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TANKS AND ARMORED TROOPS

A. Kh. Babdzhanyan

Army Tank-Automotive Command
Warren, Michigan

1970

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Part Two: Combat Operations of Armored Forces

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Brief Annotation

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Book consists of two pa s.

Part One deals with the contemporary state-of-the-art of armored technology and the effect of the advent of nuclear weapons upon its development. Separate chapters treat the layout of tanks and armored personnel carriers, the improvement of armament, electrical and navigational equipment, communication systems, infrared technology, as well as the operation and repair of vehicles.

Part Two deals with the combat use of tanks in contemporary warfare including an analysis of their place and role in various types of combat operations and describes applicable mathematical methods of modelling investigation and combat operations of tanks.

This book is based on materials, published in foreign and Soviet military sources. It systematizes the estimates of foreign military specialists relative to the state-of-the-art of armored technology abroad and the outlook for long-range development, their combat deployment in contemporary warfare. Par. 8 of Section 2 and Par. 2 of Section 5 (Chapter II) as well as Section 2, Chapter VI are based exclusively on data obtained from foreign sources.

The book is designed for officers and generals.

It is a collective work with the participation of the following authors: Lt.Gen. A.S. Karpenko, Eng.Tech. Services; Lt.Gen. G.T. Zavizion, Armored Troops; Major General L.V. Sergeyev, Eng.Tech.

Services; Colonels S. V. Vasil'yev, V. M. Derevyanskiy, I. M. Yeremin, V. M. Kulikov, A. P. Pervushin, A. V. Polyakov, P. G. Skachko, V. S. Chernov, L. A. Chernov, N. K. Shishkin; Colonels (Corps of Engineers) L. G. Barkhudarov, M. D. Bezborod'ko, N. S. Galandin, M. I. Maryutin, V. I. Medvedkov, V. D. Mostovenko (deceased), R. A. Nesterov, P. Ya. Oreshkin, V. G. Suvorov, A. K. Frumkin; Lt. Col. (Corps of Engineers) E. D. Prikhod'ko, and Colonel V. A. Yakovkin. The manuscript was prepared by Col. P. G. Skachko and Colonels (Corps of Engineers) L. G. Barkhudarov and M. D. Bezborod'ko.

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FOREWORD

The teachings of Marxism-Lenism hold that the military might of a state is above all determined by its economic potential. On this subject, V.I. Lenin pointed out on several occasions that the deepest roots of the military might of a state are imbedded in its economics, that a strong and well-organized economic system is imperative for a successful prosecution of a war, and that in contemporary warfare, the economic backbone is of a decisive significance. In this age, this stipulation acquired an added imperative and dimensions.

The burgeoning economy, the high level of its material and technological basis, the remarkable discoveries and accomplishments in science and technology led to the development of new ways and means of combat with an enormous destructive potential and to a considerable gain in the combat qualities of conventional and traditional means of warfare.

All this, in turn, produced changes in the theory and practice of military science, in the organizational and logistical problems of modern combat forces, in the ordnance and in the combat applications, and in methods of warfare as a whole. In other words -- military science experienced a revolution.

The world, in which we live, is subject to continuous changes. Investigations, studies and improvements open new vistas, leading to new horizons in military science and these horizons, indeed, are limitless. However, along with increasing knowledge in the military field, the number of problems, involved in the art of waging a war, also increase. By multiplying and expanding, these problems hinder the effective application of new methods of warfare, of applications of new military hardware and new concepts, which emanate on the basis of newly acquired knowledge.

To go ahead, it is imperative to resolve these problems in due time; it is furthermore imperative to now penetrate the nature of these problems and processes that will take place during a war, if it were to occur. Combat actions will proceed at an extremely accelerated rate and accordingly, during the course of the operations, there will be hardly any time left for the correction of erroneous concepts and mistakes of commanders. Field commanders will have very few opportunities left to acquire experience during combat. Thus it is twice as important to check the prevailing and newly occurring ideas and concepts step-by-step, excercising the utmost possible care.

In this perspective, current and long-range problems of armored troops acquire added significance.

It is commonly known, that in this age of technology, both empirical data and theory become rapidly obsolescent. The intensive development of new means of combat in the post-war period generated many new concepts in military science. We have witnessed a re-evaluation of the existing standards. Discussions regarding the role and influence of armed forces and types of armed forces upon the course and result of a war are continuing until now.

This equally applies to armored forces. Is a tank needed, as such; which is the best tank in modern conditions; what is the optimum armament of a tank, its design and layout? Which armored vehicles are best suited for motorized infantry since armies became completely motorized? This, in our judgement, are the principal problems of armored troops which cause excitement among theoreticians and practioners of military science and which are debated from various angles and points of view.

It is generally acknowledged that the entire potential of the whole range of modern weapons can be fully utilized only in a war that allows room for maneuvering and the tank is the most powerful weapon of ground attack, capable of fullfilling numerous combat tasks, assigned to ground forces. However, there frequently exist directly opposite view-points as to the tank as such, the organizational structure and the theory of application of armored troops. This is quite understandable and presumably justified, inasmuch as the dialectics of life entail the struggle of opposite schools of thought and the resolution of opposing opinions.

In this respect, the task of military science is in a timely and correct exposure of the objective laws of war and in a correct exposure of the trends of the required development of armored technology, of the organizational structure of armored troops and of combat application principles.

The authors of this study have specifically attempted to expose these laws and tendencies, which, in the currently available flow of military information, are rather difficult to detect.

Based on data, available from the Soviet and foreign sources, the authors of this monograph attempted to expose the general trends and laws of the development of armored technology and of the organizational structure of armored troops, as well as the application principles on the battlefield, without going into details. It stands to reason, that the experience of World War II was duly taken into account. But this experience was considered only insofar as the necessary and useful elements for the future were concerned, because success was not on the side of those who were blindly and slavishly copying old patterns but rather on the side of those who skillfully were able to take into account new experience, to discard obsolete concepts and to make new roadways. In this context, the authors hope that the ideas, discussed in this study, will offer new food for the creative search in the design, operation and combat application of tanks -- the combat chariots of the nuclear age.

History tells us that the tank was produced as a necessity, caused by the objective realities of combat conditions. Since 15 September 1916, when a tank first appeared on a battlefield, its role and missions were perpetually changing. First introduced as an infantry support element, the tank was gradually transformed into a means of developing the tactical success of the infantry and cavalry. As technical perfection advanced, the tank eventually assured its right for survival and became a factor of operative significance.

The Communist Party and V.I. Lenin personally attributed an enormous significance to the technical equipment of the Red Army and determined the role and place of the armored forces in combat. Analyzing the conditions of warfare, conducted in the mechanical age, V.I. Lenin concluded that without technology and without the appropriate knowledge of applying it, victory cannot be attained. He stated that in a war "the one who gets the upper hand is the one who has the greatest technology, organization, discipline and the best machines and equipment".* The armored troops, created at the very inception of theSoviet government became a powerful deterrent in the defense of the first Socialist state from imperialist aggression.

Based on Marxist-Lennist teachings, our country was the first to estimate and evaluate the operational potential of tanks. As a consequence, large tank units were organized and the theory of their applications was developed long before WW II. On the basis of the development of Soviet military science, the theory of deep penetration was developed for the first time in military history. In this operation, tanks played one of the decisive roles. The experience of WW II fully confirmed the validity of this theory. Large tank units, operating jointly with the air force, handled major operative problems, penetrating deep into enemy positions.

(*) V.I. Lenin, Complete Works, fifth edition, Vol. 36, p. 116.

Without playing down the role of other troops and means of combat, one could justifiably say that tanks played one of the major roles in attaining victory over the enemy in WW II.

The accomplisyments and achivements of tank troops in WW II were so significant and obvious, that the development of tank troops after WW II was accelerated by all armies throughout the world. However, upon analyzing the tremendous destructive power of nuclear weapons, some foreign military theoreticians and practitioners had considerable doubts as to a major tank force which, at that time, included three categories of tanks: light, medium and heavy. Inasmuch as these specialists visualized the major role of suppressing and destroying the enemy assigned to nuclear weapons, the principal task of ground troops being the occupation of enemy territory, it was felt that it is sufficient to equip the armed forces with light tanks and other armored vehicles, capable of being airlifted, that could be used to resolve this task.

The appearance of anti-tank guided missiles, capable of penetrating armor of any thickness with which tanks can be equipped, contributed to the development of this doctrine. Thus, for example, France, for a long time after the war produced only light tanks, armored cars and personnel carriers.

Other military specialists held a different view. They were taking into account the entire gamut of relationships in a war of the future. They held that the necessity of large-scale combat operations calls for equipping armored troops with various types of military technology, to include different vehicles, i.e., tanks, self-propelled artillery designed for different missions, armored cars, personnel carriers and various special-purpose vehicles.

Proponents of this school of thought feel that the backbone of tank troops are tanks, i.e., highly-mobile tracked combat vehicles with modern equipment and armored protection. Tanks are designed for the solution of a variety of problems and above all for engaging enemy armor. They are an offensive weapon for direct fire contact with the enemy.

Taking this into account, it follows that tanks must have universal equipment and the basic armament capable of fullfilling their missions, i.e., reconnaissance and combat with enemy armor, suppression and destruction of the enemy's anti-tank defenses and artillery, the destruction of defensive perimeters and enemy personnel. Obviously, to fulfill this range of missions, tanks must be equipped with devices that will provide a high firing rate and maneuverability in time and in space.

All this indicates that it is practically impossible to combine all required characteristics and capabilities in one model. Thus, at this stage of development, and in the near future, as stated in the press, tanks will be produced that will differ substantially in terms of combat and technical indexes, as well as design parameters. However, this multiplicity of types of combat vehicles entails considerable difficulties -- requirement for spare parts for each type of vehicle, additional personnel training for operation and maintenance, etc. These problems, in turn, gave birth to the idea of standartization of combat vehicles. The trend emerged to aim at fulfilling all required combat missions, using a minimal quantity of the required types of tanks.

The tank arsenals of most armies of the world now have a so-called "main battle tank", designed for a wide range of capabilities, the principal ones being combat with enemy armor, destruction of enemy anti-tank vehicles, fortifications and personnel. All other types of combat vehicles are narrowly specialized.

Over and above that, the current period of tank development and of armored troops is specific in that its development is predicated on the nature of the future war, the role that armored troops will play in it, and the nature of application of armored forces. In this sense, the basic requirement to a tank is its capability for effective deployment in modern warfare.

It is commonly known that a modern tank is a highly-complex combat vehicle and that armored troops are extremely mobile military units, endowed with optimum capabilities for conducting successful operations in nuclear warfare. Modern tanks are much more perfected than the best tanks, deployed in WW II. They reflect the latest accomplishments of electronics, optics, radio engineering, chemistry and power plant engineering.

Using data from the Soviet and foreign press, the authors attempted to demonstrate the contemporary state of the art of armored technology and armored troops and also to examine the future aspects of the development of armor, without dwelling too much into history. In our view, an analysis of the very general tendencies and laws, applicable to tanks and armored troops is the correct direction, inasmuch as specific tendencies and special issues become rapidly obsolete, whereas general issues, as exposed in prevailing tendencies, have a longer life span.

Marshall, Armored Troops of the Union of Soviet Socialist Republics,
A. Kh. Babadzhanyan

PART ONE

ARMORED VEHICLES

Chapter I

CONTEMPORARY ARMORED TECHNOLOGY AND THE OUTLOOK FOR ITS DEVELOPMENT

Section One

MODERN TANKS

Par. 1: Tanks and General Layout Problems

The state-of-the-art, regarding the development and general tendencies, can be assessed from a consideration of combat and engineering characteristics and properties of the principal types of tanks, adopted within the past few years by the armies of countries, who are leading in the development of armored technology.

Such tanks, above all, include the M60A1 (USA), weight - 46.3 tons; Fig. 1; Chieftain (Great Britain), weight - 52 tons, Fig. 2; AMX-30 (France), weight - 34 tons, Fig. 3; Leopard (Federal Republic of Germany), 40 tons, Fig. 4. Despite the considerable difference in combat weight, these tanks are the main battle tanks of the armies of the respective countries and accordingly are designed for analogous missions.

All these tanks so far retain the traditional classic configuration, where the main armament -- a long-barrel gun, is installed in a rotating turret, the driver-mechanic is in the front of the hull in the driver compartment, the commander, gunner and loader are in the combat compartment and the engine-transmission assembly is in the rear of the vehicle.

Novelties with a similar layout are the Chieftain (Fig. 5), where the driver-mechanic is in a semi-reclining position. This is caused by the desire to reduce the overall height of the vehicle by reducing the height of the hull which, in turn, permits to reduce the weight with the given armor and to decrease the probability of hits on the battlefield.

The criteria for the layout tightness of a tank and for certain other qualities are the dimensions. It should be noted in this connection that the M-60 is the highest tank (2980 mm), whereas the AMX-30 is the lowest. The first one is almost 700 mm taller than the second. The longest hull is sported by the Chieftain (7545 mm), whereas the record for width is held by the M60A1 (3630 mm!). According to these factors, the AMX-30 has the smallest dimensions: length - 6712 mm, width - 3100 mm.

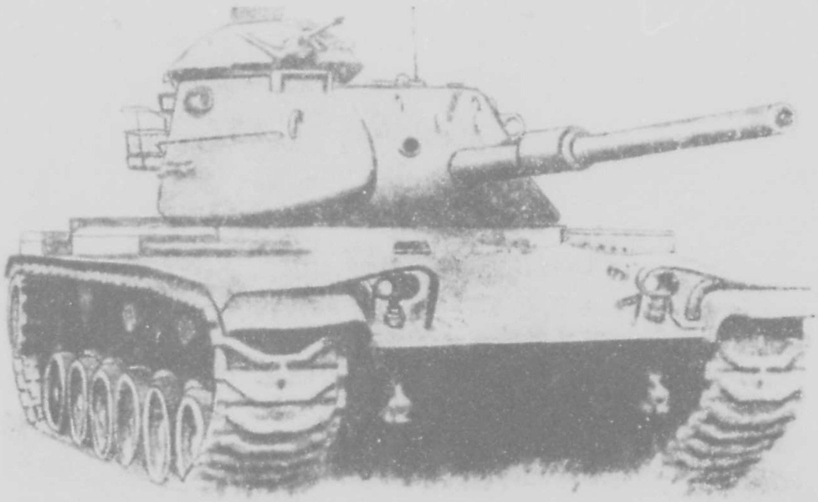

Fig. 1: M60 A (USA)

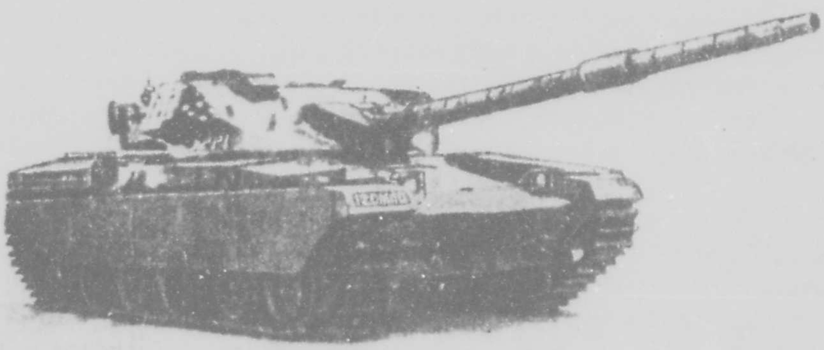

Fig. 2: Chieftain (Great Britain)

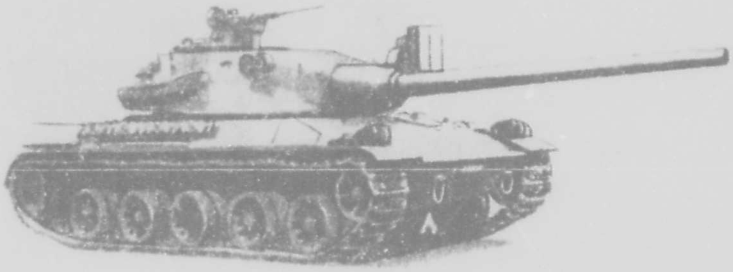

Fig. 3: AMX-30 (France)

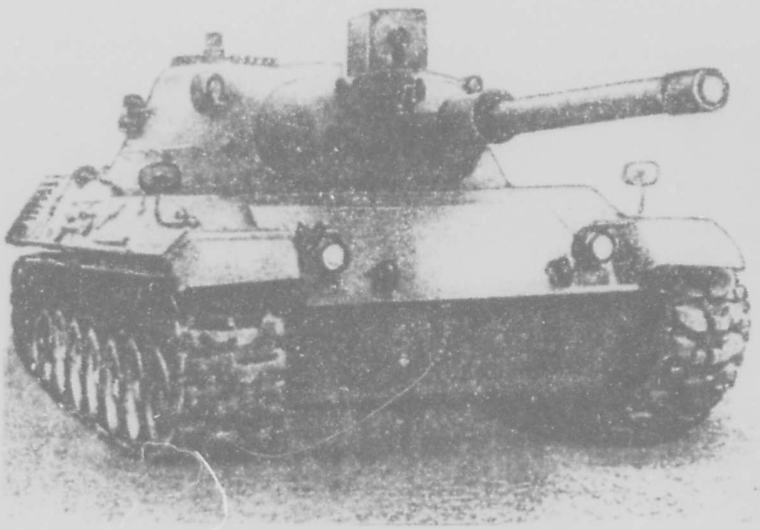

Fig. 4: Leopard (Federal Republic of Germany)

The highest combat weight record is held by the Chieftain, whereas the lightest tank of them all is the AMX-30. The difference amounts to about 20 tons, creating a considerable advantage fo the AMX in terms of transportability (on the ground, by water and by air).

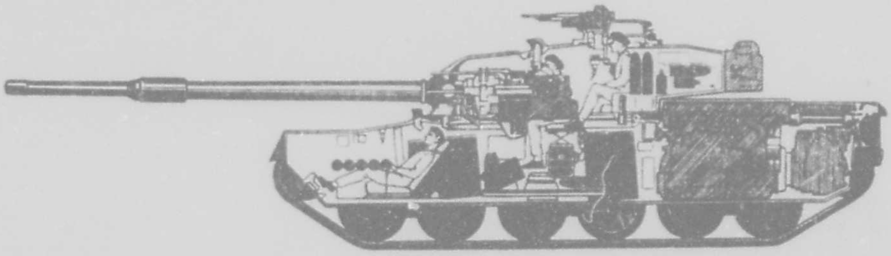

Fig. 5: Longitudinal Section of The Chieftain

Using these indexes, the Leopard is in an intermediate position. To reduce the vulnerability of the driver-mechanic's hatch, its vertical projection is reduced. In some tanks, the driver's hatch is located in the roof of the hull.

The new Swedish turretless tank "S" (Fig. 6) has a somewhat unique design -- the vehicle weighs 37 tons, and the 105 mm cannon is not mounted in the turret but in the hull (Fig. 7).

Combat vehicles with this type of layout of the armament were usually classified as self-propelled artillery, however, in this case, obviously proceeding from considerations of the purpose, including properties and capabilities of the main armament, the aforenamed vehicle is referred to as a turretless tank in the western press.

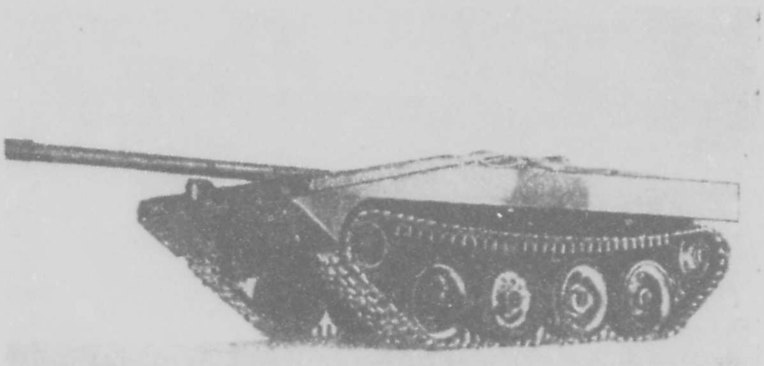

Fig. 6: "S-Tank" (Sweden)

The rifled long-barrel gun, in the opinion of foreign specialists, is sufficiently universal in its capabilities, as well as in maneuvering. It is effectively used for suppressing armored vehicles and, even though not mounted in a rotating turret, has a high maneuverability in transferring fire from one target to another.

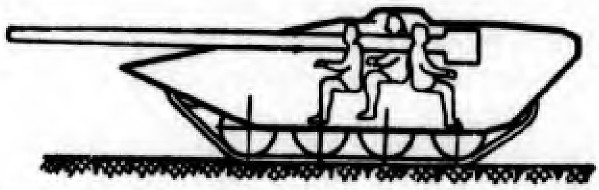

Fig. 7: Placement of Cannon and Crew in the "S"-Tank

Aiming can be done by the commander, as well as by the driver (who is also the gunner) by using motorcycle-type handles and power assists. When a handle is rotated, the turning mechanism of the tank triggers and the gun is aimed in a horizontal plane. The hydropneumatic suspension of the vehicle provides for raising or lowering of the fore or of the aft of the tank by rotating the steering handles -- in this manner the gun is targeted in a vertical plane (Fig. 8).

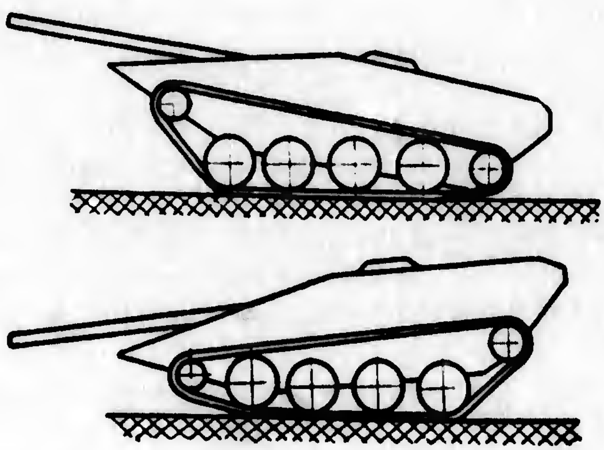

Fig. 8: Targeting Diagram of the "S"-Tank Gun in a Vertical Plane

By means of the hydropneumatic suspension, the weight of the tank can be transferred on the intermediate roadwheels (see Fig. 9), thus reducing the tank's turning resistance and enabling to raise the hull for firing from behind a cover.

The turretless construction is prompted by the desire to develop a vehicle with strong armor, yet staying within the given weight specifications. The rigid installation of the armament in the hull permitted to reduce the crew to three men on account of the automated loading. When the gun recoils, almost the entire length of the hull is utilized; cartridges can be ejected through the aft hatch, thus reducing the gas content in the combat compartment.

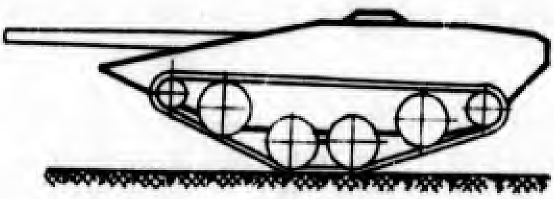

Fig. 9: Elevation Diagram of the "S"-Tank on the Intermediate Roadwheels

Inasmuch as the gun and the four machine guns, rigidly mounted in the front sector of the hull, are loaded automatically, the third crew member, sitting with his back to the commander and driver, is used as a backup driver for driving the vehicle in reverse direction (with respect to the combat position of the gun); he can also perform the functions of a loader in the event of an automation failure.

Thus, a new design concept -- trading off the turret and a rigid gun mounting in the hull reduced the vehicle height and automated the loading. Generally, in the opinion of foreign specialists, this design decreases the interior volume of the vehicle and thus improves the armored protection within the specified weight, or conversely, results in a lighter vehicle, while staying within the specified armor strength.

At the same time, these specialists point out a substantial deficiency of this design -- it does not allow for aimed firing while the vehicle is in motion, thus seriously curtailing the efficiency of this tank in combat conditions.

Concluding the analysis of new tank designs, a few words are in order regarding the "oscillating" (composite) turrets. When they appeared in the light French tank AMX-13, they were hailed by the foreign press as a new an advanced design, leading to a simple automation of the loading. However, in time a lot of flaws were discovered, e.g., limitation in corners in vertical aiming, complex hermetization of the "halves" of the turret, etc.; consequently, these turrets were not used in main battletanks.

We will now consider the principal combat properties of modern battle tanks -- their fire power, armored and special protection, and mobility in order to obtain an adequately complete understanding of the level of the current state-of-the-art and of the projected future developments.

Par. 2: Fire Power

The latest specimens of main battle tanks, adopted as standard armament in armies of capitalist states, all have a drastically increased firepower. This has been accomplished by the installation of large-caliber guns with high muzzle velocities, providing powerful high-velocity ammunition with high target-destructing power, equipping the tanks with devices and mechanisms that improve the fire accuracy and the fire rate.

High fire efficiency under varying conditions is attained by using stabilizers, range finders, aiming and night observation devices, automatic loading devices, designed to compensate for deviations of the firing conditions from normal.

Modern battle tanks, as noted previously, are equipped with long-barrel large-caliber guns.

The US tank M60A1, as well as the West German "Leopard" are equipped with 105 mm British rifled guns, first used in the British tank "Centurion". The French "AMX-30" and the Swedish "S"-tank are equipped with rifled systems of the same caliber, but of their respective native manufacture. The British "Chieftain" is equipped with a 120 mm rifled gun.

Armored targets can be effectively suppressed by using hard-core projectiles with tracers and shaped high-explosive (hollow charge) projectiles. Thus, according to the foreign press, the shaped high-exposive projectiles of the British 105 mm gun penetrate 300 mm steel armor at a distance of 100 meters. The high muzzle velocity of the hollow charges of this gun (1475 m/sec) provides for high reliability of target acquisition and a long firing range.

Modern hollow charges have even a higher armor penetrating capability -- they are capable of penetrating armor 3.5 to 4.0 times their caliber, regardless of the distance to the target.

As known, one of the main drawbacks of hollow charges (when used in rifled guns) is the reduction of the armor-piercing action by about 30 percent, due to the influence of the rapid rotation of the charge upon the formation of the hollow-cone jet.

To eliminate this deficiency, the French developed a projectile, whose hollow charge is enclosed in an inner housing, separated by ball bearings from the outer housing to which rotation is imparted by the rifling of the barrel. Thus, the rotary movement of the outer housing is not transferred to the hollow charge. In this manner, the high armor-piercing capability of a non-rotating hollow charge is combined with high firing accuracy, inasmuch as the firing is done through a rifled barrel.

Projectiles of this type are visualized for the 105 mm gun of the new French tank AMX-30. The muzzle velocity of these projectiles is 1000 m/sec, and the armor piercing capability reaches up to 400 mm.

The British have recently developed armor-piercing high-explosive ammunition with plastic explosives and a deformable nose portion. The nose portion is designed in the shape of a thin steel hemisphere, covered by the ballistic cap. The housing thickness is about 0.1 caliber and it is filled with plastic explosives. When the projectile impacts against the armor, the nose portion flattens. The diameter of the contact area may reach up to two calibers. When the base fuze is triggered, the explosive charge goes off on the surface of the armor and, as a consequence, metal peels off from the interior of the armor. The explosive force pushes this metal inside the tank, thereby destroying the interior and personnel. The effectiveness of charges with plastic explosives has little to do with the angle of impacting the armor. The British consider this type of ammunition of prime importance, primarily because of its versatility and the possibility of deployment against infantry.

The US tank M60A1 uses hard-core projectiles with a separating sabot and shaped high-explosive charges with stabilizing fins, as well as armor-piercing high-explosive ammunition with plastic charges, developed by the British for their 105 mm gun.

The ammunition arsenal of main US battle tanks also includes smoke or incendiary shells, equipped with white phosphorus, designed both for target acquisition and for the laying of smoke screens.

The availability of several types of shells provides for an effective acquisition of different types of targets on the battlefield and imparts the large multipurposeness of the on-board weapons which is so vitally important for tanks.

Typical for the armament of the main battle tanks of capitalist states is the large amount of ammunition (of the order of 60 rounds), inspite of the large caliber of the on-board guns.

The tank's fire accuracy is improved as a result of introducing stabilizers for the two aiming planes (e. g., in the British Centurion and Chieftain), as well as by introducing range finders (M60A1, AMX-30, Leopard and others). Calculations indicate that range finders increase the hit probability at a distance of 2000 m approximately by the factor of two, even with a muzzle velocity of $v = 1600$ m/sec. According to published data, the optical range finder of the "Considence" type, used on the M60A1 tanks, provides for an accuracy of $\pm$ 25 m at a distance of 2000 m.

Of certain interest are the attempts to use optical quantum generators (lasers) for range finders -- this is frequently mentioned in the foreign press. It is felt that one of the principal advantages of a laser rangefinder, as compared to an optical rangefinder, is that its accuracy practically does not diminish with increasing distance.

Stabilizers and rangefinders are rather complex equipment from the viewpoint of production; to operate them properly, the personnel must have advanced training.

The use of this type of equipment has a considerable effect upon the tactical aspects of the combat deployment of tanks. While stabilizers provide for effective firing when the tank is in motion, the availability of a rangefinder makes it feasible to engage the enemy from short stops, when the opportunity presents itself for an effective target acquisition from a large distance.

Fire accuracy from on-board guns is sometimes improved by utilizing paired ranging machine guns (as on the Chieftain), or even small-caliber guns, as used on the Swiss tank Pz-58.

However, this method of improving the firing accuracy increases the time required for the preparation of firing of the first round and also reveals the location of the vehicle.

Automation of the preparation for firing, the actual firing and the fire control is one of the directions of development of tank armament.

In modern tanks, the commander can rotate the turret from his control panel. This permits him to take over the fire control in combat. Moreover, the commander can aim and fire from the on-board cannon, using the rangefinder (as on the M60A1) if the gun layer is incapacitated.

Some tanks (M60A1, and others) use computerized devices which automatically introduce corrections for every type of shell for deflection, incline of pins, jump, bend of the barrel and other factors.

Computers also take into account the difference in checking and ranging for every type of ammunition. Devices of this type substantially increase the probability of target acquisition, starting from the first round, especially for low-muzzle velocity shells.

The experience of WW II and of the Korean war demonstrated that troops must be capable of combat, regardless of visibility. In view of this, and to provide for successful operations of armored troops at night and in conditions of poor visibility, the commanders, driver-mechanics and gunners in modern tanks are equipped with special infrared observation and fire-control devices. This feature considerably expands the combat deployment possibilities of tanks and improves their camouflage. However, inasmuch as these devices operate with infrared projectors, they can be discovered by means of similar devices.

The gas level in the combat compartment of a tank during firing can be reduced by special ejection devices, used to blow out the barrel. In some instances ("S"-tank, AMX-13, Centurion) an ejection mechanism for spent cartridge shells is used in order to cope with the rising gas level in the combat compartment and the fact that it is cluttered with shell casings, is the use of combustible or semi-combustible shells.

This, in turn, entails a metal economy (bronze or steel) in the manufacturing of shell casings and eliminates the need for a troop detail assigned to the collection of spent shell casings.

Extensive operations, conducted in a number of countries in that direction, have culminated in a certain amount of success, so in the near future, one could expect the introduction of combustible (or semi-combustible) shells in everyday military use.

The Leopard tank, in addition to the gun ejector, is equipped with a special ventillation-exhaust system to remove the gases, emitted from firing from the gun or from the machine gun. The fan removes gases, emitted during the firing from the machine gun directly from the opening in the mask or via a flexible hose, whereby this device is connected to a box, immediately under the breech mechanism, where the spent shell casings are dropped.

As previously, tanks are equipped with auxilliary machine gun armament, including anti-aircraft weapons, to fight weakly-armored ground and air targets, and infantry.

The principle of paired installation of a machine gun with a cannon is still generally accepted. Frequently, various purpose machine guns are placed on commander's cupolas, equipped with their own ball support for turning with respect to the main turret. Thus, "M60A1", "AMX-30" and the "Chieftain" are equipped with commander's cupolas, carrying machine guns. On the "Leopard", anti-aircraft machine gun can be installed on the race plate above the loader's hatch, or above the commander's hatch.

To bolster the effectiveness of tank armament in long-distance combat, some tanks, in addition to the main gun, are equipped with several anti-tank guided missiles with high-explosive hard-core charges with high armor-piercing capability. Wire-guided missilcs of this type are installed outside the turrets of the light French tanks (see Fig. 10). The US have experimentally installed five guided missiles "SS-10" in the front of the turret of the M48A2.

The British have been using "Malcara"-type guided missiles on the turrets of several Conqueror tanks.

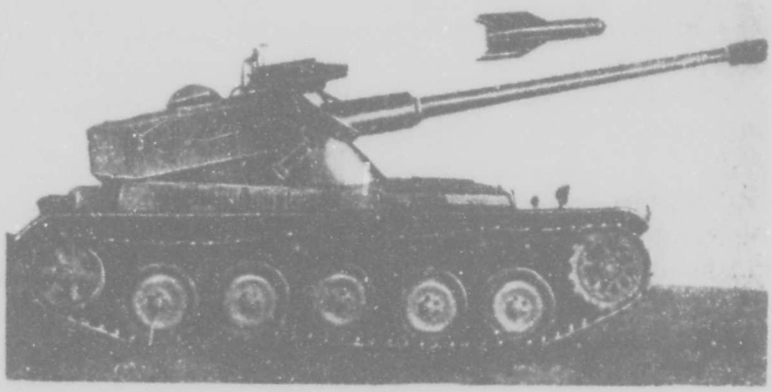

Fig. 10: AMX-13 (France) With Guided Missiles

In spite of the accomplishments in the development of barrel artillery in the US, France and some other capitalist states, intensive work is being performed to design main armament for tanks in the form of guided missiles, which is frequently considered to be the most advanced type of armament.

Notably, gun equipment restricts the possibilities of a substantive improvement in new tank models. Thus, a long-barrel gun in a tank calls for gun installation in the rotating turret. As known, the turret with the gun amounts to about 25 percent of the weight of the entire vehicle. A long-barrel gun is a handicap in the negotiation of obstacles, the turret (increased height) increases the probability of hits in combat and prevents from using optimal solutions in terms of nuclear protection, presenting in itself a number of difficulties.

In the judgement of many Western experts, the advances in nuclear technology, automation, telemechanics as well as the development of anti-tank guided missiles have provided the premises for the use of the latter as the main armament of tanks. The installation of specially designed and perfected guided missiles on a tank will, in their opinion, provide a qualitative jump in fire power. As compared to conventional gun equipment, guided missiles will provide a high combat efficiency when the tank is in motion and when it is at standstill, allowing a target acquisition with the first -- second missile at distances of up to four hilometers. The use of guided missiles will allow to trade off the heavy turret, use new layout modifications, improve the armor and the radiation protection, reduce the overall height of the vehicle and thus drastically reduce the changes of the vehicle being hit in combat.

Guided missiles, as a new type of armament, are, in the opinion of foreign experts, still at an early stage of development and consequently their characteristics as yet do not match the requirements to the main armament of a tank.

It should be mentioned in that connection that the US are perfecting an amphibious and air-transportable light tank (about 14 tons) - Sheridan (Fig. 11), equipped with a short-barrel filed 152 mm gun. The gun is designed for conventional ammunition and can be also used for firing nuclear ammunition Shillelagh, guided by an IR beam. It is further reported in the press that it is proposed to use nuclear ammunition of the "ACRA" type (currently still in the development stage) in the French tank AMX-30, by firing it directly from the gun. Thus, it is entirely possible that in the not so far removed future, rockets will become the main armament of tanks.

One of the directions, in which the US is moving to improve the firepower of armored vehicles, is the usage of artillery shells armed

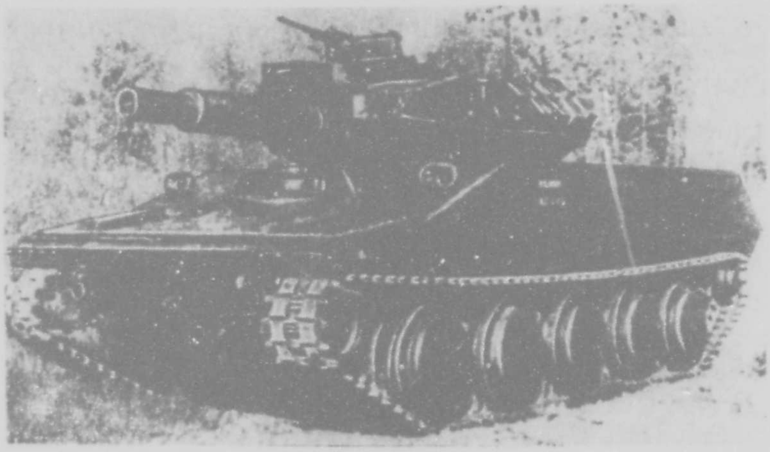

Fig. 11: Sheridan (USA)

with nuclear warheads. It is felt that the usage of small-caliber nuclear weapons will greatly improve the firepower of tanks.

Low-yield nuclear ammunition for tactical applications on the battlefield, in conjunction with conventional ammunition, has been developed for the mass-produced self-propelled gun M110 (203.2 mm howitzer) and for the M-109 (155 mm gun).

Par. 3: Armored and Special Protection of Tanks

The successful development of means of armor suppression and above all the advent of guided anti-tank missiles led to the frequent speculation in specialized foreign sources as to the feasibility of reducing the armor protection of a tank. In the opinion of the authors of this concept, this is entirely compensated by giving the vehicle greater mobility and hence lesser vulnerability on the battlefield, inasmuch as the vehicle weight will be decreased.

In analyzing this concept, it should be above all remembered that tanks with invulnerable armor never existed. There were always some means on the combat field to penetrate the armor. Considering the pair of adversaries armor--projectile, the projectile always has the upper hand. Nonetheless, in the entire course of the development of main battle tanks, there was a notable tendency to increase their armored protection. Essentially, the same situation exists presently, where such well known main battle tanks of the armies of capitalist countries like the M60A1, the Chieftain and others have a powerful armored protection.

The trend to use powerful armored protection stems from the fact that such armor considerably reduces the probability of hits by miscellaneous anti-tank weapons which can be encountered on the battlefields and primarily, it provides protection from enemy tank guns. Powerful armor puts a tank into a favorable position during a fire fight with enemy tanks which have a comparably weaker armor, since in such an engagement the decisive factor is the complex fire power-- armored protection which, in turn, determins the combat life of a tank.

The relative ease of target acquisition by guided missiles at the present time can be discussed in proving grounds terms, i.e., under peace conditions when no combat means are engaged to suppress the operators of these guided missiles. At the same time, there are all reasons to believe that under modern combat conditions the guided missiles' operators will be rather vulnerable, and the effectiveness of guided missiles, deployed against tanks in actual combat conditions, will be drastically reduced.

Not the least argument in favor of heavy armor is the fact that thick and efficient armor is one of the most reliable means of protecting the crew and the interior equipment of a tank from the damaging effects of nuclear explosions, i.e., penetrating radiation and shock waves.

Thus the principal shortcomings in the use of heavy armor are the increase in combat weight, resulting in losses of mobility and terrain negotiation capability, transportability, and of some other properties.

Hence, the strengthening of armored protection of tanks in recent years moves not so much in the direction of increasing the thickness of the armor, but rather in the direction of providing the principal armored components (mainly the frontal ones) with larger angles of incline to the vertical (reaching 60 degrees and more on the M60A1 and Chieftain) and toward a more differentiated distribution of the thickness of the armor, taking into account the hit probabilities in combat.

Optimum distribution of the thickness of armored components, while maintaining the specified weight can be accomplished by casting them -- this is reflected in the design and construction of turrets which are presently produced as casts on all main battle tanks.

The hulls of most foreign tanks are produced from rolled sheet stock and joined by welding, and only the hulls of the US M60A1 and of the Swiss Pz-61 are all-cast.

Anti-shell armor (presently, as well as during the entire period of tank development) is manufactured exclusively from special armor alloyed steels. Armor from light alloys, so far, is used only to provide anti-bullet protection. Specifically, aluminum alloy armor is used on US personnel carriers M113 and M114, as well as on self-propelled artillery M-108 and M-109, on the light tank Sheridan and some other vehicles.

The multiplicity of modern means to combat tanks produces additional difficulties in terms of simultaneously providing a reliable protection from armor-piercing charges and high-explosive charges, whose armor-piercing effect is based on different principles. The action mechanism of projectiles with plastic charges has its own peculiarities. In developing and designing tank armor, one must not forget about the necessity of protection from penetrating radiation in the form of γ -radiation and the neutron flux.

In view of this, numerous ideas were advanced, dealing with the design of the so-called combination armor, or laminated armor, consisting of plates (or sheets), made of different materials.

The recommended protection against armor-piercing shells, as a combination-type protection, usually involves the use of a combination of armored steel sheets to protect the vehicle from the effect of armor-piercing sheels, and of plates (or sheets) of non-metallic materials, capable of destroying the armor-piercing jet, thus providing some token protection from armor-piercing.

The Sheridan's armor-piercing protection is made in the form of a reinforced skin for the hull. Prior to combat operations, the space between the external skin and the base armor is filled by sand (or water) which is removed after combat.

Plastic tank armor, which was frequently reported in the Western press, so far has not received any practical applications and no data are available, other than usual advertising notices.

The requirement for lengthy and extended operations in radio-actively-contaminated terrain and crew protection from chemical and bacteriological agents led to the development of reliable hermetization and the introduction of filtering-ventillating equipment for the purification of the crew's air supply, as well as pressurization, to prevent the entry of contaminating agents together with the air.

Par. 4: Mobility

All foreign military experts unanimously agree that the scope, depth of penetration and their rate in conditions of nuclear war require a substantial increase of the mobility of armored troops and an increase of their capability for continuous operation. This is reflected in the development of tanks wi th higher maximum and average speeds, in an increase of their action radiuses on one supply of fuel. The technical relability of components and mechanisms has also been substantially increased.

Increased mobility calls for the increase of the specific power (i.e., power per ton-weight) and depends on the design of the power train, control elements, perfection of the elements in track/ground interface (specifically suspension elements), and provisions for good visibility.

Thus, while post-war US and British tanks (M26, Conqueror, Centurior and others) had a specific output of about 12 hp/ton, the M60 presently rates at 16.2 hp/ton, whereas with the Leopard and AMX-30, this factor reaches 21 hp/ton and 22 hp/ton, respectively.

The increase of the specific power up to the indicated figures permitted the Leopard and AMX to reach maximum speeds of 65 km/hr (and 70 km/hr, according to certain other sources), whereas the application of perfected transmissions, control elements and suspension systems apparently led to a high speed range also in off-the-road locomotion.

The foreign development of powerplants for tanks is typical in the introduction of diesel engines -- notably, we have installed diesel engines in Soviet tanks going back to the pre-WW II period. The reason for this development, of course, was the fuel consumption economy which substantially increased the action radius.

Another typical direction in the development of tank power is the provision for multifuel characteristics of the engines, i.e., the capability of operating on benzine, kerosine, diesel and special aircraft fuels, all of which considerably simplifies the logistics of supplying tank troops with fuel.

Multifuel engines are currently installed on the Chieftain, and on the Leopard; the use of multifueld engines is also visualized on the AMX-30 and on some other tanks.

Along with the introduction of multifuel engines, in a number of countries, and above all in the USA, intensive development work is on the way to produce gas turbine engines for tanks, even though the initial prototypes, at least for the time being, are less economical in terms of fuel consumption than piston engines.

The emphasis on gas turbine engines is due to the lighter weight and smaller dimensions, as compared to piston engines, which presents certain advantages in the overall development of a compact powerplant for a tank. Moreover, the advantageous drawbar characteristic of gas-turbine powered vehicle permits to simplify the design and to reduce the dimensions of the powertrain, which presents additional possibilities to reduce the volume of the power plant compartment and of the power train. This volume, in turn, can be used for placing reserve fuel, thus compensating for the low economy of the engine.

Gas turbines can operate on different fuels and have good starting properties. So far, they were only used on prototypes (e.g., on a special prototype, built around the Conqueror chassis). In the Swedish "S"-tank, the gas-turbine power plant is installed in parallel to the main multifuel piston plant and is switched on only when the power requirements are higher than those that can be delivered by the main powerplant. The GT engine of this tank is also used to start the main engine.

Some of the specific features of power plants, common for US and FRG tanks, should be pointed out, inasmuch as they reflect the orientation for the emergence in the near future of anti-tank weapons, based on new principles of reaching high target acquisition capabilities. This entails the design of heat-dissipating devices for intensive mixing (cooling) of the engine exhaust gases with the airflow, prior to their removal from the tank. The appearance of such devices is predicated on the possibility of the enemy's use of guided missiles with heat-seeking heads.

One of the ways of increasing the action radius of tanks, in addition to introducing low fuel consumption engines, is the increase of the fuel tank capacity. Inspite of the trend to reduce the vehicle combat weight, which requires a minimization of the interior volume of the hull, the necessity to increase the operating radius of the vehicle calls for an increase of the on-board fuel supply. Thus, the fuel tank capacity of the M60A1 is 1460 liters, the Leopard carries 1000 liters, and the AMX-30 carries 920 liters. The quantity of fuel, carried in auxiliary tanks outside the vehicle has also increased considerably.

As a consequence, the crusing radius of late-model foreign tanks on a highway exceeds 500 kms.

A gain in mobility, as indicated previously, is also attained by using more perfected powertrains, hull suspensions systems and drives, contributing to better and easier operation of the vehicle, and increased visibility.

Modern tanks use various types of mechanical transmissions, including five-stage gearboxes, as well as hydromechanical transmissions (hmt).

Hydromechanical transmissions, which became rather popular in the US within the past few years, in both tracked and wheeled vehicles, include a hydrodynamic torque converter, which varies the torque steplessly and automatically on the driven shaft of the hmt within a quite large range, while the operating mode of the driving shaft remains almost unchanged. The torque on the driven shaft, depending on its speed, changes with a characteristic that is close to hyperbolic; accordingly, when the vehicle moves with different resistances this feature permits to more fully utilize the rated engine output and to increase the average speed of the tank.

The characteristics of the hydrodynamic torque converter permit to reduce the number of stages in the transmission, to simplify and to facilitate the control of the vehicle, up to and including the automation of the shifting process, which in turn, contributes to an increase of the average speed. As a rule, hydromechanical transmissions are equipped with hydraulic drives with servomechanisms (or power assists). Their life expectancy is rather high.

In view of those properties, transmissions of this type became quite popular in US tanks and in some late-model European tanks. Specifically, they are used in the M60A1, the Leopard, and in the turretless "S"-tank.

Compared to conventional mechanical transmission, the hydromechanical transmissions have certain inherent and substantial flaws and deficiencies -- basically the reduced coefficient of effectiveness, which has a detrimental effect upon the vehicle's operating radius, the increased complexity of the design, and the increased volume, in view of the requirement for a self-sustained cooling system for the deflection of heat from the hydraulic transmission.

The design of the control drives and mechanisms, to a large extent influences the pulling and dynamic properties of the vehicle, which are, in turn, provided by the power plant and by the transmission assembly. The driver must perform a multitude of operations, and if need be, exert considerable effort operating levers and pedals, in order to overcome their resistance. Fatigue reduces perception and response in the framework of a rapidly changing situation; this, in turn, not only affects the driver's response and reaction in combat conditions, but also contributes to a reduction of the engine load, leading to a reduction of the average speed. Driver fatigue also leads to a reduction of the extent of large combat marches (both in time and in distance). Also this explains the extensive use of different power elements (or servomechanisms) in modern tanks and the tendency to automate certain control processes, to facilitate the modus operandi of the driver. Rather popular are hydraulic powerdrives which almost completely relegate the driving to the energy of special energy sources. Thus, in the Chieftain, the switching of gears in the transmission is accomplished by an electrical drive. In the Leopard the slide valves of the hydraulic drive are remotely-controlled by an electromagnetic system.

From the standpoint of design, the control elements in certain tanks for turns are developed similarly to the automotive and aircraft elements, i.e., in the form of a control stick (M60A1, Leopard). Motorcycle-type designs, used in the "S"-tank, were discussed previously.

The suspension system plays a decisive role in attaining a high average vehicle speed in the terrain.

Hull vibrations, shocks and impacts, occurring when the vehicle moves in off-the-road conditions, cause considerable crew fatigue, reduce the accuracy of firing while the vehicle is in motion (even with the use of armament stabilizers), and rigid impacts of the balancers of the roadwheels against the stroke limiters (suspension "bottom-out") require a reduction of the speed of the vehicle. Thus, the improvement of suspension systems is currently a very important area of research. Individual torsion suspensions with large dynamic stroke of the rollers have become quite popular, and powerful hydraulic telescopic shock-absorbers are used to attenuate the hull vibrations. Numerous studies in Sweden, USA and other countries are aimed at the development of hydropneumatic suspensions which, in addition to serving as suspension systems, will easily permit to vary the vehicle clearance, up to lowering the hull on the ground.

As compared to other groups of mechanisms, the tracked vehicle has the smallest life span. This is essentially caused by the extremely difficult working conditions of such elements as the track hinges and the grousers.

Currently, two types of track hinges are used -- the open metal track hinge and the annular rubber-metal type (also known as the "silent block"). Each has its positive and negative properties. Tracks with metal hinges are simple and inexpensive in production, they are also light and easily replaceble in operating conditions. Tracks with rubber-metal hinges last longer -- this is their tremendous advantage, as opposed to open metal hinges.

Tracks with rubber-metal hinges are used on US tanks, the Leopard et al. Notably, tracks with rubber-metal hinges, in view of the relatively more rigid connection between the tracks, all other conditions being equal, provide for better mobility on swampy terrain, as compared to tracks with open metal joints.

The high mobility of tanks is accomplished by the low specific pressure of the tracks upon the ground and a good cohesion in the track/soil interface. This led to the development of wide track chains with well-developed grousers.

Obviously, taking into account the experience of WW II, the Leopard and the AMX-30 vehicles have a low specific ground pressure, particularly the AMX-30, where it is only about 0.71 kg/cm^2.

The capability of a tank to negotiate water barriers was always considered extremely important. This acquires special significance in modern conditions, when the combat operations are performed at a very high speed.

Modern tanks are capable of negotiating water barriers without the use of bulky auxiliary equipment, moving along the bottom of the barrier, and/or floating.

Hermetization of the hulls and reliable seals used in the turret support assemblies, permit tanks to negotiate deep waterways without any preparation.

Underwater driving of tanks at depths of 4 to 5 meters is considered an almost necessary requirement to modern tanks of the basic types and is implemented in practice. The M60A1, Leopard, AMX-30 and the Chieftain have this characteristic.

Incidentally, in the Soviet Union, underwater operation of tanks was tested a long time before WW II.

To be capable of negotiating a water barrier on its own, a tank must be floatable and be equipped with an adequate propulsion assembly.

The floatability of the heavily-armored basic types of tanks, which also weigh accordingly and yet have a relatively small volume, is attained by using miscellaneous floating devices of various designs (as in US tanks), or by the use of light removable hoods (or carcasses) which increase the water displacement; these are made of water-tight canvas (Chieftain) or of other materials. Thus, the floatability of the Swedish "S"-tank is attained by means of a collapsible carcass made of elastic plastic material, which is placed over the perimeter of the tank into special armor-protected crevices. The carcass is placed into working condition by using a device that employs compressed air.

The removable equipment, as a rule, is discarded, after the tank reaches shore, by using low-power pyrocartridges.

The water propulsion unit is either based on the standard tracks ("S"-tank), or on special removable propellers, powered from the driving wheels of the tank (Chieftain) and other vehicles.

The tendency to expand the combat capabilities of a tank led to the development and installation of navigational devices on tanks that permit the crew to determine its location under any conditions of visibility, even on extremely difficult cross-country terrain. Thus, according to published reports, equipment was developed for the M60A1 which includes a gyrocompass, computing devices, a road sensor and a correction device for the incline of the terrain. The total weight of the equipment is about 55 kg. This entire equipment assembly indicates on a small circular scale with two hands, one showing the direction of motion of the tank, the other one showing the required direction. The driver must turn the tank up to a point where the two hands will coincide, and then the tank is moving in the assigned target direction.

Of special significance currently is the reliability of the vehicle. Notably, in this context, the reliability of a tank is interpreted as its operational capability without interruptions, performing in accordance with combat characteristics, with repairs or complex adjustments or replacement of components and assemblies if such is not provided for as conventional maintenance of this type of equipment.

The considerable depth of the military operations, the unavoidable maneuvering and transport under its own power without any lengthy interruptions between the operations -- all this leads to a substantial increase in the overall operating radius of a tank. High-speed mobility involving large distances with rare occasional short stops, lack of time for maintenance and checking create very difficult conditions for the work and operation of the assemblies and components. At the same time, forced delays under conditions of fast and incessant combat to a great tactical depth may separate a tank from its combat formations for a long time.

Hence, modern tanks require a very high reliability to provide for safe operation, a high technical lifespan, and minimum maintenance.

The improvement of the reliability of assemblies and mechanisms of foreign tanks led to the introduction of transmission friction clutches and transmission brakes, operating in oil, replacing dry frictionating elements, which are subject to high wear and require frequent adjustment; another improvement was the introduction of tracks with rubber-metal joints. Tracks of this type are more complex in manufacture and less convenient in operation, than tracks with an open metal joint, however, they are more advantageous because of their longer life.

Conditions of modern warfare will require a lengthy confinement of the crew inside the tank with all hatches sealed. At the same time, the trend toward a compact layout, caused by requirements to reduce the weight, reducing the dimensions and strengthening of the armor bround about a small interior, whereas the need to protect the crew from various aspects of a nuclear explosion required a reliable hermetization of the vehicle. If we are to add to this the gas contamination of the combat compartment and of the driver's compartment during a sustained firing rate, we can visualize the difficult conditions under which the crew will operate, especially at high temperatures of the ambient air.

In view of this, it became necessary to design and incorporate air-conditioning devices to provide for a certain air composition and to maintain the required temperature and humidity, i.e., provide the necessary microclimate.

Section Two

SELF-PROPELLED ARTILLERY (SPA)

Self-propelled artillery (SPA) is an important category of armored technology. In addition to tanks and armored personnel carriers (APC), it also includes other armored vehicles, equipped with barrel artillery armament.

SPA emerged somewhat later than tanks, as armored technology became more and more developed and specialized for specific and limited missions. Hence their armament is not as versatile (in terms of characteristics and applications) as the armament of tanks.

SPA differs from APC in that it does not carry assault and landing troops, but is equipped with powerful artillery weapons.

SPA's were widely used in WW II, primarily as a means to improve the effectiveness of anti-tank warfare, being that the armored protection and firepower of tanks was continuously increasing in the course of the war.

Naturally, tanks with their firepower, armored protection and mobility are the best means of suppressing enemy armor; however, for an effective performance of this mission, they must exceed the enemy in armament and have a very insignificant trade-off in terms of the strength of their own armored protection.

Notably, to produce a new tank in war conditions in a short span of time and to set up the mass-production of it to satisfy the requirements of front-line troops with the requirement that this tank surpasses enemy tanks is an extremely complex task and frequently an impossible one at that. During combat operations on a scale and intensity as they were conducted in WW II, a lengthy interruption in the supply of logistics and ordnance cannot be afforded or tolerated.

In the opinion of foreign specialists, thepossibilities of increasing the firepower of a main battle tank by increasing the gun caliber or by increasing the initial muzzle velocity (or both simultaneously) are rather limited, primarily by the volume available of the combat compartment and thus, an increase in firepower in this manner is not always feasible.

At various stages of WW II, it was found that a simpler solution of the problem would be the development of self-propelled artillery vehicles, based on existing tanks, which had their armament mounted on a rigidly-installed unit on the hull, rather than on the rotating turret. In the tank, on the basis of which the SPA was designed, the volume of the rigid unit was larger than the volume of the combat compartment of the tank -- this, in turn, permitted the installation of more powerful armament. In addition, the SPA vehicle turned out to be lower, and there were numerous instances where the armor protection could be improved retaining the weight equal to that of the tank, without affecting the mobility.

Inasmuch as the armament was installed into a rigid unit (hull), the SPA vehicles had a limited angle of horizontal incidence of the guns which, in turn, affected the fire maneuverability and consequently, the field applications and turned the SPA's (as compared to tanks) into combat vehicles with a considerably narrower range of missions.

Another motivation, that prompted the development of SPA's during the WW II period, was the strengthening of the infantry-suppressing characteristics of armored combat vehicles. To this end, the SPA pieces designed on a tank base, as a rule, carried larger caliber guns in their rigid elements than the prototype tanks, or else they were equipped with cannons-howitzers, or simple howitzers.

SPA vehicles, that came into being in this manner, were designed in different ways. Light and medium SPA's were intended for direct infantry support, whereas the heavy SPA's were designed for the support and the amplification of armored troops operations, and for the support of their respective units.

Such a method of improving the principal combat qualities of tanks in war conditions was justified, inasmuch as SPA's, obtained in such manner, were simpler than tanks from the viewpoint of design which naturally influenced their quantitative production possibilities.

In peace time, when enough time is available for the design and development of perfected tank models, this method of creating SPA's is hardly desirable, hence their production was discontinued in all countries.

Finally, in view of the extensive use of airforce against ground troops, anti-aircraft self-propelled artillery units, designed to combat low-altitude enemy aircraft were developed independently during this period.

In the post-war period, SPA's designed for general and direct support of combat operations became popular in the armies of several countries, especially in the USA.

Their usage is predicated on the premiss that even in conditions of thermo nuclear warfare, nuclear attacks will not take place everywhere and/or at all times, moreover, artillery support may be required for an effective operation of tanks and motorized infantry in the preparation of an assault, or during its course. To this end, the arsenal of US, France, the Federal Republic of Germany and of other nations include (on division and corps level) artillery units, equipped with SPA's; these are lightly-armored and rather mobile tracked vehicles, equipped with howitzers and sometimes cannons. As a rule, they are intended to maintain a group fire from closed positions.

In accordance with their missions, the armament of such SPA's must have a long firing range, the capability for target acquisition over a large area, good maneuverability of fire (both in terms of range and horizon), a large supply of ammunition, including high-explosive fragmentation projectiles.

It was found from practical experience, that the armament of SPA's up to 155 mm caliber can be installed in a closed turret with circular rotation. Western experts feel that antibullet armor, designed to protect from large-caliber machine gun fire and shell fragments, is quite adequate, inasmuch as these vehicles will not come in direct contact with the enemy.

Nuclear protection is accomplished by sealing the hull and the turret and providing the necessary accessories for filtration and ventillation.

In the early 60-ies, the US Army Command, being quite concerned about the development of self-propelled barrel artillery, adopted four new types of vehicles of this type.

Presently, the artillery batallions, attached to the motorized and armored divisions of the US Army, utilize the SPA's vehicles M108 and M109, equipped with 105 mm and 155 mm caliber howitzers, respectively. To a large extent, these vehicles are based on the assemblies and sub-assemblies of the M113 APC.

The guns on SPA's are installed in turrets with vertical rotation; the antibullet armor of the hulls and turrets is made of aluminum alloys, thus providing for floatability. Propulsion in water is accomplished by standard tracks.

The combat weight of the M109 (Fig. 12) is 24.6 tons. The vehicle carries a crew of six. The vertical aiming angles of the guns are -3 deg. and + 75 deg. The maximum fire range is 18.1 km. Nuclear shells with a trotyl equivalent of under 1 kt are provided for the 155 mm howitzer. Maximum operating speeds on the ground and in the water are 56 kmh and 4.3 kmh, respectively.

According to press releases, the M109, having more powerful armament as compared to the M108, will substitute the latter in the US Army. Additionally, the M109 is also furnished to the West German Bundeswehr.

The SPA's M110 (203.2 mm howitzer) are both made on the same special base. Artillery systems are mounted open on the chassis, in the aft of the hull. The hull is welded of steel armored plate stock of different thickness and separated into compartments, i.e., the control compartment, the powerplant compartment and the transmission compartment, located in the front of the hull, left and right respectively; the combat compartment is in the aft. The crew consists of five men (driver-mechanic, who also performs the function of the commander, two gunlayers and two loaders). The front wheels are powered. The directional wheels perform the function of sprung supporting rollers. The track is equipped with rubber-metal joints. The combat weight of the M107 (Fig. 13) is 28 tons. According to press releases, it can be airlifted by two aircraft, where one carries the chassis and the other carries the oscillating part of the gun.

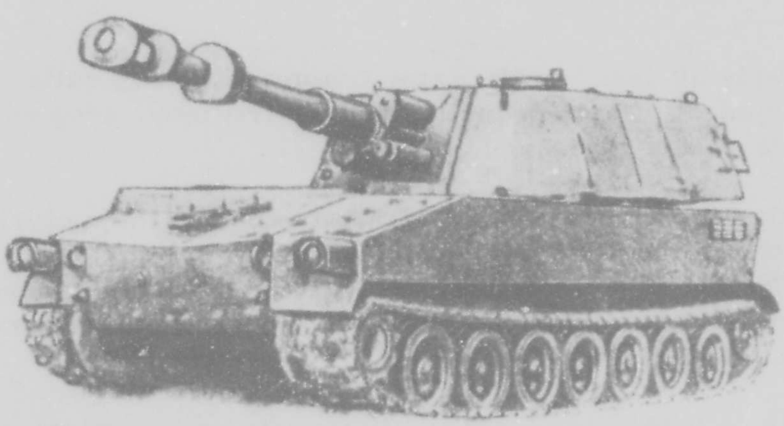

Fig. 12: The M109

Horizontal and vertical firing angles are 60 and 65 deg., respectively. The firing range is 32 km. A recently developed projectile, known as the M437, provides for a firing range of 40 km. Maximum vehicle speed is 55 kmh. The ammunition includes high-explosive shells only.

The M107 is furnished to the Artillery Corps of the US Army and to the West German Army.

The combat weight of the SPA M110 (Fig. 14) is 26.1 tons. The horizontal aiming angle of the howitzer is $\pm$ 30 deg, the vertical angle is 60 deg. The maximum firing range is 17 km. The howitzer ammunition includes a high-explosive grenade and a nuclear shell with a small trotyl equivalent.

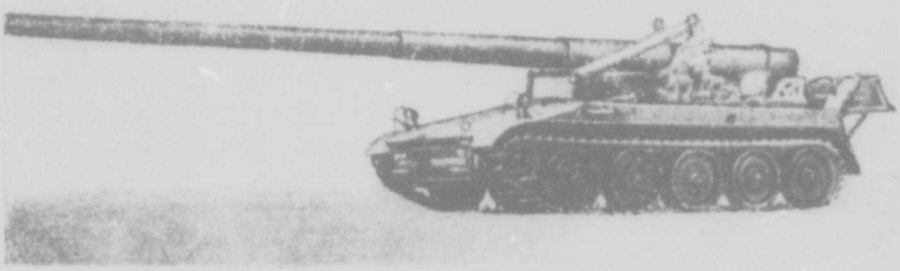

Fig. 13: The M107

The M110 are included in artillery batallions, incorporated into motorized and armored divisions of the USA (four vehicles per batallion). They too, are furnished to the West German Army.

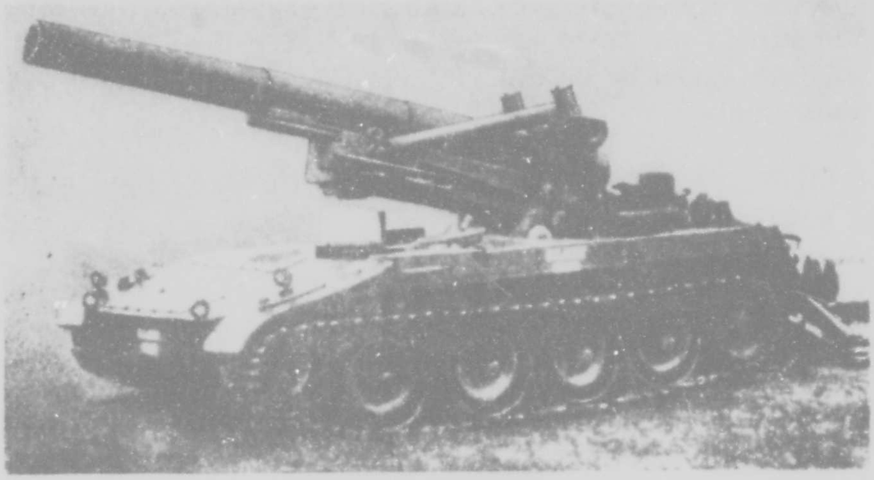

Fig. 14: The M110

In 1963, the British Army adopted a 105 mm self-propelled gun, known as the "Abbot" (Fig. 15) -- note the design resemblance to the M108 and M109. This piece of ordnance was developed on the chassis of the APC FV432 ("Troyan"). It is designed with amphibious capabilities and is equipped with a totally armored hull and a rotating roof-mounted turret with a 7.62 mm machine gun.

Fig. 15: The Self-Propelled Gun Abbot

The combat weight of this unit is 13.5 tons and it carries a crew of four. The ammunition includes armor-piercing, high-explosive and smoke shells. The maximum firing range is 18.5 km. The maximum speeds on the ground and in the water are 47 kmh and 5.6 kmh, respectively.

The French Army also adopted some SPA's. Thus, the 105 mm self-propelled howitzer, developed on the base of the AMX-13 in its design is analogous to the US-made M108 and M109. The vehicle is fully armored; the howitzer is mounted in a rotating turret. Notably, prior to modernization performed in 1962, the howitzer was mounted in a rigid combat unit.

The design of the French 155 mm self-propelled howitzer is strongly resembling the M107 and M110. It was developed in 1962 on a modified chassis of the AMX-13 light tank. The gun, which is a modernized oscillating element of the 155 mm M50 howitzer is open-mounted in the aft of the vehicle without any armor protection.

In addition to SPA's designed for artillery support during the post-war period, a number of countries developed SPA's of different types, specifically, small-caliber anti-aircraft units were designed for suppressing rotary-wing and fixed-wing aircraft a low altitudes. Some specially-designed radar equipped self-propelled units have been appearing recently.

SPA's of the tank destroyer type and designed for suppressing other armored targets, which have been widely used in WW II, are currently produced only at rare occasions. The only one that is worth-while mentioning in this category is the West German SPA "Widder" (23 tons), developed on the base of the armored personnel carrier "Neu". In addition to the 90 mm gun, mounted in the front of the vehicle, this unit is also equipped with 7.62 mm paired and anti-aircraft machine guns. The vehicle maximum speed is 70 kmh; the crew is four men.

Section Three

ARMORED PERSONNEL CARRIERS AND INFANTRY COMBAT VEHICLES

Armored personnel carriers (APC) and infantry combat vehicles

(ICV) are being considered abroad with increasing interest. While tank designs do influence the development of this type of vehicles, the development of certain characteristics of APC's and of ICV's is nonetheless proceeding along its own lines, which are a consequence of their missions, properties and combat applications.

Par. 1: Armored Personnel Carriers

Armored personnel carriers were used in combat during WW II. They were used for reconnaisance, for mounting miscellaneous anti-aircraft requipment, gun transport and for gun crews and ammunition -- all in the same carrier. These vehicles of WW II vintage were completely open from the top.

In terms of drive assemblies, APC's are classified as wheeled and tracked vehicles, and half-tracks.

During the post-war period, APC's were widely used to transport infantry to combat areas. Thus, with increasing troop mobility, the infantry was protected against mp/mg fire, fragmentation from grenades, mortars and shells, and was able to make it in time.

Until recently, the two basic types of mass-produced APC's were wheeled and tracked vehicles only. Halftracks or wheeled-tracked vehicles have not been produced for some time, even though the R & D work in this field does not cease in view of the desirability and the attractive characteristics, that a combination of the positive features of these vehicles can offer.

The simultaneous application of wheeled and tracked APC's by the armies is caused by the following reasons.

A tra ked motive assembly provides for an overall design simplicity, high mobility under different operating conditions a d a high survival factor on the battlefield. However, it is substantially below a wheeled vehicle in terms of service life and efficiency, which is reflected in fuel consumption and required engine output.

Moreover, a wheeled vehicle operates noiselessly on roads with artificial surfaces, without destroying them. The wheeled vehicle concept in the design of APC has acquired additional significance in view of the availability of a vast industrial and production basis - i.e., the automotive industry.

The tracked vs. wheeled vehicle competition, aimed at introducing them into the class of APC's, eliminated the flaws that were typical for both types of vehicles, without establishing the superiority of either type as opposed to the other.

Rubber-metal tracks considerably improved the service life and the efficiency factor of the track assembly at sustained high speeds.

Simultaneously, the use of APC's with all powered wheels and the development of special tire designs contributed to the mobility of wheeled vehicles; the development of bulletproof tires improved their life expectancy in combat conditions.

It should be mentioned that the tracked power train (suspension system) is presently more popular in combat vehicles of this class.

The experience, gained in the Korean War, propagated the tendency to increase the volume of armored personnel carriers. To some extent, this was justified by certain tactical considerations, inasmuch as it did reduce the length of columns on marches, simplified traffic logistics, etc.

However, from the viewpoint of combat applications, again APC's did not prove themselves in modern combat conditions. They turned out to be a means of transport of the infantry to the battlefield.

Considerable changes, that took place in the design of armored personnel carriers within recent years, resulted from the projected applications of means for massed target acquisition; this, in turn, required a review of the tactical and technical requirements to armored technology.

As frequently pointed out in the Western press, APC must be suitable for negotiating contaminated areas (radioactive, chemical and bacteriological), i.e., they must be fully armored and sealed, be equipped with a system of anti-atomic protection and carry filtering and ventillating equipment to effectively reduce the effect of the contaminating factors of nuclear weapons upon the personnel.

Inasmuch as the application areas of APC are being expanded, it is desirable that they should be amphibious and air transportable (this requirement calls for a reduction of dimensions and weight).

Meanwhile, only the armed forces of the USSR, USA (M113, M114, "Commando") and Great Britain ("Trojan") have amphibious APC's. The water propulsion of these vehicles is accomplished by means of propellers, tracks or hydroreactive units (water jet propulsion). Each of the aforementioned types has its advantages and disadvantages. Recently, a preference has been expressed for water jets (which provide a good maneuverability) and tracks (simplicity of the design).

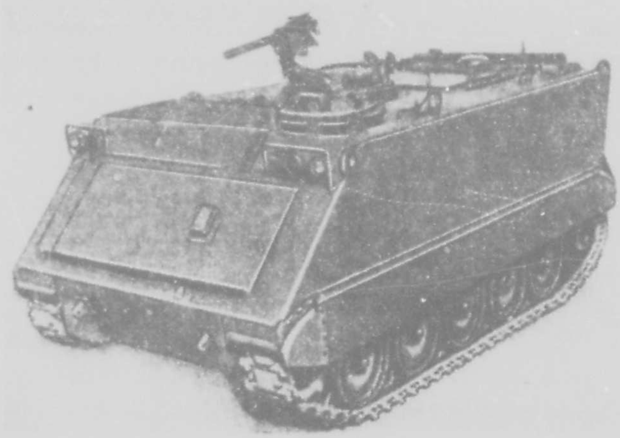

Fig. 16: Armored Personnel Carrier M113

One of the presently most popular APC's is the M113 (Fig. 16). The USA furnishes it to the armies of many countries of the world -- Federal Republic of Germany, Italy, Canada, Turkey et al. Combat weight - 10 tons; the crew (including the driver - 13 men; length, width and height are 4.8 m, 2.7 m and 2.6 m, respectively; armament - 12.7 mm anti-aircraft machine gun.

The completely enclosed armored hull (aluminum alloy) protects the crew and the troops from infantry fire and from shell fragments. Maximum ground speed is 64 kmh; maximum water speed is 6 kmh (propulsion by tracks).

On the basis of the M113, the US developed a self-propelled flamethrower, a 106.7 mm mortar M106, a mobile command point, a reconnaissance vehicle, transporters for Pershing rockets and for the anti-aircraft rocket complex Mauler.

The tracked APC M114 (Fig. 17) is used by the US Army as a reconnaissance and command vehicle. It carries four men; combat weight - 6 tons (7.5 tons, according to other sources); length, width and height - 4 m, 2.4 m and 1.9 m, respectively. The armament consists of a 12.7 mm machine gun, mounted on the turret ring of the immobile commander's turret, and of a 7.62 mm machine gun, mounted on a rod on the hull cover. Armor -- bullet resistant (aluminum alloy). Maximum ground speed - 64 kmh; maximum water speed - 6 kmh (track propulsion).

The West German Bundeswehr is extensively using tracked armored personnel carriers SPW (developed on the basis of the HS-30 armored personnel carrier by the Swiss company Hispano-Suiza) and the SP1A (developed on the basis of the French APC "Hotchkiss"). These vehicles are not amphibious. However, they are equipped with a more powerful armament and front armor (up to 30 mm). The steel armor sheets have larger angles of incline with respect to the vertical (especially in the front); the main armament is a 20 mm automatic cannon with a high initial muzzle velocity, mounted in a rotating turret.

The SPW armored personnel carrier is furnished to motorized infantry units. Combat weight - 14.6 tons; the vehicle carries 8 men. Length, width and height are 5.5 m, 2.5 m and 1.9 m, respectively. The maximum speed is 51 kmh.

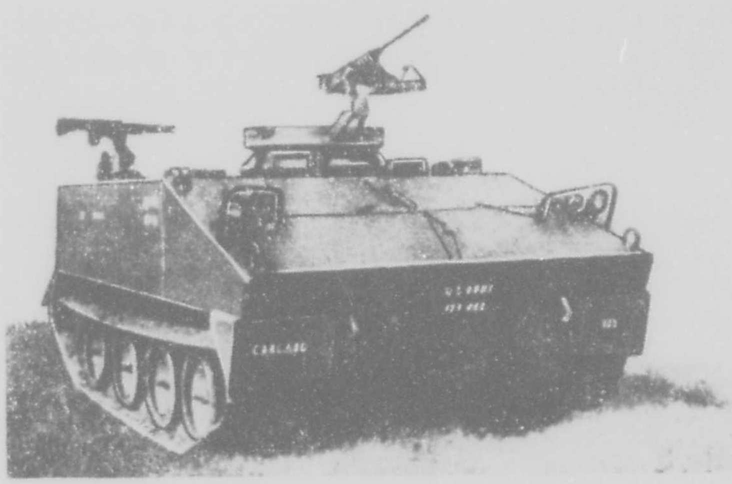

Fig. 17: The M114 Armored Personnel Carrier

The cannon can be used against ground and air targets. The hull is completely armored. Behind the driver's hatch in the hull cover is a hatch for the machine-gunner, as well as exit hatches for the troop members. These hatches can be used for fire from personal arms, as well as for observation.

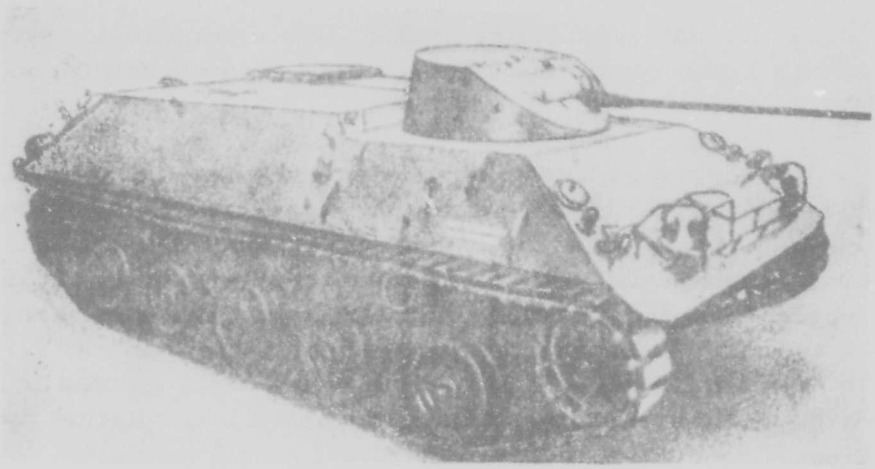

Fig. 18: The SPW Armored Personnel Carrier

The SPW armored personnel carrier has a multi-purpose chassis. It is used as a skeleton for a tank destroyer, equipped with French-made anti-tank guided missiles "SS-11", for a self-propelled 90 mm anti-tank gun, for a 30 mm paired anti-aircraft installation, and for a self-propelled mortar.

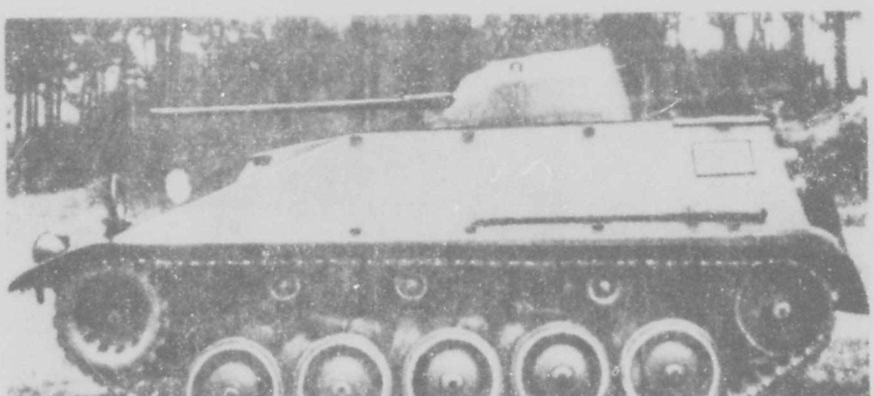

Fig. 19: The SP1A Armored Personnel Carrier

The SP1A armored personnel carrier (Fig. 19) is furnished to reconnaissance companies of brigades and to reconnaissance batallions of divisions. Its combat weight is 8.2 tons; length, width and height - 4.5 m, 2.3 m and 2 m, respectively. It carries a crew of five -- commander, driver, gun layer in the turret and two gunners (one of them is also the radio operator). The gunners can leave the vehicle during reconnaissance operations and eliminate obstacles. For exit and entry of the crew, two wide doors in the aft of the vehicle are provided.

The US personnel carriers (the M113, above all) and the British personnel carriers (Trojan) differ from the armored personnel carriers of the Bundeswehr (SPW and SP1A) and from the comparable Swiss models (Pirate) not only in their amphibious properties, but also in their applications on the battlefield. The aforenamed US and British APC's are, above all, designed to transport the infantry to the battlefield, whereas the SPW, the SP1A and the "Pirate" are proposed to be extensively used for direct combat operations, involving the vehicle.

In terms of design, the latest versions of the US-made APC's (the M114 and the "Commando") are more suited for conducting combat operations from the vehicle.

In recent years, marked new trends emerged, involving the use of APC's. Thus, for reconnaissance purposes, smaller APC's, carrying a smaller crew with higher mobility and off-the-road capabilities, are used (SP1A in the Federal Bundeswehr and the M114 in the USA); at the same time, the motorized infantry employs bigger vehicles with a larger crew (SPW in the Bundeswher, and the M113 in the USA).

Par 2: Infantry Combat Vehicles

The infantry still remains a necessary component of ground and parachute landing troops in modern warfare, even though its role and significance have substantially changed.

Infantry elements attack, jointly with tanks, to ultimately suppress the enemy, after nuclear attacks (completing the function after the enemy has been exposed to nuclear bombardment and armored attacks) and finally "appropriates" (Translator's Note: Quotes by author) the occupied territory.

In some instances (e.g., combat in a city or village) the infantry may act independently.

A specific feature of infantry operations are the individual actions of a fighting man within the framework of an organized collective (the combat unit). A characteristic feature of the firepower effect upon the enemy, as produced by the infantry, is the massive use of automatic weapons with a high firing rate but with limited kill capabilities. It is these properties, rather than the methods of transportation that distinguish the infantry from other service branches.

In view of its combat characteristics, the infantry effectively helps the advance of tanks, destroying and suppressing numerous small, however dangerous, fire emplacements of the enemy, which are capable to inflict serious losses among the armored contingent.

Nuclear weapons and tanks fulfil the principal missions of a combat engagement, but they do not complete it. The infantry is capable of completing the mission, i.e., destroying the enemy, or taking prisoners.

In the view held by many Western experts, the extensive use of nuclear weapons, the high speed of attack combined with extensive maneuvering, the increased attrition capability of conventional weaponry, the improved protection of a variety of objects from infantry fire -- all told, brought about a situation where the infantry at present can no longer perform its assigned functions by conventional methods. It follows, that successful infantry operations are possible only when the infantry is provided with high mobility, safe protection from nuclear weapons and fire arms, combined with its own and highly-effective fire effect upon the enemy. Developing this concept somewhat further, it is held that for successful infantry operations, the troops must be placed into special combat vehicles which serve not just as a means of transportation, but are in fact the principal instruments of combat.

Infantry combat vehicles (ICV) are machines which help the infantry to retain its inherent combat capabilities and contribute to the acquisition of new properties: protection, mobility and fire effectiveness. Thus, ICV's cannot be considered as a means of engaging tanks or as means of troop transport to combat areas and partially on the battlefield. ICV's, in fact, are the principal means of infantry combat in modern conditions. Wester experts visualize ICV's as a fully-armored mobile combat vehicle, endowed with great mobility, preferably amphibious, which, in addition to the crew (driver-mechanic and operator of stationary armament) carry a troop of several fighting men. Each fighting man in the vehicle must be capable of active combat participation, using his individual weapons. The design of the ICV must provide for convenient and protected exit into and entry out of the vehicle.

In recent years, the Western press has been emphasizing that for an effective performance of missions, inherent to the infantry as well as to perform a new function -- the suppression of comparable enemy vehicles -- the individual arms of the troops, inspite of various probable improvements are not adequate. Hence, ICV's are equipped with adequately powerful stationary weapons, capable of substantially extending the range of target acquisition and increasing the effective fire range. The stationary equipment must be extensively used for support of the dismounted troops. To provide the necessary defensive stability, it is necessary to use modern means of anti-tank warfare.

Western experts unanimously agree that in view of the high specific weight of the infantry in modern armies, a mass-production of vehicles is required to saturate the armies with machines of this type. This consideration, obviously, will influence the design and the combat characteristics of the ICV. Furthermore, it is obvious that the ICV, being ostensibly a mass-produced vehicle, will have to be used as a basis for the development of other combat vehicles in a similar weight category.

Since ICV's are barely entering the development stage, it is frequently difficult to optimize the direction of the development of machines of this category, even if the fundamental designs are taken into account. Thus, what type of power train could be preferred for an ICV -- wheeled or tracked? At this point, it is hardly possible to categorically state an affirmative preference in that area. In all likelyhood, in years to come, we will witness a parallel development of both -- tracked and wheeled vehicles.

To support this possibility, we will cite a few examples.

In terms of combat characteristics, and requirements to an ICV, the wheeled amphibious Commando combat vehicle* approaches the general concept (Fig. 20, a). This is a multipurpose vehicle; when used as an APC, it has stationary armament in a rotating turret in the form of two machine guns (large-caliber and conventional). Optional and upon customer's request, the machine guns can be substituted by a 20 mm high-speed short-recoil cannon, or by a 90 mm gun "Energa", produced by Mecar (Belgium). This also involves a coaxial mounting (with respect to the gun) of two conventional caliber machine guns.

The ammunition of the 90 mm "Electra" gun includes four categories of projectiles: shaped high-explosive (hollow-charge), high-

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(*) The tactical and engineering specifications of this vehicle are listed in Table 5.

explosive fragmentation, smoke and incendiary. The shaped high-explosive anti-tank charge will penetrate 355 mm steel armor, whereas the anti-infantry charge is effective in the suppression of enemy fire emplacements.

The "Commando" has a welded water-tight hull of extra-hard steel plates, designed to protect the crew and the combat troop from conventional and armor-piercing bullets of 7.62 mm and 12.7 mm caliber at any distance.

When the "Commando" is used as an armored personnel carrier, it can carry a troop of 11 men (Fig. 20, b); the troop can fire through the embrazures. Visibility is provided by 20 removable glass blocks. The crew and the troop exit and enter through three doors (one on each side and one in the aft, and two hatches on the cover of the hull.

The powerplant develops maximum ground and water speeds of 104 kmh and up to 6 kmh, respectively.

The Cadillac Gage Company developed low-pressure, bullet-proof tires, capable of self-regeneration. In view of this important property, the vehicle can travel up to 160 km with punctured tires.

A general characteristic of this vehicle is its capability to travel off-the-road in cross-country terrain, and good mobility in mud, sand and snow.

