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HISTORICAL STUDY

GERMAN TANK MAINTENANCE IN WORLD WAR II

DEPARTMENT OF THE ARMY JUNE 1954

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DEPARTMENT OF THE ARMY
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For explanation of abbreviations used, see SR 320–50–1.

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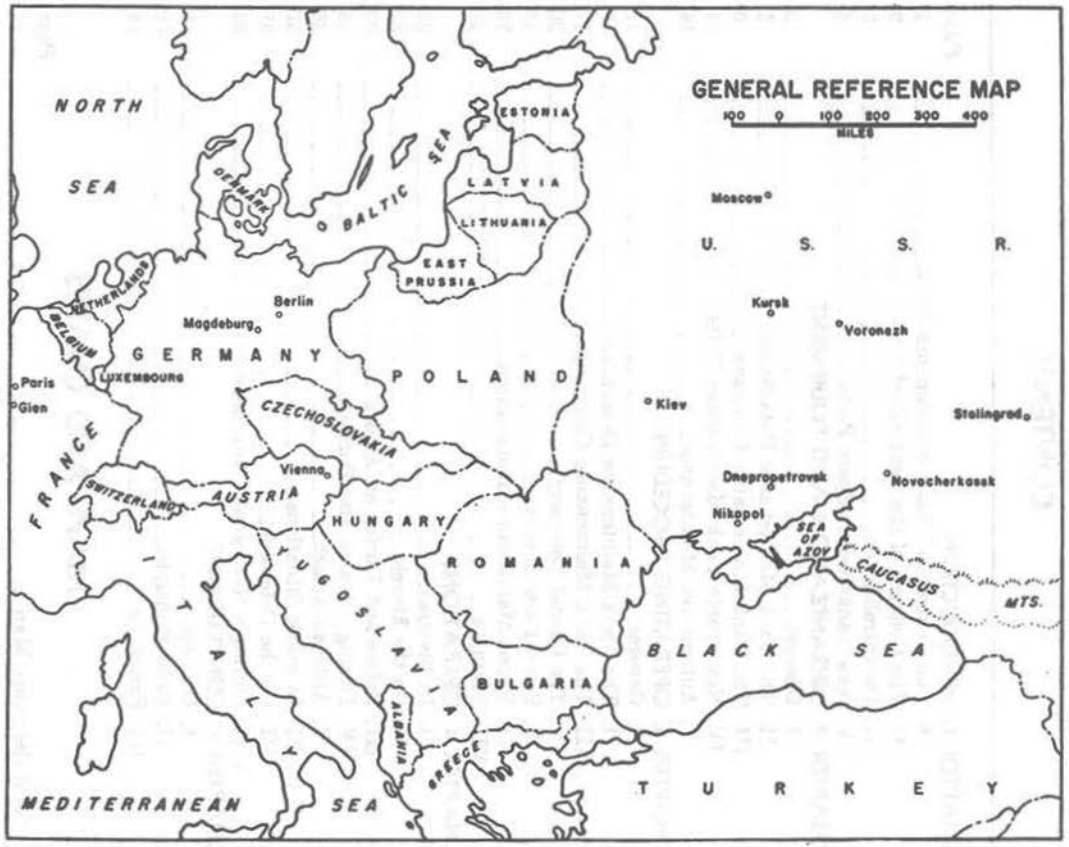
FOREWORD

The material for this pamphlet was prepared for the Historical Division, EUCOM, by a group of former German generals, general staff officers, and tank maintenance specialists. The principal author, General Burkhart H. Mueller-Hillebrand, served as aide to the Chief of the Army General Staff before assuming command of an armored regiment on the Russian front. Successively appointed chief of staff of a panzer corps and a panzer army, he saw action in the Ukraine, Poland, and East Prussia.

The reader is reminded that all publications in the GERMAN REPORT SERIES were written from the German point of view, and that the procedures of the German Army normally differed widely from those of the United States Army. "German Tank Maintenance in World War II" will be of interest to persons who want to compare the United States and German systems of tank maintenance.

CONTENTS

MAPS AND CHARTS


GENERAL REFERENCE MAP
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MILES
NORTH SEA
DENMARK
BALTIC SEA
ESTONIA
LATVIA
LITHUANIA
EAST PRUSSIA
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NETHERLANDS
BELGIUM
LUXEMBOURG
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CHAPTER 1

INTRODUCTION

I. The Centralized Tank Maintenance System

Even before the outbreak of World War II, German experts in armored warfare realized that a well-functioning tank maintenance system would be essential. Initially, a centralized system was planned in which only minor repairs would be carried out in the field, and tanks that had sustained more serious damage would be returned to the factory of origin in the zone of interior.

During the short Polish campaign in September 1939, this system worked well and very few difficulties were encountered. As soon as Poland had been conquered, the armored divisions returned to their respective peacetime garrisons in Germany, where all vehicles were quickly repaired and restored to maximum efficiency at depot maintenance installations and tank production plants.

The French campaign of May–June 1940 presented only a few maintenance problems. Minor organizational deficiencies that had first cropped up during the Polish campaign were corrected and the strength of the organic maintenance personnel was increased. A large tank spare parts depot, from which the armored forces drew their supplies, was established in northern France. At the end of the campaign, which lasted only 6 weeks, most of the armored divisions returned once more to their garrisons in Germany. Those divisions remaining in France were able to utilize the services and facilities of the many former French Army repair shops. Moreover, the distance to the tank factories in Germany was relatively short. As a result, all armored divisions were combat-ready shortly after the conclusion of the French campaign.

During the campaigns in the Balkans in the spring of 1941 the Germans committed numerous panzer divisions. These campaigns were also short and involved few tank losses, most of them caused by bad road conditions and accelerated march movements during which it was not always possible to perform preventive maintenance. After the conclusion of the operations against Yugoslavia and Greece, the armored divisions were rehabilitated in the zone of interior and transferred to assembly areas for the campaign against Russia.

When German armored units first landed in North Africa in February 1941, it was realized that a rigidly centralized maintenance system was not feasible in the new theater. Since relatively few damaged tanks could be returned to the zone of interior, greater emphasis had to be placed on field maintenance. As the German Army became more heavily engaged in Russia, the supply situation within the North African theater grew precarious and tank maintenance personnel had to rely mainly on improvisation and cannibalization.

For the Russian campaign the Germans intended to apply a slightly modified, but essentially centralized system of tank maintenance. Most of the tank repairs were still to be performed in the zone of interior. On the other hand, each of the three army groups in the Russian theater was to have a spare-parts depot. Improved maintenance vehicles, recovery vehicles, and better shop equipment were issued to the maintenance units in the field. No further planning was considered necessary because both the military and the political leaders assumed that military operations would reach their climax during the autumn of 1941 and that most of the armored forces would return to Germany before the winter. Those remaining in the Russian theater would be withdrawn from action and rehabilitated in suitable areas during the winter months.

II. The Collapse of the Centralized System

Once the Russian campaign got under way, the need for tank maintenance installations and the demand for spare parts increased by leaps and bounds. German tank losses in Russia were far heavier than during the preceding campaigns. For the first time large numbers of tanks were put out of action by enemy fire and mines. With operations being conducted over great distances under unusual conditions, such as extreme heat and dust in summer and subzero temperatures in winter, the mechanical operation of tanks was greatly affected, resulting in an unexpectedly high attrition rate. The tank maintenance services were handicapped because only the larger towns contained buildings that provided even minimum shop and billeting facilities. Despite strenuous efforts, the maintenance personnel were unable to cope with the ever-increasing volume of repair work. The German Army's requirements for all types of supplies, particularly ammunition, fuel, and medical supplies, exceeded all expectations. The inadequate road and rail nets made it impossible to support the rapidly advancing armored columns. Since very little rolling stock was captured, the railroad tracks had to be converted from the wide Russian to standard European gage. Moreover, the Russians demolished most railroad bridges and locomotive maintenance shops during their withdrawal. The unsatisfactory rail transportation situ-

ation had a disastrous effect on the tank maintenance system at a time when the number of disabled tanks reached an alltime high. Obviously the centralized system of maintenance was no longer practical, and major changes had to be introduced without delay.

III. Decentralization

Most of the repair work that had hitherto been performed in the zone of interior had to be undertaken by maintenance units in the field. The following measures were therefore initiated:

a. The strength of the maintenance units in the field was considerably increased and replacements were given better technical training.

b. Improved equipment and more efficient recovery vehicles were made available. Some new special-purpose equipment was developed.

c. New depot maintenance installations were established in the Russian theater to take over those repair functions that formerly had been performed in Germany.

d. The manufacture of spare parts in Germany was stepped up to meet the increased demands of units in the field.

e. The parts supply organization was radically changed in order to afford a more rapid and efficient distribution of spare parts.

f. Qualified officers were given specialized tank maintenance training before being assigned to commands in the field and to technical staff positions.

g. Certain functions hitherto accomplished by top-level agencies in the zone of interior were transferred to headquarters in the field.

Since such a comprehensive reorganization program could not materialize overnight, the new system did not become fully effective until the summer of 1942. During the interim period new tank models were developed, and those in service were improved so that they would be at least equal if not superior to the excellent Russian tanks. Because of the limited capacity of the German armament industry, it was not feasible to scrap obsolete tank models and replace them with better ones. As a result, the number of tank models and types within each series issued to the field forces increased steadily, which in turn had an adverse effect on the efficiency of the maintenance services.

The measures designed to increase personnel strength and provide better equipment were carried out without much trouble, but the rest of the program was more difficult to execute. Large quantities of spare parts stored in the zone of interior were hurriedly loaded on trains and shipped to the Russian theater. Since the average staff officer was not acquainted with the intricacies of tank maintenance,

464-729 O - 85 - 2

many of the trains were misdirected. Army Group South, for instance, received several shipments of spare parts for tank models it did not have, whereas Army Group North was in urgent need of the very same parts.

During the summer offensive of 1942 the Germans discovered that the tank maintenance personnel were still inadequately trained. Supplementary on-the-job training and refresher courses were given to officer and enlisted personnel. Manuals stressing the importance of safeguarding equipment and the responsibilities of first and second echelon maintenance were given wide distribution. Additional personnel and equipment were provided for the maintenance units to assist in reducing the accumulated backlog of repairs.

