Radiation of Polymers, a Literature Review
IDENTIFICATION: Report No. 53-4519
DATE OF REPORT: 5 November 1953
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine the effect of irradiation of polymers on physical properties such as oil and heat resistance and aging
METHOD: A survey of the available pertinent literature was made. The Atomic Energy Commission was contacted to obtain additional information.

DESCRIPTION: The various articles used in the survey were taken from chemical and nuclear science abstracts for the past five years. A bibliography was included in the report.
CONCLUSIONS: It was found that it was possible to produce cross-linkage in various polymers by exposure to high radiation. Cross-linkage could also be produced in a variety of elastomers by means of irradiation with high energy electrons. The effect of neutron irradiation rubber vulcanizates was found to be advantageous for natural rubber but degrading for polyisobutylene. The harmful effect of radiation decreased in the following sequence: halogenated polymers, aliphatic polymers, and aromatic polymers. The irradiation of polyethylene was found to improve its resistance to heat and solvents; it was believed, therefore, that the heat and oil resistance of rubber might be improved by exposure to radiation. It was recommended that a program be initiated at the Rock Island Arsenal to study the possibility of improving the oil and heat resistance and aging characteristics of various rubber formulations by exposure to high energy radiation.
GENERAL: This 18-page report is not illustrated.

RIA 54-2085

SUBJECT: Tests, Special, Miscellaneous
TITLE: A Procedure for the Use of the Platinum Resistance Thermometer as a Temperature Standard
IDENTIFICATION: Report No. 54-2085
DATE OF REPORT: 9 June 1954
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To set up a detailed procedure for the use of the platinum resistance thermometer; and to calibrate various mercury-in-glass-thermometers, and a copper-constantan thermocouple at temperatures that were utilized in corrosion preventive work at the Rock Island Arsenal
METHOD: The determination of the various temperatures by platinum resistance thermometry was carried out by the use of a Leed and Northrup apparatus in which temperature was determined by the resistance of a constant length of platinum wire. In the initial calibration of this unit, the resistance of the platinum coil was measured at the ice point, the steam point, and the boiling point of sulfur. Mercury-in-glass thermometers and a copper-constantan thermocouple were calibrated at various temperatures between -65° and 250°F.
DESCRIPTION: None.
CONCLUSIONS: The platinum resistance thermometer and associated apparatus were assembled and found satisfactory for applications at the Rock Island Arsenal.
GENERAL: This 20-page report includes one photograph of the assembled apparatus for platinum resistance thermometry.

RIA 54-2086

SUBJECT: Tests, Special, Miscellaneous
TITLE: Phosphate Coating Retention During Cold Extrusion of Artillery Shells
IDENTIFICATION: Report No. 54-2086
DATE OF REPORT: 10 June 1954
ORIGIN: Rock Island Arsenal, Illinois
PURPOSE: To determine whether the zinc phosphate coating applied to steel pieces prior to extrusion was substantially removed during the cold extrusion process
METHOD: Steel slugs which had been through the first step of the 105mm shell extrusion process were prepared for the second step by precleaning, phosphating in a radioactive phosphating bath and applying a lubricating soap film. Counting rates before and after extrusion were then determined by a radiometric technique, and the percent of retained phosphate coating was calculated.
DESCRIPTION: This report was concerned with phosphate coatings applied to steel pieces prior to extrusion. These coatings were utilized for the purpose of preventing a metal-to-metal contact between the die and the metal being worked, thus preventing wear to the die under the tremendous pressures applied during the cold extrusion process.
CONCLUSIONS: The zinc phosphate coating applied to steel pieces prior to extrusion was not substantially removed by the cold extrusion process as evidenced by an average retention of 89%. The area with the least elongation after the extrusion contained more phosphate than the areas with the most elongation.
GENERAL: This 15-page report contains two photographs, one of the test setup, the other of a steel slug after the second cold extrusion.