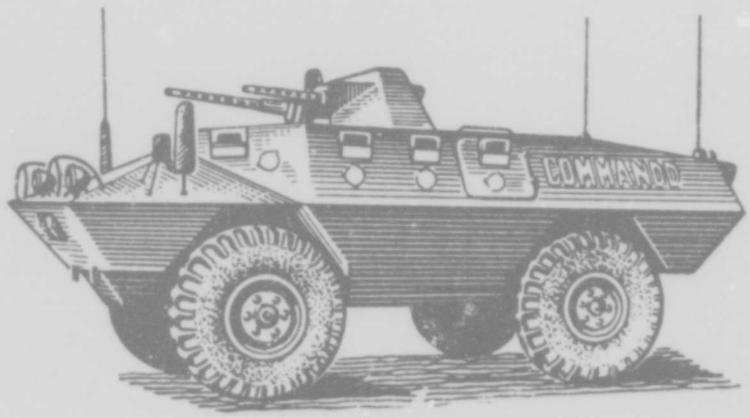
Obviously, judging that the "Commando" cannot satisfactorily resolve all the problems which face a vehicle of this type, the US is presently developing a special tracked ICV (Fig. 21). This vehicle presumably will be furnished to the troops in the early 70-ties. It will carry a crew of three: driver-mechanic, commander and gun-layer and is designed to transport an infantry combat groups of nine men.

This vehicle will be equipped with a 20 mm gun and a paired light 7.62 mm machine gun, installed in a rotating turret.

The embrazures on the sides and in the aft will permit to fire from the vehicle.

Maximum speed (60 kmh) is provided by 425 hp diesel powerplant. The operating radius is 640 km.

In terms of armored and nuclear protection, mobility and life expectancy in combat, this vehicle is expected to be superior to the "Commando".



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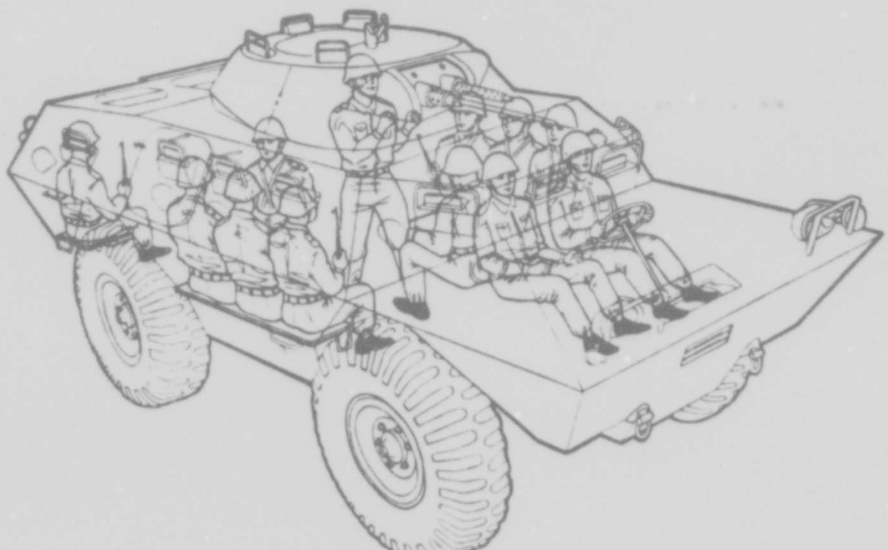

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Fig. 20: The "Commando" Armored Personnel Carrier;
(a) General View; (b) Troop Placement.

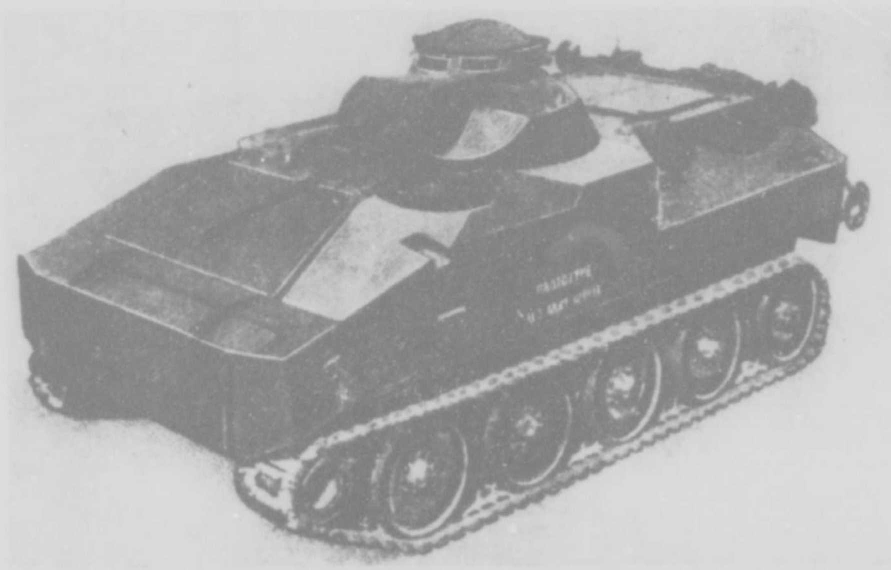

Fig. 21: Tracked ICV

Chapter II

TANKS

Section One

THE LAYOUT AND DESIGN OF TANKS

The general layout of a tank, in this context, is defined as the reciprocal positioning of the principal assemblies, subassemblies and crew stations. The general layout is predicated on obtaining optimum tactical and technical characteristics, required from a combat vehicle. Thus, when approaching the design of a tank, it is imperative to pay close attention to principal design solutions which, in many ways, predicate the success or failure of the design project.

The principal task of the designer is to provide an optimal combination of the combat characteristics of the vehicle, taking duly into account the state-of-the-art of science and technology, and to ascertain that the following parameters are maintained:

* The required mean specific pressure in the track/soil interface;

* The ratio between the bearing surface (L) and the width of the track (B) to provide optimum conditions for good turnability;

* Appropriate location of the coordinates of the center of gravity over the length and width of the vehicle;

* Dimensions of the vehicle taking into account the proposed principal mode of transport;

* The combat weight must not exceed the specified combat weight.

Moreover, provisions must be made for future development of the vehicle, using it as a base to create a family of vehicles.

The mean specific pressure in the track/soil interface must not exceed 0.85 kgF/cm^2 for tracks with an open joint and 1 kgF/cm^2 for tracks with a rubber-metal joint (RMJ). In new foreign tanks, the mean specific pressure in the track/soil interface does not exceed 0.85 kgF/cm^2 even when RMJ are used. Such limiting values of this parameter were determined from the conditions of motion on cohesive soils, taking into account the resistance in turns and the resistance to linear motion.

The ratio of the bearing surface to the track width (L/B) has a considerable influence upon the turnability of any tracked vehicle, including that of a tank. If this ratio is too big, turning will be impossible regardless of the engine output, inasmuch as the required drawbar force (considering the required cohesion conditions in the track/soil interface) cannot be attained on account of the skid of the vehicle. The turning mechanisms of modern tanks use several calculated radii and the L/B factor is set within the limits of 1.7 - 1.8, whereas with one calculated turning radius (with side clutches) L/B cannot exceed 1.5.

The effect of the L/B (known in foreign literature as the "turning factor") upon the design and layout of tank components is quite considerable. The development of rational and practically-applicable L/B factors by Soviet tank designers contributed in a great measure to their success. Using L/B within the limits of 1.72 - 1.78 for heavy tanks (which is quite acceptable with such turning mechanisms, as the two-stage planetary type) created an important base for the development of tight designs.

It is considered desirable that in longitudinal projection, the cg of the tank be located above the geometric center of the supporting surface of the tracks. Such a positioning of the cg provides the tank with better capabilities to negotiate obstacles and uniform load distribution on the roadwheels (provided the suspension system has a symmetrical design).

To transport a tank by railroad, the tank width must be taken into account, also considering the applicable rules regarding the transportation of cargo of varying dimensions. In terms of USSR standards, the dimensions of Class 1-B classification are 3250 mm in width. The maximum width of the cargo, while it is still within the limits of dimensional requirements, is 3414 mm.

In Western European countries, the loads measure in width up to 3150 mm; in the USA it is up to 3130 mm, in Great Britain - 2920 mm.

The widespread usage of trailers for tank transport and the impossibility of developing a fully-equipped and optimized main battle tank 3.0 to 3.15 m wide resulted in increased dimensions of foreign tanks. This applies to the US M60A1 (3.63 m), the British Chieftain (3.61 m) and the West German Leopard (3.25 m). Thus, in order to obtain the required combat characteristics, the designers proceeded in the direction of complicating railroad transport and did not trade off the principal combat characteristics to transportation requirements.

Perfection and development of the design are invariably related to the increasing weight. Thus, our medium tank, the T-34, had initially a combat weight of 25.6 t, whereas subsequently, the combat weight of the T-34-85 modification reached 32 tons.

Foreign tank designs and engineering offers comparable examples. Thus, the specific engine outputs, the transmission characteristics and the characteristics of the power train are being accepted with a consideration of an inevitable future development of the vehicle and an increase of the weight. As demonstrated by half a century of armored technology development, tanks, designed with optimized parameters, were rapidly removed from the arsenals.

Par. 1: Typical Designs and the General Layout of Modern Tanks

Many tank designs were tested and tried in the course of half a century of tank development. Nonethless, only two basic versions which have survived the test of time are used in contemporary tank design:

A design, involving a rear engine and transmission (the Soviet T-34, T-54, IS-3; the US M-60 and Sheridan; the British Centurion and Chieftain; the West German Leopard; the French AMX-30, and some other vehicles);

A design, involving a front engine and transmission (the French AMX-13, the Swedish "S" tank, all of the field self-propelled guns designed in the USA after WW II, e.g., M-52, M-108, M-109, et al.)

A third version, which no longer is built, enjoyed maximum popularity before WW II. In this design, the transmission was located in the front of the hull, whereas the engine was in the rear. During the war, the first and the third variants (in terms of models) were distributed approximately equally. All series-produced tanks of fascist Germany had a rear engine and front transmission; this also applied to the most popular war-time US tanks (Sherman and Stewart), as well as Japanese and Italian tanks of war-time vintage.

During the post-war period, the first variant begain to gain in popularity; notably, its principal and theoretical advantages were correctly analyzed and estimated by Soviet tank designers as early as the 30-ies, long before any other nation began to comprehend the theory, combined with practical applications. In fact, it was because of the influence of Soviet tank design, which demonstrated the advantages of such models as the T-34, KV, IS, foreign tank engineering experts departed from a front transmission and proceeded to design their tanks with an almost exclusively rear transmission and engine layout.

We will now consider the characteristic design features of modern tanks.

When the engine and the transmission are located in the rear, the power plant compartment and the transmission are insulated from the crew, and the crew, as a consequence, operates in more favorable conditions (Fig. 22). The front of the hull is not packed with sub-assemblies, consequently, the frontal elements of the armor can be installed at large angles of incline (70 to 75 degrees with respect to the vertical).

In tanks with a frontal transmission, the maximum angles of incline of the upper frontal hull components does not exceed 55 degrees with respect to the vertical. Moreover, the frontal part of the hull is laid out considerably tighter, provided that the transmission is in the rear. It will suffice, e.g., to compare the layout of the front of the body of the T-54 with that of the Panther. While the front of the Soviet tank has the driver-mechanic and elements of control, storage batteries and forward fuel tanks which adequately fill up the space available including ammunition stowage, the German tank design does not utilize a considerable portion of the volume available. Part of the volume is used for a better blow-down of the transmission, to facilitate its dismantling, as well as for the placement of propeller shafts, connecting the transmission to the engine and to the side drives.

When the transmission is located in the rear, it is possible to combine the power and transmission compartments, thus attaining a better tightness of the overall design and, as a consequence, decrease of the overall length. A good example of this concept is the Soviet T-54; in this combat vehicle, the cross-position of the power plant allowed to substantially decrease the length of the power and transmission compartments, as compared to the T-34. It also facilitated a more effective cooling of the transmission subassemblies. Generally, the subassemblies are blown down by an airflow, generated by the radiators of the cooling system. However, with the introduction of ejection heating, oil radiators are required for the transmission.

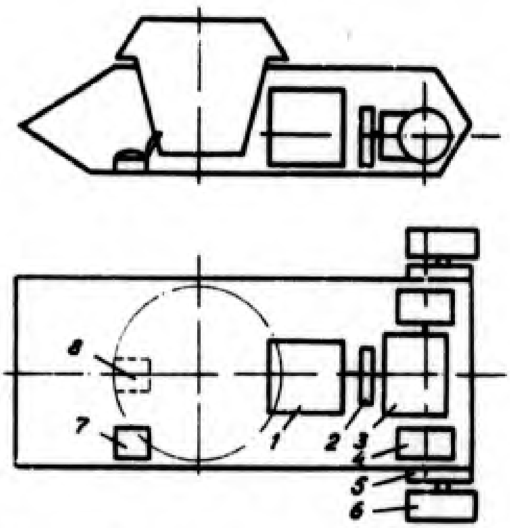

Fig. 22: Tank layout diagram with a rear transmission and rear engine:

1 - engine; 2 - main clutch; 3 - transmission; 4 - turning mechanism; 5 - side clutch; 6 - powered wheel (sprocket); 7 - driver's seat; 8 - driver's seat in a heavy tank.

It is, in fact, much simpler to provide the necessary convenience for disassembly and installation of the transmission subassemblies in the field when they are in the rear of the vehicle. The vehicle's rear is a much less strategic area than the front or, for that matter, the side. Thus, the use of tipping or removable armor elements and of access hatches to the subassembly does not involve any difficulties.

The sprocket location in the rear of the tank decreases the hit probability of the vehicle. A hit of the idler is considerably less dangerous. The rear location of the transmission, however, has its own disadvantages. If the engine is located longitudinally, the turret is moved into the front part of the hull. This complicates the layout of the driver-mechanic's hatch on the cover of the control compartment, especially if the pivoting diameter of the turret "in the clear" exceeds 1600 mm. For this reason, our T-34 had the driver-mechanic's hatch on the upper frontal part of the hull. Such a solution was acceptable, when the armor was designed essentially for protection from small-caliber artillery shells. However, it is not acceptable with armor designed for protection from medium-caliber shells, since the hatch cover can break through with fragments entering the vehicle's interior. For this reason, the driver-mechanic of the heavy tank IS-2 did not have a separate and independant hatch, and had to enter the control compartment through turret hatches. This involved a number of obvious handicaps. To eliminate these, the nose portion of the heavy tank IS-3 was given a special tapered shape which, in turn, provided the possibility of placing the hatch on the roof of the command compartment.

In foreign tanks, the problem was resolved in different ways. The contemporary Leopard model has a considerably longer hull (6.8 m), with a relatively short V-10 engine. Thus, there is room for the hatch on the hull cover.

The British tanks, which appeared during the last period of the war (Cromwell and Comet) had hatches in the covers of the control compartments. This was possible in view of the usage of relatively small diameter turret pivots, locating the shafts of the transmission and turning mechanisms in a vertical plane (which considerably reduced the length of the transmission) and abandoning the use of effective angles of incline for the most important frontal elements of the hull.

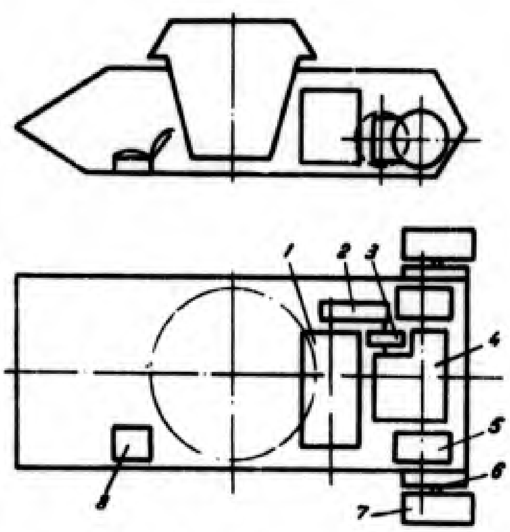

Fig. 23: Layout diagram of a tank with a transverse engine location:

1 - engine; 2 - bracket mount; 3 - main clutch; 4 - transmission case; 5 - turning mechanism; 6 - side drive; 7 - powered sprocket; 8 - driver's seat.

In the future, the British used larger incline angles of the frontal elements in the Centurion, Conqueror and Chieftain, on account of cover can break through with fragments entering the vehicle's interior. For this reason, the driver-mechanic of the heavy tank IS-2 did not have a separate and independant hatch, and had to enter the control compartment through turret hatches. This involved a number of obvious handicaps. To eliminate these, the nose portion of the heavy tank IS-3 was given a special tapered shape which, in turn, provided the possibility of placing the hatch on the roof of the command compartment.

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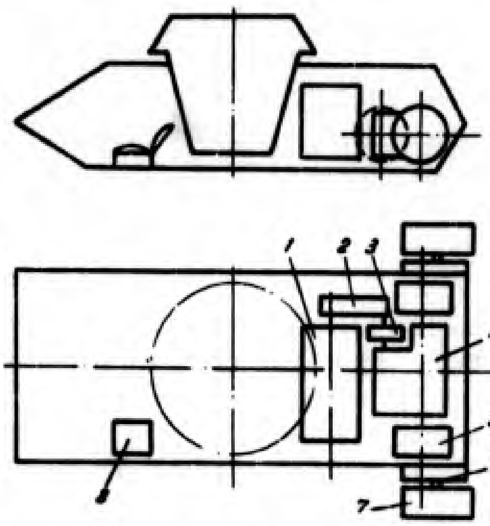


Fig. 23: Layout diagram of a tank with a transverse engine location:

1 - engine; 2 - bracket mount; 3 - main clutch; 4 - transmission case; 5 - turning mechanism; 6 - side drive; 7 - powered sprocket; 8 - driver's seat.

In the future, the British used larger incline angles of the frontal elements in the Centurion, Conqueror and Chieftain, on account of increasing the length of the hulls, without attempting to compact the layout. As a consequence, a distinguishing feature of British post-war tanks is their weak frontal armor.

Even the Conqueror (66 tons) has a side hull armor not exceeding 51 mm, the upper frontal armor segment is 130 mm, and the lower frontal armor segment is 77 mm with a 60 degree angle of incline. The thickness of the turret, however, varies within 280 to 90 mm.

If a tank with a rear transmission is equipped with a transverse V-engine or single line engine, then the length of the power plant compartment will be reduced; this allows to move the turret toward the rear (Fig. 23) and place the driver's hatch on the cover of the control compartment.

However, a rear transmission considerably complicates the drive control elements. If the drive control elements are mechanical, then the crosstie rods to the main clutch, to the gear box and to the turning mechanism pass nearly over the entire length of the hull; this complicates the installation of the assemblies and the service adjustment of the drives.

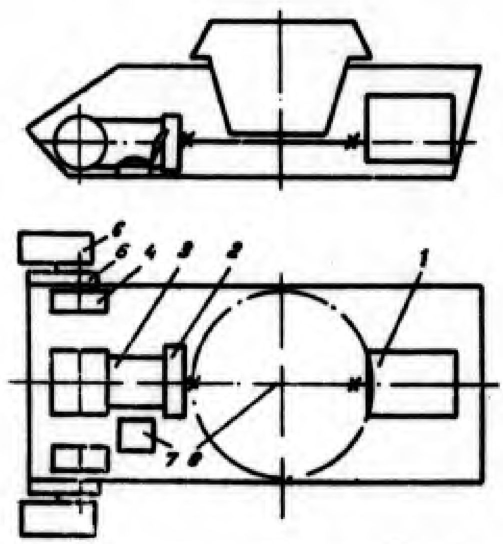


Fig. 24: Layout diagram of a tank with a rear engine and frontal transmission:

1 - power plant; 2 - main clutch; 3 - transmission; 4 - turning mechanism; 5 - side drive; 6 - powered sprocket; 7 - driver's seat; 8 - propeller shaft.

When the transmission is in the front and the power plant in the rear of the vehicle (Fig. 24), these defects are eliminated. In this instance, the control compartment is combined with the transmission compartment which, in turn, allows to increase the length of the combat compartment; the control drives are simplified; adjustments and minor repairs can be performed on the transmission subassemblies by the crew without leaving the vehicle.

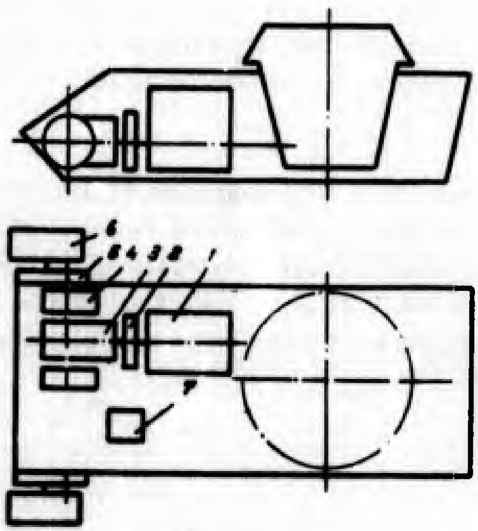


Fig. 25: Tank layout diagram with power plant and transmission in the front:

1 - power plant; 2 - main clutch; 3 - transmission; 4 - turning mechanism; 5 - side drive; 6 - powered wheel (sprocket); 7 - driver's seat.

However, these advantages do not in any form whatsoever compensate for the theoretical deficiencies of this type of design. The disadvantages are essentially related to the increased vehicle height on account of the propeller shaft, deteriorating operating conditions of the crew, the complications, arising in the course of the installation and dismantling of transmission subassemblies and the increasing vulnerability of the sprocket. In addition, the frontal location of the side drives makes it difficult to attain large angles of incline of the frontal armored elements of the hull.

All of the aforementioned shortcomings led to the situation, that a layout with a frontal transmission with a rear engine is being used with decreasing frequency.

During the postwar period, some of the combat vehicles employed a frontal transmission and engine with the combat compartment in the rear (Fig. 25). This layout, used in US self-propelled artillery (M-108 and M-109), the French light tank (AMX-13) and the Swedish S-tank, was prompted by the necessity of moving the combat compartment into the rear of the vehicle in view of the long-barrel guns, used in these designs. The rationale behind this approach, of course, was to prevent the chance of a long gun barrel hitting the ground. This layout also offered certain possibilities to load quickly a relatively large supply of ammunition (in the self-propelled artillery), and some advantages in terms of ammunition stowage (in the Swedish "S" tank). It did, however, entail a certain trade-off in terms of difficulties involved in the protection of the roof of the driver's compartment, the overall visibility, the comfort of the driver-mechanic as well as the placement of the air intake and air exhaust conduits and the exhaust system of the power plant.

Some self-propelled artillery vehicles, designed with this type of layout are, in fact, vehicles developed from prototypes with a rear transmission where in the process of redesigning a tank into a piece of self-propelled artillery, the rear suddenly became the front. In this instance, the driver-mechanic is relocated into the combat compartment, and his seat is placed relatively high.

If a combat vehicle is being redesigned from the ground up, the driver-mechanic is placed, as conventionally, in a tank with a frontal transmission; it becomes necessary to provide him with normal working conditions, since the temperature in the driver-mechanic's sub-compartment is going to be rather high.

Inasmuch as the penetration of exhaust gasses into the combat compartment cannot be permitted, the entire exhaust system becomes considerably more complicated. It hence becomes desirable to place the exhaust muffler (or silencer) in the rear of the vehicle which, in turn, considerably complicates the entire exhaust assembly.

Moreover, the protection of the power plant compartment roof also becomes quite involved; it has to be designed taking into account the possible ricochet of projectiles, bouncing from the front of the turret, the effects of high-explosive fragmentation rocket projectiles, etc.

The experience, acquired in recent years, appears to indicate that a frontal location of the power plant and transmission compartments is being increasingly used for a new category of combat vehicles, namely the ICV. The rear of the vehicle is usually designated for the troops. This is the design used in the USA for an ICV that is presently in the development stage.

In modern vehicles, regardless of their type, designed ostensibly for conditions of modern warfare, the power plant and the transmission compartments are predominantly located in the rear of the vehicle, whereas in self-propelled artillery and in ICV's, these compartments are usually located in the front of the vehicle.

We will now consider the new ideas, proposed and applied to the design of tanks during the post-war years.

On various occasions, the press reported about tanks with armament enclosed in an oscillating turret (the French AMX-13 and AMX-50), the placing of the driver-mechanic in a semi-reclining position, on turretless "S"-tanks, on articulated vehicles, and on other models.

All advanced designs are predicated on the desire to improve the protection of the crew, to equip the tank with an automatic loading system, and/or to resolve both problems simultaneously.

The height of a tank, as known from elementary theory, is influenced by three factors: the hull height, the height of the tower, and the vehicle's clearance. To improve the protection of the tank, it is desirable to make it lower, since this reduces the target dimensions; at the same time, the armor can be made thicker within the limits of the specified weight.

Inasmuch as the desired ground clearance is usually stipulated, and the height of the turret (considering the armament and the required angle of incidence) cannot be changed, it is quite natural that the designers turned toward the hull. The height of the hull usually depends upon the height of the engine and the seating of the driver-mechanic. The engine height can be reduced by adopting a horizontal layout of the cylinders, But -- can the height of the control compartment be decreased? Obviously, the driver-mechanic, being seated, requires not less than one meter of space in height.

To decrease the height of the control compartment (and consequently, the height of the tank), it was proposed to place the driver-mechanic inside a rotating turret (Fig. 26) in a special control station; this station, would turn in the opposite direction, yet at the same angle during a turn of the turret so that the driver-mechanic's sighting instruments would be always directed along the course of motion of the vehicle.

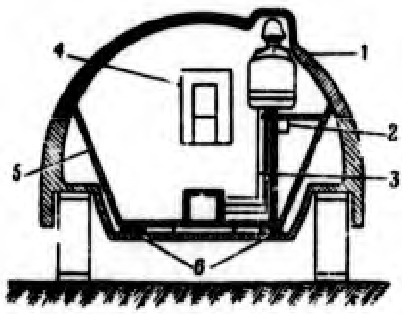


Fig. 26: Placement diagram of the driver-mechanic in the turret:

1 - driver-mechanic; 2 - mechanism that rotates his seat;
3 - control drives; 4 - gun; 5 - suspended floor of the turret;
6 - floor supports.

The layout diagram, putting the driver-mechanic into the rotating turret, has been used in the experimental US-German tank MBT-70.

In the British Chieftain, the driver-mechanic is located in a semi-reclining position, in order to decrase the height of the combat compartment. He observes the road through special periscopes and controls the transmission by means of electrohydraulic power controls. It was reported in the press that this design reduced the tank height to 2.4 meters. This height, however, can also be attained using traditional layouts.

Placing the driver-mechanic in a semi-reclining position in the Chieftain permits to increase the angle of incline of the upper frontal element of the hull.

The introduction of automatic loading into the armament assembly is a rather complicated matter, providing that the turret designs and the disposition of the ammunition supplies are retained.

In modern tanks, the ammunitionis stowed in several stations and hence the automation of the loading becomes extremely complicated. The weight of the turrets and cannons is more than 20 percent of the combat weight of the vehicle; the diameters of the races "in the clear" have a determining effect upon the dimensions of the upper part of the hull and consequently also upon the vehicle weight. If the dimensions of a conventional turret had to be increased to provide for automated loading, the dimensions of the armored hull would increase accordingly. Is it possible to develop a tank design where the introduction of automated loading would not affect the turret and hull dimensions but, on the contrary, reduce them, thus providing criteria for overall weight reduction? These opportunities are provided by the oscillating turret. In a turret of such type, the cannon can be shifted forward and removed from the turret. This, in turn, adds volume to the combat compartment and its dimensions, as a consequence, can be reduced. The ammunition can be stoward in the combat compartment, which cannot be done in conventional turrets. By interrelating the automated ammunition stowage with the oscillating segment of the turret, a "rigid" trajectory of the artillery shell can be provided, when it moves from the ammunition stowage to the loading compartment of the tank.

This provides for the two most important conditions of a simple automatic loading design of the tank gun -- a concentrated ammunition stowage area and the availability of a "rigid" trajectory for the shell during loading.

After the appearance of the AMX-13, the foreign press noted that one of the important shortcomings of the oscillating turret is the weakening of the protection on account of the use of composition armor. This deficiency, in the view of foreign experts, is not important insofar as tanks and other combat vehicles with anti-bullet protection are concerned. For this reason, oscillating turrets are widely used on French light tanks (AMX-13) of various modifications, as well as on armored cars. The designers of the Swedish turretless "S" tank attempted to increase its life in combat conditions by decreasing the height, as well as by introducing a more powerful armor, than generally used in NATO tanks. The most important criterion to decrease the height was automated loading, which permitted the entire crew to perform its functions in a sitting position. The crew, in fact, has no loader -- this permitted to decrase the armored volume of the vehicle. The positioning of the combat compartment in the rear decreased the vehicle length, even though the 105 mm Swedish cannon is longer than the British one by 11 calibers. The aiming in horizontal plane by means of a hydropneumatic suspension permitted to design the upper frontal part of the hull without grooves for the gun and for the sight and simplified the hermetization system. The foreign press reported that the turretless configuration permitted to substantially increase the armored protection, as compared to the one used by tanks of NATO countries. Of course, only operational experience will show the extent of the theoretical shortcomings of this design, i.e., the impossibility of effective firing while the vehicle is in motion, and questionable aiming accuracy when the vehicle is turning on slippery soil.

The search for new designs of combat vehicles led to the advancement of a proposition to design a tank that would consist of actually two combat vehicles: One, propelled by electrical motors, which would, for practical purposes, be a self-propelled combat compartment, well-armored and equipped with main armament; the second vehicle would be a self-propelled power plant with an engine powering the generators, which, in turn, supply the current to the first vehicle. The second vehicle could have weaker armor, inasmuch as the combat compartment is capable of engaging in combat independently, moving away from the power unit for the length of available cables. One such design received the first prize in a US competition in 1962.

Generally, oscillating turrets in the French armored troops and turretless design in Sweden are the only radical design departures that came to fore in tank design in the post-war years.

The majority of the tanks follow a classic layout with the power and transmission compartments in the rear.

SECTION TWO

THE FIRE POWER OF A TANK

The massive use of tanks and other armored vehicles requires a heavy troop saturation by long-range and short-range anti-tank weapons. Thus, tank armament must be capable of rapid destruction and suppression of various targets on the combat field -- from an individual entrenched grenade launcher to launching pads for nuclear weapons. These are the essential criteria for the armament of a modern battle tank.

Par. 1: The Armament of Modern Battle Tanks

Tank armament includes weaponry, ammunition, aiming devices and mechanisms, stabilizers and other equipment.

At the present time, it is either unfeasible or impossible to resolve a firing mission, using tanks exclusively. For this reason, tanks are being equipped with a complex of armament. This complex includes main and auxilliary weapons, with additional weapons being installed on some tanks.

The main armament is designed to destroy and suppress targets that have a high firepower and strong protection. This includes armored targets and SPA, various fortifications in the field, enemy artillery and launching pads for rocketry, as well as infantry and its means of fire.

The main weapon of a tank is its cannon.

The main firing mode from a tank is direct aiming, covering all ranges provided the targets are within view. As a rule, the crews locate the targets independently and commence firing upon their own discretion. In order to destroy the major and most important targets, as well as to accelerate the acquisition of targets at distances in excess of 1.5 to 2 km, a tank unit conducts concentrated fire at one target.

Auxilliary weapons are designed to destroy and suppress short-range anti-tank weapons (grenade launchers, recoilless guns, etc.), to destroy light-armored and low-speed air targets, as well as enemy infantry.

Auxilliary weapons include tank machine guns, i.e., paired machine guns, bow machine guns, and anti-aircraft machine guns. Some foreign tanks also use targeting machine guns.

Auxilliary weapons are designed for missions that cannot be successfully solved by the main armament when long-range fire is called for. To this end, some foreign tanks use anti-tank guided missiles (AGM).

The tank gun, as a rule, is in a revolving turret. A machine gun is mounted on the gun's cradle. This cannon-machine gun combination is said to be a twin installation. The turret rotates by means of electrical or electro-hydraulic servo-mechanisms operated from the control panel and/or manually.

The cannon (machine gun) is aimed by means of the sight or a sight-rangefinder combination. To provide for firing at night, tanks are equipped with special sights. There are also devices for indirect fire, when the target, due to limited visibility, cannot be spotted. To improve the hit probability during firing when the vehicle is in motion, the twin installations are equipped with stabilizing devices.

All told, the armament of modern combat vehicles is a complex system. The fire power of tanks and of SPA depends on the perfection of this system and on the degree of the combat readiness of the crews that man it.

Par. 2: The Principal Factors Determining the Fire Power of a Tank When Firing in Motion

The fire power of a tank is determined by the vehicle's capability of hitting or suppressing various targets within the shortest time available and with minimal expenditure of ammunition.

We will now consider the principal factors that influence the fire power when firing is conducted from a tank in motion, i.e., when the combat properties of the vehicle are used to the fullest extent namely when tanks are advancing in combat formation at optimized speeds, taking into account the demoralizing effect that they produce upon enemy troops. Notably, when firing is conducted while the combat formation is advancing, the vehicle attrition rate is reduced, inasmuch as the enemy is put into a rather difficult position, involving firing at fast-moving argets.

The fire power of a tank is determined by such fundamental factors as the power of the shell impace upon the target, the hit probability, the maneuverability of the fire, the time element of opening fire, the practical (or combat) firing rate, as well as the invulnerability of the weapons and of the crew in the vehicle.

The relationship between the principal factors, determining the fire power of a tank, is shown on Fig. 27.

In order to explore the future improvement of the fire power of tanks, it becomes necessary to analyze the components of each one of the principal factors (as applied to the main armament).

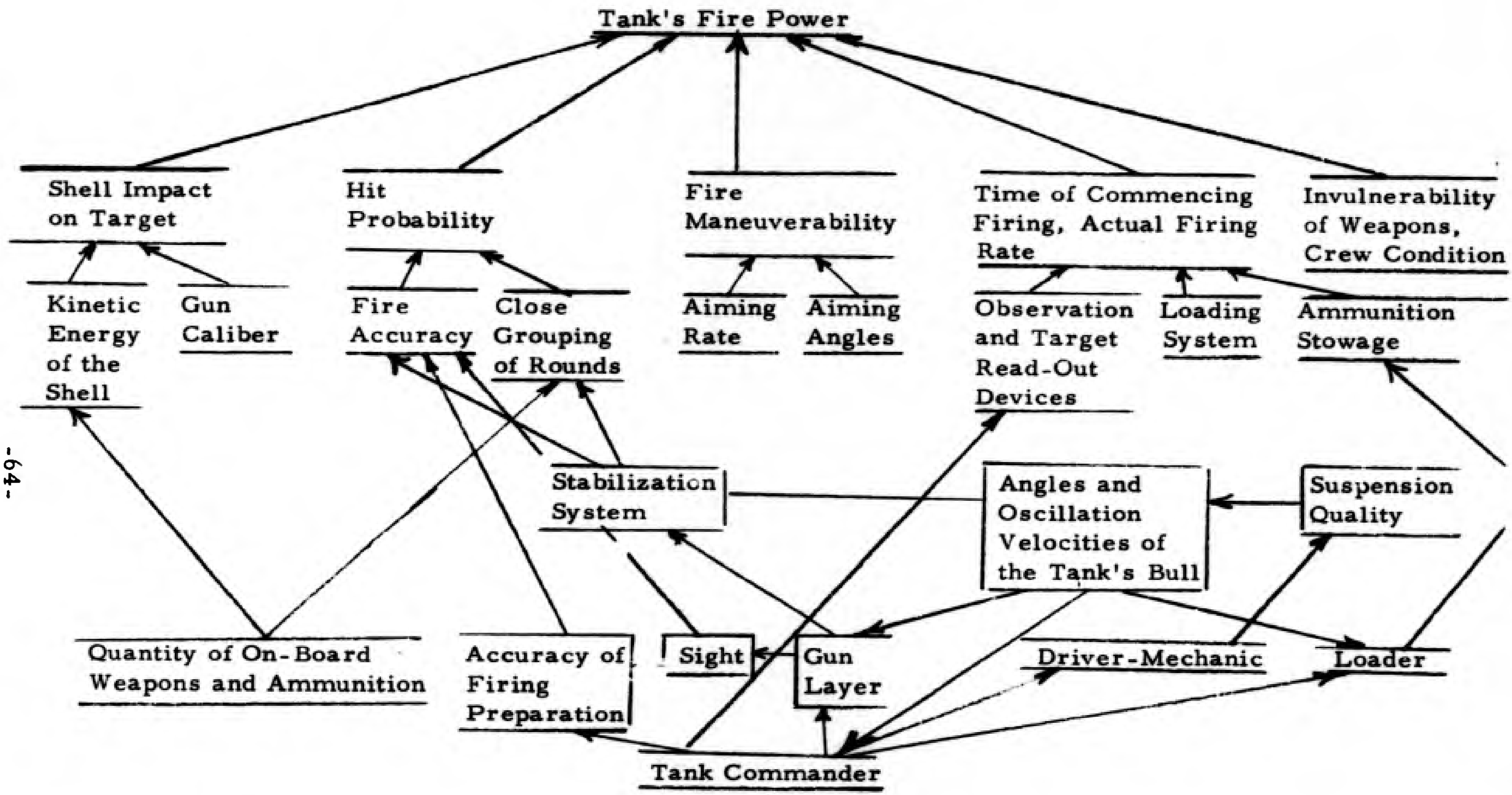


Fig. 27: The relationship between the principal factors determining the tank's fire power while the vehicle is in motion.

Par. 3: Improving the Tank's Fire Power by Improving the Shell Effect Upon the Target

The power of a shell is determined by the nature of the effect, produced during the shell/target impact.

To destroy armored and concrete-reinforced targets, a shell must have a large impact effect. To destroy various types of field fortifications and enemy personnel, high-explosive fragmentation rocket projectiles are required.

To suppress armored targets, some foreign tanks use armor-piercing (conventional) ammunition, hard-core projectiles (sub-caliber), shaped high-explosive projectiles, and projectiles with plastic charges.

Armor Piercing Shells

The effect of an armor-piercing shell is determined by the thickness of the penetrated armor and by the effectiveness of the damage, inflicted beyond the armor. Approximately, the armor piercing capability can be determined from the following formula:

$$b=\left(\frac{q^{0,5}v_c \sin\alpha}{Kd^{0,75}}\right)^{\frac{10}{7}}, \qquad (1)$$

where b - thickness of the penetrated armor, in decimeters;

v_c - the impact velocity of the shell upon the armor, in m/sec;

α - angle of attack, shell-to-armor, in degrees;

K - coefficient, predicated on the armor quality and design parameters of the shell; usually K = 2200 -- 2400

d - caliber of th shell, in decimeters.

q - weight of the shell, in kg;

An analysis of this formula reveals that for a given weight and caliber, the armor piercing capability of a shell depends upon the shell velocity and upon the angle of impact upon the armor, as well as upon the armor quality and on the shape of the ogival part of the shell. At large angles of impact, the armor piercing capability decreases rapidly as a result of a ricochet of the projectile.

The high-explosive and fragmentation effects of armor piercing shells is not very appreciable, however, the damage inflicted by them is quite considerable, inasmuch as they explode in the small enclosed volume of a tank. Moreover, armor piercing shells have a high incendiary effect.

In terms of configuration of the ballistic cap, all conventional armor piercing projectiles are either sharp-nose or blunt-nose with ballistic caps, and shap-nose with both armor piercing and ballistic caps (Fig. 28).

Sharp-nose projectiles are most effective against low-hardness armor, whereas blunt-nose projectiles are desirable for the suppression of high-hardness armor.

Blunt-nose projectiles with a ballistic cap have better ballistic properties than sharp-nose projectiles; they have a better retention of their flight speed and a smaller derivation. Also, they deflect less from their initial direction with side wind.

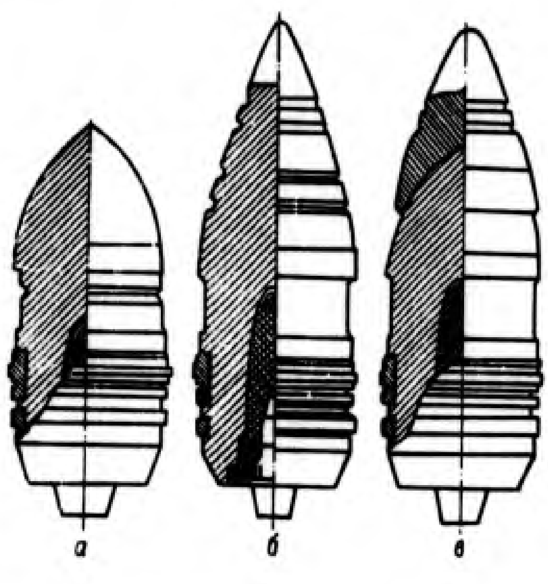


Fig. 28: Conventional Armor piercing ammunition:
a) - blunt-nose; b) - sharp-nose; c) - sharp-nose with armor piercing and ballistic caps.

Armor-piercing ballistic caps are used to improve the strength of sharp-nose ammunition; these caps protect the head portion of the charge from destruction at the impact.

The effect of armor-piercing ammunition can be bolstered by improving the muzzle velocity of the projectile. This makes the trajectory of the shell flatter, thus increasing the range of a straight line shot. The higher the initial velocity of an armor-piercing shell (all other conditions being equal), the greater the armor-piercing effect. The initial velocity of an armor-piercing shell can be improved by raising the pressure of the powder gases in the barrel during the shot, and by increasing the barrel length. However, this also increases the dimensions and the weight of the barrel which, in turn, involves layout problems and additional power requirements to the aiming mechanisms.

Long-barrel guns extend quite far over the vehicle hull which involves the danger of the barrel being stuck into the ground when the vehicle is negotiating obstacles; it is also a handicap to maneuvering in forests and in urban areas.

An increased initial muzzle velocity drastically reduces the barrel life to several hundred rounds.

According to foreign data, an increase of the initial velocity of conventional ammunition over 1200 m/sec is impractical, since it considerably increases the dimensions and the weight of the barrel. The muzzle velocity can be increased above 1200 m/sec, using sub-caliber (hard-core) projectiles.

Sub-Caliber (Hard-Core) Shells

Shells, where the diameter of the part that pierces the armor is smaller than the caliber of the weapon, are defined sub-caliber shells.

The core (or hard-steel plug) of a modern sub-caliber shell is enclosed in a sabot (Fig. 29). After the projectile leaves the barrel, the sabot separates from it under the impact of the air resistance. Having a large transverse load, the projectile is capable of good retention of its speed over the entire trajectory.

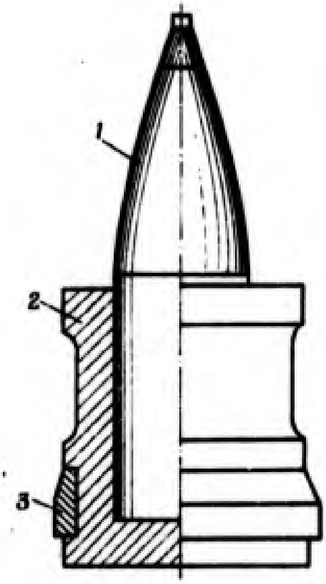


Fig. 29: Sub-caliber charge with a separating sabot:

1 - charge; 2 - sabot, 3 - rotary driving band.

A modified version of these charges are the encased charges (Fig. 30) with the casing consisting of three parts that separate from the core after the projectile leaves the barrel. The initial velocity of charges with a separating sabot may exceed 1400 m/sec. For example, the initial velocity of a sub-caliber charge with separating sabot, as used in the British 105 mm tank gun, is 1475 m/sec.

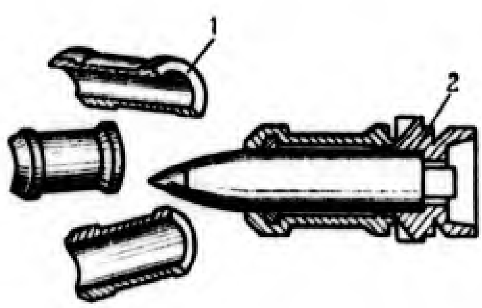


Fig. 30: Sub-caliber charge with separating casing:

1 - casing; 2 - sabot.

Nonetheless, foreign specialists hold that sub-caliber charges with separating sabots, as a rule, have a number of shortcomings. Above all, the separation of the casings from the shells is rather complicated. If the casing separates prematurely, the fire scattering is considerably increased. When the charge vs. armor impact angle is under 35 deg., the charges ricochet. In addition, the separating elements of the casing can hurt the troops which move ahead of the tank.

It is believed that the kinetic energy of sub-caliber ammunition and the actual firing range can also be improved by increasing the caliber of the gun. Thus, the British Chieftain tank employes a 120 mm tank gun which fires primarily sub-caliber ammunition.

Shaped High-Explosive (Hollow-Charge) Projectiles

Foreign military specialists hold that the principal advantage of shaped high-explosive projectiles (Fig. 31), as compared to conventional armor-piercing and sub-caliber projectiles, is their high armor-piercing capability (the calibers being equal) which does not depend on the distance to the target. The impact upon the armor triggers the head exploder. Its effect is transfered through a booster lead to a percussion cap, which triggers the detonation of the explosive charge. The metal casing is compressed under a pressure of several hundreds of thousands atmospheres. From the compressed area, a metal jet is ejected at a velocity of the order of 10,000 m/sec. The jet diameter in medium-caliber charges amounts to 3 to 4 mm. As a result, the jet is capable of penetrating armor, whose thickness is in excess of three calibers of the shell.

Specialists hold that the armor-piercing capability of shaped high-explosive charges is reduced several times if the charges rotate during the explosion. This is explained by the fact that the rotation of the charge has a deteriorating effect upon the conditions of formation of the cumulative jet.

It is believed that the effectiveness of shaped high-explosive (hollow-charge) projectiles can be improved by reducing their rotation rate. In flight, tank gun charges rotate at a rate of 17,000 to 18,000 rpm. To reduce the rotation rate, a high-explosive charge can be used that employe a steel hull. The rotation is imparted to the steel hull during the firing, whereas the hollow-charge projectile, emplaced in it on ball bearings, remains stable on account of the force of inertia. Charges of this type are used in the French 105 mm tank gun of the AMX-30 medium tank. But -- its manufacture requires a high grade of precision which, in turn, considerably increases the cost per charge.

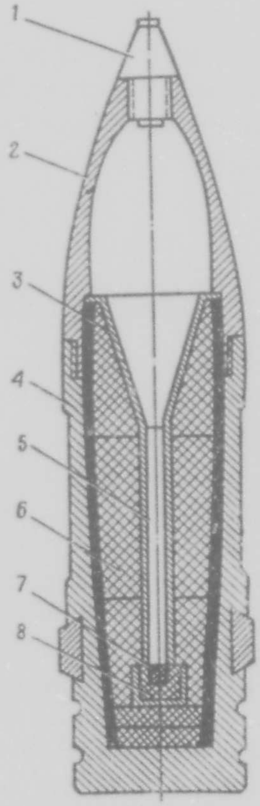


Fig. 31: Shaped High-Explosive Projectile:

1 - instant-action fuse; 2 - screw-down cap; 3 - facing; 4 - body of the charge; 5 - central channel; 6 - composition; 7 - percussion cap (detonator); 8 - booster.

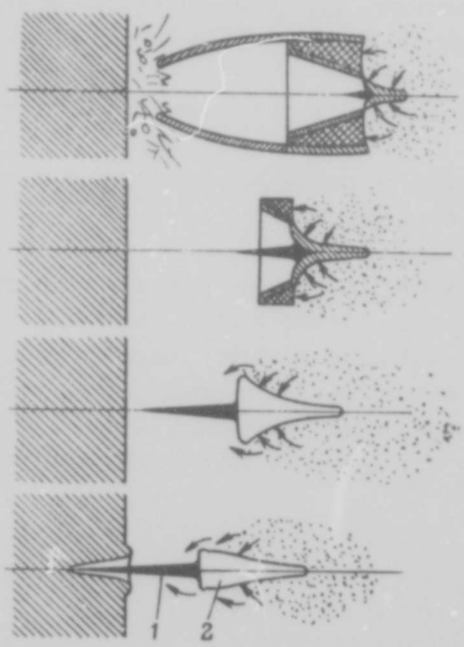


Fig. 32: Diagram, showing the formation of a cumulative jet:

1 - cumulative jet; 2 - the pestel.

Shells with Plastic Explosives (PE)

Shells with plastic explosives (PE) can be used for the acquisition of armored targets and other objects. Their action is based on projecting spalls upon impact into the interior of the vehicle.

Upon impacting the armor, the projectile is deformed and its charge molds into the shape of a hull (Fig. 33). This being an overhatching projectile, the contact area between the hull and the armor may reach up to two calibers of the shell. The plastic explosive is detonated by a fuse.

An important advantage of these shells is that they can be used for the acquisition of non-armored targets.

However, shells with PE also have serious drawbacks. Above all, the charge must explode at an established time interval. The triggering of the PE depends on the finite velocity of the projectile and upon the angle of impact with the armor; these factors vary, depending on the range of fire. Thus, the velocity of such projectiles cannot exceed 800 m/sec. Moreover, bullwarks and other devices can be used to significantly reduce their combat effectiveness.

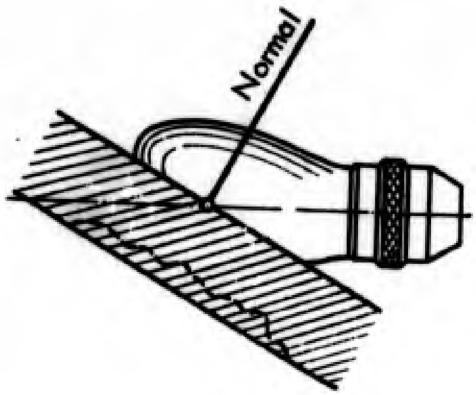


Fig. 33: Impact diagram of a shell with a plastic explosive upon the armor.

Presently, shells with PE are adopted for the gun armament of the US M-60, the British Chieftain and the Swedish "S" tank.

Par. 4: Improving the Tank's Firepower by Increasing The Probability of Target Acquisition

No matter how powerful the shell-target impact might be, the tank's firepower will be low, unless provisions are made for a high rate of target acquisition. In short -- the higher the target acquisition probability -- the higher the vehicle's firepower. The target acquisition probability depends on the fire accuracy and on the fire effect (i. e. , the minimization of the spread of the shells in the immediate traget area). The fire accuracy is estimated by deviations of the mean trajectory from the center of the target, whereas the fire effect is estimated by the deviation of single shells from the mean trajectory.

Improving the Fire Accuracy

Errors in determining and assigning the initial firing data essentially depend on the accuracy of determining the distance to the target, on taking into account the variations of firing conditions from normal, and on the speed of the movements of the tank and of the target. These errors also depend on the training and briefing of the crew, and on the actual firing conditions.

The distance to the target can be estimated visually; it also can be determined from the scales of the aiming or observation device, from the range-finding scale of the aiming device, by using the machine gun for adjustment fire, and/or by a range meter (or range-finder).

Visual estimates require experience and systematic training of the crew. The accuracy of this method does not exceed 10 - 15% of the distance to target, determined under good observation conditions.

A determination of the distance to the target using the scale of the aiming device is possible only when the target dimensions are known. In that case, the distance is calculated, using the formula of "a thousandth". The accuracy of this method does not exceed 8 - 10% of the distance to be determined; in combat conditions, this is not always convenient or, for that matter, even feasible.

The range determination, using a special range correction board in the field of vision of the aiming device, is relatively simple, however, the ballistic correction applies only to a certain elevation of the target.

The range can be also determined by fire-for-adjustment machine guns.

The machine gun fire determines the range, then the main gun is fired. The advantages of this method are in the higher accuracy of range determination (compared to the previously considered methods), and the relatively uncomplicated personnel training. However, with this method, the range can be determined over a limited distance only. This, on the other hand, takes considerable time, and fire-for-adjustment can prematurely reveal the location of the tank.

Some foreign tanks currently employ optical rangefinders, rangefinder/aiming device combination units and quantum (laser) optical rangefinders.

Optical rangefinders exist in the monocular and stereoscopic version.

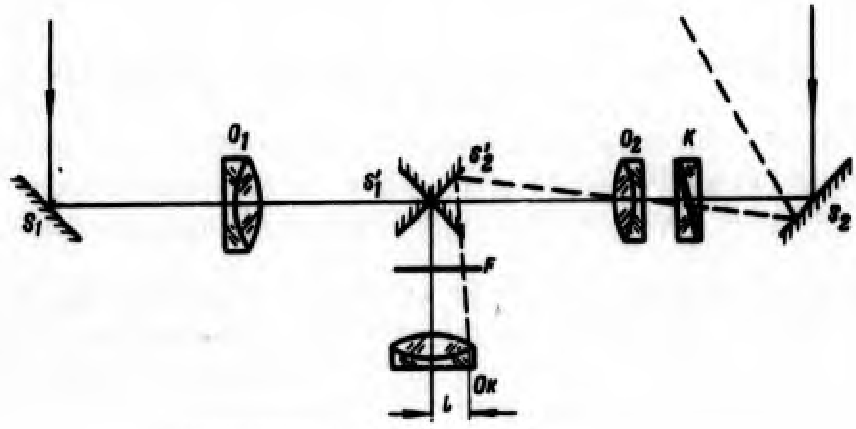


Fig. 34: Theoretical diagram of a monocluar rangefinder.

S_1 and S_2 - terminal reflectors; O_1 and O_2 - objective lenses; S_1' and S_2' - central mirrors; K - wedge compensator; Ok - eyepiece; F - focal plane of eyepiece.

The theoretical diagram of a monocular rangefinder is shown on Fig. 34. Rays from an object at infinite distance reach the terminal reflectors S_1 and S_2 in a parallel beam and, upon passing objective lenses O_1 and O_2, reach the central mirros (prisms) S_1' and S_2' which are at a 90^o angle with respect to each other and form a horizontal separating line in the field of vision, separating the field of vision into two halves. The mirror S_1' reflects the rays from the left branch of the rangefinder into the lower portion of the field of vision, whereas mirror S_2 reflects the rays from the right branch into the upper portion of the field of vision. Thus, the image is formed in the focal plane of the eyepiece and viewed through the eyepiece with one eye. Hence, rangefinders of this type are said to be monocular.

If the object is at a finite distance, then the images in the upper and lower fields of vision are divergent, since the rays from the target reach the terminal reflectors at different angles (Fig. 35). The magnitude of the divergence of the two halves of the image will depend on the distance to the object. The greater the distance, the smaller the divergence of the image.

Thus, a rangefinder can be used to measure the divergence of the halves of the image in linear terms. For practical purposes, the ranging by a monocular rangefinder amounts to attaining the convergence of the halves of the image.

The principal advantage of monocular rangefinders is in the simplicity of the range finding. However, for effective operation, it is imperative that the observed objects have a properly contrasted delineation. Rangefinder operators get quickly fatigued, and the range finding, when the tank is in motion, is practically impossible. The rangefinder's field of vision is divided by a separating line, which makes its utilization as a functional measuring device rather difficult.

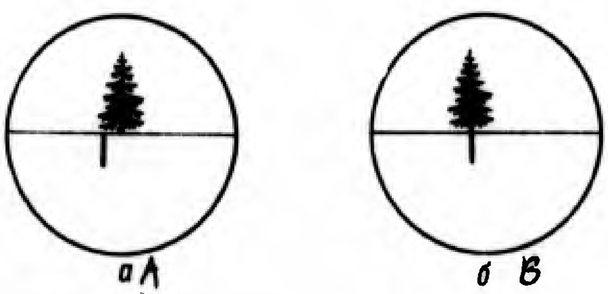


Fig. 35: The image in a monocular rangefinder: a - image of an object at finite distance; b - image of an object a infinity.

In stereoscopic rangefinders, as opposed to monocular rangefinders, the central mirrors (or prisms) S_1' and S_2' reflect the image from the left and right branches of the rangefinder not into one eyepiece, but into two (Fig. 36). Hence, in a stereoscopic rangefinder, the distance is measured by superimposing in depth the object image and the measuring node in the rangefinder's field of vision. The nodes (mostly of a rhombrid shape) appear on plane-parallel plates, mounted in the focal plane of the objective lenses. The centers of the measuring nodes are located on the optical axis of the left and right branches of the rangefinder.

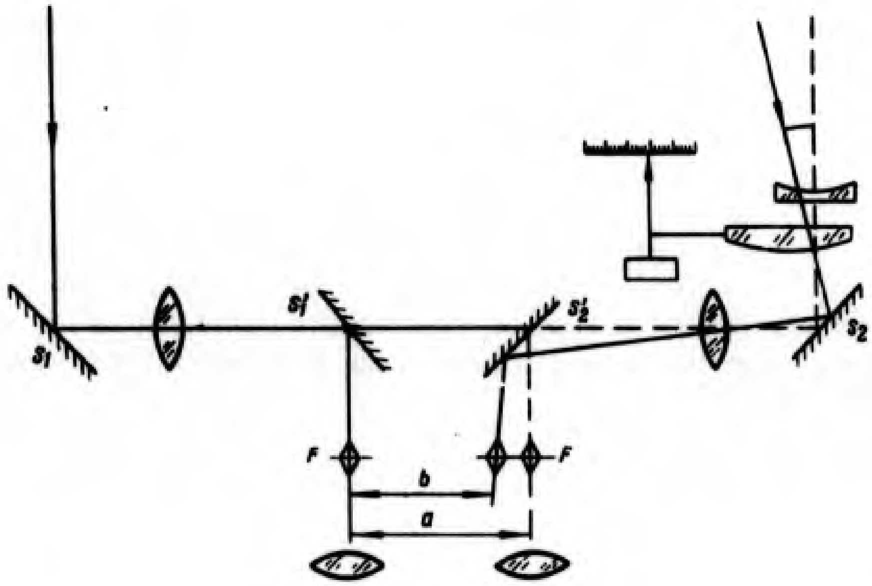


Fig. 36: The optical diagram of a stereoscopic rangefinder.

When an object at infinite distance is observed through the oculars of a rangefinder, the field of vision shows the images of the object and of the node, which are superimposed in depth. However, if the observed object is at a finite distance, its image through the right brancn of the rangefinder (at identical adjustment of the compensator) will be displaced by a magnitude that equals the difference (a-b). Thus, the images of the object and of the reference node will seem to appear at distances that are different in depth from the rangefinder. The difference between a and b can be completely compensated by using a compensator with a movable lense with a long focal distance, thus bringing the difference a-b to zero. The images of the object and of the reference node will appear to be located in the same plane in depth. Since the compensator is connected to the rangefinder scale, the appropriate distance (in meters) is shown when the reference node coincides with the target in one plane in depth.

The advantage of stereoscopic rangefinders is in that they provide the possibility to determine the range of any tactical targets, regardless of whether these targets are stationary or moving. Moreover, rangefinders also make good observation devices.

To operate stereoscopic rangefinders properly, it is necessary to have crews specifically trained in stereoscopy and rangefinding; to obtain precise ranging data, these crews must be systematically trained and upgraded.

When a rangefinder and an aiming device are installed in a tank as two separate units, a considerable amount of time must be spent for the range determination with subsequent site-scale adjustments. For this reason, some foreign tanks employ a combination rangefinder-aiming device, designed to aim automatically, taking into account the measured range.

In the US-made M-12 rangefinder-aiming device combination system, the rangefinding and angle determination mechanisms automatically fix the aim for the measured distance, whereas special cam mechanisms adjust for the selected projectile.

A rangefinder, mounted in a tank, is exposed to vibrations, shocks and unequally-distributed heat over the component parts of the device. This may cause a disruption of the rangefinder's functions -- both in terms of elevation and range. Thus, modern tank rangefinders are equipped with optical systems which eliminate the possibility of any significant malfunctions in terms of range. However, this substantially complicates the optical diagram of such rangefinders.

Foreign specialists hold that quantum optical rangefinders, whose principal component is a quantum generator (laser) producing a narrow light beam, are best suited for precision-rangefinding.

A quantum generator is manufactured from a crystalline core of a ruby, whereby the faces of the ruby are precision-ground to be parallel to each other. Thereupon the faces of the ruby core are carefully polished and silverplated so that they form opposing mirrors. The silverplating is dense from one end and opaque from the other end.

For excitation, the ruby is exposed to light from a pulse tube which encircles the core in the form of a coil. This type of tube is said to be a pumping tube.

The sequence of the process, taking place in a ruby when it is exposed to a pumping tube is shown on Figure 37.

Other methods of manufacture of quantum generators have been discovered abroad -- they entail not just the manufacture on the basis of a ruby, but also other crystals, as well as gases and semiconductors.

Figure 38 shows oneof the block-diagram variants of an experimental foreign rangefinder. The optical quantum (laser) generator (OQG) includes three principal subassemblies: transmi:ter, receiver and indicator.

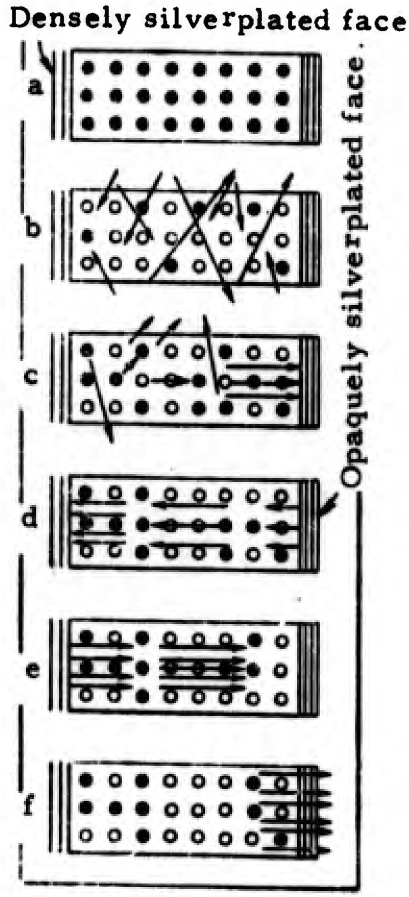


Fig. 37: Diagram of stages, taking place in a ruby when exposed to a pulse tube.

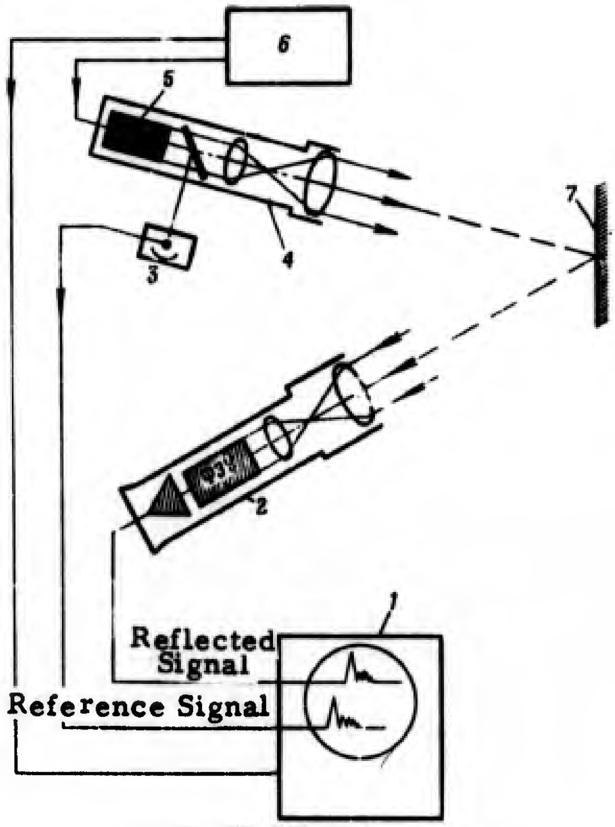


Fig. 38: Theoretical block-diagram of experimental optical rangefinder: (1) - range indicator; (2) - receiver; (3) - photoelement; (4) - transmitter's telescopic system; (5) - OQG on a ruby base; (6) - power souce; (7) - target.

The transmitter includes a ruby-based Optical Quantum Generator (OQG), a telescopic system and auxilliary devices. The radiation source in the transmitter is an OQG with a ruby core. The ruby radiations are focused by the telescopic system, which provides for a narrowing of the beam of up to 0.4 of a thousandths.

The receiver includes an optical system, light filters, and a photoelectric device (PED).

Immediately after the PED is a preamplifier, whose signal is fed onto a two-beam oscillography, which is used as an indicator.

The rangefinder operates as follows. The light flux from the optical generator is aimed at the object whose range is to be measured. A part of this flux deflected on the photoelement, which provices luminescence stimulation of a reference signal on the screen of the oscillograph. The light flux, reflected from the target, is trapped by the optical system of the receiver and, being transformed into an electrical signal, also makes a mark on the screen of the oscillograph. This mark is displaced with respect to the mark of the reference signal; the magnitude of the displacement in scale equals the distance to the target.

A specimen device of this type is the rangefinder developed by the British firm "Bradly" with the participation of US specialists. The laser transmitter and receiver, the telescopic aiming device, as well as the measuring and range fixation unit are located in the head of the rangefinder. The total weight of the rangefinder assembly is 23 kg, the average power consumption is 50 wt, the measurement accuracy is within $\pm$ 10 m at distances over 3000 meters.

Minimizing the determination and estimation errors of the actual firing conditions as compared to normal (theoretical) conditions. Normal (or tabular) firing conditions are conditions that fit into the framework of certain defined topographic, ballistic and morphological characteristics, i.e., the level point of the projectile is on the gun's horizon, the initial velocity of the charge is theoretical (tabular), the combat charge temperature is 15°C, the weight of the equipped charge is tabular, the wind velocity is zero, the barometric pressure is 750 mm, the air temperature is + 15°C.

However, a tank, as a rule, fires under conditions, that are considerably different from normal. Hence, to minimize the determination errors of the initial setting, it becomes necessary to use topograph, ballistic and meteorological correcting devices for automatic adjustment of the setting of the aiming device. Moreover, an increase of the initial charge velocities of tank guns increases the barrel wear which, in turn, reduces the initial velocity of the charge. Hence, the ballistic correction device must be designed with extreme care, taking into account this decrease in the initial velocity of the charge.

Minimizing errors of determining the reciprocal movements of the tank and of the target. During reciprocal movements of the tank and of the target, the determination of the initial firing data becomes considerably more complex in view of the continuous changes of the range and direction to the target.

Aiming devices, which are equipped to determine the lead during lateral movements of the target, as well as for an automatic introduction of the appropriate correction into the initial firing data are known as tachometric devices. Such devices are used in some foreign tanks, e.g., the French AMX-30.

Minimizing the Spread

Minimal spread (or scattering) is assured by high quality and rigid manufacturing standards of guns and ammunition, as well as meticulous preparation for firing. In the manufacture of a cannon, extreme attention should be paid to the distribution of masses of the recoiling parts, and the barrel curvature, which determine the jump angle of the projectile.

The principal causes of the angle of jump are the turn of the entire oscillating part of the gun about the trunnion plus with the elevating mechanism and the dynamic flexure of the barrel during the shot.

During the shot, the oscillating part of the gun turns as a result of the action of two factors: the resultant force R_{KH}, direction along the axis of the barrel, and the force R of the acting counter-recoil forces. These forces are not located in the same straight line and contribute to the creation of a torque.

The dynamic flexure of the barrel during the shot is caused by two forces: form P_{KH} acting upon the barrel, and the weight of the barrel Q_c. Inasmuch as the resultant force of these two forces is directed at some angle to the barrel's axis, the barrel deflects downward. This component of barrel deflection is further amplified by the force of the weight of the projectile, that travels along the barrel.

When a barrel curvature occurs, the jump angle increases, since a centrifugal force is generated during the movement of the projectile in a curved barrel; this force also contributes to barrel vibration. Moreover, the jump angle may vary on account of the varying maximum pressure of the powder gases and, as a consequence, also of force P_{KH}. There may be several reasons for that, i.e., the differing weight of the charges, the composition and shape of the powder grain, as well as varying loading densities (when charges are loaded individually).

The minimization of scattering is influenced by the weight, dimensions, shape and position of the center of gravity of the charge. When the weight is increased, the initial charge velocity decreases and, as a consequence, the scattering rate goes up. In many ways, the shape of the charge determines the magnitude of the air-resistance factor. Optimized charge shapes (depending on the initial velocity) are shown on Figure 39. Obviously, the larger the production tolerances with respect to shape, the larger the scattering.

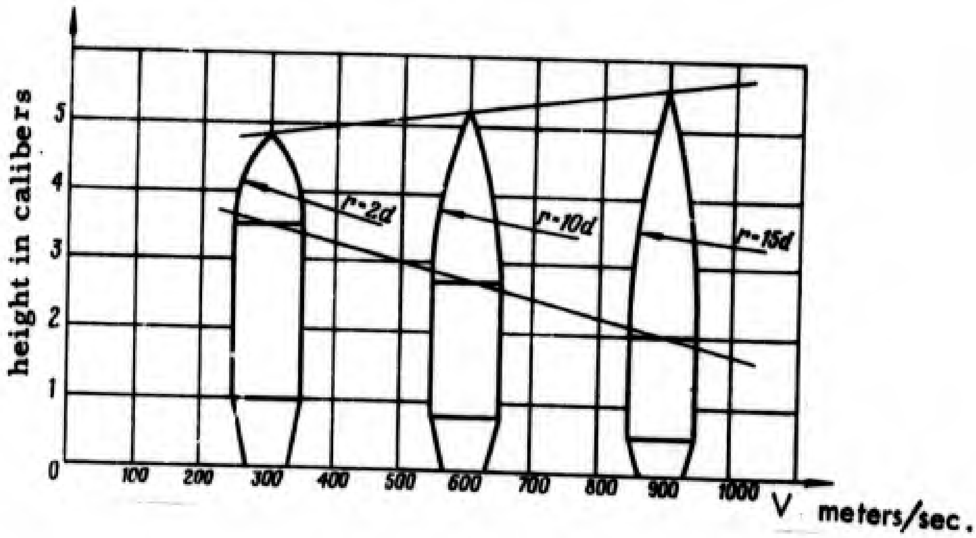


Fig. 39: Relationship between velocity and shape of the charge.

Scattering is also affected by the flight stability of the charge. A charge that rotates in flight, is subject to influence by air resistance and by the force of gravity.

To provide stable flight of the charge, it is necessary to comply with the following conditions: (1) the deflection angle of the charge's axis in precessionaly motion must be minimized (a condition of gyroscopic stability) and (2) the deflection of the axis of dynamic equilibrium from the direction of the tangent to the trajectory must be small (condition of correct motion of the charge over a curvilinear portion of the trajectory).

When tanks are equipped with a stabilization system, the scattering is minimized and the aiming accuracy while the vehicle is in motion are considerably improved. The optimal effect is attained when the tank's armament is stabilized in two planes: the oscillating part of the gun is stabilized in a vertical plane, and the turret with the gun is stabilized in a horizontal plane. When this type of armament stabilization (or fire direction set) system is used, the angles and the angular oscillation velocities of the armament decrease considerably -- both in the vertical as well as in the horizontal planes.

The higher the quality of the stabilization systems (or fire direction sets), the more accurate the aiming and the less the fire scattering when the vehicle is in motion.

Notably, to improve accuracy and minimize fire scattering when the vehicle is in motion, it is imperative to devote considerably attention to perfecting vehicle suspension systems, along with the improvement of fire direction sets.

It should be kept in mind that fire-direction sets (or stabilization systems) do not downgrade the training requirements for the driver-mechanic. Hence, in tank gunnery practice it is vitally important to emphasize not just the gunner's training, but also the training of the driver-mechanic. The driver-mechanic must be trained to drive the vehicle so as to provide for optimized conditions for firing while fully utilizing a cannon with a fire-direction set.

Par. 5: Increasing the Firepower of Tanks by Optimizing Fire Maneuverability

The optimization of the charge impact on the target and the optimization of the hit probability in conditions of modern mobile warfare does not necessarily guarantee the optimized firepower of tanks. The short duration of combat, the surprise element and the instantaneous appearance and disappearance of targets present a serious challenge to tank armament -- high fire maneuverability.

To improve fire maneuverability, tanks are equipped with servo-drives, designed to provide maximum aiming speed and a rapid fire transfer from one target to another. Minimal time for gun laying is also extremely important for precise aiming and subsequent target acquisition. Fire maneuverability also depends upon the gun-laying angles. Gun-mounting in the turret prermits to conduct circumferential fireing (over a given perimeter) while retaining the fire maneuverability when the tank is stationary. It is desirable that the gun-laying speed should vary from zero. However, using electro-hydraulic servodrives, it is not feasible to vary the gun-laying from zero, on account of the instability of minimal speeds. Usually, the minimal gun-laying speed varies between 0.05 and 0.1 deg./sec.

The maximum speed of gun laying in a vertical plane is selected, depending o. the performance speed of the gun laying system, while the vehicle is in motion. In that, it must not be below the average rates of the longitudinal angular vibrations of the vehicle hull. In fact, this speed depends primarily on the suspension quality of the tank. The required maximum speed of horizontal gun laying can be established from firing conditions at a moving target (at distance D) while the tank is in motion and the tank and target move on head-on parallel courses (Fig. 40). The relative speed of the target v_{rel} equals the sum of the speeds of the tank

v_{tank} and of the target v_{target} ($v_{tank} + v_{target}$). Analyzing the diagram, we find that the angular velocity of horizontal gun laying is

$$w_{r_{max}} = \frac{v_{rel} \operatorname{Sin} q_{target}}{D} \cdot \frac{180}{\pi} \text{ deg. sec.} \qquad (2)$$

Under extremely adverse firing conditions, v_{rel} = 50 kmh (or approximately 14 m/sec), D = 100 m and $q_{target} = 90°$; thus, the maximum gun laying speed

$$w_{r_{max}} = \frac{14 \times 180}{100 \times 3.14} = 8 \text{ deg./sec.}$$

It is essential that the gun laying speed varies smoothly from $w_{r_{min}}$ to $w_{r_{max}}$. To minimize the time required for the transfer of fire from one target to another, while the turret is turning at large angles, it is necessary that the traversing velocity is considerably larger than the maximum velocity of the horizontal gun laying (Fig. 41).

In modern foreign tanks, the traversing velocity of turret rotation tends to reach 30 deg./sec., and more.

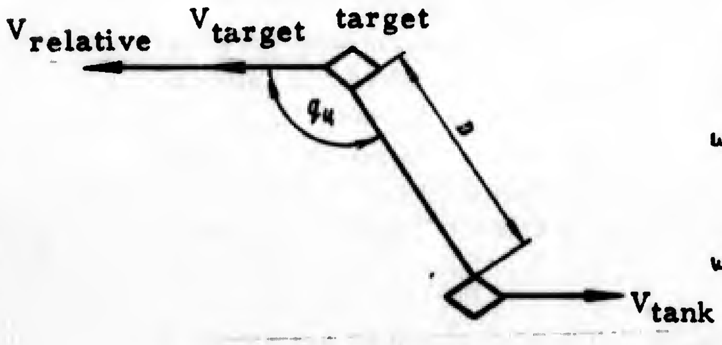


Fig. 40: Diagram of the movement of the tank and the target on parallel head-on courses.

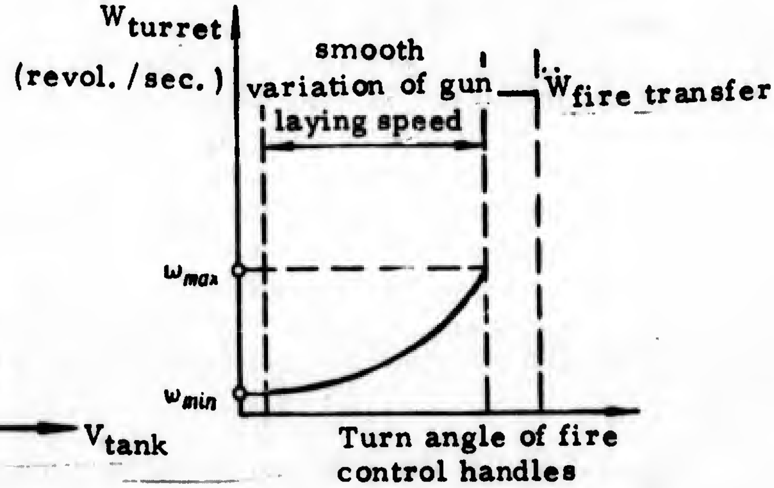


Fig. 41: Relationship between the turning speed of the turret and the turn angle of the drive control handles.

The fire maneuverability of a tank in a vertical plane is considerably influenced by the magnitude of the angles of vertical gun laying. A large elevation angle permits an effective usage of the gun in mountainous terrain and in large populated areas. The maximum elevation angle of a tank gun is 20 to 30 deg.

The gun-lowering angle determines the non-vulnerable area around the tank. The operating effectiveness of the stabilization devices depends largely upon the magnitude of the lowering angle. A small lowering angle does not allow the stabilization device to stabilize the gun during large longitudinal angular vibrations of the hull, since the gun is frequently put on the lower support (turn limiter). For this reason, the attempt is made to increase the lowering angle in modern tanks to about 8 to 10 degrees.

To establish a lead over the enemy in opening fire, it is, above all, important to have a lead in target detection. The time required for target detection depends on the quality of the observation devices, the number of observers, the operating mode of the tank during observation (mobile or stationary), the availability of stabilization devices, the mode of the target (movement, firing, etc.).

The time of opening of the fire, i.e., the time from target detection by any member of the crew to the time when the first round is fired, essentially depends upon the commander's system of target discrimination. Using this system, the tank's commander must be capable of rough-guiding the gun at the target from his own station. It is desirable to have a system where the range of gun-laying variation speeds by the tank's commander and the fire accuracy would correspond to those of the gun-layer. This substantially reduces the time of fire inception and fire transfer from target to target, if the latter is beyond the aiming field of vision of the gun layer.

Par. 6: Improving Tank Firepower by Raising the Combat Firing Rate

The combat firing rate is defined as the maximum number of rounds that can be fired from a cannon, including the time required for gun aiming correction after each round, and the change in aiming set-ups. The higher the combat firing rate -- the less the time for target acquisition; as a consequence -- more targets can be hit in the same period of time. Improving the combat firing rate and fire maneuverability give an important lead over the enemy in terms of decisive situations.

When the gun is manually-loaded, 70 to 75 percent of the time required for firing is spent on loading the gun; this, essentially, accounts for the complexity of the crew/artillery relationship in combat, when the firing of heavy artillery rounds is involved, within the confines of a compact compartment. In addition, the loading time in a moving tank is also increased. It follows, that in order to improve the firing rate in combat conditions, it is imperative to minimize the loading time. To this end, it is important to stow the major portion of the ammunition in the combat compartment, close to the loader, and to secure the artillery rounds in stowage in such manner that they can be readily accessible. Foreign specialists, however, feel that this problem can be resolved once-and-for-all only by automatic loading.

The complex of mechanisms that provides for gun-loading without the loader's participation, is said to be the loading automated equipment. The designs of loading automata may vary, depending on the gun caliber, weight and dimensions of loading automata may differ, depending on the dimension of the combat compartment. However, foreign experts hold that regardless of its design, an automatic loading device must provide the following features:

* A loading discrimination, i.e., the choice among different types of charges. In this instance, the detonator setting must be automatically varied, when firing high-explosive fragmentation charges.

* Storage compartments supplying the gun ammunition must be rapidly replenished, provided that the entire ammunition supply is not located in the automated storage complex.

* Automated mechanisms and firing stations must be at top functioning level regardless of the firing conditions.

* Optimal crew safety must be provided, while the automatic equipment is operating.

The establishing of the aforenamed characteristics of the automatic loading equipment involves considerable design problems, caused essentially by the large dimensions and weight of the ammunition, as well as by the limited dimensions of the tank's combat compartment.

The development of a safe design allows to eliminate the loader which, in turn, may reduce the height of the vehicle and increase the available on-board ammo supply.

Automatic loading devices were installed on the light French tank AMX-13 and on the Swedish "S" tank.

Notably, the tendency to increase the firing rate in combat by installing automatic loading devices, brought about the problem of removing the gun cartridge cases from the combat compartment. This can be explained by the fact that storing cartridge cases in the tank is difficult in view of the limited volume of the vehicle. Moreover, with a high firing rate, the powder gas level content of the combat compartment rapidly increases. The powder gas emanates from spent gun cartidge cases.

In the opinion of foreign specialists, a special device is required which would eject the spent cartridge cases through a special hatch, that opens when the round is fired. The Swedish "S" tank is equipped with this type of device.

Another way is the utilization of combustible cartridge cases. The advantage of such cases is the resulting economy of strategic materials (brass), the simplicity of their production, and the improvement of the conditions of the crew due to the decreased gas contamination level and the absence of cartridge cases which clutter the combat compartment.

Combustible cases require a special breach design. In order not to redesign existing breach assemblies, combustible cartridge cases were developed in the US specifically for the 105 mm gun of the M-60 tank; these cases are equipped with a small metal sabot to provide the required sealing of gases.

Par. 7: Improving the Firepower of a Tank by Optimizing the Invulnerability of the Weapons and Improving the Crew Conditions

With inadequate armament protection, the firepower of a tank is drastically reduced. The invulnerability of the armament is attained basically by rational armoring of the cannon and of the tank, as a whole, and also by considering the dynamic loads (at design stage), acting upon the armament components. Improvement of anti-atomic armament requires special attention.

At this point, we should emphasize the extremely important relationship that exists between the tank's firepower and the microclimate in the interior of the vehicle. The microclimate (or inhabitability) is defined as the sum-total of conditions, that prevail when the crew performs its route tasks on march and in combat, also including rest periods and other vital functions, while in the tank.

The nature of modern warfare puts the crew under extreme physical and moral stress. Rapidly setting in physical fatigue of the crew results in a loss of the sharpness of perception of the continuously changing combat situation, slows down the speed and the precision of reactions to external factors, increases the number of errors in performing assigned tasks and in final analysis, decreases the firepower of the tank.

Crew fatigue can be reduced by providing a stable and natural position of head and body when the men are handling the aiming and observation devices, by the use of special forehead protectors, by provisions for seat adjustment (height and direction) and armrests.

The design of the aiming devices must provide a stationary ocular subassembly with respect to the gun layer's head when the position of the barrel changes. All observation and aiming devices must be provided with ocular subassemblies, suitable for depth of field definition.

The handles for manual gun laying, switches and pushbuttons must be conveniently located; working with them must conform to the natural movements of hands. The gun must be laid with servodrives from one control panel.

Extremely important is the timely removal of carbon oxides, formed in large quantities as a result of powder combustion during firing of the cannon and machine guns. The powder gases, that enter the combat compartment with the ejected casing, contain up to 40 percent carbon oxide. Depending on the concentration and length of the crew's exposure, this results in fatigue, mental depression and reduced reflex responses.

For thorough ventilation of the combat compartment and removal of powder gases, it is necessary to raise the output of the fans which, in turn, calls for an increase of their dimensions and increases the electrical power consumption.

It is more practical to completely prevent the penetration of powder gases from the barrel into the combat compartment. To this end, modern tanks are equipped with ejection devices, mounted at the end of the barrel or at some distance from it (Fig. 42). When a round is fired, the powder gases fill a special receiver, and then flow out at high velocities through inclined nozzle openings in the barrel. These gas jets form a rarefied cone behind them, which drags the powder gases from the barrel and ejects them outside.

As a result of such blow-down, the gas contamination of the combat compartment goes down by several factors, as compared to firing cannons without a blow-down device.