Most of the difficulties encountered in 1942 arose because decentralization was not consistently applied. There was constant interference in the allocation of parts between depot and field maintenance units. Although the transportation system was functioning more smoothly by the middle of 1942, a new and even more urgent problem was to overshadow all other deficiencies of the tank maintenance system.

IV. New Tanks Versus Spare Parts

The stocks of spare parts, of which there had never been an abundance, fell below the critical level during the summer of 1942. Some of the armament production officials who had failed to realize the importance of spare parts in the field of maintenance were partly responsible for the seriousness of the situation. While pressing for an increase in the production of new tanks, they had neglected the urgent need for spare parts until it was too late and irreparable damage had been done.

With its limited industrial capacity, Germany was unable to produce more new tanks and a satisfactory amount of spare parts at the same time. The armored forces therefore suffered from a constant shortage of tank spare parts until the end of the war.

For a better understanding of the above-mentioned problems and the solutions that the Germans attempted to find, it is necessary to analyze the organization, procedures, and operations of their tank maintenance services.

CHAPTER 2

ORGANIZATION AND EQUIPMENT

I. General

Maintenance of track-laying vehicles was the function of organic and nonorganic units. The organic units were established exclusively at the company and regimental levels, while the nonorganic ones were attached—either as entities or in part—to the maintenance detachments or companies in the field to assist them in carrying out their mission.

II. The Tank Maintenance Detachment

The smallest organic unit was the maintenance detachment of the tank company, which was composed of 19 enlisted men. (Chart 1.) The senior noncommissioned officer—the detachment leader—supervised operations. He was assisted by two crew chiefs. Among the privates were 6 mechanics (2 of whom drove the shop trucks), 2 radio repairmen, 2 armorers, 1 electrician, 1 welder, 1 spare parts clerk, and 3 drivers. Initially, wheeled equipment of the detachment consisted of 3 to 4 vehicles, including a motorcycle with sidecar or a personnel carrier, a light 1-ton half-track prime mover, and a parts truck. During the later phases of the Russian campaign, the T/E for the maintenance detachment was changed to 2 shop trucks, 2 light 1-ton half-track prime movers, a parts truck, and 1 passenger car. The shop trucks were used exclusively for the transport of such tools and equipment as a workbench with vise, a gas welding unit, a hand drill set, as well as mechanics', tinsmiths', and electricians' tools. The recovery equipment carried on the shop truck included cables, winches, pulleys, and jacks. The repair crews were transported on the prime movers.

The detachment was responsible for on-the-spot repairs of disabled tanks, including soldering and welding. It was highly mobile and capable of operating in any terrain. The personnel were trained to determine the extent of damage and either perform the necessary repairs or arrange for evacuation by the recovery platoon of the tank regiment's maintenance company.

III. The Tank Maintenance Company

The principal function of the maintenance company of a tank regiment was to perform those repairs which could not be carried out by the detachments in the tank companies. The company's mission was to eliminate technical defects, repair electrical equipment, radio sets, tank weapons, optical instruments, damage resulting from direct hits, recover and remove disabled tanks from the battlefield, and maintain stocks of spare parts. In addition, the company was responsible for the welfare of the tank crews who accompanied their disabled vehicles to the field repair shop. The repair of the regiment's wheeled vehicles was not within the scope of a tank maintenance company's responsibilities because such an additional workload would have required the handling of greater stocks of parts and would have hampered tank repair operations.

The strength of the company depended upon the type of armored vehicles issued to the tank regiment and varied between 120 and 200 men. The company consisted of a company headquarters, 1 recovery and 2 maintenance platoons, and a weapons, a radio repair, and a spare parts section. (Chart 2.)

a. Company Headquarters. According to the T/O, the company headquarters consisted of 2 officers, 8 noncommissioned officers, and 24 privates. Its vehicular equipment included 5 command cars, 4 passenger vehicles, and 5 trucks.

The company commander, preferably an officer with a degree in automotive engineering, was directly subordinate to the commander of the tank regiment.

The assistant company commander, an officer with a background in automechanics, was responsible for the operation of the field repair shop. He directed and coordinated the activities of the maintenance platoons as well as of the weapons, radio repair, and spare-parts sections and was responsible for all matters pertaining to repairs and spare parts.

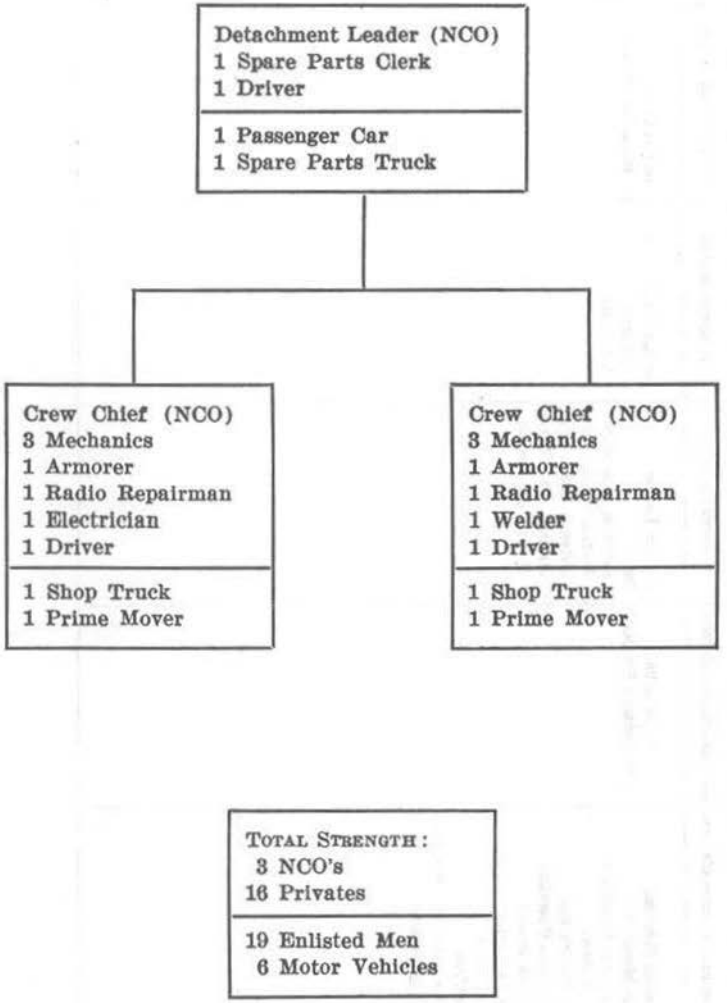
The first sergeant, assisted by a company clerk, was responsible for administrative matters and had no part in shop operations.

The motor sergeant, assisted by a clerk, a mechanic, and three drivers, was responsible for the maintenance of the company's organic vehicles, including the requisitioning of POL and spare parts. He assigned vehicles to headquarters section personnel employed as temporary drivers.

The mess personnel, consisting of 2 cooks and 2 assistants, operated 2 field kitchens because the maintenance personnel were usually divided into 2 echelons. Their hours of duty were long because of the unscheduled arrivals of tank crews accompanying their disabled

Chart 1

ORGANIZATION OF A GERMAN TANK MAINTENANCE DETACHMENT



TOTAL STRENGTH:
3 NCO's
16 Privates

19 Enlisted Men
6 Motor Vehicles

Chart 2. Organization of a German Tank Maintenance Company

Company headquarters	1st maintenance platoon	2d maintenance platoon	Recovery platoon	Weapons section	Radio repair section	Spare parts section
Company Commander Asst Co Cmdr First Sergeant Payroll Clerk Company Clerk 3 Messengers 2 Medical Aidmen 1 Cobbler 1 Tailor	Shop Foreman 24 Mechanics 2 Lathe Operators 2 Welders 2 Electricians 2 Crane Operators 1 Blacksmith 1 Carpenter 1 Painter 1 Clerk 1 Canvas & Webbing Repairman	Same as 1st Maintenance Platoon	Platoon Leader Driver 6 Sections, each with 1 Section Chief, 2 Drivers, and 2 Asst Drivers, 2 Prime Movers per Section	Section Chief 2 Armorers 4 Assistants	Section Chief 3 Radio Repairmen	Section Chief 4 Stock Clerks, each in charge of 1 Parts Truck. 4 Drivers for Parts Trucks. 2 Drivers for Supply Pickup Trucks
Motor Sergeant Clerk Mechanic 3 Drivers						
2 Cooks 2 Asst Cooks						
Chief, Signal Section 3 Radio Operators 1 Driver						
Chief, AA Section 3 Crew Members						
Supply Sergeant 2 Drivers						

2 Officers 8 NCO's 24 Privates	8 NCO's 30 Privates	8 NCO's 30 Privates	1 Officer 6 NCO's 25 Privates	3 NCO's 4 Privates	1 NCO 3 Privates	1 Off./Civ. Technician 4 NCO's 6 Privates
5 Command Cars 4 Passenger Cars 5 Trucks	1 Motorcycle 4 Shop Trucks 1 Bus 1 Wrecker 1 Trailer for Generator	Same as 1st Maintenance Platoon	1 Passenger Car or Heavy Motorcycle. 12 Prime Movers 4 Tank Transporters	2 Trucks	1 Truck	6 Trucks 1 Passenger Car

Total Strength: 4 Officers
38 NCO's
122 Privates

164 Officers and Enlisted Men
57 Motor Vehicles

vehicles to the field repair shop. In some instances, the feeding of such tank crews was taken care of by the casual company attached to the field repair shop.

The personnel of the signal section, consisting of a chief, 3 radio operators, and 1 driver, maintained radio communication with regimental headquarters, transmitting reports on the status of the tanks under repair and receiving messages on the location of disabled tanks.

The antiaircraft personnel consisted of 1 noncommissioned officer and 3 privates, equipped with a four-barreled 20-mm. antiaircraft gun mounted on a truck.

The supply sergeant, assisted by 1 or 2 drivers with trucks, was responsible for the issue of clothing, equipment, and rations. Drawing the proper number of rations presented a problem because of the great variations in the daily ration strength. The supply sergeant also had to obtain fresh milk to supplement the ration of welders and painters. As a rule, he drew clothing and equipment from the regimental supply point. On many occasions, however, when the company was far removed from this source, supplies were obtained from the nearest depot.