SC-13B

SUBJECT: Tests, Special, Miscellaneous
TITLE: Ferromagnetic Resonance in Iron Oxide
IDENTIFICATION: Report No. 13B
DATE OF REPORT: 11 March 1949
ORIGIN: Princeton University, Princeton, New Jersey
PURPOSE: To present analyses of ferromagnetic resonance in iron oxides
METHOD: Previous investigations on the phenomenon of ferromagnetic resonance in iron oxides were reviewed. Examinations were made of the observed permeability versus frequency curves of two iron oxides. Formulas were presented showing the broad field of resonance of the oxides. Calculations were made of the internal anisotropic magnetic field intensities. Attempts were made to represent an absorption mechanism by an idealized damped oscillator or Gaussian absorption mechanism. The report was prepared by the Plastics Laboratory of Princeton University.
DESCRIPTION: The two iron oxides considered were ferrosoferric oxide and gamma-ferric oxide.
CONCLUSIONS: An analysis of the data indicated that an idealized mechanism such as a Gaussian or damped oscillator does not represent the resonant mechanism for Fe_3O_4 and gamma-Fe_2O_3. Reasonable values of the internal anistropic magnetic fields appeared to be 600 Gauss for Fe_3O_4 and 400 Gauss for gamma-Fe_2O_3. It was thought that the broadness of the observed ferromagnetic resonance absorption may have been due in part to the interaction of magnetic dipoles causing

perturbations in the valve of the internal magnetic field about which there is spin precession.
GENERAL: This 19-page report contains five graphs.

T-61905

SUBJECT: Tests, Special, Miscellaneous
TITLE: Medium Tank M3A4 with A-57-A Engine — Kinetic Energy of Rotation and Equivalent Weights of all Rotating Parts
IDENTIFICATION: Report No. T-61905
DATE OF REPORT: 18 March 1942
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine the kinetic energy of rotation and equivalent weights of all rotating parts in the tank
METHOD: The moments of inertia of the various test objects were calculated after obtaining test object periods of oscillation from calibrated torsional pendulum arrangements. The speed of the respective rotating parts with respect to ground speed was determined. From these factors, the kinetic energy of rotation was calculated. The effect of this energy was then expressed in equivalent weights at different tank speeds.
DESCRIPTION: The information in this report was primarily based on a Medium Tank M3A4 powered by a Chrysler multi-bank A-57-A engine with a 71:25 final-drive ratio and 1.25:1 engine-reduction ratio. To obtain the more practical equivalent weights, the effect of the kinetic energy of a rotating part, i.e., crankshaft, drive gear, clutch, etc., was expressed as a mass (equivalent weight divided by acceleration due to gravity) which produced an equivalent kinetic energy when it traveled at the speed of the vehicle.
CONCLUSIONS: The inertia of the rotating parts of the test tank had the same effect on the total inertia in fifth gear operation as adding 22,000 pounds or 35% to the tank weight. In fourth gear this increased to 62% and in third gear it reached 138%. This inertia was predominantly due to the effect of the fan and clutch; the effect of the engine was small and not significant enough to disqualify the multi-bank in favor of a radial-type engine.
GENERAL: This 24-page report includes two curve sheets and the mathematics used for calculating rotational energy and equivalent weights.

T-62202.8

SUBJECT: Tests, Special, Miscellaneous
TITLE: Weight Study of Combat Vehicles
IDENTIFICATION: Report No. T-62202.8; CX Project No. 161
DATE OF REPORT: 22 February 1944
ORIGIN: Chrysler Engineering Division, Detroit, Michigan
PURPOSE: To determine comparable basic weights of various types of vehicles under similar loading conditions
METHOD: Four Hi-way Loadmeter scales were placed under the corners of each vehicle. Vehicles under modification at the time had their hulls and turrets weighed separately and then the weights were combined for total weight. The weights of the various tracks and stowed equipment were taken separately and added to the total vehicle weights.
DESCRIPTION: The vehicles weighed were the M4, M4A1, M4A2, M4A3, M4E5 and M4E6 Tanks and the T-22 and T-70 Gun Motor Carriages. The combat weight allowance for the crew was set at 875 pounds.
CONCLUSIONS: No formal conclusion was drawn due to the nature of the project. Comparison lists of the combat weights of the various vehicles and vehicle accessories were included.
GENERAL: This 76-page report contains 23 photographs showing construction of the various types of tracks used on the vehicles and the method of weighing the hulls of the vehicles.