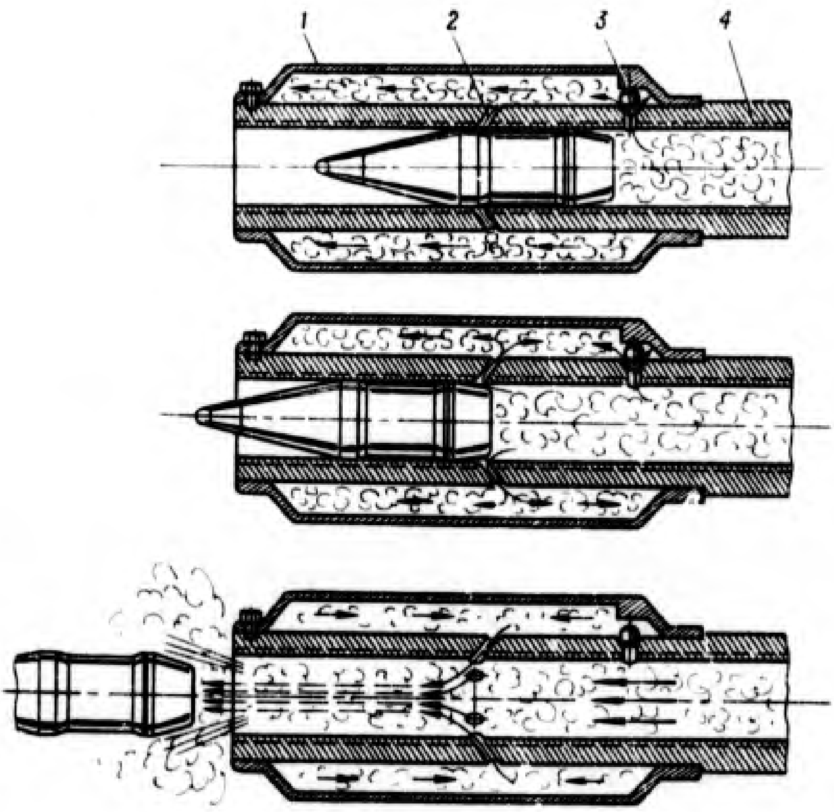


Fig. 42: Ejection device for blow-down of the barrel: (1) - receiver; (2) - nozzle opening; (3) - valve; (4) - barrel.

Par. 8: Additional Methods to Increase the Firepower of Tanks

In the view of foreign specialists, the possibilities of improving the efficiency of barrel weapons are being perpetually exhausted. Moreover, considerable difficulties seem to arise in conjunction with the installation of on-board guns.

The large weight and dimensions, as well as the powerful recoil, require the installation of a heavy turret. This increases the vehicle weight and, in turn, adversely affects its mobility. The relatively small dimensions of the combat compartment create additional difficulties in terms of automated loading. The research, conducted in recent years, aimed at improving the firepower of tanks points in the direction of equipping tanks with rocket-missile complexes. The practicality of this school of thought is confirmed by the successful development of various types of anti-tank guided missiles (AGM). It is commonly known that the big advantage of AGM is their high target acquisition probability, and also the significant fact that the maneuverability of the target has practically no effect upon the effectiveness of its acquisition.

In view of this, foreign specialists suggested the necessity of developing special guided missiles for deployment by tanks and the deployment of a new armament system, to include guided high-explosive fragmentation rocket projectiles to suppress tanks, machine guns for the acquisition of enemy personnel targets, as well as recoilless guns for the acquisition of enemy artillery batteries and other targets.

A number of countires have undertaken active steps to develop tanks with on-board AGM equipment. Nonetheless, substantial disadvantages that would preclude mass-usage of this equipment, were also pointed out, i.e.,

* A quantitative reduction of the on-board ammunition supply, on account of the large dimensions of AGM, necessitating their installation outside the tank, using open lauchers.

* The low firing rate (wire-guided missiles must be guided to the target during their entire flight time, until they connect with the target, which may take from 10 to 30 seconds).

* Impossibility of firing while the vehicle is in motion.

* The impossibility (or difficulty) of hitting targets at relatively close range (500 to 600 m), as well as the dependance of the firing results on terrain features and vegetation (tall grass, bushes, trees).

As a consequence, AGM are presently used on foreign tanks purely as auxilliary weapons. Thus, certain tanks have a provision in the aft of the turret for the installation of AGM.

In the attempt to utilize the positive features of rockets and guns, a course has been mapped to develop a rocket-missile -- cannon tank. Tanks are under development that will feature rifled barrels, suitable for conventional high-explosive fragmentation ammunition (for the acquisition of close targets) as well as for AGM. A specimen, exemplifying this approach, is the US light tank "Sheridan".

Another new foreign direction in the development of tank weaponry is the utilization of laser weapons as the main armament.

Inview of the high energy densities that are obtained by focusing the radiation of quantum generator, it is possible to create radiation (laser) weapons. A narrow-focused quantum generator ray creates extremely high temperatures on the surface of the irradiated object with enormous specific energy densities. It is assumed that this can result in the acquisition of armored targets.

An advantage of this type of weapon is that it is noiseless; accordingly, when properly camouflaged, it could produce devastating results. Moreover, the speed of propagation of radiation (which equals the speed of light) eliminates the need for corrections and compensation mechanisms, which are normally required to work out the data for reciprocal tank/target movements, as well as other mechanisms.

Inspite of the fact that at the present time a considerable progress in the direction of raising the laser output of optical quantum generators was made, the development of laser weapons, nonetheless, requires the solution of a number of complex technical problems. These problems include, above all, an improvement of the radiation powder of the impulse. In addition, the system development and the radiation focusing over large distances involve considerable difficulties. The interactions between the powerful radiation of an optical quantum generator and the atmosphere and/or other elements have as yet not been sufficiently explored.

To use lasers as weapons for the acquisition of live targets, experiments were made abroad to establish the effect of the biological action of lasers upon a living organism. It was established that action effect essentially depends upon the laser radiation power and the capability of cells and tissue to rapidly absorb the radiation energy. It was also found that the central nervous system, eyes and skin tissues are most sensitive to laser radiation.

An important property of the biological action of laser radiation is the presence of a clearly-defined boundary between the damaged area and the healthy tissue. Notably, the exposure mechanism of a living organism to laser radiation has not yet been sufficiently explored.

It is typical that the emergence of laser weapon projects immediately led to the development of studies, aimed at laser radiation protection. One of the possible methods of protection is the application of special optical devices which disperse the input radiation and also weaken the local concentration of the radiation flux. Studies are now conducted to develop methods of weakening the radiation of optical quantum generators using artificial smoke screens.

The firepower of tanks can be substantially increased by equipping them with nuclear weapons. In the opinion of foreign military experts, this can eliminate the need for tank support by self-propelled artillery. The US and England have developed low-capacity warheads for AGM "Shilelagh" and "Malcara" that are currently installed in tanks.

Section Three

TANK DEFENSE

Protecting the crew and the inside tank equipment from various antitank media under modern combat conditions is a complex problem. It is particularly complicated by the fact that the destructive effect of the main antitank media -- armor piercing and low-calibery shells, cumulative and atomic weapons -- are based on different principles and consequently require different means of defense.

To a large measure, tank defense is guaranteed by its fire power and its maneuverability; the more powerful and effective the tank armaments, the greater its moving speed and maneuverability on the battlefield the less vulnerable it is. However, the basis for protecting the crew and equipment of modern tanks, now as before, consists of the armor plated hull and turret, supplementary means of anti-atomic defense, fire-fighting equipment, thermosmoke apparatus for setting up a smoke screen, etc.

Par. 1: Special Features of Armor Protection on Modern Tanks

The armor protection of modern foreign tanks still remains anti-shell and sharp differentiation. As a rule, light tanks have bullet-proof armor plating.

Differentiated protection is achieved in accordance with the anticipated density with which shells will hit on the various surfaces of the hull and turret which is approximately estimated with mathematical methods of working out statistical data (on tanks) of past wars and predictions for the future.

Armor plating differs with regard to thickness and angle of inclination of the armor components. Greater thickness and angles of inclination are provided for on the frontal surfaces of the hull and turret which is the most exposed to enemy fire. The side of the turret, the hull and the stern are less thick, and the roof and bottom are made of thinner sheets.

Up to the present time, differential armor plating has been the only method which has been comparatively effective in satisfying the requirements made for tank hulls and turrets, the main ones of which are:

reliability of protection from destruction, hardness and stability with minimum weight. It is assumed that protecting the crew from harmful effects of penetrating radiation in an atomic blast requires a zone of varying stability for disposing the crew. However, with the existing scheme of general components, this leads to unacceptably increasing the weight of the tank and makes it necessary to look for other methods of anti-radiation protection. Increasing the firepower and increasing the maneuvarability of modern tanks sometimes leads to impairing their armor plating, since the general weight of the vehicle is limited. So, in the case of the Western German tank "Leopard", the French tank AMX-30, the thickness at the side is 35 - 40 mm, i.e., less than in the case of the Soviet tank, T-34, discharging a fourth of its weight at the rear. However, the T-34 tank was equipped with an 85 mm cannon and generates a maximum speed of 55 km/h, while the "Leopard" and the AMX-30 tanks have 105 mm cannons and develop a speed up to 65 - 70 km/h. It is true that the frontal surface of the turret and the hull in all these tanks is made comparatively thick and with large angles of inclination. An especially large angle of inclination is guaranteed by the front sheet on the hull of the "Chieftain" tank.

The angle of inclination of the armor plating to the vertical has an important influence on its protective characteristics, mostly because it increases the path of the shell into the armor, i.e. the penetration length is increased (Fig. 43) since the trajectory of the shells at the general firing distances is along the tank flooring.

With simple geometric ratios it is not difficult to establish that the reduced thickness of armor plating h_0 equals the actual thickness h_α, divided by $\cos\alpha$:

$$h_0 = \frac{h_\alpha}{\cos\alpha}$$

In reality, the influence of the reduced thickness of the armor on the angle of inclination is more complicated. In particular, it is influenced by the type of shell and the quality of the armor plating. Calculating all the factors:

$$h_0 = \frac{h_\alpha}{\cos^n \alpha} \tag{3}$$

where n is the indicator of the degree determined experimentally. An approximate value is n = 1.0 - 1.6.

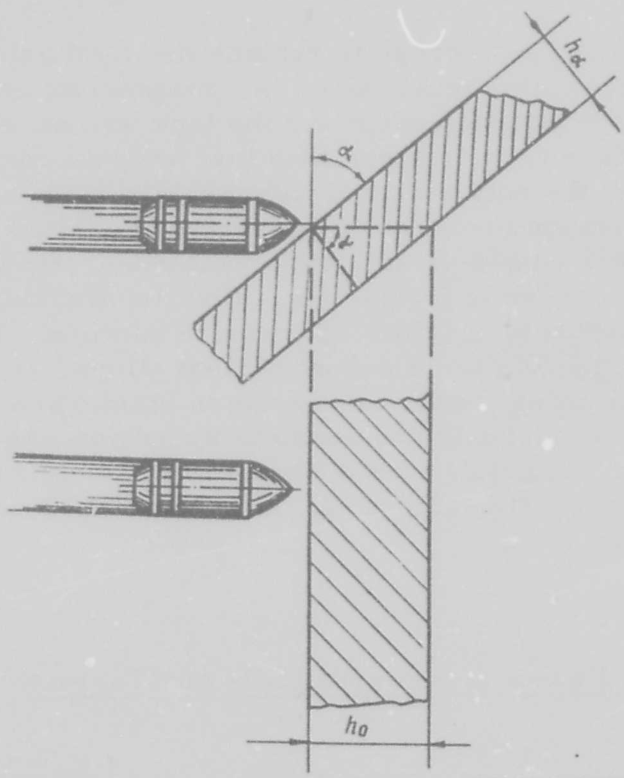


Fig. 43: Influence of the angle of encounter on piercing the armor.

Thus, the greater the angle of inclination of the armor plated components to the vertical, the greater are its protective characteristics because, first of all, the corrected thickness is increased, and secondly the probability of shell ricochet is increased. Larger angle of inclination improve the anti-accumulation stability of the hull.

The most important mechanical qualities of tank armor are hardness, ductility and stability.

Hardness is necessary to destroy the head of the shell and avert it from penetrating the armor plating; ductility protects the armor plating from cracking and splitting of the inner surface.

Stell armor plating has higher mechanical characteristics which are preferable and are used on modern tanks. Combining the necessary stability, hardness and ductility is achieved by adding different alloying additions to the armor plating steel. The deficiency of the many alloying elements is explained by the tendency to reduce the weight and the metallic content of the hull and turret of each tank.

Work is being carried out abroad to replace the steel armor with metal armor of light alloys: aluminum, titanium, magnesium and lithium. Use of light alloys makes it possible to reduce the tank weight, due to the fact that equal shell stability is guaranteed with less weight compared to steel armor. In addition, the hull design of light vehicles is simplified with such armor plating, since the armor components are thicker and consequently do not require supplemental reinforcing ribs, transverse and longitudinal beams, connection plates, etc. Finally, the aluminum hull is in no danger of corrosion and does not require painting. In addition to the work being carried out to create armor of light alloys, as was pointed out earlier, other work is being conducted abroad on plastic and combination armor, combining layers of metallic and nonmetallic armor. It is assumed that such a combination of materials with different mechanical and chemical properties may more fully provide anti-shell, anti-cumulative and anti-radiation protection for the tank.

Par. 2: Design Forms of Armored Hulls and Turrets

The form of the tank body is selected with consideration of providing the best possible shell stability, facility of disposition for equipment and crew, the maximum possible width in the upper part for setting up the turret with a large diagemter and simplicity of manufacture. These qualities must be achieved with the lowest possible weight, but to achieve this it is necessary to reduce the inside volume of the hull and the total area of its armor components.

Selection of a rational relationship between the hull dimensions is important -- its length, width and height. These dimensions influence the width differently with regard to a sharp differentiation of the armor plating. If the hull length is decreased by a certain value δ (Fig. 44), and together with the reduction of the weight is mistaken for a unit, then with a reduction of the width by the same value δ, the gain in weight amounts to 2 - 2.5 units, and with the same reduction of height 3 - 7 units. The greater influence of height on weight is explained by the fact that thicker bow, side and stern sheets go into the horizontal cross section of the hull, having the same maximum perimeter. From this, there is a tendency to make the tank lower. The bow parts of hulls of a majority of modern tanks has either the shape of a horizontal wedge with large angles of inclination, as on the T-54 tank (Fig. 45, a), or more complex in manufacture such as the so-called "ship" form of the IS-3 (Fig. 45, b.).

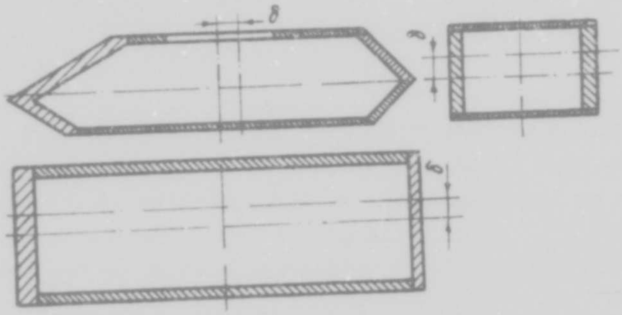


Fig. 44: Drawing of the tank body.

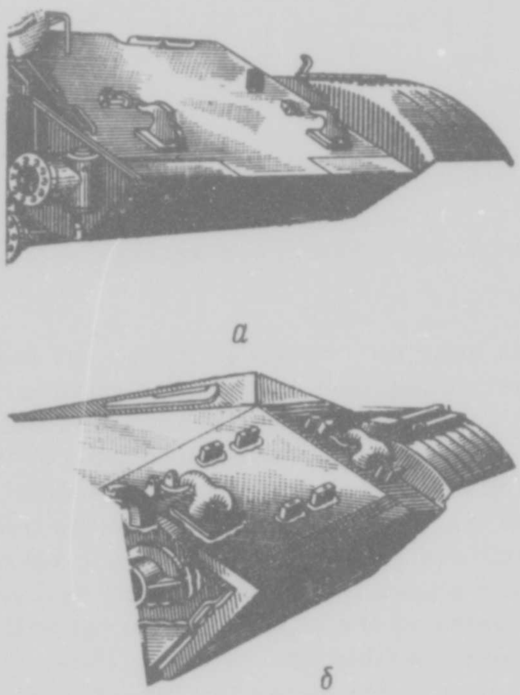


Fig. 45: Shape of the bow parts on the hull.
(a) - T-54 tank; (b) - IS-3 tank

As a rule, the shape of the bow part of the hull is determined by the dimensions and the configuration of the aggregates disposed there.

The greatest variety is observed in the transverse cross section of the hulls. The shape of the hull on the T-54 tank (Fig. 45, a) is simple and rational, the trough-shaped bottom of which decreases the inside volume, and local widening makes it possible to dispose a fraction of the large diameter.

The caterpillar form (Fig. 46, b) is characteristic for heavier tanks where the upper part of the hull is placed above tracks. In the case of the M-48 and M-60 tanks, the projecting parts of the sides were disposed inside of the track outline (Fig. 46, c). Such a complex form inside the track in transverse cross section turned out to be possible thanks to the use of a one-piece hull (Fig. 47).

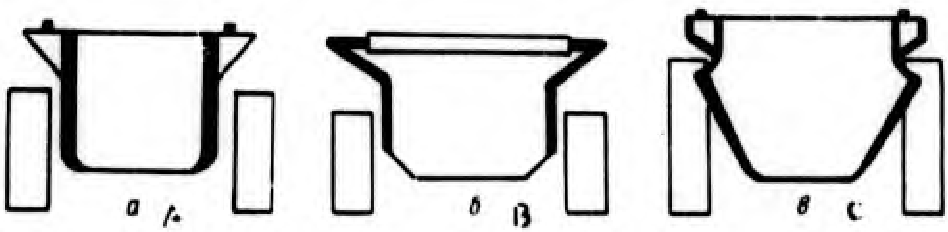


Fig. 46: Forms of the transverse cross section of hulls.

The use of hull shapes over the track and inside the track in a series of modern tanks, making their production much more complex and expensive, is explained by the following. As has already been pointed out, the general width of the tank is limited by their being loaded onto railroads and trailers. A high degree of passability of the vehicle must be guaranteed with this limited width (this required wide tracks), and at the same time the possibility of setting up a high-powered artillery system in the rotating turret. The experience of tank construction shows that with cannons having a caliber higher than 100 mm, the diameter of the adjustable turret will be slightly different from the maximum permissible tank width. Thus, it is necessary to make the hull wide in the upper parts under the turret and narrower in the lower parts, in order to have room to dispose the track running gear.

The shape of the hull must guarantee the maximum shell stability, a high degree of stability and hardness as well as facility of disposing the crew and equipment. These requirements are most completely fulfilled by

Fig. 47: One-piece hull of the M-60 tank.

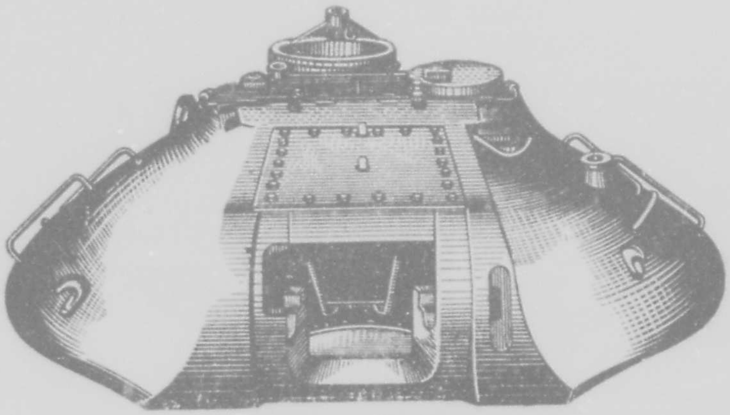
the semi-spherical shape of the foundry cast Soviet tanks IS-3 (Fig. 48, a) and the T-54 (Fig. 48, b), which have great influence on the turret shape of modern foreign tanks. When an engine is set up on the tank for air-cooling the stern parts of the turret, it is necessary to give it a shape which will provide good air access to the engine (Fig. 48, c). This decreases the shell stability of the turret and increases the vulnerability of the tank, since there is the possibility of shells ricocheting into the roof of the power unit.

For light tanks with bullet-proof armor plating, it is customary to use welded turrets of the conical shape.

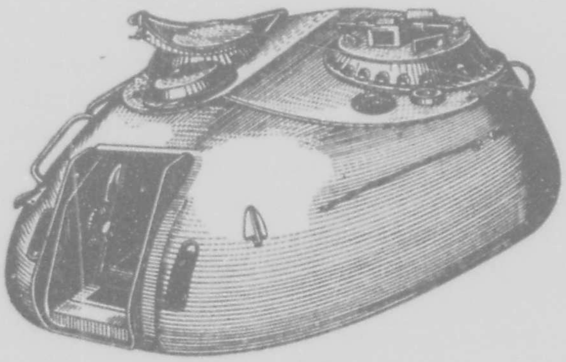
As has been pointed out, the French light tank AMX-13 has a tilting turret (Fig. 49). Such a turret consists of two parts. The upper part 2 of the turret is set up on pivots 3 of the lower part 1 and can be swung in a vertical plane. The cannon mounted in it and the automatic loader with shell packing swings together with the upper part.

The circular rotation of the turret is provided by ball bearings, the packing of which is given special attention. The hermetic state of the bearings is necessary to overcome water obstacles and also for the anti-atomic protection of the tank. At the same time, the packing must not create much resistance to the turret rotation.

The turret rotates with the aid of a turning mechanism having electrical (or hydraulic) and manual control mechanisms. The basic drive mechanism is the electrical (hydraulic), while the manual one is used as an auxiliary when the engine is not operating (so as not to run down the batteries)



а A



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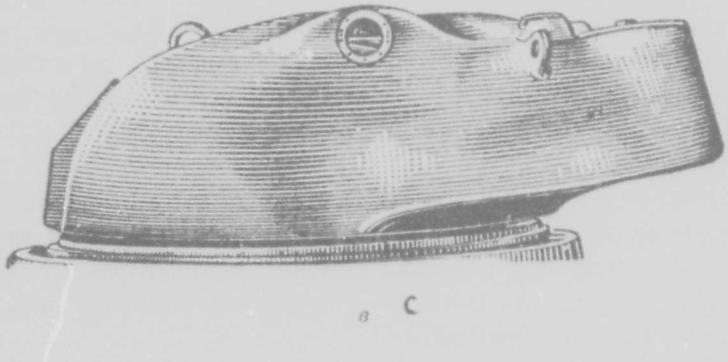


в C

Fig. 48: Turret shapes: (a) - IS-3 tank; (b) - T-54 tank; (c) - turret with projection.

and adjusting the weapons. The electrical (hydraulic) drive mechanism must provide a wide range of regulating speeds for rotating the turret from the slowest -- in order to accurately aim the weapon on the target (0.05 - 0.07 deg./sec.) up to the fastest -- for a rapid fire maneuver (25 - 30 deg./sec.).

On a series of tanks, the control for rotating the turret is duplicated and can be carried out by the gunner as well as by the vehicle commander.

In order to reduce the rotational resistance of the turret, an attempt is made to guarantee its complete equilibrium with regard to the axis of rotation. In order to accomplish this, the center of gravity of the equipped turret must lie on the rotational axis.

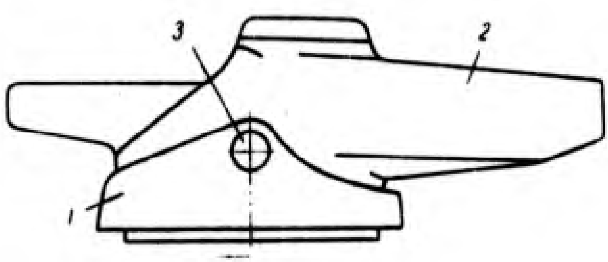


Fig. 49: Tilting turret of the AMX-13 tank: (1) - lower part of the turret; (2) - upper part of the turret; (3) - pivots.

Par. 3: Anti-Cumulative Protection of the Tank

In the past few years, the cumulative means of destroying tanks has been extremely widespread. Two circumstances have widly contributed to this: a high degree of armor penetrability of the shells, independent of firing distance, and the simplicity of the shell, guaranteeing its low cost.

As has been pointed out, when a cumulative shell explodes, a current of air is formed which has a tremendous velocity and pressure and penetrates the armor, as well as into liquid media. Piercing the armor, the current of air diffuses the metal and bursts into the hull, injuring the crew and damaging tank equipment. However, the velocity of the air current and consequently its penetrating force diminishes very rapidly after the explosion. This characteristic is utilized for anti-cumulative tank defense.

One of the methods for effective tank defense is giving the armor plating large angles of inclination. In addition, the thickness of the armor referred to is increased while the conditions for the cumulative air current forming are impaired, since the form of the hollow is disturbed with the impact of the shell on armor which is tilted.

Another method of protection is to explode the shell at a certain distance from the armor with the aid of a special screen. In this case, the cumulative air current is formed at a certain distance from the armor plating and, it loses its penetrating force before it reaches the armor plating. There are such screens in the form of bulwarks on the English tanks "Centurion" and "Chieftan".

Par. 4: Anti-Atomic Protection of the Tank

In the course of the first 10 years after the war, in connection with equipping the armies with rocket-nuclear weapons, many articles have been printed in the pages of the foreign military press concerning the future destiny of armored forces. Skeptical judgments have been expressed concerning the onset of their decline due to their inability to defend against new means of mass destruction. In the meantime, studies made in the US have permitted the foreign military specialists to come to the conclusion that there are no types of troops more stable against the damaging factors of a nuclear blast than armored forces. The shock wave of an atomic blast, the light radiation, the penetrating radiation as well as the radioactive substances turn out to be less dangerous for armored forces than for any other type of troops. The armor plated hull and the tank turret withstand the damaging factors of a nuclear blast very well. However, the crew disposed inside of it is not sufficiently protected. Thus, at determined distances from the center of the blast, the tank is preserved as a combat vehicle, but the crew is injured by penetrating radiation or the shock wave flowing inside, also damaging the inside tank equipment. In addition, radioactive substances, not dangerous for the tank, are dangerous for personnel. In connection with this, a great deal of attention has been devoted to working out special systems of atomic-proof protection for the crew in new tanks.

Protection from penetrating radiation is more complicated, which is in the form of a stream of gamma rays and fast neutrons. Gamma rays are attenuated by passing through any material, while the attenuation is greater, the greater the density of the material. The degree of attentuation of a gamma flow is characterized by the so-called half-value layer, by which we mean the thickness of a layer of given material attenuating the gamma flow by half. The thickness of the half value layer also depends on the energy of the gamma radiation. According to the information of the American press, we must distinguish between primary radiation occurring in the first minute of the blast and residual radiation, forming a few minutes after the blast from the bomb fragments, and the induced radioactivity of the atmosphere elements.

The energy of initial radiation is much greater compared with residual radiation. Table 1 gives values for the density and thickness of half value layers for radiation on some materials.

TABLE 1: Density and thickness values for half-value layers for radiation on some materials.

Materials	Density of the layer g/cm^3	Thickness of half-value layers, cm -- Initial Radiation	Residual Radiation
Steel	7.8	3.8	1.8
Concrete	2.3	15.2	5.6
Ground	1.62	19.0	8.4
Wood	0.55	58.4	21.4

The data of Table 1 show that steel attenuates gamma radiation many times more than other materials. If the thickness of the half value layer and the actual thickness of the obstacle are known, then it is not difficult to determine the degree of general gamma-flow attenuation. For example, a layer of steel with a thickness of 38 mm attenuates initial radiation by half, double that layer provides for a quadruple attenuation, three layers, eight-fold, etc. This gradual dependence is determined by a simple formula:

$$K = \frac{v}{2 \quad v_P} \tag{4}$$

where K is the degree of gamma-radiation attenuation; v is the thickness of the material layer; vp is the thickness of the half value layer.

According to the data of the foreign press, steel armor plating, giving good protection from gamma rays, is insufficiently effective against the neutron flow and requires a special plastic layer, capable of absorbing the neutrons.

The crew and the inside equipment of the tank are protected from the shock wave by the hermetically sealed hull and turret, by special sealing of the moving joints, the port holes, the observation equipment, the hatch lids, etc.

Such hermetic sealing is necessary to protect against radio-active dust and at the same time to prevent water from getting into the tank when driving under water.

New foreign tanks are hermetically sealed and equipped with filter-ventilation equipment, permitting the tank to carry on combat operations under conditions of radio-active, bateriological and chemical contamination of the terrain. The tanks are equipped with dosimeters to check on the radiation level.

Par. 5: Other Means of Tank Defense

Other means of tank defense include fire-fighting equipment, a camouflage system, and on a series of foreign tanks there is a heat dispersion mechanism protecting the tank from heat detection instruments.

Fire-fighting equipment of post-war tanks was given special attention in connection with large tank losses from fires on the battlefield in the war years. For putting out fires, tanks of this period had only slightly effective hand-pumped fire extinguishers.

Modern tanks are equipped with stationary fire-fighting equipment consisting of several flasks with an extinguishing mixture and a system of pipes with sprayers situated in places considered most in danger of catching fire. The control of this equipment is manual (button) or automatic.

When a fire occurs, a membrane is broken in the head of the flask and the extinguishing mixture, for example carbonic acid, is directed along the tubing to the sprayers. Coming out of the sprayers, the liquid carbonic acid evaporates, displacing the air from the zone of the fire and lowering the temperature in this zone. Thus, conditions for further combustion are excluded and the fire goes out.

The camouflage means for a tank is the smoke screen which each tank is in a position to set up. Smoke pots are used to set up the smoke screen, which are lit and thrown from the tank without the crew leaving the vehicle, in addition to smoke grenades or a thermo-smoke apparatus. Unlike smoke pots, after the dropping of which the tank already has means for camouflage, the thermo-smoke apparatus is a system of multiple use.

The heat dispersion device, with which the engines of some modern tanks are supplied (M48A2, M-60, Chieftan, and others) is designed to protect the tank from heat detection instruments and the anti-tank guided reactive missile with a homing device which works on heat radiation. The principle of heat dispersion includes the fact that the exhaust gases are mixed with the air of the cooling engine and after this are ejected into the atmosphere.

Section Four

MANEUVERABILITY AND PASSABILITY

The main combat characteristics of a tank are its maneuverability and its passability, characterized by slow or medium moving speeds along various roads and off the road, the rated cruising range with one refueling for different road conditions, its ability to overcome different natural or artificial obstacles, among them crossing water obstacles along the bottom or afloat.

The main direction for increasing the maneuverability and passability for tanks is to decrease the tank weight, provide for an increase of their specific power and consequently, their moving speed. On some tanks ("Leopard", AMX-30), as has already been pointed out, the armor plating has been reduced in order to decrease the weight.

The other direction, improving the power unit, the transmission and the running gear, has exerted a decisive influence on maneuverability and passability of the tank.

Par. 1: Power Unit

The power unit of the tank consists of the engine and the system maintaining it: fuel supply, lubrication, cooling and starting. The composition of the power unit is a complex problem. The basic difficulty consists in the fact that it is necessary to place a high-power engine in the limited space of the power unit and free as large a space as possible for the combat compartment, where the crew, the equipment and the ammunition are placed.

Requirements for the Modern Tank Engine

A series of requirements have been made for the modern tank engine which must respond to its energy, economic, design and usage indicators.

The tank engine must have a great deal of power, minimum dimensions and weight, and must be easy to arrange in the power compartment of the tank hull. It must have as small a specific fuel consumption as possible over the entire range of the operating rotations and loads, and must operate on different fuels from diesel to high octane gasolines without decreasing the power and without increasing the fuel expenditure, and in addition it must consume the minimum amount of air per unit of power and must have as small a heat transfer as possible in the coolant and in the oil.

The engine must be easily and reliably started in any temperature and without special preparation and operate in any climatic belt, at any height, under water and in zones of radioactive radiation, have good pickup, i.e. ability to rapidly increase and decrease revolutions, with a high coefficient of adaptability to changes in the external load, it must be well-balanced and have high uniformity of movement. It must have a sufficiently large supply of motor reserves, a high degree of operational reliability and good repair potential with minimum upkeep time in the process of being used and, have a design suitable for mass production or large series production.

Up to the present time, an engine has not yet been made which fully satisfies all of the enumerated requirements. Considering the contradictory character of these requirements, making such an engine presents itself as a very complex problem.

The engine power of modern basic tanks reaches 600 - 850 hp, and has a tendency to go even higher.

One of the most important indicators of a tank engine is its overall power N_g -- the ratio of maximum effective power N_e of an engine to its overall volume V_g, calculated to produce the maximum overall engine

Table 2: Characteristics of Modern Tanks with Piston Engines.

Parameters	USSR B-54	USA Continental AVDS-1790-2	USA Caterpillar LVDS-1100	USA Caterpillar engine (experimental) LVMS-1050
Type	4-stroke diesel			
Combustion chamber	inseparable	inseparable	precombustion chamber	precombustion chamber
Degree of compression	14,5	14,5	19	20,5
Fuel	diesel	kerosene, diesel	multifuel 1	multifuel
Cooling	liquid	air		liquid
Supercharger	—		turbocompressor	
Degree of pressure increase in the supercharger	—	1,9	2,5	3
Number of placement of cylinders	12—V—60°	12—V—90°	8—V—90°	12—V—60°
Maximum power, h.p.	520	750	700[2]	1000
Revolutions w th maximum power, n_N, rpm	2000	2400	2200	2800
Maximum torque, kg/m	230	240	240	—
Revolutions with max. torque, n_M, rpm	1200	1600	1700	—
Range of operating revolutions, n_N-n_M, rpm	800	800	500	—
Relative size of the zone $(n_N-n_M):n_N$	0,4	0,33	0,227	—
Diameter of the cylinder, mm	150	146,1	137	114,3
Piston movement, mm	180 (186,7)	146,1	165	139,7
Ratio of piston movement to diameter	1,2 (1,24)	1	1,2	1,22
Mean piston speed, m/sec	12 (12,45)	11,7	12,1	13
Displacement, l	38,88	29,4	19,6	17,2
Mean effective pressure, kg/cm^2	6,02	9,6	14,7	18,6
Liter power, hp/l	13,4	25,6	35,8	58,2
Specific fuel consumption, g/hp-h	180	159—172	172	—
Overall dimensions, mm:				
length	1583	1640[3]	1320	1231
width	827	1380[3]	1220	—
height	897	1115[3]	1090	—
Overall volume, m^3	1,17	2,52[3]	1,755	0,92
Overall power, hp/m^3	443	298[3]	398	1087
Coefficient of compactness, l/m^3	33,2	11,7[3]	11,15	18,7
Engine weight, kg	895	1710	1157	1130
Specific weight, kg/hp	1,72	2,28	1,65	1,13

1. In the planning stage.
2. With cooling of the air after the compressor.
3. With consideration of cooling system aggregates.
4. With consideration of the oil tank and radiator.

engine	England	Germany	France	Japan
	Leiland L-60	Daimler-Benz MB 838 Ca-500	Spanish-Swiss HS-110	Mitsubishi 12 HM-21-WT
	2-stroke diesel between the pistons	precombustion chamber	4-stroke diesel vortical	inseparable
	16,75	18	—	15,5
	multifuel	multifuel 1	multifuel	—
	liquid			air
	drive volume	drive centrifugal	turbocompressor	
	1,4	—	—	—
	6 in a series, vertical	10—V—90°	12—180°, horizontal	12—V—90°
	700	830	720	600
	2400	2200	2800	2100
	218	258	—	230
	1400	1600	—	1500
	1000	600	—	600
	0,46	0,273	—	0,286
	117,5	165	—	140
	146×2	175	—	160
	1,24	1,06	—	1,14
	11,7	12,8	—	11,2
	19	37,4	—	29,6
	6,9	8,3	—	8,68
	36,8	22,2	—	20,3
	—	180	—	210
	1370[3]	1480[4]	—	2132[3]
	860[3]	1325[4]	—	2088[3]
	1192[3]	950[4]	—	1183[3]
	1,41[3]	1,86[4]	—	5,25[3]
	498[3]	445[4]	—	114[3]
	13,5[3]	20,2[4]	—	5,65[3]
	1400	1675	—	2250
	2	2,02	—	3,76

dimensions: length L, width B and height H.

The overall power of an engine depends on its liter power N_1, characterizing the degree of use of the working volume of the cylinders or the degree of engine boosting, and on the compactness of its design. The compactness of an engine is evaluated by the ratio of the engine displacement to its overall volume. This ratio may be obtained by multiplying the expression of overall power and dividing by displacement V_1:

$$\frac{N_g}{V_g} = \frac{N_e}{V_1} = \frac{N_e \times V_1}{V_g} = N_1 K \qquad \text{h. p/m}^3$$

The ratio V_1/V_g is called the coefficient of compactness K ($1/m^3$).

The second basic indicator of a tank engine is the specific effective fuel consumption

$$g_e = G_T/N_e \times 1000 \text{ g/hp-h}$$

where G_T is the hourly fuel consumption, kg/h.

With a limited volume of the fuel tanks, the engine provides the maximum rated cruising range without refueling (under stable, equal conditions), operating with heavier fuel and having a lower specific fuel consumption.

The best combination of these two basic indicators still remains the diesel. This is explained by the fact that the diesel presently occupies the exclusive position as the best tank engine, although according to energy, weight and overall indicators it must yield to the gasoline engine with spark ignition as well as to the gas turbine engine.

Soviet designers take pride in the fact that the Soviet diesel V-2 was the first tank engine in the world installed in the T-34. The V-2 plays an important role in providing this tank with high maneuverability indicators. It is known that contemporary tendencies in tank engine developments were formed under the influence of the successful use of the V-2 diesel. At the present time, the gasoline engine does not remain on one foreign tank -- the diesel has been installed on all of them without exception.

The Contemporary State of Piston Engines

and

Prospects for their Future Improvement

Table 2 presents data on modern tank engines of basically capitalistic countries and for comparison, data on the Soviet tank engine V-54 (Fig. 50), released in the post-war years. As is evident from Table 2, according to overall power, the V-54 engine yields only to the English 2-stroke Diesel L-60 tank the "Chieftan".

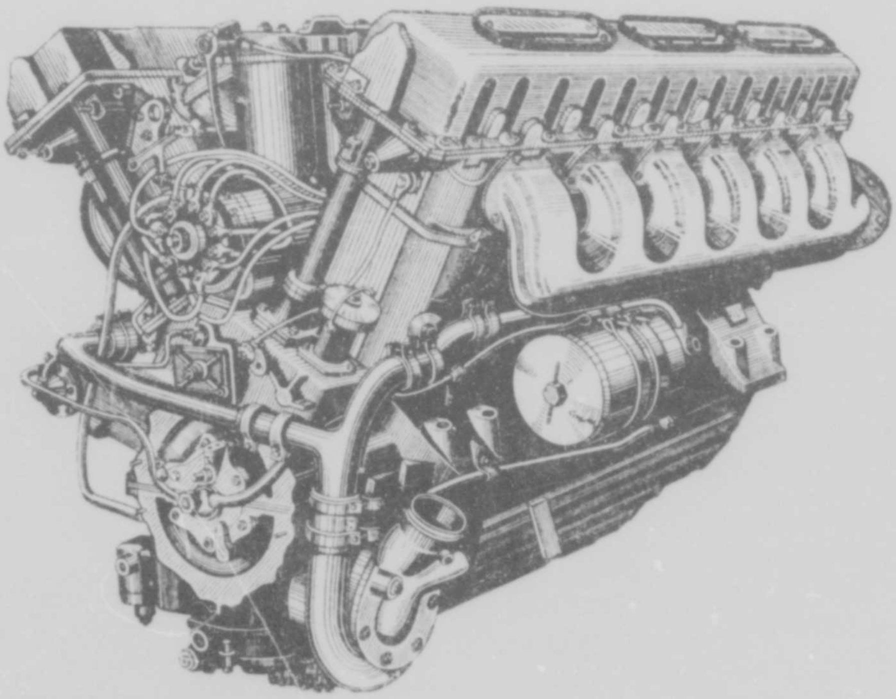


Fig. 50: Soviet Tank Diesel Type V-54.

It is true that the American diesel Caterpillar LVMS-1050 has a large overall power, but it is still in the development stage. At the present time, according to the degree of boosting, many engines significantly define the V-54 engine: their displacement power is significantly higher. In spite of this, the design of the V-2 engine is more successful since the coefficient of compactness K, equal to 33.2 l/m^3, has not been achieved up to the present time in one of the modern tank engines. The design of the V-54 engine also attests to the fact that the diesel (as well as the tank engine) has large reserves for increasing the overall indicators. Experience in creating the Caterpillar LVMS-1050 engine has corroborated the same thing.

According to specific fuel consumption, the engines with turbo-pressure charging has some better indicators, but the engines with a driven supercharger are no better than the V-54 engine.

The majority of modern tank engines are four-stroke and have liquid cooling. Two-stroke diesels are installed only in the English tank "Chieftan" and in the Swedish tank "S". The low degree of distribution of two-stroke engine is explained by determined difficulties connected with guaranteeing the efficiency of the piston assembly because of the higher mean temperature of the gases after the cycle, and accordingly the large amount of heat taken up by the pistons, which causes overheating of the pistons and the piston rings. In addition, in a two-stroke engine, it is difficult to guarantee good cleaning of the cylinders from exhaust gases and filling them with a fresh charge with moderate expenditure of air with scavenging. However, the high energy indicators of the two-stroke engine create the potential possibility for obtaining large overall power which is produced by these engines which are prospective for tanks, but the experience of creating the Leiland engine demonstrates the possibility of overcoming the difficulties enumerated above.

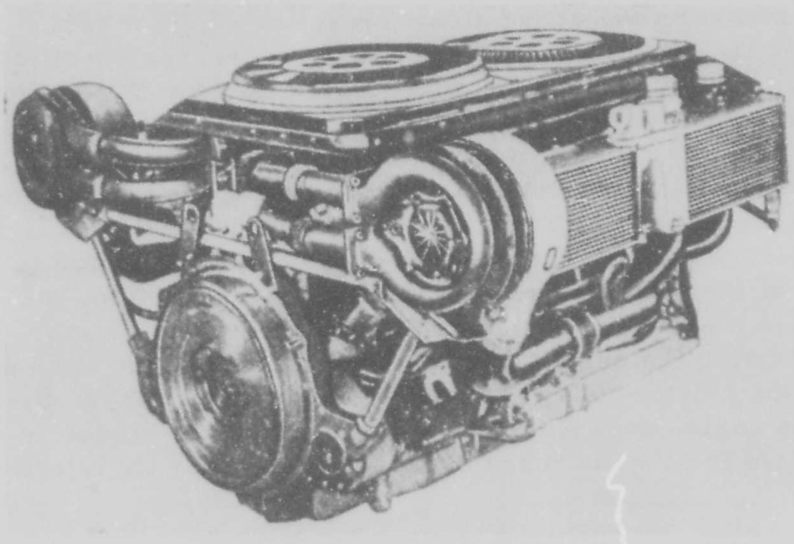


Fig. 51: Continental AVDS-1790-2 Engine

The American engine Continental AVDS-1790-2 of the M-60 tank (Fig. 51) has air cooling as does the Japanese engine Mitsubishi 12HM-21WT. But evidently these engines are the last representatives of tank engines with air cooling. It is generally achknowledged that when the engine is situated in a closed compartment of the hull, it is much more difficult to guarantee its reliable cooling directly with air than with the aid of an intermediate cooling agent -- liquid. The resultant engine is unwieldy, with small overall power, but to create an intense air flow, it is necessary to use a relatively large part of engine power. With air cooling, it is impossible to isolate the air circuit of the cooling system from the other psrts of the power compartment in the tank hull, which greatly complicates cooling the engine with water and increases contamination of the power compartment with radioactive dust when going through a zone of radio-active contamination.

So, for example, the overall power of the American engine AVDS-1790-2, having comparatively successful scheme of air cooling, totals about 300 hp/m^3, i.e. less than the B-54 engine, even with consideration of the volumes occupied by the water and oil radiators, the ventilator and the oil tank in the T-54. But the power expenditure in cooling of the AVDS-1790-2 engine (120 hp) amounts to 16% of the maximum power, i.e., more than in the T-54 tank. It is characteristic that the new American tank engines developed by the Caterpillar company, already have liquid cooling.

All the modern tank engines are multi-fuel. The ability of an engine to operate with any fuel -- from diesel to high-octane gasolines -- greatly simplifies the problem of supplying the armored forces with fuel.

The diesel, as an engine type, has the ability to operate with various fuels. However, converting the conventional diesel to a lighter fuel noticeably decreases its power and correspondingly increases specific fuel consumption; engine operation becomes more inflexible, knock and smoke are increased, motor-reserves of the engine are curtailed, and it becomes more difficult to start the engine at low temperatures. The reason for all this involves the fact that kerosene and especially gasoline ignites at a higher temperature than diesel fuel. In connection with this, the period of ignition lag is increased, after which a large quantity of fuel is accumulated in the cylinder. Because of the rapid burning of this fuel after ignition, the pressure of the gases increases at a high rate, which causes the stiff operation. When starting the engine at a low temperature of the ambient air, the temperature in the cylinder may prove to be insufficient for ignition, as a result of which the engine does not start. The much lower viscosity of light fuels is the cause for the increase of fuel leakage after its injection into the cylinder.

In order to guarantee uniformly good operation and reliable starting of the engine with any fuel, in its design it is necessary to provide for a series of special features. The degree of compression of multifuel engines must be of the order of 18-20 which guarantees a sufficiently high temperature at the beginning of fuel injection into the cylinder. The combustion chamber must guarantee rapid combustion of the fuel coming into the cylinder in drops. A combustion chamber (groove with special form), made in the bottom of the piston is better for the multi-fuel engine. Fair results were obtained with so-called divided chambers -- vortical and precombustion chamber. The American Caterpillar engine and the West German Daimler-Benz engine have the precombustion chamber, while the French engine Swiss-Spanish has the vortical chamber.

The fuel feed system of multifuel engines must also have a series of special features. Increasing the period of ignition lag causes the necessity of automatically changing the moment fuel feed begins. The position of the stopping device for maximum fuel feed must be changed in order that the change of the volume portion of fuel compensates for the change in its density and the difference in dissipation, depending on viscosity. The pressure created by the fuel pump is increased up to 2.5 - 5 kg/cm^2 in order to exclude the possibility of fuel vapors forming in the intake chamber of the pump under high pressure and in order to improve the filling of the piston volume. For this reason, the fuel-pumping system is made in a flow-through manner. A special system of sealing and drainage is provided for, preventing gasoline from getting into the oil. When operating on gasoline, the piston pairs of the fuel pump do not require special lubrication, but lubrication is required on the camshaft and the feed plungers.

Tank engines have increased energy indicators and are designed to operate up to 500 - 1000 moto-hours, and less in individual cases. Such engines are called booster engines.

To increase the liter power -- the basic energy indicator of the engine -- as follows from the expression

$$N_l = p_e n \; / \; 225 \; \tau$$

is possible in two ways with a given stroke τ : increase the mean effective pressure p_e and increase the revolutions n.

It is expedient to increase the revolutions until production $p_e n$ increases. However, with an increase in revolutions, the mean effective pressure decreases first, due to the curtailment of time in the process of carburetion and combustion, as a result of which the effective work of the gases decreases and, secondly, due to the increase of mechanical losses, which proportional to the mean speed of piston movement, is calculated according to the formula

$$v_p = Sn/30,$$

where S is piston movement, m; n is the number of crankshaft revolutions per minute.

It has practically been determined that the mean speed of piston movement in the diesel must not exceed 12 - 13 m/sec, since at high moving speeds, cylinder and piston component wear is greatly increased.

In order that the mean speed of piston movement does not increase with an increase of the revolutions, piston movement is decreased, i.e., the engines are made for short movements. A decrease of the relative short movement is characteristic for modern engines, when the ratio of piston movement S to cylinder diameter D is decreased. At the present time, the ratio S/D in diesels approaches unity, and in gasoline engines we achieve 0.8 - 0.75 and even less. The ratio $S/D < 1$ is not obtained in diesels of wide propagation, since due to the low height of the combustion chambers it is difficult to give them the necessary shape.

It is also necessary to take into account that increasing the revolutions involves increasing the force of inertia in the moving parts of the crankshaft mechanism, in connection with which the load and the crank bearings and the connecting rod pistons of the crankshaft as well as the wear are increased.

By virtue of the reasons indicated above, in modern tank engines the revolutions of the crankshaft do not exceed 3000 rpm.

The second possible method for increasing the liter power of a diesel is to increase the mean effective pressure which results in useful effective operation obtained after the cycle with one cubic centimeter of the working volume of the cylinder.

The mean effective pressure is determined from the known expression

$$p_e = \frac{0.0427\, H_H}{\alpha\, l_0} \eta_e \eta_V \gamma_B \quad \mathrm{KG/cm^2}$$

where H_H is the lowest heat-producing capacity of the fuel, kcal/kg; α is the coefficient of air excess; l_0 is the amount of air theoretically necessary for combustion of one kilogram of fuel, kg/kg fuel; η_e is the effective coefficient of useful operation of an engine; η_V is the coefficient of filling; γ_B is the air density, kg/m^3.

Thus, it is possible to increase p_e only at the expense of increasing the density of air going into the engine cylinder, because the other parameters are either constant (H_H, l_0) or may be changed only by an insignificant amount. So, for example, the effective coefficient of useful operation and the filling coefficient of the diesel can be increased only by a unit of percent. The coefficient of air excess α, although it remains much greater than unity in the diesel, especially in diesels with an inseparable combustion chamber, its decrease brings with it an increase of the engine heat intensity, impairing the process of fuel consumption, increasing the fraction of heat exiting into the cooling system, and as a result there is a decrease in the effective coefficient of useful engine operation. Thus, at the expense of decreasing α, we have not been successful in increasing the mean effective pressure.

The density of the air can be increased by compressing it first in a special compressor-supercharger, installed on the engine. The feed of air into the engine cylinders under pressure is called pressure charging.

The essence of pressure charging as a means of boosting the engine is included in the following. It is known that the amount of air filling a determined volume is proportional to the density. Filling the engine cylinders with compressed air would increase their capacity which provides the possibility of compressing more fuel in them after the cycle and accordingly obtaining more effective operation.

At the present time, pressure charging is being widely used as a means to boost the diesel. All this is not to exclude the modern tank engines equipped with superchargers, increasing the air pressure up to 1.5 - 3 ata. The effectiveness of pressure charging is seen from Table 2: the liter power of modern mass-produced tank Diesels amounts to 20 - 37 hp/l, and in experiments with the American engine Caterpillar LVMS-1050, it equalled 58.2 hp/l, while according to the data of the foreign press, the company assumed it would reach 80 - 100 hp/hr.

However, a series of new problems arose with the use of pressure charging. There was an increase in the pressure at the end of the compression stroke and in maximum pressure of the gasses in the cylinder, and along with this the load on the crankshaft mechanism increased. The compression of the of the air in the compressor was accompanied by an increase of its temperature, as a result of which the mean temperature of the cycle increased as did the heat intensity of the engine.

With a pressure charging of 1.5 - 2.0 ata on the majority of modern diesels, the maximum pressure and the temperature of the gases was comparatively small. At the same time, the inflexibility of operation, characteristic for a diesel, decreased as a rule, since with a pressure increase and an increase of air temperature at the end of the compression stroke, the combustion process was improved and the period of ignition lag decreased. Thus, such pressure charging does not bring with it the necessity of introducing essential changes in engine design.

With a pressure charging of 2.5 - 3.0 ata and higher, the heat and mechanical intensity of the engine increases, thus special measures are required to guarantee its efficiency.

The American Caterpillar firm was the first to use high pressure charging in tank diesels, cooling the air behind the compressor which lowered the temperature, accordingly decreased the heat intensity of the engine and increased the air density. As a result, engine power is greatly increased. So, for example, the LVDS-1100 Caterpillar engine without air cooling behind the compressor develops a liter power of 29.3 hp/l, and with cooling to 30° -- 35.8 hp/l.

Lowering the temperature of air entering into the cylinders is favorably reflected in a reduction in the amount of heat exiting into the cooling system, thanks to which it is possible to abbreviate the dimensions of the radiator and reduce the power expended in driving the fan. When increasing the pressure charging up to 2.5 - 3.0 ata, there is a significant increase in the gas pressure. The pressure is increased especially strongly in modern multi-fuel engines having a high degree of compression. Calculations have shown that with pressure charging of 3 ata and air cooling behind the pressure to 30°, the pressure at the end of combustion with a compression degree of 20.5 must reach a minimum of 180 - 200 ata.

Since a high degree of compression is necessary mainly to start the multi-fuel engine and to decrease the inflexibility of its operation to low loads, and to normal operation with correspondingly large loads, it is not optimum in engines with high pressure charging to use pistons which special design, with the aid of which the maximum pressure of the gases is limited to a given value, and moreover the degree of compression is automatically changed depending on load.

Figure 52 shows the constructional drawing of a piston which consists of an external glass 1 and an insertion piece 2 (more over the glass may be moved with relation to the insertion piece). In the chamber 3 between the glass and the insertion piece, the motor moves the oil out of the lubrication system through the return valve 7. The oil pressure in chamber 3 is limited by reduction valve 4. If the pressure of the gases exceeds the calculated one, part of the oil flows out of chamber 3 through the reduction valve and the glass is lowered; moreover, the volume of the compression chamber is increased and

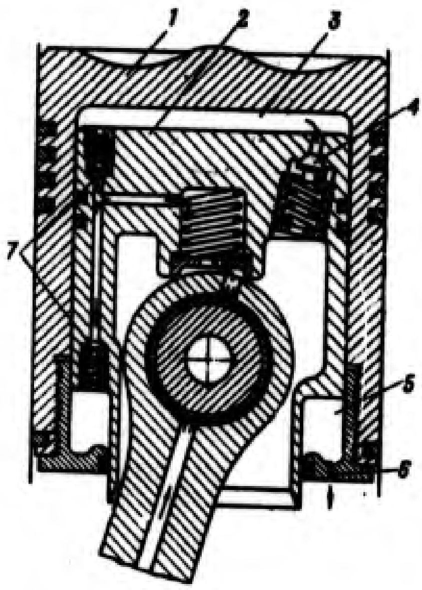


Fig. 52: Drawing of a piston guaranteeing automatic regulation of the degree of compression.

(1) - external glass; (2) - insertion piece; (3) - upper oil chamber; (4) - reduction valve; (5) - lower oil chamber; (6) - calibrated opening; (7) - return valve.

the degree of compression is reduced correspondingly. The limits for changing the degree of compression from 12 - 22 fully guarantee the range of possible loads. In order to limit the moving speed of the glass in the uppermost position, use is made of a lower chamber 5, also filled with oil. When the glass 1 moves upward, the volume of the chamber 5 is decreased, but the flow of oil from it is limited by the caliber of the opening 6, selected with such calculation that the glass has time to rise after the cycle not more than 0. 1 - 0. 2 mm.

Considerable power is expended to compress the air in the compressor. Even with a charging pressure of 1. 6 - 1. 7 ata, in the engine with a power of 700 - 750 hp, 100 - 120 hp is expended on the compressor. If the compressor is actuated directly by the crankshaft (driven compressor), this power put together with mechanical losses, noticeably decreases the mechanical and effective coefficients of useful engine operation; accordingly the specific fuel expenditure is increased by 3 - 5 percent. At the present time, driven superchargers are used comparatively rarely. They are used on the Engine two-stroke engine the Leiland L-60 and the Western German engine, the Daimler Benz.

On the majority of diesels, pressure charging is accomplished by the aggregates, called turbo-compressors. The turbo-compressor consists of a compressor and turbines connected by the main shaft. The exhaust gases, ejected by the engine cylinders, are directed to the turbine blades, turning the turbine and the compressor. Thus, we succeed in using the energy of the exhaust gases to drive the compressor and do not take away the power from the crankshaft. It is true that installing turbines somewhat increases the pressure in the exhaust manifold of the engine and increases the energy losses on the gases ejected from the cylinders in the starting stroke. But these losses are not large compared to the power generated by the turbine. Thanks to this fact, the specific fuel consumption in engines with turbo-compressors is always smaller than in engines without pressure charging or with engines having a driven compressor, and does not exceed 155 - 170 g/hp-h.

According to the disposition of the cylinders, modern four-stroke tank engines have a great deal in common. They are all double-rowed with a V-shape or opposite placement of the cylinders. The number of cylinders is from 8 to 12. The angle of inclination is equal to 60° in only two 12-cylinder engines (V-54 and Caterpillar LVMS-1050), and the rest (except for the opposite) is 90°.

In order to provide for uniform rotation of the power stroke, the angle of inclination γ must be equal in the four-stroke engines:

$$\gamma = 720^\circ / i \quad \text{or} \quad \gamma = 720^\circ / i \; (1 + 2m),$$

where i is the number of engine cylinders, and m is any whole number. So, for example, for a 12-cylinder engine the angle γ must be equal to 60° of 180°, for an 8-cylinder engine 90°, for a 10-cylinder engine 72°. However, the angle of inclination must be selected with consideration of the balancing the force of inertia reciprocally between the mass of the crankshaft mechanism and their moments.

In the 12-cylinder engine, these forces and moments are mutually balanced in each 6-cylinder block, thus from the point of view of balancing, the cylinders can have any angle of inclination.

For engines with a number of cylinders less than 12, the best angle of inclination is 90° since in this case to counterbalance and forces of inertia of the first row and their moments, the most dangerous due to their size, is possible with counterweights disposed on the ends of the crankshaft.

For an 8-cylinder engine, an angle of inclination γ equal to 90° is optimum since it guarantees simultaneous uniformity of rotation of the power stroke and mutual equilibration of the forces of inertia of the second row and their moments.

When selecting the angle of inclination, it is very important to consider the order of design suitable for disposing the engine aggregates, the necessity for reducing its height, etc. In the 12-cylinder Continental engine, the 90° angle of inclination is selected just for design considerations, which makes it possible to place the fans of the cooling system in the space between the cylinders.

The Western German Daimler-Benz engine (Fig. 53) has an unusual number of cylinders (ten). Probably this is due to the tendency to decrease the length of the engine with considerable displacement (37. 4 l).

A horizontal opposite-lying disposition of the cylinders is expedient in those cases when it is necessary to obtain the lowest engine height. With such a disposition of the cylinders, the engine height is determined by the

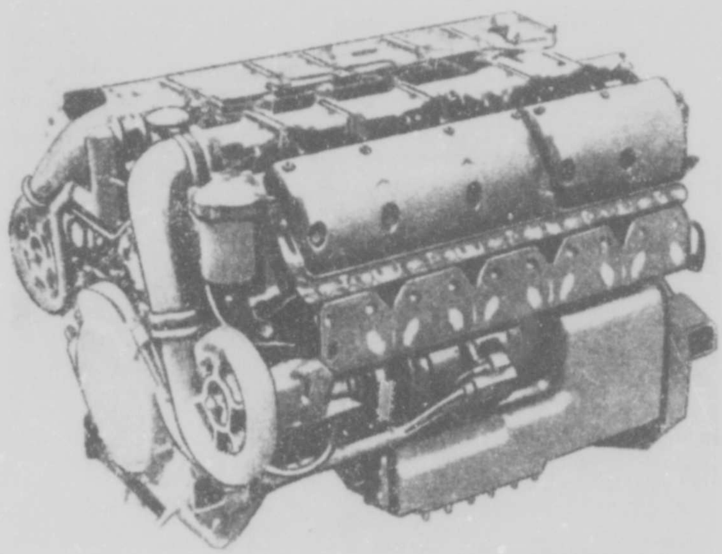


Fig. 53: Daimler-Benz engine MB 838 Ca-500.

height of its crankcase or the diameter of the flywheel. However, in this case the overall volume of the engine remains large since all the engine aggregates turn out to be on the outside in the sense that they cannot be entered into the overall dimensions of the engine itself, as with the V-disposition of cylinders.

Attempts to use other designs for arranging the cylinders (X-shaped or N-shaped, etc.) were not successful, since not giving any noticeable overall dimensions preference, they greatly complicated the problem of disposing the aggregates and access to them.

The design of the experimental tank engine Caterpillar LVMS-1050 is of interest, the external view of which is shown in Figure 54, and the crankcase unit and the crankshaft on Figure 55. The crankcase unit is cast of aluminum alloys. Between the block and the head there is a steel plate, providing sealing of the gas joint. The suspension of the crank bearings rests on inclined planes of the crankcase partition, which guarantees their reliable fixation. The crankshaft is distinguished by the absence of a flange: the main and connecting rod journals, developed according to diameter, somewhat overlap each other; the sufficient stability and rigidity of the shaft is provided for only by the overlapping of the journals. This simplifies the design of the shaft and makes it possible to dispose along two single connecting rods on each connecting rod journal.

The universality of the engine design deserves attention. It is possible to select the power from either end of the crankshaft. The turbo-compressors (both of them) can be installed on either side of the cylinder blocks. The system of driving the auxiliary aggregates has four consequences and makes it possible to place the aggregates in any convenient place. Each conclusion is calculated with a selection of power of 75 hp.

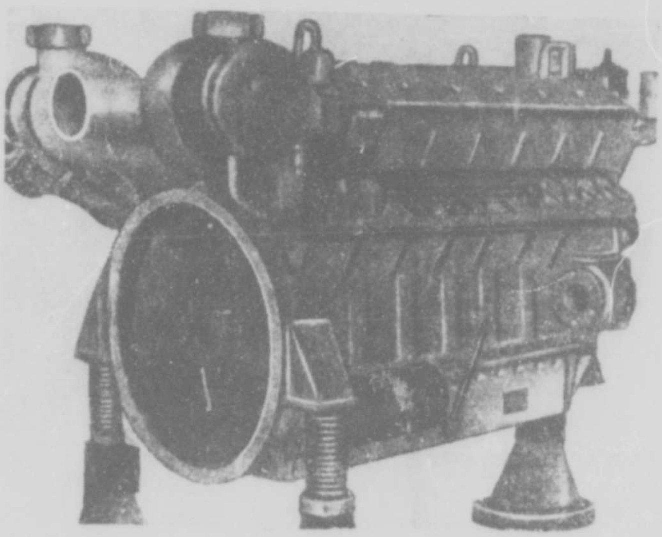


Fig. 54: LVMS-1050 Caterpillar engine.

In the series of engines created with a power from 250 - 1000 hp, including 4 and 6 cylinder, single row and 8 - 12 cylinder V-shaped engines, about 90 percent are interchangeable components.

The engine is designed to operate with diesel fuel as well as on gasoline with an octane number of 83 - 91. A special automatic device installed on the engine frees it from the necessity of any adjustment of the fuel feed system with transition from one type ot fuel to another. The fuel pumps are individual for each cylinder.

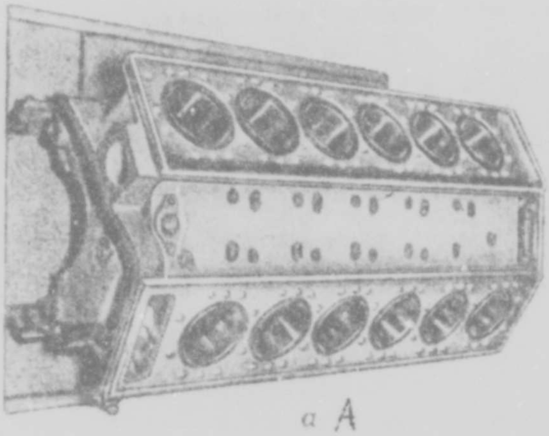
The two-stroke engine installed on the English tank "Chieftan" and on the Swedish tank "S", is executed according to a similar scheme. This is single-row 6-cylinder engine with two opposite-lying moving pistons in each cylinder. The cylinders are disposed vertically.

Figure 56 shows a transverse cross section of the English engine Leiland L-60. Each piston of one cylinder is connected to its own crankshaft; both crankshafts are connected with power takeoff shaft with a gear reducer. The power takeoff shaft rotates somewhat more rapidly than the crankshaft. Diverging in the expansion stroke, the pistons open an exhaust and a blow-through window at the end of the stroke; the blow-through process takes place during which the cylinder is cleared of exhaust gases and filled with fresh air.

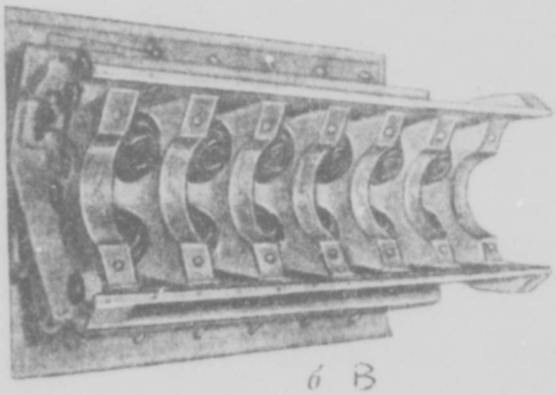
A blow-through, double-rotor compressor of the volumetric type is installed on the engine maintaining the pressure in the reserve in front of the blow-through windows at a level of 1.4 ata. The combustion chamber is formed between the piston heads when they approach one another. The fuel is injected into the cylinders through four jets stiuated in the middle part of the cylinder.

In the opinion of foreign specialists, such a scheme of a two-stroke engine has a series of advantages and has great prospects. The location of the exhaust and the blow-through windows on the opposite-lying ends of the cylinders (so-called direct-flow blowing through) makes it possible to successfully solve one of the most difficult problems for a two-stroke engine -- to provide thorough cleaning of the cylinder from the exhaust gases with a small coefficient of surplus blow-through air. The position of the combustion chamber between the pistons reduces the cooling surface of the cylinder, thanks to which the amount of heat conducted into the cooling system is reduced, which, in turn, makes it possible to reduce the dimensions of the water radiator and the amount of cooling air. Thus, in engines made according to such a scheme, the fraction of heat conducted into the cooling system is less than in four-stroke engines, despite the higher medium temperature of the cycle.

A shortcoming of the scheme is that it is necessary to have two crank-shafts connected with the reducing gear, and correspondingly two crankcases



a A



б B

в C

Fig. 55: Components of the LVMS-1050 engine. (a) - crankcase unit (upper view); (b) - crankcase unit (lower view); (c) - crankshaft.

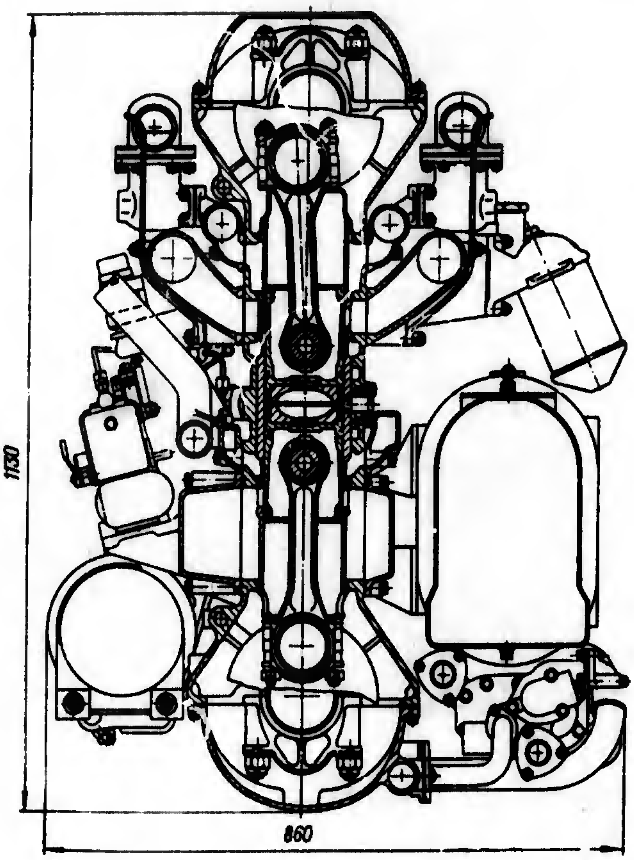


Fig. 56: Transverse cross section of the Leiland L-60 engine.

which makes the engine unwieldy and heavy. This very fact explaines the comparatively small value of the coefficient of compactness -- 13.5 l/m^3 and the overall power -- 498 hp/l (at a high liter power 36.8 hp/l) and the sufficiently high specific weight of this engine -- 2.02 kg/hp.

The general shortcoming of two-stroke engines, from which the Leiland engine has not escaped, is the high head intensity of the pistons. In order to guarantee the efficiency of the piston component, it is necessary to take special measures. Even if it is cooled with oil, the conventional piston of aluminum alloy is unsuitable. The piston of the Leiland engine is a combination one (Fig. 57); it is made of an aluminum alloy, and to its head is fastened a cover plate 2 made of heat-resistant steel. The upper compression ring 4 is protected from hot gases with a continuous heat ring 3, also made of heat-resistant steel. The oil arriving along the channel in the shaft of the connecting rod goes down continuously into the bottom of the piston.

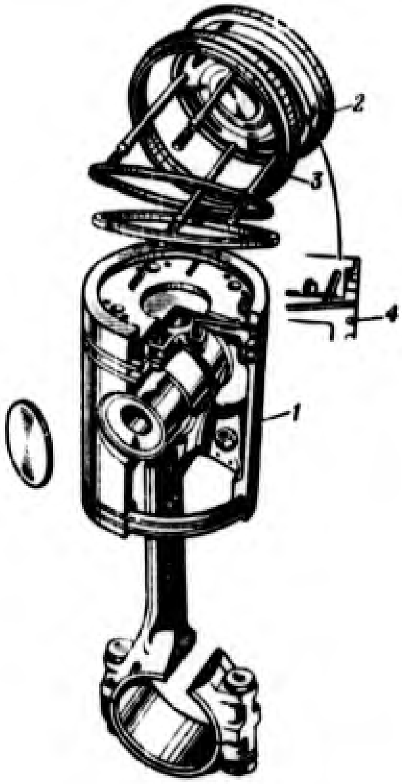


Fig. 57: Piston of the Leiland L-60 engine.
(1) - piston; (2) - cover plate; (3) - heat ring; (4) - upper compression ring.

Prospects for Using Gas Turbine Engines in Tanks

The gas turbine engine, just as the piston engine, refers to internal combustion engines, but unlike the piston engine, all the processes in it are divided territorially and take place continuously; air is drawn in and compressed in the compressor, the fuel is burned in the combustion chamber, the combustion products are expanded in the turbine. The rotors of the compressor and of the turbines effect only a rotary motion; there is no reciprocating mass in the engine and, consequently, the force of inertia is exerted on the shaft bearings. All this permits the gas turbine engine (in comparison with the piston engine) to develop more revolutions since they are limited only by the stability of disks and blades of the compressor and turbines. The greater speeds open the potential possibility of creating an engine with a higher overall power. This circumstance makes the gas turbine engine extremely prospective for tanks where the small scale of the engine has great value.

The experience of creating avaiation gas turbine engines shows that their overall power may reach 3000-4000 hp/m^3. Constructionally, the gas turbine engine is simpler than the piston engine and much lighter. In addition, as was pointed out earlier, it is easier to start at low temperature without preheating and does not require extended initial heating; about 3 - 4 minutes after starting, it is ready to assume any load. This is very important for a tank as well as for a combat vehicle. The characteristics of the double-shaft gas turbine engine make it possible to get by with a much smaller transmission, to simplify the transmission and make it easier to control the vehicle. The much simpler cooling system of the gas turbine engine requires less expenditure of power.

However, at the present time it is considered that the gas turbine engine cannot compete with the diesel. Its basic shortcoming is a low coefficient of efficiency and accordingly a high specific fuel consumption; a vehicle with a gas turbine engine without a heat exchanger consumes one and one-half to two times as much fuel over a distance of 100 km as the vehicle with a diesel engine.

Among the other shortcomings of the gas turbeine engine making its use difficult in the tank, it is necessary to take note: the many-times greater expenditure of air and hence the difficulties involving cleaning the air of dust and feeding air to the engine when moving under water; the considerably lower pickup compared to the piston engine which makes the vehicle less maneuverable and essentially reduces the average moving speed over broken terrain; the impossibility of braking the vehicle with the engine (without special equipment), which also makes driving more complicated. It is necessary to point out the strong dependence of gas turbine engine power on temperature and the presence of the ambient air, on resistance to the entry of air into the compressor and on the exist of exhaust gases from the turbine.

The low economy of the gas turbine engine involves the necessity of limiting the temperature of the gasses arriving at the turbine blades due to the difficulty of cooling them effectively; in modern engines it does not exceed 900 - 950°C. The temperature is limited at the expense of increasing the coefficient of excess air which in gas turbine engines is two-four times greater than in piston engines, and this increases the consumption of air and the expenditure of power when compressing it in the compressor; the power, consumed by the compressor amounts to 150 - 200 percent of the effective power of the gas turbine engine.

It is possible to increase the economy of the gas turbine engine in two ways. The first way is to increase the temperature of the gases in front of the turbine. But this requires sufficiently effective cooling of the turbine blades, which is difficult to achieve due to their small dimensions, or making the blades of a new, more heat-resistant material which also presents a very difficult problem. The second way is to use heat exchangers in which part of the heat of the exhaust gases is directed through the combustion chamber into the air. Due to this, the quantity of fuel is reduced which must be burned in the combustion chamber in order to heat the gases to the required temperature. This way is easier and all modern gas engines of the transport type are equipped with heat exchangers. The installation of a heat exchanger with a degree of heat exchange of 0.8 - 0.85 * at a temperature in front of the turbine of 900 - 950°C reduces the specific fuel consumption to 200 - 220 g/hp-h. However, the gas turbine engine also loses its basic advantage; its overall power is reduced down to 350 - 450 hp/m^3.

Work in creating a tank gas turbine engine is presently being carried out in many countries. In the United States of America, this work was carried on parallel by three companies: Ford, Solar and Orenda (Canadian). All the companies worked out a design for a gas turbine engine with a power of 600 hp, with a heat exchanger.

Table 3 presents the projected data of these engines. Judging by them we have not obtained bad economic indicators, but according to the overall indicators, the planned engines do not have advantages over the diesel. It should be pointed out that published economic indicators must be approached cautiously, because up to now there is no information concerning confirmation of projected data from experiments, however, it is known that the Defense Department of the USA cut off fudning of this work and reviewed the tactical-technical requirements for a tank-gas turbine engine.

Nevertheless, the plans developed by the companies listed above are of interest. The low specific fuel consumption deserves interest, which is

(*) The degree of heat exchange σ is called the ratio of effective increase of air temperature in the heat exchanger to that which is theoretically possible (up to the temperature of the exhaust gases). It is characterized by the use of heat of the exhaust gases. So, for example, if the temperature of the gases behind the turbine is t_B = 700°C, and the air temperature in the heat exchanger exceeds t_c = 300°C (with which it exits from the compressor) up to t_r = 600°C, then

TABLE 3: Basic inducators of gas turbine engines.

Parameters	USSR	USA					Canada	England		France	Switzerland
Engine Make	NAMI 053A1	Boeing 502-10MA	General Motors T-503	Ford L-704	Ford -705	Solar T-600	Orenda OT-4	Rover T-6	Parsons	Turbomeka Artust 600	Volvo DRGT-1
Designation	automobile	automobile	automobile	automobile	transport	transport	transport	auto-mobile	trans-port	auto-mobile	trans-port
Maximum power. hp	350	330	225	300	600	630	600	120	1000	450	250
Specific fuel consumption, g/hp-h	500	417	250	254[2]	217[3]	182[4]	182[5]	300	410	470	180
Maximum temperature of the gases, °C	850	900	870	930	954	871	945	870	800	820	850
Air consumption, kg/sec	—	—	—	1,22	2	3,85	2,95	0,9	—	3,25	1,31
Degree of increasing the compressor pressure	3,5	4,8	3,5	16	4,16	3,8	4	3,5	4	3,6	4,25
Heat exchanger	—	—	rotating	rotating	stationary	stationary	rotating	—	—	—	rotating
Degree of heat exchange	—	—	0,8	0,8—0,9	—	0,8	0,89	—	—	—	0,85
Engine weight, kg	550	152	270	295	545	680	635	136	422	133	370
Specific engine weight, kg/hp	1,57	0,47	0,75	1,02	0,985	0,91	1,14	0,313	—	0,296	1,48
Overall dimensions. mm:											
length	1630	1070	940	970	1244	—	—	865	—	1170	1300
weight	690	610	610	712	1118	—	—	572	—	533	670
height	710	610	670	740	965	—	—	610	—	435	760
Overall volume, m^3	0,71	0,398	0,384	0,51	1,36	1,69	1,41	0,305	—	0,272	0,758
Overall power, hp/m^3	493	830	596	588	440	355	425	393	—	1655	330

1. 15,000 km on an autobus ZIL-127
2. In normal operation 0.5N_{max} fuel consumption 218 g/hp-h
3. In normal operation 0.4N_{max} fuel consumption 182 g/hp-h
4. In normal operation 0.4N_{max} fuel consumption 198 g/hp-h
5. In normal operation 0.4N_{max} fuel consumption 217 h/hp-h

obtained for all three engines and the fact that the same fuel consumption is obtained in the Solar and Orenda engines at lower values of the gas temperature in front of the turbine and the degree of heat exchange. Obviously, this is connected with a difference in the coefficient of efficiency of the compressor and the turbines and also in the pressure losses along the gas-air circuits, which has great influence on the economy of the engine. Judging by its overall power, the Solar engine is less compact than the Orenda engine, which causes the much lower gas temperatures and accordingly a higher expenditure of air.

The Ford Company used the three-shaft scheme for the Ford-705 engine, tested the engine in the automobile variation Ford-704 with a power of 300 hp. The engine has two turbocompressors and a separate power turbine, two combustion chambers, a heat exchanger and an intermediate cooler for cooling the air in front of the second compressor. This makes it possible to greatly increase the degree the pressure is raised (in this engine it equals 16, and in the conventional double-shaft 4 - 6) and to increase the temperature of the gases in front of the power turbine at the expense of fuel burned in the additional combustion chamber. The degree the pressure is raised in this engine is selected higher than optimum for maximum power operation, thus the fuel consumption in this operation is higher than with the Solar and Orenda engines. On the other hand, on operations with an incomplete load where it is necessary for the engine to operate a large part of the time, consumption is reduced to 182 g/hp-h in operation 0.4 from the maximum power against 198 and 217 g/hp-h for the Solar and Orenda engines. Such an engine characteristic according to specific consumption puts it close to piston engines.

A drawing of the Ford-705 engine is given in Figure 58. The atmospheric air goes into the low-pressure compressor of the centrifugal type where it is compressed to 4 ata. Before entering the high pressure compressor, the air goes through an intermediate cooler in which it is cooled with a flow of air created by special fans. The intermediate air cooler at constant pressure reduces its volume, thanks to which the dimensions of the high-pressure compressor are reduced as well as the power expended in driving it. From the cooler, the air is directed into a high-pressure compressor of the centrifugal type where it is compressed to 16 ata, and through a heat exchanger it arrives in the compression chamber where the temperature of the gases is increased to 954°C. From the chamber, the gases arrive at the blades of the high-pressure centripetal turbine connected with the high-pressure compressor. Passing through this turbine, the gases arrive at the supplementary combustion chamber in which their temperature is again raised, and subsequently they pass through the axial power turbine, a low-pressure axial turbine connected with a low-pressure compressor and a heat exchanger, after which they are ejected into the atmosphere.

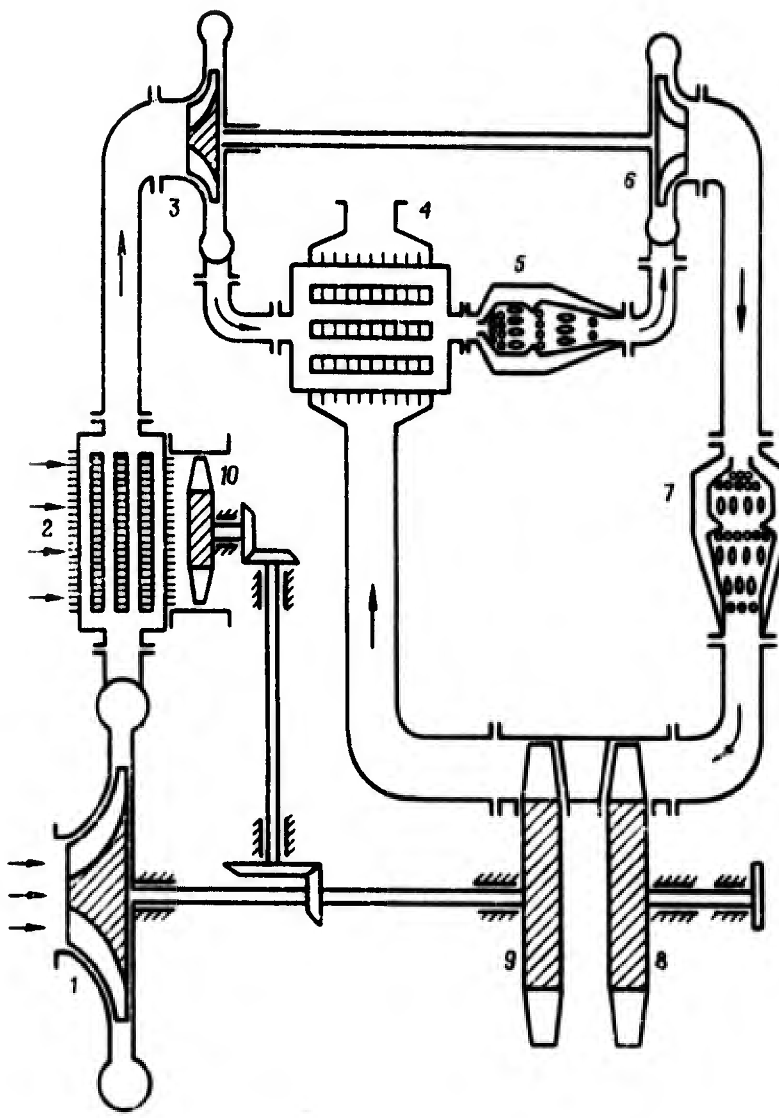


Fig. 58: Drawing of a triple-shaft gas gurbine Ford-705 engine: (1) - low-pressure compressor; (2) - intermediate cooler; (3) - high-pressure compressor; (4) - heat exchanger; (5) - combustion chamber; (6) high-pressure turbine; (7) - additional combustion chamber; (8) power turbine; (9) - low-pressure turbine; (10) - fan of the intermediate cooler.

The air consumption in this engine is relatively small -- 2 kg/sec, which is much lower than in the double-shaft Solar and Orenda engines (but also much greater than in the diesel of the same power). However, despite the small air consumption and the small dimensions of the operating wheels of the compressors and the turbines, due to the complexity of construction (Fig. 59) and the large number of aggregates, the resultant engine is unwieldy and has an overall power of 440 hp/m^3 (the same as with the V-54 diesel without pressure charging). From this, it is seen that the complicated scheme of the gas turbine engine does not always result in a gain factor in overall dimensions.

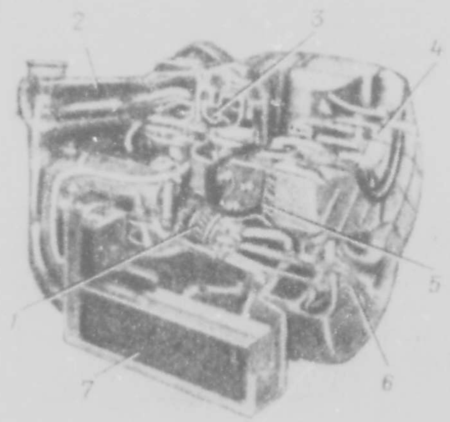


Fig. 59: Ford-705 triple-shaft gas turbine engine.
(1) - power turbine; (2) combustion chamber; (3) - high pressure compressor; (4) - fan; (5) - intermediate cooler; (6) - low pressure compressor; (7) - heat exchanger.

The power unit of the Swedish tank "S" (Fig. 60) consists of a gas turbine engine Volvo-DRGT-1 and a two-stroke Rolls-Royce diesel. Both engines have almost the same power; the diesel develops 240 hp and the gas turbine engine develops 250 hp. The engines can operate together or separately. According to overall dimensions, this unit yields to the conventional one with one engine, but it is rational to use the power of each engine as little as possible. Statistics show that the tank engine operates a long time with 60 - 70 percent maximum power which neither of the "S" tank engines can guarantee.

The Swedish gas turbine engine Volvo-DRGT-1 is of interest due to

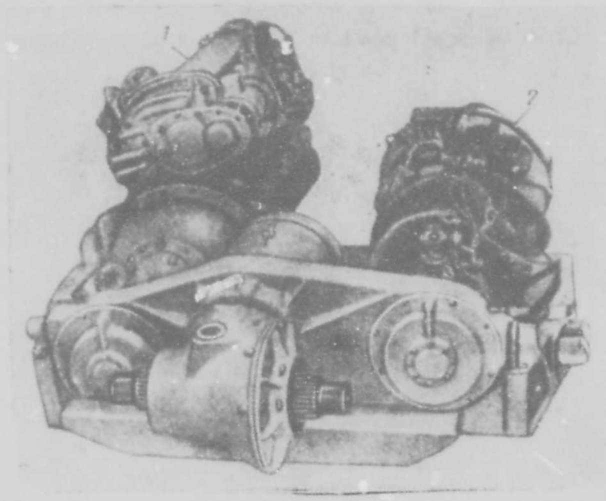


Fig. 60: Power unit of the Swedish tank "S".
(1) - piston engine; (2) - gas turbine engine.

the fact that between the two phases of its power turbine there is a differential gear and pinion, thanks to which the torque changes more rapidly with a change of shaft revolutions at the selected power than is the case with the conventional double-shaft engine. The engine is equipped with a hydro-brake in order to increase the braking moment. The engine is equipped with a revolving heat exchanger with a high degree of heat exchange (0.85) and with a comparatively low temperature of the gases in front of the turbine there is a good specific fuel consumption (180 g/hp-h). The overall power of the engine is small (330 hp/m^3) and is at a level of the piston automobile engines.