Other personnel of the headquarters section included a payroll clerk, a cobbler, a tailor, and several medical aidmen and messengers.

b. The Maintenance Platoon. Each maintenance platoon consisted of 8 NCO's and 30 privates—1 shop foreman, 24 mechanics, 2 lathe operators, 2 welders, 2 electricians, 2 crane operators, 1 blacksmith, 1 carpenter, 1 canvas and webbing repairman, 1 painter, and 1 clerk. The wheeled vehicles included 1 motorcycle, 4 shop trucks, 1 bus, 1 wrecker, and 1 trailer.

The foreman, assisted by the shop clerk, was in charge of the platoon. He formed crews according to the nature of each repair job and supervised the men while they were at work. Being responsible for the tools and equipment issued to the platoon, he checked toolboxes and nonexpendable items of equipment at regular intervals. After repairs had been completed, he inspected each tank before its return to the combat unit.

The 12 engine and 12 transmission mechanics formed crews of 3 to 4 men each under the supervision of a noncommissioned officer who acted as crew chief. On the march to a new operating site, all mechanics were transported by bus except those who were employed as drivers and assistant drivers of the four shop trucks.

The lathe operators performed simple machining work. They were also responsible for the care and servicing of the machinery in Shop Truck No. 1 and the issue of special tools carried on this vehicle. The welders were trained in acetylene and arc welding, and had to be capable of carrying out major jobs. They were responsible for

the equipment in their care. On the march, the welders drove one of the company vehicles.

The electricians repaired electrical systems and were responsible for the electrical equipment in the company. Occasionally, they were assigned to drive a company vehicle during a march.

The blacksmith, carpenter, canvas and webbing repairman, and painter performed their respective routine duties and kept their tools and equipment on one of the shop trucks. When on the move, they rode in the company bus.

The equipment of each maintenance platoon was carried on the four shop trucks as follows:

(1) Shop Truck No. 1 contained one light precision lathe, one electrical drill, and an emery wheel, all of which were bolted to the floor. In addition to a workbench, there were bins and lockers for the storage of tools and equipment such as blocks, drills, special pliers, wheel pulleys, and precision gages. The special tools of the engine and transmission mechanics were also carried on this vehicle.

(2) Shop Truck No. 2 carried electrical equipment, such as battery chargers and electrical testing devices, and electricians' tools.

(3) Shop Truck No. 3 usually carried a forge, gas welding units, a transformer for arc welding, and some mechanics' toolboxes.

(4) Shop Truck No. 4 carried the remaining mechanics' toolboxes, carpenter and canvas repair tools, the painter's equipment, the repair-shop tents, and sundry items.

The mechanics' toolboxes contained all the basic tools, including complete sets of wrenches, hammers, files, pliers, screwdrivers, and punches. All toolboxes were numbered and each mechanic was held responsible for the contents of the toolbox he was issued.

The forge was equipped as a complete blacksmith unit, including anvil, hammers, and tongs. A small supply of forge coal was kept on hand.

The welding equipment consisted of a high-voltage transformer, protective shields, aprons, electrodes of various diameters, and welding and cutting devices. Gas and oxygen cylinders were carried in stock.

The electrical power for the operation of the field repair shop was produced by a powerplant consisting of a heavy diesel engine and an electric generator. This equipment was mounted on four-wheeled trailers attached to Shop Truck No. 1 or 2 of each platoon. Whenever possible, each company was issued a reserve unit. The powerplant had to furnish current for the machines mounted in Shop Trucks

464-729 O - 85 - 3

No. 1 and 2, the arc-welding equipment, and the emergency lighting system. A sufficient supply of wire and light bulbs was carried in stock for night operations.

The wrecker was equipped with a traversable lever crane capable of lifting 3 tons. The shop personnel often installed special devices on the wrecker for lifting heavy assemblies, such as cross shafts and drive sprockets, at their proper angle.

c. The Recovery Platoon. The recovery platoon of a tank maintenance company consisted of 1 officer, 6 noncommissioned officers, and 25 privates. Its equipment included 1 passenger car or heavy motorcycle, 12 prime movers, and 4 tank transporters.

The platoon leader was an officer with some training in automotive engineering who was well versed in both technical matters and armored tactics. His platoon was divided into 6 sections of 2 prime movers each, with a noncommissioned officer in charge of each section. The crew of each prime mover consisted of 1 driver and 1 assistant driver.

The personnel were selected on the basis of their technical training and knowledge. Reliability combined with all other characteristics of a good soldier were prerequisites because the men were often away from the supervision of the tank maintenance company commander for long periods of time. Recovery personnel also had to be capable of performing temporary repairs in order to permit the removal of damaged tanks under their own power. Repeated attempts to increase the strength of the organic recovery units were frustrated by the shortage of prime movers and tank transporters. Equally unsuccessful were the many efforts to establish a separate tank recovery organization that would have operated independently of the field repair shop units.

The equipment used for the recovery of disabled tanks consisted of tow bars, cables, cable winches, grapnels, prime movers, and tank transporters. The normal recovery procedure was to use a prime mover, with a tow bar, having a pulling capacity of 12 tons. Cables were used whenever tow bars were unavailable and the brakes of the disabled tank were in working condition. The tractive power of a cable winch equipped with a pulley was 7 tons when mounted on a prime mover, and 40 tons when mounted on a heavy tank. With the aid of a grapnel a prime mover could pull even a 50-ton vehicle.

The prime mover, used both for towing and evacuation, was an 18-ton half-track vehicle with a Maybach engine. It was adequate for towing standard tanks weighing up to 20 tons. The recovery of heavier tanks presented no problem because 2 or 3 prime movers were coupled together whenever necessary. The 18-ton prime mover was

easy to operate in any type of terrain. Wherever possible, tanks bogged down in the mud were extricated by prime movers anchored to the base of a tree.

Tank transporters were used for the removal of tanks that could not move under their own power. The transporter was a special-purpose vehicle with eight wheels and a wide loading surface. It had two ramps and a low bed on which the tank was transported. The steering mechanism was in the rear ramp. In order to load a tank on the transporter, the rear ramp was removed and the bed lowered to the ground. After the tank was loaded, the rear ramp was hooked on and the bed raised to traveling position. There were three types of transporters with carrying capacities of 12, 22, and 60 tons, respectively.

Tank recovery implied the removal of disabled vehicles from the battlefield, their collection at a point where they were protected from enemy observation and fire, and their evacuation from the collecting point to the field repair shop or the nearest railhead for shipment to a rear area installation. It also included pulling immobilized tanks out of mud, snow, swamps, and ditches as well as righting overturned vehicles. If the organic recovery elements were unable to accomplish their mission alone, the assistance of one of the nonorganic recovery units attached to army or army group headquarters could be requested.

d. The Weapons Section. The weapons section was composed of 3 noncommissioned officers and 4 privates. The section chief had the rank of master sergeant. The vehicular equipment consisted of two trucks that carried spare parts.

The section was responsible for the repair or replacement of defective tank guns and mounts, stabilizers, and turret traversing mechanisms.

Gun and equipment replacements were requisitioned directly from regimental headquarters.

e. The Radio Repair Section. The radio repair section consisted of a radio technician with the rank of sergeant, and three repairmen. The section was assigned one truck to carry its tools, equipment, and spare parts. The sergeant was responsible for all tank radio repairs in the regiment.

f. The Spare Parts Section. The total strength of the spare parts section was 1 officer or civilian technician, 3 noncommissioned officers, and 7 privates. The section chief, a company-grade officer with some background in automotive engineering or a civilian inspector with assimilated rank, was responsible for the control of spare parts. The vehicular equipment consisted of 6 trucks and 1 passenger car. Four of the trucks had fixed superstructures with facilities for the storage and issue of parts. These trucks always remained in the field repair

shop area. The other two trucks were employed to pick up spare parts requisitioned from depots.

IV. Nonorganic Tank Maintenance Units

a. The Tank Maintenance Platoon. The maintenance platoon was the lowest-echelon, nonorganic tank maintenance unit. It was usually attached to a tank battalion operating separately. Its strength varied between 50 and 120 men, including recovery crews. Its mission was to perform field maintenance, including the replacement of engines and transmissions as well as some of the more complicated welding jobs. During operations the platoon detached one maintenance detail to each tank company and set up a repair shop at platoon headquarters. Depending on the tactical situation and the condition of the disabled tank, the latter would either be repaired on the spot or evacuated to the repair shop.

b. The Tank Maintenance and Tank Recovery Companies. These companies were GHQ units under the jurisdiction of the Army High Command, which attached them to an army group or army headquarters as the need arose. The composition of the nonorganic tank maintenance companies was similar to that of the organic ones forming part of the tank regiments, except that they had no recovery personnel and equipment. Separate recovery companies were responsible for the removal and evacuation of disabled tanks. The function of the nonorganic companies was to support armored forces that did not have adequate maintenance facilities at their disposal and to reinforce the organic maintenance units whenever the rate of tank attrition became particularly heavy.

c. Tank Maintenance Battalions. In December 1944 the Germans organized eight tank maintenance battalions, whose composition, capacity, and mission were essentially the same as those of full-strength nonorganic tank maintenance companies. The main difference was that each battalion included a tank recovery platoon or company.

V. Automotive Maintenance

The wheeled and half-track vehicles in an armored division far outnumbered the track-laying ones. The mission of the automotive maintenance units was complicated because of the great variety of requisitioned civilian vehicles used by the German Army. Attempts to standardize division vehicular equipment by intraunit exchange in order to simplify parts supply procedures were unsuccessful because the high rate of attrition necessitated the constant replacement of motor vehicles from the zone of interior.

Each motorized company and battalion had its respective automotive maintenance section or platoon. There was no need for any automotive maintenance units at the regimental level because 1 heavy and 2 medium automotive maintenance companies at the division level effected third and fourth echelon repairs that could not be carried out on the spot.

a. The Division Ordnance Officer. The three automotive maintenance companies plus a spare parts section were under the technical supervision of the division ordnance officer. He was responsible for the maintenance of the wheeled and half-track vehicles in the division. Self-propelled artillery and assault gun battalions had their own organic maintenance units for routine repair work and could call on the tank maintenance company of the tank regiment for all major repairs.

The heavy automotive maintenance company performed body, frame, and engine repairs, rebored cylinder walls, turned down crankshafts, cast bearings, overhauled motors, installed connecting rods, relined brakes, and reconditioned electrical systems and diesel injection pumps. In addition, it rebuilt engines, starters, and generators.

One of the two medium automotive maintenance companies was primarily concerned with the maintenance of wheeled vehicles; the other, to which a weapons section was attached, specialized in the repair of the many half-track vehicles that were issued to each armored division.