WAL 120/42

SUBJECT: Tests, Special, Miscellaneous
TITLE: The Chemical Analysis of Tool Tips Containing Carbides of Tungsten, Columbium, Tantalum Bonded in a Cobalt Matrix
IDENTIFICATION: Report No. WAL 120/42
DATE OF REPORT: 25 February 1946
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To describe a method for the analysis of tool tips containing carbides of tungsten, columbium, tantalum and titanium bonded in a cobalt matrix
METHOD: Five methods of chemical analysis of carbide tips were tried and evaluated. The method adopted with modifications was a combination of methods furnished by General Electric and Kenna-Metal Inc.
DESCRIPTION: The test apparatus included a 300 ml platinum dish, steam bath, Spectrophotometer, Jones Reductor, muffle furnace, Braun electrolytic apparatus, and carbon combustion apparatus. The test procedure employed 30 reagents.
CONCLUSIONS: The procedure adopted proved satisfactory, with a reasonable expenditure of time. The method was adequate for relatively coarse materials (80 mesh).
GENERAL: This 15-page report includes a table of typical compositions of the carbide materials analyzed.

WAL 142/45

SUBJECT: Tests, Special, Miscellaneous
TITLE: An Evaluation of Radiography, With Particular Emphasis on Detection Methods
IDENTIFICATION: Report No. 142/45
DATE OF REPORT: 1 March 1950
ORIGIN: Watertown Arsenal Laboratory, Mass.
PURPOSE: To analyze radiographic methods as applied to production; to evaluate the possibility of developing improved detection devices for penetrating radiation
METHOD: The radiographic method for the nondestructive testing of materials was described with respect to its past development, present status, and possible future objectives.
DESCRIPTION: Penetrating radiations utilized for nondestructive testing, up to the time of this report, have consisted of X-rays and radium emanation, with X-rays having the greater application. References consulted for this discussion were listed in the report.

CONCLUSIONS: It was concluded that the most profitable line of investigation in the field of radiographic testing involved the development of new and improved detection techniques. Suggested techniques employing television and electronic principles showed promise of improvement in both the quality of inspection data and the speed with which it could be obtained. The ultimate end product of such developmental efforts could be automatic or semi-automatic inspection instrumentation serving in modern, high speed, industrial production. Increased assurance of the quality of production over that obtained by spot check or sampling methods could thereby be realized.
GENERAL: This 15-page report contains two X-ray photographs showing contrasting thickness of steel.

WAL 142/53
SUBJECT: Tests, Special, Miscellaneous
TITLE: An Evaluation of Stereoradiography as an Ordnance Inspection Tool
IDENTIFICATION: Report No. 142/53
DATE OF REPORT: 25 April 1951
ORIGIN: Watertown Arsenal Laboratory, Watertown, Massachusetts
PURPOSE: To evaluate the applicability of stereoradiography to the examination of Ordnance material.
METHOD: Fifty stereoradiographic pairs were produced in an effort to investigate the importance of radiographic procedure and method of presentation upon the ability of an observer to appreciate the third dimension. A comprehensive examination of literature concerning stereoradiography was made, and the findings were employed in a discussion of the practical problems associated with the subject.
DESCRIPTION: In stereoradiography, it was necessary to make two exposures of each subject. In each instance, a different prospective was used, thus stimulating the conditions of binocular vision. The display of the resulting negatives was accomplished by utilizing an equipment or means wherein each eye of the observer was permitted to view but one negative. Thus, the fundamental prerequisites for three dimensional vision were fulfilled.
CONCLUSIONS: The success of stereoradiographic methods for inspection of material was heavily dependent upon the physiological and psychological aptitude of the individual observer. Although the radiographic production of three dimensional pairs required certain adherence to fundamental rules, it was routine and but little more difficult to perform than standard two-dimensional radiography. The application of stereoradiography to the examination of Ordnance material has been limited in scope; however, such limitation could be reduced by adequate training of the personnel involved.
GENERAL: This 27-page report contains a drawing illustrating the principle of stereoscopic vision.