Prospects for Changes in Tank Rotary Engines

According to the data of the foreign press, at the present time designers are still being attracted to one type of engine -- the rotary engine. There are a large number of plans for engines in which the reciprocating pistons are being replaced with the rotating movement of the rotor, performing the role of the piston. One of the most real plans is the plan of the German engineer Wankel who proposes replacing the piston with a triangular rotor effecting a planetary rotation in the housing, the working surface of which is shaped like epitrochoids.

It is seen from the drawing (Fig. 61) that the volume included between the two adjacent tops of the rotor, moving together with them when the rotor rotates along the working surface of the housing and after each revolution of the rotor is doubled or cut in half. This makes it possible to complete a four-stroke cycle as in the conventional piston engine not having a reciprocating mass.

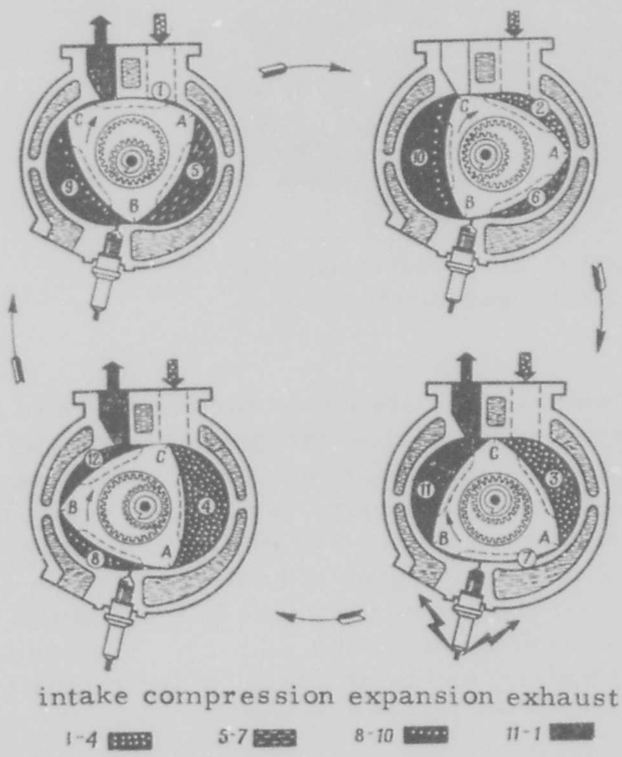


Fig. 61: Drawing of how the rotary engine works.

Developed initially as a gasoline engine with spark ignition, the Wankel has a series of advantages over the piston engine. The absence of a reciprocating mass makes it possible to substantially increase the shaft rotation. In spite of this, the filling coefficient remains high, thanks to which the flow of fresh charge into the intake window is practically continuous because of the reciprocal overlapping of the filling periods of the individual volumes. The absence of valves simplifies engine design and guarantees detonationless combustion of the gasoline at significantly higher degrees of compression than in piston engines with spark ignition.

Made of metal, the rotor engines have high liter and overall power and a specific fuel consumption which is small for a gasoline engine. The compactness and economy of rotary engines has aroused great interest in them in many countries. But, since gasoline engines are not suitable for tanks, attempts have been begun to use the rotary engine to realize a cycle in them with ignition due to compression. Great difficulties are encountered here. First, in rotary engines it is difficult to achieve a sufficiently high degree of compression in order to have the possibility of giving the combustion chamber the required shape. Secondly, due to the high pressure of the cycle with ignition from compression, the difficulty arises of guaranteeing reliable sealing of the space between the rotor tops and in the work of the bearings on which enormous gas pressure forces act as well as centrifugal forces from the rotating mass.

Up to the present time, there has been no word in the press as to where the design of a rotary diesel has been worked out, although there has been word that such work is being carried out. Up to the present time, insufficient data have been accumulated in order to make a definite judgment concerning the prospects for rotary engines in tanks, but work on them will no doubt arouse interest.

Power Unit of the Tank

Just as with the engine, the basic requirement for the power unit of a tank is compactness; of the other requirements we should note reliability, the smallest possible working volume for servicing, good access to the aggregates, simplicity of mounting and demounting during repair.

The compactness of the power unit depends on the dimensions of its aggregates (radiators, fans, oil tank, air cleaner, etc.), as well as on mutual disposition. For a series of foreign tanks, it is characteristic at the present time to group the aggregates of the cooling and lubrication system in one unit with the engine. So the power unit of the American M-60 tank is equipped with a Continental AVDS-1790-2 air-cooled engine. In the English tank "Chieftan", the radiators and fans of the cooling system are combined in one unit with the engine.

Figure 62 shows the L-60 Leiland engine of this tank with normal position of the radiators and with the radiators raised in order to provide access to the engine. Such a combination provides an important convenience: the turbopipes connecting the engine with the radiator and the oil tank turn out to be shorter; a lower degree of engine vibration is transmitted on them compared to the tank body. The unit may be assembled beforehand outside the vehicle body which makes work much easier and shortens the time for installing the power unit in the tank.

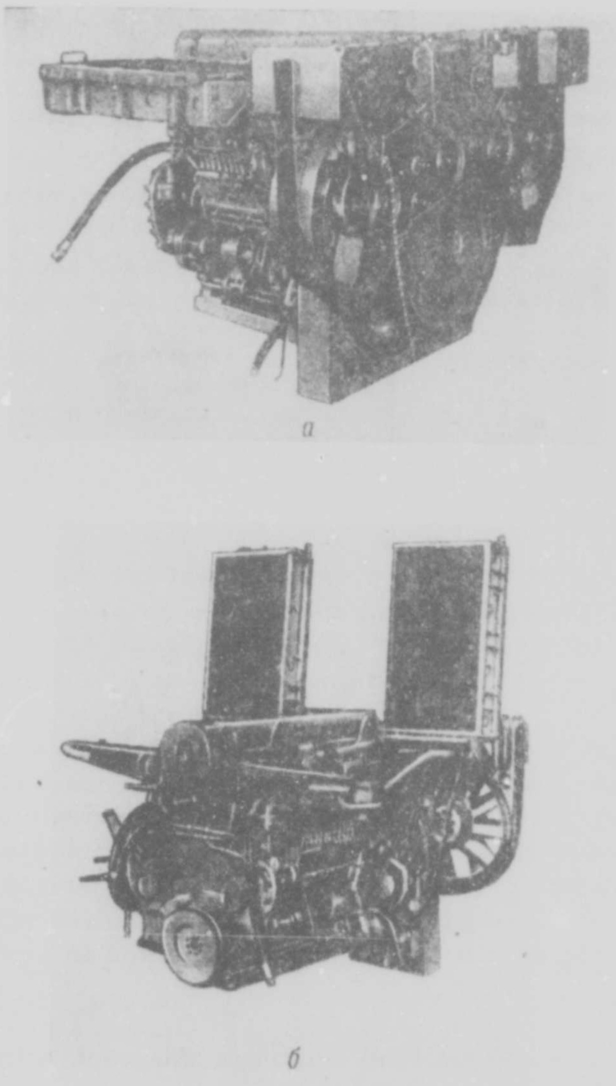


Fig. 62: Leiland L-60 engine in one unit with the cooling system. (a) - radiator in normal position; (b) - radiator raised.

The dimensions of the radiators and fans of the cooling system depend on the amount of heat discharged from the engine and on the temperature drop between the coolant and the air. The relative amount of heat discharged into the cooling system is determined by the heat intensity of the engine, the design of the combustion chamber (diesels with an inseparable chamber or with a chamber in the piston have the least heat discharge), as well as the temperature of the coolant.

For tanks with a closed-type cooling system, it is possible to greatly increase the temperature of the coolant without damaging the engine. Modern tank engines can operate at a coolant temperature of 115 - 125°C, which makes it possible to essentially reduce the dimensions of the radiators and fan, and lower the power expended in driving the fan.

The ejection cooling system is the most effective in which a flow of cooling air is created through the radiator at the expense of using the energy of the exhaust gases. The ejection system has a series of advantages over the fan system: it design is simpler, there are no moving parts connected with the engine crankshaft, which expands the combination possibilities, making it possible to isolate the air circuit and provides the possibility of cooling the engine when moving under water by sealing the radiators, and also decreases the dusting up of the power unit and essentially decreases the temperature of the exhaust gases and, consequently, decreases the heat emission of the tank body.

When boosting the engine, the load on the lubrication system is greatly increased since there is an increase in the quantity of heat discharged with the oil from the bearings and the piston. In addition, it is necessary to increase the output of the oil pump, the permeability of the filter and the cooling surfaces of the oil radiator. Keeping the increased flow of oil clean presents great difficulties.

Of the great number of different filters, the most promising one is the coefficient of cleaning, invariable resistance, not dependent on the degree of its dirt content, and the capability of working for an extended period without maintenance.

The starting system of the engine must guarantee reliable starting under any atmospheric conditions. To accomplish this, it must primarily have sufficient power. In connection with this, the use of an electro-starter in the tank in the capacity of a starting mechanism (with an increase in engine power) causes great difficulties due to the limited capacity of the batteries. Auxiliary aggregates with automatic internal combustion engines are used most often in tanks which provide charging of the batteries and feeding of all electro-energy consumers when the basic engine does not operate, and also warming up of the basic engine before starting.

To start the engine, it is more expedient to use compressed air, conducting it directly into the engine cylinders to using special pneumatic or hydrostarters. In this case, a compressor is necessary to supplement the supply of compressed air.

Great difficulties arise in starting the diesel during winter. The solution of this problem involves many factors, the main ones being ignitability of the fuel and the viscosity of the oil. Reliable ignition of the fuel can be guaranteed by increasing the starting rotations of the engine, but this is made difficult due to the high viscosity of the oil at low temperature. The creation of lubricating oil with declining viscosity characteristics to a large degree reduces the complexity of this problem. It is necessary to shorten the time for warming up the engine, since the possibility emerges of loading the engine at a lower oil temperature.

Up to the present time, there is no such oil which is the sole means of heating the engine before starting in winter time. The shortcoming of the spray preheaters used at the present time in all positive qualities is their dependence on the electro-energy source -- the batteries. The most promising is the preheater with the automatic engine which may combine two functions: warming up of the engine and charging the batteries. The gas turbine is very suitable in the capacity of an engine for such an aggregate. The most simple single-shaft engine may be made with small dimensions and light, since in the given case the coefficient of efficiency of an engine does not play an essential role; then, the head which is not converted into useful work will be used to heat up the basic engine.

Par. 2: Tank Transmission

The tank transmission must provide for a high degree of tractive quality when moving in an straight line or when turning, good reliability during an extended period of use, ease of driving, high efficiency, low weight and especially small overall dimensions of the aggregates, low production cost, convenience of maintenance and repair under field conditions.

These requirements are most fully satisfied with a mechanical and hydromechanical transmission which is used on modern tanks. Also in tanks they are beginning to use hydrovolumetric transmissions.

As far as electromechanical transmissions are concerned, used on transport vehicles and providing for automatic change of speed depending on resistance to movement and ease of driving, they are unsuitable for tanks mainly because of their overall dimensions and their weight.

Mechanical transmissions continue to be used on Soviet, English and French tanks. They are characterized by a high degree of efficiency, compactness and reliability, comparatively cheap production costs, and simplicity of mounting. Their main shortcoming is a multistage change of the gear ratio which leads to some of the engine power not being used and reduces the mean moving speed. In addition, engine operation is unfavorable under such transmission conditions, since the load on it is continuously changing.

The mechanical transmissions of modern tanks are being developed in the following directions: using the synchronizers or the individual friction connection in simple gear boxes, replacing the simple box with planetary ones, transition to a friction clutch and brake, operating in oil, use of servo-drives, use of shock absorbers with torsional vibrations of the engine and compensating mechanisms in the caterpillar running gear to increase reliability.

Transmission and turning mechanisms have received widespread use in mechanical transmissions (MPP), connecting the main clutch, the gear box and the turning mechanisms in a general crankcase with double power supply which makes it possible to improve the agility of the tank at the expense of guaranteeing a large number of calculated turning radii without the loss of engine power due to friction in the clutches or in the brakes of the turning mechanism.

The distinguishing feature of transmission and turning mechanisms is the presence of summation planetary rows in which the epicycles receive rotation from the engine through the gear box, and the sun gears through the supplementary transmission with constant gear ratios (Fig. 63). The gear ratios to the sun gear of the right and left sides are the same with straight-line travel and are different with turning. Due to this, provision is made for the change of moving speeds of the tracks and the tank turns. Since the rotations of the epicycles depend on the gear in the transmission, and the revolutions of the sun gears are the same in all gears (with unchanging engine rotation), then a calculated turning radius is obtained in each gear which is greater the higher the gear.

Further improvement of a transmission of this type may lead to a creation of transmission mechanisms and turning mechanisms with a continuous friction or hydrovolumetric gear in the auxiliary drive.

Such continuous gearing makes it possible to obtain any gear ratio from the engine to the sun gears, and thus guarantees infinite possibility of calculated radii with each shift. In other words, the tank turning mechanisms approaches the ideal according to its own parameters.

Hydromechanical transmissions (HMT), widely used in vehicles of the national economy in many countries of the world, are also used in a series of modern tanks. A complex hydraulic transmission is usually included in such a transmission which at low loads works as a hydroclutch, and with an increase in load automatically goes over to a working operation of a torque converter. The torque converter has the property of adapting to changes of external load: with an increase in resistance, the revolutions of the turbine wheel on the transformer decrease and the moment in it increases.

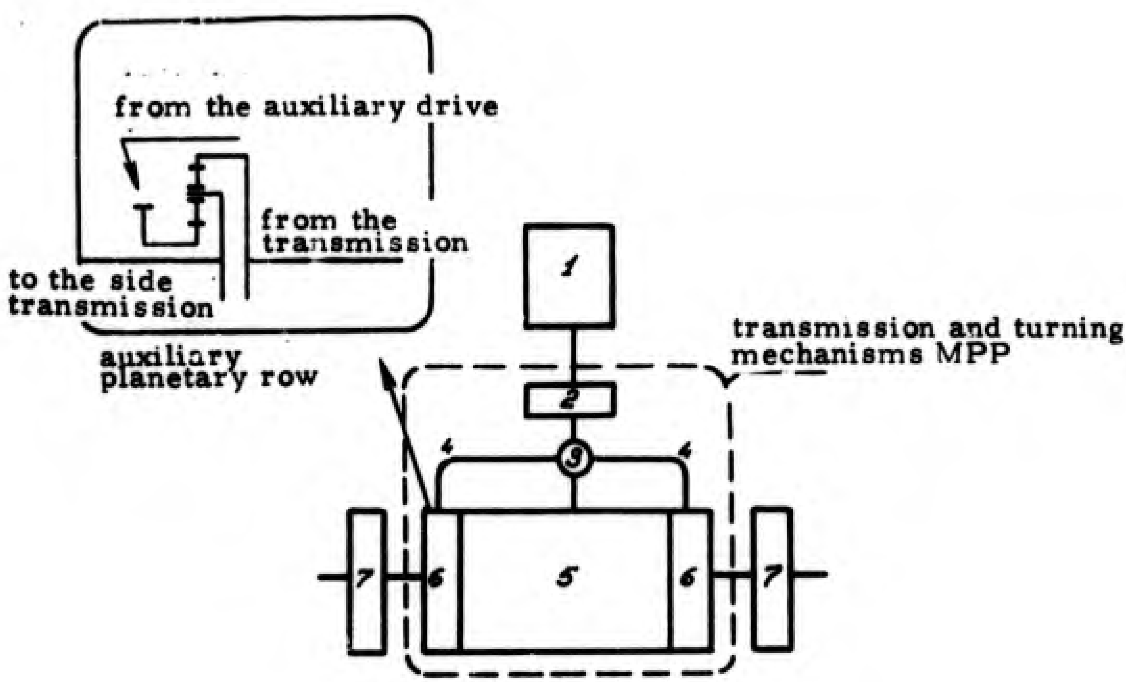


Fig. 63: Generalized drawing of the shifting and turning mechanism. (1) - engine; (2) - main friction clutch; (3) - shaft branching; (4) - auxiliary drive; (5) - gear box; (6) - summary planetary row; (7) - side transmission.

In other words, the transformer is a continuous gear box automatically regulating the necessary gear ratio between the engine and the driving wheel of the tank depending on the moving resistance. However, the range of automatic changes of the gear ratio with a complex hydraulic transmission in the case of an acceptable efficiency does not exceed 2 - 2.5, while to guarantee high dynamic qualities of a tank requires a range of not less than ten. Thus, together with a complex hydraulic transmission in the hydromechanical transmission, there must be a transmission in three or four stages connecting the reverse gear.

Thus, the following are characteristic for hydromechanical transmissions: continuous and automatic change of tractive effort on the tracks in the range of 2 - 2.5, in accordance with changes in resistance which increases the medium speed and makes driving the tank easier; a greater reliability of engine and transmission operation due to the elasticity of their connection (energy is transmitted through the liquid into the complex hydraulic transmission).

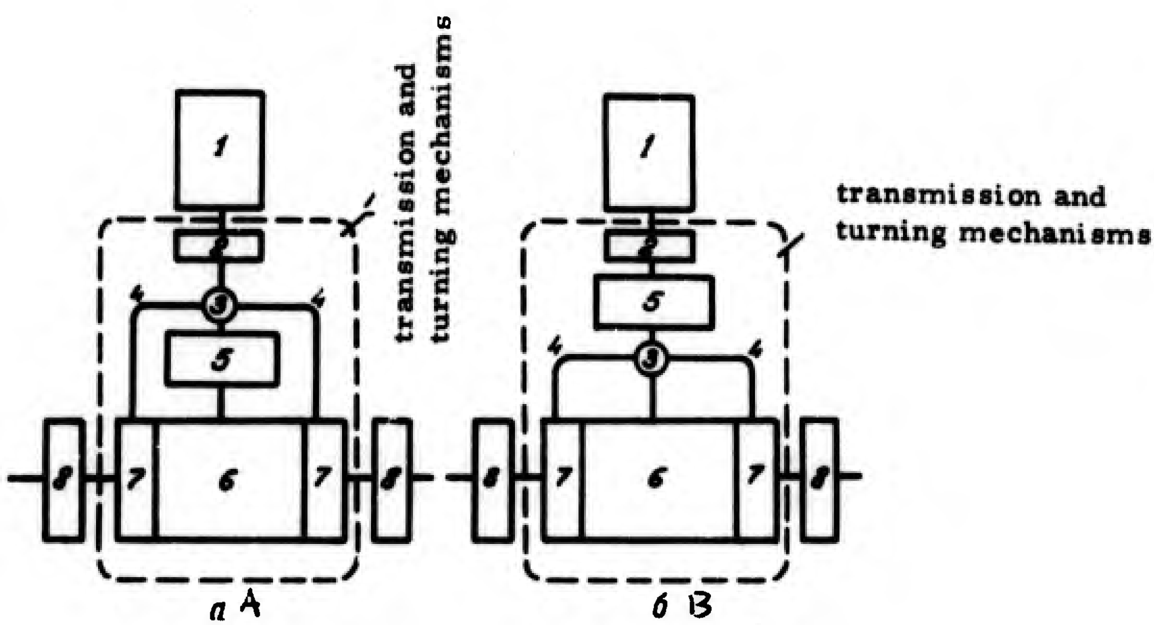


Fig. 64: Principal schemes of a hydromechanical transmission. (a) - parallel; (b) - successive; (1) - engine; (2) - inlet reduces; (3) - shaft branching; (4) - auxiliary drive; (5) - complex hydraulic transmission; (6) - mechanical transmission; (7) - summary rows; (8) - side transmissions.

In modern hydromechanical transmissions as well as in mechanical ones, wide use of transmission and turning mechanisms is made, including in the general crankcase a complex hydraulic transmission with input reducer, a mechanical stepped transmission, summary planetary rows, an auxiliary drive to the sun gears, friction clutches and brakes, necessary for driving in straight-ahead movement and when turning, i. e. all the transmission aggregates in addition to the side transmission.

On a series of vehicles, the crankcase of the transmission and turning mechanisms is solidly connected with the engine, presenting a single-unit design which simplifies the attachment of the power unit and transmission aggregates and their mutual centering.

The complex hydraulic transmission can be connected with the other transmission aggregates in parallel or successively. In the parallel scheme (Fig. 64, a), the power flow is branched along the complex hydraulic transmission, i. e., through it passes only a part of the engine power, and the other part goes to the summary rows along the mechanical branches. According to this scheme, the transmission is executed with the "Cross Drive" CD-850 of the American medium and heavy tanks. The full cinematic scheme of the CD-850-6 transmission on the M-60 tank is shown in Figure 65.

In the case of the successive scheme (Fig. 64, b) used on the American light tanks, all the engine power goes through the complex hydraulic transmission and is branched only after this. The successive scheme yields to the parallel one according to the value of general transmission efficiency. Efficiency is higher in the case of the parallel scheme, since only a part of the engine power passes through the hydraulic transmission.

Together with the advantages of the hydromechanical transmissions (in comparision with the mechanical ones), there are shortcomings, influencing the combat characteristics of the tank. In particular, the rated crusing range is reduced due to the large power losses with its passage through the hydroaggregate; composition difficulties arise in connection with increasing the overall transmission dimensions in which, together with the mechanical transmission (by three or four stages), the hydraulic transmission appears with its own cooling and maintenance systems; the production of the tank and its repair are made more complicated, especially under field conditions.

Hydrovolumetric transmissions have begun to be used on the past few years on transport vehicles and may turn out to be prospective for tanks in connection with the general success of hydro-machine construction, making it possible to create hydroaggregates operating under high pressure (200 - 300 kgs/cm^2) with an efficiency reaching 0. 75 - 0. 85.

Every volumetric hydraulic transmission consists of a hydropump and a hydromotor (Fig. 66). The energy in these hydromachines is transmitted by means of a static pressure head or, in other words, by the pressure of the liquid. The higher the pressure, the more compact the aggregate, but the more

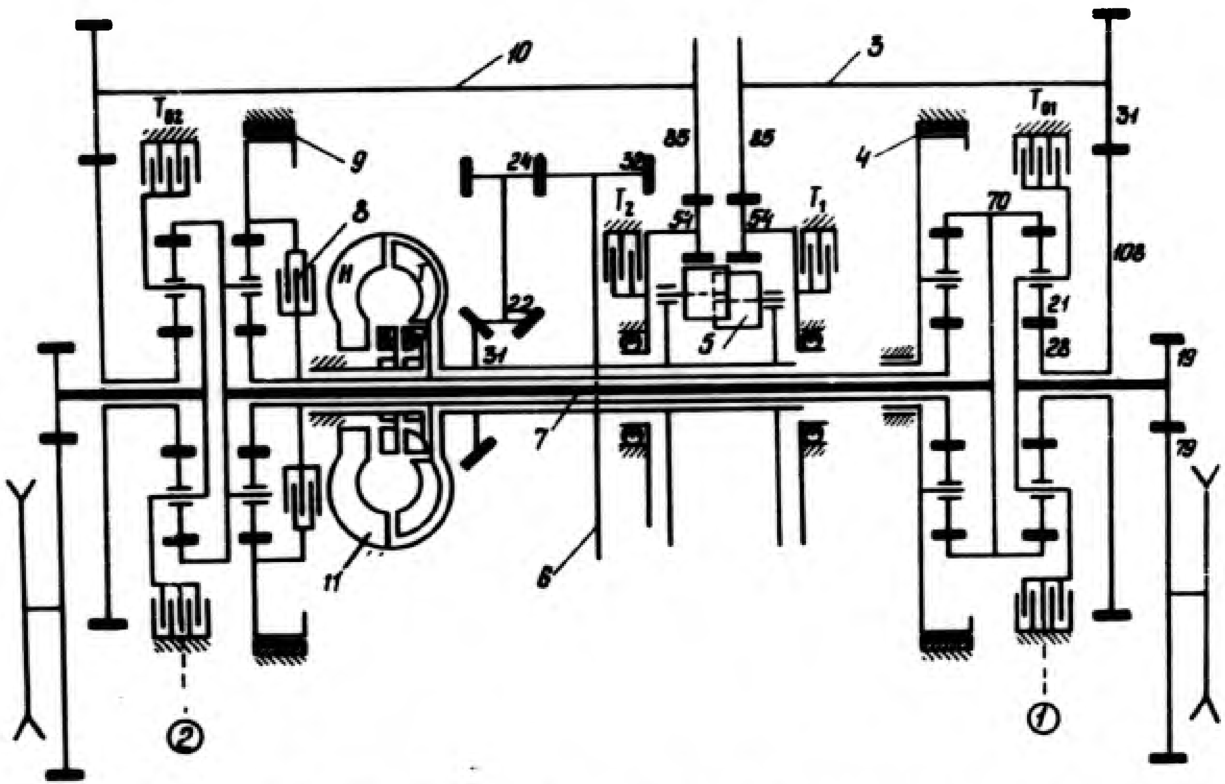


Fig. 65: Cinematic scheme of the CD-850-6 "Cross Drive" Transmission. (1), (2) - disk stopping trakes; (3), (10) - drive to the sun gears of the summary rows, (4), (9) - band brakes, (5) cylindrical differential, (6) - shaft connected to the engine, (7) - shaft of the epicycles, (8) - blocked friction clutch, (11) - complex hydraulic transmission

difficult it is to achieve sealing. The pump is made so that it is possible to regulate its output and to alternate in certain places with a suction and a pressure main line. Reversal of movement is guaranteed thanks to this.

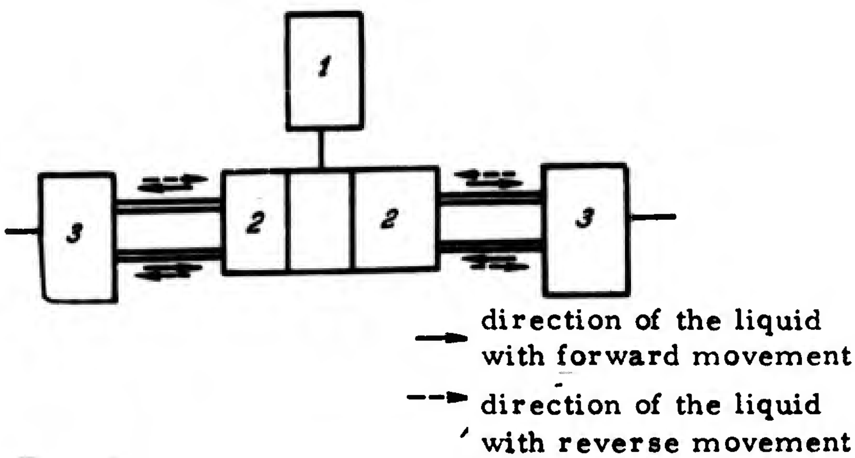


Fig. 66: Scheme of the hydrovolumetric transmission.
(1) - engine; (2) - hydropumps; (3) - hydromotors.

The hydrovolumetric transmission makes it possible to continuously (uninterruptedly) change the gear ratio over a wide range with satisfactory efficiency. It is true that this change is not automatic, but it permits use of an automatic system of driving. When operating under a high pressure compactness, these transmission are convenient for composition and preclude the necessity of having a main friction clutch, a gear box, and turning mechanism and even a side transmission. Finally, they are simple and convenient for driving, making it possible to achieve automation almost completely.

However, the hydrovolumetric transmission has inherent shortcomings. The main one is low efficiency and insufficient reliability when transmitting large forces due to the susceptibility of these transmissions to wear and broken seals. In completed tank transmissions, attempts have been made to use hydrovolumetric transmissions in transmission and turning mechanisms in the auxiliary drive in order to improve the agility of the vehicle. In this case, they are loaded with only part of the engine power and operate only in the turn.

By way of example, Figure 67 shows a drawing of one of the variations of a hydromechanical transmission with successive-parallel connection of the complex hydraulic transmission and the hydrovolumetric transmission in the auxiliary drive.

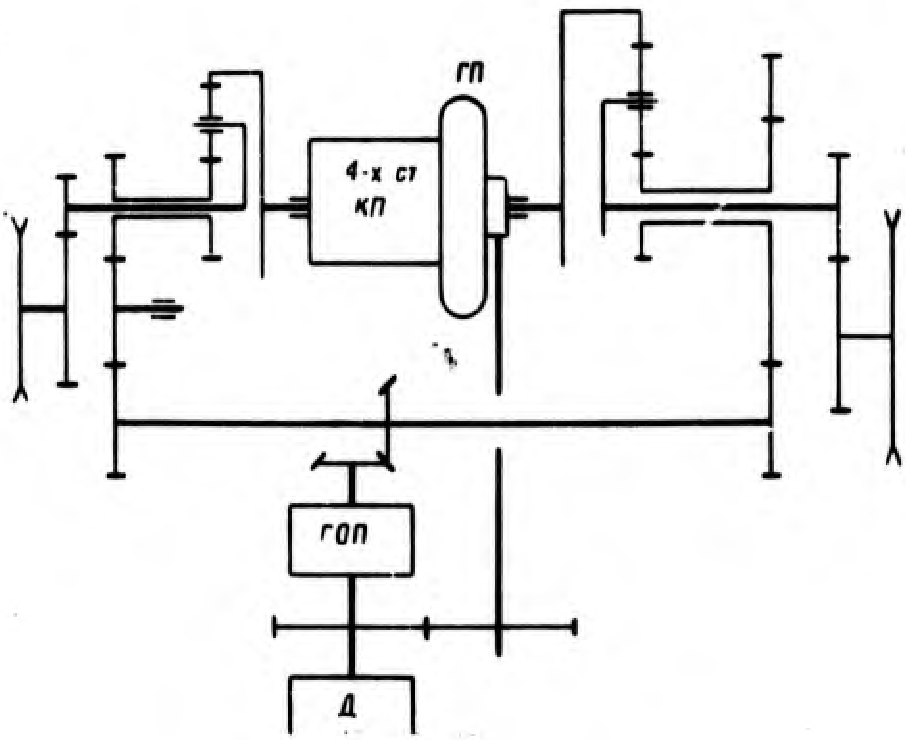


Fig. 67: Principle scheme of a hydromechanical transmission. (D) - engine; (GOP) - hydrovolumetric transmission; (GP) - complex hydraulic transmission; (KP) - gear box.

The hydrovolumetric transmission consists of a hydropump with regulatable output and a hydromotor, a shaft which is connected to the sun gears of the summation rows of the cylindrical transmission. Since the cylindrical transmission is executed on one side with an auxiliary drive gear (idler), then when the hydromotor shaft rotated, the sun gears will be rotated on different sides.

With straight-ahead driving, the output of the pump equals zero (zero eccentricity), the hydromotor shaft does not rotate and restrains the sun gears from rotating, due to which there is an idler on one side of the cylindrical transmission and not on the other side. In order to turn, the driver operating the driving organs changes the eccentricity of the pump according to a value and a sign, i.e., he sets up a definite gear ratio between the pump and the hydromotor. The sun gears are rotated at a certain speed on different sides, guaranteeing a stable turn of the tank with the necessary radius. With such a scheme, all turning radii turn out to be as calculated.

As a rule, control of the transmission aggregates, the power unit and other systems of modern foreign tanks is achieved with the aid of a servo drive mechanism of which the hydraulic ones have received preferential propagation. In addition, pneumatic, electrical and combination drives have been used. The extensive attention which has been given to the problem of controlling the movement of the tank is explained by the fact that the type and design of the driving mechanism control has a direct influence on the average moving speed of the tank and, what is especially important, on the fatigue of the mechanic driver. Since an extended march and long daily transitions are characteristic for tanks under new conditions, then ease and facility of control becomes the most important requirement for the drive mechanism.

Under the new conditions, the forces on the levers and pedals are already inadmissible, reaching several tens of kilograms, as was true on the tanks in the period of the second world war, thus servo drive mechanisms have received wide propagation. For example, on the Chieftan" tank, the driver, situated in a reclining position easily drives the tank with the aide of electrohydraulic drive mechanisms. The "S" tank is driven by two members of the crew sitting back to back. This makes it possible to move back and forth at the same speed, without upsetting the vehicle.

On American medium tanks, control of the transmission case and of the turning mechanism is achieved with the aid of hydro drive mechanisms from a small lever and an automobile type steering wheel. And only the stopping brakes have a mechanical drive making it possible to restrain the tank on brakes when the engine is not running.

All other modern foreign tanks are equipped with servodrives.

In the servodrive, all the work in controlling the aggregate is done by a slave servomotor, obtaining its energy from some outside source, and the driver only gives a signal actuating the control organ and at the same time providing connection of the energy source with the slave servomotor. The principal scheme of the hydraulic servomotor is shown on Figure 68. The servodrive mechanism of this type is suitable for controlling any aggregates requiring a great deal of effort.

As far as the automatic systems for controlling movement are concerned, used on transmissions, they are suitable only to shift the transmission. Control of the turn has not yielded completely to automation, since the turning moment may be selected only by the mechanic-driver. Two external parameters are used to automatically shift the transmission: load on the engine and the moving speed of the tank. When the load on the engine increases, and the speed decreases, then the automatic mechanism shifts to a lower gear and, on the other hand, when the moving speed increases and the load decreases, it automatically shifts to a higher gear. Thus, the automatic system achieves gear shifting in conformity with external conditions of movement with no participation of the driver. However, whenever he so desires, the driver may limit the operation of the automatic mechanism and take over driving himself.

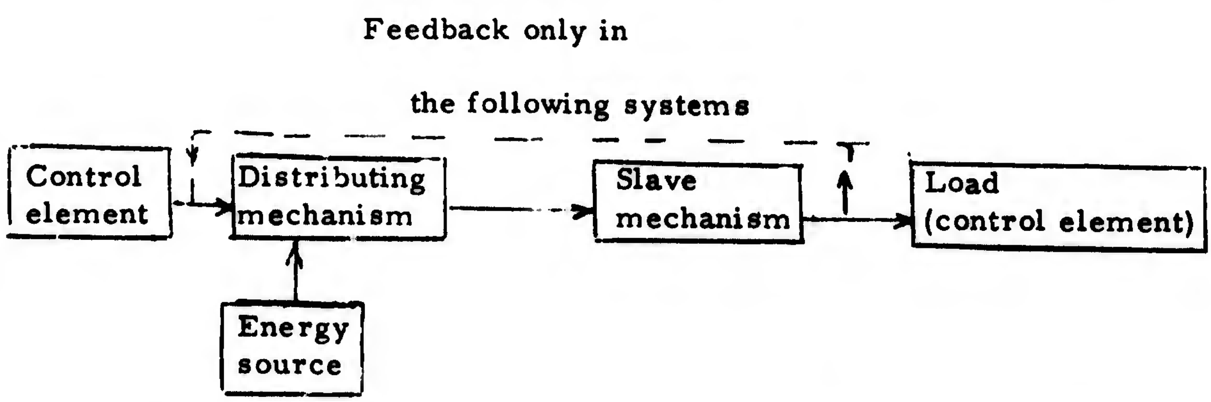


Fig. 68: Principle scheme of a hydraulic servodrive mechanism.

The automatic mechanism is comparatively simple on hydromechanical transmissions having a gear box with two or three stages.

The use of a servodrive mechanism in the automatic system makes it possible to have simple and convenient drive organs for the driver in the driving compartment in the form of buttons, small levers, pedals, steering wheels, etc.

Par. 3: Running Gear of the Tank

The running gear of the tank consists of a system of springs and tracks.

The spring system of the tank must guarantee the possibility of realization available specific power under different road conditions. The suspension parameters and damping parameters largely depend on the mean moving speeds, reliability and habitability of the tank.

The tank suspension must have a sharply expressed non-linear progressive characteristic, permitting the tank to move smoothly, without shocks and jolts along roads with various unevennesses as well as off the road.

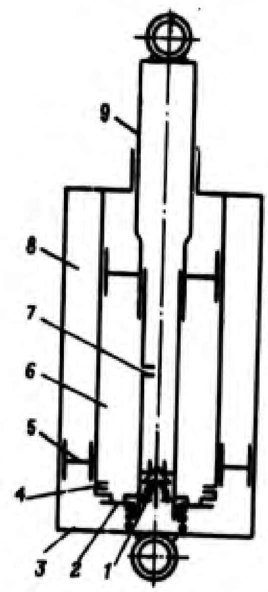


Fig. 69: Drawing of the hydropneumatic suspension.
(1) - high-pressure valve; (2) - forward stroke valve; (3) - housing;
(4) - calibrated opening; (5) - piston-spacer; (6) - inside cylinder;
(7) - boring; (8) - ring cavity; (9) coupling rod.

In order to increase the passability of the tank, it is very important to provide varying clearance, to reduce the silhouette of the vehicle and to set the tank with its bottom on the ground as well as to stop the suspension in any position when conducting fire.

The majority of modern foreign tanks use individual torsion suspension in combination with rubber springs and high-power hydraulic shock absorbers with two-way action. One exception is the English tank "Chieftan" having a blocked suspension.

In the past few years, there has been increasing interest in hydropneumatic suspension in which the role of the elastic element is not fulfilled with metal, but air and a special liquid. The hydropneumatic suspension simultaneously fulfills the function of a shock absorber. As has already been pointed out above, facilitates regulation of clearance, and is convenient for composition, since it can be completely taken out of the tank hull.

A principal drawing of the hydropneumatic suspension is shown in Figure 69. The suspension consists of a housing 3, connected by a supporting roller, and a coupling rod 9 with a piston connected with the tank hull. In the suspension housing 3, there are an inside cylinder 6, a piston-spacer 5, a forward-stroke valve 2 and a high-pressure valve 1. There is air in the ring cavity 8, and the rest of the space is filled with a specially compressed liquid. Reliable separation of the air and the liquid is guaranteed by a piston-spacer. With straight-ahead movement (lifting of the roller), coupling rod 9 with the psiton goes into the cylinder and displaces the liquid from the hollow of the coupling rod into the inside cylinder along boring 7, and from there through a calibrated opening 4 and forward-stroke valve 2 into the outside cylinder. The liquid moves the piston-spacer which compresses the air in the ring cavity 8. The boring 7 is superimposed with a determined movement of the coupling rod and further movement of the coupling rod is accompanied by compression of the liquid inside the coupling rod cavity (in the high pressure cavity). The compression of air continues simultaneously in the process, since the liquid is displaced from the inside cylinder into the outside one. The pressure in the cavity increases until a limit valve opens 1.

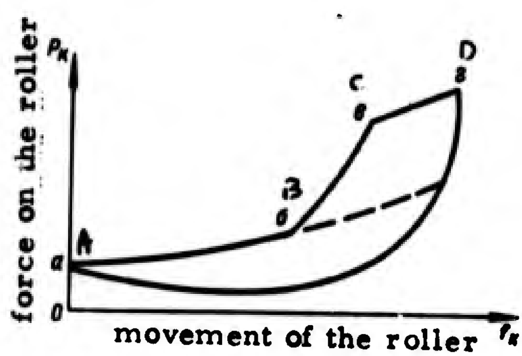


Fig. 70: Characteristics of hydropneumatic suspension.

Thus, up until the boring 7 is covered over, the suspension operates pneumatically (section a-b on Fig. 70), after the superposition it operates hydropneumatically (section b-c) and after the limit valve 1 is opened (Fig. 69) it again operates pneumatically (section c-d).

In reverse driving (lowering the roller), the liquid is displaced by the piston-spacer from the outside cylinder into the inside one under the effect of expanding air (curve d-a). Moreover, valves 1 and 2 (Fig. 69) are closed and flow is possible only through the calibrated opening 4, where it loses a large part of its energy, as in the shock absorber. The area abcda (Fig. 70) characterizes the energy losses. It is evident from the drawing that the hydropneumatic suspension makes it possible to achieve the desired non-linear characteristic and achieve rapid attenuation of the vibrations.

The Swedish "S" turretless vehicle has such a suspension, in which the cannon is attached firmly to the hull and is aimed in vertical plane at the expense of moving the hull on the suspension relative to the rollers. For example, in order to give the cannon an elevated angle, the liquid is pumped from the rear suspension into the front one.

Research work is being carried out abroad to create a spring system with automatic regulation of the rigidity of the suspension elements and the resistance of the shock absorbers.

In spite of its disadvantages, the track running gear continues to be the only one acceptable for tanks, since only it is able to guarantee a high degree of passability and reliability under combat conditions. Thus, all modern tanks have a track running gear without exception.

The basic directions for improving the track running gear are determined by its shortcomings, the main ones of which are: insufficient maintenance time, low efficiency and comparatively large weight.

Efforts to improve the longevity of the running gear brought about the use of rubber-metal links along with the conventional tracks. Such a link lasts several times longer than the open one due to the fact that the friction characteristic for an open link, the slip of metal on metal with an abrasive is replaced by inner friction deforming the rubber layers.

A compensating mechanism proves to be necessary for tracks with rubber-metal links, guaranteeing the stability of the tension in the track enclosure when the hull vibrates. With the aid of these mechanisms, the front supporting roller is connected to the idler wheel when the roller is lifted, the idler wheel is moved forward, compensating the relaxation of the track. For this purpose, it is possible to use a tension roller, situated on the rear inclined branch of the track between the outer supporting roller and the driving wheel.

The compensating mechanism is necessary primarily to prevent collapse which is characteristic for tracks with elastic rubber-metal links. In addition, this mechanism reduces the dynamic load improving the operating conditions of the transmission and the engine.

Reducing the weight of the track running gear, as in all running gear parts, it is necessary especially for fast vehicles, for which use has been made of light alloys and plastics in the components and units of the running gear. Light alloys are being already used, for example, in the running gear of the American medium M-60 "Sheridan" tank.

Par. 4. Equipment for Underwater Driving and Individual Amphibious Means

Problems concerning the overcoming of water obstacles have been given special attention in the past few years.

Since most of the theaters of combat activity are characterized by an abundance of water boundaries, then it is difficult to imagine combat activity during the course of which it would not be necessary to overcome rivers of different width and depth.

Under these conditions, high rates of attack and the precipitous character of combat activities are possible only if the river can be crossed in a short period of time. And in order to accomplish this, it is necessary to independently cross the water boundary and continue to carry out its combat tasks on the opposite shore.

Amphibious tracked vehicles have been created to cross water obstacles, tanks which are equipped with means for underwater driving (OPVT) and individual amphibious facilities. Some tanks have OPVT and amphibious facilities (M60A1, "Chieftan", and others).

Amphibious tanks and armored transports, as a rule, are light armored vehicles with a displacement exceeding its weight. These tanks usually fulfill reconnaissance tasks and take part in landing operations while the armored transports serve to transport personnel or combat loads. Models of such Soviet tanks are the PT-76, the armored transport BTR-50P, the American transports M113, M114, the marine tank LVTH6, and others.

To drive on the water, use is made of a hydroreactive jet, a screw propeller or a paddle track, the upper branch of which is closed with a special hydrodynamic cover when it is in water. This makes it possible to increase the support and power, moving the tank.

Equipment for underwater driving has been installed in the majority of modern medium tanks. In order to guarantee underwater driving, the tank must be hermetically sealed and have simple, detachable equipment which includes the air feed pipe, various seals and valves for the exahust pipes, preventing the entry of water into the engine when it is immersed in water.

On the M-60 tank, the engine is hermetically sealed and can operate under water.

After the tank arives on the shore with the OPVT, the air feed tube is discarded (from inside the vehicle) and the tank is ready to move into combat. The M60A1 tank with the OPVT is shown in Figure 71.

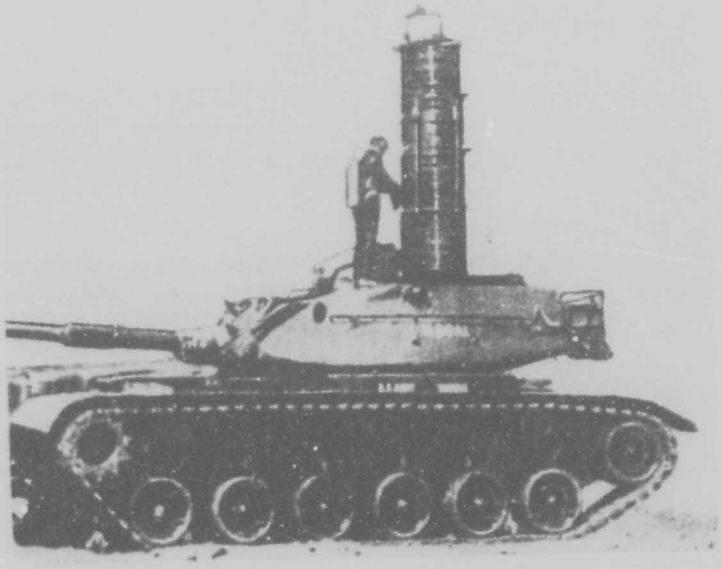


Fig. 71: M60A1 tank with OPVT.

Individual amphibious facilities on a series of foreign tanks in the form of separable members or attached and easily-removable pontoons make it possible to make the tank amphibious at the expense of increasing its displacement. The speed when moving with these facilities on water amount to 10 km/h.

Individual amphibious facilities in the form of attached pontoons consist of several parts. In the rear pontoons are propellors driven by the driving wheel. After the tank arrives on shore, the pontoons are easily discarded without the crew leaving the tank.

Such amphibious facilities, in contrast to an extensible cover, permits the tank to conduct fire on the water and when it exists onto the shore. In addition, it is resistant to rifle and machine gun fire, since the pontoons are made of waterproof light materials with a specific weight of about 0.05 g/cm^3.

Amphibious vehicles, tanks with OPVT and amphibious facilities are equipped with water pumps, navigation equipment and rescue facilities for members of the crew.

Section Five

ELECTRONIC EQUIPMENT, AUTOMATIC AND NAVIGATION APPARATUS

Par. 1: Electronic Equipment of the Tank

In order to increase the combat preparedness and combat capability of combat vehicles, extensive use of automatic equipment is made in the design of modern tanks. Now, the combat characteristics of a tank depend to a large degree on the efficiency and reliability of electrical and automatic systems installed in them, as well as of the electrical machines, instruments and apparatuses.

The characteristic special feature of the electrical equipment systems of modern tanks is its saturation with high powered consumption of electrical energy, caused by a great increase in the electrical energy power sources.

The increase in the amount and power of electrical energy consumers in the tank is explained by the preference of electrical energy and electrical drive compared to other energy forms and other forms of slave (power) drive mechanisms, for example, hydraulic and pneumatic.

The use of electrical energy to operate the slave (power) drive mechanisms provides the possibility of achieving remote control, which makes it possible to reduce the weight and simplify the design of all systems of the slave drive mechanism. The electrical control system of the slave drive mechanism, in turn, permits more effective achievement of its automation with the aid of simple means and schematic solutions. Automation of the drive mechanisms increases their high speed action, improves their characteristics and provides maximum facility of use.

The electrical equipment of tanks was developed simultaneously with the progress of tank design, tank weapons and tank engines. Despite the process of development and improvements which have taken place over the course of many years, the principal scheme of tank electrical equipment has remained almost unchanged. Up to the present time, an electrical equipment system has been used on tanks with a direct current voltage of 26 $\pm$ 4 v, having the following essential merits:

- The system is more developed and has been more thoroughly studied. The standardization of nominal voltages provides the possibility of creating unified engines, contactors, relays and other apparatuses.

- Simplicity of the system, which provides the possibility for completing it according to a single-wire scheme.

- Safety of crew work at the accepted nominal voltage of the on-board network.

- Large values of the starting moments on the power-driven electric engine with direct current.

- The possibility of the generator operating in the regime of the electric motor with its use as a starter.

- The possibility of directly driving the generator from the tank engine (without a clutch of constant speed).

Considering the constant growth of the total power of tank electrical equipment, the number of power consumers, accompanied by an increase in the extension of the electrical energy transmission lines, and the extensive use of consumers with alternating current, we may conclude that the possibilities of further developing the given electrical equipment system are limited. The basic shortcomings of the electrical equipment system on direct current are as follows:

- The presence of a brush-manifold unit in the electrical machines.

- The difficulty of accomplising liquid cooling of the generator with direct current.

- The impossibility of setting up a current converter in order to obtain an alternating current of the necessary parameters.

- Increase in the weight of the electrical equipment system, maintaining the nominal voltage of the on-board network 26 $\pm$ 4 v.

When increasing the power of the tank electrical system and the expansion of the electrical transmission line higher than the determined limits, it is expedient to increase the nominal voltage up to some optimum value at which the weight of the wires and of the individual electrical equipment elements can be lowered.

It has been established that the weight of the individual tank electrical equipment elements is changed non-uniformly when there is an increase in the nominal voltage; the weight of some elements is decreased, and the weight of other elements is increased. So, for example,

- The weight of the generators, of the electrical motor and of the different armatures is somewhat reduced.

- The weight of the batteries of given capacity is noticeably increased.

- The weight of the electrical wire in the power networks, through which the energy is transmitted to feed the high-power consumers, is greatly reduced; the weight of the wires through which the low current passes, is changed little, since their cross section is selected not according to the permissible load or the voltage drop, but from considerations of mechanical stability of the wire.

In addition, at the furthermost increase of the nominal voltage, the service time of a small-dimensioned incandescent lamp is shortened, since the lamp filaments must be made thinner to increase the resistance, which greately decreases their mechanical stability.

These contradictory circumstances force designers composing tank electrical equipment systems to use dynamoelectric voltage transformers in order to obtain the needed operating voltages in the individual systems, and in order to obtain the alternating current, they are forced to use dynamoelectric current converters which increases the weight, the overall dimensions and the cost of the electric equipment system.

A voltage of the on-board network higher than 30 v is not expedient since this does not solve all the problems posed, but the necessity of feeding alternating current to the consumers again requires installation of a current converter.

Based on the experience developing electrical equipment, it can be said that the tank electrical equipment system on direct current fulfills the requirements of the present day. With further expansion of the tank electrical equipment system and more intensive introduction of alternating current to the consumers, it is not impossible that the traditional system of alternating current will be an appropriate form of the reconstruction.

Tank generators. The generator is the basic electrical source of energy in a tank.

The construction of tank generators is characterized by the special features causing the necessity of installing them in the tank in a very limited and difficultly accessible place. Thus, the tank generator must have small overall dimensions and a high degree of reliability, which guarantees its normal operation in the course of an entire guaranteed period without maintenance and changing the brushes.

The tank generator operates under difficult conditions which are distinguished by intense shaking and vibrations of the places where the gnerator is fastened, high temperature (up to 105°C) and heavy dust conditions.

The power of the direct-current tank generators is continuously increasing and at the present time has reached 15 kilowatts. When increasing the power of the direct-current tank generators, it is difficult to create a reliable brush-manifold unit, since the mass of the manifold is also increased, making it difficult to guarantee its mechanical stability, increasing the losses in the brush-manifold unit, which causes overheating of the brushes, the maximum temperature of which must not exceed 180 - 220°C. Switching gets worse when this determined temperature is exceeded, and the brushes quickly wear out.

Increasing the power of the direct current tank generators is accompanied by continuous improvement of their construction and cooling which shows up positively in switching.

The necessity of increasing the overall dimensions and the weight of the direct current tank generator requires an increase in the initial and maximum speed of its shaft rotation. This leads to additional losses on the manifold and a change for the worse in switching, rapid wear of the brushes and the necessity of increasing the mechanical stability of the manifold, as well as using bearings with a high degree of reliability. In addition, the presence of the manifold-brush unit limits the possibility of using a more effective liquid in the generator cooling system.

Thus, with an increase in the rotational speed of the shaft in the direct-current tank generator, it is impossible to guarantee creation of a generator with a high degree of power and the necessary reliability.

The experience of using an alternating current generator in automobiles and in airplanes shows that the synchronous generator is free of these shortcomings. The reliability of an airplane alternating current generator is double that of a direct current generator. The specific power of an alternating current automobile generator is 1.5 times higher than that of a direct current generator (due to its much lower weight).

The maximum rotational speed of the armature on an alternating current generator is limited only by the bearings, and in case it needs lubrication with liquid oils, it may achieve much greater values.

The method for regulating the voltage exerts great influence on the generator dimensions and their characteristics, more precisely the value of the excitation current of the generator determined with the aid of this method. The use of vibrating voltage regulators causes the need to the generator excitation current to a value which provides for normal operation of the voltage regulator contacts. This means that the magnetic circuit of the generators were weakly saturated, and this worsens the indicators of the electromagnetic use of iron in the generator. This shortcoming is eliminated by dividing the exciter windings on two parallel braches and connecting the proper voltage regulator in each of them. As a result, the total generator excitation current is double, which increased the saturation generator magnetic circuit.

The use of vibration regulators to regulate the voltage of the tank generators to a great degree lowers the operating reliability of the generator as the basic electrical energy source.

The main shortcoming of the vibrating regulators is the instability of their regulation. The value of the voltage at which the voltage regulator was regulated changes with the course of time due to wear of the contacts, aging of the springs and suspension of the armature. In addition, overheating and aging of the insulating of the basic voltage regulator windings has been observed, and it is very difficult to guarantee reliable thermocompensation of the voltage regulators with a change of the surrounding temperature from -40 to + 70°C.

Thus, it would be expedient to renounce the vibrating voltage regulators and make the transition of contactless transistor voltage regulators, not limiting the value of the generator excitation current.

The principal scheme of a contactless transistor voltage regulator with direct current (Fig. 72) consists of a measuring instrument (MI), composed of resistances R_1, R_2, a controlled transistor T_1 and a stabilizer C, and of a regulating device (RU), acting on the excitation circuit, the function of which is fulfilled by T_2 transistor.

The voltage generator U_g is set at the inlet of the measuring apparatus. The input voltage of the measuring apparatus is voltage U_{EK} taken from terminals E and K of the transistor T_1. Transistor T_2 is switched to the output of the measuring organ, in the manifold circuit which connects the generator exciter windings.

Transistor T_2 is variable in resistance, the value of which changes within broad areas. When transistor T_2 is open, its resistance is equal to one hundredth of an ohm, and when it is closed, it reaches one hundred thousandth of an ohm.

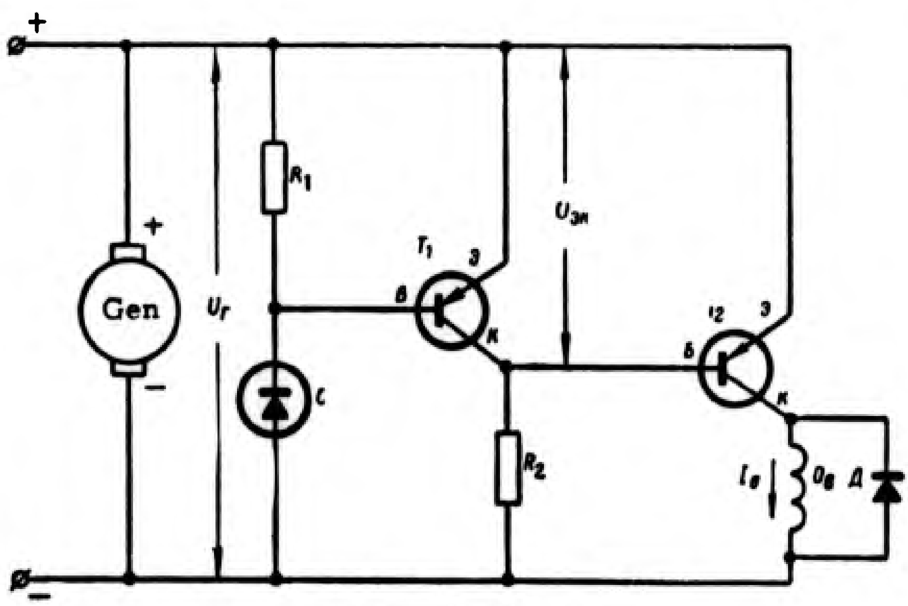


Fig. 72: Principal drawing of a contactless transistor voltage regulator.

In order that transistor T_2 be in an open position, it is necessary that the emitter transition (emitter base) on it be given a determined triggering voltage.

Up to the present time, while the voltage generator will be lower than the breakdown voltage of the stabilizer C, the current will not pass through it. Thus, there will not be a voltage drop on resistance R_1. Therefore, the potential of the base and of the transistor emitter T_1 will be the same, on account of which the transistor T_1 will be blocked. Since the resistance of transistor T_1 at this moment will be immeasurably higher than resistance R_2, it is thought that almost all the generator voltage will be applied on terminals E and K of transistor T_1. The same voltage is applied to terminals E and B of the T_2 transistor.

Transistor T_2 is triggered and the exciter current I_B of the generator will pass through it.

Since only the generator voltage increases breakdown voltage of the stabilizer C, current passes through it. This current creates a voltage drop on the resistance R_1 which is applied to the emitter transition of the transistor T_1 in the triggering direction, due to which transistor T_1 is triggered and its resistance is decreased down to an insignficantly low value. Moreover, the voltage drop on transitor T_1 is also greatly decreased (up to several tens of volts).

It is thought that the output signal of the measuring organ in this moment is equal to zero. This causes closing of the transistor T_2 and a sharp decrease of the exciter current and the generator voltage. Moreover, transistor T_1 is closed and T_2 again opens. This process will be continued at the determined frequency.

The given scheme is finding progressively wider use.

Tank accumulator batteries. The characteristic special feature of modern batteries installed on tanks and in automobiles is the possibility of storing them for extended periods of time in a dry charged condition in warehouses (up to five years). The use of powdered technology to produce the active mass for the positive and negative grids and the use of separators made of microporous rubber and microplastics (together with wood) guarantees reliable operation of the accumulator batteries and to a large degree decreases the probability of the grids sulfating.

The excellent starting properties of contemporary accumulator batteries, guaranteeing starting of the tank and automobile engines with a high degree of compression in cold weather is explained by the introduction of wood-organic additions-expanders (humic acid, peat products, etc.) to the active mass of the negative grid, increasing the battery voltage during discharge. However, these additions bring about the necessity of increasing the charging voltage. In order to decrease their influence on the active mass of the grid, we introduce a small quantity of cobalt or nickel ions, reducing the charge voltage. The nickel ions reduce the potential of the negative grids, and the cobaltions reduce the potential of the positive grid. The nickel compounds used are safe for the battery components.

Along with the positive properties of the plumbic acid in the batteries, it is necessary to take note of their essential shortcomings as far as use is concerned: when the temperature of the battery is decreased, its charge on the vehicle is made much worse -- the battery does not accept a charge. This is explained by the fact that in the process of charging, an electromotive force appears on its terminals, directed toward the applied charging voltage. The value of this opposition electromotive force primarily depends on the density of the electrolyte in the pores of the grid and on the concentration of lead ions in it. The difference between the applied charge voltage and the opposition electromotive force is the same effective electromotive force as the internal resistance of the accumulator battery which determines its charging rate. Special methods have been worked out to evaluate the ability of accumulator batteries to accept a charge at low temperatures.

The essence of one of these methods includes the following: In order to check the acceptability of the charge, we take a new, untested, completely charged battery with an electrolyte temperature of 21-32°C. The battery must be charged with the current of a 20-hour discharge: $I_z = I_{p20r}$. Then, the battery is discharged by 50 percent and cooled down to -1°C. The battery, having a nominal voltage of 12 v, is charged at 14.4 v.

The appraisable parameter for charge acceptability is the value of the charging current at the end of ten minutes after beginning of the charge. Knowing the value of the charging current, it is possible to obtain exhaustive information concerning the battery reliability in use.

Par. 2: Automation of Tanks

Automatic systems have been used in tanks for a long time to regulate the rotational speed of the engine and the voltage of the tank generator.

In the past few years, there has been automation of the processes for controlling tank armaments and effective stabilization of tank weapons has been achieved which provides the possibility of conducting fire from the tank under movement. In addition, anti-atomic protection systems (PAZ) and fire-proof equipment have been used on tanks.

Tanks Armaments Stabilizers

Vibrations of the tank hull makes observing the battlefield more difficult, as well as seeking out targets, aiming weapons at the target and observing the results of firing. This is due to the fact that when the tank hull vibrates, the field of view of the gun sight as well as of other optical tank instruments, does not remain stationary relative to the terrain, and vibrates continuously together with the gun sight field of view. The vibrations of the sighting mark relative to the target greatly increases errors when aiming and impairs the firing results from movement compared to firing when the tank is standing still.

The time lag of the shots combined with the angle the tank hull vibrates causes an increase in the scattering of shells and bullets and impairs firing results.

For modern tank weapons, in the presence of electromagnetic firing equipment, the time lag of a shot amounts to not less than 0.14 sec. After this time, the axis of the gun barrel is inclined at a large angle and its direction in space is changed, which causes large deflections of the shells or bullets according to height and direction. The dispersion of shells and bullets when firing from a tank under movement is many times higher than when firing from a tank standing still.

Disturbing moments will be transmitted from the tank hull to the weapon when the tank hull vibrates angularly. The magnitude of the disturbing moments is determined by the amount the weapon is out of alignment, the absolute rate the weapon is turned and the friction moment in the weapon support (journals or race-ring of the turret). The effects of the disturbing moments on the weapon causes it to turn in the support and to change the given direction of the barrel axis.

In order to maintain the given direction of the weapon, it is necessary to apply an additional (stabilizing moment) to it, equal in magnitude and opposite to the direction of the disturbing moment.

This problem has been successfully solved by installing special weapons stabilizers on the tank with the aid of which one determines the direction and changes the magnitude of the angular weapons deflection from a given direction. These deflections are converted into an electrical control signal which later in the slave organ of the stabilizer is converted into a stabilizing moment, due to which the weapon is maintained in a given position.

The tank armaments stabilizer is conceived as an automatic regulating system reacting to the angular deflection of a weapon from a given position and making it possible to maintain the given position of the weapon which results in improving the accuracy when firing from a moving tank.

To aim the weapon at the target, the stabilizer is equipped with an aiming system which makes it possible to change the given direction of the weapon.

Hydroscopic instruments, three-degree and two-degree gyroscopes are used in the capacity of direction controllers, making it possible to maintain (set) any necessary direction of the weapon, in all tank armaments stabilizers without exception.

The direction controller is fastened on the weapon or is solidly connected to it.

In completed designs of stabilizers, the stabilizing moments (proportional magnitude of the directed signals), acting on the weapon and the tank turret, are created by dynamoelectric or electrohydraulic drive mechanisms.

The accepted classification of tank weapons stabilizers make apparent the following principal and design special features of stabilizers: the number of surfaces stabilized, the methods for transmitting the effect from the direction controller onto the object of stabilization and the type of slave drive mechanism.

1.. All weapons stabilizers are classified into single-plane and double-plane according to the number of stabilization planes.

2. The effect of the gyroscope direction controller on the stabilizing object in the armaments stabilizer can be transmitted directly by connecting the direction controller with the stabilized object with the aid of mechanical transmission or from the direction controller to the slave organ of the directed signal stabilizer.

Depending on the sign and magnitude of the directed signal, the slave organ of the stabilizer will have a corresponding effect on the stabilized object and prevent its deflection under the effect of the disturbing moments.

The stabilizers in which the direction controllers do not have any effect on the stabilization object, but are used only to create direction signals, are usually called indicating. A necessary element of such a stabilizer is the amplifier which amplifies the signals issued by the direction controllers in order to control the stabilizer slave organs.

3. Type of slave drive mechanism. The stabilizing moment, proportional to the sign and the magnitude of the directed signal, received from the direction controller, and the force effect on the stabilization object is created by the slave drive mechanism of the armaments stabilizer.

Electromechanical (dynamoelectric) and electrohydraulic drive mechanisms are used in weapons stabilizers.

As has already been pointed out, the tank armaments stabilizer is a system of automatic regulation controlling deflection. The automatic control system provides for constantly regulated magnitudes with a change of the distrubing effect and its proportional change with a change of sign and magnitude of the directed signal. The automatic control system with regulation of deflection provides for successive execution of the following basic operations.

Assigning a regulating magnitude (applicable to the tank armaments stabilizer) -- assigning an angle for raising the weapon, i.e., assigning a direction of the axis of the barrel (φ_{zad}).

Measuring the deflection of the regulating magnitude from the given magnitude (in the tank armaments stabilizer) -- measuring the deflection of the axis of the weapon's barrel from a given direction, i.e., measuring the displacement angle $/ \Delta \varphi = \pm (\varphi_{zad} - \varphi_0)/$. For this purpose, it is necessary to introduce rigidly negative feedback into the stabilization system, the presence of which makes it possible to compare the actual direction of the weapon φ_0 with the fixed on φ_{zad}.

Creation of a directional signal, proportional to the magnitude of the deflection-displacement. In addition, the physical nature of the direction signal must provide the possibility of transmitting it into the subsequent elements of the system. In the armaments stabilizer, it is more convenient to receive electrical directional signals.

Eliminating a deflection which occurs of the regulated magnitude from the set magnitude (eliminating the displacement). In order to eliminate a displacement in the tank weapons stabilizer, it is necessary to create a stabilizing moment (M_s) which counteracts the disturbing moment (M_v) and, acting on the weapon, returns it to the assigned position. The moment acting on the weapon is equal to $M_o = M_s - M_v$.

Thus, assignment of the regulating magnitude, i.e., assignment of the angle of elevation of the weapon (φ_{zad}) on a moving tank and its stabilization when firing from movement is a primary problem and the gyroscopic directions controller is an important element in the tank weapons stabilizer. The gyroscopic direction controller together with the electrical pickup (Figure 73) forms the pickup angle.

In addition, the pickup angle is supplied with a special aiming system with the aid of which the gunner can change the direction of the barrel angle.

The tank weapons stabilizer operates in the following sequence: The gunner, detecting the target, actuates the gyroscopic controller with the aid of the guidance system and gives the required direction to the stabilizing axis of the gyroscopic φ_{zad} which must correspond to the barrel axis of the stabilized weapon, after which the gunner stops aiming (discontinues actuating the guidance system) and makes a decision as to firing.

Under the influence of the disturbing moment M_v, transmitted to the weapon when the tank hull vibrates, the barrel axis is deflected from its set direction. The angular displacement ($\Delta\varphi$ which occurs between the given direction of the axis of the weapon barrel φ_{zad} and its actual direction φ_0 is measured with an electrical pickup. Moreover, the angular displacement is converted into a directed electrical signal. This signal is amplified in the amplifier up to a magnitude which is necessary to control the slave drive mechanism of the weapons stabilizer.

The slave drive mechanism creates a stabilizing moment M_s, under the effect of which the weapon is turned to the side opposite to the direction the tank hull is turned. Thanks to this the displacement angle is reduced and the direction of the weapons axis remains unchanged with a determined accuracy.

Thus, during the time the tank is moving, after the gunner discontinues aiming, the weapon will perceive the effect of external disturbing moments M_v, which will cause deflection of the weapon from the set position. At the same time, the weapon will find itself under the influence of the stabilizer, which will continuously guide the weapon in accordance with the set position.

The shortcoming of the weapons stabilizer executed according to the drawing (Fig. 73) is that after the effect of the disturbing moment M_v, the weapon will be vibrated along a set direction with an extremely large amplitude over an extended period of time. This shortcoming of simplified stabilizers precludes the possibility of using them in tanks.

However, the character of the simplified armaments stabilizer may be greatly improved if we decrease the amplitude of weapons vibrations with relation to a given direction. The regulation time is shortened simultaneously, i. e., the time during which the weapons vibrations are attenuated to an allowable magnitude.

Decreasing the amplitude of weapons vibrations may be achieved by changing the form of the directional signal (the curve shape of the directional signal), delivering the angle to the pickup.

For this purpose in the first moment a displacement occurs, immediately after the effect of the disturbing moment, it is necessary to sharply increase the directional signal in order that the slave drive mechanism of the stabilizer energetically prevents the beginning of weapons deflection. During the approach of a weapon to the set position, it is necessary to change the sign of the directional signal in order to change the direction of the effect of the stabilizer slave drive mechanism back and brake the weapon, allowing it to pass through the set direction.

It is possible to change the form of the directional signal if an additional signal of determined magnitude is introduced into the weapons stabilizing system,

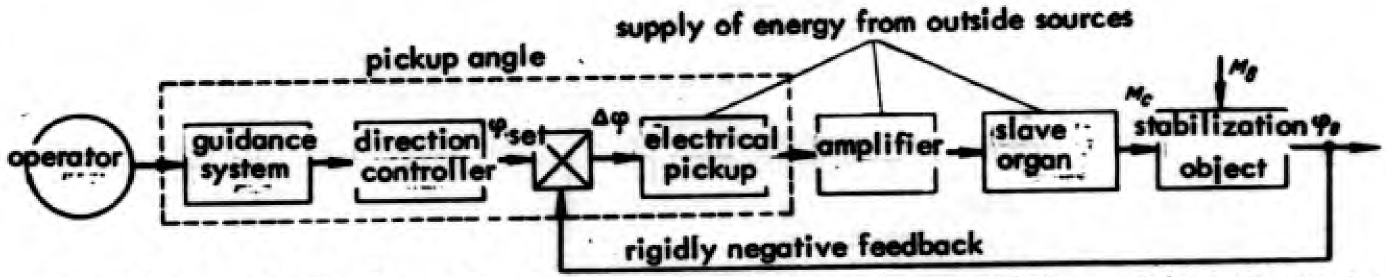


Fig. 73: Functional scheme of a simplified single-plane weapons stabilizer of the indicator type.

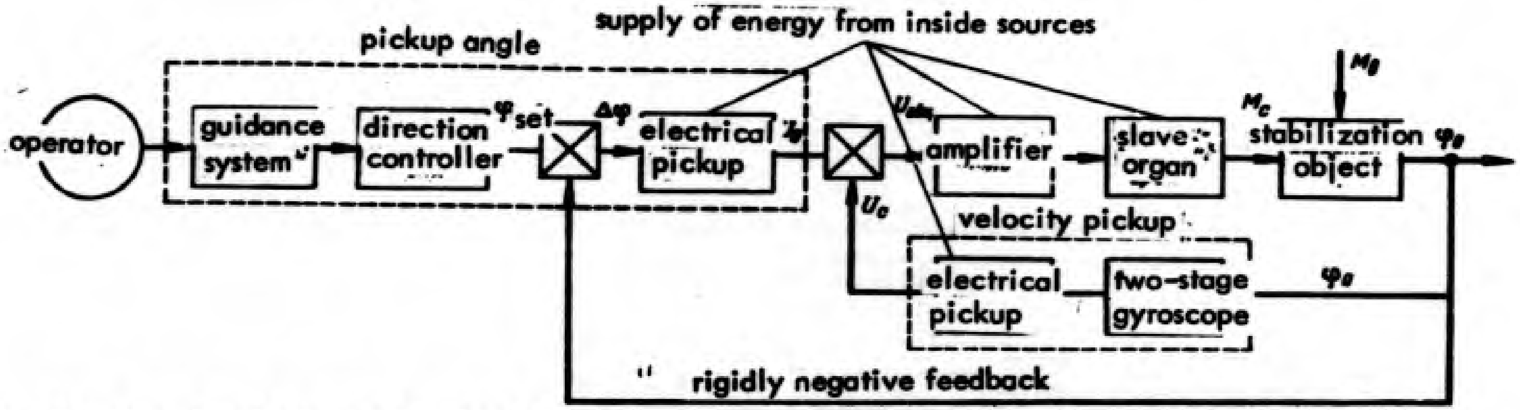


Fig. 74: Functional scheme of a single-plane armaments stabilizer having an anglc and velocity pickup.

proportional to the deflection speed of the weapon. This signal must be summed up with the signal of the pickup angle, and then it is possible to obtain a directional signal of the necessary shape and magnitude.

Thanks to the presence of a signal, proportional to the speed, the weapon will be deflected from the set direction to a much smaller value, and it will be braked during the approach to it; effecting two or three vibra[illegible] [illegible]th a small amplitude, the weapon assumes its correction direction after a [illegible] period of time.

The complete functional scheme of the weapons stabilizer with speed pickup is shown in Figure 74. The basic difference of this scheme from the one examined above (Figure 73), is the presence of a speed pickup.

Due to the fact that the signal giving the speed to the pickup is proportional to the deflection speed of the weapon from the set direction, its introduction into the weapons stabilizer system is made with the introduction of a flexible feedback. As is known, in the case of a flexible feedback in the automatic regulating system rapidly trips the system and decreases the number of weapons vibrations, after which the gunner, having completed aiming, returns the control level to neutral position, or after the effect of the disturbing moment, transmitted to the weapons when the tank hull vibrates.

Together with the armaments stabilizer, having an angle pickup and a speed pickup, stabilizers are being made which have only a speed pickup as for example on the English tank "Chieftan" where the armaments stabilizer provides for weapons stabilization in two planes and consists of a turret stabilizer and a weapons stabilizer. Both stabilizers are of the indicator type.

The special feature of the "Chieftan" tank stabilizer is the presence of control instruments connected into the system at all times, with the aid of which it is possible to check the stabilizer and locate damage. The functional scheme of this stabilizer is shown in Figure 75.

In the stabilization regime, the speed pickup gives off the basic signal which reacts to the absolute moving speed of the weapon.

The slave drive mechanism of the stabilizer is executed on the electrical machines. The slave motor generates the torque M_d and through the reducer acts on the stabilization object (turret with weapon), which compensates the effect of the external disturbing moment M_v.

Due to the fact that there is not an angle pickup in the stabilizer, but only a speed pickup, after the turret stops, the weapon will not be returned to its original position, but remains in the new position. But since the effects of the external moment M_v have a sign-changing character, the turret together with

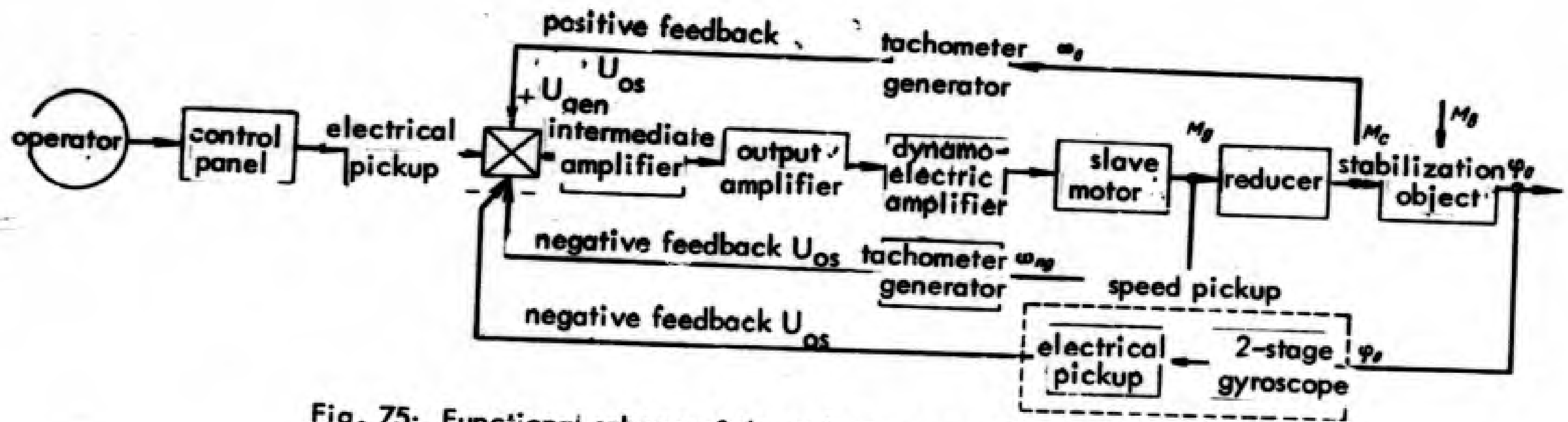


Fig. 75: Functional scheme of the stabilizor on a "Chieftan" tank turret.

the weapon will be retained in the set position with some degree of accuracy. However, under the effect of the external moment on the turret, having a stable direction, the turret will be turned in the direction of the effect of the external moment. The deflection of the weapon from the set direction which occurs may be eliminated only by the operator (gunner or tank commander).

The rapid effect of the turret stabilizer is guaranteed by the introduction of an additional negative feedback according to the rotational speed of the slave engine, which is achieved with the aid of a special tachometer generator connected with the slave engine.

To eliminate the auto-vibrations which may occur in the system due to the presence of gaps and other elastic elements in the reducer (turret turning mechanism), a positive feedback is introduced according to the revolving speed of the turret relative to the tank hull. This feedback is introduced into the tachometer generator, the rotor of which is connected with the toothed rim of the turret race ring.

To guarantee the safety of members of the crew and to prevent breakdown of the stabilizor, when in use, the stabilizer must be equipped with special protective devices -- blockings.

By way of an example of a blocking, we will examine the exclusive abandonment of a weapon after firing and providing for stopping up of the weapon for a period of "recoil-rolling on-contamination".

In the case of firing when moving backwards, the recoiled parts of the weapon create a moment of out of balance, the magnitude of which greately increases the moment generated by the stabilizer. This moment out of balance causes compulsory turning of the weapon in the journals to the wide of the increasing angle of elevation up to its maximum value (abandoment of the weapon). If the firing is carried out at a small angle of elevation of the weapon, then in the case of abandonment, the weapon is turned at a large angle due to which the gunner loses the target from his field of vision immediately after the shot and cannot check the results of the firing. This phenomenon may be prevented by stopping the weapon at the time of the shot in the position near to the set one which makes it easier for the gunner to observe the target and the results of the shot. However, beginning immediately after rolling on, stabilization of the weapon is made very difficult due to the effect of contamination, and it is necessary to reload the weapon. When the tank is moving, its hull, and together with it, the contaminated and other members of the crew will achieve vibrations relative to the stabilized weapon. It will appear to all the members of the crew that the vibrations are being caused by the weapon, the breech of which is continuously moving up and down within the combat compartment. It is very difficult to reload the weapon under these conditions. Thus, it is expedient to increase the time for stopping the weapon during the entire period of contamination. For this, it is necessary that the device providing for stopping of the weapon during the period "recoil-moving on" be switched off not at the end of rolling on the moving parts of the weapon, but after loading the weapon manually with charges.

The presence of such a mechanism greatly eases the conditions for reloading the weapon, since when the tank moves and the hull vibrates, the breech part of the weapon will maintain its own position in the combat compartment.

Blocking in modern stabilizers provides high operational reliability and guarantees that the crew works in safety.

Par. 3: Ground Navigation Apparatus

Ground navigation apparatus represents one of the basic means of automating troop command. When commanding troops in combat, on the march and in reconnaissance, they are oriented with the aid of combat-topographical maps, by comparing local landmarks and the terrain relief with their representationson the map. This method of orientation may be successfully used under conditions of good visibility, when sufficient time is available and with a high degree of topogeodetic preparation of the officers. In night time conditions or with poor visibility, orientation in forests, mountains and steppe terrain is extremely difficult, and in many cases even impossible. Thus, the presence of navigation apparatus on the tank is very necessary in order to determine the position of the vehicle.

Of all the possible systems of navigational apparatus on tanks, only those may be used in which use is made of gyroscopic equipment, instruments based on the principle of radio wave propagation and combination of them.

A navigational system having a gyroscopic course indicator is automatic, since the original data and the subsequent navigational information are determined in it directly on board the moving object. The accuracy of such systems is sufficient for their practical use on tanks and armor-plated vehicles.

Radio-navigation systems which may be used on tanks and armor plated vehicles of foreign armies are classified into three groups, depending on the method for determining the coordinate of the moving object: angle-measuring, distance measuring and difference-distance measuring.

In the radio-navigational angle-measuring systems, the coordinates and the direction of movement of the moving object are determined by measuring the bearings on two radio-range beacons or more, established in points with known coordinates.

The distance-measuring radio-navigation system is based on using the propagation rate of radio waves. The position of a moving object is determined by the point of intersection of two curves, created by two radio range beacons, the coordinatesof which are known.

The difference-distance measuring radio navigational system is based on measuring the difference of the distances from a moving object up to two (or up to two pairs) of ground radio stations with known coordinates. The position of the moving object is determined according to points of intersecting lines, which are characterized by a constant difference of distances between two stationary radio stations and have the form of complex curves of the hyperbolic type.

The radio navigational systems are used in practice. So, the radio-navigational system developed and tested abroad, creates an electromagnetic network on the battlefield, from which any number of consumers may receive continuous information concerning its position. The radius of action of the main transmitting station is 480 km. The accuracy of orientation is not more than 100 m. The weight of the infantry navigation apparatus which can be carried in a knapsack, is 9.5 kg.

A ground navigation apparatus "Amber-AM-route" was developed in the USSR which is installed on special armor plated vehicles, and somewhat later the TNA-2 navigationalapparatus. With the aid of the ground navigation apparatus it is possible to determine the positional coordinates of a moving object, conduct individual vehicles and columns along a given march route or in a given region, lay out the column path by plotting the movement march route on the map, plot new roads on the m ap and solve problems of topographic tie-ups of combat ranks.

A simplified functional scheme of the ground navigation apparatus is shown in Figure 76.

To determine the running coordinates X and Y of a moving object, continuously measure the increase of paths ΔS and the magnitude of the current values of the directional angles α. The increase of paths ΔS is measured with the path pickup DP, and the magnitudes of the directional angle are constantly multiplied by multiples of the mechanisms MM_X and MM_Y on appropriate paths ΔS. The products $\Delta S \cos\alpha = \Delta X$ and $\Delta S \sin\alpha = \Delta Y$ are the increased in the coordinates of the moving object.

When the apparatus is operating on a moving object, the increased of coordinates ΔS and ΔY are constantly being added to the initial coordinates X_0 and Y_0 which characterize the position of the object before the start of movement.

The running coordinates X and Y are calculated with the scale of the RU recording mechanism and the PK plotter plots the movement march route on a topographical map. At the same time, special recorders take into account the path followed by the object, and the running value of the directional angle.

A gyro-semicompass is used in the capacity of angle monitor which before the start of movement must develop in the plane of the meridian.

The basic characteristics of the domestic ground navigation apparatuses are shown in Table 4.

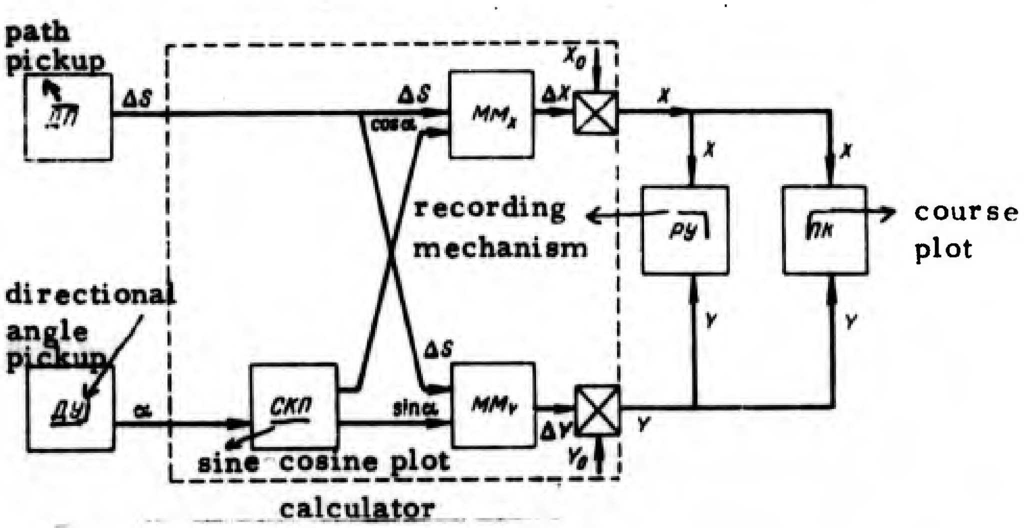


Fig. 76: Simplified functional diagram of ground navigation apparatus.

The practicality of using ground navigation apparatuses on tanks and other armor plated objects was also verified by a series of studies carried out abroad in the past few years.

At the present time, a series of automatic navigation systems are being developed abroad designed for installation on armored transports.