The spare-parts section, whose trucks were capable of carrying 75 tons of automotive parts, was always located in the immediate vicinity of one of the maintenance companies.

b. The Regimental Motor Officer. The regimental motor officer advised the commander of the tank regiment on technical matters pertaining to motor transportation and was his deputy for the operation of all motor transportation in the regiment. The battalion motor officers were under his technical supervision, and the tank maintenance company was under his operational control. He maintained contact with the division ordnance officer and other technical staff agencies responsible for motor transportation.

Although he did not exercise immediate control over the various maintenance units, the regimental motor officer was responsible for coordinating all maintenance efforts within the tank regiment. He also produced advance estimates of spare-parts requirements. In the field of tank maintenance the regimental motor officer was primarily concerned with expediting operations.

c. The Battalion Motor Officer. The battalion motor officer advised the tank battalion commander on matters pertaining to motor transportation. The automotive maintenance elements were under

his technical supervision. He was also responsible for the supervision and employment of all tank maintenance detachments in the battalion as well as for the procurement of spare parts. This centralized control guaranteed efficient battlefield repair operations. He divided the workload in accordance with the mission and capability of each unit. He was assisted by a civilian technician with assimilated military rank who supervised the maintenance detachment leaders under his control.

The battalion motor officer submitted a daily report to the battalion commander and the regimental motor officer, indicating the location of disabled tanks, the extent of damage, and whether they could be repaired by the maintenance detachments or whether their evacuation to the field repair shop or to the rear was necessary.

CHAPTER 3
OPERATING PROCEDURES

I. General

More than any other motor vehicle, the tank is subject to defects. Some part is always in need of attention, even if it is only a loose nut or bolt that needs tightening. For this reason, the drivers as well as the tank crews were instructed to constantly check even apparently serviceable tanks for defects and repair them immediately. Whenever a minor defect was overlooked, it eventually developed into a major repair job. German field maintenance personnel made every effort to repair disabled vehicles within the tank regiment. Tank crews had to feel confident that the organic maintenance units were as well qualified to look after their vehicles as those at a higher level. Moreover, the personnel of the tank maintenance detachments and company knew each tank and tank crew in the regiment. They made every effort to get the tank back into action as quickly as possible.

II. The Tank Maintenance Detachment

Tank maintenance detachment personnel were responsible for effecting any repair that did not require more than half a day's work. Damages of greater magnitude could be repaired by detachment personnel on condition that they were staying in one location for an extended period. When necessary, a maintenance detachment could replace an engine by means of an improvised hoist, even though this work went beyond the scope of its normal duties. This was done particularly in instances when a replacement engine could be obtained from the field repair shop in less time than was required to move the damaged tank to the shop. More serious damages that could not be repaired by the maintenance detachments were brought to the attention of the battalion motor officer. There was no strict delineation between the functions of the detachments and those of the company; the decision of assigning repair jobs to specific units usually depended on the tactical situation and the capacity of the maintenance detachments.

III. The Tank Maintenance Company

The principal task of the tank maintenance company was to repair those tanks which could not be repaired by the maintenance detach-

ment or, if necessary, to transfer them to the depot maintenance installations in the rear. In order to carry out this mission, the maintenance company had to have the proper tools and spare parts as well as carefully selected personnel. With respect to the latter, a man had to be both experienced and able to improvise, since the repair shop often operated on its own for prolonged periods of combat.

According to standing operating procedures, the crew of a disabled tank reported to one of the shop foremen immediately upon arrival at the field repair shop. The shop foreman inspected the vehicle and entered the damages on a maintenance record. The crew had to report any possible defect at the time the tank was inspected so that the work of the shop personnel would not have to be duplicated. The shop could handle 30 to 40 tanks at a time.

The shop foreman decided the order in which repairs were to be made and by whom. Normally, he assigned engine, transmission, or gear mechanics to work on the tank first, followed by the welders, electricians, and painters, respectively. Subsequently, the tank was turned over to the weapons or radio sections. He also decided in which maintenance and repair jobs the tank crew members could assist. Usually, these consisted of servicing the tank or replacing damaged bogie wheels. Upon the completion of such minor duties as they were assigned, the crew members were sent to the casual company where they remained until the tank was repaired. The tank driver remained with his vehicle and assisted with the repairs.

Final tests were performed by the shop foreman in the presence of the crew member responsible for the tank. Upon the completion of the test, an entry was made on the maintenance record indicating that the tank had been repaired and was in perfect working condition.

Ammunition and fuel, which had been removed upon arrival, were replaced before the tank was checked out. If the repair shop was located at a considerable distance from the front, the tank would be returned to its unit by rail, the maintenance company making the necessary arrangements for transportation. Normally, tanks returned to their units under their own power in groups of 4 to 8, each group under the command of an officer and accompanied by a maintenance vehicle.

Theoretically, the maintenance company field repair shop handled only those repairs which could be completed within a specified time. Work requiring more than 14 days was supposed to be turned over to depot maintenance installations. In practice, however, most of the field repair shops were able to handle all types of repairs, provided adequate stocks of spare parts were available. Usually the larger items were in short supply. If, for example, three tanks were disabled

because of damaged engines and the time required to supply the necessary parts was 3 weeks, the tanks would usually remain at the shop and return to service within 4 weeks. Had they been dispatched to some depot maintenance installation, the unit of origin would surely have been compelled to wait longer for their return and probably would not have seen them again. This unsatisfactory condition was caused by jurisdictional conflicts, the critical shortage of spare parts, the great distances between depot maintenance installations and the front lines, as well as inter- and intra-theater transfers of armored units.

Under these circumstances, the personnel at the field repair shops preferred to deadline the tanks for prolonged periods or even cannibalize them rather than use the depot maintenance services. Among the armored forces in Russia there was a strong aversion to allowing a disabled tank to leave the regimental area. Even though cannibalization of a tank meant its loss, this procedure enabled the maintenance personnel to put other tanks back into operation.

In selecting a suitable location for the field repair shop, the tank maintenance company commander took under consideration such factors as the availability of facilities, protection against inclement weather, security, parking areas for maintenance equipment and disabled vehicles, and proximity to a road net. Operating efficiency was considerably higher when buildings containing shop facilities were available. On some occasions these buildings were located at a considerable distance from the front lines, but the advantage of having good facilities outweighed the disadvantage of longer hauls. Whenever the field repair shop was set up in the field, an area bordering a forest and having access to fresh water was most desirable. Parking in such areas presented no problem as long as the forest was dense or extensive. In general, the field repair shop was near regimental headquarters and not far from the front, so as to expedite work and reduce towing time. An antiaircraft gun with a trained crew was attached to the company to protect the repair shop against attacks by low-flying aircraft.

Before the outset of an offensive operation, the regimental motor officer and the tank maintenance company commander discussed organizational matters. On such occasions they usually decided that unnecessary equipment and spare parts were to be left behind and only items of equipment whose attrition rate had proved to be high were to be taken along. Such factors as the model of tanks on hand in the regiment, the type of terrain to be covered, the season of the year, and the probable weather conditions to be encountered during the forthcoming offensive played an important part in making these decisions.

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IV. The Casual Company

In Russia, where operations extended over great distances, the Germans experienced the need for closer control over the crews of disabled tanks. The tank crews usually remained at the field repair shop until the repairs to their vehicles had been completed. The unannounced arrival of replacements presented another personnel problem because tank company commanders were often unable to take charge of the new men while operations were under way. On such occasions these replacements were temporarily attached to the field repair shops, where they, as well as the crews of disabled tanks, constituted an administrative liability for the tank maintenance companies.

The number of tank personnel immobilized while awaiting repairs to their vehicles at the field repair shop averaged from 80 to 100 men. The commander of the maintenance company had to provide them with quarters and rations, in addition to keeping them occupied. During the winter months the administrative problem was aggravated by the scarcity of heated billets.

While the tank drivers were able to assist in minor repair work, an attempt was made to keep the other crew members busy with first echelon maintenance of their vehicle. As a rule, however, the crew members would stand around and interfere with the work of the shop personnel.

Starting in 1943, some commanders of tank regiments organized casual companies to take care of tank crews at the field repair shops and replacements arriving from the zone of interior. The casual company of the tank regiment was set up next to the field repair shop so that closer supervision could be exercised over the activities of its personnel.

The commander of the tank regiment assigned a qualified line officer to command the casual company, which represented the manpower reserve pool of the regiment. The casual company commander was responsible for the welfare of crews awaiting repairs of their vehicles, the supervision and training of extra tank crews and replacements, and the security of the field repair shop. The accomplishment of these duties required special ability and experience, and casual company commanders were therefore exempted from reassignment whenever possible. During extended periods of inactivity, casual companies were sometimes deactivated.

During the later phases of the Russian campaign when the fortunes of war turned against Germany, tank personnel showed a tendency toward considering the field repair shop as a place of quiet and therefore as a desirable refuge. Since certain tank crews brought in their vehicles more often than others, maintenance company commanders

were requested to investigate the causes of unusually frequent mechanical breakdowns. Moreover, to promote strict discipline, commanders of tank maintenance companies would usually authorize only the tank drivers to assist with the repair work, while the other crew members and incoming replacements attended training courses.

V. Spare-Parts Supply

a. General. An adequate supply of spare parts is essential for the efficient operation of a maintenance system. During the initial campaigns of World War II, Germany's supply of tank spare parts was satisfactory. In March 1940 Hitler created the Ministry of Armaments and Ammunition, headed by a civilian who was made directly responsible to the Fuehrer. Even though the activities of this civilian agency tended to curtail the influence of the military, its creation was welcomed by the latter because it fulfilled an urgent need. Friction between the Army and the Ministry of Armaments arose during the Russian campaign, when the production of new tanks was stepped up and that of spare parts neglected.

b. Planning and Procurement. At the beginning of World War II, the Ordnance Inspectorate of the General Army Office was responsible for the procurement of spare parts. The Inspectorate submitted requisitions for tanks and spare parts to the Army Ordnance Office which, in turn, awarded contracts for their manufacture to the armament industry. Before being accepted the tank or part was inspected and tested, whereupon it was shipped to the Armored Ordnance Depot at Magdeburg for storage and issue.