WAL 143/14-42
B 2.8
SUBJECT: Tests, Special, Miscellaneous
TITLE: The Detection of Intermediate and Small Flaws in Solid Materials
IDENTIFICATION: Report No. WAL 143/14-42
DATE OF REPORT: November 1953
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To demonstrate the possibility of detecting the presence of minute flaws in solid materials by ultrasonic radiation even though no echo from the flaw is observable
METHOD: Direct ultrasonic attenuation measurements were made of steel samples with a directly coupled transducer. Measurements were conducted until it was found that the echo patterns were almost all anomalous. Two samples were cut open for visual observation. The balance of the samples were "scanned" using the water bath technique. Photographs were taken of the process starting at the center of the sample and spaced evenly in both directions from the sample. This project was conducted by Brown University.
DESCRIPTION: The 4150 steel test samples were cut from 1-1/2-inch diameter bar stock and each sample was about 2-1/2 inches long. The test material was hardened, cut, and ground flat and parallel.
CONCLUSIONS: It was found that flaws which could not be detected by conventional echo methods in solid material could be detected by observation of certain behavior of the pulse attenuation pattern. The deviation of the pulse amplitude decay from exponential form was, under proper circumstances, taken as evidence of intermediate or small flaws.
GENERAL: This 16-page report includes two pages of photographs of test patterns, one specimen drawing, and one test diagram.

WAL 310/118-1 (310/121)
SUBJECT: Tests, Special, Miscellaneous
TITLE: Discontinuous Crack Propagation — Further Studies (Second Partial Report on Crack Propagation)
IDENTIFICATION: Report No. 310/118-1 (310/121)
DATE OF REPORT: 3 August 1949
ORIGIN: Watertown Arsenal, Watertown, Mass.
PURPOSE: To study discontinuous crack propagation in specimens fractured under conditions of repeated bending and of dynamic loading
METHOD: Specimens which had been subjected to and had failed under fatigue and impact tests were examined microscopically to determine the presence, origin, path, and nature of the discontinuous crack propagation.
DESCRIPTION: The test specimens were made of steel.
CONCLUSIONS: Microcracks of a discontinuous transcrystalline nature appeared to occur in severly stressed areas devoid of appreciable plastic deformation. These microcracks apparently developed as a result of localized points of high stress concentration induced under triaxial stress conditions. The microcracks indicated that brittle transgranular fracture of polycrystalline metals did not originate at one point and propagate continuously across the material, but rather nucleated at numerous points, leading to a series of microcracks, part of which subsequently linked up to form the final fracture.

GENERAL: This 23-page report includes 10 microphotographs of the fractured specimens.

WAL 401/98-13

SUBJECT: Tests, Special, Miscellaneous
TITLE: Spectrochemical Analysis of Titanium Metals and Alloys
IDENTIFICATION: Report No. WAL 401/98-13; Project No. TB4-15C
DATE OF REPORT: September 1952
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To study spectrochemical methods for analyzing titanium and titanium alloys
METHOD: Three different solutions of titanium alloys were prepared from fusion mixtures, titanium iodide metal, and titanium-potassium oxalate from the titanium alloys. A spectrochemical method was used to analyze the solutions. Solutions containing ions of the three alloying test elements were treated with oxidizing agents to alter their valences. The solutions were then analyzed by the porous-cup technique for the purpose of checking the valence effect of spectral intensities and intensity ratios. Metal samples were analyzed by direct sparking. Photographic recording was made and analytical curves were drawn. This research project was conducted by the University of Michigan.
DESCRIPTION: The two test titanium-base alloys had the nominal composition of 1.3% iron — 2.7% chromium (150A) and 5% iron — 10% chromium. The synthetic standard solutions were from titanium sources which were either titanium oxide, titanium metal, or titanium-potassium oxalate. The spectrograph used was a large Litrow quartz-prism instrument.
CONCLUSIONS: The test procedure used was practical for quantitative spectrochemical analysis without available standards. Direct sparking of metal samples brought out the segregation properties of titanium alloys. The test methods had adequate sensitivity for trace analysis down to .05% and possibly to .01% of either Fe or Cr. The titanium solutions prepared from fused TiO_2 were not stable. The spectrochemical analysis of solutions was not sensitive to the ionic state of the elements and had no effect upon the intensities.
GENERAL: This 30-page report includes four pages of analytical curves.