TABLE 4: Characteristics of Ground Navigation Apparatuses

Characteristics	"Amber-AM-Route"
Automatic calculation of coordinates with relative error, no more	1.5% (medium quadratic)
Drift of the gyroscope from the course	25 directional angle pick up/hr.
Automatic blackening out of traversed path on map	1:25,000 1:50,000 1:100,000
Weight of the apparatuses	156 kg

Path monitors with the introduction of path correctors are used in these systems to measure the paths traversed. A gyrocompass is used in the capacity of a directional angle monitor having a magnetic system which guarantees automatic output of the gyroscope axis in the measuring plane after 30 minutes.

Magneto-indication compasses with two indicating monitors have been used in some systems of navigation apparatuses, which are simpler in design than the gyrocompass.

The apparatus set usually consists of a path monitor, a gyrocompass, a calculator-determining unit (calculating instrument), and indicator unit (recording mechanism), a map case with a map (a course plotter), a course indicator and a feed source. The path corrector is introduced manually with a knowledge of the path corrector.

At the present time, apparatuses can be used on vehicles developing a speed up to 110 km/h. Moreover, errors in determining the course must not exceed 1 percent on the march extending 100 km.

Two types of map cases are used in navigation apparatuses:

- A map case with a rewind of a topographical map on rollers. A new setting of the light indicator is necessary with a traistion from one place on the map to another.

- Projection map case in which light photofilm is used with a map having scale of 1:50,000. The form of the signals given off by the calculating-determining unit to the projector provides the possibility of their transmission by radio.

The widespread installation of automatic equipment in the construction of modern tanks has greatly increased their technical completeness.

The creation of new tank automatic systems at the present level of the state of technology does not present great technical difficulties.

Increasing the technical completeness of the tank is only a partial solution to the problem of improving the tank's combat capability. No less important is training and preparing the personnel of armored forces. Only prepared specialists, well versed in all automatic systems, can guarantee their effective operation and at the same time increase the effectiveness of the tank's use in combat.

Section Six

COMMUNICATION FACILITIES AND INFRARED TECHNOLOGY

Par. 1: Communication Facilities

The tank crew executed its combat duties in the makeup of the subdivision. The tank commander directs them by radio. This is the reason there is a radio station installed in every tank (armored object). It guarantees the crew communication with the outside. Internal communication in the armored object between members of the crew is provided by the tank telephone (TPU).

External communication must make it possible for the commander to command subordinate subdivisions (tanks), provide communications with the commander-in-chief, and also interaction with the subdivisions of other type of troops. It is difficult to solve these problems with the aid of one radio station. Thus, an outside communication of the tank subdivision commander must be accomplished with not less than two radio stations installed in his tank.

Requirements made of the tank radio station, stemming from the character of modern warfare and the conditions under which the radio equipment is used. In the majority of cases, these requirements include the following: The highly maneuvering character of modern warfare makes it necessary to accomplish communication under movement at the maximum distance possible in the course of combat operations between the subdivision commander and the tanks. Under conditions of continuous conducting of battle, the tank radio station must provide communications at these distances both when standing still and when moving, in the day time or at night, at any time of the year. The work of the radio station at a distance, increasing the maximum possible distance between the commander of the subdivision and the tanks in combat, is not expedient, since the possibility will be excluded of repeating the communication frequency in other subdivisions and the possibility will be increased of mutual interference from radio stations of other subdivisions operation on these same freqencies.

Since tank subdivisions interact in the course of battle with each other and with subdivisions of other types of troops, radio stations are required having a general wave length and a sufficient number of operating frequencies for radio networks of all subdivisions. In addition, it is necessary to take into consideration the attempts of the enemy to disrupt communications and the command of troops by setting up radio interference. In order to maintain reliable communications under conditions of active radio interference by the enemy, it is necessary to reorganize radio-stations on reserve frequencies, which increases the requirement for the number of radio station frequencies still further. Reorganizing the radio stations on other frequencies comes up in different situations. For example, to establish communications with subdivisions of other types of troops and also when the tank is damaged, and its commander requires communication with other repair-evacuation subdivisions, In order that this reorganization be accomplished rapidly and simply, preliminary tuning must be provided for on several communication frequencies.

Inside communication in the armor plated object guarantees its commander the command of the crew and communication of crew members with one another. It is accomplished with the aid of a tank telephone, which must be switched over if the situation so requires (one or several crew members) with inside communication to the outside for work on radio stations.

The commander executes his tasks under complex conditions. He must continuously maintain radio communications with the subdivision, observe the battlefield and direct the troops. Thus, the tank radio equipment must be complete and reliable in use, have a minimum number of control organs and must not cause excessive overfatigue in operation. Fatigue of the crew members in working on the radio station is caused by continuously hearing reception noises in the telephones and increased attention to the summons of the radio correspondant. In order to avoid this, at the moment communications are interrupted, it is necessary to automatically disconnect the helmet phone from the transceiver of the radio station and switch to outside communication; and with the arrival of a call from the correspondant, again turn on the radio network. This requires a call indicator on the radio station from another correspondant. In addition, while conducting conversations it is necessary to suppress noise from the receiver.

Since the hands of the tank commander and of the other crew members are often occupied, the necessity arises of switching over the radio transmitter from reception to voice transmission.

The inside space of the combat compartment and tank driver's compartment is very limited. Thus increased requirements are placed on the overall dimensions of tank radio equipment. It must be minimum in volume and in its placement must not prevent the crew from successfully carrying out their duties.

Since the tank radio stations and the TPU guarantee control in combat, but it is very difficult to correct faults in the tank, high requirements are placed on the communications facilities as far as reliability and simplicity of operation are concerned. The design of the radio equipment, access to it and its preservation must be such that the possibility is practically excluded of failures occurring during operation.

In some armies, modern tank radio stations operate in an ultra-short circuit range in which the frequency modulation quality of the equipment and its range of activity practically does not depend on the time of day and year and is guaranteed at a maximum possible range between the subdivision commander and the tanks in the execution of any tasks.

So, in the US army, the tank radio station AN/VRC-12 operates in a range of 30 - 75.95 megahertz at the following distances: during movement up to 25 km, and when standing still up to 35 km.

In the West German army, the Fugt/sem-25 radio station is installed on the Leopard tank, operating in a range of 20 - 69 megahertz and providing communications up to a distance of 40 km.

In the ultra-short wave range of the radio station there are a sufficient number of operating frequencies (AN/VRC-12 has 920, and the Fugt-sem-25 has 880) for all tank subdivisions with consideration of the possible effect of radio interference by the enemy, when transition to a reserve frequency is required, and in order to preclude interference of radio stations from other subdivisions. A high degree of stability in the radio stations makes it possible to achieve stable radio communications on previously established fixed frequencies not only with a standing but in the case of a moving tank. Preliminary tuning of the radio station on several frequencies (AN/VRC-12 to 10 frequencies) helps in cases of necessity to transfer from one frequency to another and switch over the radio station from one radio network to another without additional tuning operations.

Tank radio stations make it possible to switch them over from reception to voice transmission in the Duplex regime and to liquidate the noise of the receiver by switching on the noise suppressor. Moreover, when conducting radio communications in the Duplex regime, the tank driver must be very attentive, because each word spoken by him automatically turns on the radio station transmitter and goes out over the air. This may lead to disrupting communications with other radio network correspondents. Thus, the given operating regime on a radio station is expediently used when the tank commander's hands are occupied. During the rest of the time, it is necessary to set up a Simplex regime in which the radio station is switched back and forth from reception to transmission by the tank driver with the help of a breast change-over switch. In this regime, the radio station can send tonal calls to its correspondent by pressing a special button.

This signal is heard by the tank (subdivision) commander on the receiver outlet of the correspondent.

Sometimes, the radio station is not allowed to transmit. This is necessary up to the start of active combat operations of a tank subdivision for the purpose of making it difficult for the enemy to find the location of the subdivision. During this time, the radio station must always operate on reception so that under conditions of sudden enemy attack, the commander-in-chief can immediately assign a task to a subordinate and direct him during the course of combat. For this purpose, the tank radio station has three operating regimes on duty reception, in which the comsumption of electrical energy is reduced due to which feed of the incandescent lamp filaments, not operating on reception, are turned off. If radio operation on transmission is required, it is necessary to switch over the type of work of the radio station from "on duty reception" position to "Simplex" position and warm up the transmitter lamp for one minute.

Turning on the noise attenuator of the receiver decreases the fatigue of the tank driver when working at the radio station, but together with this it decreases the communications distance for example one and one half to two times. This must be taken into account when communicating over a large distance.

All the control knobs of the radio station are situated on the front panel of the transceiver. The radio station is tuned successively on several set fixed waves. However, after the radio station is tuned in on the necessary number of waves, it is switched over from one frequency to another rapidly and simply with one fixed wave changeover switch.

In order to reduce the mutual inteference of radio stations located at one command point, a short distance from each other (up to 100 m), but operating on different radio networks, operating frequencies are designated for them with considerable dispersion. Radio communication is possible on neighboring frequencies in different radio networks without mutual interference if the radio stations included in them are not less than one kilometer from one another.

According to the opinion of foreign specialists, short-term (with signals) and clear operation on transmission makes radio reconnaissance of the enemy more difficult and provides more reliable communication. They think that in the Simplex regime, after transmitting the radio signal it is necessary to immediately switch over the station to reception, otherwise the carrier frequency of the switched on transmitter prevents communication between other correspondents of the network; in the Duplex regime, when transmitting a word it is necessary to pronounce smoothly, without extended (not more than half a second) pauses, in the course of which it is possible to automatically turn off the station transmitter.

The tank telephone mechanism consists of abonent /unknown/ apparatuses, breast changeover switches, helmet phones and plug in joints.

Apparatus No. 1 is intended to provide the tank commander inside communication with any member of the crew and for his work on radio.

Apparatus No. 2, connected to apparatus No. 1, provides execution of the same tasks for the driver. The other apparatuses make it possible to have inside telephone communication between members of the crew.

In case two radio stations are disposed inside the armor plated object, apparatus No. 1 set up on the charger and apparatus No. 2 at the commander.

A special relay is included in the switching part of apparatus No. 1 with the aid of which, when switching over the tangent of any chest changeover switch into call position, the telephones and throat mikes of the tank commander or driver, operating during this time on the radio station, are switched over to inside communication.

When the TPU is present on the vehicle, subscribers No. 1 and No. 2 control the radio station by pressing tangents of the chest change-over switch into position "prd" for operation on transmission and releasing it into center position "prm" for switching over to reception.

The radio equipment of the armor plated object must always be in full combat preparedness.

The impetuous development of radio electronics has made it possible in the present time to develop highly reliable, small-dimensioned and economical radio electronic equipment provide for transition multiple discrete active and passive elements to microminiaturized mono-units, fulfilling the same functions as in the conventional radio electronic units.

Radio electronic mechanism schemes executed from such mono-units of a solid body, have received the designation of solid schemes. In conventional schemes, a large part of the volume and weight is occupied by constructional elements, not part of the electronic process (panels, insulating and fastening components, layout of the outer design, encasing the radio components, the outlet system, etc.). Thus, the radio of the volume and weight of the active materials, directly participating in the electrical processes to the general weight and volume of the installation adds up to whole fractions of a percent. In addition, in conventional schemes, the compactness of the mounting does not exceed two or three elements per 1 cm^3. In solid schemes, the fraction of active materials is greatly reduced, which sharply reduces the weight and volume of the radio-electronic mechanisms. Together with this, the compactness in packaging the equivalent elements in them may reach 200 - 300 thousand per 1 cm^3, i.e., five orders greater than in conventional schemes. The necessity of providing for the heat system, design grouping of the scheme and other difficulties do not make it possible to obtain such a large gain factor in full measure, however a decrease of the overall dimensions by 200 - 300 times has practically been achieved with solid schemes in comparison with conventional ones.

The main merit of the solid schemes is their high operational reliability which is explained by the reduction, for example by three-fourths, of the inside unit soldered connections due to the use of an individual crystal monounit and the hermetic sealing of the active and passive elements of the scheme, which sharply reduces the moisture on them.

However, the cost of the layout on the solid scheme is higher than the cost of the layout on the conventional scheme. There are prospects for reducing it.

Consequently, using the solid schemes in radio equipment make it possible to sharply increase the reliability of its operation, reduce the overall dimensions and greatly simplify maintenance.

Par. 2: Infrared Technology

The night viewing instruments may serve as the chief means for providing secrecy of combat operations in the dark. Already at the present time, with their aid it is possible to drive combat vehicles on march and in combat, detect targets on the terrain and carry out night firing.

The night viewing instruments (Fig. 77) are based on the use of the infrared rays invisible to the human eye. They usually consist of three

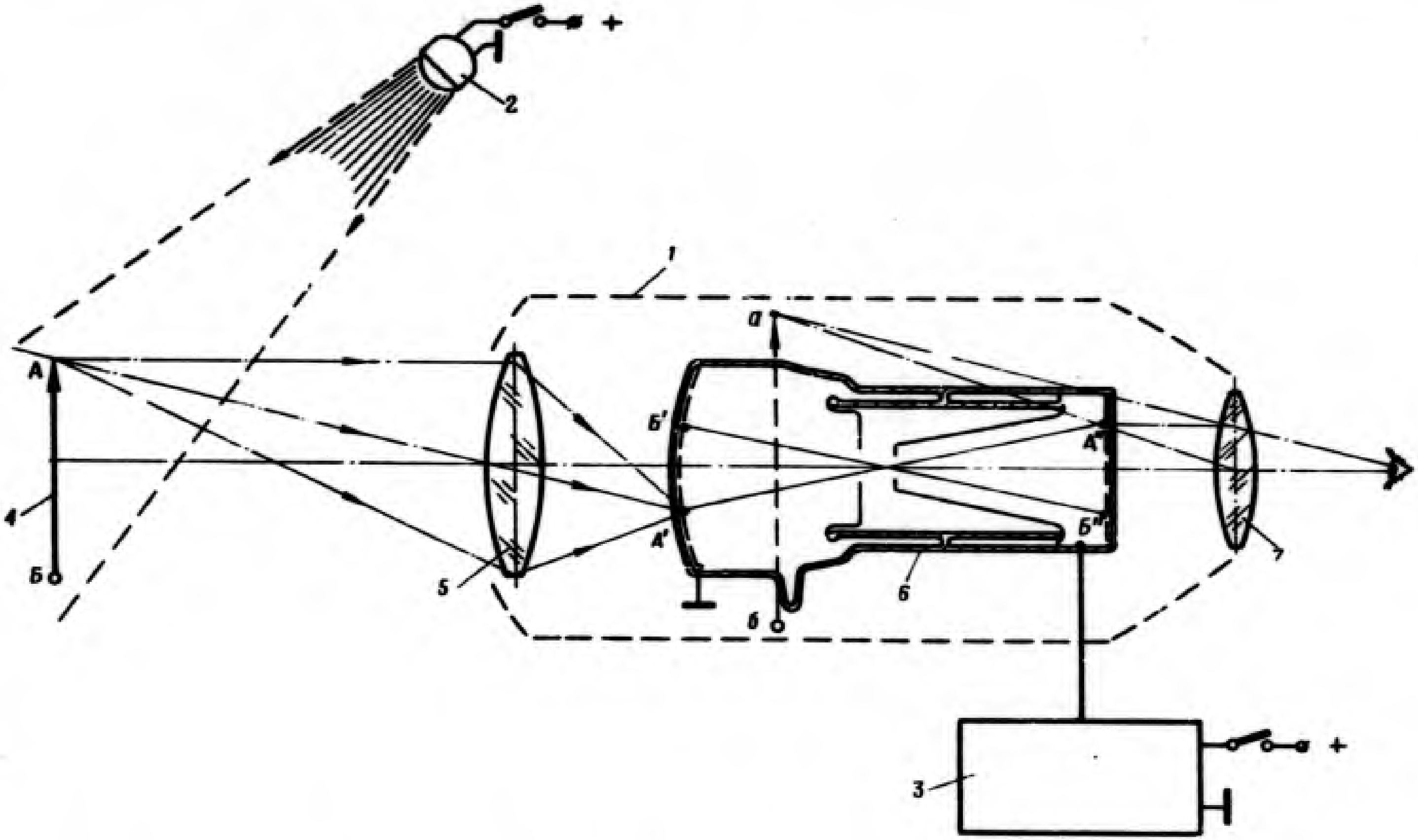


Fig. 77: Principle scheme of night viewing instrument. (1) - observation instrument; (2) - illuminator; (3) - feed unit; (4) - observation object; (5) - lens; (6) - electronic-optical converter; (7) - eyepiece.

basic units: an electron-optical instrument 1 for observation (sighting), an infrared illuminator 2 and a feed unit 3. The infrared illuminator irradiates the object 4 on the terrain with infrared rays and is characterized by conventional lights or projectors with special light filter in them holding back the visible light and letting through the infrared radiation. The infrared rays reflected by the terrain partially enter into the instrument and make it possible to carry out secret observation.

Fig. 78: General view of the helmet binoculars for night viewing. (1) - periscopic telescopes with electronic-optical converters, (2) - helmet; (3) - power unit.

The electronic optical instrument converts the invisible images of the terrain and target, constructed with lens 5 into infrared rays A 'B', with the aid of a special electronic-optical converter 6 into images A"B" visible to the eye. This image is observed by the observer through eye piece 7. The electronic-optical instrument operates only when a high voltage of 15-20 thousand volts is constantly connected to it, generated by the power unit.

Night viewing instruments have been executed abroad in the form of a binocular (Fig. 78) which with the aid of a hinged support is fastened to the driver's helmet, or in the form of a periscope (Fig. 79), solidly installed in the tank hull.

The infrared illuminator is disposed together with conventional headlights or projectors.

As has been confirmed by the foreign press, night viewing instruments may provide rapidity of movement for armor plated objects at night, approaching their moving speed over dirt roads in the day time. The range of operation of night sighting makes it possible to fire the tank cannon directly by the gunner.

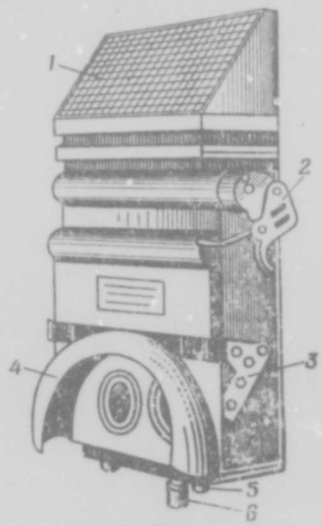


Fig. 79: General view of the periscope of the tank mechanical-driver. (1) - protective cap; (2) - lever for setting the periscope at the angle of elevation; (3) - fastening screws; (4) - forehead guar (5) - focusing regulator button; (6) knob for switching on high voltage conductor.

In the opinion of foreign specialists, the moving speed of armor plated objects and the firing range with night instruments is limited by a series of factors. These include the comparatively short range of operations due to the insufficient sensitivity of the electronic-optical converters and the limited power of the infrared ray sources. In addition, night instruments have a small field of vision and are sensitive to light interference.

Operating tank instruments of night viewing and sighting, having infrared illuminators in their assembly are not detected with the naked eye. However, it is impossible to conceal them from the enemy they are also making observations with night viewing facilities. Thus, in order to increase the secretness of troop operations, the foreign press recommends that when conducting columns, turn on the instruments on the lead tank, or the one following at a short distance. On all others, it is proposed to install special light indicators on board.

For sighting, the most prospects are in the variety of night viewing instruments, which, according to foreign combat specialists may operate according to natural night illumination without a special bias lighting. The exclusive sensitivity of such an apparatus is achieved due to the use of special electronic -optical converts and light power optics. But, the absolute secrecy of such facilities for night viewing will be combined with low protection against interference and large overall dimensions of the observing instruments.

Chapter III

WHEELED ARMORED VEHICLES

Section One

ARMORED VEHICLES

The problem of using wheeled armored vehicles for combat purposes arose simultaneously with the appearance of the automobile. Already in the First World War, in the armies of the basic warring nations, several hundred armored automobiles were used in tactical units (divisions, batteries, platoons).

The turbulent development of the automatic weapon and successes in the production of armor plating after the First World War created a basic for expanding the production of armored wheeled vehicles. Thus, in the Second World War, the scale for using wheeled vehicles of this type greatly increased. The total number of wheeled, armor-plated vehicles used by warring nations amounted to about 250,000. It is known that in the period of the Second World War more than 113,000 armored transports and armored automobiles were produced in the USA, among them about 40,000 half-tracks, in England, about 75,000 armored wheeled vehicles.

If only armored automobiles were used in the First World War, the tasks of which were to do battle with manpower and enemy firing points, then in the Second World War, armored transports were used for the first time along with armor-plated automobiles, to widely increase the maneuverability of the infantry which, by the end of the war, had become the basic type of wheeled, armored technical equipment. However, these vehicles did not turn out to be well suited for combat interaction with tanks. According to its technology and combat characteristics, the armored transport was only a transport means, and the infantry, on vehicles, could not actively participate in combat. As a rule, in order to conduct combat, the infantry rushed ahead and the official firing facilities of the armored transport were used to support the infantry.

The evolution of combat technical equipment created new means for conducting combat; the development of operational-tactical views on conducting combat operations in the post-war period led to a wider use of armored wheeled vehicles.

Significant changes in wheeled, armored vehicles as well as in track-laying vehicles were required when problems arose concerning the use of new types of weapons and when requirements were re-examined concerning the technical equipment of armored-tank troops in new conditions. According to these requirements, applicable to wheeled armored transports, it turned out to be necessary to adapt vehicles for moving through contaminated areas, to reduce the effect of the harmful factors of new types of weapons on the vehicle, as well as to increase the operational and tactical maneuverability of wheeled vehicles.

In the view of foreign specialists, the most important new requirement was principally the new approach to arming vehicles. The armaments must be suitable for combat not only with manpower, but with objects of armored tank technical equipment used by the enemy. The vehicle must make it possible for the infantry to conveniently and effectively participate in the combat. In other words, the question arose abroad concerning the development of a new type of vehicle -- an infantry combat vehicle.

Thus, the development of armored wheeled vehicles took place in stages, the armor-plated automobile, the armored transport, the infantry combat vehicle. It is thought that the basic type of combat wheeled technical equipment became infantry combat vehicles, however, no doubt armor plated automobiles and armor plated transports received further development for use as auxiliary combat vehicles.

The wheeled armor plated vehicle is massive, thus the production of such vehicles is closely connected with the automobile industry. However, since it is based on the automobile industry, contradictions arose between requirements for the design of aggregates and a system for combat vehicles, and for vehicles intended for the general economy.

History had it that in the first period of development, armored vehicles were made by placing the armored body on the chassis of commercial automobiles with very slight alterations of the chassis. This method of producing armored vehicles was successful only in the early stages of development of wheeled technical equipment. With an increase in tactical-technical requirements for vehicles, such a method, in a series of instances, led to discrediting the very idea of creating combat technical equipment on a wheeled basis.

At the present time, [illegible]s generally acknowledged that vehicles satisfying contemporary tactical-technical requirements must be produced on the basis of special aggregates and must have a specific composition. However, according to economic considerations, there must be a broader use of production efficiency and technology in the automobile industry. Also, aggregates and especially mass-produced vehicle components must be used wherever possible. An example of the armored transport, in which the aggregates of a series-produced truck are used to the maximum degree, is the first post-war Soviet armored transport the BTR-40 (Fig. 80). This armored transport retained the composition of the army truck with increased maneuverability (GAZ-63). However, it had a frameless design with a supporting body.

The armored transport was designed to carry ten men, and was equipped with a machine gun of normal caliber. The body of the armored transport is bullet-proof. In order to improve the dynamic qualities of the armored transport, the engine of the load bearing vehicle is boosted somewhat and its power is increased from 70 to 80 h. p. which makes it possible to increase the speed of the armored transport to 80 km/h. All the transmission mechanisms and the steering system are unified on the basic load-bearing vehicle.

Modern, highly mechanized armies require large expenditures of forces and facilities, which play a primary role even in more economically developed capitalistic countries, in solving problems of equipping armies with combat technical equipment. This explains the clear tendency of more closely combining the problems in developing technical equipment for use in the commercial economy with requirements set for combat technical equipment.

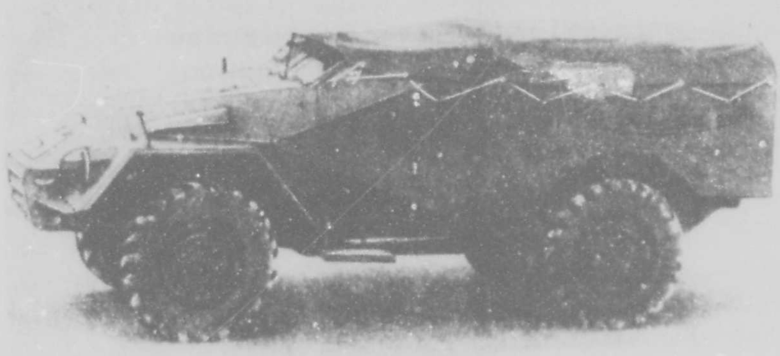


Fig. 80: BTR-40 Armored Transport

Thus, in the opinion of many foreign specialists, directly unifying commercial and combat vehicles on the level of modern requirements has not justified itself; there has been a tendency in the past few years toward reverse unification when, according to assignment and under the direction of army offices, designs were worked out for special chassis, the elements of which must form the basis for vehicles to be used in the commercial economy. Thus, in the post-war years, in order to increase the tactical-technical properties, some countries produced a large number of armored wheeled vehicles with a special composition and with specially developed basic aggregates. An example of such a vehicle is the French armored automobile "Panar" (Fig. 81).

Fig. 81: French Armored Automobile "Panar"

This armored automobile was executed according to a four-axle scheme with middle wheels of the tractor type which, when necessary, are lowered to the ground. The armor plated automobile is equipped with guns, reinforced armor plating (up to 40 mm) and has a maximum speed of 100 km/h. The engine, the transmission mechanism and the elements of the steering system are specially developed for this vehicle.

Still another example of the unified vehicle with a specially constructed chassis is the series of English three-axled vehicles (Fig. 82), including a series of armored transports, armored automobiles and modifications of army vehicles of which the transport amphibious vehicle, the "Sta l'vet" has attracted the special attention of specialists (Fig. 82, e).

A general uniformity may be noted in the improvement of combat army wheeled technical equipment which is characteristic for industrially developed countries. The basic tendency of this development is unification and standardization of the vehicle design elements, a tendency to increase the dynamic qualities and passability, among them to guarantee amphibiousness and the ability to surmount trenches; an increase in the protective characteristics of the body and a reinforcement of armaments are characteristic for armor-plated vehicles.

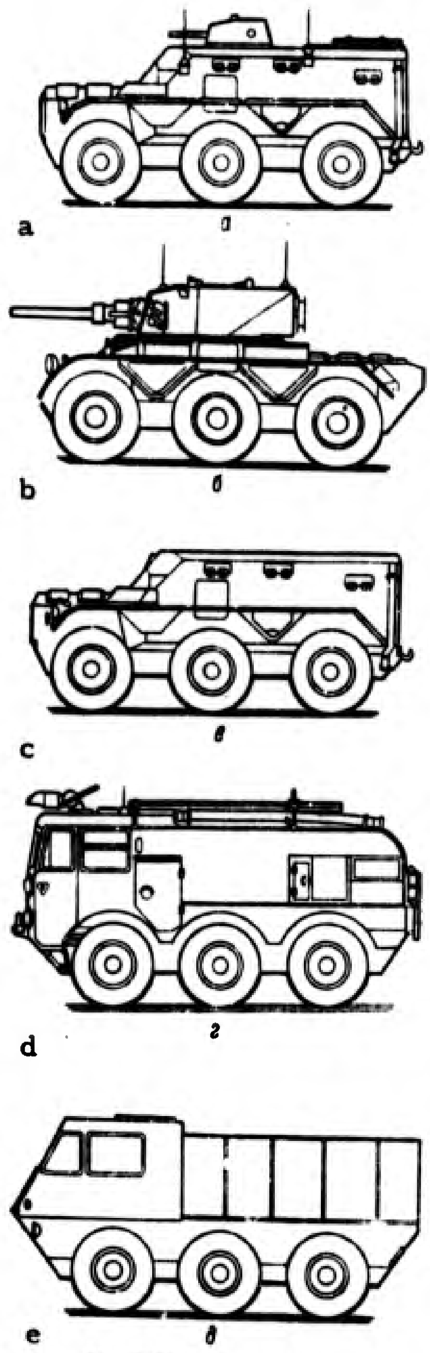


Fig. 82: Series of three-axled vehicles: (a) - "Saratsin" armored transport; (b) - "Saladin" armored transport; (c) - staff armored transport; (d) - "Salamander" fire-fighting vehicle; (e) - "Stal'vet" transport vehicle.

Work to improve combat and transport wheeled technical equipment is proceeding in the direction of improvind the aggregates and the system for maintaining the general transport scheme of wheeled vehicles, as well as searching for new schemes and constructional solutions.

Section Two

BASIC TYPES OF WHEELED, ARMORED VEHICLES

Armored wheeled vehicles are classified into three groups: armored automobiles, armored transports and infantry combat vehicles.

Armored automobiles (Fig. 83, 84) are designated for combat with personnel and firing points as well as with enemy armored objects. Comparatively high-powered equipment, reinforced armor plating and a small crew are characteristic for armor plated automobiles. The armored automobile is used to conduct reconnaissance, for keeping security and for moving communications officers forward.

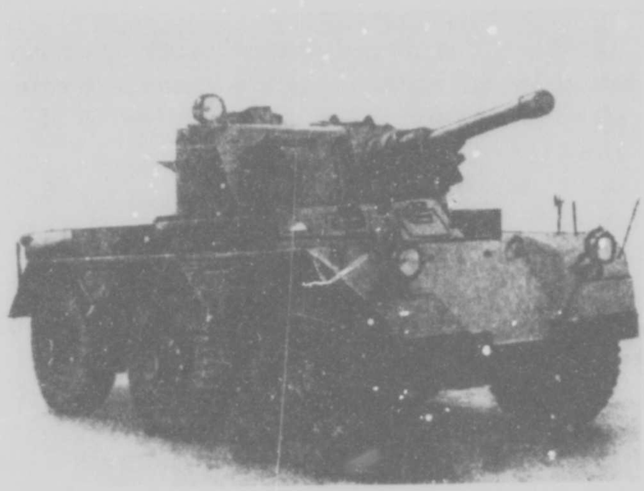


Fig. 83: English Armored Automobile "Saladin"

According to their weight, armored automobiles are classified into: light -- up to 4 t, medium -- 4-8 t, and heavy -- more than 8 t.

The light armored automobile usually has a machine gun, and lately it has had reliable weapons such as the antitank guided reactive missile. As a rule, the armor plated body is of the closed type, with a turret. Some designs are made with an open type armor plated body without a turret (for example, the English armored automobile "Ferret" FV-701 (c). The armor plating is bullet proof. The thickness of the armor plating is 8-12 mm.

Fig. 84: French Armored Automobile AML-245

The medium and the heavy armored automobiles have cannons and machine guns, supplemented by the antitank guided reactive missile. The caliber of the cannons set up on the armored automobiles is 75 mm. The armor plated body is of the closed type with a turret.

Sometimes turrets of light and even medium tanks are set up on heavy armor plated automobiles.

The armor plating on medium and heavy armored automobiles is different; the frontal plates on some armored vehicles guarantees protection from high-caliber machine guns and low-caliber cannons.

The thickness of the frontal armor plating of medium armored automobiles is 15-20 mm, side - 8-15 mm, bottom - 4-5 mm. Heavy armor plated automobiles have a frontal armor plating thickness of 30-40 mm, side 20-25 mm, bottom - 4-5 mm. The angles of inclination of the frontal plates are up to 70°.

Wheeled armored transports (Figs. 85, 86, 87) are basically designed to transport infantry to the field of combat, while, as a rule, infantry on the battlefield operate on foot. On the field of combat, the wheeled vehicles may be used only in favorable combat conditions and on good terrain. The wheeled armor-plated transports may also be used for conducting reconnaissance and for maintaining security. Depending on the number of personnel to be transported, they may have a small, medium or large capacity.

Fig. 85: English Armored Transport "Saratsin"

Wheeled armored transports with a small capacity include vehicles in which up to one division is disposed; if up to two divisions can be disposed, then the armored transport belongs to the medium type, and if more than two divisions can be transported, the armored transport belongs to large-capacity vehicles.

Machine-gun equipment is characteristic for wheeled armored transports, however in a series of instances it suppelements contemporary means for the struggle with armor plated objects. Sometimes, their equipment may be specialized to carry out determined tasks. For example, vehicles are in existence abroad with antiaircraft equipment, with antitank and chemical equipment, etc. The armored body is of the open (without a roof) or of the closed type; the latter is used most often. Their armor plating is usually bullet-proof.

In some cases, it is difficult to classify the vehicle as an armored automobile or an armored transport due to the common features of its basic characteristics (equipment, size of crew, character of use).

Wheeled infantry combat vehicles as well as the track-laying BMF, are designated for infantry combat operations under contemporary conditions.

These vehicles must have a high degree of passability, making it possible to move behind tanks under combat conditions, a thick armor plating and anti-atomic protection. The vehicle equipment must be adaptable for combat not only with personnel, but with objects of armored tank technical equipment on tanks used by the enemy.

a

b

Fig. 86: American Armored Transport "Commando"

(a) - General View of Armored Transport;
(b) - Armored Transport Afloat.

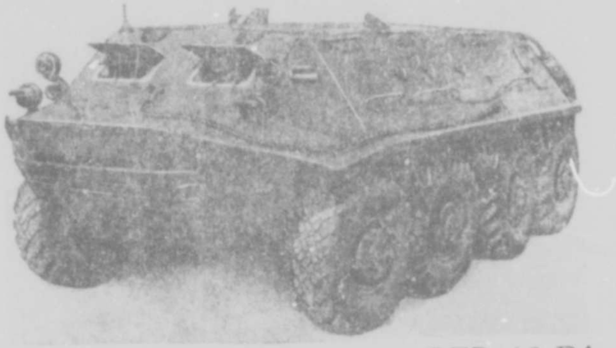
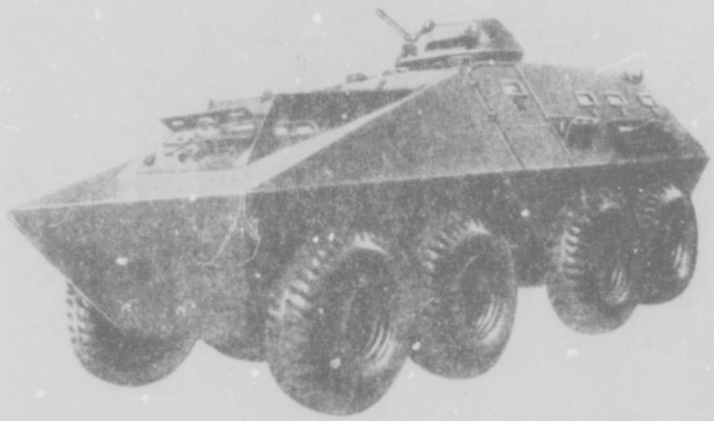
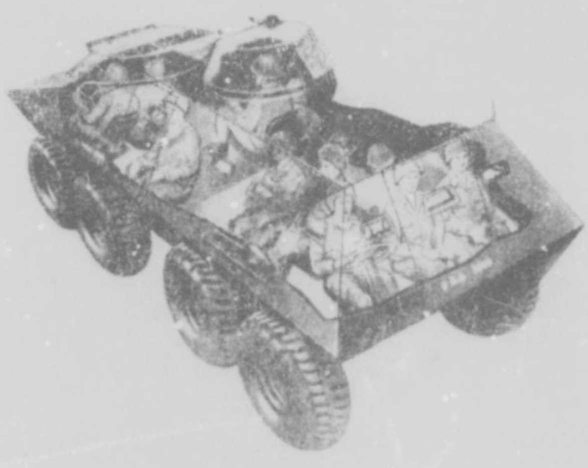


Fig. 87: Amored Transport BTR-60 PA



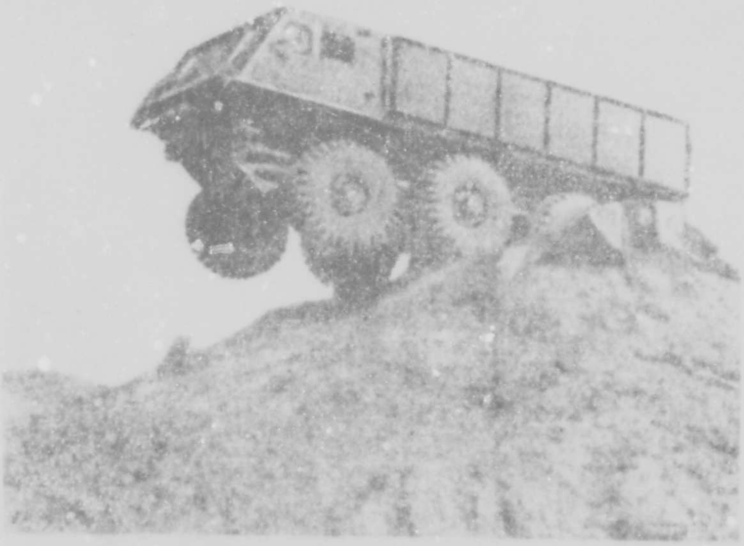
a a



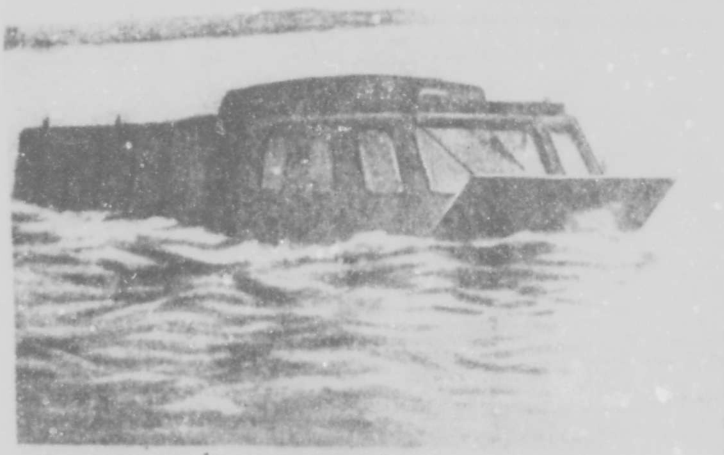
b б

Fig. 88: American Wheeled Armored Vehicle "Svot"

(a) General View; (b) Disposition of the Crew



a а



b б

Fig. 89: English Amphibious Army Automobile "Stal'vet" With Armor Plated Cabin

(a) Submounting an Obstacle
(b) The Vehicle Afloat

It must be possible to dispose from 10-15 men and they must be able to effectively participate in combat in the vehicle.

Thus, the wheeled combat infantry vehicle, combining the characteristics of the armored automobile and the armor-plated transport, is a new type of armor-plated wheeled vehicle. However, characteristics for these vehicles have not been established up to the present time. Work is being carried out in this direction. In the past few years, several types of armored wheeled vehicles have been produced in the USA which may to some degree concern wheeled infantry combat vehicles.

Quite recently the American four-axled amphibious armor plated wheeled vehicle "Svot" appeared (Fig. 88). In publications concerning this vehicle, it is pointed out that the vehicle is intended particuarly for participation in the attack operations of armored tank troops. It is characteristic that the vehicle equipment may include two three-barrelled anti-tank rifle-grenade throwers. The crew is able to actively participate in the combat. The vehicle has two steering columns (front and rear) to increase the maneuverability.

In addition to the enumerated types of armored wheeled vehicles, in the past few years, transport wheeled vehicles have been widely propagated with partial armor plating or with a hermetically sealed cabin, which also dictates use of transport technical equipment for the troops under modern conditions. The English army amphibious automobile with an armor plated and hermetically sealed cabin may serve as an example (Fig. 89).

Table 5 gives the tactical-technical characteristics of a series of foreign armored automobiles and armored transports.

TABLE 5: Characteristic Foreign Armored Automobiles and Armored Transports

Country	Vehicle Brand Name	Vehicle Type & Wheel Formula	Crew and Descent	Combat Weight, t	Armor Plating, mm	Equipment	
USA	M-8	BA 6×6	4	7,5	20—17—13	1 пушка 37 мм	cannon
USA	Commando	BTR 4×4	12	7,0	anti-machine gun	1 пулемет 12,7 мм 1 пулемет 12,7 мм 1 пулемет 7,62 мм	machine gun
USA	Chrysler	BA 4×4	4	6,7	anti-machine gun	1 пушка 20 мм	cannon
ENGLAND	Ferret Mk-11	Recon.* BA 4×4	2	4,32	11—8	2 пулемета 7,5 мм 1 пулемет 7,62 мм	machine gun
ENGLAND	Saratsin Mk-1	BTR 6×6	12	10,2	19—11—8	1 пулемет 7,62 мм 1 пулемет 7,7 мм 4 миномета	machine gun mine throwers
ENGLAND	Saladin Mk-1	BA 6×6	3	10,68	19—11—8	1 пушка 76 мм 2 пулемета 7,62 мм 4 миномета	machine gun mine throwers
ENGLAND	Chamber	BTR 4×4	10	5,64	anti-machine gun	ПТУРС[3]	antitank guided reactor missile
FRANCE	EBR-75 54-10	BA 8×8	3—4	15,2	40—16	1 пушка 75 мм 3 пулемета 7,5 мм 4 миномета	machine gun mine throwers
FRANCE	Panar EBR-ETT	BTR 8×8	15	13,5	40—16	2 башни с пулеметами	turrets with machine guns
FRANCE	AML-245	Recon.* BA 4×4	3	4,5	15—10	1 пушка 60 мм и 2 пулемета 7,5 мм	canon & 2 machine guns
HOLLAND	UR-104 DAF	Recon.* BA 4×4	3	5,4	anti-machine gun	1 пулемет 7,62 мм	machine gun
HOLLAND	UR-408 DAF	BTR 8×6	12	9,5	16—8	1 пулемет 12,7 мм	machine gun
GERMANY	Unimog	BA 4×4	2—3	4,8	anti-machine gun	1 пушка 20 мм или 1 пулемет 7,62 мм	cannon or 1 machine gun
GERMANY	HWR-07	BA, BTR SU 4×4	3	7,35	—	1 пушка 20 мм	cannon
SWITZERLAND	Movag	BTR 4×4	7	7,4	12—6 anti-machine gun	1 пулемет 7,5 мм	machine gun
SWITZERLAND	Movag	BA 4×4	4	8,5	12—6 anti-machine gun	1 пушка 90 мм 1 пулемет 7,5 мм	cannon machine gun
SWITZERLAND	Movag	BTR 4×4	12	10	anti-machine gun	1 пулемет 7,62 мм	machine gun

* Reconnaissance

1. There are data concerning the equipment on the Command Chrysler B361 engine with a power of 220 h.p., a variation of the equipment: 20 mm cannon and 100 shots.
2. A trench with a width of 3.2 m is surmounted with the aid of a small transportable bridge.
3. On the basis of the BTR Chamber-Homet with antitank guided reactive missile, 1961.

Dimension, m			Maneuverability & Passability									
Length	Width	Height	max. speed, km/h	rated crusing range, km	amphibious speed, km/h	climbing gradient, deg	Fording Depth, m	Trench Width, m	minimum turning radius	type & power of engine, hp	type of transmission	Type of Suspension and Tire Dimensions
5,0	2,54	2,29	90	644	—	32	0,81			carb. 110	mech.	Dependent
5,6	2,26	2,16	96—104	800—900	6,4	35	amphibious		7,5	carb.[1] 185	mech.	Dependent 14.00—20
5,26	2,44	2,1	104	480						carb. 191	mech.	11.00—20
3,84	1,91	1,88	72	300		30	0,9	1,2		carb. 116		Independent 9.00—16
4,85	2,52	2,44	70	400		33	1—1,8	1,5	7	carb. 160	hydro. mech.	Independent 11.00—20
4,9	2,52	2,26	70	400		30	1—1,8	1,5	7	carb. 160	hydro. mech.	Independent 12.00—20
4,93	2,045	2,12	64	400						carb.	mech.	Independent
5,56 (7.32 w/cannon)	2,44	2,54	100	600		32	1,2	2	7	carb. 200	mech.	Independent 14.00—14
5,61	2,44	[illegible]	105	650		32	1,2	2	7	carb. 200	mech.	Independent 14.00—24
3,68	1,93	2,18	100	650		32	1,1	0,8 (3,2)[2]		carb. 90	mech.	Independent 11.00—16
4,33	2,08	2,03	98	500		27	0,9		7,5	carb. 131	mech.	Independent 11.00—20
6,1	2,4	1,8	80	600		26	1,2		9	diesel 145 (232)	mech.	Independent 1.2: Dependent 3,4; 11.00—20
4,55	2,20	1,6 (w/o a turret)	96							carb. 90	mech.	
—			100							carb. 132		
5,31	2,20	2,20	85	300						carb. 175—8	mech.	
5,2	2,2	2,46	85	300						carb. 175—8	mech.	10.00—20
5,7	2,51	2,2	80	500	12—14		amphibious			carb. 175—8		Dependent 14.50—20

Section Three

COMPOSITION OF WHEELED ARMORED VEHICLES

As was pointed out in Chapter II, the general composition of combat vehicles was subordinated to the problem of obtaining its optimum tactical-technical characteristics.

The assumed composition of the vehicle largely determined its combat weight, its overall dimensions, passability, rational utilization of the inside volume and area, field of vision and convenience of conducting fire, inhabitability, etc.

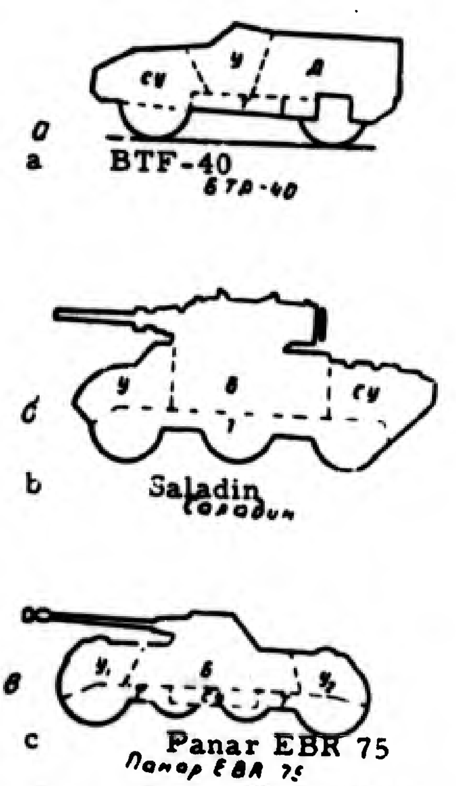
The basic component sections of an armored wheeled vehicle are the power unit, the steering, landing or combat; sometimes there is separate execution of the power and transmission sections (e. g. the BTR-60P).

Variations in combinations of infantry armored transports and armored automobiles are shown in Fig. 90, while the amphibious armored transports are shown in Fig. 91. In the case of the chassis of an armored vehicle, a determination is made as to where to place the power unit, and the type of engine, the type transmission is selected as well as the characteristics of the wheeled engine.

Power Unit. The power unit may be disposed in the front, in the middle or in the rear part of the vehicle. Each of these methods has its own merits and shortcomings.

Forward disposition of the power unit is usually used on armored automobiles and armored transports, executed on the chassis of army automobiles of high passability. The merits of such a disposition are use of mass-produced vehicle aggregates, simplicity of the drive mechanism, the steering system, the engine and basic transmission aggregates, rapid and convenient entering and leaving of the vehicle are guaranteed through the door and through the rear part of the body. However, in order to guarantee the necessary field of vision, in this case it is necessary to place the drive rather high over the engine which, in turn, leads to an increased vehicle height and to increasing the zone around the vehicle where firing cannot be done.

When the power unit is placed in the forward position, the working temperature conditions worsen, increasing the gas buildup of the crew compartment. Such a disposition of the engine often leads to overloading of the front axle. An additional difficulty occurs in the case of amphibious vehicles in that it is necessary to increase the water displacement of the front part. Moreover, the overall dimensions of the vehicle are increased due to lengthening the forward parts of the body which worsens the field of view still more from the driver's and commander's position (Fig. 91, a) and leads to reducing the forward angle of passability.



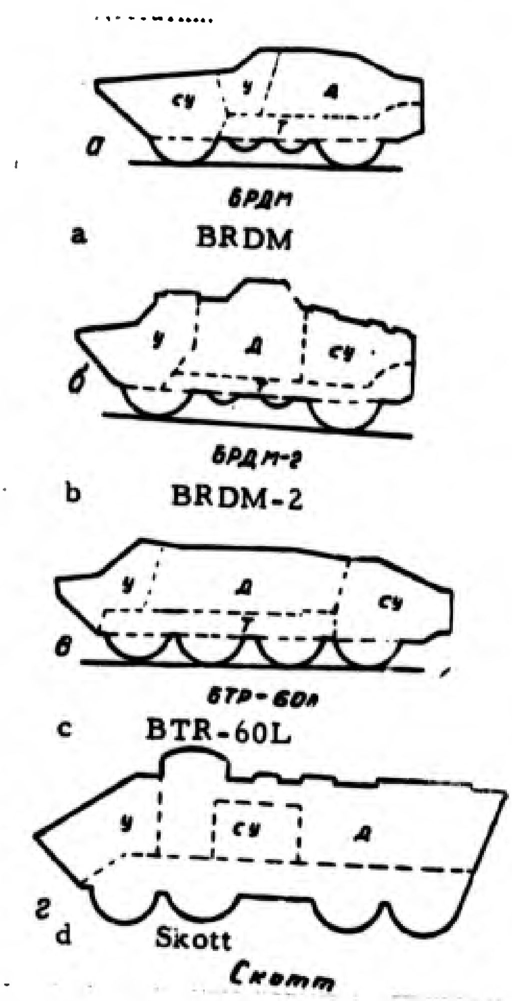


Fig. 90: Composition Variations of Infantry Wheeled Armored Vehicles.

Fig. 91: Composition Variations of Amphibious Wheeled Armored Vehicles.

Rear disposition of the power unit (Fig. 91, b, c) assumes a reduced unification of the aggregates and components of the mass-produced commercial vehicle. Moreover, the conditions for habitation are greatly improved when calculating the shape of the forward part of the body, the forward angle of passability is increased and the field of view from the driver's position is increased, reducing the area where the gunner is unable to fire. In the case of amphibious vehicles, fulfillment of the optimum differential is made easier on the stern when moving on water.

The disadvantages of such a disposition of the engine are complicating the drive mechanism, the steering system, the engine and basic transmission aggregates, since they must be executed at a distance (remote control), making it more difficult to organize exit through the stern; additional difficulties arise with regard to component sequence (disposition of the jet, disposition of the cooling system elements).

Disposition of the engine in the middle part of the chassis is utilized in a series of armor-plated vehicles ("Panar", "Skott").

Such a vehicle composition may achieve good results with the presence of a special engine with horizontal (opposite) disposition of the cylinders and a small height. Such an engine, for example is installed in the armored automobiles and the armored transports "Panar". The exceptionally small height of the engine (210 mm) makes composition easier, and makes it possible to obtain optimum component characteristics. The presence of such an engine makes it possible to give the armored "Panar" body a symmetrical, rational shape, and to guarantee comfortable disposition of two drivers at the front and rear driving posts.

If the engine is installed in the center part of the vehicle with vertical or V-shape disposition of the cylinders, then the driving and crew compartments turn out to be practically separate, which in a series of instances may create serious difficulties in combat use of the vehicle. Disposition of the engine in the center section requires careful hermetic sealing and heat insulation of the power compartment.

Independent of the engine disposition in armored wheeled vehicles, it is expedient to use small overall dimensions (according to height and length), i.e., preference must be given to an engine with horizontal disposition of the cylinders and V-shaped engines with a large cylinder angle.

In the practice of automobile design, sometimes two engines are installed on a vehicle chassis which is usually explained by the absence of one engine of required power and the possibility of using two comparatively inexpensive, mass-produced engines. As a rule, two similar engines are selected for this, but there are designs in which one of the high-powered engines is the basic one and the other engine with lower power is the booster and is turned on to increase the traction on the wheels in difficult road conditions. Sometimes the booster engine is used as an energy source to drive the auxiliary mechanisms and to charge the batteries. This guarantees operation of the basic engine only to move the vehicle.

The use of two engines has its positive and its negative sides.

The use of two engines makes it possible to use standard engines. Moreover, it is possible to use appropriate basic transmission aggregates of mass-produced vehicles. It is also thought that two engines somewhat increases the working life of the vehicle, since when one of the engines goes out of commission, the vehicle can still be moved. A series of domestic four-axle armored transports may serve as an example of two engines being installed on one chassis. Two engines are also used on some American armored automobiles (T-17F1, T-17E2). In all these vehicles, the engine is placed in the rear.

In the opinion of foreign specialists, the disadvantages of using two engines are complicating the transmission system and increasing the number of its aggregates, complicating engine operation and increasing the volume of technical maintenance. When two engines are placed in the rear, the stern section of the body is encumbered and the possibility is excluded of constructing a passage for exiting through the stern.

Possible arrangements for a vehicle with two engines are: one engine placed in the front part, the other in the rear part of the vehicle. Such a disposition of engines for armored transports makes it possible to guarantee exit through the rear. For armor plated automobiles and combat infantry vehicles, it is possible to organize front and rear driving posts.

It was pointed out above that the composition of a vehicle is determined not only by the disposition of the power unit, but also by the type of engine. In its contemporary form, the engine does not completely satisfy armored vehicle designers chiefly according to its weight and overall dimensions, according to its starting reliability in low temperatures as well as according to other characteristics.

In spite of the continuous improvements of piston engines, it is hardly possible to expect a sharp increase of their characteristics. Thus, in the past few years, as reported in the foreign press, intense work has been conducted in creating new type engines for use on combat and transport wheeled vehicles.

There is a real prospect in the near future for using gas turbine engines. At the present time, there is a large number of designs abroad for army wheeled vehicles with gas turbine engines, while economy-wise such engines do not yield to engines with carburetor engines of corresponding power.

Rotary engines are no less of a prospect for wheeled vehicles.

At the present time, the technological and constructional short-comings of the primary models of these engines have been overcome. The executed models of rotary engines for wheeled vehicles have, for example, 2 - 2.5-fold preference with regard to weight and volume in comparison with piston engines of the same power. Rotary engines have shown some prospects in their manufacture by a series of firms in different countries. The American NSU company installed the rotary engine in a series of light automobiles.

Interesting prospects are opened up by the use of so-called fuel elements making it possible to convert the chemical energy of the used fuel into electrical energy. At the present time, however, this idea is practically only in the stage of intensive development. According to some data, in the near future, it is assumed that the specific weight of the power unit with fuel elements will be reduced to the level of specific weights of standard engines.

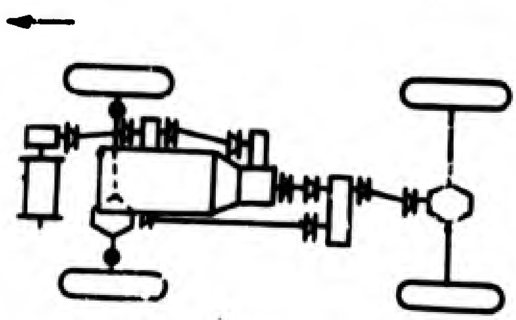
Transmissions. The composition of the transmission depends on the vehicle designation, the disposition of the engine and to what degree the armor plated vehicle is in present auto production.

The mechanical transmission system of wheeled armored vehicles is very different. When basing the armor plated vehicle on the chassis of a suitable army automobile, we use the conventional system with central (according to longitudinal vehicle axis) position of the basic transmission aggregates which is sometimes called the bridge system.

Such a system is used on a series of domestic armored transports with forward disposition of the engine, for example, the BTR-40, the BTR-152, the BRDM (Fig. 92). As already pointed out, such a system permits maximum utilization of the mass-produced aggregates. It may be used for vehicles with rear disposition of the engine (Fig. 93), however in this case the degree of using series-produced aggregates is somewhat decreased.

The use of the bridge system with dependent suspension leads to an increase in the general height of the vehicle, which together with the need to guarantee clearance between the bottom and the bridge beam within the limits of dynamic suspension movement, reduces the passability of the vehicle due to the low clearance under the crankcase of the main transmission. In addition, the possibility is limited for improving the amphibiousness of the vehicle due to heavy weight of the unsupported parts. If the bridge scheme is used with an independent suspension, then some of the disadvantages listed above can be avoided. For example, placing the main transmission inside of the body (BTR-60P) makes it possible to execute the bottom smoothly, and to reduce the weight of the unsupported parts.

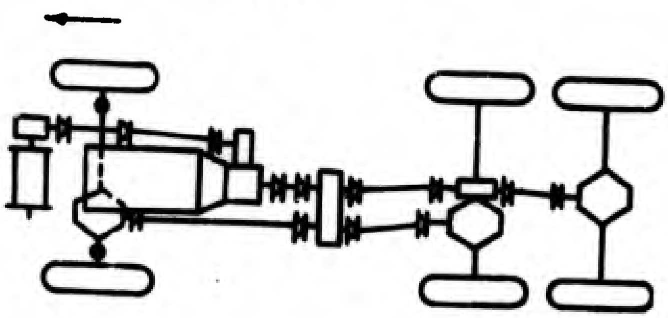
а



БТР-40

a BTR-40

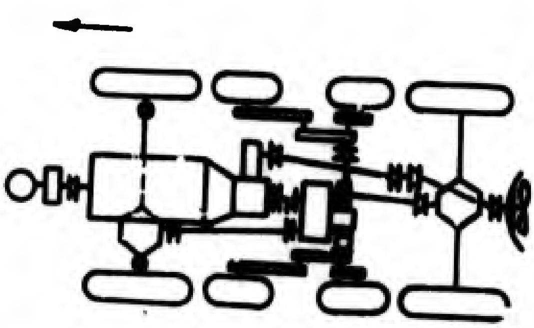
б



БТР-152

b BRT-152

в

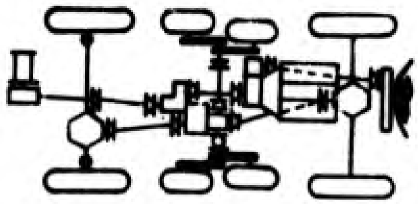


c BRDM

БРДМ

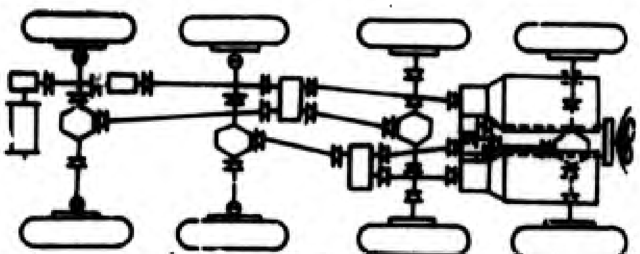
Fig. 92: Transmission Executed on a Bridge System

(With Forward Placement of the Engine)



БРДМ-2

a BRDM-2



b BTR-60P

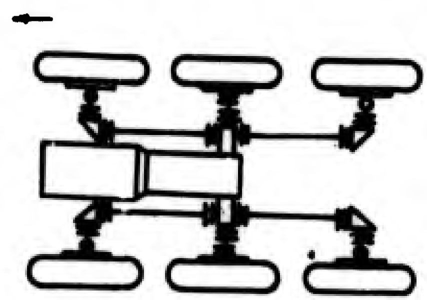
БТР-60П

Fig. 93: Transmission Executed on a Bridge

(With Rear Placement of the Engine)

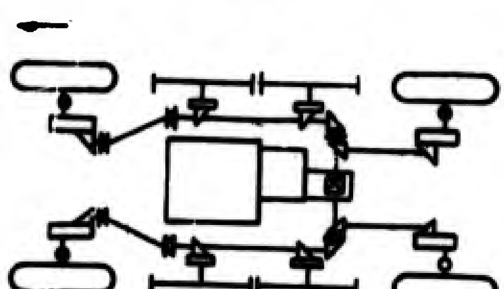
With an independent suspension, in principle the bridge scheme makes it possible to reduce the overall dimensions of the vehicle according to height in the case where the seat is disposed over the transmission aggregates along the longitudinal vehicle axis. However, in the case of the complicated transmission scheme (BTF-60P) when the number of aggregates is doubled and they are disposed over the entire bottom area, it is necessary to enclose the transmission section with a special floor. In connection with this, the general vehicle height is increased to the distance between the floor and the bottom.

In the past few years, many vehicles have been distributed with an N-shaped transmission scheme; sometimes this scheme is called the scheme with side distribution of the torque (side scheme). Fig. 94 shows a drawing of the transmission of the four-axles armored automobile "Panar" and a three-axled armored transport - the "Saratsin". These drawings are connected with the use of special transmission aggregates, with which it is possible to use only an independent suspension. The basic preference of the system is the possibility of reducing the overall vehicle height, due to which the floor of the crew compartment is in the bottom of the vehicle, and the descent seats are disposed over the transmission aggregates along the edge of the body. Such a composition may be considered expedient for armored transports in which infantry may be disposed with their backs to the edge of the body.



Сарацин

Saratsin



Panar

Панар

Fig. 94: Transmission Executed along the Edge

At the same time, such a scheme may cause the additional difficulty in composing combat infantry vehicles where it is necessary to dispose the personnel at the edge in order to conduct firing.

The side composition of the transmission leads to is complication, because the number of aggregates almost doubles.. Sometimes only one inter-edge differential is used to simplify the transmission in this system. However, in this case, the harmful circulation of force appears between the wheels of each of the edges, which leads to increasing the loss in transmission, increasing tire and aggregate wear. Thus, in a series of designs, provision was made for differentials between the wheels of each side of the disconnect clutch, making it possible, under good road conditions, to disconnect some of the drive wheels.

As has already been pointed out, the transmission scheme depends on the disposition of the engine. The bridge and side transmission system can be used in equal measure with front or rear disposition of the engine. When the engine is placed in the center part of the chassis, it is expedient to use the side system, since this makes it possible to greatly reduce the overall vehicle height.

The use of two engines in the rear makes it possible to use the bridge as well as the side transmission system. In the case of the bridge system, each of the engines leads to rotation of one-half of the leading bridges (BTR-60P); in the case of the side system, each of the engines guarantees driving of a wheel on one side. It is possible to combine the power of the two engines with the aid of swinging arms or a distributor box with subsequent transfer of the torque through general transmission onto all the driving wheels.

If two engines are used, one of which is disposed in the front, the other in the rear part of the vehicle, several variations of the transmission scheme are possible. The movement may be transmitted from the front engine (for example on the 1st and 3rd bridges), and from the rear engine onto the other bridges. Both engines can operate on a common distributor box from which all the leading bridges are driven. It must be noted that the realization of this sytem involves greatly complicating the remote control drive with the engines and transmission aggregates. Applicable to amphibious vehicles, such a disposition of the engines may cause some difficulty in drive to the jets.

The overwhelming majority of wheeled vehicles used in the armies have a mechanized transmission which for multidrive engines has a rather complicated result, and leads to an increase in mechanical losses and complicating the steering. Thus, the basic direction in the development of transmissions for wheeled vehicles, especially multidrive vehicles, is reducing the losses in the transmission and making steering easier.

Mechanical losses are reduced by increasing the efficiency coefficient of all transmission elements by means of technological and design measures on the separate units, selecting a rational transmission system, disconnecting or even raising a part of the driving wheels when moving under good road conditions (for example on the armored automobile "Panar").

In wheeled vehicles as well as in tanks, automatic controls are being used more frequently to facilitate control of the mechanical transmission. An automatic hydromechanical transmission is being used on many wheeled vehicles as a means to make control easier and to increase the mean moving speed. For multidrive vehicles, the perspectives are hydrovolume and electrical transmissions.

The question of using hydrovolume transmissions has been given a great deal of attention in foreign countries. A series of models of wheeled vehicles has appeared equipped with hydrovolume transmissions and auto-trains with active trailers. The hydrovolume transmission has a great compositional advantage, especially for multidrive vehicles, due to the inner housing of the body being freed of aggregates, characteristic for a mechanical transmission, and hydromotors situated near the drive wheels. The merit of such a transmission is also the possibility of one step changing of the tractive effort on the drive wheels, which is very important for increasing the pass-ability of wheeled vehicles.

A basic difficulty for wide propagation of electrotransmissions is their great weight and the overall dimensions of the traction motor which does not allow it to be disposed in the wheels and increases the weight of the unsupported parts. Thus, at the present time, such a transmission is used mainly on heavy class vehicles.

Running Gear. In the characteristics of vehicle composition, a great deal of influence is being lent to the wheeled running gear.

When selecting a wheeled running gear, we proceed on the basis of lifting capacity, guaranteeing the given parameters of passability and tractive properties, as well as considerations of combat viability.

The armored wheeled vehicle may be executed with two (4 x 4), three (6 x 6) or four axles (8 x 8).

The merit of double-axle vehicles is good use of the inside volume in the interaxle space, especially in the presence of only one pair of steering wheels. In addition, other advantages of double-axle systems are simplicity of the transmission and wide possibility for using aggregates of mass production vehicles, as well as simplifying the drive controls.

The indicated positive characteristics of the double-axle system led to repeated attempts to set up heavier vehicles on a double-axle basis (for example the English armored automobile AEC). These attempts are being continued at the present time. According to press reports, in Germany an experimental double-axle armored transport model has been created with a combat weight of 10 t and tire dimensions of 23.5 - 25.

The basic disadvantage of vehicles executed on the double-axle system is limited possibility for passability and especially for overcoming trenches. As is known, for such vehicles, the width of a trench to be surmounted does not exceed 2/3 of the wheel diameter.

Three axles are executed on armored vehicles of medium and heavy type (Soviet BTR-152, the English vehicles "Saratsin" and "Saladin"). The three-axle vehicle may be executed with converging rear bridges and controlled front wheels (BTR-152). Such a system has some compositional advantage in the use of volume and area.

In some designs of three-axle vehicles, the bridges are uniformly distributed along the base, and wheel control is executed with either two front bridges ("Saratsin") or outside bridges. As a rule, in vehicles with uniform distribution, the transmission aggregates are disposed along the side.

The three-axle vehicles with uniform disposition of the bridges has some preference in surmounting trenches. With good technical driving of such vehicles it is possible to surmount trenches of great width. In designing, it is necessary to take into account that the center bridge must be reinforced, because when surmounting the summit of an obstacle, all the weight of the vehicle is transmitted to the center bridge. The presence of guide wheels on the two bridges impairs the volume indicators of the composition.

The four-axle system is more characteristic for contemporary medium and heavy armored vehicles ("Panar", BTR-60P). This system is distinguished by the complexity of the transmission and the running gear. It is characterized by a comparatively large power loss in the transmission and the running gear (efficiency higher than 0.8). However, four-axled vehicles have been propaged more widely which is explained by their high degree of passability due to the possibility of transmitting a considerable degree of tractive effort with small specific pressures onto the ground. With such vehicles, the specific pressure on the ground approaches the specific pressure of track-laying tank engines (0.7 - 0.9 kg/cm^2). The four-axled vehicle is capable of overcoming trenches and ditches with a width of 2 - 2.5 m. The merit of this sytem is also that the combat viability of the vehicle is increased, since if one or two wheels on the vehicle are damaged, the vehicle can continue moving.

The compositional possibilities of four-axle vehicles depend on the disposition on the base as well as on the number and the size of the steering wheels. For example, with a shift of the bridges in pairs to the vehicle edges, the composition possibilities are improved with regard to use of volume, but at the same time the passability characteristics are made worse in regard to overcoming ditches and obstacles with a crest. In four-axled vehicles, it is often necessary to limit oneself to two pairs of steering wheels because increasing their number not only complicates drive control, but it increases the useful volume of the vehicle.

There are designs in which the problem arises of realizing the advantages of the four-axle design and at the same time reducing its disadvantages. It was pointed out earlier that on the four-axle "Panar" armored transport, when moving under good road conditions, the middle wheel can be lifted up, which considerably reduces the power losses during movement.

Studies made in the past few years show that an effective means for increasing passability is increasing the tire dimensions, especially increasing their diameter. In connection with developing the "Gouer" concept in the USA, it has been found that two wheels with a diameter of 1600 mm cost just as much as the coupling and tractive possibilities of ten wheels with a diameter of 1060 mm. The rolling resistance is decreased at the same time the wheel diameter is increased, which is especially important when moving over soft ground.

It should be noted that the idea of increasing wheel diameters in order to increase passability was realized on the majority of special army vehicles in all countries, although the overall dimensions were increased, the efficiency of the overall dimensions and weight was reduced, which complicated the technical maintenance of the tires, etc.

The tendency to eliminate the disadvantages, involving the use of similar wheels, led to the appearance of new vehicle systems, among them articulated systems. Along with increasing the tire diameter, there was investigation into creating the optimum tire profile and improving the grousers on their running parts. Wide profile tires, arched tires and pneumatic tires have appeared in the past few years. Without doubt these tires are being used on special vehicles with a high passability.

One of the basic disadvantages of wheeled combat vehicles is that the viability of the running gear is reduced on the field of battle. This problem arises at once, when wheeled vehicles with pneumatic tires begin to be used in a combat capacity. When conventional pneumatic tires are punctured or pierced by a bullet, it makes the vehicle practically unusable. The problem of creating bullet-proof tires has been solved in different ways. In the pre-war years, tires with fillers made of sponge rubber were rather widely used. However, they limited the moving speed and had other disadvantages in use, as a result of which they are not used on armored vehicles at the present time. Thick-walled tires, self-sealing tires and tires with sectional chambers were used, but these tires do not fully satisfy the set requirements and have not received wide distribution.

In the search for means to increase the passability of wheeled vehicles, we arrived at a system of regulating the pressure in tires. This system made it possible to increase the working life of the tire by pumping air into them when damage occurs.

The system of regulating the air pressure in tires did not completely solve the problem of working life, since when pierced by a bullet, the wheel rim of the system did not make up for the air leak. In the past few years, this problem has been solved in a number of countries by joint use of a system regulating the air pressure in tires and a special mechanism within the tire making it possible to continue moving the vehicle even at very low pressures. Annular supports, polyurethane fillers, etc., have been used as these mechanisms.

Fig. 95 shows some designs of modern bullet-proof tires. Thick-walled tires (Fig. 95, a), even with a large number of bullet punctures, make it possible to continue movement. However, these tires do not permit use of a air pressure regulating system, since due to the rigidity of the carcass, the tires contact surface with the ground is hardly increased when pressure is decreased.

Tires with elastic fillers (Fig. 95, b, c) also do not make it possible to regulate pressure and, in addition, they have the disadvantage of a high degree of heat emanation during movement. Fig. 95 d, e, show tires with elastic and rigid interiors to limit deformation. Intensive work is being carried out abroad to create new designs of bullet-proof tires.

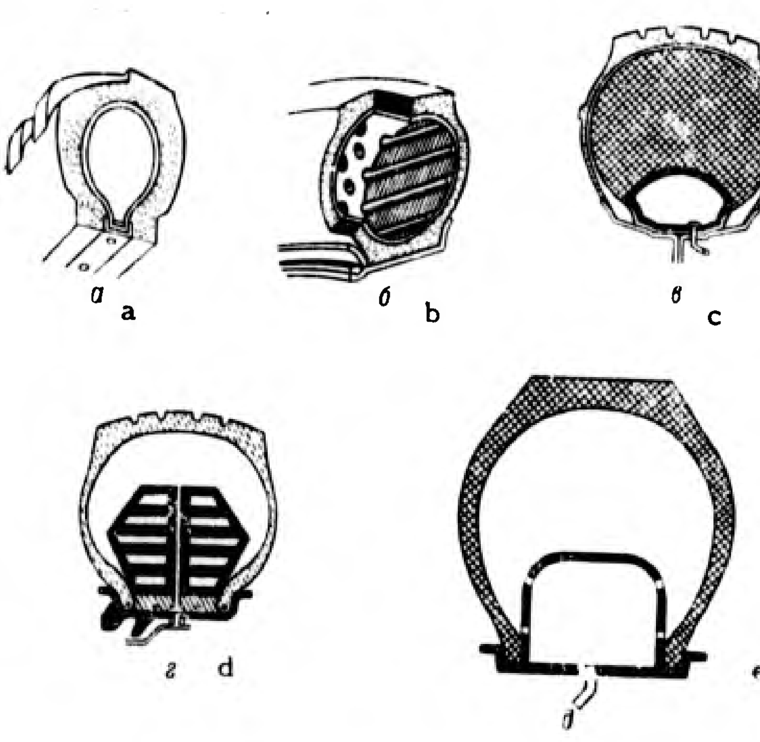


Fig. 95: Basic Types of Bullet-Proof Tires

The type of suspension used also influences the composition volume and the shape of the body. A characteristic special feature of the running gear of modern wheeled combat vehicles is the use of independent suspensions which guarantee better characteristics as to passability and vehicle amphibiousness (increasing the clearance and the smooth bottom). Among the independent suspensions, the use of systems with wheel oscillations in the longitudinal plane guarantees the largest inside volume. With this sytem, the suspension lever may serve as crankcase of the gear drive to the wheel, as this is executed, for example, in the "Panar" vehicle. With wheel oscillations in the transverse plane, the shape of the lower part of the body is complicated due to the necessity of constructing apertures for oscillations of the suspensions levers.

Supportive work is being carried out in the area of improving the elastic elements. The basic direction is the search for elastic elements having small overall dimensions with a high degree of energy capacity and non-linear characteristics. A great deal of attention has been paid to regulating the position of the body (clearance) for overcoming concentrated obstacles (tree stumps, rocks, etc.) or for the purpose of lowering the vehicle to the ground to camouflage it, as well as to guarantee protection against aircraft.

All this is very difficult to achieve with metallic elastic elements; hydrulaic, pneumatic and hydropneumatic elastic elements have greater prospects in this regard.

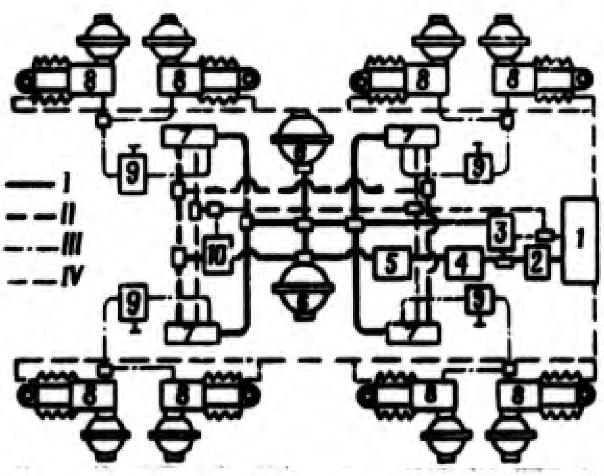


Fig. 96: System for Regulating the Position of the Body

I - pressure channels; II - channels for regulating the position of the body, III - channels for tracking the suspension system; IV - overflow channels, 1 - tank, 2 - pump, 3 - automatic discharge, 4 - filter, 5 - return valve, 6 - hydroaccumulator, 7 - position regulator, 8 - elastic elements, 9 - valves, 10 -cock.

Figure 96 shows one of the variations of the modern system for regulating the position of the body on a wheeled vehicle.

When the hydrosystem is operating, the fluid from tank 1 flows into the gear pump 2, which creates a pressure in the system. A parallel pump is connected to automatic discharge 3. Further on, the liquid, passing through filter 4 and return valve 5, enters the accumulators 6. From them the liquid reaches the position regulator 7. When reducing the distance between the wheels and the body, the regulators feed fluid into the elastic elements 8. When decreasing this distance, the liquid pours out of the elements through the regulators. The valves 9 guarantee transition to the unregulated suspension. The cock 10 makes it possible to set the body either in the lowest position (liquid from the elastic elements), or in medium position or in uppermost position when the clearance under the bottom of the vehicle is maximum.

Armor Plated Body: On modern wheeled armor plated vehicles, the armor plated body is executed in a supporting manner of the open or closed type. When composing the body, it is necessary to take the convenience of crew disposition and comfort of exiting into account, as well as requirements for the protective characteristics of the body and weight limitations.

Depending on the type and the designation of the vehicle, the relative weight of the body is 25 - 35% of the combat weight. The body is executed of welded armor sheets of various thicknesses. Fastening with bolts is used only for individual dismountable sheets, necessary for repairs and technical maintenance of the vehicle aggregates. The thickness of the armor sheets depends on the requirements made for protection of the weapons and the damaging factors of nuclear weapons. When designing the body, it is customary to take into account the reduced thickness of the armor, the connecting practical thickness with the angle of inclination of these sheets on the body.

For armored transports, the problem usually comes up of protection from rifle-machine gun fire within the limits of the course angle $\pm 45^{\circ}$ at all distances; thus the actual thickness of the armor plating on any part of the body usually amounts to 10 - 15 mm. The requirements for the protective characteristics of armored automobiles are higher, thus the thickness of the armor plating must be increased (up to 25 -30 mm). Still higher requirements are set for the protective characteristics on the body of an infantry combat vehicle.

In the majority of cases, the thickness of the side sheets on the body is about half that of the front sheets. The rear sheets are thinner even yet. The sheets on the roof and on the bottom of the body are the thinnest. The protective characteristics of the turret are equal to those of any part of the body.

In the design, it is necessary to rationally combine the protective characteristics with simplicity of body shape. For amphibious vehicles, the shape and the body dimensions must guarantee appropriate displacement and minimum moving resistance in the water; in particular, special attention is paid to the shape of the bow.

The inside volume of the body is combined with the volume of the power unit, driver's and crew compartments. For armored transports, the relationship between the volumes of the power unit compartment and the crew and driver's compartments depends on the type of the vehicle. The body measurements on a series of armored transports show that in the case of an overland armored transport, the volume of the power unit compartment amounts to 11 - 13% of the general inside volume of the body, and 87 - 89% is taken up by the volume of the descent compartment and the driver's compartment. In the case of armored transports, the volume of the power unit compartment amounts to 33 - 37% of the general inside volume of the body and accordingly 63 - 67% of the volume of the driver's and crew compartments. The increased volume of the power unit compartments on amphibious vehicles is explained by the necessity of guaranteeing its displacement in connection with the large weight of the entire equipment. The specific inside volume of the driver's and crew compartments depends chiefly on the capacity of the armored transport. For armored transports with a small capacity, the specific volume amounts to 1 - 1.5 m^2 and on armored transports of large volume it amounts to 0.5 - 0.6 m^3.

The area used directly for disposing the carried soldiers and the crew amounts to 30 - 40% of the general area of the armored transport for amphibious vehicles and 50 - 60% for overland armored transports.

The specific body weight calculated for one soldier amounts to 150 - 200 kg for overland armored transports with a large capacity, 250 - 300 kg for amphibious armored transports with a large capacity. For armored transports of a low capacity, it is 100 - 150 larger.

The armored body of the closed type has a series of hatches of different designations. The hatches for the crew to enter and leave can be placed in the rear part of the body, in the roof and in the sides. The disposition of the hatches in the side body plates guarantees facility entering and evacuation when the power unit is in front. When the power unit is in back, it is usually not possible to guarantee exit through the rear. In some designs it is possible to provide a narrow passage between the engine and the side of the body at the expense of disposing the engine at the side, however, this does not guarantee convenience of entry and evacuation.

Executing the hatches in the side sheets usually involves a significant reduction of body rigidity. Thus, these hatches are made with small overall dimensions, which creates inconvience for evacuation. In connection with this, when the engine is disposed in the rear, the hatches are usually put in the roof of the body. In addition to the entry hatches, hatches are provided for conducting fire with rifles, hatches are provided for maintenance, for ventilation, etc., according to the perimeter of the body. In some cases, there is an emergency hatch in the bottom of the body.

In the case of amphibious vehicles, the body is made water impenetrable; all the hatches must be reliably sealed.

The radiation protection of the crew is provided not only by the thick and inclined armor plating of the body, but also by other aggregates which are appropriately disposed. The crew compartment and the driver's compartment must be hermetically sealed for protection against the penetration of radioactive dust.

Modern wheeled armor plated vehicles must provide for an extended stay of the crew in the vehicle without a great deal of fatigue which requires that special attention be paid to their comfortable disposition in the body. For comfortable disposition of the crew members, the seat width must be not less than 400 - 430 mm, the depth 320 - 350 mm and the seat height from the floor 250 - 350 mm. The distance of the seats from the roof must be 900 - 950 mm.

The disposition of the crew (men) depends on the type and designation of the wheeled vehicle. Fig. 97 gives different systems for disposing the crew (men). For armored transports with a large capacity, the characteristic disposition of the crew is on seats along the inside wall (Fig. 97, a); for combat infantry vehicles, such a disposition is required which provides for a clear field of vision for conducting fire. In the disposition, it must be considered that minimum time be spent in entering and leaving.

The vehicle dimensions according to height are added up from the distance from the support surface to the bottom, from the bottom to the floor of the crew compartment (if the transmission compartment is isolated, for example as in the BTR-60P) and from the height of the crew compartment and the turret. If we assume the distance from the support surface to the bottom is 500 m, then the minimum vehicle height is 1600 - 1700 mm in the turretless variation with normal disposition of the crew and where the floor of the crew compartment serves as the bottom. The placement of the turret increases the vehicle height by 300 - 350 mm, and the presence of a transmission compartment between the bottom and the crew compartment floor increases it by still another 200 - 250 mm. The distance between the bottom and the support surface (with an independent suspension), is mainly determined by the necessity to provide for wheeled vehicles with a large clearance, as well as tanks for sure movement on tank tracks.

To a considerable degree, the body width depends on the selected track, the disposition of the crew, the equipment and some other factors. On modern wheeled armored vehicles the width of the track, as a rule, for medium and heavy vehicles is assumed to be near to that of the tank, i.e., 2200 - 2400 mm. In this case, it is possible to execute the vehicle at the width which provides sufficently comfortable disposition of the crew and of the equipment. However, the maximum body width is limited to the overall dimensions either according to railroad transportation or according to the requirements of aviation transport vehicles. On the majority of vehicles, the body width reaches 2750 - 2900 mm.

The vehicle length is determined on the basis of the wheel formula, the wheel dimensions and their disposition. The vehicle capacity has an influence on the overall length of armored transports. The specific vehicle length for one soldier is 0.37 - 0.8 m; the larger the capacity, the smaller the specific length. The specific length for armored transports amounts to 1.3 to 2 m.

Control. Modern combat vehicles are equipped with a large number of different mechanisms and systems which require remote control. In addition to controlling the turning of the wheels, the brakes, the engine, the gears in the transmission, modern combat vehicles must be directly controlled by other mechanisms; the differential, the drive propellor and the jet baffle, the wave deflector panel, the air pressure regulator in the tires, etc. This involves a great deal of physical effort. Thus, at the present time, there is a clearly expressed tendency to mechanize and automate control processes. Hydraulic, pneumatic and electrical drive mechanisms have received the widest dissemination.

Section Four

ADDITIONAL EQUIPMENT FOR WHEELED ARMORED VEHICLES

Modern wheeled armored vehicles are equipped with different mechanisms and systems designed to increase the combat and technical qualities of the vehicle.

Additional equipment includes mechanisms to increase its capability to overcome various obstacles when moving along impassable roads, equipment for overcoming water barriers, equipment to facilitate driving and creating conditions for extended stay of the crew in the vehicle, equipment to increase vehicle protectiveness.

In order to increase passability on soft ground and the ability to overcome various obstacles when moving over difficult to pass roads, the vehicles are equipped with systems regulating the air pressure in the tires, powerful winches or capstans, suitable for overcoming trenches.