When a new tank model was being introduced, the Ordnance Inspectorate sent qualified personnel to the prime contractor to assist the tank designers in compiling a standard nomenclature list for spare parts. Each item was listed under the proper group heading, such as engine, suspension, turret, hull, track, and ignition. Great care had to be taken in compiling these lists and in numbering and illustrating each item. The terminology had to be so simple that any mechanic could understand what was meant.

The compilation of the standard nomenclature lists was complicated by the frequent changes in design introduced during the production of a new model. As a rule, however, the lists were ready for distribution by the time the first tank left the factory.

Proper planning for the production of an adequate amount of spare parts was difficult before the new tank had been field tested and the attrition rate of the various parts established. Provisional estimates, which took every known factor into account, served as basis for contracts placed with the armament industry.

From the very beginning, the number of spare parts actually delivered was by no means equal to the demand. Some tanks required spare parts immediately after their first test run. The limited stocks of spare parts on hand were often insufficient to meet the demands. Supplementary requisitions for certain parts were placed in good time with the Ordnance Office, but deliveries to the parts depots usually suffered long delays. The rapid expansion of the armored forces may have had a considerable effect on the manufacturers' capabilities of delivering spare parts on schedule. Most industrial enterprises were overloaded with military and civilian orders.

c. Distribution. During the initial phase of the Russian campaign—June to December 1941—manufacturers in the zone of interior shipped parts either to tank ordnance depots in Germany or directly to the three army groups in the Russian theater. Each army group maintained a separate tank spare-parts depot and established advance dumps at army level.

The tank maintenance companies requisitioned and drew the spare parts for the entire tank regiment from an army advance dump or army group depot. The motor sergeant of each tank company was responsible for parts supply and stock control. Whenever an item was in low supply or out of stock, he requisitioned it from the spare-parts section of the tank maintenance company. For items in critical demand, the motor sergeant dispatched a vehicle to the tank maintenance company or requested by radio that the item be brought forward. The armorers and radio mechanics, on the other hand, requisitioned parts directly through ordnance or signal channels.

d. Stock Control and Storage. Each tank maintenance company had a spare-parts section, which was responsible for the storage, stock control, and issue of spare parts. A card index filing system was set up on the basis of the standard nomenclature list. By maintaining an efficient stock record system, the parts clerks were able to ascertain at all times the type and quantity of parts on hand. As soon as the stock levels dropped to a specified minimum, stocks were replenished automatically. At periodic intervals, inventory was taken to determine which parts were not moving or had become obsolete. This was particularly important whenever a new tank model or series was issued. Since the storage of obsolete parts served no useful purpose and took up valuable space, the tank maintenance companies returned them to fixed installations and depots.

Special requisitions were sent to the nearest dump or depot whenever certain parts were used at a more rapid rate than expected. Within the field repair shops, parts were issued only upon the presentation of a request slip signed by one of the foremen. This procedure

was necessary because such items as electrical equipment and kerosene could be used for barter on the black market.

Special care was given to the proper storage of spare parts. The shop trucks were equipped with solid superstructures and contained bins, drawers, and shelves to keep the parts in place, so that even severe jolts during a march would not dislodge them.

Parts such as ball bearings, which were shipped in waterproof containers from the manufacturer or tank ordnance depot, were stored in their original wrapping. Exposed parts were coated with protective grease before being placed in stock.

e. Supply Problems and Tentative Solutions. During the first 3 months of the Russian campaign, the German armored units had sufficient spare parts. In the autumn of 1941, however, parts grew scarce in the Russian theater. The supply lines were overextended at the time when the muddy season set in. Most of the roads in Russia became impassable and truck columns were therefore unable to move up supplies. At the same time the railroads proved incapable of carrying the entire supply load. Damaged tanks could not be repaired for lack of spare parts and could not be evacuated to the zone of interior because of the transportation bottleneck.

Throughout this period the Ministry of Armaments pushed the production of new tanks to the detriment of the manufacture of spare parts. With the increase in the number of tank models and the continuous changes in design, many parts became obsolete by the time they reached the maintenance units in the field. This was primarily the result of excessive procurement lead time for parts.

In May 1942 the Ministry of Armaments decided to curtail new tank production and increase the output of spare parts. This change failed to remedy the situation because the total quantity of spare parts thus gained amounted to no more than the loss in new tank production, but in disassembled form. In other words, for each tank that was not assembled, only 1 engine, 1 transmission, and 1 steering mechanism, etc., were made available as spare parts. This solution was very unsatisfactory and did little to alleviate the spare-parts problem. Urgently needed parts, such as engines and transmissions, were produced in equal number to hulls and other parts which were not in great demand.

When the Germans launched their summer offensive in 1942, more than 75 percent of their total tank strength was employed in the southern part of the Russian theater. Within a short time hundreds of tanks were disabled and a major backlog of repairs accumulated because the necessary spare parts were not available. Most of the disabled tanks could have been quickly restored to service since the repairs involved only the replacement of defective parts. Less than

30 percent of the damaged tanks required welding or time-consuming labor. Had parts been in stock or available at a nearby depot, most of the repairs involving the replacement of defective parts could probably have been accomplished within 2 weeks. However, at this time the spare-parts problem had become so critical that it had a paralyzing effect on the simultaneous thrusts toward Stalingrad and into the Caucasus.

In the autumn of 1942 the Ministry of Armaments introduced three additional measures to relieve the shortage of spare parts. First, it designated various plants whose production capacity was to be devoted exclusively to the manufacture of spare parts. Certain factories were to turn out only tank engines, whereas others produced transmissions, etc. While this measure was sound in principle, it did not work out in practice because the contractors were unable to convert their plants quickly. By the time they went into full production, their effort was insufficient to relieve the shortage of spare parts, because the Ministry of Armaments had to divert most, if not their entire output to new tank production in order to compensate for the damage inflicted on the tank manufacturing plants by Allied air bombardments.

The second measure was the institution of the so-called contract exchange in October 1942. At this exchange, various spare parts in critical demand were exhibited. Manufacturers interested in producing these parts were requested to submit their bids. To be eligible for consideration, each manufacturer had to indicate in writing that, if awarded, the new contract would not interfere with deliveries on previously awarded war contracts. If a manufacturer's bid was accepted, his plant received a higher priority rating which protected his manpower and production facilities from being diverted against his wishes.

The third step was to transfer machinery from the large tank plants to machine shops and small factories in order to enable the latter to enter the field of spare-parts production. This measure achieved a limited decentralization of the war industry and thus contributed to reducing the effect of Allied air raids on the German armaments program.

While the cumulative effect of these measures resulted in a temporary easing of the spare-parts problem, the lack of proper planning, which had characterized the production of tanks and spare parts from the outset, was to have a lasting effect until the very end of the war. On many occasions the limited relief that resulted from these measures was offset by serious mistakes.

In the autumn of 1942, for instance, heavy Tiger tanks were committed for the first time in the Russian theater. The production of

extra parts for this tank had been neglected to the extent that only 1 spare engine and 1 spare transmission were produced for every 10 tanks. Within a short time almost all of the new Tiger tanks were lost or deadlined because of lack of parts.

A similar mistake with even more far-reaching consequences took place a few months later when the new Panther tanks came off the assembly line. In a desperate attempt to speed up production, the Ministry of Armaments had ordered the mass production of this new tank model before it had been properly tested. Early in 1943 the first Panther tanks arrived in the Russian theater and were immediately committed. Almost at once major defects in design and construction—particularly of the steering and control mechanism—were discovered with the result that all 325 Panther tanks had to be withdrawn and returned to the zone of interior for complete rebuilding. To perform the necessary work, a special tank-rebuild plant was established near Berlin. By the time the initial deficiencies had been corrected, the engine proved inadequate. It was not until the autumn of 1943 that a fully satisfactory engine became available. Under these circumstances it was hardly surprising that most of the Panther tanks shipped to Russia arrived without sufficient spare parts. Many a Panther was lost because of the shortage of some elementary spare part or because it could not be repaired in time.

Late in 1943 a shortage of spare tank engines was caused by the multiple defects that the standard German tank engines produced by Maybach developed in the field. Instead of simplifying the design of the engine, Maybach continued to turn out new, improved series, so that eventually a tremendous variety of spare parts was required for the repair of the tank engines.

f. Improvisations. The failure of the armament industry to provide sufficient spare parts forced the tank maintenance personnel to improvise. One of the most widespread expedients was the practice of cannibalizing disabled tanks, especially those destined for return to the zone of interior. The cannibalization crews were so thorough that the manufacturer would rarely receive more than the empty hull by the time the tank reached his plant. Disabled tanks awaiting engine replacements at field repair shops were also subject to being stripped, and by the time the new engine arrived there usually was little left of the tank for which it had been intended.

Since the advance dumps and army group depots were usually out of those parts for which there was a heavy demand, the tank maintenance companies began to send details to the depots to represent their interests. Upon the arrival of a supply train carrying spare parts, each detail tried to secure the parts its company needed most urgently. When more and more companies adopted this procedure,

the depots became the scenes of fierce struggles for priority items. As soon as a detail had secured some parts, it would contact its parent organization by radio or telephone. In a matter of minutes the trucks would be on their way to the depots to pick up the "spoils." If the distance between the depot and the field repair shop was too great, the spare parts would be shipped by rail under escort. In order to maintain some control over the various details between the arrivals of supply trains, the depot commanders eventually organized casual companies and assigned the men to minor tasks.

More arbitrary measures were often employed by some of the tank maintenance company commanders who believed that they were acting in the interest of their own unit. During the latter part of the war some of them even resorted to bribery. Others would contact manufacturers in the zone of interior outside of normal channels to procure parts directly at the source. Occasionally, even tactical commanders took part in the hunt for parts when the number of serviceable tanks at their disposal began to dwindle. It happened in several instances that a private or noncommissioned officer escorting a rail shipment of laboriously acquired spare parts would suddenly be confronted by a field grade officer of some other regiment or division who simply ordered him to surrender the entire cargo.

Such expedients obviously did more harm than good. Moreover, the persistent shortage of spare parts affected the morale of the tank maintenance personnel who, though capable and willing, were unable to accomplish their mission at a time when every tank counted.

During the final phase of the war in 1944, the fighting rapidly drew nearer to the German borders. The shortening of the supply lines might have improved the spare-parts situation, had not the withdrawal movement been coupled with the loss of vital armament plants and depots through evacuation and air attacks.