WAL 730/652

SUBJECT: Tests, Special, Miscellaneous
TITLE: Procedure for Estimating Band Loss Due to Wear During Travel and Application to Projectile Fired from a 37mm Gun
IDENTIFICATION: Report No. 730/652
DATE OF REPORT: 10 October 1952
ORIGIN: Watertown Arsenal, Watertown, Mass.
PURPOSE: To develop a computational procedure utilizing experimental data for estimating reduction in band diameter due to wear during travel in the gun tube, and to apply this method to data obtained in a firing test of a 37mm gun
METHOD: A detailed outline of the development of the procedure is presented in the report. Data accumulated from a firing test of a 37mm gun, described in Report No. 739/95 were used to illustrate the procedure.
DESCRIPTION: Not applicable
CONCLUSIONS: A procedure was developed for estimating the reduction in band diameter due to its wear during travel in the gun tube. Knowledge of band pressure, gas pressure, and projectile velocity during travel was required, as well as the values of the original dimensions of the projectile and the gun tube and the changes in the gun tube bore dimensions as a result of previous firing. For a band on a projectile used in the firing test, the rate, with respect to travel, of reduction of band diameter due to wear in the tube was calculated and was found to be approximately 1.4×10^{-4} inches of band diameter per inch of travel.
GENERAL: This 27-page report is not illustrated.

WAL 740/58

SUBJECT: Tests, Special, Miscellaneous
TITLE: Analogical Solutions of Equations of Motion of a Gun Carriage Subject to Traveling Conditions
IDENTIFICATION: Report No. 740/58
DATE OF REPORT: 10 October 1948
ORIGIN: Watertown Arsenal, Watertown, Mass.
PURPOSE: To demonstrate the possibility, ease, and general principles of solving certain equations of motion by analogy to electrical circuits
METHOD: A typical gun carriage was sketched in its simplest dynamic components and this system was assumed to be subjected to a sinusoidally varying displacement. The equations of motion of the mechanical system were involved and from these two electrical analogies were established. The direct analogy was based on the equivalence of voltage to force, the inverse analogy, on the equivalence of current to force. Experimental response curves were obtained for the equivalent electrical analogy and compared with the theoretical results and showed good correlation particularly when damping was taken into account in the theoretical computations.
DESCRIPTION: Not applicable.
CONCLUSIONS: The applications of the electrical analogy to gun carriage problems when discontinuous loading (bumps) was encountered, sources of errors in the analogy methods, the advantages and disadvantages of mechanical analogies, and a typical carriage problem illustrating the analogical solution of equations of motion applicable to the 105mm, T19 gun, were shown in the report.
GENERAL: This 32-page report includes two photographs of the test equipment and a complete derivation of the subject equations.

WAL 760/514

SUBJECT: Tests, Special, Miscellaneous
TITLE: Conditions for Yielding of Rotating Band Due to Bending
IDENTIFICATION: Report No. 760/514
DATE OF REPORT: 14 May 1953
ORIGIN: Watertown Arsenal, Watertown, Mass.
PURPOSE: To present design criteria for the approximate determination of the bending conditions under which plastic deformation of a rotating band will occur
METHOD: The rotating band was considered to

be modeled by an axial strip having a width of one band and groove, and was tested as a simple support beam (simulating the influence of constraint, such as band seat undercut or friction). Justification of the procedure was conditioned upon the length of the band and appropriate limitation was presented as a simple curve. The band strip was then considered to be subjected to the normal centrifugal force induced by its rotation and was analyzed for the resulting stresses and deformations. The conditions for initial and complete yielding were obtained. This latter condition governed the potential escape of the band from the underseal cut.
DESCRIPTION: None
CONCLUSIONS: The design criterion governing the initial yielding in bending of a band strip was presented as an equation in the body of this report. This criterion was supplementary to and not a substitute for criteria governing failure by hoop stress given in Report WAL No. 760/410. Complete yielding in bending occurred in the band strip at a muzzle velocity 22.5% greater than that at which initial yielding occurred. For long bands, hoop stress criteria were suitable whereas, for short bands, constrained by undercuts or end friction, failure was governed by the criterion presented in this report.
GENERAL: This 11-page report contains two drawings of band strip rotation.