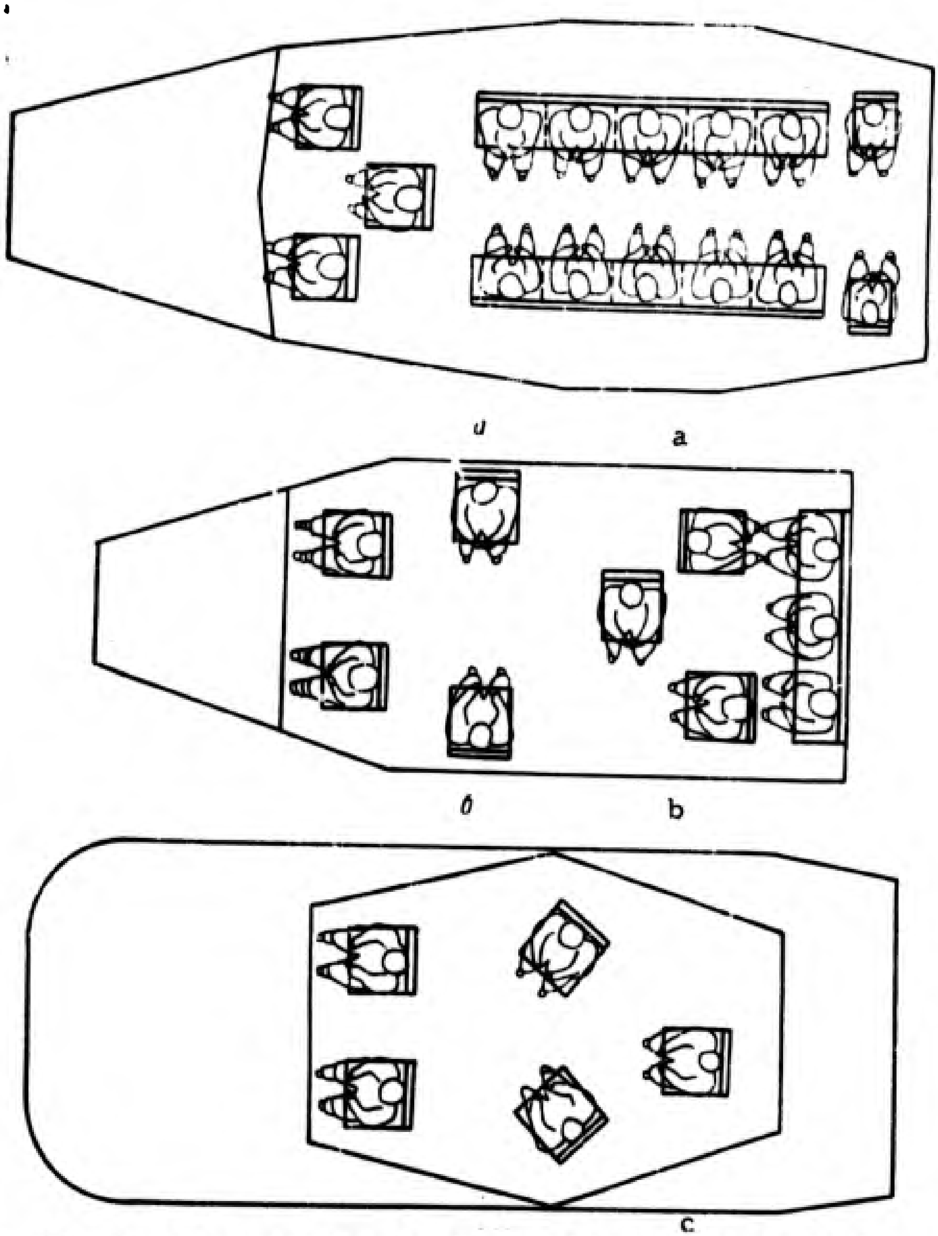


Fig. 97: Drawing showing the disposition of the crew and the soldiers being carried.

As was already pointed out, for two- and three-axled wheeled vehicles, the width of the trench to be overcome does not exceed two-three times the wheel diameter, i.e., 0.7 - 0.8 mm. For overcoming wider trenches, two-axle wheeled vehicles are sometimes equipped with additional equipment. For example, the Soviet armored vehicle BRDM is equipped with two pairs of additional lifting driving wheels of small diameter, disposed between two basic wheels on either side. Usually, the supplementary wheels are located in raised position, and the vehicle is moved on the basic wheels. When overcoming trenches, the supplementary wheels are lowered, the drive mechanism being connected to these wheels from the transmission, as a result of which the vehicle has four driving wheels on either side which permits it to overcome very wide trenches.

Modern foreign double-axle armored automobiles, the "Ferret" and the AML-245, are complemented with special composite bridges, the use of which makes it possible to overcome a trench with a width up to 1.5 - 3 m.

One of the basic devices for increasing vehicle passability on soft ground is a system for egulating air pressure in the tires. The internal air pressure should correspond to the condition of the supporting surface. There is an optimum internal pressure for each type of ground surface and type of tire, guaranteeing the optimum indicators according to tractive power realized and wheel rolling resistance.

Fig. 98 shows a system for regulating the air pressure in the tires of twin-axle vehicles. The system provides automatic maintenance of the givern air pressure, disconnecting wheels from the system and regulating the pressure in each of the wheels individually. The optimum inside pressure values and moving speeds for the different supporting surfaces are given in Table 6.

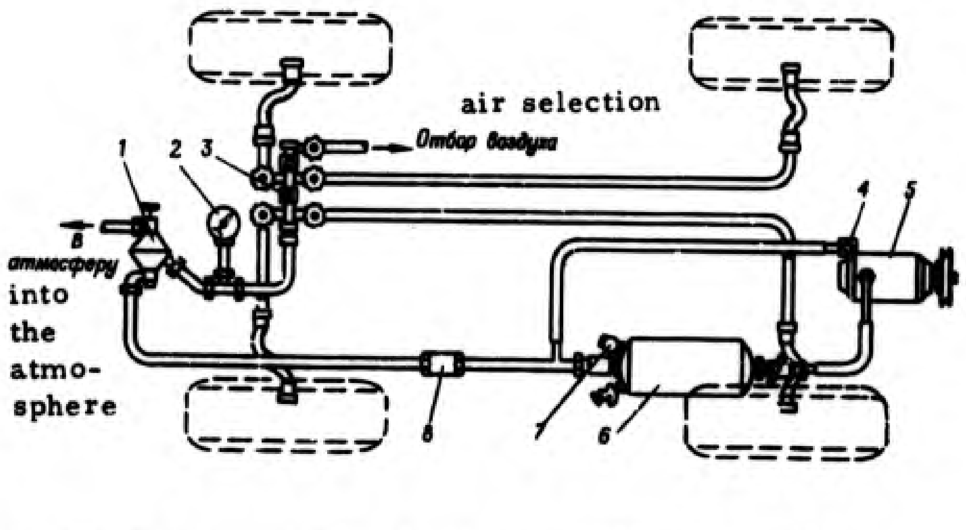


Fig. 98: System for Regulating Air Pressure in Tires

1 - Control cock; 2 - Pressure gauge; 3 - Tire cock unit;
4 - Pressure regulator; 5 - Compressor; 6 - Receiver;
7 - safety valve; 8 - Return valve.

TABLE 6: Pressure and Moving Speed Values for Different Support Surfaces.

Characteristics of the Supporting Surfaces	Air Pressure in the Tires, kg/cm^2	Moving Speed km/h
Smooth dirt roads in dry condition	2.5 - 3	to 60
Double layer ground: dirt roads with water-logged upper layer, ground in poor condition	2.5 - 3	to 40
Dirt roads not smoothed down, virgin soil with turf cover, dense sand	1.5 - 2	30 - 40
Loose sand, plowed field in wet condition, snowy virgin soil (snow packed down)	0.7 - 1.3	10 - 20
Swamp regions	0.5 - 0.7	to 10

Providing amphibiousness is one of the basic requirements for modern wheeled armored vehicles.

For overcoming water obstacles the wheeled armored vehicles, just as the track-laying vehicles, have a water-impenetrable body, a water-passable engine (more frequently a jet since we are assuming the use of vehicles on shallow water), a water pumping system, rescue and other equipment, facilitating use of the vehicle on water.

When using a water-passable engine, the vehicle speed on the water reaches 10 - 12 km/h. If a special water-passable engine is not installed on the vehicle, it can move with a speed of 3 - 4 km/h on still water at the expense of vehicle rotation.

For driving, making observations and for firing under night-time conditions, modern wheeled vehicles are equipped with appropriate infra-red technical equipment, including equipment for the driver, the commander and those firing the basic vehicle weapons.

A great deal of attention has been paid to guaranteeing an extended stay of the crew and of the troops being carried in armored transports. The vehicles are equipped for this purpose with heaters, filter-ventilation equipment and, in some cases, air conditioning equipment; provision is made for keeping food in the body, disposing the troops and other equipment required for favorable living conditions of the crew.

Navigation equipment is used for orientation while moving.

Increasing the protective characteristics of the vehicle and providing the opportunity to move through contaminated areas is achieved by means of appropriate protective facilities. The vehicle is also equipped with instruments for indicating chemical and radiation conditions.

For combating fires, the vehicle is equipped with effective fire-fighting equipment, which is often automated.

It must be noted that in regard to inside equipment, supplementary equipment and equipment increasing the protective characteristics of the vehicle as well as according to observation facilities, sighting equipment, communications equipment and camouflage facilities, the equipment of modern wheeled vehicles is tending to be unified with tank equipment.

Section Five

NEW SYSTEMS FOR WHEELED VEHICLES

In spite of the significant improvement of individual aggregates and systems, it is hardly possible to expect a large qualitative jump in the development of wheeled vehicles with traditional systems. Thus, wheeled technical equipment has also developed along paths searching for new solutions and working out new principles for design systems.

The fact is that the growth in the qualitative indicators of wheeled vehicles, executed according to traditional systems, is somewhat limited. For example, the maneuverability of wheeled vehicles, especially multi-axled vehicles, is limited by their turning ability, determined by the minimum turning radius. The possibility is also limited for such vehicles to overcome vertical obstacles, and only four-axled vehicles are reliably suited to overcome ditches and trenches. Thus, in order to fulfill the requirements made above, and in order to eliminate the the disadvantages of conventional traditional systems, work has been carried out to seek new vehicle systems and to create engines with new qualities.

Considering the fact that wheeled armored technical equipment is based on the achievements of the automobile industry, new achievements are being examined abroad in the area of automobile technology as new paths for further improving armored vehicles. Let us point out some basic directions which seem promising.

Medium vehicles, having an unconventional design system, offer the possibility of overcoming high vertical objects, include the "Metrak" and the "Flekstrack", developed in Switzerland. The basic special design feature of the "Metrak" automobile (Fig. 99) is that the front and rear parts are hinged to the center axle. This makes it possible for each part of the automobile to turn with regard to the other in a vertical plant at an angle up to 30°. Such a design makes it possible for the vehicle to overcome essentially vertical obstacles. In addition, it makes it possible to move at a slant, maintaining the horizontal position of the vehicle body and the cabin at the expense of lowering the wheels on one side of the vehicle. Along roads with a solid surface, the automobile moves with the center axis raised a little, in this case front guide wheels. The automobile can turn at a small radius with the front or the rear wheels raised, at the expense of braking one of the wheels of the middle axis. Using such a turning principle makes it possible to obtain new vehicle qualities with regard to turning ability.

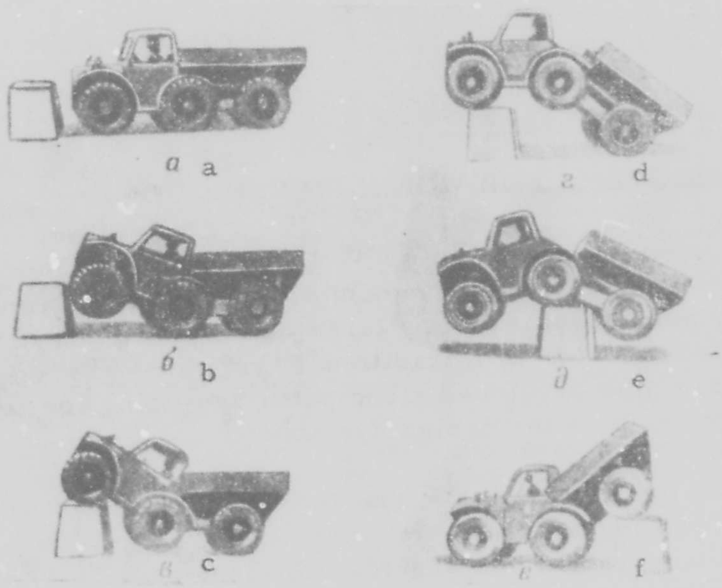


Fig. 99: Wheeled Vehicle "Metrak" with Hinged Frame (Overcoming a Wall).

Fig. 100 shows a vehicle with a high degree of passability, the basic design special feature of which is the possibility of steering by shifting the wheels, as a result of which the vehicle can overcome essentially vertical obstacles, move at a slant, maintaining the vertical position of the body, etc.

A series of articulated vehicles have appeared in the past few years

Fig. 100: Wheeled Cross-Country Vehicle "Go Devil" (Overcoming an Obstacle).

consisting of two or several elements. In the opinion of foreign specialists, the prospects for an articulated system are determined not only by the possibility of improving the turning ability and the passability of vehicles of this type, but by a series of advantages in the tactical regard. These advantages include increasing possibilities for air transport, the possibility for quickly repairing a damaged vehicle at the expense of complicating the engine and trailer elements of the vehicle which are in good working order.

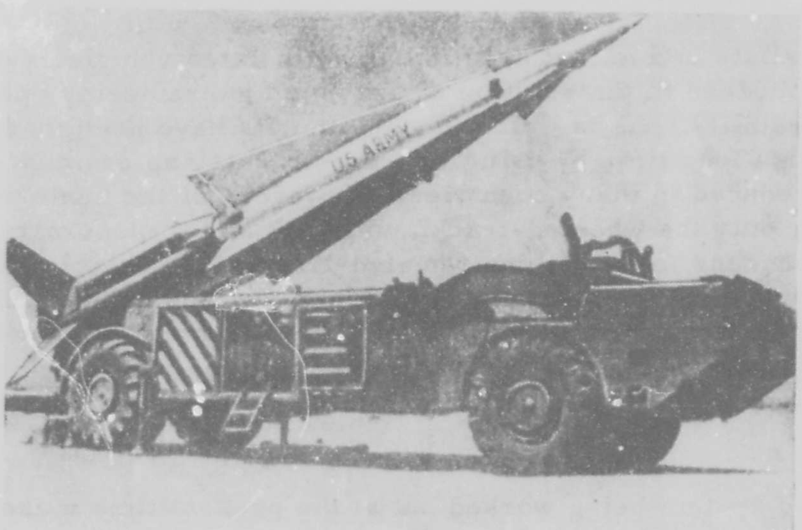


Fig. 101: "Gower" Vehicle with Rocket System

In the USA, a complex of vehicles with a combat designation has been developed for more than 15 years already which are executed according to the articulated system ("Houwer" concept). The "Houwer" vehicle (Fig. 101) consists of a single-axle tow car and a single-axle trailer attached to it. Such a connection makes it possible to change the direction in which the vehicle is moving without turning its steering wheels, as is the case with conventional vehicles, but by turning the entire front element of the vehicle relative to the rear element at an angle of up to 90°. The turning mechanism has a hydraulic drive. The absence of a frame, suspension and the use of a supporting body on the vehicle makes it possible to increase the useful weight coefficient and the volume. On the "Houwer" vehicle, the bottom of the vehicle body is made smooth which, and combined with the large wheel diameter and the absence of suspension, makes it possible to increase the clearance up to 610 mm and to greatly improve passability.

The broad dissemination of the "Houwer" concept on the vehicles of different designations is limited by the comparatively low maximum moving speed (40 km/h). We have information that at the present time, this sytem is being improved at the expense of introducing a suspension, as a result of which moving speed can be increased.

Fig. 102 shows tha amphibious articulated vehicle "Gama Goat" (USA), consistinf of a double-axled tow car and an active trailer. When moving under good road conditions, it is steered with the center wheels, while under bad conditions, it is steered with all the wheels. The automobile can overcome a vertical wall 0.66 m. It is air-transportable and is capable of being dropped from a parachute. The use of the articulated system and the supporting automobile body makes it possible to obtain a high useful weight coefficient for this vehicle.

Foreign specialists belive that creating an articulated vehicle system makes it possible to proceed to the solution of problems guaranteeing operational and tactical maneuverability. As is well known, attempts have been made to solve this problem for a long time by using wheeled-tracklaying engines. Such vehicles have been produced in many countries. However, of the numerous experimental models, only the wheeled-tracklaying tank and transporters have been used. Lack of success in developing wheeled-tracklaying vehicles have been connected with tendencies to provide for two fully-dimensioned running gears, wheeled and track-laying with independent drive systems and control systems for each of these running gears. Naturally, this led to a considerable complexity in design and to an abrupt curtailment of the inside useful volume of the vehicle.

The articulated system being worked out at the present time makes it possible to return to the idea of a wheeled-tracked vehicle without especially complicating the design of the wheeled vehicle which was based on the method. In such vehicles, a light tracked strip is slipped directly over the wheel of each composite vehicle element and the vehicle can be steered at the expense of interchanging the positions of the vehicle elements. By way of an example of an articulated vehicle of this type, Fig. 103 shows the American XM-549 vehicle ("Guad Trak") with a lifting capacity of 4.5 t. At a characteristic weight of 6.8 t, the vehicle has a high degree of passability at the expense of a large clearance (620 mm) and a small specific pressure on the ground (0.3 kg/cm^2) when moving on tracks. Under satisfactory road conditions, the track is transferred to the vehicle body.

Fig. 102: Articulated Vehicle "Gama-Goat"

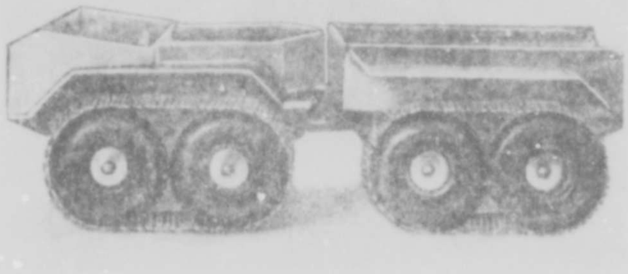


Fig. 103: Articulated Vehicle XM-549 ("Guad-Trak")

Fig. 104: Wheeled-Tracklaying Vehicle "Rover"

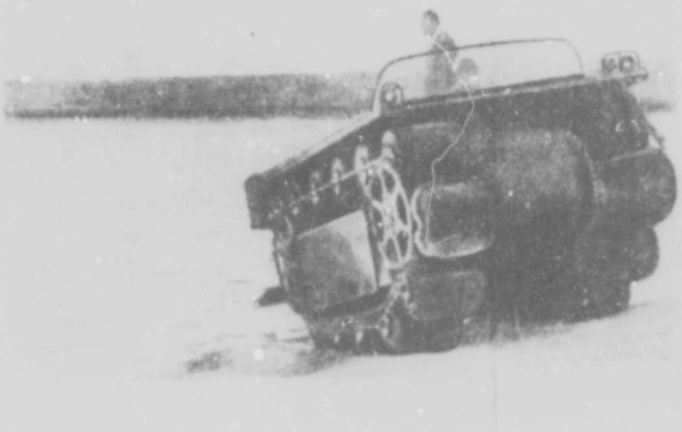
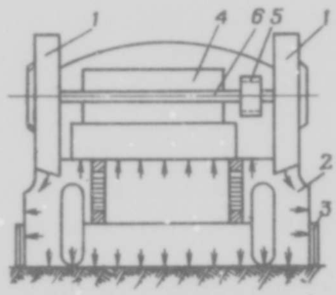


Fig. 105: "Arol" Vehicle with Wheel-Tracklaying Running Gear

The tendency to utilize the merits of a wheeled and a tracked running gear on one vehicle continued to attract the attention of designers in various countries. In the past few years, a series of original running gear designs has appeared on the "Rover" (Fig. 104) and the "Earol" (Fig. 105), the majority of which are still in the experimental stage.

a a



б b

Fig. 106: Vehicle with Partial Weight Removal from The Wheels with the Aid of an Air Cushion

a) - general view; b) - method of operation.

1) - ventilator; 2) - skirt; 3) - strip; 4) - engine; 5) - transmission; 6) - shaft

On the "Rover" vehicle it is possible to replace the wheels with tracks.

The special feature of the wheeled-tracked running gear of the "Earol" is the extremely low specific pressure in the contact between the running gear and soft ground and the automatic changeover from a wheeled running gear (along hard ground) to a tracked running gear (along soft ground).

When moving along soft ground, each roller becomes like a track guaranteeing good engagement with the ground and it is possible to transmit large tractive efforts.

Over the years, there has been an increase in many countries of vehicles on air cushions. Experience has been accumulating in design and experimental vehicles of this type which gives basic consideration to the fact that a vehicle on an air cushion can be effectively used in certain cases (for example, on water).

The opinion has been expressed in the foreign press that for combat vehicles it is more expedient to use air pillows in the capacity of temporarily operating weight removal mechanisms, reducing the specific pressure on the ground of the basic running gear (wheeled or tracked). Such a weight removal is extremely useful for overcoming parts of the terrain with a small supporting capacity.

Fig. 106 shows the English vehicle with a wheeled running gear partially weight removed by an air cushion. Two centrally located ventilators 1, situated at the sides of the platform, force the air into the chamber, which is formed of a rubber skirt, 2, and a corrugated strip 3. The ventilators are rotated by the accessory engine 4 by means of the transmission 5 and shaft 6.

Such wheeled and tracked vehicles with partial weight removed from the running gear have been developed in a series of countries.

In addition to the considered directions in the development of wheeled technical equipment, each of which has a real technical basis and guarantees that all or part of the high characteristics will be obtained, it should be noted that in the past few years, attempts have been made to attract the attention of specialists to technical ideas which sometimes have a fantastic character. Such ideas include, for example, the idea of creating a vehicle with square wheels, walking, or jumping vehicles, etc.

The lage number of new concepts is evidence of the fact that wheeled technical equipment is in a stage of intensive development.

Chapter IV

MAINTENANCE AND REPAIR OF ARMORED TANK TECHNICAL EQUIPMENT

Section One

MAINTENANCE OF ARMORED TANK TECHNICAL EQUIPMENT

The combat and technical characteristics of tanks must be changed within comparatively small limits in the time between repair and servicing. The intensity of these changes is determined by perfection of the design, the mechanism operating systems and the quality of their servicing. The technical use of the vehicles (driving) and their servicing constitute the content of maintenance concepts of armored tank technical equipment.

The techniques of literate maintenance indicate setting up operational regimes for the mechanisms during start up and when moving the tank as well as their periodical servicing, which is guaranteed by a smooth preventive system of technical servicing. The substance of it is that a specified amount of work is carried out on vehicles which are in good condition at a certain mileage. This makes it possible to guarantee reliable vehicle operation without servicing at a given time. The technical and combat potential of the vehicles, determined by their design, are used to a maximum degree only under these conditions.

The combat capability of units and subunits is determined by the execution of a complex of maintenance measures. The most important of them is guaranteeing a high degree of vehicle combat preparedness, maintaining maintenance reliability at a high level, decreasing the amount of labor consumption, during maintenance as well as increasing the amount of mileage between repairs. Thus, in the maintenance of combat vehicles it is necessary to solve a whole series of technical problems. Their successful solution is possible only as a result of correlating the experiences of maintenance, especially studying and analyzing prospects for developing tank maintenance techniques. All this must increase the effectiveness of tank utilization and consequently techniques to guarantee a high degree of combat preparedness for tank units and subunits.

In the armies of foreign countries (USA and others), maintenance of combat track-laying and wheeled vehicles is understood to be only their utilization. The responsibility for technical servicing, maintenance and evacuation lay on the repair subunits. The maintenance and repair system is precautionary. Four types of continuous maintenance is provided for all vehicles, A, B, C, and D, as well as inspection before leaving and when parked.

Maintenance A (daily) includes work preparing the vehicle for further exploitation (supplementing maintenance materials, making necessary repairs).

Maintenance B (daily). In addition to work done during daily maintenance, filters are cleaned, linkage is checked and adjusted, etc.

Maintenance C (monthly) is carried out after the tanks have 400 km on them or after 1600 for wheeled vehicles. Personnel of infantry repair sections are called in to execute the work. The volume of work includes changing the filter elements in the systems, changing the lubricant in the running gear, etc.

Quarterly maintenance D is carred out after the tanks have run 1200 km or 9600 km for wheeled vehicles.

Maintenance may be changed periodically depending on the conditions of exploitation. The purpose of maintenance is: generally checking the technical condition of the vehicle and making repairs. It includes a volume of obligatory work (changing the lubricant, washing filters, etc.) and a volume of work making necessary repairs.

The technical condition of the vehicle before maintenance and the quality of the work carried out after it is evaluated after the vehicle has run 5 - 8 km.

All maintenance work is executed by special repair subunits with the cooperation of crews servicing the vehicles.

Par. 1: Operational Characteristics of Tanks

The combat and technical characteristics of tanks make it possible to evaluate their combat qualities. Some indicators of the combat and technical characteristics change during the time of exploitation and, consequently, change their combat power and possibility for operational-tactical utilization. For example, engine wear reduces its power. This leads to a reduction in moving speed, increasing the expenditure for maintenance materials which, in turn, decreases tank mileage on one fueling and demands increasing maintenance time, organizing the delivery of materials, etc.

Thus, a change in the indicators of combat and technical characteristics is allowable, but it is expedient only in such limits that the vehicle is able to be effectively used in the makeup of units and subunits. This is possible only if those characteristics of the mechanisms and vehicle system are not essentially made worse, as well as wear-resistance, reliability, economy in the expenditure of maintenance materials, labor expenditure in maintenance and suitability for preservation. The sum total of all these characteristics make up the exploitation characteristics of tanks.

Any vehicle (tank, tow car, tractor, automobile, etc.) must have specified characteristics. But their importance is specific for combat vehicles. Since combat vehicles are not used continuously in peace time, they must be well suited for storage. The large volume of maintenance work will make it more difficult to use the vehicle in combat, thus it is important to select the optimum exploitation characteristics as well as the importance of their changes.

Let us analyze the indicators of exploitation characteristics.

Wear Resistance of Components is characterized by changes in the mechanisms which are mainly subject to wear. The wear and tear of mechanism components is one of the main reasons for a decline in the exploitation characteristics of tanks. Wear and tear causes a reduction of power generated by engines, increased losses in mechanisms. The result is a decrease in the medium moving speed of tanks and armored transports.

Since when moving along roads, 70 - 80% of the engine power is used, then expeditiously it declines not more than 15 - 20% between repairs. Then, the engines of new vehicles will operate with underload, and the engines of worn vehicles will be more loaded. Moreover, vehicles with mileage close to intermediate repair may develop high medium speeds. The useful engine power may drop as a result of wear (curve 1 on Fig. 107), as well as damage to fuel-conveying apparatuses (curve 2), excessive strain on tracks, accumulation of dirt in radiators, etc.

The intensity of wear declines with rational heat and speed regimes in vehicle exploitation, well-timed and high quality maintenance and, on the other hand, systematic exploitation of tank engines at low temperatures with cooling liquids (50 - 60°) may decrease the time between repairs by 30 - 40%, necessitated by corrosion wear of cylinder sleeves and piston rings. Poorly timed maintenance of air cleaners also leads to shortening the period of engine service.

A no less important problem is knowing how to evaluate the technical condition of the mechanisms. It is clear from Fig. 107 that a decline in power may be caused not only by wear, but by a number of other reasons.

Thus, one of the most important problems consists of prolonging the service time between repairs and working out methods of evaluating the technical conditions of mechanisms in exploitation.

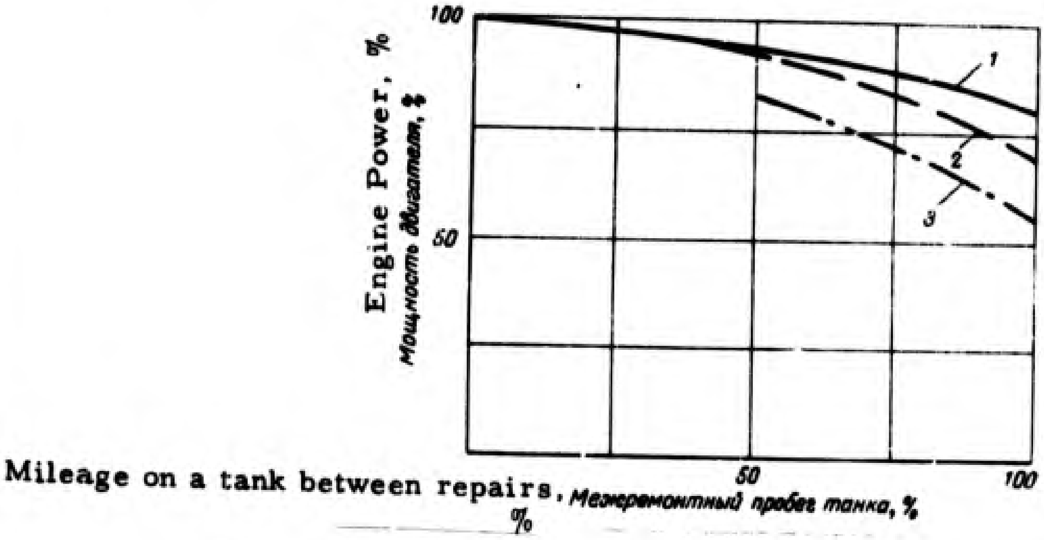


Fig. 107: Reduction in the useful power of an engine during use:

1 - engine wear; 2 - damage to fuel-conducting apparatuses; 3 - excessive strain on tracks.

The reliability of combat vehicle mechanisms must be such that the vehicle going out of commission for technical reasons is precluded with the completion of a march and in combat. Defects which may occur in a vehicle during use must be corrected in planned maintenance, in addition to which the vehicle must not fall behind the subunit (on the march, in combat).

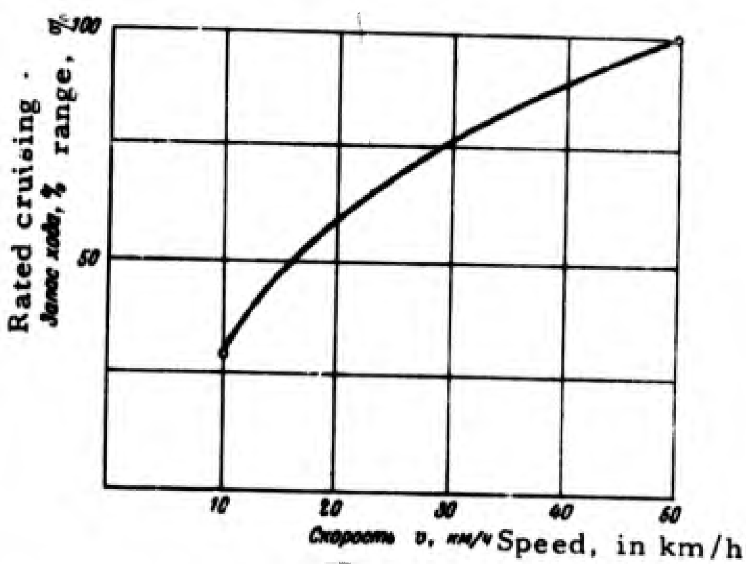


Fig. 108: Influence of moving conditions on the rated cruising range of a tank without refueling.

Economy in the expenditure of maintenance materials determines the rated cruising range of the vehicle without refueling the tanks. For modern tanks, this may be in the range of 100 - 600 km. However, this value may decline due to wear of components and damage to heat conducting regulating mechanisms. In addition, the rated cruising range depends on road conditions (Fig. 108) and a correct selection of the gear for moving. Thus, the rated cruising range without refueling is guaranteed by keeping the engine (and other mechanisms) in good condition, as well as by skill in driving the tank.

The rated cruising range is essentially changed by the oil consumption. This is connected with the fact that engine wear increases oil consumption. Consequently, the struggle to prolong the periods between repairs (i.e., increase wear resistance) also determines economy in the expenditure of various maintenance materials.

Labor consumption in maintaining combat vehicles is determined by periodic and continuous maintenance. Labor consumption must be minimum, because continuance of maintenance tends to be reduced and periodicity tends to be increased.

The suitability of a vehicle for maintenance may be evaluated on the basis of coefficients of technological maintenance and labor consumption.

The technology coefficient K is characterized by the convenience of accessibility to the aggregate to be serviced and the simplicity of the demounting-mounting work:

$$K = T/T_{p.z} + T$$

Where T is the time spent in maintenance, for example in washing an air cleaner cartridge, and $T_{p.z}$ is the preliminary-concluding time (time in removing them and subsequent set-up).

A large values of $T_{p.z}$ and small T, it is expedient to mechanize the work according to maintenance. Thus, it has significance only if $K > 0.5$.

It is expedient to evaluate the labor consumption in maintenance with the aid of the maintenance coefficient C, which is represented by the ratio of time T spent on maintenance, to the time the tank is in use T_e.

$$C = T/T_e$$

For modern vehicles, it is necessary, in order that $C_{oper} = 0.15$ in the course of operation, i.e., maintenance must be limited only to filling the tanks with maintenance materials. It is desirable that $C \leq 0.3$ in the periods between maintenance.

At the present time, the most work is done in daily technical servicing. It amounts to 70 - 75% of the general volume. Consequently, this work must primarily be mechanized. The use of movable mechanization means (MTO, fuel and oil tanks, PRZC) makes it possible to reduce the labor consumption in completing the work on an average of 25% in daily technical maintenance, and TO-1 and TO-2 correspondingly by 15 - 10%.

The labor consumption in maintenance can be reduced by a complex of measures: constructionally improved mechanisms, using operational materials, providing extended operation of mechanisms without servicing and, finally, mechanizing the most labor-consuming work.

The suitability of combat vehicles for storage must satisfy two requirements. It is necessary that their combat preparedness not be impaired. Also, the labor consumption in preparing the vehicle for storage must be minimum. Fulfilling these requirements forces us to use only lubrication materials to protect the mechanisms from corrosion which are used in exploitation. Important improvements of the vehicles in providing for underwater driving and protecting the body from dust simplifies their hermetic sealing. This, of course, reduces labor consumption to a minimum as far as hermetic sealing of the body is concerned. Thus, its value does not exceed 10 - 15% of the general labor consumption in tank maintenance before putting them into storage.

The operational characteristics make it possible to compare the degree of technical perfection of the mechanisms, the system and combat vehicles as a whole, since the change of indicators concerning operational characteristics is an objective indicator of the change in their technical conditions. And, finally, on this basis it is possible to determine the measures necessary to keep the combat characteristics of tanks and armored transports at a high level.

Par. 2: Reliability of Armored Tank Technical Equipment

Forced stops of tanks and armored transports on marches and on the field of combat leads to reducing the combat power of divisions and subdivisions and may be the cause of irrevocable vehicle losses. Changes in the units and in the communications networks, as well as observation instruments does not make it possible to control the vehicles and use their combat power.

Changes in the mechanisms, friction units and instruments leading to an unacceptable worsening or curtailment of their operational capabilities, are called failures. Failures can occur due to regular changes. Examples of random failures breakdowns due to blows, for example, are torsion breakdowns, destruction of durite, connecting pipelines, punctures of the condensor instruments, the engine going out of commission when it overheats, etc.

Failures occurring due to regular changes in the mechanisms can be characterized by the following examples. Brake bands (shoes) gradually wear out in the operation of tanks and armored transports. Braking becomes impossible due to a high degree of wear. Excessive wear of cylinder sleeves and piston rings leads to an unacceptable pressure reduction at the end of the compression stroke and it is impossible to start the engine.

From the foregoing, it is clear that regular failures can be provided for, and consequently they can be prevented. For this it is necessary to know how to evaluate the technical condition of the vehicle. The appearance of unexpected failures can be predicted in time. The maintenance period of each vehicle is limited by the longevity of its system, the mechanisms and the aggregates. For tanks and armored transports, it is limited by the mileage between repairs. Even during this period, it is necessary to guarantee the reliability of using combat vehicles.

The regularity in the appearance of failures is studied by the theory of reliability, with a mathematical apparatus which is the theory of reliability and mathematical statistics.

Reliability is the ability of a vehicle (mechanism) to maintain its operational properties, specifying their adaptability to be used according to designation. It follows from this determination that reliability is stipulated primarily by operational dependability. At the present level of technical development, we have not always been successful in creating mechanisms and apparatuses for combat vehicles which would be reliable in the periods between repairs. Thus, reliability must be determined by the time required to eliminate the failure or by repair adaptability.

On the basis of what has been said, it follows that the reliability of combat vehicles can be determined quantitatively by the number of failures occurring during the time of operation and the time required to eliminate them.

The number of failures m, referred to the amount of mileage on the vehicle, is called the frequency of failures λ (m). The frequency of failures (m) and time t, required to correct them, do not remain constant during vehicle operation.

The reliability of tanks, as other vehicles, must be measured or accurately predicted. But, using mean values m_{med} or t_{med}, obtained in the results of special studies and correlations from operational experience, it is possible to evaluate the probability of reliability in vehicle operation with great confidence.

The frequency of vehicle failures can change as shown in Fig. 109. The increase in the beginning of tank mileage -- in the period of breaking in (point a) stipulates the components going out of commission, which have design or technological defects, and also a short service period. The increase of m at the end of the period between repairs (point b) stipulates that the wear of many components has reached the limit values.

The reliability of tank mechanisms decreases with an increase in the mileage at the start of operation. For tank mechanisms, its value may change as shown in Fig. 110.

Constants do not remain in time t for correcting the failures. When the mechanisms are not sufficiently reliable, a great deal of time is required to secure marches completed with tanks and armored transports, as well as combat. The labor consumption in eliminating the failures in the case of poor vehicle reliability may exceed the labor consumption in servicing the tanks. This requires organization in using the repair facilities, delivering spare parts, mechanisms, etc. Organizing this work under field conditions is extremely complicated. Thus, it is necessary that mechanisms and systems be used up with consideration of a high degree of reliability. Possible failures can be corrected by the crew with the use of ZIP, and the time for their correction must be minimum.

What are the ways to guarantee the reliability of combat vehicles?

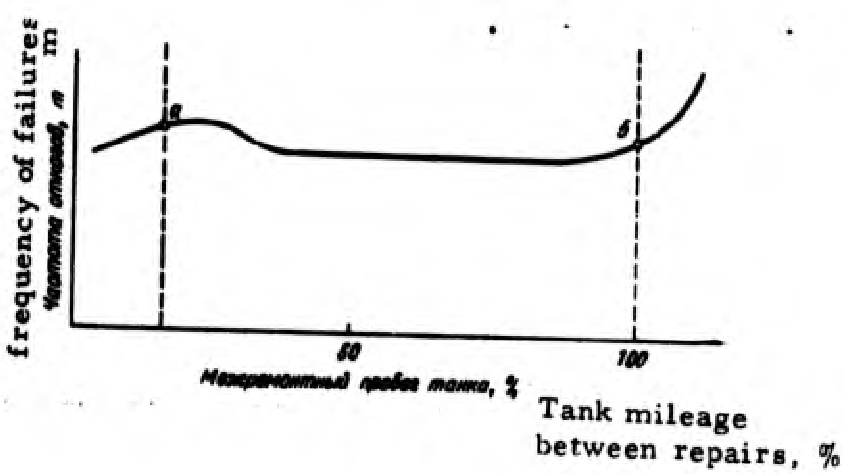


Fig. 109: Frequency of failures as a function of continuance of tank operation.

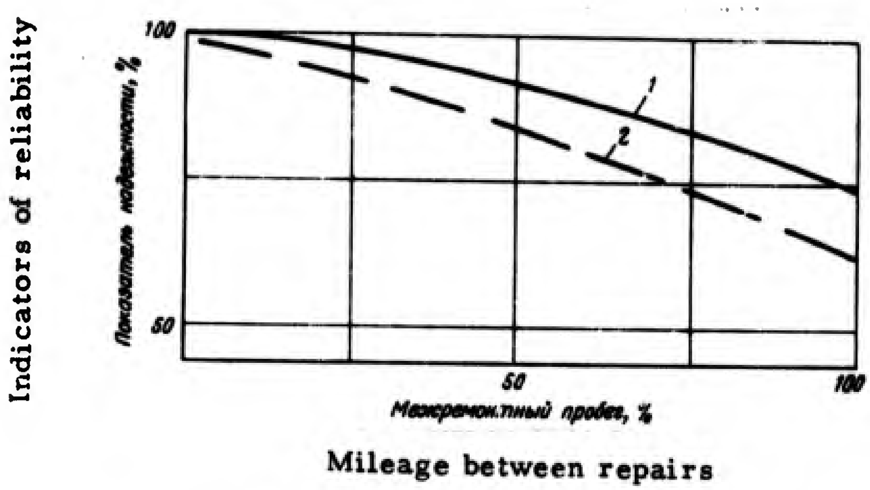


Fig. 110: Reliability in the operation of tank mechanisms: 1 - engine; 2 - transmission

New vehicles are being created on the basis of tactical-technical and operational requirements including the requirement for reliable operation of the mechanisms in the course of a given period between repairs. Their reliability has theoretically been improved by reworking vehicle design. An evaluation of this may be made only approximately on the basis of analyzing various re-worked variations, testing the individual experimental units and mechanisms.

In order to improve the reliabilty, it is customary to limit the operational systems of mechanisms in the design. Examples are a specified length of time in using the starter, the oil pump in the lubricating system, limiting temperature and speed regimes when operating the engine, etc.

The reliability of vehicles, systems and mechanisms can be achieved with so-called reservations. One example is duplicating the methods for starting the engine with a starter and with compressed air.

When producing vehicles in a factory, their reliability is guaranteed in fact. This is achieved by producing components and mechanical units from materials with appropriate mechanical properties, carrying out the necessary mechanical and thermal treatments of the components, adhering to the optimum tolerances, etc.

As a result of testing an experimental model, and especially artillery and troops tests, weak units, defects in the mechanims have appeared, the established periodicity of maintenance is checked, and a determined working regime is specified.

In order to evaluate the reliability of tanks and the correctness of the given periodicity of maintenance, it is necessary first of all to determine the necessary volume of information obtained from the tests, i. e. , it is necessary to solve some problems, some tanks must be operated in order to obtain authentic mean values m_{med} and t_{med}. It is established that in order to obtain authentic data, it is sufficient to study those vehicles in such a volume of operation that it is possible to obtain medium values m_{med} and t_{med} with a probability of about 0. 8 and with confidential intervals $\pm$ (15 -20) %. Such an authenticity must be considered sufficient. It means that in 80 cases out of 100, the obtained values m_{med} and t_{med} will differ from the actual values 15 - 20 percent.

The results thus obtained are a sufficiently good basis for improving the design of units and mechanisms, perfecting the technology of their production and correcting boundary operational systems of vehicles and their maintenance.

Thus, such vehicle come into use having fully determined reliability, established operating regimes in their mechanisms and periodicity of their maintenance. The final evaluation of vehicle reliability will be determined with massive operation. For this it is necessary to determine the character of failures in operation, their number and causes, as well as the labor consumption it takes to correct them.

The design improvements of modern tank and armored transports, a high technological production level, and accumulated experience in vehicle operation guarantee high reliability of basic components and mechanisms.

The obtained information and the reliability of its analysis is the basis for working out measures to improve the design of mechanisms and the technology of manufacturing their components as far as maintaining reliability of operation is concerned.

Failures detected during tank operation, occur because of design of production defects or incorrect maintenance. In the latter case, they appear either because of breaches in the vehicle use regime, or due to poor quality or ill-timed maintenance of their mechanisms. Examples of failures taking place because of incorrect operation or overheating of the engine, torsion- breakdowns when obstacles are surmounted incorrectly, etc. Examples of failures taking place due to not observing the rules for the maintenance of mechanisms are leakages of unfiltered air with incorrect assembly of the air cleaner, impossibility of turning the tank due to ill-timed or incorrect regulation of the brake mechanisms, etc.

The majority of failures caused by incorrect operation can be corrected. This is achieved by raising the level of technical preparation for personnel, improving driving skills, carefully conducted maintenance.

Thus, scientific correlation of the experience in using combat vehicles makes it possible to set up requirements for improving the design of mechanisms. It provides a possibility for working out objective measures for maintaining vehicle reliability at a high level.

Par. 3: Protecting Armored Tank Technical Equipment from Corrosion

A limited number of vehicles are used in peace time to guarantee combat preparedness. The majority of vehicles are in storage, which must be organized in that first, the technical condition of the mechanisms, the system and the instruments remain unchanged and, secondly, that the combat preparedness of the vehicles remain at a high level.

In order to guarantee the combat preparedness in foreign armies with combat vehicles, they do not remove the instruments, the equipment, the communication facilities, but the engine and the crankcase are serviced with operational material. In their opinion, the vehicles cannot be in such a condition for an extended period of time, since it is possible to worsen their technical condition due to the effect on mechanisms and on components of ambient air, i. e., atmosphere or operational material.

The effect of media on metal causes their corrosion. The influence of media on non-metallic materials leads to their aging.

The corrosion of metals is chemical and electromechanical.

Chemical corrosion is possible whenever the metal interacts with a medium not conducting an electric current. The active substances present in this medium, for example atmospheric oxygen, enter into chemical reaction with the metal.

Electrochemical corrosion occurs in media capable of conducting an electrical current (in salt, acid and alkali solutions). The reasons for this lie in the technical metals. Admixtures and inclusions form micro-galvanic vapors with the basic metal. Current conducting media close a circuit, and the galvanic elements begin to work.

The corrosion of metals and the aging of materials lends to an irreversible change of the surface layers on components. This seems to be the reason for a reduction in the longevity of mechanisms and the reliability of their operation. Thus, for example, if the pipes of the cooling system or the components of the fuel pump are damaged due to corrosion, then it will be necessary to repair them before use. If the engine is not protected then, its operation may be reduced by 50 percent or more due to corrosion on the cylinder casing in the period between repairs.

The operational materials have anti-corrosion characteristics. However, they turn out to be insufficiently effective for extended storage.

The components of fuel pumping mechanisms may also corrode in the presence of diesel fuel or gasoline, since corrosion is caused by sulfur compounds present in the fuel, and by the presence of moisture. Thus, when the vehicle is being operated, it is necessary to prevent penetration of water into the fuel feed system.

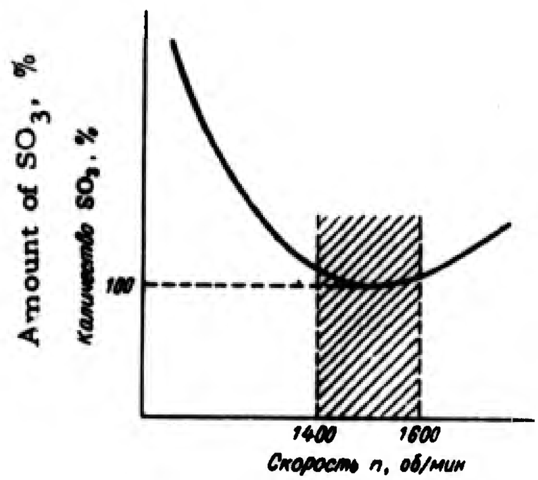


Fig. 111: Influence of Operating Speed on the Amount of SO_3 in the Combustion Chamber.

Sulfur compounds in the fuel are the cause of corrosion on the cylinder casings of the engine. SO_2 and SO_3 may form in the engine when fuel burns. SO_3 is the most dangerous, since with moisture it forms sulfurnic acid which damages the surface of the cylinder casings. The SO_3 concentration depends on the amount of sulfur compounds as well as on the operating system of the engine. At all operating speeds, the most SO_3 is formed under conditions of reduced heat. This is the basic cause of most wear on cylinder casings when the temperature of the coolant is below + 60°C. The less the engine operates, at low coolant temperatures, the less its wear.

The engine operating speed has a great influence on the formation of SO_3. The most favorable speeds turn out to be those near the operating speed (Fig. 111). Thus, operation at optimum speeds and heat conditions is not only the most economical, but it facilitates increasing the longevity of the engine. However, even under these conditions, it is not possible to completely exclude the formation of SO_3. Thus, about 25-30 days after the engine is stopped, corrosion deposits may form on the cylinder casing surfaces.

It is possible to prevent corrosion of the cylinder casings if the formation of sulfuric acid is prevented by one of the following methods. First of all, you may introduce admixtures into the fuel neutralizing the effect of SO_3. It is possible to introduce the neutralizing substance into the combustion chamber. The use of ammonia also turns out to be effective. However, technical difficulties do not permit the use of this method. Thus, the method of washing the cylinder casings has found widespread use, in which the oil film containing SO_3 or traces of H_2SO_4 is removed. Continuous washing is more effective, when the heated oil, under pressure, gets into all the cylinders when the crankshaft rotates. Special automatic equipment is needed to execute this work. Their use not only guarantees a high quality of operation, but makes it possible to reduce the labor consumption 10-15 times.

Electrochemical corrosion of mechanism components under the effect of atmosphere is called atmospheric. The most influence on corrosion aggressiveness of the atmosphere is exerted by moisture and various admixtures in the air. For example, SO_2 with moisture or salts, contained in sea moisture, are electrolytic and are capable of forming on metal surfaces of microgalvanic elements.

Industrial or other dust, settling on metal surfaces, increase the absorption of water vapors and at the same time increase the corrosion intensity. The amount of these admixtures may reach regions of 300 - 400 t/km^2 in industry. Corrosion aggressiveness of the atmosphere does not remain constant, since the moisture content in the air changes continuously.

It is thought that combat vehicles can be protected from corrosion using lubricating materials containing corrosion inhibitors, inert gas media or drying air. However, as shown in Table 7, not all these methods are universal, since their use involves great technical difficulties, and the use of volatile inhibitors requires careful hermetic sealing of the protected objects.

It is expedient to use inert gases, for example nitrogen, to cover the surfaces of crankcases or packages. However, inert gases are effective only if their concentration is near 100%, which is difficult to realize in practice.

TABLE 7: Effectiveness of Various Methods for Protecting Armored Tank Technical Equipment from Corrosion.

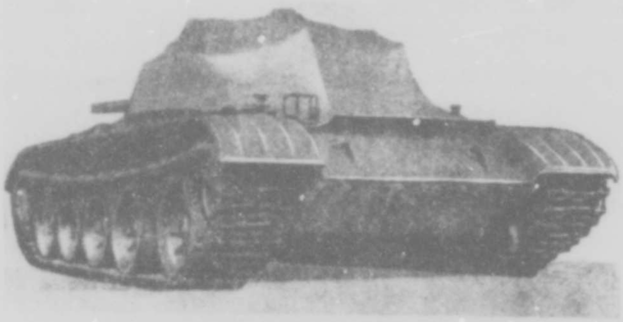
PROTECTIVE METHODS	Metals	Rubber-technical articles	Plastic and moisture-absorbing materials	GSM	Paint and varnish coating	Electro-radio equipment
Preservation with oils & lubricants	+	-	-	-	-	-
Use of inhibitors	+	+	-	-	+	-
Use of inert gases	+	++	+	+	+	=
Hermetic sealing with dry air	++	+	++	+	++	++

Nomenclature:
++ good protection
+ partial protection
- no protection

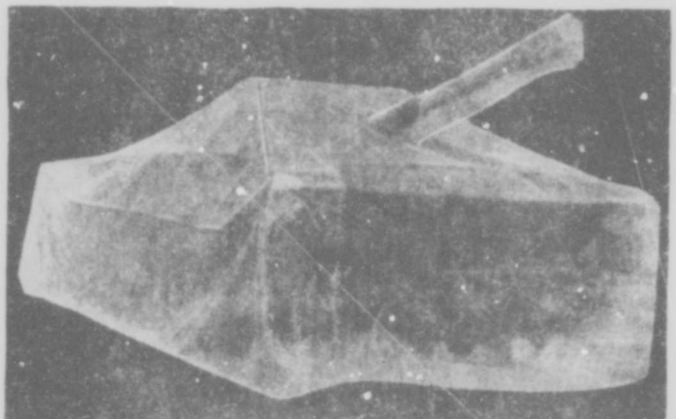
The rate of atmospheric corrosion sharply declines if the relative moisture in the air is less than 60 percent. Low moisture is maintained in vehicles if their body is hermetically sealed and their interior has a moisture absorber. The same method can dry the air in any hermetically sealed package, for example in containers.

To dry the air inside the bodies of hermetically sealed vehicles or vessels down to low relative humidity values is not expedient, since dry air in the atmosphere reduces the quality of insulating materials in electro-, radio and special apparatuses, and increases the aging rate in rubber-technical articles. It must be kept in mind that in the presence of very low humidity inside the vehicle body, the difference in the partial pressures of moisture vapors in the ambient and drying air will be great, which brings about the necessity to improve the hermetic materials and the quality of the hermetic sealing. Thus, the materials used, in addition to mechanical stability, frost-resistance and ability to resist aging under the effect of atmospheric conditions, must have optimum moisture penetrability within the limits of 0.1 - 1.5 mg/m^2 (in one day). Moisture, penetrating through hermetic materials or untight hermetic sealing, is absorbed by moisture absorbers.

The vehicle body can be hermetically sealed with various methods. It is easiest to hermetically seal the body by stopping up chinks and cracks with special fabrics or paper with low vapor penetrability. In order that the fabric or the paper can be removed, the adhesives used to stick it on must be non-drying. Peeling of armor plated which are hermetically sealed or moisture flowing under them must be prevented. In order to accomplish this, beads of protective lubrication are applied along the perimeter of the paper (fabric), so that the cement secures the hermetic material to the armor plating. The thus hermetically sealed vehicle can be stored under a shed.



a   а



b   б

Fig 112: Tanks Hermetically Sealed with Various Methods.
(a) - cocoon; (b) - film of polymer materials.

It is possible to create solid coatings using special enamels with the aid of paint sprayers on the turret and the transmission compartments of the tank, the armored transport and other vehicles. For this purpose, first prepare the carcass with cotton strips. Cover them with a web-like lacquer or gauze and apply several layers of enamel along them. The thus obtained film is stuck along the perimeter of the vehicle. The remaining part of the body is hermetically sealed with cement. Such a method of hermetic sealing achieves the so-called "cocoon" (Fig. 112, a). Using it, it is possible to store the vehicle outside for an extended period of time.

The prospects are to store components, mechanisms, instruments, radio equipment and vehicles in coverings of synthetic materials having a low vapor penetration. For this purpose, we use polyethylene films of various thicknesses. The coverings are made with welded, electric welded, heating apparatuses. The polyethylene, well stabilized against aging, can guarantee hermetic sealing of the vehicle in the open for an extended period of time.

The air inside of hermetically sealed objects is dried with moisture absorbers located inside of them. The quality of hermetic sealing is checked with a suspended control bag containing the moisture absorber. No other maintenance work in hermetically sealing the objects is necessary. Because of this, hermetic sealing, the vehicle is not only technically expedient, but economically efficient. So, for example, if the average cost for extended storage without hermetic sealing is taken as 100 percent, then the use of hermetic sealing methods makes it possible to reduce the expenditure of materials by 15 - 25 percent and lower the labor expenditure for maintenance by 60 - 70 percent.

The successful development of chemicals makes it possible to widely introduce corrosion inhibitors (retarders) into practice. They can be used either directly or can be introduced into the lubricating materials. The use of inhibitors is very important because they reduce the expenditures for storing components and mechanisms. So, the use of thickened solutions of sodium nitrate guaranteeing extensive protection from corrosion of components made of ferrous metals turns out to be cheaper than using protective lubricants made on a petroleum basis.

Introducing inhibitors into the lubricating materials makes it possible to begin exploitation of the mechanisms without preliminary preparation. How expedient this is may be seen from the following example. When the engines are stored in mixtures of motor oil with gun lubricant, it was necessary to heat the engine for 5 - 8 hours in order to remove the protective lubricant. To carry out this work under field conditions is very difficult, especially in winter. The use of oils with inhibitors completely eliminates the work of preparing the engine.

The use of hermetic methods makes it possible to store all the apparatuses on the vehicles, i.e. to guarantee their combat preparedness. The use of corrosion inhibitors and inhibiting oils is not only economically advantageous, but it eliminates or somewhat shortens the time necessary for getting the mechanisms and instruments ready. Thus, perfecting the methods for protecting armored tank technical equipment from corrosion creates a good basis for their high combat preparedness while reducing the labor expenditure for their use.

Part of the combat vehicles of troop units in the US Army are in base or rear storage. The vehicles are prepared for storage by crews and repair specialists.

Before storage, all the vehicles are subjected to quarterly maintenance, the coolant is drained out of the cooling system. The batteries are removed from the tank. All hatches and openings are carefully covered, and the vehicles are covered with tarpaulins. The thus prepared vehicles can be stored up to three months.

For extended storage, the vehicles are carefully hermetically sealed (stopped up with special materials, using film covering, the "cocoon" method, etc.) with air-dried inside the vehicle by means of a moisture absorber (silica gel).

Par. 4: Combat Preparedness of Tanks

The combat preparedness of sub-units is evaluated in time, during which the vehicles can be prepared to enter or lead combat operations.

The time for making a vehicle combat ready depends on the organization of work, the adaptability of vehicles for operation in various climate conditions, the condition of the starting facilities and the training of personnel.

Let us examine the technical possibilities of the vehicles and the ways of reducing the time for preparing them.

The most time for preparing a vehicle is required in winter. This is due to the fact at low temperature, a great deal of time is spent creating the necessary heat condition for the engine. Thus, if preparation and starting of the engine are carried out at plus temperatures in the course of a few minutes, then about 10 minutes will be required at low temperatures.

To start the engine, it is necessary that spontaneous combustion of the fuel take place in the combustion chambers. This is possible only when, with the crankshaft rotating, the temperature at the end of the compression stroke is higher than the temperature of the spontaneous combusted fuel T_c.

Modern fuels and starting means make it possible to achieve T_c at temperatures of the ambient air higher than -7°. Spontaneous combustion of the fuel does not occur at a lower temperature. To increase the T_c, it would be necessary to increase the rotational speed of the engine crankshaft. However, to do this is extremely difficult, since the viscosity of the lubricating materials greatly increases at low temperature, as a result of which the resistance moment to the crankshaft rotation also increases. In addition, at a low air temperature, the operation of the starting mechanisms is more difficult. In cold batteries, due to the increase in the viscosity of the electrolyte, its access is made more difficult in times of active mass of the grid. Thus, the capacity delivered by the batteries is decreased. The result is a sharp voltage drop on the battery terminals. Consequently, there is a drop in the power developed by the starter.

To prepare the engine for starting, it is necessary to guarantee its reliable operation, i.e., put in a sufficient amount of oil on the crankshaft bearings. This is possible for modern engines if the viscosity of the oil is less than 50 st (for MT-16P oil, such a viscosity is reached at 0°C).

In order to decrease the resistance moment and to increase the amount of oil pumped through, it is necessary either to heat it up in the system or use oil of low viscosity. Engine crankshaft rotation becomes possible at oil viscosities of about 100 st, but delivery of the oil to the crankshaft bearings will not be guaranteed.

Reliable operation of the engine is guaranteed only at lower viscosity. However, even in this case, spontaneous combustion of the fuel will not occur. Thus, it is necessary either to heat up the engine in order to heat up the air drawn into the combustion chamber, or use special fuel with low spontaneous ignition temperature values. Such a fuel is called a starter fluid. It is usually an ether mixture with spontaneous combustion temperatures 150 - 200°C lower than Diesel fuels. Consequently, they can come to spontaneous combustion at crankshaft rotational speeds 1.5 - 2 times less than the nominal.

Thus, using oils of low viscosity and starter fluids, the engine can be started when it is cold. However, cold starting the engine has essential disadvantages: after starting, engine operation is characterized by great rigidity, which shows up disadvantageously on the crankshaft bearings, but initial warm up of the engine is accompanied by a high degree of corrosive wear of the cylinder casings and the piston rings. If the indicated undesirable phenomena accompanying cold starting of the engine can be eliminated, then this method will be prevalent everywhere. For the time being, it is used to a limited extent.

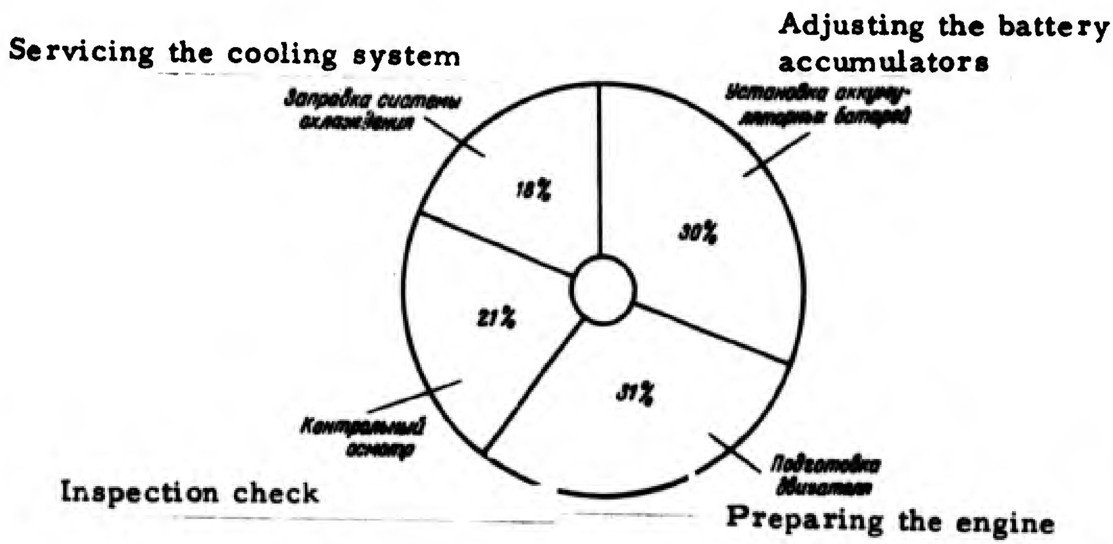


Fig. 113: Work Expended in Preparing the Engine for Starting.

Air and liquid preheaters are used to heat up the engine, and in addition air is heated up initialy in the manifolds. Liquid preheaters are connected to the engine cooling system. In addition, it is possible to warm up the cylinder heads and the engine crankcase, the oil in the oil containers as well as the intake pipes. It has proven practical to heat up the cylinder heads to +40°C. In addition, the air drawn into the combustion chamber is heated up and the fuel injected into the combustion chamber is ignited. However, it is impossible to pump oil guaranteeing reliable operation of the engine. Thus, it is necessary to heat the engine up to coolant temperatures 80 - 100°. The length of time the engine is heated up depends on the engine design and power of the engine preheater to heat up the colant 2 - 3°C in one minute.

In order to prepare the tank, it is necessary to carry out a complex of work, indicated in Fig. 113. The preparation time for starting can be decreased if this work is carried out in a specified sequence: servicing the cooling system, adjusting the batteries in the tank, connecting up the preheater, heating up the engine.

It is not permitted to hook up the preheater until the cooling system has been prepared and the batteries adjusted. Thus, it is necessary to speed up servicing the cooling system. Coolant must already be in the tanks. It is possible to adjust the cooling system individually and in a centralized manner. In cases where the tanks and the accumulator batteries are in storage, it is necessary to mechanize their transportation to the vehicle.

When the accumulator batteries for the tank are in storage, they must be kept fully charged. When the batteries are fully charged, this makes it possible to reliably start the engine.

To prepare the vehicle for movement in a short time is possible only if the crew is well aware of its responsibilities and the sequence for performing work. Thus, the time to prepare the engine for starting can be shortened to the time in which the inspection check is carried out.

The use of heating up facilities on the engine makes it possible to maintain the tanks, the SAU and armored transports in combat condition under field conditions at any temperature. For this it is necessary to periodically turn on the preheater.

How often the preheater should be turned on depends on the air temperature, the wind direction and other conditions. The necessity of turning them on is determined according to the coolant temperature. It must be such that it is possible to start the engine without preheating and begin moving the tank at low temperatures. This is possible if the coolant temperature is not lower than 35 - 40°C, and the temperature of the oil on the crankshaft is higher than 0°C. Moreover, not only easy starting of the engine is guaranteed with little wear, but reliable operation of the crankshaft bearings.

Heating up the engine with a preheater takes place up to the maximum possible temperatures. Starting with a preheater at a coolant temperature higher than +40°C and stopping it at a temperature lower than the maximum leads to a decrease in the periodicity of starting with a preheater, to unjustified discharge of the accumulator batteries and to additional fuel expenditure.

Thus, the presence of a preheater on modern combat vehicles makes it possible to greatly increase their combat preparedness compared with tanks in the period of the Great Patrician war. Their rational use facilitates increasing the time between which servicing is necessary and makes it easier for the crew to keep the vehicle in combat preparedness under field conditions.

A great deal of attention has been given to guaranteeing tank operation at low temperatures in the armies of capitalist countries. Moreover, a high degree of combat preparedness is achieved by carrying out the following measures.

The first group is measures guaranteeing starting of the engine. This includes using low viscosity oils and arctic fuels, fuel injection or special starter fluids in the combustion chamber and the use of progressive (air and liquid) means for preheating the engine. Preheaters are used on a series of vehicles, connected to the cooling system.

The second group is measures guaranteeing efficiency of the starting mechanism. Thisincludes installation of charging aggregates in the tanks, preheating the accumulator batteries.

The third group is measures guaranteeing normal working conditions for the crew: use of preheaters for heating up the tank compartments, adoption of heat insulating linings, etc.

Section Two

RESTORATION OF ARMORED TANK TECHNICAL EQUIPMENT

The success of the Soviet economy in the post-war period has made it possible to equip armored forces with first-class armored tank technical equipment. Maintaining this technical equipment in constant combat preparedness is a very complex and real problem.

In operating tanks and their mechanisms, units and aggregates, various defects occur as a result of which the vehicles may go out of commission. The vehicles go out of commission if they incur combat damage.

The damage and the mechanical defects in the vehicles are eliminated during repair. Consequently, well-timed and high-quality repair is one of the constantly active factors which facilitates prolonging the operating life of vehicles.

Karl Marx pointed out the necessity of repair as a factor facilitating prolonging the operating life of vehicles. Determining the importance of repair, he wrote that each vehicle is subject to two types of failure, the failure of infancy and the more numerous failures of age: "What would be an ideal vehicle design, for example, neither entered into the manufacturing process, with its use in practice, defects have been detected which must be corrected with additional difficulty. On the other hand, the more it goes to the limits of its medium age, consequently the more normal wear increases, the more the material is used and weakened from which it is made, the more significant repairs must be made necessary to maintain the vehicles for its average life." (K. Marx. Capital. Vol. 2, p. 171, 1951.)

Thus, vehicle repair is a constant factor accompanying the life of a vehicle, having as its purpose to keep the vehicle in existence until the expiration of its average life.

Together with this, repair of armored tank technical equipment has great economic significance. To evaluate its importance, it is necessary to examine the technical expedience of repair and show its role in the system of technically securing armored forces.

Par. 1: Combat and Economic Importance of Repair

Vehicle repair is expedient only if the damage and mechanical trouble does not occur simultaneously in all units and aggregates. The experience of operating armored tank technical equipment shows that the mechanical difficulties occurring in vehicles have a local character. Even combat damage, as was shown from the experience of the last war, bears a local character in the majority of cases. So, for example with tanks and SAU having shell punctures in the side sheets of the body, the engine failes in 45 - 55% of the cases and the transmission and the turning mechanisms fail in 15 - 20% of the cases.

In cases of contemporary combat operations with the use of nuclear weapons, the character and the degree of combat damage to armored tank technical equipment may change. However, in this case the damage will bear a local character. The only exception is a vehicle in the direct vicinity of the blast epicenter of a nuclear weapon. In this case the damage may be inflicted on the majority of components, units, and vehicle aggregates, thus repair of such vehicles will not be expedient from a technical viewpoint.

Mechanical defects occuring due to component wear, do not appear simultaneously in units and aggregates. Thus, independent of whether the defects appear as a result of wear of combat damage, they bear a local character. This determines the technical expediency of repairing the armored tank technical equipment, since in this case the vehicles can be rapidly restored and returned to service.

Analyzing the role of repair in the technical security of armored forces, it is necessary primarily to underline its combat importance.

The operational-tactical possibilities of sections and units of armored forces are determined mainly by the presence in formation of basic combat technical equipment, tanks and SAU. In the course of combat operations, the troops bear the loss of personnel and combat vehicles due to which their operational-tactical possibilities of sections are reduced. Consequently, in the course of combat operations, sections and units of armored forces, in order to maintain their combat capabilities, theywill be required to be constantly replaced by combat vehicles either newly received from the factory or vehicles repaired by forces and facilities of repair organs.

An analysis of the large amount of data concerning the failure of tanks and SAU in different operations in the Great Patrician War shows that of the number of tanks and SAW going out of commission, 75 - 80 percent of the vehicles were restored and only 20 - 25 percent were not liable to restoration. Consequently, vehicle repair is one of the basic sources for supplementing parts of armored tank technical equipment and the successful operations of armored forces greatly depends on the organization of this repair. However, the absolute number of tanks and SAU subjected to restoration in the course of combat operations cannot fully characterize the combat importance of repair.

Secondly, and no less important, is the frequency of vehicle repair.

An analysis of the character of tank and SAU damage shows that 80 - 90 percent of the vehicles subjected to restoration required a small volume of work and could be returned to operation one or two days after being damaged. Thanks to this restoration rate of damaged and mechanically defective vehicles, we maximally approach the accumulation rate of the repair fund. So, for example, in troops of the 4th gv. TA in August 1943, the accumulation rate of the repair fund exceeded the restoration rate on three units in a day, and in the 1 gv, this difference amounted to two units in a day.

The charactersitic data in this regard are given in Fig. 114. As is evident from the graph, thanks to the correctly organized repair unit, combat operations were carried on continously for 25 days and nights. If the tanks and SAU were not repaired in the course of the operation, then the section would maintain combat capability only for seven or eight days.

Thus, the importance of tank and SAU repair in war time includes the fact that in the course of combat operations, restoration and systematic return to operation is possible for a significant number of damaged vehicles. This guarantees the possiblity for sections and units of armored forces operating over a wide front to maintain their combat capability for an extended period of time.

Together with the great combat importance, tank and SAU repair has a significant economic effect. It is determined primarily by the fact that repair increases the service period of tanks and thus makes it possible to reduce the requirements in the manufacture of new tanks and SAU.

No less important is the fact that thanks to repair, the hugh amounts of material and monetary means are saved, since cost of the most complex vehicle repair is less than the cost of manufacture. To evaluate the economic importance of tank and SAU repair, it is sufficient to examine some statistical data on the experience of the past war.

In the period of 46 months of the Great Patrician war, repair facilities of armored tank and mechanized troops executed about 430,000 current, medium and principal repairs. If we consider the fact that in each of the last three years of the war, our industry turned out about 30,000 tanks, SAU and armored tanks, then thinking in terms of units, only due to repair, as many combat vehicles were returned to service as industry could produce in a 15 year period.

This is the economic significance of tank and SAU repair.

Under modern conditions, repair of armored tank technical equipment is even more important.

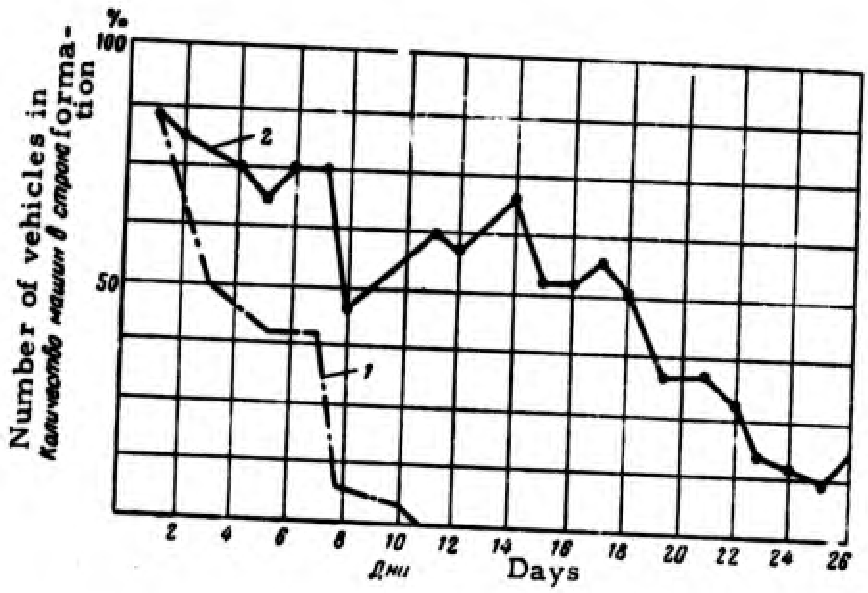


Fig. 114: Influence of tank repair on the combat preparedness of tanks according to the experience of the Great Patrician war.

(1) - number of undamaged vehicles; (2) - number of vehicles with consideration of restoration.

The probability of the use of thermonuclear weapons, the precipitous pace of combat operations, when parts and units of armored forces will quite often operate in independent directions and can become broken off from the main forces, have all caused an increase in the role of damaged tank restoration. In these cases, supplementing troops with new armored tank technical equipment from the rear regions of the country turns out to be difficult. Thus, repair of disabled technical equipment becomes an important source for guaranteeing the combat preparedness of overland troops. Thus, when conducting combat operations along with other elements of technical security, a great deal of attention is paid to repairing armored tank technical equipment as one of the essential factors influencing the combat preparedness of armored forces.

Par. 2: Systems, Ways and Methods for Repairing Armored Tank Technical Equipment

The organization of repairing armored tank technical equipment depends primarily on the accepted repair system, the character and the volume of repair work as well as on the selected method of reapir.

In the armies of capitalist countries (USA, Great Britain, Federal Republic of Germany, etc.), they adopted the planned-preventive system of technical maintenance and vehicle repair. It includes systematic maintenance of vehicles and their inspection as well as eliminating all mechanical defects, evacuation, repair and preparing the vehicle for prolonged storage.

Depending on the character and the volume of the repair work, the facilities carrying out the work, and other conditions, three categories are set up for repair: troop repair and maintenance, field repair and base repair. In the Army of the Federal Republic of Germany, repair is called factory.

In the US Army, troop repair is carried out by repair sections of tank companies and repair platoons of tank batallions which are equipped with repair evacuation vehicles on the base of official tanks, trucks and vehicles of general use. Tanks are repaired with the aggregate method where they went out of commission or near to cover.

Field repair is carried out by artillery-technical supply batallions, by armored tank repair divisions, by artillery-technical supply groups and repair reserves of the command.

The batallion of artillery-technical supply and repair is the official means of the armored tank division and is designated to execute the field repair of tanks and other armored tank technical equipment. It is used in its full composition as well as in two or three parts when they are sufficiently independent from a technological point of view. As a rule, these sections work on the group repair fund.

The artillery-technical supply and repair group is the repair facility for the reserve of the ma n command and can be attached to the army or to a separate army corps.

The basic tasks of artillery-technical supply and repair groups includes guaranteeing troops and repair subdivisions spare parts and in restoring vehicles and equipment requiring field repairs which, according to the voluem and complexity of the work, cannot be executed by facilities of armored tank divisions.

The artillery-technical supply and repair group does not have a set-up, official organization. Its use and official organization change depending on the conditions.

Base repair, as a rule, is accomplished in industrial plants present in a given theater of combat operations.

In the German army, each of the repair categories is broken down in turn to the stage of repair based on the character of the work, the presence of qualified personnel and equipment.

Five repair stages are provided for according to classification, from which the first stage is additionally subdivided into two parts: 1 "a" and 1 "b".

Troop repair is broken down into the first and second stage, field repair is broken down into third and fourth stages and finally, plant repair constitutes the fifth stage. According to the available data, the volume of repair work is determined for each stage according to the vehicle make, the appropriate lists drawn up in the repair and operational instructions.

It should be noted that the repair facilities of the US, British and German armies are constantly being perfected.

The system for vehicle repair must guarantee the maximum number of combat vehicles be kept in constant operation. In addition, the accepted system must provide for the possiblity of planning repair and guaranteeing maximum increase of the repair intervals.

In the equipment of Soviet Union forces, a system for repairing armored tank technical equipment has been accepted in which medium and important vehicle repairs are planned in accordance with established norms of inter-repair periods, and the practical requirements for repair are set up according to the results of checking the technical condition of the vehicles.

The accepted system guarantees:

- keeping the maximum number of combat vehicles in order;

- increasing the established time between repairs;

- decreasing the labor consumption of repair crews and, consequently, shortening the time a vehicle stays in repair;

- economy of spare parts and materials needed to repair the armored tank technical equipment;

- uniform load of repair facilities in accordance with their destination and productive power;

- constant command information concerning the condition of the vehicle.

The classification of the types of repair is very important in organizing the repair of armored tank technical equipment, which is set-up depending on the volume and character of the work to be executed. It is the basic prerequisite for creating a rational system of repair facilities for armored forces.

The classifications provide for three types of repair for a vehicle (current, medium and fundamental), and two types of repair for the aggregates (current and fundamental).

The types of repair are distinguished not only by the volume, but by the character of the repair work. So, for example, current vehicle repair is limited to correcting mechanical defects by replacing or repairing the individual components and units, as well as conducting necessary regulatory or special work. Medium repair indluces replacing or repairing worn or damaged aggregates and units. Moreover, the technical condition is checked, regulation is set up, the other aggregates and units are safely tightened, mechanical defects in them are repaired and other necessary work is executed.

Fundamental repair of the vehicle assumes its complete dissmantling and replacement (except for the armor plated body) or fundamental repair of all worn components, units and aggregates. After repair, the vehicle is tested in accordance with established technical conditions for fundamental repair.

The time spent on the individual types of repair is determined by planned standards, established for vehicles and aggregates of each make. These standards are established on the basis of experience in repairing vehicles and aggregates in troop repair units and in factories.

Establishing the types of repair guarantees facility in planning and calculating the repair, the possibility for specializing repair facilities and rationally organizing their supply to armored tank stocks.

Selecting the method of repair is essentially important in organizing restoration of a vehicle. It must guarantee rapid restoration of damaged vehicles as well as high quality repair.

Three repair methods are used in armored forces: individual, repair and miscellaneous.

In the case of the individual repair method, the faulty aggregates and units, removed from the vehicle, are not depersonalized and after repair are again installed on the same vehicle. The vehicle is in repair as long as it is being put into technically sound condition with all aggregates and units removed from it being repaired. Consequently, the basic shortcoming of the individual method is the extended stay of the vehicle in repair. Usually, the use of this method is determined by the absence of working units and aggregates. Thus, it is used with a small and differently marked program.

With the aggregate method of repair, faulty units and aggregates are removed, depersonalized and new or repaired ones are installed in their place.

In order to accomplish the aggregate repair method, it is necessary that the following conditions prevail. First of all, in the design of the single-typed vehicles, provision must be made for interchangeability of the basic aggregates, units and components. In addition, the repair facilities must have reversible aggregates.

The aggregate repair method has a series of merits. First, its use reduces the time the vehicle stays in repair, since the length of the repair is determined by the volume of the demounting-mounting work. In addition, the productivity of the repair facilities is increased due to more simplicity in the organization of production and the productive area is limited for demounting-mounting sections of the repair facilities. It is also important that the requirements for complex special equipment and highly qualified workers are reduced.

With the miscellaneous repair method, a part of the aggregates and units of the vehicle is repaired and each part is replaced by a finished one. This method is used if the principle of interchangeability was not completely adhered to in the vehicle design or reversible aggregates are absent.

The basic method of vehicle repair is the aggregate method, since it guarantees the most rapid return of the vehicle to operation and a high quality of repair.

The technology of repairing armored tank technical equipment has undergone great changes. Let us examine this on a drawing of the technological process for repairing tanks and SAU.

Scheme of the Technological Process for Repairing Tanks and SAU

Repairing modern tanks and SAU is an involved industrial process. It involves a whole complex of work in repair and different measures executed in a determined sequence. These measures include auxiliary processes connected with work organization, preparing the space, developing workshops, planning repair work, organizing supply, etc. Thus, the concept of the production process in repairing tanks (SAU) includes the organizational work of the repair units (sections) as well as the work in executing the repair.

The technological process of repairing tanks and SAU is that part of the production process in which work is executed to correct mechanical difficulties in mechanisms and aggregates. It consists of individual stages, each of which can be viewed independently of the technological process constituting the operations.

The technological repair process must guarantee minimum time of stay for the vehicle in repair together with a high quality of repair. The time may be greatly shortened as a result of using the aggregate repair method as well as widespread introduction of mechanized and automated means.

A high quality of repair is guaranteed with the use of foremost methods for restoring components, quality assembling and a high organization of technical control.

The original data for planning the technological processes for tank repair (SAU), their aggregates, units and components is:

- drawing of the object to be repaired;

- technical conditions for repair;

- characteristic condition of the repair object (type of repair);

- productive possibilities of the repair method for which the repair process was worked out;

- characteristics of the equipment at the disposal of the repair facilities;

- data concerning the latest achievements of science and technology and about the foremost experience in the area of technological repair.

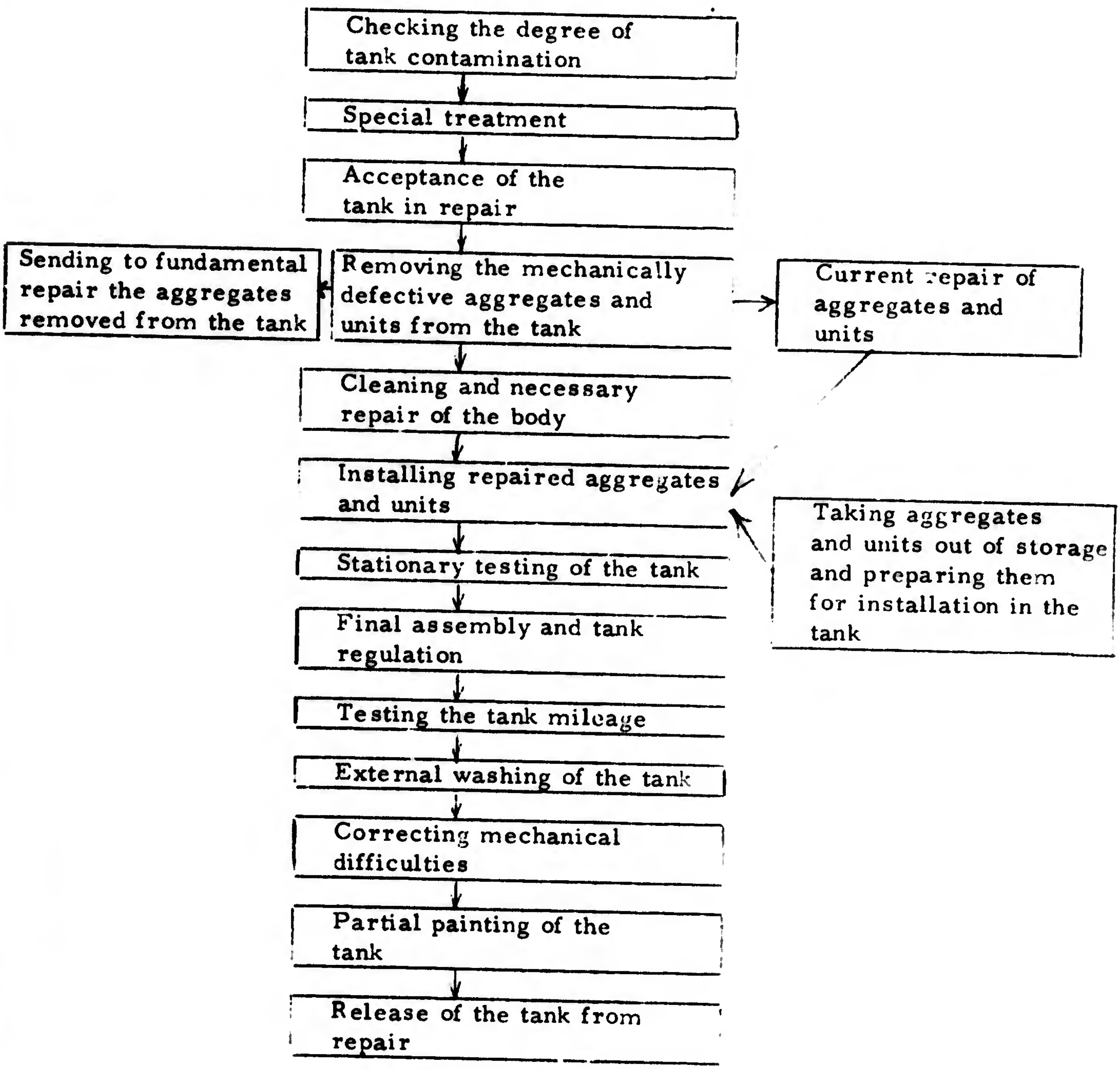


Fig. 115: Drawing of a typical technological process for current and average repair of tanks and SAU with the aggregate method.

In conformity with the classification of the types of repair, the technological processes are classified as current, medium and fundamental repair of tanks (SAU). Typical schemes have been worked out on each of them. Fig. 115 shows the scheme of a typical technological process for current and medium repair of tanks (SAU) with the aggregate method, receiving widespread use in troop repair units and sections.