VI. Depot Maintenance Installations

Until the autumn of 1941, disabled tanks that could not be repaired by the maintenance units in the field were usually shipped to a tank ordnance depot in Germany before being returned to the original manufacturer. Upon the completion of repairs at the factory, the vehicles were dispatched to a tank ordnance depot for the installation of radio equipment and armament before being reissued to the combat units. However, since the production of new tanks took up their full capacity in late 1941, manufacturers were unable to handle tank repairs, and it was not long before an enormous backlog in repair work had accumulated.

a. Fixed Installations in Russia. When this matter was brought to Hitler's attention, the Fuehrer ordered three major depot main-

tenance installations—one for each army group—established in the Russian theater. The mission of these installations was to perform a general overhaul of badly damaged tanks according to modern methods and thus eliminate the necessity of shipping them to Germany. A civilian agency was put in charge of this project because Hitler expected a higher degree of efficiency from civilians using modern engineering methods than from military personnel.

Damaged vehicles were to be shipped by rail at regular intervals, and each train was to carry only vehicles of the same type or model. The internal organization of each installation was drawn up along civilian lines, with one German firm providing the personnel and assuming the responsibility for plant operations. Small military staffs, which were under the Ordnance Inspectorate, were responsible for such administrative details as rations and billets of the civilian personnel, security measures, spare-parts supply, acceptance of disabled equipment, and delivery of repaired tanks.

To guarantee a sufficient supply of spare parts, a tank spare parts depot was set up near each installation. In addition, a stockroom carrying the most important tank parts was attached to each installation. All other parts needed by the maintenance personnel could be obtained directly from the tank spare-parts depot.

Though sound on paper, the plan failed from the outset because of the confusion created by the sudden decentralization efforts. The idea of sending damaged equipment to the maintenance installations in shipments separated according to types or models proved impractical for the simple reason that vehicles do not become disabled according to categories.

Moreover, the civilian personnel engaged in constructing the depot maintenance installations were unable to adapt themselves to the conditions in Russia and give up the high standards to which they were accustomed. This gave rise to such delays in construction that the unfavorable turn meanwhile taken by military events prevented the installations from operating at full efficiency. The civilian managements adhered to their customary operating procedures, which resulted in more thorough but also more time and materiel-consuming maintenance. What the military considered reparable, the civilians regarded as scrap. Time and again the civilian firms were guided by principles of economy rather than of expediency. Thus, there was constant friction between the civilian managements and the military staffs.

The displacement of a depot maintenance installation to a new location interrupted repair work for several months. The evacuation of these installations to the rear, which became necessary in 1943–44, was really a mad scramble to save personnel and materiel.

Because these installations took so long to start operations and performed in such an unsatisfactory manner, the Army High Command decided in 1944 to establish its own depot maintenance installations along purely military lines. This measure was taken to eliminate the difficulties that had arisen from employing civilian personnel. However, the war ended before any conclusions could be drawn from this experiment.

Aside from the above depot maintenance installations, existing facilities and installations in German-occupied countries were used for the repair of tanks. By late 1942 a number of the installations had gone into operation, with the result that a marked relief was felt by the overburdened armament industry.

Typical examples of such installations were the tank repair shop at Vienna, whose main function was the repair of tanks disabled on the Russian front, and the tank rebuild shop at Gien, France, which specialized in salvaging former French armored equipment and repairing German tanks.

b. The Tank Repair Shop in Vienna. The tank repair shop in Vienna was the former Austrian Army's central automotive maintenance shop, which had been converted to tank repair by the Germans. Its installations included all depot maintenance facilities needed for the repair of wheeled and track-laying vehicles. Spare-parts procurement was transacted through normal channels with some parts being obtained locally.

Being well equipped and efficiently organized, the Vienna shop repaired from 60 to 100 tanks per month with a personnel strength of 1,200 civilian workers. When more and more disabled tanks arrived from the Russian theater in 1942, the Vienna shop had to discontinue the repair of wheeled vehicles.

In 1943, when the first disabled Panther and Tiger tanks began to arrive in Vienna, new facilities were needed because the hydraulic lifts were not strong enough to handle the heavier equipment. A nearby locomotive shed contained one 40-ton and two 16-ton cranes as well as suitable workshop areas for turret, weapon, engine, and transmission repairs. The supervisors selected for the repair of the heavy tanks were particularly skilled mechanics who were in charge of military shop personnel. After 1943 the efficiency of the repair shop was greatly reduced because of the increasing intensity of air attacks. During one raid the workshops were so severely damaged that many of the subsequent operations had to take place in the open, regardless of the weather.

As the overall situation deteriorated during the last year of the war and parts became a critical item, the Vienna shop organized a special section for salvaging parts from irreparable tanks. This

measure proved successful and helped to overcome many difficulties which otherwise might have been insurmountable.

c. The Tank Rebuild Shop in Gien. After their speedy campaign against France in the spring of 1940, the Germans took over the French tank repair shop in Gien, along with about 3,000 French armored vehicles and an almost inexhaustible supply of raw materials, tools, and spare parts. The Germans were quick to convert the installation to their own needs and decided that a large number of French tanks of various types could be restored to service. Unserviceable tanks that were beyond repair were stripped and the parts installed on other vehicles. Parts not available at the depot were manufactured in the local workshops or procured from other depots and salvage dumps. Similarly, older and obsolescent tanks were modernized and their maneuverability, speed, and firepower improved. Some of the chassis were rebuilt and converted into self-propelled mounts for heavy field pieces or antiaircraft guns.

The personnel in Gien consisted of 6 officers, 46 NCO's, 14 civilian technical inspectors, and about 200 French civilian mechanics. A casual company, the strength of which fluctuated, was also part of the Gien organization.

The output of the depot averaged about 40 tanks per month despite two heavy air raids, which destroyed or badly damaged some of the workshops and storage buildings. Later in the war, when the supply of spare parts became more difficult, increasing emphasis was placed on stripping unserviceable tanks in order to maintain a steady production of repaired tanks.

The former French tanks were issued to combat units, Army service schools, internal security forces in Germany and in occupied areas, airbases, and higher headquarters. A substantial number of them were shipped from Gien to the Hungarian Army.

User agencies sent receiving personnel to Gien before the tanks were ready for delivery so that the men could familiarize themselves with the operation and maintenance of the French tanks and tank weapons. For this purpose the enlisted personnel performed routine maintenance on serviceable tanks under the supervision of the civilian technicians working at the depot.

VII. Training

The German Army did not have a uniform basic training program. Upon induction, each recruit joined a unit of the arm or service to which he had been assigned. In peacetime, the recruit destined for the armored forces was immediately assigned to a tank company, whereas in wartime he joined a tank training company of the replacement army. Early in World War II basic training was conducted for a

period of 12 weeks—later reduced to 8 weeks—at the end of which the recruit was considered fully trained and ready for assignment.

Until the Russian campaign got under way in 1941, the training of tank maintenance personnel received little attention. Only the tank drivers and the organizational maintenance personnel were given special instruction as part of their basic training. When this method proved unsatisfactory, tank maintenance and recovery personnel were given specialized courses upon completion of their basic training. In addition, they received special instruction in the operation of tanks in extreme heat, under heavy dust, and in subzero temperatures.

The theory that maintenance personnel would acquire the necessary skill through practical experience in the field repair shops proved erroneous. Additional courses therefore had to be organized at the armored schools in order to provide specialized training for maintenance and recovery personnel, drivers, and officer candidates of the armored forces. Civilian technicians as well as tank maintenance and motor officers also attended these courses in order to improve their technical knowledge. The students assisted in the preparation of maintenance directives and technical manuals.

Being responsible for the training of all replacements within their areas, the Wehrkreis [Ed: the basic military area in Germany under the jurisdiction of a corps-size unit] headquarters later established technical training courses of 6 weeks' duration for tank maintenance personnel. Trainees took specialized courses, the completion of which qualified them for assignment to depot maintenance installations as specialists in the repair of tank chassis, engines, hulls, and transmissions, and as electricians and electrical welders.

Advanced training was provided at the depot maintenance installations, where enlisted tank maintenance personnel performed repair work under the supervision of civilian technicians and expert mechanics, thus gaining some practical experience before joining a tank maintenance unit in the field. Similar advanced training courses were also given to armor officers up to the rank of general.

This type of advanced training offered numerous advantages because it provided tank maintenance units with personnel familiar with various tank models and skilled in their specialty. During his assignment to a depot maintenance installation, the trainee became thoroughly acquainted with the military repair methods, tools, and equipment that frequently differed from the ones he had known in civilian life. In general, he was not supposed to work with any other tools or equipment than those which would actually be available to him in the field. At the same time, great emphasis was placed on teaching the trainee to improvise because in the field some essential item or part would often be missing and, if the tank was to be put back into

service as quickly as possible, the repairman would have to use expedients.

When new tank models such as the Panther and the Tiger were introduced, specialized training courses had to be conducted for the tank maintenance personnel. On such occasions the maintenance units in the field found it expedient to send some of their personnel to the Wehrkreis schools, where they could familiarize themselves with the operation and repair of the new tanks.

During periods of relative inactivity in the field, the personnel of the tank maintenance detachments were often detailed to the field repair shops of the tank maintenance companies. There, the men were given on-the-job training based on the lessons learned from previous experience and were also instructed in new methods and procedures.

CHAPTER 4

OPERATIONS

I. In Bivouac

In bivouac or assembly areas the tank maintenance personnel were dispersed in such a manner that they could easily check the condition of the track-laying vehicles, perform minor repairs, and assist the tank crews. Except in emergencies, the personnel performed only those repairs the battalion motor officer assigned to them.

II. On the March

The smooth functioning of the tank maintenance services could be achieved only by carefully planning, routing, scheduling, and directing each march movement. Instructions were issued during the daily briefing or sent by messenger during periods of radio silence.

All tank maintenance vehicles were marked very plainly in prominent places to insure easy identification by the armored units. In the performance of their duties, maintenance personnel were authorized to overtake any unit on the march.

a. The Tank Maintenance Detachments. The basic principle applied in planning the march of a tank regiment was to separate the track-laying from the wheeled vehicles. As a rule, the track-laying vehicles of each tank company were followed by one prime mover and the passenger car. The other elements of the maintenance detachment normally marched at the end of the column under the supervision of the battalion motor officer and made repairs on vehicles that had fallen out en route.

Before a march, the key maintenance personnel were briefed on the route to be followed and the destination of the combat and maintenance units.