WAL 801/1-6

SUBJECT: Tests, Special, Miscellaneous
TITLE: Retrogression of Temper Brittleness
IDENTIFICATION: Report No. 801/1-6
DATE OF REPORT: 17 April 1950
ORIGIN: Watertown Arsenal, Watertown, Mass.
PURPOSE: To investigate the removal of temper brittleness by reheating within the ferrite range
METHOD: Groups of temper brittle specimens of SAE 3140 steel were reheated for various times just below the lower critical temperature. The temperature of transition from tough to brittle failure in the V-Notch Charpy impact test was determined for each group.
DESCRIPTION: The material used in this investigation was commercial SAE 3140 steel bar stock, received as 5/8-inch hot rolled rounds, supplied by Pennsylvania State College.
CONCLUSIONS: Temper brittleness was rapidly reduced by reheating the steel to a temperature above that at which the brittleness developed, but below the A_{e1}. On continued holding at this temperature, temper brittleness gradually reappeared. This was an example of retrogression, well known in non-ferrous alloys. Temper brittleness was developed by a process involving nucleation and growth and not caused by solute segregations. Hundreds of hours were required to approach an equilibrium condition of temper brittleness even at temperatures just below A_{e1}. Most, if not all, of the earlier data on removal of temper brittleness by reheating below A_{e1} pertained to retrogression and provided no information about equilibrium conditions.
GENERAL: This 12-page report includes two pages of test result curves.

WAL 843/8

SUBJECT: Tests, Special, Miscellaneous
TITLE: Metallurgical Applications of Autoradiography
IDENTIFICATION: Report No. WAL 843/8; Project No. TB4-910
DATE OF REPORT: 2 January 1952
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To determine the possible use of autoradiography in metallurgical problems and to report preliminary experimental procedures
METHOD: A literature survey of autoradiographic techniques as applied to metallurgy was made. The possible application of autoradiographic techniques at high magnification (X1500) to the study of temper brittleness in steels and other problems in physical metallurgy was proposed. Samples of SAE 2335 steel and of an iron-phosphorous alloy were activated by neutron irradiation and the resulting activities analyzed. Use of nuclear track emulsions and developments of experimental procedures were initiated.
DESCRIPTION: Autoradiography was defined in general terms as consisting of the detection of ionizing radiations by use of photographic emulsions, when the source was contained within the sample itself.
CONCLUSIONS: Neutron-irradiated specimens could be analyzed by means of their resulting activities only for simple systems. Use of autoradiography for detection of grain boundary constituents in neutron irradiated metals would be limited to systems in which favorable activities might be generated. It was necessary to choose the systems with care to insure that only one activity was present and that this activity was due to a constituent that segregated at the grain boundaries.
GENERAL: This 30-page report includes three photomicrographs, nine data sheets, and sketches of test specimens.

WAL 847/39

SUBJECT: Tests, Special, Miscellaneous
TITLE: Neutron Crystal Monochromators
IDENTIFICATION: Report No. 847/39; Project No. TB4-121
DATE OF REPORT: 6 July 1951
ORIGIN: Watertown Arsenal, Mass.
PURPOSE: To investigate the effect of lineage upon the performance of neutron crystal monochromators and demonstrate the feasibility of detecting lineage with neutrons
METHOD: Twenty crystals from the melt (Be, Mg, Cu, Ni, Pb, Bi, NaCh, LiF) were examined and found to contain lineage with an over-all angular deviation of about 30 minutes. Two curves were plotted from the data. One was a diffraction pattern of a crystal from a diffracting plane approximately perpendicular to the growth direction, the beam intercepting many lineage regions. The other was a diffraction pattern from a diffraction plane parallel to the growth direction. Data were obtained with a polychromatic beam of thermal neutrons from the Brookhaven reactor collimated to about one minute divergence (slit geometry). These were diffracted from a single crystal and

the contour of the diffracted beam plotted out with a slit mounted on a comparator in front of a BF_3 counter. Coherent regions of the crystal tilted with respect to one another will diffract (through slightly different angles) according to the Bragg law.

DESCRIPTION: Lineages were defined as large regions of the crystal tilted with respect to one another but not to such an extent as to call them grains. Lineage structure was a result of the crystal growth process and appeared as a fibrous structure in the direction of the growth.

CONCLUSIONS: Because of its ease of growth, its high coherent cross section, low absorption, and the ability to vary the lineage to some extent, lead was apparently a suitable monochromotor for neutrons. Because of depth of penetration, neutrons more readily revealed lineage structure than X-rays.

GENERAL: This five-page report includes one curve sheet.