As is seen from the drawing, in order to execute all type of work with regard to repairing tanks (SAU) in field conditions, the repair subunits and sections must have various technological equipment and personnel of different qualifications in its makeup.

In other words, the character of the work executed at various stages of the technological process in the repair of a vehicle determines the nomenclature of the mobile workshops and their equipment as well as the qualification of the personnel of repair subunits and sections.

Technical Characteristics of Mobile Repair Facilities

In conformity with the volume and character of the work executed during current and medium repair of a combat vehicle, a special complex of mobile tank-repairing workshops have been developed.

The basis of this complex is formed by:

- tank repair workshop type A (TRM-A);

- tank repair workshop type B (TRM-B);

- electrical-gas welding workshop (ECWW);

- workshop for repairing electrical welding equipment (WEWE);

- workshop for repairing tank equipment and optics (WREO);

- mobile repair-loading station (MRLS).

The designation of the workshops, the list of the basic work, executed with the aid of their equipment, the disposition of the posts as well as the time expended in development are listed in Table 8.

As is seen from the Table, the Mobile Workshops are specialized according to the type of work. As a rule, they are equipped with series equipment which is widely used in the general economy. The chassis and the basic equipment of the workshops (machines, power aggregates, etc.) have long operating times which guarantees the possibility of their extended operatic ı.

TABLE 8: Characteristics of Repair Facilities

Name	Designation	Disposition of the working posts	Time expenditure, min. In development	Time expenditure, min. In curtailment
Mobile tank repair shop type A (TRM-A) *	Repair shop designated for demounting-mounting, centering and regulating work, simple repair. artillery equipment, instruments and apparatuses, electrical equipment on tanks, self-powered artillery equipment and track-laying armored transports with current and medium repair in field conditions.	In the body of the shop, on the object, in a stand.	25	20
Mobile tank repair shop type B (TRM-B)	Shop designated for performance of mechanical work, executed in current or medium tank repair, self-propelled artillery and trank-laying armored transports under field conditions.	In the body of the workshop.	25	20
Mobile electro-gas welding shop (MEGW)	Shop designated for welding steel, cast iron, non-ferrous metals, soft and hard soldering, cutting metals and blacksmith-copper work with current and medium repair of tanks, self-propelled artillery and track-laying armored transports in field conditions.	In the stand, on the object, on developed working placed.	40	35

(*) Mobile tank repair shop mounted on the chassis of the automobile ZIL-157E (ZIL-157KE) in an entirely metal body DM-157.

Name	Designation	Disposition of the working posts	Time expenditure, min.	
			In development	In Curtailment
Mobile workshops for repairing electro-radio equipment on tanks (MERO)	Workshop designed to test and repair electrical equipment, communication facilities, special systems and tank apparatuses, self-propelled artillery and track-laying armored transpoits under field conditions.	In the body of the workshop.	20	10
Mobile repair-charge station	Station designated for repair, charging, and conducting control-training of battery cycles with current and medium tank repair, self-propelled artillery and track-laying armored transports under field conditions.	For repairing batteries in the body of the workshop; for charging batteries, for preparing the electrolyte in the stank.	40	30
Moving repair shop for repairing tank equipment and optics*	Workshop designated for repairing equipment and optical instruments (without dismantling the optical system) of tanks and self-propelled artillery with current and medium repair in field conditions.	In the body of workshop and stand.	40	30

(*) The MTVO workshop is mounted on the chassis of the ZIL-157 in a wooden-metal body KH-157.

All the basic work connected with eliminating mechanical faults, caused by combat damage, actual wear or other causes, can be executed under field conditions with the aid of technological equipment of mobile tanks repair shops.

Perfecting Organization and the Technology of Repair

Continuous improvement of combat vehicles and methods used by armored forces requires essential changes in the technical securing system. One of the most important directions for its improvement is further improviding the organization and technological repair of armored tank technical equipment with consideration of the conditions for conducting modern combat.

Organization and technology of repairing armored tank technical equipment is improved by changing and official organization structure of repair facilities, improving their technological equipment, raising the qualifications of the personnel of repair units and sections. This, basically, determines the time expended in repair. However, these directions will exert a non-uniform influence on shortening the time for conducting repairs.

The basic efforts are usually directed toward improving the type and nomenclature of mobile tank repair shops, the mechanization of labor-consuming processes, abbreviating the time expended on position changes, developing means for improving the quality of repair. Together with this, improvements are made in the organization official structure and heightening the qualifications of the personnel in repair units and sections.

Accomplishing these measures encounters a series of difficulties and limitations. So the proposals for improving the state of production for workers and the number of mobile tank repair shops in order to reduce the time expended on repair cannot always be accepted, since this leads to increasing the rear. As a rule, this shows up negatively on the maneuvering possibilities of sections and units of armored forces.

A great deal of attention has been given to perfecting the organization structure and increasing the qualifications of the personnel, causing the necessity to increase the mobility of repair subunits and sections, their technological divisibility and productive power. This requires reworking of the various official repair subunits and sections, and selection of their optimal variations.

To essentially reduce the time spent on repair is possible by equipping the repair facilities with highly efficient technological equipment. However, it is not always useful and rational to charge mobile workshops with various technological equipment. First, this leads to reducing the maneuvering possibilities of the workshops and rather frequently this equipment is not sufficiently effective. So, for the past few years, mobile repair shops have been equipped with various means for mechanizing the labor-consuming work, among them mechanized instruments with electrified drive mechanisms.

However, using mechanized instruments with troop repair of armored tank technical equipment is not too effective. This is explained by the fact that current and medium repair is performed with only partial dismantling necessary for demounting and mounting damaged aggregates and units. In addition, the composition of aggregates and units in modern tanks and SAU is such that the approach of a mechanized instrument to the point of fixing is difficult. This somewhat decreases the effective degree of mechanization. In connection with this, when complementing mobile tank repair shops with technical equipment, it is necessary to proceed on the basis of fundamental assumptions -- how effective is this equipment and how will it reduce the time expended in repair.

The experience and qualifications of personnel exerts an essential ifnluence on lowering the time expenditure. Thus, repair subunits and sections must be complemented by highly-qualified specialists.

Part II

COMBAT OPERATIONS OF ARMORED FORCES

Chapter 5

Modern Warfare and the Armored Forces

Section 1

Armored Forces--Main Striking Power of Land Forces

It is known that the role of modern land forces is to lead combat operations in order to break the resistance of the enemy or to crush his ability to resist. Their basic task, under conditions of nuclear combat, is to destroy the enemy after nuclear strikes have been inflicted or to take prisoners. In addition, land forces may capture the major economic and geographical regions controlled by the enemy.

It is hardly possible to determine the outcome of a combat with one nuclear weapon. In order to completely destroy the enemy, it is necessary to take control of his territory and population. It is evident that this task could not be carried out without land forces.

What kind of land forces should we have? Is their role and significance changing in connection with the widespread introduction of nuclear weapons into the army?

Let us examine these problems briefly.

Two points of view are known abroad concerning the role of land forces under new conditions.

The advocates of the one viewpoint regard the nuclear weapon as the ultimate means with which it is possible to solve all problems emerging from combat operations. According to this, land forces are relegated to the role of occupation troops which must enter the enemy territory destroyed by nuclear weapons and take control of it. It must be concluded from this that the land forces need be few in number, lightly equipped and adaptable as air combat forces.

The advocates of the other point of view, although acknowledging nuclear weapons as the basic fire power for defeating the enemy, point out, however, that victory may be final only when the enemy, which remains after the nuclear weapons have been inflicted, has been demolished or taken prisoner, and secure control has been established over his territory. Thus a great deal of effort is expended on land forces, and consequently they must have all the modern combat means; first of all there must be armored forces adaptable for nuclear combat operations.

The advocates of the first viewpoint usually refer to the use of American atomic bombs on August 6th and 9th, 1945 on the Japanese cities of Hiroshima and Nagasaki, maintaining that Japan surrendered after these atomic bombardments. Such an assertion does not stand up to serious criticism, because it is generally known that the surrender of Japan took place almost one month after the atomic bomb was dropped (September 2nd, 1945), after the Quantoon army was destroyed, the backbone of its land forces. Abroad it was considered doubtful to expect a powerful enemy to surrender after the primary nuclear strike. On the contrary, it can be assumed that his will to resist was strengthened.

Certain foreign military theorists express the thought that a nuclear weapon is the very means with which it is possible to conclude the traditional tactical breakthroughs of single and dual areas as well as of surrounding territory. Their opponents assert the contrary and point out that the maneuver on the field of battle remains the basic combat operation. They assert that sooner or later, any change in the form of the maneuver is always encountered by an appropriate counteraction on the part of the enemy. Just as the appearance of the musket forced renunciation of deep military formations, and the invention of the machine gun forced renunciation of closed columns and lines, the acceptance of nuclear weapons as armaments led to the necessity of dispersing troop combat ranks. As a result, the selection of targets for inflicting nuclear strikes is made extremely difficult, especially for large nuclear ammunition. In addition, the determination of epicenters of the detonations is not a simple business, since the objects will always be in movement on the field of combat. By virtue of this, their use always turns out to be a complex problem, because the target, having a high degree of maneuverability from the moment it is spotted until the moment the rocket is launched, can evade the impact zone. Consequently, the fired nuclear ammunition may not strike the target where it would have been most advantageously applied for their side, as a result of which the enemy, which was thought to have been destroyed and defeated, will turn up in the path of the approaching troops. In such a situation, in order to defeat the enemy in mobile forms of combat it sometimes turns out to be necessary to maneuver part of the ground forces, the armored forces. They assert that it is not possible to do this without the indicated higher form of maneuver; thus the basis of armored forces is the maneuver!

Some foreign combat theoreticians point out that on the field of combat in future wars, individual nuclear strikes, even if all targets are covered, will be insufficient to gain total victory. A part of the enemy's strength will escape destruction. Although conventional means of combat turn out to be insignificant compared with nuclear weapons, nevertheless they are necessary for the concluding stage of the battle, when the attacking troops of one side meet face to face with the forces of the other side which have escaped destruction or their reserves which succeeded in hiding from the attacking forces. Under these conditions, it is necessary to apply conventional means, in particular tanks to destroy the enemy with well-aimed and destructive tank strikes. Moreover, this strike will be applied until the enemy collects itself and can regroup. There was a similar situation in the recent past when heavy artillery replaced the grenade and the machine gun replaced the pistol and the bayonet. This tendency of inflicting dagger strikes has been preserved for the present.

They also take into accout the fact that if any region would be converted into a dead zone or into a zone of complete suppression, then in this case, evidently, it can remain a focal point of resistance, the possibilities of which cannot be disregarded. The calculation of a rapid victory without the active participation of ground forces can hardly lead to success, if we think that only one nuclear weapon completely opens the road for a maximum rapid advancement of troops. Such a result is possible only if the morale of the enemy is suddenly and completely broken by the initial strikes. Consequently, such cases of complete suppression of the enemy also requires the application of ground forces and maneuvers which this suppression involves.

Thus, it is thought that in nuclear war the necessity for high power ground troops using all combat means still remains. Their operational tactics are unthinkable without maneuvers, that is combining fire and movement, without dispersing strength on targets and their interactions.

Obviously, much greater and diverse problems will precede ground troops in future wars. But since this is the case, ground forces themselves cannot be monotonous, similar masses. Theoreticians express such an opinion in many countries. It is known that in all armies of the world, ground forces consist of various types of troops and special forces, supplementing each other in a harmonious way. In all foreign armies it is generally accepted that the armored forced are the main striking force of the ground troops. Above all, they are suitable for conducting battles such as in nuclear war as well as for leading combat operations without the application of nuclear weapons.

At the present time we are observing animated discussions in all armies of the world concerning the following problems: what sort of armored forces should we have, how should they be organized, what kind of technology should be used for equipping armored forces, should they be equipped with one unified vehicle or with combat vehicles of various types?

The opinion is being expressed in the foreing military press that in universal nuclear combat, nuclear weapons will be used in large quantities to inflict strikes on troop concentrations, major sites of an area, supply points, communication junctions and other objectives. Moreover, ground as well as air nuclear blasts will be carried out. Also, consideration is being given to using a large number of nuclear weapons in a limited nuclear war. In their opinion, war can be conducted under the thread of using nuclear weapons, but without their actual use. Even under conditions of universal or limited nuclear war, battles will often occur in which conventional means are used.

The conditions on the battlefield, as considered by foreign combat specialists, will be characterized by the following:

First, the continuous thread of inflicting nuclear strikes of various force on all sections of the battlefield.

Second, the effect of harmful factors of nuclear weapons on the troops: shock wave, light radiation and the penetrating radiation. It is assumed that the impact of the nuclear strike on troops, situated in exposed areas without cover, will be effective at a distance up to 3-5 km from the epicenter of the blast depending on the power of the nuclear weapon, while individual personnel in armor plated vehicles can maintain their combat capabilities even if these forces are at a distance from the epicenter of the blast which is three times closer than those outside of the armor protection.

Third, radioactive contamination of the site as a result of fallout from the nuclear blast. A ground explosion or an explosion near the surface of the earth may lead to contamination of a wide area with a level of radiation which may persist over a long period of time and incapacitate unprotected individual personnel. However, individual personnel in armored plated vehicles, weakened from radioactive radiation, can function under these conditions, not subjected to the danger of radioactive contamination.

Fourth, the constant thread of losing the entire unit, supply points, radiocommunication facilities, communication centers as well as disruption of rear area operations due to infliction of nuclear strikes by the enemy.

As a result of the aforementioned, it is considered abroad that armored forces must have equipment as well as organization which would allow it to successfully operate under conditions of nuclear war and to actively conduct combat operations under conditions when nuclear weapons are not being used.

With what kind of combat vehicles should armored forces be equipped?

Different opinions will be found abroad concerning this problem. One states that in the armament there must be light, medium and heavy tanks. The other states that under new conditions it is expedient to have only two types of vehicles: the light and the basic medium combat tank.

This problem is not new. It was widely discussed abroad right after the end of World War Two and after the adaptation of nuclear weapons to equipment. The discussion of this problem continues up to the present time.

It is known that for a long time tanks in all countries have been classified into light, medium and heavy. At the time of the Second World War and after it there was the tendency to classify tanks into light-gunned, medium-gunned and heavy-gunned. Such a classification was acknowledged to be unsatisfactory, since guns of a low caliber were set up on a heavy chassis. For example, there was a 42-mm gun on the "Churchill" tank, there was a 76-mm gun on the heavy KB-1 and KB-2, while, for example, a high-power 88 mm cannon was set up on the light Czech chasses; large caliber cannon-howitzers were set up on the chassis of the T-34 medium tanks.

At the present time, the tendency is being observed in foreign armies to classify track-laying vehicles according to fulfillment of their functions, classifying them into reconnaissance tanks, air-descent, standard combat tanks, tank support. attack vehicles, maximum self-propelled equipment, etc.

It is true that in many countries tanks are classified according to the old principle--light, medium and heavy.

Taking the classification of tanks according to the fulfillment of their functions, as acknowledged in the foreign press, it is possible to compare them only within the limits of one group, designated as a fulfillment of established functions. As a result, a large number of vehicles has been excluded. However, even under these conditions, in their opinion, it is difficult to compare the vehicles, not having established tactical concepts accepted in different countries or in the armies of some countries. Take for example the well-known French tank AMX-13. As is well known, it was designed as a tank destroyer and considered as such in France. However, in other countries purchasing this tank, it was used as a reconnaissance tank (Netherlands and Switzerland) or as a police tank (Venezuela).

In foreign countries, the military press has been discussing which tanks would be used under conditions of nuclear war. The combat characteristics of nuclear weapons and anti-tank guided reactive shells, practically useful for piercing armor of any thickness which might be used on tanks, obliged combat theoreticians and designers to consider the following principal problems: what is most important for the tank--maneuverability or armor plating, what vehicle types are better, what kind of equipment should a tank have--cannon or reactive?

Many foreign armies are adhering to creating and producing the basic light tanks equipped with high-power anti-tank cannons in conjunction with PTURS. The designers of this concept conclude that the PTURS can practically destroy any tank. It this is true, according to their opinion, then it is not a question of creating a tank with thicker armor plating.

They are also adhering to creating medium and heavy tanks. As for the latter, it is considered that such tanks may influence a man in matters of morale on the field of combat due to its fire power, they will be better at overcoming difficult terrain and withstanding the shock wave of a nuclear explosion, guaranteeing the crew good protection against radiation and also overcoming the destroyed and demolished radioactive material of the locality.

At the present time, in many armies of the world we are observing the tendency to standardize combat vehicles. An effort is being made to create multipurpose vehicles which would be capable of solving three basic problems: conducting reconnaissance, supplying combat material and carrying out combat interacting with other combat means.

It is considered obvious that it will be difficult to solve the complex and various problems in the near future with one type of armored combat vehicle. The creation of an armor-plated combat vehicle with reliable armor plating and high-powered equipment which would be amphibious and aero-transportable is an extremely complex problem. In order to solve the combat problems indicated above it is evident that we will need at least several types of combat vehicles.

In foreign combat literature it is pointed out that in order to objectively evaluate tank designs it will be necessary to use a probability approach, that is determine the probability of the tank fulfilling its functions in combat in all or at least in one of its stages. Such an approach above all permits a correct evaluation of many tactical-technical tank characteristics and gives objective qualitative criteria for comparing vehicles of various designs. The application of mathematical methods in operations study may solve this problem. It is known that the most difficult function the tank has to fulfill is destroying enemy tanks. Thus, on the basis of this criterion, it is necessary to consider the ability of the tank to destroy an armored vehicle of the enemy as well as its crew.

Section 2

The Place and Role of Tanks in Future Wars

It is generally known that tanks, by virtue of their combat characteristics, are especially suited for leading combat operations under conditions of nuclear combat. They make up the basis of armored forces. Thus tanks retain their usual importance.

We will not attempt to examine the place and role of tanks in contemporary nuclear combat.

The role of tanks remains a leading one in the conduct of combat operations with land troops. Since the armored forces are the basic striking force of the land-based troops, they will be swiftly advanced forward behind the nuclear strikes, demolishing in their path all surviving focal points of enemy resistance or operational reserves advancing from the depths. The armored forces will first overcome the nuclear mine belt and will surmount the enemy obstacle zones, they will come out in its deep rear flank and destroy it partially. This is now already clear for everyone.

Tanks present themselves as a powerful means, capable of leading combat operations under any conditions. Experience in past battles shows that they have been successfully operated on the plains of Europe, on the deserts of Africa, and in the mountains of Asia. Future battles will also develop at different places. We would like to express the thought that it is obviously necessary to use tanks under complex conditions of contemporary combat in order to be successful. To achieve victory without tanks is now simply impossible.

Now the fact is recognized in many foreign armies that tanks can be used in war in large-scale formations. The basis of these formations is considered the tank unit. It is also recognized that parts and units of other types of troops must enter into their make-up. Such formations present themselves as powerful tank groupings. Armored forces, consisting of parts and units of various types of troops, in a nuclear war will maintain their capability of attacking, breaking up, disorganizing and destroying enemy troops. The ultimate goals of winning the battle have not changed--the enemy must be destroyed or forced to surrended; other goals are only circumstantial and matt of combat technique. But the changes which involve the appearance nuclear weapons are enormous in scale and do not compare with changes occurring in previous warfare. It is pointed out in the foreign press that armored forces, interacting with nuclear weapons, can now evidently fulfill a wide range of tasks in an independent manner. This is a very important change in the role of armored forces in comparison with their role in past wars.

It is generally known that the successful operation of armored forces is hindered by broken terrain, deep ravines, permafrost, dense thickets, rivers, lakes, channels, etc. Thus, the combat power of armored forces can be more effectively utilized at places which are favorable for their application. The maximum effectiveness of armored forces is achieved with an intelligent and creative approach to solving problems of combat. The more difficult the conditions of the locality, the more carefully the actions should be thought out as to decreasing the influence of the unfavorable conditions of the place on troop operations with regard to repair, supplies from the rear and engineering provisions. The problem of communication becomes particularly complicated; thus it is important to provide for the use of available means to improve passability of armored vehicles. When surmounting rocky terrain, boulders, channels and ravines on highly broken terrain, wear of track components and the suspension system increases; under these conditions, an attempt should be made to devote more attention to repair and replacing worn parts.

As tank battle operations progress, there will be increased importance concerning well-timed provision of fuel and lubricating materials, ammunition as well as other material means. Thus, it is necessary to take special care for material provisions.

Tanks may often advance in separate directions, sometimes isolating themselves from each other. Moreover, while performing the tasks imposed on them, they may lose contact with other advancing troops. This loss of contact will not have the character of a systematic separation from the residual forces of attacking troops, but rather will be an irregularly precipitated forward movement. As considered by foreign combat theoreticians, such an attack will have the character of a movement of tank divisions on a wide front and with great depth. They believe that it cannot be a question of such a front line as it was in past wars. The operations will develop over wider areas. Under these conditions, the maneuvering of troops will assume decisive importance.

In connection with the fact that an attack assumes such a character, the term "occupied territory" loses its former meaning. The occupation of any territory by troops will present itself as an advantageous goal for nuclear strikes of the enemy. At the same time, large areas will practically not be held by troops. The concept of "occupation" of a locality must evidently yield to the concept of "control".

One of the ways of decreasing combat losses and damage to tanks during the course of combat operations appears to be the dispersion of combat ranks. However, this guarantee is relative. In order to determine the sufficient degree of dispersion, it is necessary to know the caliber of the nuclear ammunition which the enemy may use in a given concrete situation. But it is almost impossible to know this beforehand. Thus, since this is the case, some dispersion of troops is always necessary. The greater this dispersion, the more difficult it is for the enemy to determine a target and inflict a strike. In small units, such a dispersion causes no trouble in fulfilling tactical tasks in destroying the enemy according to which the nuclear strike was first inflicted. But obviously the dispersion will have some limitation. Such a limit may be the batallion (division); at least is is now considered so in many armies. The extent of the dispersion will be selected as a function of various factors (the possible mean caliber of the nuclear ammunition of the enemy, the character of the locality, etc).

At the present time the foreign press is pointed out the fact that the defense of sections or subsections is losing its more or less statistical character which is had earlier. In principle, an aggressive characteristic has already been imposed on the conduct of defense. Henceforth in defense activities a responsible role will be imposed on armored forces, interacting with other types of troops in destroying the entrenched enemy and re-establishing the primary position. Moreover, it is being taken into account that under favorable conditions, the armored, forces, having re-established the defense position, may proceed to the attack and in this way create conditions for counterattack of ground troops. We had similar precedents already in past wars. For example, the counter-strike of the 5th guard tank army under Proxorovka in July, 1943 was successful and the defending troops of the Voroneshkovo front proceeded with the counterattack. Such moments are all the more possible in future combat operations since the defending troops may create conditions for transition to the counterattack using their own nuclear weapons.

It is known that one of the basic characteristics of armored forces is their maneuverability. It provides them with the capability of successfully solving problems concerned with attack as well as defense. Sometimes the maneuverability of armored forces tends to represent a universal means guaranteeing the safety of tank troops. There is the tendency aborad to increase maneuverability even at the expense of reducing the armor plating of tanks and other armor plated combat vehicles. However, their maneuverability cannot be continuous. In the contrary case, this may lead to rapid fatigue of the crew and wear and tear on material parts of the tank. It seems to us that maneuverability may be a factor in guaranteeing the safety of the crew to the extent that it leads the enemy to miscalculate the relative placement of the troops, and inasmuch as it permits the exposed sections to rapidly abandon a given area before the enemy inflicts a nuclear strike. Maneuverability and concealment of vehicles on the ground--these are two different methods for guaranteeing the safety of tanks which will be combined in nuclear combat.

Judging by the pronouncements of the foreign military press, the utmost importance will be given to the maneuvering of armored forces in nuclear war. We consider that the planning of combat operations must be rapidly reflected in directives and orders. In these directives it is necessary to determine the problems as accurately as possible, determine the basic features of the operation as well as the contemplated target. A broad initiative must be left to subordinates after the start of combat operations since only they are in a position to analyze the arising complex situation.

According to the views of foreing combat specialists, decentralization of maneuvers sometimes becomes necessary down to the lowest organization levels; in this case it will leave more initiative to the troops. They consider that directives must be extremely clear. When active on the battlefield, the armored forces will have the possibility of making their own contribution to solving the general problems and achieving ultimate success. From statements made in the foreign military press, it follows that in a nuclear war the important factors may be centralization in the preparation for and the conduct of combat operations and leaving a large degree of initiative to the troops.

In directing the combat operations of armored forces according to individual directions and over a wide range due to disruption of communications caused by the enemy, issuing orders will be very difficult to orient in complex and, at the time, contradictory situations, even in the case where the commander maintains control in his own hands. Decentralizing the combat operation maneuvers will be carefully prepared beforehand, otherwise the troop attack will be paralyzed in a few hours. In this period the tank units must operate in an organized manner, taking account of the posed problems, attacking with all available means.

Foreign combat specialists consider that rear guard security of the combat operation of tanks will have a decisive importance. Material provision will be formulated such that the forces will not be hampered in their operations due to shortages of fuel and particularly ammunition. The conventional rear-guard system which is based on the deployment of large amounts of supplies and on transportation of goods over broad areas does not turn out to be suitable, as viewed by the foreign press. Large amounts of supplies become extremely vulnerable and the transportation of goods over long distances will be made difficult due to disruption of communications. As the foreigners see it, in addition to the dispersion of troops, there is also need for the decentralization of supplies, which involves replacing the large amount of supplies with a large number of multipurpose supplies, corresponding to the manner of distribution over broad territories.

They consider that for purposes of compensating the disruption of ground communication, the wide application of air transport may turn out to be expedient. This, of course, not to the degree that it excludes the use of generally-available means to supply material to tanks conducting combat operations. It is completely obvious that on the field of combat where armored forces are operating, shortages of material means may occur to an usual degree in different areas. This will risk rapidly paralyzing the activity of the armored forces which cannot operate without fuel and ammunition. In these situations, wide maneuvering of materials by air may help alleviate this danger.

It is believed abroad that in future rocket-nuclear wars, and even in wars without the use of nuclear weapons, wide use will be made of air and sea landings. The nucleus of these landings may turn out to be tanks. Air landing of tanks may be used behind enemy lines, rapidly shifting from place to place. Air landing units, equipped with tanks, may serve for a while as the basic striking force of air-dropped troops.

It is pointed out in the foreign military press that air transport means are being created for the transfer of tanks of the type AMX-30 "Leopard" and the "S" tank. The transfer by air of combat vehicles of such types may change the character of air-drop combat operations. Some combat theorists and practitioners consider that evidently future attacks will be carried out through the air. Moreover, they surmise that primarily sections and subsections of armored forces will be used, since under present day conditions only the mechanized sections can carry out an attack after a landing.

In order for air-dropped troops to be fully able to realize their specific advantages, foreign military specialists suggest they be given tank support, because without this air drop they will be able to fulfill only those tasks which, under the force of conventional infantry, are assisted by air.

They believe that in landing air drops in future rocket-nuclear wars, tanks will not even play the latter role. Past wars as well as the events of post-war years show that sea drop operations have not lost their importance. Their importance is intensified in the nuclear age and now it is considered necessary in the first landing waves to drop tanks and other amphibious, armor plated vehicles. They protect individual personnel from machine gun fire and enemy shell fragments and bombs. According to their opinion, this forces us to the conclusion that in the first waves it would be expedient to have tanks and armor plated transports which could emerge from landing crafts and then go ashore under their own power. Many foreign combat specialists believe that for the rapid build-up of forces and inflicting precipitous strikes on the shore, in the last waves it would be expedient to land tank units using tank-landing ships and cutters for this purpose.

Nevertheless, the creation of amphibious armor-plated vehicles (tanks and armor-plated transports), as well as different kinds of amphibious means for tanks, according to the opinion of many foreign combat specialists, will open new perspectives for use of armored forces in sea-landing operations, providing the possibility of using independent amphibious tank landings.

Thus it is recognized in foreign armies that armored forces are the basic striking force of ground troops. They can also play a leading role in sea and air landings.

Section 3

Future Tanks

An analysis of the views expressed in the pages of the military press of many countries shows that one of the most vitally important questions in the art of warfare is the future tank. The widespread introduction of nuclear weapons has caused the emergence of two opposing viewpoints in some armies, giving rise to two specific tendencies. One of these tendencies originates from the increasing role of armored plated vehicles, especially tanks, and their recognition as better means for armed combat in nuclear war and includes the tendency toward troops with maximum "armor plating", that is to say equipping them with armor plated combat vehicles. It would seem that this tendency must lead to the future development of organizational structures in armored forces. However, this has not happened.

Secondly, the tendency has been observed in some foreing armies that while acknowledging the importance of the role of tanks, it is considered that land troops must consist of single, unified divisions, equipped with a large number of armor plating techniques. The supporters of this point of view proceed on the basis that they consider nuclear weapons the ultimate means, with the aid of which it is possible to solve all problems arising in warfare. In their opinion, the unified division must fulfill the mission of occupational troops which enter a locality where the outcome of a struggle has already been decided by nuclear weapons. The adherents of this concept propose equipping these divisions with one or two types of universal combat vehicles.

The emergence in almost all armies of anti-tank guided missiles and other anti-tank media has aggravated still more the struggle of tanks with these antipodes. In consequence of this, adherents have appeared abroad for the production and acceptance of only lightly armored plated and well-equipped vehicles.

At the present time, as if to determine the viewpoint on the creation of the basic tank which to a large degree will satisfy the conditions for conducting combat in a nuclear war, a discussion concerning this question is continuing in the foreign press.

It is generally known that the business of designers is to create a combat vehicle, the role of commanders consists in confronting the designers with the problems emerging from the perspectives and views of the future. An analysis of the character of combat operations in the near future predetermines many basic changes in the concepts and procedures of combat operations. It is thought that creative development of views concerning organization, combat-utilization and the equipping of tank troops of the future will be an ongoing matter.

At the present time, many foreigners and theoreticians as well as practitioners have come to the conclusion that tactical concepts require creation of a lighter tank in comparison with existing heavy vehicles, having a high degree of maneuverability off the road under any weather conditions, having a large reserve, improved observation equipment, more powerful weapons, improved armor plating and operable with any fuel.

An analysis of the foreign military press shows that many military specialists have arrived at an opinion concerning the impossibility of solving complex and multifaceted military problems with the use of only one type of armor-plated vehicle. At least in the near future it is considered expedient to have two types of combat vehicles--the light and the medium tank.

With regard to the organization of tank troops, judging from the foreign military press, there are also two points of view. According to one of them, the highest tactical unit of tank troops in a nuclear war must be the tank brigade. The other viewpoint states that the more expedient organization proves to be the tank division. Moreover, the adherents of both viewpoints acknowledge the possibility of creating a more powerful group of tank troops from the brigade and the division. They are of the opinion that the tank troops will be the basic striking force of the land troops, the motorized infantry, combining individual groups of tank troops.

The thought is being expressed in the foreign military press that under present-day conditions victory is possible to achieve only by joining the forces of various types of troops, the number and the use depending on the various destinations.

There are supporters for unifying the divisions of land troops. However, in their opinion such an organization of divisions with one-sided direction gives rise to doubts as to whether it is capable of achieving victory over the enemy. Thus the opinion is being expressed in the foreign press that in the near future, as far as land troops are concerned, it will be expedient to have divisions with different designations and on the edge of strikes using footsoldiers it will be necessary to have armored forces.

As is evident from an analysis of the foreign press, under modern conditions and in the near future armored troops will be the striking force of footsoldiers. They will also play a leading role in air drops and sea landings. It is believed that the basic types of armored vehicles will be light and medium tanks as well as armored transports and infantry combat vehicles. These vehicles must be amphibious and aero-transportable. According to their opinion, the highest tactical unit is the tank division. But from the concrete conditions and combat requirements there may emerge an even larger classification of armored forces.

Chapter VI

Combat Operations of Armored Forces

Section 1

Nuclear Explosions and Tanks

1. How Tanks Use the Results of Nuclear Explosions

Nuclear weapons are the most power means of mass destruction. In a short period of time they are able to disable all units, parts and even combinations, destroy different buildings and objects, create a broad zone of radioactive contamination and in addition have a strong morale influence on the troops.

The destructive power of a nuclear explosion is one hundred thousand times greater than the power of conventional shells and bombs. So, for example, in order to suppress a well-equipped company resistance points, in years of past wars only about ten weapons and mortars were available expending thousands of shells and mines; quite a lot of time was required to complete such a task. Now this problem can be solved all at once with nuclear ammunition of appropriate power, which is more effective and much faster.

It is indisputable that equipping armored forces with nuclear weapons greatly increases their firepower and striking power and fundamentally changes the character and nature of contemporary warfare. A new and important combat element has appeared, the nuclear strike which in a certain region inflicts complete defeat on the enemy and creates disruption in his combat ranks.

It is quite evident that the basic content of contemporary general-troop combat will be the destruction of nuclear means and the main troop concentrations of the enemy with nuclear weapons, combainted with precipitated attack of tanks through gaps created in the enemy's defense. Thus, the operations of armored forces on the battlefield will probably be primarily coordinated with nuclear strikes and will be directed toward effective utilization of their results.

It is known that in the equipment of armies of basically capitalistic countries we are dealing with rockets with nuclear charges of varying power. They have a long range, a high degree of impact accuracy, dependability in destroying the target, and are launched from equipment of high maneuverability. It is believed that rocket units of armored forces must have a high degree of maneuverability, must be able to move rapidly over a wide area, must be able to operate immediately in the combat ranks of troops. In addition to rockets, nuclear strikes can be inflicted with fighter-bombers and aircraft, the use of which is considered especially effective on moving objects.

It must be assumed that nuclear weapons will be used to destroy particularly important objects of the resisting enemy. It is obvious that the basic objectives for destruction with nuclear weapons in contemporary warfare may be nuclear attack facilities, support points and resistance units, reserves, especially tank reserves, defense resistance facilities, command points, ammunition and fuel supplies; but in defense there are nuclear means and basic enemy troop concentrations, primarily armored forces with their approach and deployment in combat ranks.

Air explosions will often be used when combat is encountered or in an attack, since considerable radioactive contamination occurs in the area of the explosion, impeding the attacking troops.

Obviously, low air explosions will be used to destroy defense installations and to destroy enemy tanks, whereupon strong radioactive contamination occurs only in the region of the blast epicenter. The epicenter regions of low air explosions with high levels of radiation can be successfully overcome by tanks, in addition to which irradiation doses to the crew will be insignificant.

Important objectives situated deep in enemy territory can be destroyed with nuclear weapons with the use of ground explosions. The result of such explosions may be extremely serious losses in personnel and technicians not only from the direct effect of nuclear explosions, but from radioactive contamination in zones having dangerous and strong contamination.

Nuclear weapons will be used observing the measure of safety to one's own troops even if this means a negligible decrease in their combat capacities. Thus, the objectives of nuclear strikes and the epicenters of nuclear blasts will be selected with consideration of guaranteeing the safe evacuation of one's own troops. The limit of safe evacuation will be indicated by the attacking parts and units according to the map and at places according to well observed landmarks (Fig. 116). Obviously the troops will wait for the nuclear blast at this line while the reconnaissance and outposts have previously withdrawn a safe distance.

Rapid utilization of the results of nuclear weapons for the purpose of completing destruction of the enemy may be achieved by precipitated attacks of tanks behind the nuclear strikes and advancement to the depths of enemy defense at a high rate. Tanks themselves are particularly successful in attacking behind nuclear strikes, making use of gaps in their defense, moving at high speed to surmount obstacles, rubble, fires, regions or radioactive contamination, so in a short time to reach the other side of the region of the nuclear blast.

It can be assumed that as a result of the nuclear blast at the limits of the zone, the full loss of combat capability of units and parts will be felt when personnel are disabled; behind this radius for example two times larger, the troops may prove to be under a considerable degree of suppression and may not be able to resist attacking tanks for a more or less extended period of time.

Taking into account what was stated above, in a series of events, the attack will often be conducted directly through the

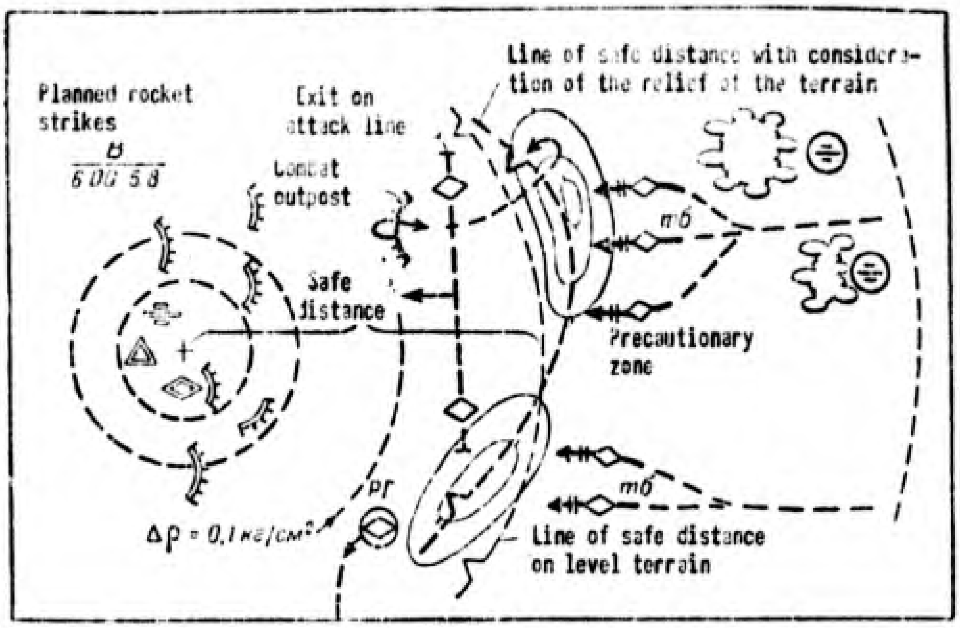


Fig. 116.--Determining the line of safe distance in the case of an attack under movement.

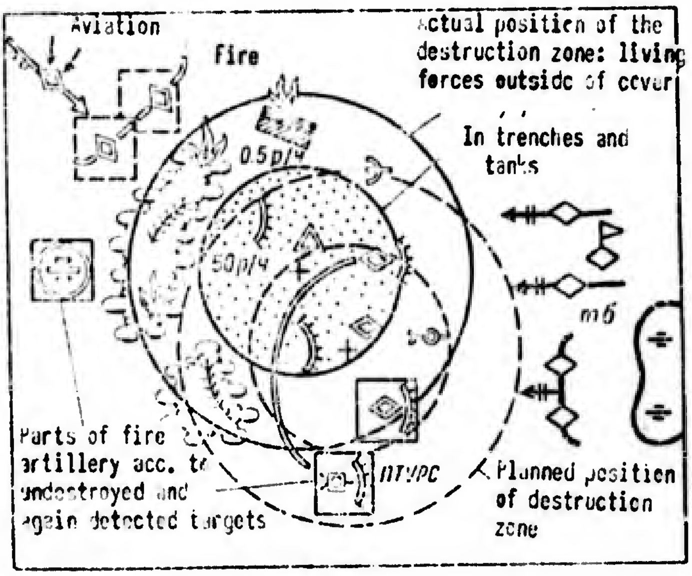


Fig. 117.--Attack of a tank batallion after a nuclear blast.

region of the air nuclear blase in pre-combat or combat ranks, where all the firepower of the enemy has been destroyed or suppressed. However, due to the deviation of the blast epicenter, a designated part of the enemy firepower may be left undestroyed. Thus immediately after the blast it is expedient to determine its results with respect to the destruction of objectives and define and set up tasks for the artillery and tanks to destroy what was not struck by the nuclear blast or recently appeared firepower, primarily tanks and enemy anti-tank facilities. (Fig. 117).

It must be kept in mind that the site of the blast will be greatly changed; individual structures, population centers, bridges may be completely destroyed, many landmarks will have disappeared, fires may occur on the boundaries of destroyed zones, and in the region of the blast, orientation will be made more difficult due to dust and smoke. Especially strong and extended dust conditions may be present with a low air explosion (and even more with a ground blast) in dry weather on sandy soil or on plowed fields. Under these complex conditions, the attacking tanks obviously will carry out reconnaissance of roads, evading destruction and obstructions or surmounting them while moving through areas of radioactive contamination, performing a radiating reconnaissance, making passageways for armor-plated vehicle transports or wheeled vehicles.

Thus when setting up tasks for the commanders of units and tank crews, it must be assumed that the possible character of their change after a nuclear strike will be pointed out on the spot, as well as the direction of operations according to well discernible landmarks having resisted the blast as well as measures for thorough security against tank attack.

A very important moment in the development of an attack is the egress of tanks onto the opposite side of the nuclear blast region. At this time the enemy firepower may be located outside of the strike zone and may be reduced in fighting efficiency. It is also possible to advance on the firing limit of tanks and antitank facilities from its reserves. All these methods may meet with organized resistance fire when the attacking tanks egress from the zone of dust formation, fire and obstructions. These facilities must be destroyed by the concentrated fire of artillery and tanks, and the moving enemy reserves must be destroyed by rocket and air strikes. Only decisive attack operations of tanks at high speeds will deprive the enemy of restoring its fighting efficiency after a nuclear strike and are capable of accomplishing its complete destruction.

2. Defense Characteristics of Tanks against Nuclear Blasts

Under conditions of nuclear war, tanks can effectively use the results of their own nuclear strikes since in all types of modern warfare techniques, armored forces have a comparatively high degree of resistance against the destructive factors of nuclear explosions and reliably guarantee the protection of the crew. The tank fully protects the crew from light radiation of a nuclear blast and greatly reduces the impact of the shock wave and the dose of penetrating radiation.

In the case of low-power nuclear blasts with the basic damage factor having a maximum radius, the impact on the crew is penetrating radiation; in the case of explosions of high power there is the shock wave. This is explained by the fact that with explosions of low power, the activity radius of penetrating radiation, and especially the flow of neutrons, is greater than the activity radius for shock waves, and for explosions of high power, the opposite is true. In turn, the flow of neutrons has a high degree of capability, compared with gamma rays, to penetrate armor plating. It is pointed out, for example, that a layer of armor plating attenuating neutrons by one-half amounts to 10 cm, for gamma rays, 3 cm. Materials consisting of chemical elements with light nuclei (hydrogen, carbon, etc), for example plastics, are difficult to penetrate for neutrons and, on the other hand, are easy to penetrate for gamma rays. It is pointed out that a layer of semi-attenuating plastics for neutrons consists of 3-5 cm, for gamma rays 15-20 cm. Knowing the layer of semi-attenuation, it is easy to find the attenuating coefficient for penetrating radiation of any obstacle according to the formula:

$$K = d/2^{sp}$$

where K is the attenuation coefficient (any number of times);
D is the thickness of the obstacle in cm;
CP is the layer of semi-attenuation in cm.

So, for example, armor plating with a thickness of 10 cm attenuates gamma rays 10 times ($K = 2^{10:3} = 2^{3.3} = 10$), the neutron flow 2 times ($K_H = 2^{10:10} = 2$); a layer of plastics of such thickness attenuates gamma rays 1.4 times ($K = 2^{0.5} = 1.4$), and a flow of neutrons 10 times ($K_H = 2^{10:3} = 10$). Thus it is believed that in order to increase the shielding characteristics of armor plating against a flow of neutrons, it will be necessary to adapt a so-called plastic screen.

The tank also guarantees reliable shielding of the crew under the effect of radioactive contamination over broad areas after ground nuclear explosions and decreases the radiation dose, according to the data of the foreign press, approximately 10 times. Reliable hermetic sealing of combat compartments protects the crew from radioactive dust. Thus even a very high degree of radioactive contamination of the exterior of tank armor plating does not present any special danger to the crew and requires only a measure of caution when servicing the tank. A high degree of shielding properties of tanks against radioactive radiation makes it possible to conduct combat operations even in zones of strong and dangerous contamination right after their formation with minimum doses of radiation to the crew.

According to the data of the foreign military press, damage to tanks themselves from nuclear blasts occurs only in the comparatively near vicinity of the blast epicenter and, as a rule, as a result of the effect of powerful shock waves.

The tank will sustain damage only from the great pressure of the shock wave, let us say exceeding 20-30 t/m^2. In addition, the overall strength of the dynamic impact on the tank may exceed 100 t, as a result of which the tank may be turned over or thrown back several meters. With a nuclear blast having a force of the order of 30 kt, such damage may be observed say, at a radius up to 250 m.

Slight and medium damage may occur with a pressure of 10-20 t/m^2. With slight and even medium damage, the maneuverability of the tank is usually maintained. Medium damage with a blast of nuclear ammunition having a power of 30 kt may occur in a radius up to 500 m, with slight damage up to 1 km. At this distance the tank crew may be disabled. At a distance two times greater, only insignificant damage to the outside equipment is possible, with hardly any effect on their combat efficiency.

On the basis of the law of similarity of blasts with increasing (decreasing) force, the destruction zone radius having destroyed tanks increases (decreases) proportionally to the square root of the blast magnitude. So, for example, from a blast having a force of 300 kt, tanks receive medium damage in a radius

$$\sqrt[3]{300:30} = \sqrt[3]{10} \approx 2,$$

that is two times greater than from a blast with a power of 30 kt, or in a radius 0.5 x 2 = 1 km, but disabling the crew and slight damage to the tank occurs in a radius 1 x 2 = 2 km. The approximate calculated dimensions of the zone for putting personnel and tanks out of commission from nuclear blasts of different force are shown in the graph (Fig. 118).

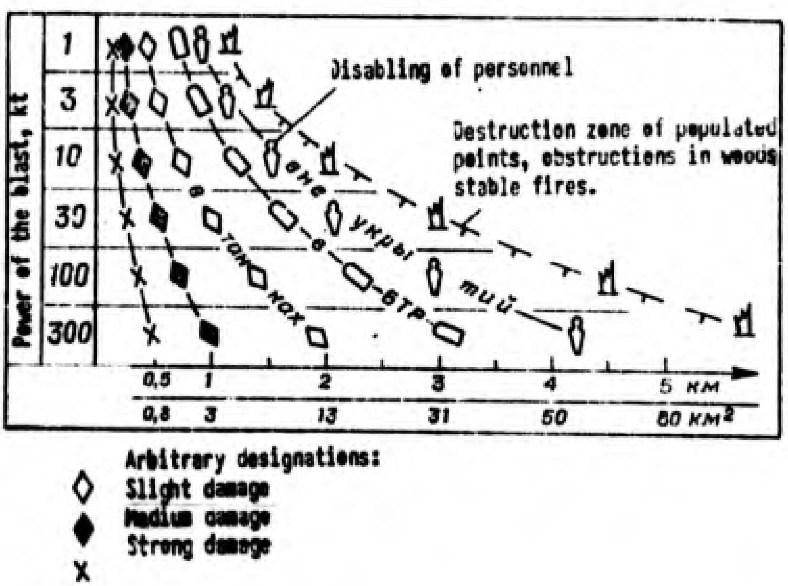


Fig. 118.--Dimensions of the zone in which personnel are disabled and tanks of damaged in a nuclear blast.

It should be noted that the skillful use of the shielding characteristics of terrain decreases the area of destruction from nuclear blasts of various objects 1.5-2 times. Even a small hollow or a ditch with a depth of 0.5-1 m greatly increases the stability of the tank against shifting and turning over from the shock wave. The destructive effect of the shock wave is sharply decreased in deep and winding ravines and gulches, on the rear side of inclines, in thickly foliated forests (in coniferous forests the danger of fire is relatively high).

Prospects for increasing the viability of armored forces in nuclear wars are greatly increased by the stability of the tanks and their shielding characteristics from the destructive effects of nuclear blasts, primarily from penetrating radiation of nuclear blasts and radioactive radiation with a prolonged effect on the contaminated terrain.

Section 2

Defense of Tanks from the PTURS and the Struggle with it

1. Modern PTURS and its Influence on Tank Operations

After the Second World War, a new a threatening enemy appeared for tanks--the antitank guided reactive missile (PUTRS). Its appearance opened a new era of bombs and confronted tanks with the necessity of investigating some method of counteracting them.

The high degree of effectiveness of the antitank guided reactive missile, its great maneuverability and facility of maintenance as well as the possibility of dropping it from light planes and helicopters, according to the material of the foreign military press, caused confusion for some theoreticians and practitioners of military affairs. And, as always happens in such cases, the more impressionable ones among them were led to the conclusion that the supremacy of tanks on the battlefield had come to an end, that tanks had outlived their usefulness. The result was that in some foreign armies, projects were promoted to change the tank into a lighter armor-plated vehicle, equipped with the antitank guided reactive missile and with conventional types of weapons, a cannon and a machine gun. These vehicles would have to fulfill the tasks arising on the battlefield.

However, it became known from experience that each new weapon, as menacing as it might be, always met with a counteraction, localizing its application or the effect of its action to a minimum. This is how the antitank guided reactive missile came about. At first, probably, with artillery testing they turned out to be all-powerful, capable of essentially changing the role of tanks on the battlefield. But later on, a more extensive study of them showed that to draw such conclusions was evidently somewhat premature. This new weapon had a series of defects which would be taken advantage of by tanks. From this the foreign military specialists draw the conclusion that tanks would be used for still a long time on future battlefields.

It was believed abroad that the antitank guided reactive missile would pierce armor plating with a thickness of say, 400-650 mm. Such an extensive effect was explained by the fact that the antitank guided reactive missile was designed according to the principle of utilizing cumulative streams of gases of highly effective explosive substances. The cumulative streams have a high temperature, a high flow rate and enormous pressure at the focus of gas flow on the war head. The antitank guided reactive missile was designed with such calculations in order to damage the armor plating located at the focus of flow of the cumulative streams. Consequently, if the antitank guided reactive missile hits a tank, then there is little change that the armor plating will not be damaged by the cumulative streams of the shell. Thus, with regard to the armor plating piercing capability, the antitank guided reactive missile seems to be a rather dangerous medium in the battle against tanks. The foreign tank specialists believe that increasing the viability of tanks will obviously be guaranteed by increasing the cumulative stability of tank armor and decreasing the cumulative effect of antitank guided reactive missiles.

As far as the weight of the antitank guided reactive missile is concerned, we observe a tendency toward its decline and the miniaturization of all shells. So, for example, if the weight of earlier models of antitank guided reactive missiles, such as the "Malkara" SS-12 and others is within 75-100 kg, then the weight of more contemporary antitank guided reactive missiles on equipment in the process of development will fluctuate between 6-25 kg. In connection with decrease in the weight, the overall dimensions of antitank guided reactive missiles is declining. This has led to an increase in the quality of antitank guided reactive missiles in the case of launching equipment mounted on automobiles, armored transports, tanks, airplanes and helicopters. Thus the tendency at present to increasing the combat unit, the antitank guided reactive missile in antitank units.

The flight speed of the antitank guided reactive missile has a direct relationship to the vulnerability of tanks on the battlefield. The greater the speed of the shell, the less time the tank has to perform a maneuver in order to take cover in the terrain or behind local objects and thus, the greater its vulnerability. Thus in creating the antitank guided reactive missile, the attempt was made to increase its flight speed. So, for example, if under most conditions the maximum flight speed of antitank guided reactive missiles attains a maximum of 80-85 m/sec (SS-10 "Entak", "Cobra 810" "Bantam" "Mosquite" ,TATM-3s) or fluctuates between 150 and 220 m/sec (SS-11, "Vigilent" "Malkara" "Swingfire", then in the case of shells now in development, the maximum flight speed will be within the boundaries of, say, 280-600 m/sec ("Xot" "Akkra").

The firing range of the antitank guided reactive missile is of great importance in the development of tactical operations of tanks on the field of battle. Usually, a distinction is made between two ranges on the antitank guided reactive missile: minimum and maximum. The minimum firing range is the distance from the launching equipment of the antitank guided reactive missile up to the moment when the discharged shell becomes controllable. The maximum range is the flight distance of the shell while it is being controlled. Usually, in the majority of cases on the antitank guided reactive missile equipment of foreign armies, the minimum range fluctuates between 300-500 m; the maximum distance from 1,500-4,000 m. However, some foreign antitank guided reactive missiles have a minimum range from 75-200 m, and a maximum range up to 6500 m ("Shilleligh" SS-12). At the minimum range, the shell is still uncontrolled and the tank is as if in a dead zone, in which it cannot be hit. This circumstance, of course, will be taken into consideration in the development of tank tactical operations, the attacking position of the antitank guided reactive missile. The tanks will try as rapidly as possible to utilize the natural features of the terrain and land marks, enter into the dead zone of the antitank guided reactive missile from where he destroys the position with the antitank guided reactive missiles.

Knowledge of the maximum firing range of the antitank guided reactive missile makes it possible to correctly select the limits of tank development outside actual firing zones of the antitank guided reactive missile. It is thought that on an even or open place, the limit of tank development will not be expediently set near the maximum firing range of the antitank guided reactive missile.

Increasing the assembly of antitank guided reactive missile launching equipment, its improvement and guaranteeing the possibility of launching with portable launching equipment led to saturation of the troops with these antitank facilities which seriously made the tank operations on the battlefield more difficult.

As was pointed out earlier, antitank guided reactive missiles available to foreign armies are launched from the ground or moving launching equipment, including aircraft and helicopters. Launching is accomplished either directly from transportable containers or from special launching devices having guide runners and mounted on mobile facilities. The antitank guided reactive missile is designed for launching from tubes, set up on special tripods. The shell can also be launched from tubes directly on the shoulder ("Milan" "Xot", "Toy" "Moy").

It is pointed out in the foreign press that the most significant factor in development of the tactical struggle with the antitank guided reactive missile is acquiring knowledge of the system guiding them to the target. Principally, the system guiding the antitank guided reactive missile to the target may be multiple. At the present time, however, as viewed by the foreign press, the basic guidance system is as follows:

a) command system (remote control with control transfer by wire and remote control with control transfer by radio);

b) semi-automatic or combined system (wire, homing head with the use of infrared or ultraviolet rays);

c) self-contained or automatic system.

In the foreign press it is pointed out that all guidance systems except for the self-contained guidance system, have manual guidance and require a gunner (operator) who must direct the flight of the shell from the beginning of the launch up to impact on the target.

In command systems, the gunner always follows behind the target and behind the shell in flight and directs it to the target by means of guidance equipment with the aid of which the commands are transmitted to the shell by wire or by radio. Superposing the target and the shell in flight from one point, the gunner directs the shell to the target. Thus in command systems we are looking over connecting lines over which it is possible to act, in order to prevent impact on the tank, namely: the target line, the flight trajectory of the shell and channel connections to transmit commands from the gunner to the shell (wire or radio channels).

In the combined or semi-automatic guidance systems, the gunner follows only behind the target. The shell is designed so that it automatically follows behind the garget line, tends to travel along this line and thus strikes the target. In these systems there are only two connecting lines: the target line and the flight trajectory of the shell.

The effective action appears to be sufficient, even if on one line of communication, in order not to permit destruction of the tank.

In self-contained or in automatic guidance systems, the shell directs itself to the target. Thus in these systems there is only one line of communication over which it necessary to act in order to hamper or prevent destruction of the target.

An analysis of the existing guidance systems shows that in the majority of them it is necessary to manually guide the shell to the target. For example Major General G. Zirdt points out in an article entitled "Methods in the Struggle against Tanks" that when an antitank guided reactive missile is fired, the gunner operator must at all times follow either behind the target and the shell simultaneously, or only behind the target. This is very important for organizing the struggle with the antitank guided reactive missile and, according to the opinion of foreign combat specialists, gives rise to a series of alluring ideas in developing tank operational methods when the antitank guided reactive missile is encountered.

2. Defensive Systems and the Struggle of Tanks with the Antitank Guided Reactive Missile

In order to successfully organize the struggle with the antitank guided reactive missile it is necessary to know its strong and weak points.

In the opinion of foreign combat specialists, the positive qualities of the antitank guided reactive missile are:

-its ability to pierce even the thicknest armor plating (from 400-650 mm), which is possible to place only on tanks;

-the possibility of generally launching it from ground or moving launching equipment as well as from aircraft and helicopters;

-high degree of maneuverability on the battlefield;

-facility of maintenance;

-possibility for its use on the battlefield against any targets;

-high degree of potential for destroying the target: according to the data of the foreign press, the probability of destroying a moving target at maximum distance is 95%, at minimum distance--85%.

The foreign military press also points out the shortcomings of these shells:

-the necessity of continuously following behind the target and the shell with control guidance systems and only behind the target in the case of semi-automatic guidance systems;

-possibility of losing the shell when the target goes out of sight for a short period of time;

-long flight time of the shell to the target;

-increases in cases of failure in guiding the shell with increasing complexity of working principle of the shell itself;

-the presence of a dead zone at a distance of 300-500 m from the launching equipment.

With consideration of the weak point of the antitank guided reactive missile, the foreign press points out the following principal defense methods for tanks in the struggle with the antitank guided reactive missile: group, individual, attack and passive.

Group method of tank defense and the struggle with the antitank guided reactive missile--this is a method where measures are carried out in a centralized manner to defend tanks from the antitank guided reactive missile as a result of which all attacking or defending tanks of tank units and sections are protected.

One of the most effective group methods of defending the tank from the antitank guided reactive missile is the use of tanks with tactical operational methods, making it difficult for the enemy to use the antitank guided reactive missile. With such an action it is possible for tank units to utilize natural landmarks (gorges, ravines, woods, forest preserves, population centers, planted regions and underbrush) in order to approach the enemy and simultaneously repress the firing positions of the antitank guided reactive missile from artillery or from aircraft. In their approach and attack, the longer they remain out of sight for enemy antitank guided reactive missile gunners the greater will be the chances of success for the tanks.

The utilization by tanks of broken terrain, underbrush cover, sparsely grown trees or places having objects useful in serving as camouflage may result in premature damage to the antitank guided reactive missile if the detonators are set up for instantaneous action or if the shell loses its direction due to disruption of the wires transmitting commands from the control panel to the shell.

As pointed out in the foreign military press, suppression of antitank guided reactive missile firing positions with nuclear weapons, massive artillery fire and air strikes as well as firing from attacking tank units is also a group method for defending tanks in the struggle with the antitank guided reactive missile. It was pointed out before that in order to damage tanks, the observer-operator of the antitank guided reactive missile must have the target continuously in sight in the guidance apparatus. In the view of foreign combat specialists, nuclear blasts as well as bombing attack strikes from aircraft and high-power artillery-mortar and machine gun fire forces the observer to seek temporary cover and consequently to lose the target and the shell.

Many combat activists abroad, among them one of the prominent English theoritists R. Ogorkevich is of the view that setting up smoke screens from airplanes, with the aid of artillery and with the aid of tanks themselves is also a method of group tank defense. The appearance of continuous or local smoke screens in front of the antitank guided reactive missile firing positions causes the gunner-operator to lose the target from his field of view and consequently to lose the shell. The use of smoke screens on open terrain having slight amounts of cover may be one of the basic methods of group tank defense. However, smoke screens can be more reliably used under those conditions when the wind is blowing from the enemy antitank guided reactive missile position or at a certain angle with it.

The opinion is being expressed in the foreign military press that one of the group methods of tank defense in the struggle with the antitank guided reactive missile may be the creation of interference for the shell guidance, directed by radio and the creation of false targets in order to create interference with the shell having a homing system. It is pointed out, however, that when the radio-control of the antitank guided reactive shell is correctly set up, it is extremely difficult to interfere with it. It is thought that radio-controlled shell guidance organs may operate on dead or on microwave and centimeter bands. Thus in order to create effective interference it is necessary to set up a wide band frequency. In the opinion of foreign military specialists this would require high-power radio and radar interference stations with a power of not less than 250 kilowatts. As the foreign press points out, such interference stations can be set up on armor plated vehicles which would have to follow in the combat ranks or tanks or on airplaces supporting the attacking tanks.

The creation of false radar targets is recommended in the movement of the tank attack which may also play a role in group tank defense. False radar targets (such as carbon filaments and other reflecting metal strips, etc) may be created with special formations of these armor plated vehicles following the attacking tanks as well as with airplanes and helicopters.

As far as shells with homing heads are concerned, it is recommended to consider the fact that all homing heads begin to operate close to the target (for example 100-150 m). This means that the time to create interference for such shells would be very short. Thus it is recommended to set up defensive measures according to the limits centralized during the course of the attack. Passive defense measures during this time may be: dispersion of napalm charges or long-range rockets from patrol or reconnoitering tanks or from helicopters and aircraft and on boundaries over which the tanks must pass; the use of special tanks to create a defensive fire screen before the front and on the flanks of the attacking tanks.

Some foreign military specialists have expressed the idea of using high-power projectors to create an infrared screen before the front of attacking tanks or on their flanks in order to defend tanks from the antitank guided reactive missile equipped with a homing head. It is thought that such projectors would be set up on armor plated vehicles following in the combat ranks of tanks or on their flanks.

Individualized Method--this is a method of tank defense and combatting the antitank guided reactive missile where each tank is protected from the enemy antitank guided reactive missile by means of different measures, carried out by the crew itself. Foreign specialists include the following among these measures: the use of smoke bombs, shells or mortars from individual tanks, camouflaging the combat vehicles and the use of active tank defense destroying the antitank guided reactive missile on the field. This method also includes reinforcing the anti-cumulative stability of the armor plated vehicles for the purpose of reducing the effect of the antitank guided reactive missile on them.

Work on increasing the stability of armor plating is being carried out in many countries. General problems concerning the stability of armor plated chassis have been studied for a long time right from the appearance of anti-tank artillery. However, the anti-cumulative stability of armor plated was studied only with the appearance of cumulative shells. It is believed that the anti-cumulative stability of armor plating may be guaranteed with the creation of combination armor plating which would be able to resist high specific pressures and high temperatures. Inasmuch as the cumulative stream burns through the armor plating, heat-resistant components may be introduced into the makeup of combined armor plating.

A second direction in studying how to guarantee the anti-cumulative stability of armor plating is believed to be the manufacture of armor plating with inserted pieces made out of glass plastics from resins.

Finally, the use of screens is proposed as a third direction for solving this problem. The screens may be different. They may be sheets of thin armor plating, metal nets, set up on the tank hull, turret armor plated coverings, etc. The English, for example, widely use armor sheets as screens, as well as constructed bulwarks. The concept of using screens was included in order to cause premature explosion of the cumulative shell and in order that the basic armor plating would be outside of the focus of the cumulative stream explosion where the pressure of the flowing gases and their temperature reach a maximum.

Camouflaging tanks also contributes to their individual protection. The use of camouflage makes the tank inconspicuous against the background of the surrounding terrain and makes it difficult to spot the tank and keep it under observation when the antitank guided reactive missile is fired. In addition, the use of anti-radar detecting cover on tank armor plating does not make them so vulnerable to shells with homing heads. This cover, made under camouflage, makes it more difficult to detect the tanks both visually and by means of radar.

The opinion is expressed that thermal camouflage is an important individual method for protecting tanks from shells having homing heads. The thermal-camouflaged armor plated object decreases the amount of heat given off by the armor plated object into the surrounding atmosphere and also decreases the capability of the homing head on the antitank guided reactive missile, according to the opinion of foreign combat specialists, it decreases detection of the tanks by enemy antitank guided missiles and the homing heads hit the target only at a short distance from it. Such an occurrence may often cause the antitank guided reactive missile to fly past the target.

It is thought that one of the most important measures of individual defense against the anti-tank guided reactive missile may be carrying out the center of heat on one of the tank sides or above it. The point of the carrying out must radiate a great deal of heat, then this turns out to be the target for the antitank guided reactive missile with a homing head. The shell may strike only the point of the carrying out of heat, but the tank remains undamaged.

Finally, individually activated tank armor may be of not insignificant importance as a means of destroying the antitank guided reactive missile on its flight to the tank. Many ideas arise in this direction. It is thought that experiments may aid in solving this problem.

It is also pointed out that in the capacity of individual means of active tank armor, facilities may be created for well-timed observation of the enemy antitank guided reactive missile which would operate as an independent automated system.

As far as the active and passive methods of tank defense are concerned and their struggle with the antitank guided reactive missile, the foreign press points out that they may be considered as group as well as individual methods of defense and combat.

The active methods of protection include: destroying the antitank guided reactive missile with the aid of auxiliary or standard tank equipment; destroying the antitank guided reactive missile on primary aviation positions, by artillery, tank fire, and with nuclear weapons; destruction of antitank guided reactive missile launching equipment using the same means; creation of active interference with antitank guided reactive missile guidance systems.

Passive defense measures include: the use of camouflaging or blinding smoke screens; the use of screens on tanks and combined armor plating; the use of false targets for the purpose of interfering with a homing head missile.

In conclusion it can be stated that the tank and the antitank missile once again confirm the unity of opposites in combat affairs. The performance of tanks brought about the antitank guided reactive missile, and the latter led to a new stage in tank achievements and the development of new methods and their application in the struggle with the antitank guided reactive missile. It is pointed out in the foreign combat press that none of the objective principles talk about the decline or armored forces or about the tank becoming obsolete on the field of combat. Widely applying methods of group and individual defense and struggle with the antitank guided reactive missile, armored forces may successfully operate on the field of contemporary battles and prove themselves to be one of the basic factors of achieving victory in nuclear war. Thus one of the basic problems is the study of more expedient examples of tank operations in modern warfare in which the battlefields will be saturated with all kinds of antitank facilities.

Section 3

Space and Maneuvers

1. Modern Warfare and Space

All historians in the art of war conceive of a continuous development in the means and methods of conducting war. Weapons and other combat techniques will change and be perfected and in connection with these, the process of changing the means for conducting war will be achieved. Development of the means of conducting combat operations will be accompanied by an increase in the dimensions of the battlefield, of combat and war as a whole.

If we follow the process of increasing the dimensions of combat activity, then it is possible to set up a definite regularity which consists of the following: the space dimensions of the battlefield, battles and all of war will increase in direct proportion to the increase in power and the long-range armaments and an increase in the maneuvering capability of armaments. In other words, the greater the force and the means, the greater their combat quality (long-range capability, destructive properites, maneuverability), the larger the territory is necessary to conduct the war. In connection with these factors there is an increase in the scale of troop maneuvers, complicating the conditions of their forward movement and changing their character.

Up to and including the 19th century, wars were limited to that territory on which the combat operations were being directly carried out. At that time wars did not have continuous fronts, and the deep rear areas of the country did not enter into the sphere of combat operations. The area on which the battle unfolded could be well surveyed from one command point.

Introduction into the army in large numbers of new methods for arming the struggle guaranteed a sharp increase in fire power and the maneuvering capabilities of troops leading already in the First World War to greatly extended frameworks of combat operations, the appearance of continuous fronts, large amounts of territory became involved in the sphere of combat operations, adjacent to the front line.

The spatial dimensions of the combat operations regions increased even more in the Second World War. Battles were not carried out on gigantic continuous fronts and large regions become involved in the zone of combat operations, located deep in the territory of the warring states.

The regular process of increasing the spatial scope of wars and operations was accompanied by a change in the scale of advancing troops. The larger the region of combat operations became, the more often arose the necessity for the performance of tactical and operational maneuvers in the interest of achieving victory over the enemy. Along with this there was an increase in the scope of the maneuvers and an increasing role and importance of advancing troops. The achievement of success in any battle or operation greatly depends on the speed with which the troops are maneuvered. Experience shows that whoever makes wise use of the possibility for carrying out maneuvering of forces and facilities in the interest of achieving supremacy in decisive directions invariably guaranteed favorable conditions for achieving victory. Thus, for example in February 1944 a German-fascist commanded strike of large force in the region of Lisyanski attempted to rescue its troops surrounded by Korsoon-Shevchenkovskoi concentrations. But this attempt turned out to be in vain. Into the threatened district, after skillfully completing a maneuver, came the 3rd, 16th and 11th guard tank corps which inflicted a high-power strike against the enemy.

However, the occurrence of change in this war by no means can compare to that which will take place in the future in the case of rocket-nuclear combat. In the entire history of war there was never a stage in which the increase of territorial scope of combat operations, and increase in the scale of advancement as well as an increase in its significance was so great. In the future, on the basis of the expanded framework of the armaments struggle, it is evident there will be not only a sharp increase in the volume and proportion of forward movement in the combat activity of troops, but a change in the character of the forward movement. Obviously, the scope of advancement of armored forces will increase.

In past wars, despite the fact that combat operations were conducted over large territories, the theater of combat operations could be conditionally divided up on a space where the combat operations were being conducted and in the area where it was relatively quiet, and the war made itself known only by indirect indications. This circumstance has a decisive influence on the method for advancing tanks and mechanized troops forward. When being moved forward over great distances, under such conditions these troops could be transported by rail close to the front. Aviation was not able to disrupt rail transportation in the rear areas. Thus the region for discharging tanks and mechanized troops was often far from the adjacent line at 150-200 km and even less. As a rule, unloading from railroad echelons parts and aggregations of armored forces allowed sufficient time for full combat preparation, for careful organization of the advancement and thorough preparation for future combat operations.

It is true that in the course of the Second World War there were cases when tank and mechanized troops had to carry out a march over great distances. So in July 1943 the 4th guard tanks corps successfully completed a march from Zemlyansk region into the Oboyan region extending 450 km/ in August of 1944, the 4th guard mechanized corps covered a distance of 600 km, moving forward from the region of Dorobyantsy into the region of Burgas.

It is pointed out in the foreign press that under conditions of rocket-nuclear war the advancement of armored forces over large areas under their own power will probably not be an exception, but a basic method of advancement. This is explained by the fact that new methods of destruction are useful in overcoming any barriers in a few minutes and inflicting an inevitable blow on any object at whatever distance it might be. Consequently, all important railroad and highway junctions, bridges, dams as well as aerodromes and sea ports can be subjected to a nuclear strike and destroyed or put out of commission for an extended period of time. Such a character of destruction on communications limits the possibility for the transfer or troops by rail or water transport. Thus, in their opinion, even over large distances, armored forces often will have to advance under their own power.

In the future, the number of advancing troops will also increase. Even during past wars troops often had to be transferred on the battlefield or behind the boundaries of combat operations. According to a Czech war researcher Varvashovskii, in the Second World War "approximately 40% of the time was required for troop transfer, approximately 30-35% for combat operations and approximately 25-30% for rest, reinforcement and regoupings, etc." It must be kept in mind that these figures refer to footsoldiers (infantry). By virtue of their combat character, armored forces have to make advances more frequently. Thus it is plausible that the proportion of forward movement in combat activity of armored forces and mechanized troops was considerably greater than 40%.

The highly maneuverable character of combat operations in future wars, the possibility of massive losses and the necessity for rapid buildup of forces of the first echelon, the necessity for achieving a high rate of attack, the necessity for rapidly overcoming vast battlefield and destruction zones and also the possibility of a sudden change in conditions--all these might be a reson for the great increase in the size of armored forces forward movement. By virtue of what has been stated, it is believed that a large part of the combat activity of armored forces will include advancement in appropriate formations.

The character of the forward movement has changed to a large degree. In the past, troops performing a forward movement underwent enemy counteraction only in the direct vicinity of the front line as well as on the battlefield when they moved into occupied, more advantageous positions or lines with relation to the enemy. In the majority of cases, the forward movement of troops outside of adjacent zones was almost never distinguished by anyone from marches in peace time.

Under future conditions, forward movement will be much more complicated. Troops and communications may be subjected to enemy action at any distance from the front. Complex problems arise in connection with the practically unlimited distances using nuclear attack, the use of modern aviation as well as increased threat of the use of enemy air drops and diversionary-reconnoitering groups in any march behind determined zones of combat operations at great distances from the enemy. In addition, it is necessary to take into account that enemy diversionary reconnaissance groups, being equipped with contemporary combat means, may cause much damage to the moving troops and create considerable difficulty with their advancement.

Now while achieving the goal of their march, the troops are forced to expend a great deal of energy protecting their ammunition, overcoming obstacles as well as doing battle with various diversionary groups and enemy drops.

2. Methods of Forward Movement and March over Long Distances

Under contemporary conditions, armored forces can accomplish their advancement by means of railroad, water transport and combined methods with simultaneous r successive use of two or several types of transportation.

With selection of the method of forward movement, the troops are influenced by various factors, primarily the target, the scale, the depth of the advancement, time, feasibility of its realization, state of communications, presence and possibilities of transport means, and finally the character of enemy operations.

Forward movement of armored forces under their own power. As was pointed out in the foreign press, under contemporary conditions this form of forward movement has special importance, since to a large degree it meets the requirements and conditions of rocket-nuclear war. Above all, it guarantees achievement of a high rate of advancement, shown on the graph (Fig. 119), compiled according to the data of the foreign press applicable to the US Armored Tank Division and the Tank Division of the Germany army. It is clear from Fig. 119 that compared with forward movement under their own power, the minimum distance at which a gain in time is guaranteed is not less than 1300 km with rail transportation, and more than 2400 km with sea transportation.

The advantage of forward movement of tank troops under their on power, in their opinion, is not exhausted only with the achievement of a high rate of speed. Under contemporary conditions, primary importance is given to guaranteeing the time of transfer of organizations units of divisions and subdivisions and their constant readiness to fulfill combat duties in all stages of forward movement. At the present time, this requirement can obviously be fulfilled with the forward movement of troops under their own power. Nevertheless, completing a march under their own power, armored forces have a better possibility of maneuvering with the target to be overcome by bypassing zones of destruction and radioactive contamination and also having relative independence from large stationary objects on communications which can be destroyed by the enemy.

It is thought that the transfer of armored forces under their own power has a series of advantages with comparison to other methods of forward movement. Let us examine what possibilities for such a forward movement are available to armored forces.

The basic indications characterizing the march possibilities of troops are the average rate of movement, operational supplies in fuel for motorized and track-laying vehicles, the amount of time in the course of a 24-hour day, which the tanks may encounter in movement.

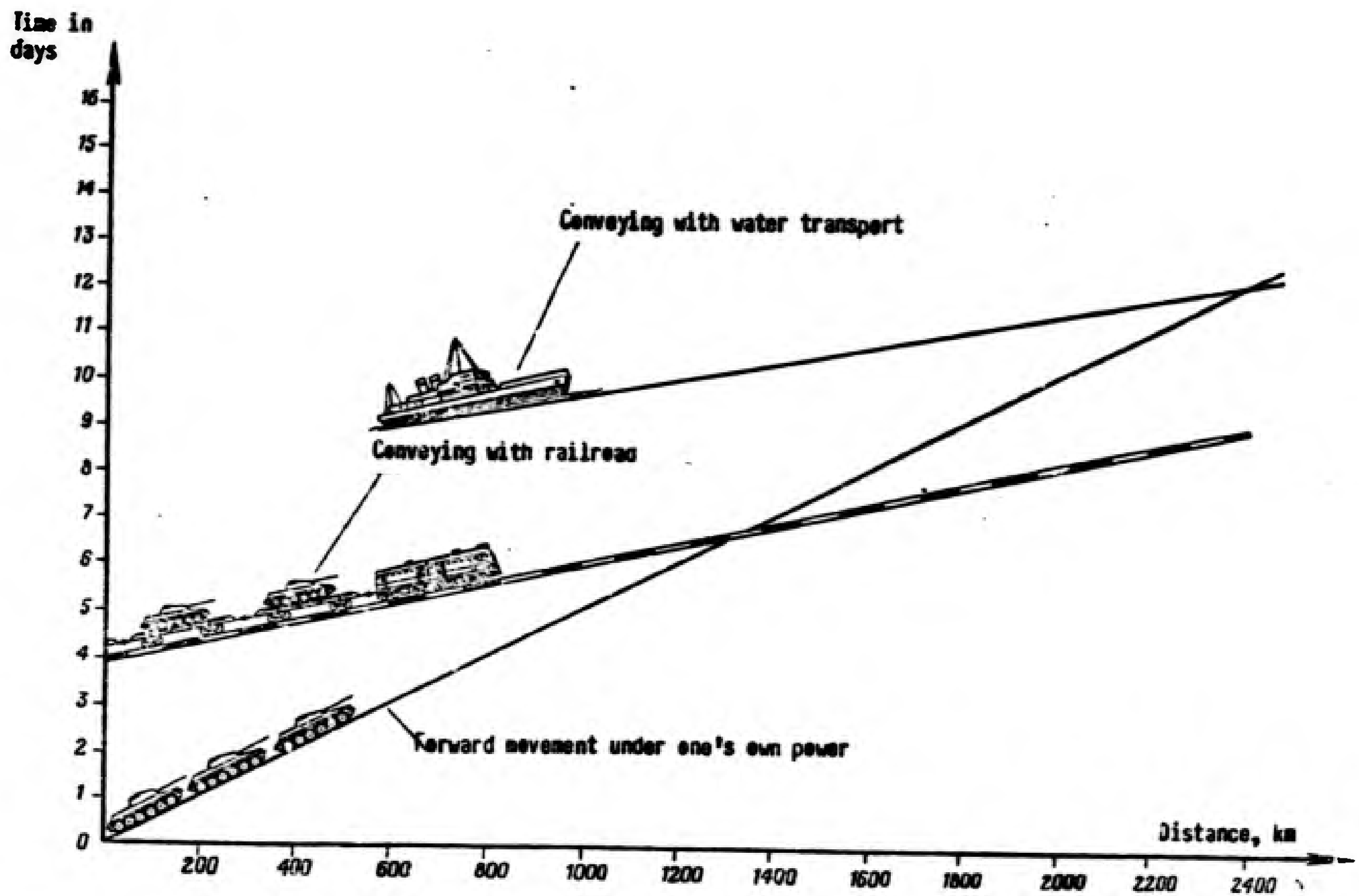


Fig. 119.--Graph showing the time expenditure for advancing armored tank divisions of the US army using different methods.

It is generally known that the average rate of troop movement primarily depends on the maneuvering the operational characteristics of the combat and transport vehicles. Even in the years of the Great Civil War, tank sections and units equipped with T-34 tanks accomplished marches at the rate of 20-25 km/h. For example, in September 1944, the 5th guard tank corps at a range of more than 300 km moved at an average rate of 20-25 km/h. Modern tanks have move ideal characteristics, thus the mean moving speed of tank columns at the present time obviously can be higher.

According to the view of foreign specialists, the supply for tank operations, fuel for motor and track-laying vehicles, is an important factor influencing the march capabilities of troops. Supplying fuel for basic contemporary tanks can be accomplished for example along a 500 km highway. Supplying tank operations with motor resources may reach more than 4500 km. Supplying track-laying vehicles is much easier: for old vehicles, it averages out to about 1500-2000 km. However, on new vehicles, thanks to the use of tracks with rubber-metal links, supply operations are made easier and may be up to 6500 km.

It is pointed out that physical resources and training of personnel also have great importance. It is believed abroad that the normal daily load for drivers may be 10-12 h work at the controls. Of the time remaining in a 24 h day, the mechanic-driver is required to spend 5-6 h resting, 1.5-2 taking nourishment, and about 4-5 h servicing his tank. Proceeding on the basis of this calculation of attainable average speeds, during the course of a 24 hour day tank columns can cover a distance of 200-250 km.

The rate of column movement and consequently the march capabilities of troops is essentially influenced by the level or preparedness of driver personnel. Thus, for example, under similar conditions, drivers with high qualifications can drive the same vehicles at an average of 25-30% faster than drivers with low qualifications.

From the evidence it is clear that modern armored forces have a high degree of march capabilities and are able to move for an extended period of time at high speeds under difficult conditions while in addition maintaining their high degree of battle preparedness.

Advancement of armored forces using rail transport. In spite of the obvious advantages of moving under one's own power, in the course of events armored forces will utilize other means of advancing--conveyance by railroad. The use of a given method is advantageous in the extent to which it preserves the motor resources of combat technicians, saves the physical strength of personnel guarantees movement in any weather at high speeds. The main shortcoming of this method is that it disrupts the organizational unity of units and sections. Nevertheless, with divisions extended over a great distance, after the arrival of the first echelons in a new district, the troops require a certain amount of time to prepare for combat. A serious shortcoming lies in the fact that the artificial installations on railroads are vulnerable to strikes from rocket-nuclear weapons, airplane attack, and operations of enemy diversionary-reconnaissance groups.

The possibility for conveying armored forces by railroad transport basically depends on loading and unloading, the moving speed of railroad echelons, the passability of the railroad, the presence of loading platforms and rolling stock.

In the years of the Second World War with the transfer of tank units by railroad transport over the territory of European countries, the moving speed of railroad echelons reached 300-500 km per 24-hour period. Thus, for example, with the transfer by railroad of parts of the 9th and 10th "SS" tank units of German-Fascist troops from Poland into the region of Nancy, the echelons moved forward at a rate of more than 400 km in a 24 hour period.

Under contemporary conditions, in connection with the further development and improvement of railroad systems, and also thanks to the restauration of railroad rolling stock, the possibilities for rail transport in the conveyance of armored forces have increased somewhat. These possibilities can be advantageously utilized while leading combat activities without the use of nuclear weapons, although the capacities of railroads may sharply decline as a result of the use of nuclear weapons by the enemy.

Conveyance of armored forces by water transport. The conveyance of troops by means of water transport can be accomplished mainly with the transfer of troops from one theater of combat operations to another. The conveyance of armored forces over maratime routes will obviously be linked with a great deal of difficulty. These difficulties, according to the data of the foreign press, include the following.

A large quantity of transport-landing vessels are required under present-day conditions for the conveyance of armored forces by water transport. For example, to convey one armored tank division, according to the data of the foreign press, requires more than 20 large transports. It is believed that to discharge such a large number of transports will not be easy, in all probability since with the beginning of combat operations, transport facilities at the disposal of commanders will primarily be used for sea landings.

The following difficulties consist in the fact that loading and unloading tanks and other heavy equipment requires special unloading and loading equipment as well as mechanisms which in the case of massive transferrals and in the case of destroyed ports would probably not be available. A great deal of time is required for the loading and unloading of armored forces.

Nevertheless, the escort of transports at embarkation points requires the generation of certain combat-sea, navy and air forces, the diversion of which is undesirable in solving second-rate problems.

From this we can conclude that in the opinion of foreign combat specialists, water transport for the conveyance of armored forces over sea routes will not find wide application.

3. Organization and Security of the March

It is thought that opportune and thorough preparation for the advancement to a considerable degree predetermines the success of the march, since the maneuvering capability of the troops depends not only on the quantity of its combat and transport vehicles, but to a large degree also on the organization of the march and the thoroughness with which it is made secure. In order for armored forces to be able to fully utilize all their maneuvering capabilities, thorough preparation and organization of the march is requires, which demands a certain amount of time. Obviously, under conditions of nuclear war, it is often necessary to organize a troop advancement in a short period of time. Moreover, it may turn out that the command organs may be confronted with the necessity to simultaneously decide several problems: guiding troops into combat preparedness, restoring combat preparedness as well as carrying out other measures. This requires from the commander and his staff a display of a high degree of organizational-operational ability. Only under this condition is there a guarantee that the necessary measures for preparing for advancement will be carried out in a short period of time.

A high degree of organizational capability in the work of command organs in organizing the forward movement will be achieved from the application of the most expedient, scientifically based methods for making decisions and planning the advancement.

The correct method guarantees security and leads to a definite operational system of the command staff, assures a rational sequence and parallelity of operation in certain instances.

Officers having such a method will not ponder how to begin the work and in what sequence to carry it out. They will be able to focus all their attention on analyzing the data of the situation and making necessary calculations.

It must be taken into account that the conditions in which the advancement preparations are carried out may be different, for which reason it must be assumed that the operational methods of the command organs will be different. However, this work is characterized by some general principles.

Experience in past wars has shown that under certain conditions, when time for organizing the forward movement is insufficient, the staff adheres to the following methods.

After the problem has been received, it is studied by the commander and his closest assistants. In parallel with this, the problem is plotted on the map. After clarification of the problem, the questions are then determined which must be solved right away. First, those problems are decided concerning organization of reconnaissance, military outposts, and command services.

Then the important problems to be decided are determined on the basis of a brief evaluation of the fundamental elements of the situation and general calculations (the distance to be covered, routes, setting up field facilities, the original boundary, the passing time of his main column). In order to shorten the time for making a decision, it is possible to make use of data prepared beforehand by the staff, particularly those such as the presence and conditions of arms and technical equipment, the presence of material supplies, calculations for moving in some variations (as a function of setting up camp facilities, road conditions, etc).

On the basis of the plan for the forward movement, they devote themselves to preliminary dispositions with a specified extension of the march, the march route of the movement and passing through times of the original point.