Whenever a tank became disabled on the march, the maintenance detachment leader determined the nature of the damage and, if the damage was slight, assigned a crew to perform the necessary repairs on the spot. As soon as the tank was repaired, it fell in at the end of the march column and resumed its proper place at the next halt. In the event that repairs could not be made on the spot, the tank was readied for evacuation, moved off the road so that it would not obstruct

traffic, and—if there was the possibility of an enemy air attack—camouflaged to prevent its total loss.

The detachment leader then rejoined the column and proceeded to the new location, where he prepared a report indicating the number of tanks disabled during the march, the extent of damage, unit designation number, names of the drivers, and the location of each piece of disabled equipment, complete with sketch. Copies of this report were submitted to both the battalion and regimental motor officers.

b. The Tank Maintenance Company. When the distance to be covered was relatively short, the tank maintenance company moved as one serial. On longer marches, the company was subdivided into 2 or 3 march units, which displaced forward in such a manner that each group had at least 3 days of uninterrupted work between moves. During long-distance marches, tank transporters were occasionally used for hauling repaired tanks to the front.

III. Before and During an Attack

Before an attack the tank maintenance company set up its field repair shop as close as possible to the assembly areas; the detachments remained with their respective tank companies. At the start of an attack, the detachments moved up behind the second wave of the attacking forces together with the vehicles of the recovery platoon. The leaders of these maintenance elements were briefed on the direction of the attack and its objectives.

The commander of the tank maintenance company was kept informed of the progress of operations and was given timely advance notice concerning a possible change of location. Before an attack, the tank maintenance company was divided into 2 or 3 echelons capable of carrying approximately equal workloads, much as during a march movement. Command over the individual echelons was exercised by one of the shop or motor officers. During an attack the forward echelon operated close behind the combat elements, performing those repairs which could not be made by the detachments. The rear echelons meanwhile completed the repairs on hand before displacing forward.

The displacement of any echelon depended on the progress of the attack. Too frequent change of location was detrimental to unit efficiency as each displacement meant the loss of at least 1 workday. In submitting suggestions for the employment of his unit, the company commander therefore based his recommendations on both tactical and operational considerations.

The maximum distance between field repair shops and the frontline was not supposed to exceed 70 kilometers. Any distance beyond this

limit resulted in excessive wear and tear of the prime movers and repaired tanks. In areas where the roads were exceedingly bad, as in Russia during the muddy seasons in the spring and fall, the Germans were often unable to remove disabled tanks to the field repair shops. In such instances the disabled tanks were assembled at collecting points behind the attack zone, where maintenance company personnel eventually caught up with them.

The employment of maintenance units during night attacks was governed by the same principles, but with more emphasis on briefing the crew chiefs regarding the direction of the attack and its objectives.

IV. During Advance and Pursuit

During advances in Russia, where the Germans initially had absolute air superiority, the tank maintenance company was moved up to within a few kilometers of the scene of fighting before the tanks went into action. During forward displacements involving great distances, only tanks within a 15-kilometer radius were brought to the operating site of the company. Disabled tanks farther ahead along the axis of advance were taken to a collecting point designated by regimental headquarters as a future operating site. The bulk of the maintenance company prepared for forward displacement after the tanks at the shop had been inspected for damage and the personnel and spare parts requirements had been established. The time needed to break camp varied from 3 to 12 hours, depending on the type of quarters occupied. A detachment was left behind to complete the repairs under way while the remainder of the company moved forward in one body. In some instances, a platoon was sent forward to the new location while the remainder of the company repaired disabled tanks along the route. The latter procedure was used successfully in 1942 during the German advance to Stalingrad by way of Kursk and Voronezh, a distance of approximately 900 kilometers. Whenever this method was impractical, the disabled tanks were brought forward by the recovery platoon.

During pursuit operations the tank maintenance detachments, having to keep up with the rapidly advancing combat elements, had to carry the main burden. If necessary, the detachments were reinforced and issued extra parts. In order to keep a maximum number of tanks in serviceable condition, the detachments often performed repairs that were beyond the scope of their normal missions. The tank maintenance company carried out major repairs exclusively and followed its tank regiment in long uninterrupted movements.

Whenever radio equipment of the type used by the armored units was available, the tank maintenance detachment could improve its efficiency by equipping one of the half-track prime movers with a radio

set. The detachment leader could thus maintain contact with the tank battalion and company commanders and exercise close control over the operations of his various crews. The latter could be dispatched to different points and immediately upon the completion of one job be directed to the next one. The disadvantage of this procedure, however, was that the detachment leader had to monitor all traffic in order to determine which messages referred to him or his crews.

V. After an Attack

As soon as an attack was broken off—generally at dusk—the maintenance crews reassembled and pooled their resources until the attack was resumed. The crew and detachment chiefs, assisted by an armorer, inspected all tanks to determine which ones were unable to participate in the next attack. The results of their inspections were reported to the tank company commander and the battalion motor officer.

Tanks disabled during an advance automatically remained in friendly territory. Their recovery was not so urgent because they were not in danger of being captured by the enemy. Because of frequent discrepancies between the reported and actual location of disabled tanks, units reporting a disabled tank had to pinpoint its location by giving map coordinates.

After a disabled tank was located, it was quickly prepared for evacuation. Tracks and suspensions were checked to determine whether the tank could be moved. In the event that the sprocket and several bogie wheels were severely damaged, the track was shortened and placed around the idler wheel and the undamaged bogie wheels. If the tank was still immobilized, new bogie wheels were installed. Normally, this work was performed by the tank maintenance crews. However, the recovery personnel were also capable of making such temporary repairs as well as loosening brakes and separating connections between the transmission and the steering mechanism.

After the track suspension system was made operative, a prime mover was hooked up to the tank by means of a tow bar. Depending on the condition of the track and suspension system, the tank could be towed from the front or the rear. As a rule, the tracks were not completely removed during a towing operation so that the undamaged bogie wheels would be protected from unnecessary wear and tear. Recovery personnel were inclined to disregard this principle in an effort to expedite the removal of disabled tanks. Tank maintenance unit commanders therefore had to constantly remind their personnel

that tanks should not be moved on their bogie wheels and that disciplinary action would be taken against recovery crews violating this order.

On occasion, some smoothly operating recovery crews were capable of extraordinary feats such as the one performed by two 18-ton prime movers in Russia. Their crews succeeded in recovering 14 seriously damaged tanks during one single night despite the fact that the disabled vehicles were stuck in deep mud that had frozen because of a sudden drop in temperature.

In Russia two prime movers were usually coupled for the recovery of a 40-ton Stalin tank. Occasionally, the much heavier German self-propelled antitank gun, the so-called Porsche-Tiger, was recovered in the same manner. Since prime movers alone were unable to meet all requirements, armored recovery vehicles were also employed in the Russian theater. Heavy German tanks that were no longer fit for combat, and captured Russian ones in operating condition, were used for this purpose.

The transporter was not widely used in the field because it bogged down in swampy or rain-soaked terrain. Good paved roads were scarce in Russia. Wherever such roads existed, the transporter stopped on the improved road at the point closest to the disabled tank. A prime mover then towed the tank to the transporter for loading. During the later phases of the Russian campaign, however, tank transporters were not issued to organic maintenance units if nonorganic recovery units possessing such equipment were within reach to lend their assistance in an emergency.

The Germans experienced very few instances in which it was not considered worthwhile to recover a disabled tank. The guiding principle was that no tank would be abandoned unless it was blown to bits or completely burnt out. In every other case recovery was mandatory, even though cannibalization was often the only possible use to which the recovered vehicle could be put.

The disposition of captured enemy tanks often confronted the Germans with major problems. Even though the use of captured tanks was against standing operating procedures, there were instances in which enemy tanks were repaired and employed for the protection of service units and for recovery operations. Tank maintenance company commanders opposed the repair of captured tanks because it involved the handling of a complete stock of Russian tank parts in addition to familiarizing the shop personnel with the operation of enemy equipment.

VI. In Static Situations

One of the crucial factors considered in selecting an operating site for a tank maintenance company was safety against enemy breakthrough attempts. Even so, it was desirable that the field repair shop be located at a minimum distance from the front. Another factor that was found to have a favorable influence on the performance of the company was the availability of permanent buildings providing shelter against inclement weather, of lifting devices, and of rail sidings. In some rare instances tank maintenance companies were able to use the powerplant and some of the machinery they found upon moving into a new shop area.

As soon as the company had moved into its new quarters, the spare parts were unloaded from the trucks and stored in a separate building situated close to the repair shop. Occasionally, special crews were organized to overhaul engines and rebuild assemblies. At Nikopol in 1943, for instance, a crew of four mechanics overhauled 20 tank engines within 2 months at a time when no spare engines were available. Even though, as a rule, the lifespan of a reconditioned engine was only about half that of a new one, this improvisation added 20 urgently needed tanks to the combat strength of the frontline units.

In static situations special attention was placed on rescuing disabled tanks in areas exposed to enemy observation and fire. For this purpose a serviceable tank of the same or a heavier type than the disabled one would tow the latter by means of a cable to the nearest depression or behind a hill offering cover and concealment. At this point 2 or 3 prime movers would take over and remove the disabled tank to the field repair shop. Because of their high silhouette, prime movers attracted enemy fire when operating in terrain exposed to enemy observation. In order to avoid losing too many prime movers, the maintenance units improvised low-silhouetted recovery vehicles by removing severely damaged turrets from disabled tanks.

VII. On the Defensive

During defensive operations the mission of the recovery crews was more difficult than during an attack because tanks that became disabled had to be removed directly from the battlefield. Although the combat troops were trained to remove their disabled equipment from the range of antitank guns, the recovery crews had to perform this function whenever the combat troops failed to do so. In such instances the recovery crews waited until dark before moving the disabled tanks from the battlefield and enemy observation. The evacua-

tion of disabled tanks to the field repair shop was usually carried out during daylight hours. The recovery platoon leader had to familiarize himself with every terrain feature in his sector so that he could control recovery operations during all hours of the day or night. Guides, preferably crew members, directed the recovery vehicles to the disabled tanks. Difficult terrain, such as swamps, gullies, and ravines, often caused delay in the recovery of tanks. Changes in temperature also had their effect on operations, particularly a sudden drop, which usually resulted in equipment being frozen fast to the ground.

Towing heavy tanks over long distances, the Tiger model in particular, was very complicated and therefore avoided whenever possible. In one instance in Russia in 1944 an attempt to evacuate a Tiger tank turned out to be a full-scale operation. It had to be interrupted for several weeks because a hard-surface road caved in under two 18-ton prime movers, one tank transporter, and one Tiger Model B (King Tiger) tank, weighing a total of about 140 tons. Over short distances, a superheavy tank such as the King Tiger, which weighed 75 tons, could be moved by another tank of the same type.

During defensive operations in which armored units were employed to support infantry, the organic tank maintenance services were echeloned in depth. The field repair shop was located beyond the range of enemy artillery fire and camouflaged against detection by enemy air reconnaissance. The normal distance from the front varied between 15 and 30 kilometers. All roads leading into the shop area were camouflaged. Alternate roads were used whenever possible and dummy installations set up. Precautions were taken against losing any of the shop trucks because replacements were not immediately available and had to be requisitioned from the zone of interior.

Radio communication with regimental headquarters was supplemented by field telephones. The radio section carried ample wire to lay a direct line to the nearest division switchboard.

The maintenance detachments of the tank companies stood by during defensive operations and remained beyond the range of light enemy artillery. They repaired any slightly damaged tank that withdrew from action. With the arrival of darkness they drove up to the combat elements, provided the latter were no longer engaged in combat. In general, only one vehicle was employed for this purpose while the others remained with the tank company's support echelon, where they performed major repairs.

If an organic maintenance company or its elements became separated from its tank regiment, some other tactical commander would usually attempt to assume control over the maintenance personnel. In 1942, for example, a tank maintenance company had its field shop at Novo-

cherkassk when the regiment to which it belonged was alerted for transfer to France. One maintenance platoon remained behind to emplace disabled tanks in defensive positions while the other regimental elements assembled near Dnepropetrovsk. The platoon leader had orders to follow his company as soon as his work was completed. No sooner had the regiment departed than the commander in charge of the defense of Novocherkassk attempted to place the platoon under his control. The platoon leader prevented this action by having his men pack up and leave without delay.

VIII. During a Retrograde Movement

During a withdrawal every effort was made to safeguard valuable maintenance equipment and leave behind as few disabled tanks as possible. The tank maintenance company had to move its field repair shop in good time so that it would not become involved in direct combat. All those tanks which could not be repaired within a short time had to be evacuated by rail in order not to delay the retrograde movement of the company. If existing difficulties in the exercise of command were not to be aggravated, the tank maintenance company had to be employed as a unit and its commander had to be issued mission-type orders. All motor vehicles and parts that were not essential had to be evacuated to future operating sites, which were selected on the basis of the availability of technical facilities and protection from air attacks.

Road conditions were an important factor in considering the feasibility of successful retrograde movements. In Russia the road conditions depended almost entirely on the weather. Rain or thaw would make the Russian roads impassable for ordinary wheeled vehicles. Only track-laying, half-track, and 4 by 4 vehicles were able to negotiate such roads.

In the spring of 1944, for instance, a tank regiment suddenly received orders to withdraw from a bridgehead near Nikopol. It was decided that the field repair shop would stay behind and complete the repair of the disabled tanks. After the departure of the regiment, a sudden thaw set in, and the Russians succeeded in reducing the bridgehead. Thousands of German vehicles clogged the only available road leading to safety. The vehicles bogged down in the mud and were unable to move in any direction. The maintenance company personnel, having three heavy prime movers at their disposal, attempted to get through by moving cross-country parallel to the road. The first day the company advanced only a few hundred meters. Its progress was so slow that it was engulfed by the enemy advance, losing all its vehicles and equipment.

Thereafter, tank maintenance companies were always divided into echelons, a highly mobile one remaining near the tanks in combat while the remainder of the shop personnel displaced to the rear as a group. Command vehicles were equipped with radio receivers tuned in on the regimental tactical net. By monitoring the traffic, the maintenance company commander and the shop foremen were kept abreast of developments at the front and were able to take the necessary precautions by evacuating the field repair shop in time. In the event contact with regimental headquarters was lost, the maintenance company commander contacted the nearest tactical commander for instructions or acted on his own initiative.

CHAPTER 5

CONCLUSIONS

I. General

During World War II the German Army acquired a wealth of experience in the field of tank maintenance and recovery. The long duration of the war and the distances over which military operations were conducted resulted in an extremely high expenditure of tanks, compelling the Germans to repeatedly reorganize their maintenance services. In Russia the difficulties of tank maintenance were aggravated by the scarcity of hard-surface roads, the limited capacity of the railroad net, and the almost complete lack of technical facilities. In addition, the German armament industry was overtaxed, and deficiencies in war production planning led to a shortage of spare parts.

In the course of the war it became evident that the factors determining the operation of a tank maintenance service varied according to theater of operations, technical developments, etc. These variations necessitated constant adaptation and improvement in the organic structure and equipment of the maintenance units. Consequently, no standard tank maintenance system having a general application could be evolved. On the other hand, some basic principles worth remembering can be derived from the German experience in World War II.

II. Basic Principles

a. Equipment. An army's fighting power depends to a large extent on adequate maintenance of its equipment. The importance of this principle cannot be overemphasized. Tanks require maintenance to the same extent that combat soldiers need medical attention. Under certain conditions, such as in Russia where the German ratio of strength was approximately 1,000 men to every tank, the loss of a tank was far more serious than that of a man.

b. Personnel. An efficient tank maintenance service must be organized before the outbreak of hostilities, otherwise it will not function properly during military operations. Failure to provide such a service in peacetime cost the Germans heavy losses in tanks and equipment. The training of tank maintenance personnel, for instance, had been neglected because of the generally accepted assumption that men who had worked as automobile mechanics and in related profes-

sions in civilian life would instantly qualify for work in a tank maintenance company. With regard to officer personnel, it was found that engineers and technicians were unsuitable for the command of tank maintenance units unless they were given thorough military training. The civilians who were given direct commissions were primarily concerned with the repair of equipment. If there was any change in the tactical situation, they lacked the ability to initiate independent action and relied too heavily on detailed orders from their immediate superiors. In fluid situations such procedures were impractical because unit commanders had to be capable of using their own initiative and of making the correct decision at the proper time.

The Germans also found that the 6-week specialized training course for tank maintenance personnel was much too short to be really effective. Both in the North African and in the Russian theaters the tank maintenance personnel had to operate independently and often without the support of major depot maintenance installations. Their performance under pressure failed to live up to expectation, and many a valuable tank had to be abandoned or destroyed on the battlefield because the maintenance crews were unable to recover or repair it.

c. Proper Emphasis. Sudden changes in the tactical situation, unfavorable weather conditions, or the breakdown of a new tank sent into battle before being fully tested, may lead to unexpectedly high tank losses. In such instances, speed in repairing the disabled tanks will be of the essence. The maintenance units in the field will be best qualified to cope with emergencies because in tank maintenance, as in other spheres of military service, personnel will perform best if they identify themselves closely with their respective unit and its equipment. The men will strive hard to accomplish a given task when they feel that they form part of a team.

No mechanic of a tank maintenance detachment or company adhered to fixed working hours when a deadline for the repair of a tank had to be met. On the other hand, tanks that were removed to depot maintenance installations in the rear were in transit for an indefinite period. Upon arrival at their destination they were handled like any other disabled vehicle, no one taking a personal interest in their repair. After a delay of many weeks the tanks would occasionally be returned to their original unit, but as a rule the tank regiment never saw its vehicles again.

In unusual situations the organic maintenance companies of tank regiments should be reinforced with skilled technicians from the zone of interior. The employment of such specialists will not only expedite the efficient repair of disabled tanks but will also save time and transport space since it is much simpler and faster to bring men and spare parts to the points where they are needed than to set up additional

maintenance shops, not to mention moving disabled tanks hundreds of miles to the rear and returning them over similar distances to the field forces after they have been repaired. In weighing the pros and cons of field versus depot maintenance, the availability of transportation should therefore be a determining factor.

The major part of all repair work should be carried out within the framework of the tank regiment so that the maintenance personnel work on "their own" tanks. Some German advocates of decentralization went to the extreme of recommending that field maintenance become the exclusive domain of the maintenance detachments forming part of the tank companies.

d. Tank Design. Maintenance requirements must be considered in the design of a tank if subsequent difficulties are to be avoided. To insure a high percentage of serviceable tanks, the design must be simple, the construction sturdy, and the parts easily accessible for service or repair. The number of different models must be kept to a minimum. Simple, sturdy, and compactly designed tanks will require a smaller variety of spare parts and less maintenance than those of a more complex nature. If, for instance, a tank regiment was equipped with 3 basic models of tanks, each of which came in 3 or 4 modified types, the maintenance system could not possibly function properly. The Germans would have done better to retain one standard tank model—as the Russians did with their T34—and forget about improvements, than to constantly introduce new and improved versions for which no spare parts were available. In general, a few weeks after a new shipment of tanks arrived at the Russian front, most of the vehicles were deadlined and many became a total loss, simply because parts whose installation would have required only a few hours were missing. This criticism does not imply that items of equipment, and tanks in particular, should not undergo constant improvement. However, before modifying the design of a tank, one must carefully examine whether any advantage resulting from such a change will not be lost because of the difficulty of obtaining the necessary parts. Every time a tank part is modified, the corresponding spare parts issued before the change automatically become obsolete and have to be replaced. Experienced maintenance officers should therefore be consulted frequently while a new model is still in the blueprint stage. Changes in tank design should be the result of long-range planning and must be put into effect systematically or they will only tend to weaken the fighting power of armored units.

e. Spare Parts. Tank maintenance requirements must be considered in establishing new tank and spare parts production schedules, which in turn are closely interrelated. Under normal circumstances the production of a sufficient amount of spare parts should have prece-

dence over that of new tanks. No advantage can be gained from sending new tanks into combat if they cannot be repaired for lack of spare parts. Some of the new German tanks that arrived in the Russian theater needed parts after being driven only a few miles. In the German experience, 7 out of 10 repair jobs involved the replacement of parts.

III. Summary

Any nation that anticipates conducting large-scale military operations in a distant theater of war can conserve the combat efficiency of its armor only if proper tank maintenance is performed in the field. An adequate amount of spare parts must be made available to the tank maintenance units in order to enable them to function effectively. For the proper accomplishment of their mission, the tank maintenance units must also be issued the proper tools and equipment and assigned fully trained officer and enlisted personnel.

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