After this, the commander and his assitants continue to work: calculating the march in detail, determining the passage time of the troops, controlling the border and arrival in a new region (if it is not determined by the commander in chief), working out problems concerning security of the march, drawing up the working map (march map), working out written combat documents. If the necessity arises, the commander can give instructions concerning the introduction of necessary changes and refinements in the plan.

Such a method shortens the time necessary for organizing the march, since it provides a possibility for organizing parallel work in some instances and contributes to clear and purposeful work in all the command organs.

However, shortening the time for organizing the work must not reduce its quality. Notwithstanding the organizational time, the organization of the march must be well thought out, the performance of the march must be accurately calculated. This is an important condition for development according to plan, rapidity and secrecy of movement, guaranteeing constant preparedness of the troops for battle. The organizing time for preparing the march must not be a reason for shortcomings in organization, loss of direction and poor security.

Thus, independent of the situation, all measures connected with organization of the march, the primarily the decisions of the commander, must be sufficiently well-founded and expedient.

The decision as to the march may be correct only if it takes into account the situation and the requirements imminent in combat operations, if it is based on careful and accurate calculations. It must be kept in mind that advancement is not an end in itself; it creates favorable grounds for solving a basic problem--destruction of the enemy in battle.

Under conditions of the massive application of contemporary combat means, highly maneuverable and air-descent troops, the situation may change rapidly and sharply during the course of the march. Thus units and sections advancing even over large distance from a line of side contact may be suddenly forced into battle with the enemy. That is why, when the commander makes a decision concerning the march, he first determines plan of action in case of encounter with the enemy, and designates what groupings of forces to have in the ultimate region. Evidently these problems have great importance for working out other elements of the decision, in particular those such as setting up camp facilities, march route of the movement, guaranteeing forward movement, etc.

Determining the formation of the field columns, the commander considers whether this setup will guarantee the combat independence and anti-atomic stability of the field columns conducting the march in a limited time, freedom of maneuver, constant preparedness for rapid deployment of combat ranks, creation of the best possible conditions for leadership, material and technical provisions, and maximum use of technical capabilities of vehicles, maintaining combat techniques and preservation of personnel.

To a considerable degree, all this is achieved with appropriate dispersion of forces and facilities according to column.

Opportune and organized forward movement of armored forces mostly depends on clear planning. The importance of planning a march includes preparation of different kinds of calculations and concretely determining the order of troop operations during the advancement, as well as working out measures for its comprehensive security. Of all the calculations which the staff makes, the complex and time-consuming one is calculation of the march.

Calculating the march of tank units and parts performing forward movement under their own power includes allocating the time required for movement, rest, eating, correcting doses, technical maintenance and repair as well as determining the times for pulling out, passing through the original point (line) and points (lines), time for entering a new region. When the march is calculated, fuel expenditure is also determined.

The basic requirement for calculating the forward movement of troops is its accuracy, which will be achieved with careful calculation of all conditions of the advance. Even a small error in the calculations may lead to serious consequences (to delay in leaving a designated region or on the deployment line to the development of "bottlenecks" in the road, and in front of obstacles and the defeat of troops at these places).

As was pointed out in the foreing military press, the initial data for calculating the march are usually: composition of the troops, stretches or march routes for the movement; number of transition points and their size; time required to complete the march; setting up field ranks; moving speed of the field columns according to the localities of the march routes; original line and line to be controlled for the movement; regions and duration of the halt (day's rest or night's rest).

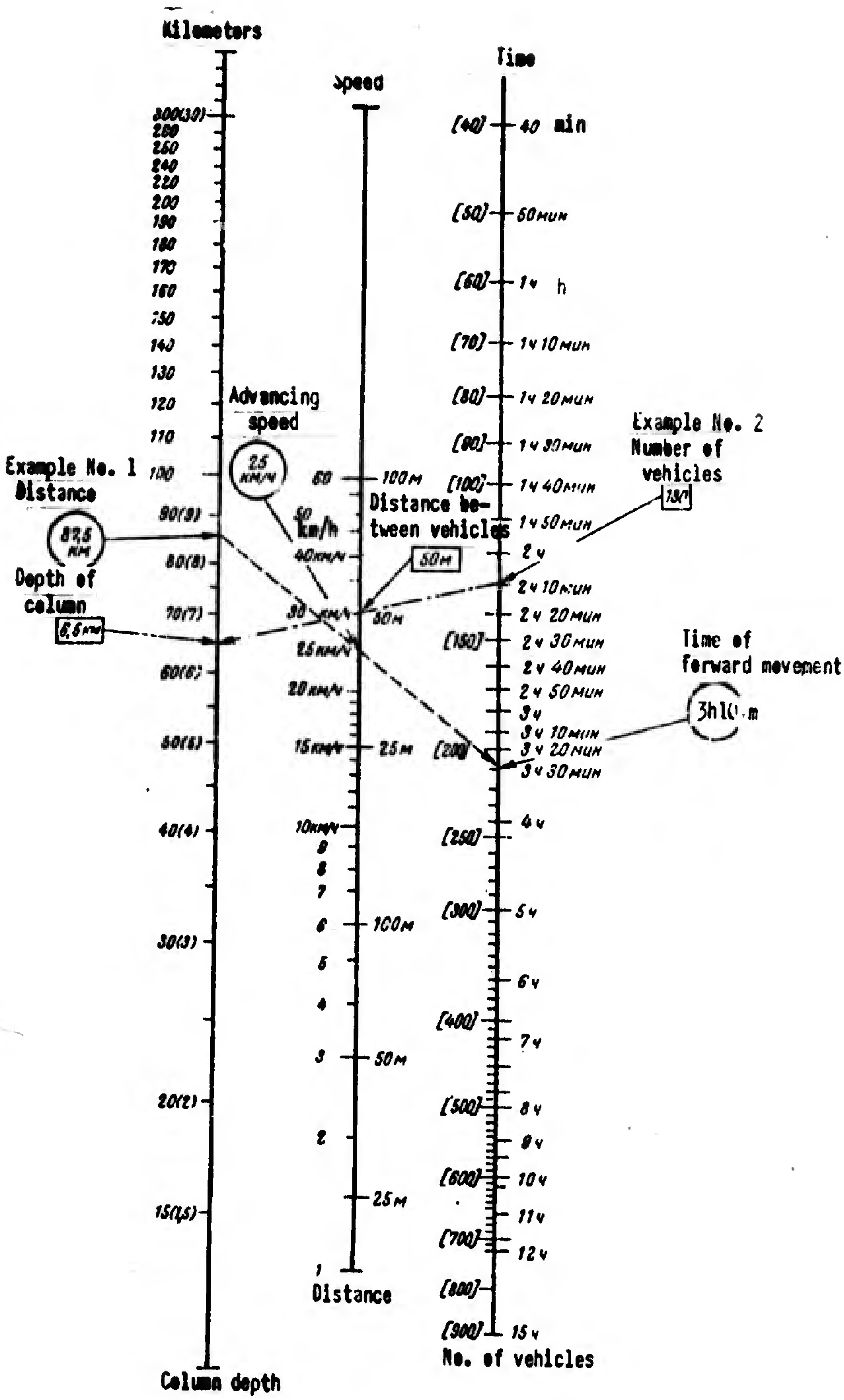


Fig. 120.--Nomogram for determining column depth and time for a column to traverse a distance (variation).

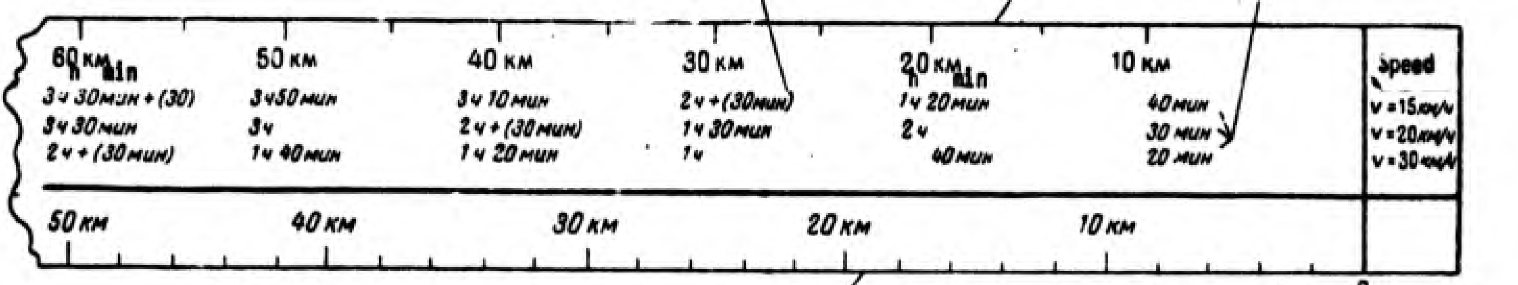


Fig. 121.--Scale ruler for calculating a march (for maps with a scale 1:200,000).

In order to shorten the time to perform calculation of the march, such data as the number of vehicles in the units, the variations in setting up field ranks. the depth of the field columns, the makeup of the reconnaissance organs, of field outposts, forces and command service facilities obviously will be prepared by the staff in advance and will define the problems more precisely.

In addition, various slide rules, tables, graphs and nomograms will be used to accelerate preparation of the calculations.

Fig. 120 depicts a nomogram set up on the scale of a logarithmic ruler to determine the depth of columns according to the number of vehicles and the distances between them, as well as the time of column movement as a function of the distance and their travel rate.

In order to prepare orienting operational-tactical calculations, it is convenient to use the scale of the rulter (Fig. 121).

Accuracy in calculating the forward movement may be achieved by using electronic computers. However, planning the forward movement with the use of electronic computers (IBM) is extremely time-consuming. As was pointed out in the foreign press, to solve problems and deliver results requires about 2 h, which under war time conditions is intolerable. Thus at the present time the IBM is being used abroad to compile tables and graphs which will be used by the staff to shorten the time for planning the march.

As a result of calculations produced by the staff, a march plan is drawn up which points out all the basic measures to be taken to advance the troops. It is one of the basic planning documents.

Organizing forward movement under contemporary conditions is not limited to the commander making decisions, setting up combat problems and planning the advancement. Nevertheless, in order to successfully accomplish the march, measures for thoroughly securing the march are of great importance, the purpose of which is to create combat conditions for the troops to successfully fulfill the tasks with which they are confronted, protecting them against air and ground enemy strikes, maintaining the combat preparedness and giving them the opportunity to simultaneously carry out movements or maneuvers for the purpose of bypassing dangerous regions, successfully completing movements under any conditions and securing the troops with all necessary means.

The possibility of a sudden change in conditions during the march, increasing the possibility of the troops being destroyed in movement, the great depth of the march and its high rate introduce a series of special features in form and content for security in general and for combat security in particular. For example, far from enemy territory, the basic forces of securing troops will be directed to columns protected from enemy aircraft, guarding roads, bridges, crossings and securing the field ranks from sudden strikes of different enemy reconnaissance-diversionary operations.

According to the distance from the front, securing the march will be subordinated to interests of troops entering into combat and creating more favorable conditions for deployment.

Security on the march includes: reconnoitering and military outposts, protection from enemy weapons of mass destruction, anti-aircraft defense, camouflage, the struggle with enemy air drops, engineering provisions, command work, rear guard and technical provisions.

The multiplicity and complexity of the security measures does not permit us to fully study them in the present work. Therefore, below we will elucidate only a few sides of the problem of combat security and command service.

Reconnaissance. The organization of reconnaissance in the conditions under consideration will be combined with great difficulty. This is explained by the confusion concerning the circumstances over the entire scope of the march and the increase in scope of important reconnaissance problems. In addition to obtaining data concerning the enemy and the terrain, reconnaissance problems include obtaining information concerning chemical, radiation and bacteriological conditions in the movement area and in areas of troop concentrations. This requires an increase in the reconnaissance depth, in conjunction with which the importance of air reconnaissance sharply increases.

The possibilities of moving troops forward to conduct the reconnaissance are limited. To a certain degree this is fulfilled by obtaining necessary information from higher staffs and directly from air reconnaissance, and according to the approach to the front, from divisions operating at the front.

Information obtained from the indicated sources possibly will not be able to fully satisfy the command of the advancing troops in making a decision for the march or under other conditions. Thus, the necessity may arise of supplementing or defining the information obtained from the higher staff. The reconnaissance units of the advancing troops will occupy themselves with solutions to these problems which will concentrate their attention on the data concerning the objects (regions), presenting the greatest interest at that time. It is fully evident that this will influence the makeup of the reconnaissance organs, their place and their distance from the main force.

Thus, when a problem comes up, reconnaissance of each march is organized for detailed study of the locality (the quality not only of the roads at the target, but their individual sections, the condition of bridges and crossings, etc), appearance on the movement strop of possible breakthrough (landing) regions for air drops, the presence of dangerous regions on the march routes, radiation and chemical conditions, definition or selection of regions for halting or rest, etc. As viewed abroad, these tasks cannot always be carried out by qualified conventional reconnaissance units. Thus now in many foreign armies, a complex of reconnaissance troops is being created on helicopters to solve these problems. These groups, headed by officers, include scouts, field officers, chemists, medical service representatives, etc.

In addition to these groups, the troops detach certain reconnaissance groups which carry out ground reconnaissance, define the conditions of individual parts of the road, alternate march routes, designate them, define the limits of sections where contamination and destruction has occurred, etc.

With their approach to the front, reconnaissance must be able not only to solve problems involving finding the enemy, but must be able to conduct active combat operations for its destruction. Under these conditions, the troops will be used to set up powerful reconnaissance organs.

It is considered that the time for carrying out reconnaissance is somewhat shorter than the possible time for moving a column of troops. Thus in some armies an attempt is made to shorten the reconnaissance time with the use of helicopters and aircraft on these targets. For instance in the US army, air reconnaissance in divisions is carried out with aircraft and helicopters of the company air reconnaissance of the reconnaissance batallion and the army aviation batallion to a depth up to 150 km. It is understood that these organs conduct reconnaissance in close cooperation with ground reconnaissance organs, paying special attention to reconnoitering movement march routes, and when combat is encountered, it observes combat operations, establishes targets for nuclear weapons, corrects artillery fire.

Outposts. The forward movement of troops over a considerable distance under conditions of great destruction, detachment from neighboring troops, in the presence of open flanks and perpetual threat of sudden attack from enemy air drops or from reconnaissance-diversionary groups requires the organization of ground outposts, capable of guaranteeing the unhindered movement of troops and not allowing sudden attacks on them by the enemy.

In the opinion of foreign combat specialists, conditions and circumstances of forward movement also create great difficulties in organizing such outposts. On one hand, increasing the distance of the influence of attack facilities, the short approach time from the side, requires considerable distance of the outpost organs from the main forces. On the other hand, too great a disruption between the forward units and the main forces inhibits entry of the main forces into battle, does not facilitate seizing the initiative, takes away the advantage in the accumulation of forces upon encounter with the enemy.

Thus at the present time it is thought that the tasks of the outpost troops can be fulfilled in cooperation with reconnaissance forces, unit cover, field outpost units, forces and facilities designated to guard and defend objects and buildings on march routes, and also constant readiness of all units to perform the frequently occurring combat tasks to guarantee the movement of main forces.

In the absence of a stable front and with the threat of enemy encounter, many foreign armies send out escorts and forward batallions. In the outposts of interest, these batallions forestall the enemy by seizing important borders, securing deployment and entry of main forces into battle. Moreover, in contrast to an advance guard, the forward batallion operates at a great distance from the main forces, first going out on a designated line, then encountering the enemy.

As a rule, the field outpost units are sent out a short distance from the main forces. For example, in the US army from each column of a main forces division they include reinforced infantry and batallions in the makeup of the advance guard. Depending on the conditions, the distance of the advance guard may be 10-15 km, sometimes more. Such a distance of the advance guard is considered to guarantee an advantage in the accumulation of forces upon encounter with the enemy. In addition, it permits deployment of main force columns outside the sighted activity of artillery fire.

However, according to the data of the foreign press, the distance of the advance guard may be greater. In particular, this may be in those situations where fire destruction facilities, moving under an advance guard escort, require more than 30 min for deployment and firing preparation.

Upon completion of the march into the deep rear, troops columns may take cover only with the immediate outpost. In the opinion of foreign combat specialists, under modern conditions armored forces will encounter great difficulty in organizing flank outposts. This difficulty is based on the fact that the unit of the flank outpost is able to cover only a part of the main forces column length with protective troops.

The low degree of effectiveness of the flank outpost is increased by the absence of roads suitable for movement. As a rule, one is forced to move along poor or difficult to pass roads, or simply along impassable roads which inevitably leads to losing the outpost column.

As is pointed out abroad, increasing the effectiveness of the combat outpost is presently being attempted by the following means. The task of covering the main forces from advancing troops falls to the unit which is moving forward in column formation to the threatened flank. At the same time, the main forces column is constantly being patrolled from the air. The column commander, receiving data from the scouts, moves the designated unit forward in the direction which is threatened.

An unmoving flank outpost is set up where enemy movement and attack is most probable.

Under present conditions, the command service assumes very great importance. It is also important to stress that with the creation of a command service, facilitating successful carrying out of the march, we must overcome great difficulties. Primarily, these difficulties are caused by an increase in the number of problems and the complexity of conditions on the march routes. In addition to the usual problems imposed on the command service under contemporary conditions, in connection with the thread of the use of nuclear weapons, there is also guaranteeing the security of the march route, carrying out radiation and chemical reconnaissance, conducting the struggle with enemy reconnaissance-diversionary groups, giving aid to troop administrative organs, as well as guaranteeing organized transfer of the local population from regions subjected to enemy nuclear strikes.

The increase in the number of problems brings about the necessity of increasing the expenditure of forces and facilities. There will be an especially great requirement for personnel and technicians upon completion of a march over a great distance. Under these conditions, as affirmed abroad, it will be necessary to dispose two command service details on each march route which would be able to complete their tasks in succession by daily passage.

In the opinion of some foreing combat specialists, one of the ways of decreasing the expenditure of forces and troop facilities in the organization of the command service is widespread introduction of the escort method with units regulating the troop column. For example, such a method for regulating movement is successfully used in NATO countries. The head of an automobile (motorcycle) column is followed by moving regulating posts which stop the encountered transport with signals and, where necessary, set up unmoving regulation posts. One moving post is moving at the tail of the column which does not allow the column to be bypassed makes regulations which were furnished by the head moving post.

In their opinion, such a regulation method is advantageous because it allows the commander to confidently lead the column at the maximum possible speeds. This depends on whether the column leader has carefully reconnoitered the march route beforehand and is well aware not only of its conditions but of alternate march routes, detours, bypasses around populated points, obstacles, alternate passages over water obstacles, etc.

However, the escort of the column moving beside the command service does not mean their rejection from the system of unmoving command posts and regulating posts. The necessity remains for setting up unmoving posts on railroad crossings, on passages, in large populated points. But their number is sharply abbreviated in view of the variation of regulating services under consideration.

4. Completing the March

As can be concluded from the foreign press, depending on the position of the troops, the march may precede the formation of field columns and their extension, which takes a great deal of time. In addition, up to the beginning of forward movement of forces, it is customary to sent out scouts, reconnoitering command services, outpost organs and other combat security units. When time is short, all this requires special flexibility and operational ability in the work of commanders and staffs.

The original line is the first and most important control point in the general system of measures for directing troops on the march. Thus, it was not by change that in past wars the passage of troops from the original line was usually controlled by staff officers. These officers, having before them the accurate movement chart of units and sections on the march routes could, if necessary, take measures on the spot to guide the formation and guarantee an organized start of the march.

The movement of field columns during the course of a march is usually regulated along the lines.

From the beginning of the march, in addition to guaranteeing well-timed passage of troops from the original line and the controlled lines, the commanders and staffs must pay special attention to maintaining the troops in the established order and in march discipline, to the movement of columns at assigned speed and in the assigned direction.

It must be noted that the command encounters great difficulty in carrying out uninterrupted supervision of the troops, especially when frequent problems occur (overcoming water barriers, destruction zones, restoring combat capability, destroying air drops, etc). The main difficulty lies in the fact that leadership must be performed during the forward march by controlling organs and troops under great limitations and with the use of radio facilities. The sought ways of overcoming these difficulties are being expressed in the foreign press with the suggested use of command points, outfitted on helicopters in order to lead troops under the conditions in question.

The maintenance of discipline on the march is guaranteed by good organization and continuous movement. Thus, the columns and the individual machines follow only along the right side of the road. Bypassing the columns is permitted for staff vehicles, communications, PVO facilities, and under necessary conditions, with the permission of the chief, with the field engineer and the rear units. Each vehicle follows at a determined place in the column, observing the assigned speed and distance. The remaining vehicles take their place at the nearest stop.

During the course of the march, the appropriate moment is selected for passing through heavily populated areas. According to the experience of past wars, it is evident that heavily populated areas must be passed through much more slowly. Thus, if possible, heavily populated points will be avoided by the troops. In the absence of detours in areas, a command service is organized.

Obviously, for the purpose of secrecy, armored forces will complete their march late at night. In the daytime, the troops will be disposed along march routes at the side of the primary road with an observed measure of camouflage. During the daytime, the personnel will service the machinery, they will eat and rest. However, the use of the night hours alone for forward movement has the disadvantage that it takes more time that in the day. Thus, as expressed in the foreign military press, the advancement of troops is permitted in the daytime, but in small, compact groups.

During the course of the march, with the threat of the use of enemy weapons of mass destruction, the troops receive the signal for taking the necessary protective measures and continuing movement. In conjunction with this, there is an intensification in look-out, radiation and chemical reconnaissance; appropriate equipment will be included as often as necessary.

After the enemy nuclear explosion, the commander, of course, will evaluate the situation and depending on the character of the secondary results of nuclear fallout, will decide as to further operations.

During the course of the march, the necessity may arise for the armored forces to surmount destruction zones or rapidly withdraw from them. The method for surmounting the destruction zone will obviously be determined depending on the radiation level in the zone, the length of the march routes and the possibility for rapid movement along them, and on the requirement for data concerning operational-tactical conditions. The zone of destruction is surmounted at the maximum permissible speed, according to the direction guaranteeing the minimum degree of radiation to personnel. As pointed out in the foreign press, these directions may be pointed out by radiation reconnaissance in helicopters. In the destruction zone, the distances between the vehicles is increased so that the dust from the vehicle ahead does not fall on the vehicle following it.

It is possible to go around the destruction zone, but usually upon the decision of or at the order of the commander in chief. This depends on whether the by-pass requires a change of the march route of the movement; independent change of the movement direction without considering the associated problems may lead to intersecting of march routes and the development of obstructions and "bottlenecks" on the roads.

Zones with a high level of radiation, bypassing of which is impossible or impractical, evidently will be surmounted after a drop of the high radiation level, according to the decision of the commander in chief.

After leaving the destruction zone, when the first chance occurs (usually on halts or rest stops), a partial special analysis will be carried out, specifying the losses, determining the degree of radioactive contamination of the personnel.

Under contemporary conditions, on the march the troops may be subjected to air attack at almost any distance from the front line. Thus, during the course of the entire march and on stops, a high degree of preparedness is maintained against enemy air strikes and efforts are made to reduce their effectiveness. Operations with the appearance of enemy aircraft and helicopters may be different depending on the circumstances. Where there is natural camouflage along the road, the column remains covered from observation from the air. If the movement is completed in the open, the troops continue their movement, increasing the distance between the vehicles, and sometimes assuming dispersion formations. Of all the methods which may lead the struggle with the air enemy, fire is opened.

Thus during the course of the march the armored forces complete complex and different operations according to the enemy aircraft attack, liquidating the secondary effect of nuclear strikes, surmounting the zone of contamination and destruction, struggle with enemy air drops, etc. Moreover, success depends on careful organization of the march, closely securing it, strictly directing the forward movement of troops, decisive and initiative operations of personnel and, observing discipline on the march.

Section 4

Dialectics of Modern Warfare

1. Encounter Combat--The Element of Armored Forces

In connection with the high degree of mechanization and motorization of troops, modern warfare is regularly converted into a war of motors. When nuclear weapons and motorized troops are used, combat operations become impetuous and highly maneuvering; but the conditions change sharply in a short period of time. A rapid maneuver in conjunction with nuclear and fire strikes and precipitous attacks, in the opinion of foreign combat specialists, now constitute the main content of modern warfare.

Encounter combat and battle occupied an important place in the combat operations of troops even during the past war, i.e. those combat operations in which both sides tried to achieve victory by attacks.

The history of encounter combat and battle goes way back, when Roman footsoldiers and Greek legions were advancing on each other at an accelerated pace, and the cavalry met at a gallop. The basic feature of this type of combat operation was set even then.

In the civil war, the Red cavalry under Orlom, Kromam, Voronesh and Kastornoi gave classical examples for that time of leading encounter combat with large, highly-maneuverable forces.

At the start of the Great Patrician War, many of our armored forces and mechanized corps successfully conducted encounter combat with the enemy (under Shaulyaem, Grodno, Rovno, Lutskom, and others). In the final operations, encounter combat became even more frequent. Moreover, they led not only units, divisions and sections, but also armored forces. Thus, for example, almost all the tank forces of the Soviet Army carried on encouter combat in the last war: 5 gv. TA in the battle below Kurskom; 3 gv. TA against 1 and 4 enemy TA in the Kiev attack operation; 2 and 6 TA in the Korsun-Shevchenkovskoi operation; 3 gv. and 4 TA in the L'vovsko-Sandomirskoi operation; 5 gv. TA in East Prussia; 1 gv and 2 gv TA led an encounter battle with counterblow groups of Germans in the Berlin operation.

It is pointed out in the foreign combat press that in a nuclear-rocket war, in connection with an increase in troop maneuverability, especially armored forces, encounter combat may arise as often in the attacking as well as in the defensive operations of troops.

In an attack, the use of nuclear weapons, a high striking force and maneuvering of armored forces create conditions for precipitated development of operations in the depth. This indisputably provokes energetic counteractivity on the defending side, in view of the counterattacks and counter-strikes made by deeply situated reserves or regrouping with other directed troops. As a result of such operations, encounter combat becomes unavoidable.

In defensive operations, with the carrying out of a counterattack, counterstrike or transition to the attack (as a result of sudden change of conditions and the ratio of forces after nuclear strikes), conditions will also arise for encounter. Under conditions of extensive dispersion and with a deep deployment of reserves, the defending side will often transfer its troops from one region to another, and the attacking side will lead its troops in the direction of designated success.

Foreign combat specialists believe that a large striking force of tanks and maneuverability gives them more capability to carry out a counterattack and to inflict counterstrikes. As a result, during the course of attack as well as defensive operations, a situation may often arise where the armored forces will come into encounter combat for the purpose of inflicting high-power strikes on the enemy.

Since under contemporary conditions the moving form of combat activity predominates, it is thought that encounter combat may generally turn out to be the predominant form of armored forces operations. This can be seen from the following.

When the circumstances change rapidly and abruptly, achieving highly maneuverable operations, thanks to the thickness of its armor plating, on the one hand, armored forces personnel have the chance to more effectively escape from enemy nuclear weapons strikes and consequently from large-scale losses, and on the other hand to more rapidly utilize the results of their nuclear strikes and attack the enemy unexpectely under conditions more disadvantageous for it. Accordingly they may essentially carry out strikes at any time and under any circumstances. It must be kept in mind that under contemporary conditions both sides will have many chances to conduct active operations and, unconditionally, will have them directed at him.

In this connection a word may be quoted from the known Civil War Theoretician Lindel Hart. In a paper "Tanks and the Future" he sayd we should talk not only about large tank units, having maximum flexibility of operations on the battlefield and capable of rapidly changing from one firing position to another, but about the entire divisions which may be rapidly transferred from one section to another in order to inflict deep counter-strikes for the purpose of destroying the enemy.

Under the conditions in question, encounter combat in the armies of the capitalist nations cannot be denied and, on the other hand, though indirectly, it is recognized as a more characteristic type of operation on contemporary combat.

The same author maintains that in future wars, in general, highly-placed commanders, as distinct from their predecessors, will strive to achieve decisive results with rapid movements and not with combat. He believes that in a rocket-nuclear war the maneuver and movement will essentially be the basic content of troop operations, in consequence of which the occurrence of encounter combat will be quite frequent and a characteristic phenomenon for troops in general and for armored forces in particular.

Thus it is thought that the development of means of destruction and the possibility for combat technology at the present time will lead to the point where the emergence of combat operations from the situation of armed conflict will become more frequent and typical.

It is pointed out in the foreign military press that with a wide scope of contemporary combat operations and widespread possibilities to achieve success in encounter combat, armored forces will be continuously transferred from one region to another. When time is limited, they must enter into combat immediately from the march. This situation is characteristic for their entry into battle and for operations in the course of the attack (with the destruction of counterattack reserves or counterattack groups), and in defense (with destruction of the intended enemy counterattack, attempting to be successful in the rear). It is thought that by virtue of this encounter combat may be very characteristic for rocket-nuclear war and may turn out to have essential influence on its course and outcome.

2. Onset and Characteristics of Encounter Combat

Foreign combat specialists believe that encounter combat may occur under various situations, on the attack as well as on defense. In principle, these conditions will be characterized by their exclusive complexity, wide use of nuclear weapons, conducting combat operations in a large zone of radioactive contamination and destruction, intense struggle for the initiative, the tendency to utilize open flanks and time intervals to inflict strikes on the flanks and on the rear, deep mutual entrenchment of sides in combat ranks.

It is pointed out that during the course of offensive operations, encounter combat may arise within the limits of tactical defense. In this case, for the attacking side it is characteristics that it be in combat ranks, that its firing facilities are developed, organized and that its communications are operating, that the controls are adjusted. However, the attacking side encounters the other side, the operations of which may markedly influence the situation with the entry of attacking tanks into the battle with approaching reserves. This requires an auxiliary force after the destruction of resistance by residual enemy groups has been completed up to entry into battle with the enemy moving up from the rear. Such a situation confronts the attacking side with complex problems concerning seizing and holding advantageous lines, disrupting organized enemy deployment, preparing for combat under conditions of continuous enemy firing operations.

In the case of operations in the depths, the situation changes substantially. The attacking side has great maneuvering freedom; often it will be situated in columns in more moving and maneuvering formation, which is important for forestalling the enemy from going in any advantageous direction or from taking any advantageous border. In a given situation, the resistance of the retreating enemy may be already broken and the attacking troops may enter into combat in full formation. As affirmed by foreign combat specialists, the conditions under consideration are favorable for entering into encounter combat, where the time and place of the strike on the enemy, in the process of developing combat operations in the depth, may be selected more freely, depending on the possibilities or the requirements of the situation. Moreover, in given situations there may not be troops close by, which would mean open flanks. This will favor the enemy, since he may select any direction for inflicting strikes. In such situations, special attention should be devoted to secured flanks.

The situations for the emergence of encounter combat are more complex for defensive operations. In this case, battle is imminent with a powerful enemy, frequently having the initiative. The advantage of the counterattacking troops lies in the fact that they know the locality better, they can prepare the lines beforehand, move forward for the strike and inflict it suddenly.

As a rule, for the situations under consideration, the emergence of encounter combat have in common that they are begun with a march, after deployment of the sides from the column.

The more characteristic features of conducting encounter combat concerns the fact that both sides attempt to reach their targets with precipitated strikes in conjunction with fire and maneuvers. Consequently, success can be achieved only with the use of more expedient operational methods, more effective than those used by the enemy. In encounter combat, usually sides meet which are equal in strength up to a determined moment, they have the same attack groups, similar objectives, almost the same time to prepare for the operation and thus almost equal chance to achieve victory. Under these conditions, the one achieves victory which best, most fully and most rapidly sizes up tht situation and uses it advantageously. It seems that a great deal must be taken into account here.

First, the approach of the sides takes place precipitously and there is a limited time to organize the combat.

Second, tank units and sections attack while moving, without stops and pauses, deploying and assuming combat ranks directly from the column.

Third, during the course of the battle, the advancement and the entrenchment of units is irregular, and there will always be a communications break between neighbors, which may be utilized by the enemy. The battle may assume the characteristic of a focal point in which bold and decisive actions are very important, even of individual crews or sizing up of weapons. Finally, up to the start of the battle as well as during it, both sides may use nuclear weapons. However, the success of their use depends on the presence of data on the enemy, which under combat conditions is somewhat more difficult to obtain that under other conditions.

Seizing and keeping the initiative plays an important role in encounter combat. According to the nature of the struggle, to seize the initiative in encounter combat is the decisive element. The fact is that, in the case of attack, for example, the initiative, already from the start of combat is in the hands of the attacking side, and in defense, up to a determined time, in the hands of the defending side. In encounter combat, the appearance of this factor is different. By virtue of the fact that encounter combat is carried on by practically evenly opposing forces, success may be achieved by either of them, but primarily by the side which is able to rapidly make use of the prevailing advantageous circumstances or rapidly create them with his own active, bold and unexpected operations.

However, this still does not decide anything about reaching the target. Seizing the initiative by passive conduct of the battle may be lost because in encounter combat the potential possibilities for achieving victory are objectively retained by both sides right up to its end. Thus maintaining the seized initiative assumes great importance until complete victory is achieved over the enemy. In addition, we should also add that during the course of encounter combat, the initiative will frequently pass from one side to the other. The frequency of this transition is characteristic for encounter combat and displays a high degree of intensity with a given type of combat operation, and makes keeping the initiative right up to the end of the battle very important. In contrast to this, in defensive combat, the first transition of initiative to the defending side already means that the attacking side will not be successful, and its chances for achieving success are slim.

In encounter combat it is very important to use the available time to prepare for it and to execute different operations. The limited nature of the time for making decisions together with the rapid and abrupt changes in conditions is one of the clearest characteristics of encounter combat, calculating the fire power of the enemy, sizing up the deployment of troops in order to pursue the advantageous situation with relation to the enemy demands that combat operations not be conducted according to the week or the 24-hour day, as was so in the past, but according to hours and minutes. In considering the firepower of one tank against another, seconds or even fractions of seconds are the decisive factor.

One of the characteristics of encounter combat is the insufficient clarity of the situation for an extended period of time up to the encounter with sides, as well as during the course of combat.

Foreign combat specialists believe that in a situation when both sides are attempting to inflict high-power strikes with nuclear weapons and aircraft right up until the encounter, they naturally will take all necessary measures to conceal their advance from enemy scouts. But since neither side usually stops at either line, but both are in movement, this leads to great lack of clarify in the situation. This results in the necessity of knowing how to organize a battle in the presence of minimal data on the enemy, data which is contradictory besides. In connection with this special feature of encounter combat, one of the most important conditions for guaranteeing the successful operation of troops is organization and continuous active reconnaissance of all types on wide fronts and over great depths.

Notwithstanding the insufficient clarity of the conditions and the great probability of them changing abruptly and unexpectedly, the clearest operations are required of troops even with the loss of communications with neighboring troops and commanders. But this is possible only with full understanding of the subordinate plan of the commander in chief (chief), in the presence of a high degree of organization, with simultaneous execution of pre-planned operations and wide display of creative initiative.

The approach of the sides in encounter combat will take place with great speed, and the encounter may take place over a relatively short period of time, after having detected one another. It is obvious that it is of the utmost importance not only to take rapid advantage of the situation with relation to the enemy, but to anticipate it and to inflict fire strikes, and take to the attack. In order to guarantee the organized deployment of main forces and to create conditions for seizing the initiative, it will also be very important to prevent the enemy from advancing to advantageous lines on his paths of advancement.

It is generally known that with the inflicting of unexpected preventive fire strikes and preventing the enemy from going to the attack, the most favorable conditions are created for conducting encounter combat even in a situation when up to its start, the enemy groups are still not fully concealed.

In connection with the high degree of maneuverability of tank troops and the presence of open flanks, combat operations in encounter combat are usually carried on over a wide front with the enemy moving on the flanks and in the rear. Taking into consideration the great importance of secret and sudden movement of force divisions onto the flanks and in the rear, both sides, as a rule, will take all measures to carry out strikes unexpectedly and in that moment when one of the sides is still not prepared and is taking a position (line) inconvient for combat. This special feature of troop operations in encounter combat shows the importance of securing the flanks and the rear, the necessity of continuously reconnoitering in all directions and, most important, maintaining a high degree of preparation for inflicting strikes in any direction or re-directing them at any moment onto their flanks or rear.

It is pointed out in the foreing military press that encounter combat of tank troops will usually be of short duration. As a rule, in these battles an unexpected and decisive attack directly after inflicting nuclear or fire strikes on the enemy may lead to victory in a short time, not only on an enemy which is equal in strength, but also on an enemy who is superior in strength. However, the problem of continuing the battle is not easy and requires careful consideration.

It is believed that encounter combat consists of two stages: their tie-ups with forward subdivisions and leading the main forces. But the situation may become more complicated in that after the encounter battle of the forward units, the main forces of one side will be forced to give up continuing the attack, i.e. to give up the encounter combat, and then the operations of both sides after the encounter may prove to be of attacking only for a short period of time, namely in the period of the encounter.

In other situations, both sides may come to the conclusion that their troops are able to achieve victory with attack operations, i.e. operations in encounter combat. Such operations will be by far more prolonged than encounter operations of forward units. So, for example, in the years of the Great Patrician War, batallions and brigades carried out and completed encounter combat after 1-3 hours, for example, but the tank corps frequently require from 10-30 h (29 tk in battle with 3 td of the German-fascist army in January 1944; 10 gv.tk. with 17 td of the enemy in January 1944 and others).

Thus, although rapidity is generally characteristic for encounter combat, in principle it is always relative and depends on the composition and number of troops participating in it. In comparison with other types of battle, for example, with an attack on a defending enemy, rapidity of encounter combat is by far the highest. It is claimed that the rapid completion of encounter combat is founded on the same basis. Anticipating the enemy in inflicting fire and especially nuclear strikes, in deployment and unexpected move to the attack, in secret moves to the flank and rear of the enemy, this is by no means a full list of the factors which guarantee destruction of an enemy equal or even greater in strength in a short period of time.

One of the most outstanding characteristics of encounter combat is intensity and complexity for small units as well as for large forces. Only these difficulties are manifested differently from one battle to another. So, for example, encounter combat of large tank forces, as was the case for example under Proxorovkoi at the time of the Kurskoi struggle in July 1943, is put together from a great number of individual encounter battles of small units dispersed along the front and in the rear. In addition, these combat operations cannot be considered as a simple combination or sum of isolated battles; their makeup is complex. Encounter battles of large tank forces encompass all other troop operations, united for one goal, to destroy the enemy in the shortest period of time possible with equal or lesser forces. It is thus assumed that in the course of encounter battles, large tank forces may carry out not only one attack operation. In these battles, the attack--this is only general according to the purpose of the operations and according to the form of these operations--may be different. The basic forces may lead the attack, and part of the forces may temporarily lead the defense, it may institute drives, lead attacks and counterattacks, move out of the battle, regroup and again go into battle, etc.

As is clear from the foreign press, in modern warfare encounter combat with large enemy forces will also be characteristic for armored forces. It is obvious that its character in the accepted sense will be similar to encounter combat during the period of the Second World War, but only with different indicators. It is pointed out, for example, that in modern warfare the encounter of large armored forces will be matched by combat operations of the type known in encounter battles, developed below Proxorovkoi at the time of the Kurskoi battle.

In combat literature, for example, determinations of these operations are given by L. Barbarshovskii in his book "Maneuverability" who points out: "Encounter combat is a battle of operative consolidations of beligerent sides, simultaneously fulfilling the tasks of attack. According to its content, encounter combat may include various types of combat operations. However, its basic part is encounter battles of units and sections, united in purpose, time, place and direction to destroy the enemy by means of decisive attacks. In encounter combat, the form of the maneuver may be changed as well as in the encounter battle, but the dimensions of these changes will be much greater. The encounter of operative units means the development of combat operations over a wide area, the width and depth of which may reach tens and hundreds of kilometers. If maneuvers are carried out on a tactical scale in encounter combat, companies, batallions and regiments, then in encounter battles it will already be carried out on an operational scale." Speaking of the characteristics of encounter combat, the same author emphasized that "some sections and units will maneuver and conduct combat activity at the rear of the enemy and, on the other hand, some enemy sections will conduct combat at our rear, attempting again to seize the abandoned important objectives and find freedom of maneuverability...In one direction, the troops will be carrying out a flank maneuver, envelopment on one or two sides, and in the other direction they will come out on the enemy rear through gaps in its combat ranks; in one of these directions they may bypass the open enemy flanks for the purpose of seizing important objectives in the rear and cutting off his second echelon."

Thus we can conclude that modern encounter combat, founded on the principle of attack operations, encompasses a whole complex of operations, united with one goal, a general attack of all groups carrying out decisive destruction of the enemy. The conduct of other operations (except for attack) during the course of a battle, for example defending parts of forces in the case of a lag in the attack of tank forces from the other side, requires departure for some time from the basic operations of their own forces, and sometimes even specially conducted menvuers, in order to achieve the main purpose of the combat, to destroy the enemy with renewed attack after some preparation. Under such conditions, the given operations must consider only a particular manifestation of the general character of encounter combat.

3. The Basis of Organizing Encounter Combat for Armored Forces

In order to achieve success in any battle, it is important to prepare for it beforehand, especially encounter combat. It usually begins with planning the operations, in the course of which encounter with the enemy is possible, for example in organizing the march in anticipation of encounter combat. The basic measures for preparing for operations in anticipated encounter combat primarily include correct determination of a plan of action upon encounter with the enemy and grouping forces and means appropriate to its character.

Advance creation of expedient group forces and means permits organization with the minimum loss of time for entry into battle and anticipating the enemy in this.

Advance acceptance of expedient troop groupings to prepare for encounter combat has its own special features. In the case of one of the operations, the force and facilities groups are set up for concrete combat, that is for struggle with a determined enemy and under determined conditions. In the case of the other operations, in the course of which only encounter with the enemy is possible, for the most part there is no information concerning the circumstances in which combat with the enemy may occur. Actually, in the organization of an attack on the defending side, the attacking side has the chance to scout the enemy beforehand, and to set up the required groups of forces and facilities in a period of time suitable for himself, corresponding to the requirements for achieving successful destruction of the concrete enemy in the designated place (region). And what is more, in the series of situations setting up the groupings of forces and facilities, the opportunity presents itself to prepare properly (right down to training in his own rear area, as this was sometimes done in past wars before breakthrough of the high-power defense.) In encounter combat, everything is different. In encounter combat it is sometimes not fully clear right up to the encounter itself what resisting enemy is confronting us with.

It is evident that setting up groups of forces and facilities in such a situation will in rare cases be matched by requirements for the same arrangements, which will be made upon encounter with the enemy. Where is the escape? How should the necessary grouping be set up beforehand? Obviously it is better to have such a grouping which would be able to enter directly into the battle in the form in which it was created, but this is possible only in rare cases. Thus it is necessary to have such a grouping in order that it be possible to set up from it any new grouping required by the situation, as necessity dictates, in a short period of time. Thus, the group set up beforehand is a more flexible, multipurpose, rapidly changing group. However, besides this, it is necessary to solve a series of problems, guaranteeing rapid setup of the required groups in the course of movement and while detecting the enemy.

Obviously, in order for troops to be able to assume the required groupings in the shortest period of time, since they are already in the process of approaching the enemy, the commanders and the staffs will be obligated to always take account of changes in the situation, carry out required specifications in the projected plan of operations in a timely manner and constantly inform themselves about subordinate troops as well as maintain their high degree of preparedness to enter into combat at any time.

As already discussed above, the outcome of encounter combat depends in large measure on anticipating the enemy in assuming the necessary groupings and inflicting strikes.

What is required in order to set up the advantageous groupings of forces and facilities? It must be remembered that the following is necessary for this.

First, when the situations occur in which encounter with the enemy is possible, the commander must rapidly determine (calculate) the place and time, where and when it will take place based on the data about the enemy, set up a plan of operations for destruction of the enemy in a given region. On the basis of profound understanding of the nature of modern general troop combat and enemy tactical operations, the commander can determine the most advantageous type of maneuver in a given situation, the direction of the main strike, required for the forces and facilities groups, and the time for inflicting the strike. Such an order of operations permits the commander to pose problems to his subordinates, point out to them the most expeditious operational means. It is evident that all operations to prepared for battle in given situations will be more expeditious and rapid when all the commanders, and all the personnel have a good understanding of the requirements of the situation and the importance of their own maneuvers, i.e. designated operations.

Secondly, it is necessary to take into account that when the enemy appears at great depth, they will not always have the same grouping at the encounter as they had when they were detached. The enemy will try to change its grouping at the moment of the encounter. The problem lies in timely detecting the beginning of the enemy grouping for battle or, more correctly, the preparation for this, and determine what the enemy grouping will be at the start of the battle. The tank commander can successfully solve these problems having a flexible, multipurpose grouping of the troops under him and setting up that group in the shortest period of time which will best respond to the requirements of the changing situation.

When solving this problem, it is necessary to keep in mind that the premature creation of any grouping of forces and facilities or its deployment, is fraught with great dangers. It must be taken into account that the enemy may complete a maneuver and go in the other direction. This makes it necessary to reorganize the combat ranks which requires additional time. Thus the commander must rather accurately and concretely calculate the time it will take to perform another grouping.

It must be emphasized that in calculating the times to form a combat formation, the preceding position of the troops plays an important role. If they are in columns, they are more maneuverable than when they are deployed. Thus, following the enemy, it is expedient to always have in mind that moment when they must not be in columns or before when they must not begin deployment.

The main thing in deciding problems concerning the troop groupings required for combat or the moment of their deployment for battle is to know the most advantageous moment for attack in a given situation.

When data are obtained concerning the encounter and combat of moving units with the enemy, a decision is made on inflicting firing strikes on them, deploying one's main forces and proceeding to the attack. The plan of operations made beforehand points out to the subordinates the concrete problems they are confronted with.

In the plan of operations, taken as a basis in this moment, such problems are defined as: the enemy which must be destroyed and the order in which this must be done; the forces and facilities at hand; the operational methods for destroying the given enemy; groupings of forces and facilities for conducting the battle; the most expedient form of the maneuver; the direction of the main strike.

As a rule, the deicsion as to an encounter combat is made after a short time. So the tasks rapidly reach the subordinates, since the timely assumption of necessary troop formations depends on this. The setting up of necessary groups and the completion of projected maneuvers is closely connected to the methods for stating the tasks. The limited nature of the time requires brief but clear and explicit statements of the tasks to the subordinates. In order to gain time it is frequently sufficient to at first bring to the subordinates such data as line and the time for proceeding to the attack; following this, the problem may be defined and supplemented with additional data.

As far as the requirement to set up the groups is concerned, as pointed out in the foreign literature, in some situations the decisive point will be the rapidity and suddenness of the strike, in others and force and power of the initial strike, i.e. the number and makeup of forces and facilities called into play. What is most important must be prompted by the situation. If in the developing conditions the possibility present itself for inflicting an unexpected strike, then in the capacity of the decisive factor it is expedient to put forward the time for setting up the group, and not its quality. If surprise in the blow cannot be achieved, and time permits some transfer of forces and facilities, then it is advantageous to set up such a grouping so that on the whole they would be able to inflict a powerful initial blow on the most vulnerable position of the enemy, etc.

Precision in command play an important role in the timely solution of all organizational problems. The location of the command points and the order of their movements will be determined in accordance with the situation and with such calculations so as to guarantee reliable and continuous communications with one's own troops, neighbors and commanders. The necessary means of communication must be present with all movements of the commander. The basic problems include attaining a high degree of communications stability in conditions of a high degree of radio interference, for which the most expedient means for maintaining it will be selected in the given situation. Under present conditions, more widely than before, use will be made of a maintenance of communications with correspondents by means of previously-prepared short, arbitrary signals and just as short radiograms.

So much for the specifics of organization and maintaining interaction of troops in encounter combat. Due to the limitation of time in organizing encounter combat operations, questions of interaction will evidently be solved inadequately. Primarily, it is necessary to solve problems concerning the order of forward movement and deployment (determination of movement routes and time for troops to move to a determined line); concerning the order of inflicting fire strikes with various destructive means (determination of objectives, time and extent of the strikes, position from which the fire strikes may be inflicted, troop operational methods during the time of these strikes;) concerning the transition of troops to the attack and maintaining their operations with firing facilities during movement to the attack, in the case of its development in the depth, in the case of securing flanks. The solution of each of these problems is tied up with subordinate troops, with neighbors and with firing facilities according to time, place (line and direction) and targets.

It is important in organizing interaction to make sure that subordinates know their own problems and those of their neighbors, as well as problems in the order of operation of given and supporting forces and facilities. The basis of interaction in modern warfare with the use of nuclear weapons, we must assume, will consist in the application of nuclear weapons. In order to guarantee concordance in operations with encounter combat, the troops must know the time and the sequence of inflicting fire strikes with forces and facilities of the main commander and neighbor, as well as the order of their operations in this time and after inflicting strikes.

Thus it is thought that the creation of groups to lead the encounter combat and its organization into armored forces i characterized by a series of special features, determining on one hand the character of their operations in this battle and, on the other, by specific combat possibilities of armored forces units and primarily, their maneuverability. Problems concerning the advance creation of expedient groups in organizing the operations for anticipating encounter combat essentially include creation of flexible "multipurpose" groups, means for quickly changing its form and content with relation to changes in the conditions and requirements which reoccur.

4. Conditions for Achieving Victory in Encounter Combat

The experience of past wars and the special features of modern warfare show that the most important conditions for achieving victory in encounter combat will be the following: timely detection of the enemy and continuously observing him; timely and quick decisions as to one's own troop operations and putting the tasks to them just as quickly; anticipating the enemy in seizing the advantageous lines, inflicting nuclear strikes, aviation strikes and artillery fire; daring maneuvers when going out on the flank and in the rear of main enemy forces; breaking the enemy up into parts and destroying them separately; seizing and keeping the initiative with a display of great decisiveness, daring and boldness; the order of destruction on the enemy with fire and the direction of the main strike; order of deployment; transition to attack and the operations of the main forces for the purpose of destroying the enemy.

All of these conditions in each individual case develops completely concretely, thus their contents are always different depending on the special features of the situation. Thus, for example, one of the main conditions for guaranteeing the infliction of powerful strikes on the enemy with firing facilities is their timely detection. The enemy must be detected in time to evaluate the situation, make a decision and submit the problem to subordinates; and after this the troops will still have the minimum necessary time for deployment and to destroy the enemy with fire.

To anticipate the enemy in deployment and moving to advantageous positions--this means that the enemy is moving his own troops to the line which is convenient for deploying tanks in combat ranks and guaranteeing that they occupy a more advantageous position than the enemy. The most important factor in victory is its special influence on the relationships of forces in battle. One side, successful in anticipating deployment and infliction of strikes, as a rule will rapidly achieve victory even over a numerically superior enemy. For example, at the time of the Kurskoi battle in July 1943, the 181st tank brigade unexpectedly encountered enemy columns in the Mixhailovka plain composed of about 40 tanks. With a daring and sudden attack of only two batallions, one (main) from the front and the other from the flank, the enemy was defeated although he was stronger than these two batallions.

Anticipating the enemy in fire strikes, deployments and attack is unthinkable without clear calculation of time and space. In order to accomplish this it is necessary to determine the advancement and deployment potential of the enemy for battle as accurately as possible,to open fire and proceed to the attack, and on the basis of this to establish times for inflicting one's own fire strikes and proceed to the attack. With such a calculation it is important to take into account with maximum accuracy the possibility of interrupting the anticipated operations of the enemy with one's own fire strikes and in accordance with this to calculate how to defeat him before he can prepare for battle.

At the present time, the value of fire strikes, among them nuclear blows, is very well known. Here, for example, is what was written in the article "A new Approach to Tactics" in the journal "Military Review" in July 1960: "We must proceed on the assumption that we will be encountering a clever opponent, which will give us an advantageous target for nuclear attack only when he is forced to do so. Thus the most successful maneuver of our troops will be the one which forces the enemy to provide us with this advantageous target."

It is thought that anticipating the enemy in deployment in combat ranks or setting up advantageous troop groupings for encounter combat has its own special features. First, in no case must it be premature; secondly; in the course of troop deployment the possibility for any unexpected maneuver must be maintained; third, deployment must not be protracted, so that the enemy cannot be successful in taking effective countermeasures and observing troop deployment. Finally, deployment must be completed without fail with a move to the attack followed up by nuclear blows and fire strikes on the enemy.

Thus, under contemporary conditions, deployment must try to initiate such an advantageous line and in advance so that the enemy will have no possibility of escaping the blow prepared for it.

Even maneuvers at this time must take into account interrupting the operations of one's own troops unexpectedly. Anticipating deployment of the enemy must include this in order that with its completion the enemy will be in the immediate vicinity of direct attack and any maneuver will be carried out only under fire.

It is thought that along with anticipation of the enemy in fire destruction, as well as with the infliction of tank strikes, the force and power of the initial blow is of great importance. If the attack is conducted with maximum forces, at high speeds and with correct calculation of the relative strength and character of the operations in concrete conditions, then this will guarantee success in a short period of time. However, under the maximum number of forces and facilities drawn into the attack, it is necessary to know only the amount of force necessary for victory, and not the maximum which may be used in battle on the basis of available number of forces and facilities. This means that if under any conditions the number of tanks necessary to achieve victory has been sufficiently determined, and they must be formed in a timely manner, then this number must be limited. Proceeding on the basis of the special features in encounter combat, the relationship of forces is important in correctly deciding problems concerning inflicting the first strike. It is necessary to take into account the lack of clarity in the situation, the possibility of sudden action on the part of the enemy. Thus in an attack it is necessary to use such forces and facilities so that with a change in conditions to the advantage of the enemy there will be sufficient forces in the attacking echelon for his destruction. Of course, we are talking about changes in conditions which do not require basic changes in the plan and entry into battle with a somewhat greater quantity of forces.

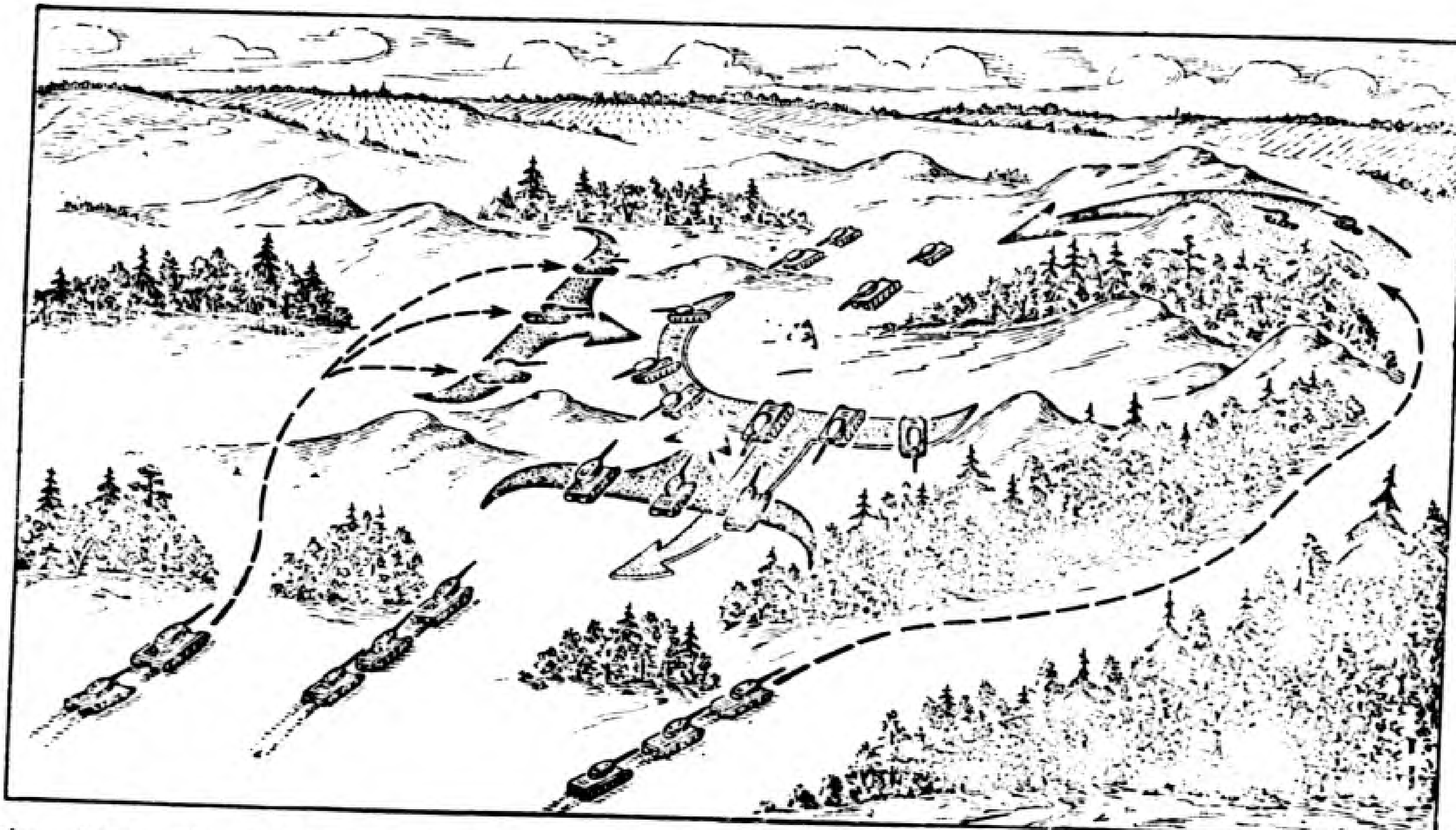


Fig. 122.--Maneuver in encounter combat (envelopment from the left, by-pass from the right).

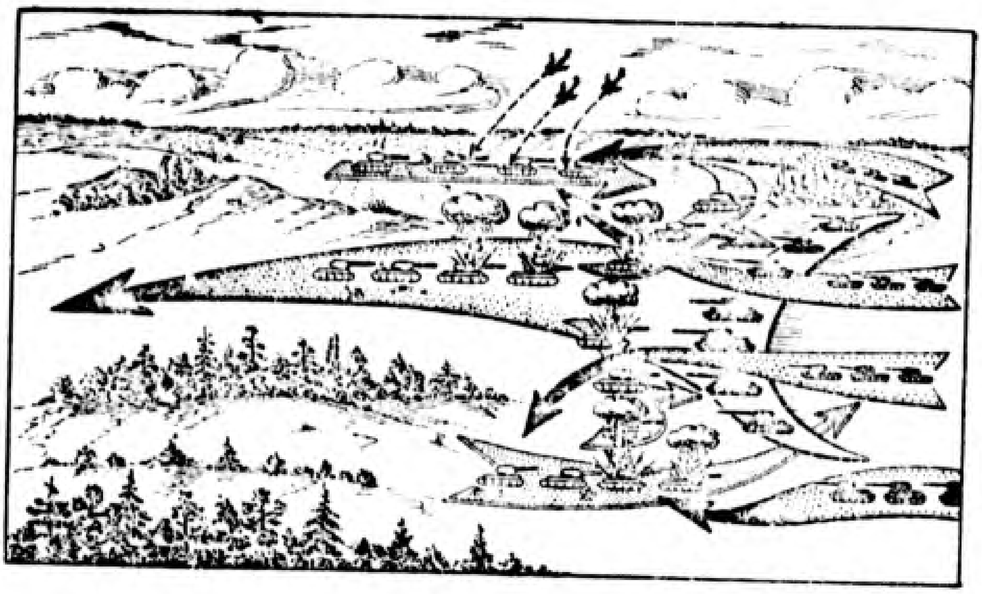


Fig. 123.--One form of maneuvering in encounter combat--frontal attack.

The element of surprise usually develops in battle according to the scope of combat operations and the quantitative makeup of the forces participating in them. Thus, for example, for platoons or companies its manifestation may be completely different than with a batallion or larger groups. For small units already in the first minutes of battle the result of a surprise blow may turn out to be decisive. However, after that such an element of surprise is exhausted, usually the basic factors come into play at once--the relationship of forces and the skill of maneuvers.

Thus, the success of encounter combat depends on the forces and power of the initial blow and the possibility of maintaining the minimum necessary relationship of forces and facilities when entering into combat. The relationship of forces and facilities must first guarantee a particular superiority in determined moments of combat in decisive directions, if the forces of the sides are completely equal. Such a superiority may be created of forces by commanders and staffs of all degrees by means of maneuvers and rapid concentrations of forces and facilities in the required directions. The ability to do this under conditions of general equality is a very important quality of the commander.

It must be emphasized that the presence of general superiority in forces and facilities still does not mean that victory over the enemy is guaranteed in this case. The presence of such a superiority creates only the possibility and the prerequisite for success. Daring action of troops plays an important role in encounter combat along with a strong will of the commanders, their decisiveness and knowledge of the art of warfare. Victory is achieved by lesser forces over numerically superior forces just on the basis of these factors. On one occation, Napoleon said:

"Having a hostile army, superior in numbers opposing me I, like lightning, cast myself at their flank, divided them up, took advantage of the enemy's confusion and attacked again with all my forces at other points. Thus I brought them down to defeat and the victory which I won, as is evident, was nothing more than victory of the strong over the weak."

In the years of the Great Patrician War, many of our tank brigades and corps carried on encounter combat, but the tank armies encountering combat with the enemy, having numerical superiority achieved their destruction.

Their operational success was first aided by skillful maneuvers on the field of battle, breaking up the enemy into parts and defeating him. For example, in the encounter battle of 10 TK with 17 TD of the German fascist army corps first destroyed 17 TD, and then interacting with associated corps 168 pd of the enemy moving from the other direction.

Consequently, in encounter combat most attention must be paid to that factor which would permit use of available forces, especially if they are low in numbers, with the maximum effect. In a short time, armored forces have every chance to concentrate themselves in the required number in the required place and to guarantee the necessary force of the initial strike and increase it without interruption.

Due to this fact, success in defeating the enemy in encounter combat depends nine-tenths on expedient use of some kind of maneuver. For armored forces in encounter combat, tank forms of maneuver are used such as surrounding and bypassing the enemy on one or two flanks, (Fig. 122) as well as a frontal blow on the enemy (Fig. 123).

The choice of any kind of maneuver in encounter combat depends on many factors. The size in number of the troops and their maneverability are very important. For example, it is very difficult to surround or bypass the enemy on two flanks with a small unit of troops, since in this case the enemy has the chance at actively attacking the bypassing forces with one or the same forces and facilities without shifting them.

Thus in encounter combat the unit is most effectively used in a bypassing maneuver on one flank. So, for example, on february 26, 1944 in combat below Leningrad, the tank batallion of one of our units, operating in the front division in the region of upper Bereshky-Gorki, met an enemy column moving toward it composed of 20 tanks with 15 automobiles and infantry. Jumping the head field enemy outpost from the front, the batallion struck from the flank with its main force. The blow was sudden and in a short time the enemy was defeated, losing 13 tanks and up to 100 men killed and injured.

In encounter combat the most powerul force, operating over a wide area, is capable of using all forms of maneuvers, among them bypassing and surrounding the enemy with both flanks. In this case, in the opinion of foreign combat specialists, the outflow of even a small part of the forces into the enemy flanks confronts them with the necessity of regrouping forces and facilities, weakening themselves from either direction. At the same time, any regrouping of troops generally reduces their combat effectiveness. These factors, of course, will contribute to the success of the attacker.

However, the maneuver in encounter combat is not an end in itself. It is useful and necessary only in the case where as a result of its application the tanks may inflict greater losses on the enemy and destroy him in a shorter period of time, sustaining lower losses himself. If, for example, as a result of the bypassing maneuver, these advantages were difficult to obtain over the enemy, or obtaining them was not very likely, and also if there was not time to accomplish the maneuver, then such a maneuver would not be expeditious to carry out. It would be more advantageous in this case to inflict high-power and sudden blows from the front with the purpose of rapidly destroying the enemy with one blow or breaking him up into parts for final destruction. Such a dispersion is facilitated with the use of nuclear weapons.

The possibility of inflicting high power strikes from the flanks or from the front without extended preparation maneuvers permits the tanks to widely and freely select the direction for their main blows and to unexpectedly transmit the forces from one part to another. The high striking force and high degree of maneuverability permit armored forces to quickly inflict blows from the flanks as well as from the front, first inflicting nuclear blows on the enemy, sharply reducing his combat capability in bringing tanks to the attack.

As asserted by the foreign press, if the nuclear blows are inflicted later than the troops can proceed to the attack, then in the presence of time and favorable circumstances, the transition of the basic forces to the attack is more expeditious from the flanks or even from the rear of enemy groupings, that is, where the enemy is more vulnerable in the setup of his groupings. The same is true for cases where the enemy is not generally destroyed by nuclear weapons. Moreover, this is not always compulsory for the enemy to move out the larger part of his forces in the flanks or in the rear. It is sometimes unexpected for the enemy to manifest his smallest forces on his flanks or in the rear, but at such times when he is still preparing for battle.

In close connection with the form of maneuver and the order of inflicting nuclear blows, there is also the direction of the main strike against the enemy.

It is pointed out in foreign military literature that if in the course of bypassing or surrounding the enemy on its flanks the possibility arises for inflicting on one of them sufficient forces for a high-power initial strike, then in this direction it is expedient to inflict the main blow. In this case it is important that the terrain permit the use of tanks with maximum utilization of their combat capabilities. When the frontal strike is inflicted, the main forces concentrate in this direction.

It is thought that with the selection of the direction of the main blow, it is necessary to consider the order of the use of nuclear weapons. Tanks may attack the enemy directly after nuclear strikes in the directions where these blows were inflicted. They can attack the enemy directly through the epicenters of the nuclear blasts, enter in these directions deep into enemy territory and turn up on its flanks. These operations may achieve superiority over the enemy in a very short period of time, seize the initiative and achieve victory.

One of the most important conditions for achieving victory in encounter combat is to destroy forces in parts. Two characteristic situations are possible here. If the battle is carried out with monolithic operating group, then a frontal blow of the tanks can break them up, which will then be defeated separately.

If the enemy forces prove to be broken up even until the battle, it is not expedient to give them a chance to join forces, but it is necessary to isolate one part of their troops from the other and destroy them in succession.

In both cases, a wise distribution of facilities and forces to fulfill the tasks of breaking up the enemy and destroying its broken up parts characterizes a high degree of the art of war on the part of the commanders at all levels. For armored forces, having a high degree of maneuverability, destruction of the enemy in parts after dispersing him will turn out to be the most typical means of operation under the conditions of rocket nuclear war.

5. Basic Operations of Armored Forces in Encounter Combat

The first thing to institute in contact with the enemy is reconnaissance. As a rule, it is wise to destroy small groups of the enemy, surround the large ones and try to advance to his main forces. With advance to the main enemy forces, reconnaissance detects their makeup, the direction of movement, their equipment and provides this extracted information to the commander in chief.

Outpost units and the avant-guard enter into attack with almost equal enemy forces and seize the line which is advantageous for the final operations of their main forces.

It is thought that one of the basic tasks of the avent guard is to set up such conditions for the enemy which would be as unfavorable as possible for him to conduct encounter combat at a given line. For this purpose, these lines would be seized which would prevent free enemy operations in front of them and, primarily, his tanks, limiting his chances to conduct secret maneuvers and rapid deployment, not giving him the opportunity to regoup unobserved.

The operations of the outpost and avant guard units upon encounter with the enemy may be different; a sudden blow directly from the front or from the flanks and back, firing from place on an advantageous line, subsequent precipitated attack and fire strikes.

The combination of ambush with attacks in encounter combat with avant guard units may guarantee success not only in combat with small enemy outpost (escort) subdivisions, but it may force the main forces to deploy into basic groups. And, thanks to this, the main forces of the other side have the opportunity not only to deploy almost at will, but to select the best moment and the most advantageous direction for attack.

As pointed out in the foreign military press, the main forces will usually move to the attack after inflicting fire upon the enemy. However, the effect of fire upon the enemy obviously will be achieved with his approach to the encounter region with main forces, from a maximum distance of operation, having destructive facilities, among them aircraft, nuclear weapons and artillery. The maximum degree of destroying the enemy with fire must be reached at the moment his main forces move to the attack.

It is thought that the long-range nature and power of contemporary firing facilities permits us to assume that encounter combat of tank groups at the present time may not begin with the combat of reconnaissance or avant-guard troops, but from the moment the enemy is fired upon. Such an order of inflicting fire strikes on the enemy must be facilitated by timely obtaining data about them even at a great distance from the probable region where they are encountered (Fig. 124). In a given case, strikes on the enemy will obviously be inflicted when they are, for example, crossing over a pass, water obstacles or wooded placed where it is more difficult for the enemy to move his troops in rank and complete maneuvers.

The method for inflicting blows on the main forces will play a large role in encounter combat. As stated in the press, blows may be inflicted simultaneously or in sequence. The most success is usually achieved with simultaneous strikes or large forces and facilities. However, to prepare such a strike is an involved matter, and sometimes requires a great deal of time. Thus to seize the initiative and to achieve a surprise operation, the strike may be inflicted by admitting available forces into combat successively, especially with a move to the attack after a nuclear strike.

As a rule, deployment of tank units for battle takes place at maximum speeds. The shortest distance and the most favorable roads are selected for this. Pauses are not allowed with deployment and moves to the attack, since even a brief hesitation may be used by the enemy to cause failure of the attack. The success of the attack may be greater if it is carried out unexpectedly, especially with a move to the flank or to the rear of the enemy.

In the opinion of foreign combat specialists, most of the forces will be moved and deployed with consideration of the anticipated (planned) results of the strikes inflicted on the enemy primarily with nuclear weapons and aircraft. In accordance with the probable length of time the enemy troops will be delayed as a result of such strikes, tank groups will move in those directions and along those regions from where they can inflict a strike on the enemy so that he cannot bring his troops to a state of combat

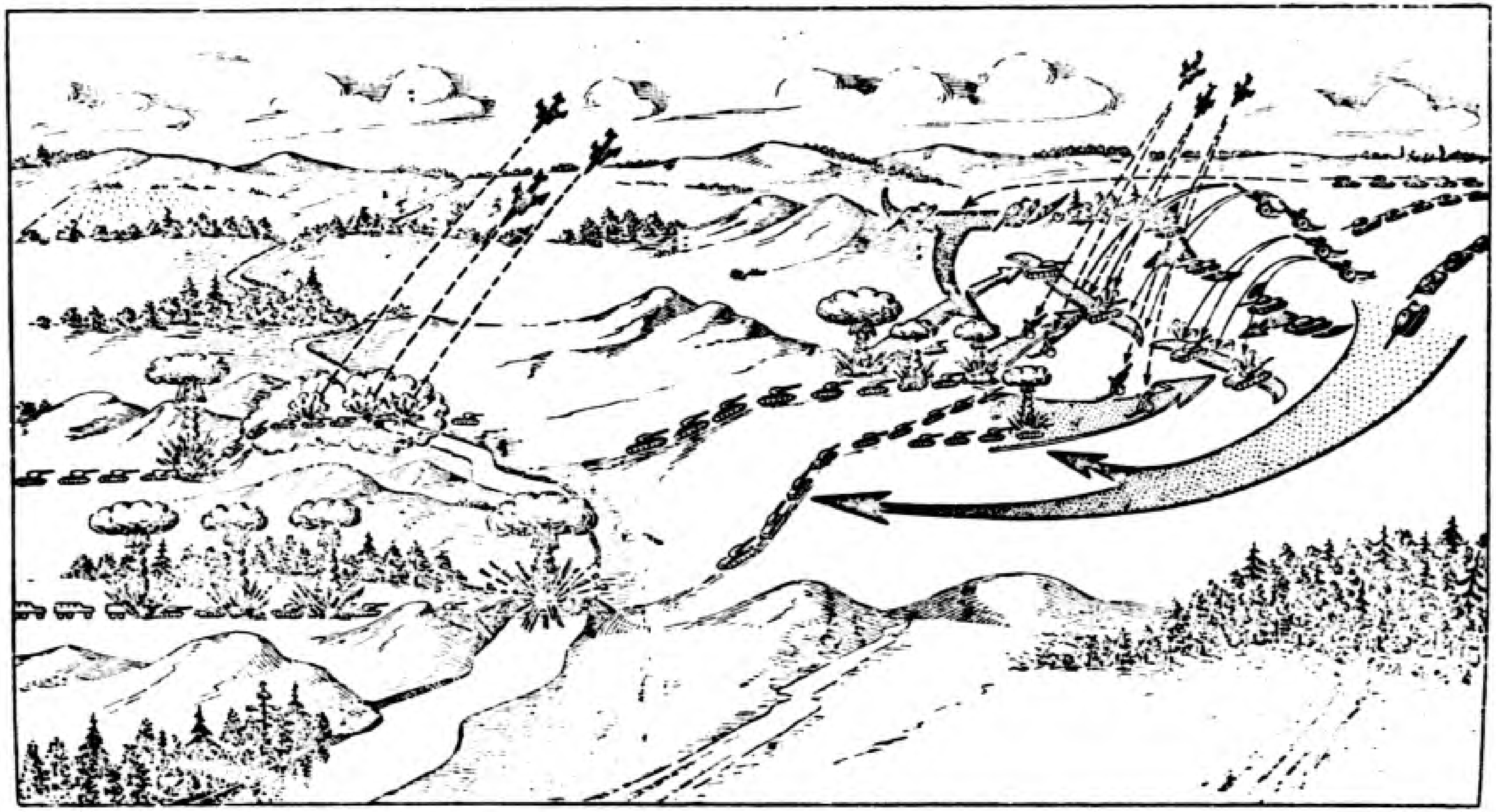


Fig. 124.--Inflicting damage on the enemy with fire in encounter combat (on distant approaches and with his deployment).

readiness. It is assumed under these conditions that the time and sequence of troops movements basically will be adapted to the times and possibilities for inflicting destruction on the enemy with nuclear weapons. Essentially, this requirement will determine the form of the maneuver and selection of the direction for the main strike.

Without doubt, during this time strikes will be made by both sides. Obviously, superiority over the enemy in such situations will be achieved by rapidly reducing their combat-ready troops, and rapidly approaching the enemy's remaining troops which retain their combat preparedness and directly proceeding to the attack while the enemy is still putting its troops in order.

Thus the main factor determining the time and order of proceeding to the attack with tanks in encounter combat and consequently the sequence of their forward movement and deployment, will obviously be the use of nuclear weapons. Of course, the troop operations and the time of inflicting nuclear strikes on the enemy are interrelated, but the use of nuclear weapons will play an important role. In the series of occurrences leading up to entry into combat, the main enemy tank forces may sustain greater losses from attacks by nuclear weapons than is necessary for their complete defeat.

It is pointed out in the foreign military press that under conditions when nuclear weapons are used, the tanks will proceed to the attack directly following fire and nuclear strikes in the directions of mass application of nuclear weapons and the most high-powered aircraft strikes.

In the course of attack development in encounter combat, the tanks will precipitously move in on the combat ranks of the enemy, break them up and destroy them. Moreover, the main forces will not begin to be delayed by the individual focal points of resistance, but will move to the depths precipitously and without stopping.

The main attacking forces will protect themselves from strikes of weak enemy troop concentrations partially by their own power.

It is thought that in the course of encounter combat, the strikes on the main enemy groupings will be continuously increasing. This will probably be accomplished by completing maneuvers of attacking troops and the entry of fresh forces into combat. In some cases, this will take place by regrouping parts of forces and facilities from less active directions or from those directions where only unimportant success has been achieved, into the direction where success is indicated or where, with the introduction of supplementary forces, enemy resistance may be broken at once. In both cases, the goal will be to complete only a maneuver with firing, guaranteeing a good long-range effect of contemporary firing facilities. Such a maneuver makes it possible to break enemy resistance in the selected direction and to develop a precipitous attack in that direction.

Regrouping forces and facilities in encounter combat is a very complex business. However, a high degree of maneuverability in the case of tanks permits them to accomplish regrouping rapidly and, what is most important, secretly and unexpectedly for the enemy. The main thing in the course of these regroupings is maintaining the interaction with units of other types of troops and also with antiaircraft facilities.

It is pointed out that in the course of encounter combat, the situation may often change; the situation of each side may suddenly go from advantageous to disadvantageous and back again. The ability of the commanders at all levels to anticipate the character of the possible changes in the situation plays an important role here. At the time the situation may turn out to be disadvantageous, it is necessary to provide for building up forces with reserves or conducting planned and prepared maneuvers of forces, facilities and fire.

The most essential change in the situation may take place when the enemy, with a maximum exertion of his own forces and introduction into the battle of all his available reserves, attempts to achieve a decisive success and change the course of combat to his own benefit. Under these conditions, the intelligent use and entry into combat of his own available reserves is especially important. It is recommended that special attention be paid to deciding the moment the basic forces will enter into combat as the main means of changing the course of the entire battle to one's own benefit.

It is acknowledged that it is important for successful introduction of reserves into battle and their achievement of important results in encounter combat that, on one hand, their introduction be well-timed, and on the other hand, execution of the attacking measures with the view to cutting off the entry into battle of enemy reserves; such a measures may be cutting them off with nuclear strikes, aircraft, artillery fire, or troop operations penetrating into the depths.

The timely introduction into combat of reserves may fundamentally change the course of the battle. Thus the reserves may be introduced at the decisive moment, at the time of maximum stress of the battle. Delay in introducing reserves into the battle may lead to their collapse, and sometimes to loss of the initiative in encounter combat one of the most important conditions for achieving victory.

Introduction of reserves into combat is most effective if it is done unexpectedly by the enemy, on the flank of its main force or from the rear. On the occasion of introducing reserves into battle, as well as up to this time, special attention must be paid to defending the flanks. The enemy may use the situation to guarantee introduction of his own reserves into combat, not only from the front but also from the flanks.

With the introduction of reserves into combat, all forces and facilities of the attacking side must attain maximum exertion, but at the same time a part of the force, especially on the threatened side, must be ready to repulse the enemy attempt by inflicting a sudden strike.

Completing destruction of resisting enemy remnants and groups, which are less powerful than the attacking troops, is entrusted to subdivisions of the first as well as the second echelons or reserves with available firing facilities supporting their strikes.

Under similar conditions in encounter combat the operations of units or sections may assume a focus character; under such conditions, a great role will be played by daring, initiative and the boldness of personnel in isolated sections, units. Notwithstanding this, part of the forces and facilities remain in a very difficult situation, cut off from the remaining forces. The stability, persistance and decisiveness of operations in such situations guarantees the successful completion of the battle even in such a complex situation. So, for example, in the Great Patrician War, in the battle of our 10 TK with 17 td of the German-fascist army in January 1943, the 61st chief tank brigade at the rear of the enemy found itself cut off from remaining forces of the corps. However, being surrounded, it heroically wrestled with the enemy and with a transition of main forces of the tank corps to the attack, it bravely inflicted a blow on the enemy from the rear and brought about his defeat.

Thus, the operations of armored forces in encounter combat are involved and different and have a many-sided character. Their high combat capability, maneuverability, striking force and viability allow them to successfully fulfill complex tasks under any conditions while interacting with other troops and to this extent to defeat the enemy in encounter combat.

In the book "Combat Strategy", the operational characteristics of such large tank groups is given as well as tank armies: they will operate in the first echelon of the attacking troops in the main directions; their main intent will be precipitous, continuous forward movement over a wide area; the attack of such groups is expeditiously carried on in a series of directions at the same time with the purpose of dividing up the resisting enemy groups and destroying their parts.

This means that very often armored forces, moving into the depths, will encounter the enemy as the enemy moves toward them.

It is pointed out in the foreign military press that the echeloning of forces and facilities and the preparedness of troops for maneuvers is particularly important. In their opinion, echeloning must be deeper, and the preparedness for maneuvering the forces and facilities must be greater, the less clear the situation and the greater the threat of enemy strikes from the flanks.

Conducting encounter combat at night gives support to its characteristic features. Encounter combat may often take place at night due to the continuous nature of combat operations in contemporary warfare. The use of night equipment in this case makes it possible to carry out this kind of combat successfully at night as well as in the daytime. On the other hand, the night permits more possibilities for completing secret maneuvers; when moving forward on the battlefield, when deploying during battle. Under nighttime conditions, it is possible to avoid large losses from conventional destructive facilities. Sudden operations of small forces may be especially successful at night by inflicting strikes on the enemy from the flanks or from the rear. The difficulty in determining the true quantity of forces and facilities taking part in the attack permits small forces to achieve decisive success in combat with powerful and superior forces. It is also pointed out that these same factors turn out to have an influence on enemy operations. Naturally, reconnaissance, guarding the flanks and the rear must be done carefully in night operations.

In night encounter combat, the accurate completion of plans is important as well as more careful regulation to guarantee the movement of troops in directions designated from them and onto deployment lines, and also takes more time for deployment.

Section 5

The Basic Principles of Victory

1. Attack--The Basic Means of Achieving Victory

It is pointed out in the foreign press that, according to their character, goals and combat means, troop combat operations are classified into two basic types: attack and defense. In the course of carrying them out, troops must often conduct other types of operations: encounter combat, pursuit, repulsing counterattacks and counterblows, rest, etc. However, attack and defense are the basic ones on which the combat activities of troops are founded.

This results from the fact that attack and defense are two interrelated activities, the one originating from the other, two sides of one process--armed combat. They must not exist isolated from each other. Moreover, elements of attack as well as of defense are always present in each of these types of operations.

However, admitting the necessity of using different types and forms of armed combat, we are guided by the following principle: only decisive attack with the use of high-power nuclear strikes, inflicted by different means, and all the combat capabilities of the troops will achieve complete victory over the enemy. Thus the basic type of combat activity of land troops, among them armored forces, is to attack with striking forces.

Two basic and rather characteristic means of tank operations are used in modern attack combat: the inflicting of strikes with weapons and advancing tanks forward. Moreover, the main operational means of attack is the strike, because only with the use of all types of weapons is it possible to inflict heavy losses on the enemy and cut off his ability to offer resistance. The forward advancement of tanks is used primarily so that troops can occupy a more advantageous position to inflict blows on the enemy, destroy him, take possession of territory in case the enemy withdraws or loses his combat capability as a result of attack strikes, and also to deprive him of the chance to use his own weapons.

It is thought that modern attack operations are characterized by a series of special features, somewhat longer than the former one, decisive goals and a sharp increase in scope, the use of nuclear weapons as the decisive and chief means for destroying the enemy and reaching the set goal. Armored forces will join forces with motor-infantry, aircarft, air drops and other means and facilities participating in the battle. It is assumed that the blows will be inflicted deeply and precipitously on the entire disposition of enemy forces. Obviously, combat operations will not be conducted on a continuous front, but in separate directions, sometimes isolated from each other, and at the same time at different depths. It is thought that for modern operations the tanks will be characterized by mass application of forces and facilities in decisive directions and the wide use of maneuvers. The combat will be characterized by great intensity and rapidity. The tanks may use various means to destroy the enemy and will rapidly convert from one operational means to another. The situation in the battle will change sharply and rapidly. Both sides will strive for the element of surprise in its operations and will constantly struggle for the initiative. The battle may be conducted with a broad outlay of material means; in addition there is the possibility of massive loss of personnel and combat technicians. It will be necessary to keep the tanks in constant preparedness to fulfill any tasks which may arise in this or in any situation.

The resolution of the goals and the wide range of the combat operations are based on the possibility of rapidly destroying the enemy with the mass application of nuclear weapons, on fuller use of the increasing distance of destructive facilities, on maneuverability of tank units, on their artful guidance and high combat morale of military personnel.

It is pointed out that the use of nuclear weapons as a decisive and as the main means of destroying the enemy will doubtlessly be a characteristic feature of attack operations and a basic, determining factor in the successful resolution of problems and reaching goals in a short time. Nuclear weapons and the basic means of delivering it to the target is the rocket, combining within itself great power, a wide range of activity, and low vulnerability, making it possible in a very short time to solve even the most complex problems.

The combination of tank forces with the motorized infantry, aviation, air drops and other forces and facilities participating in the battle guarantees the success of the attack. Although the decisive role in combat operations belong to nuclear weapons, victory may be achieved only with joint forces of all types of troops in close interaction with other types of armored forces, cooperating with tanks.

Inflicting deep and precipitous strikes with tanks at every depth of enemy disposition, based on the use of nuclear weapons and the highly maneuvering operations of tanks in interaction with other troops participating in the battle, will be one of the conditions for rapidly reaching decisive targets and the large spatial scope of the attack. Destruction of basic groups of enemy forces and facilities at all depths with strikes of rocket forces and planes will open a greater possibility for the successful operations of motorized infantry, deep, precipitous blows of tanks and air drops with the purpose of rapidly defeating the enemy, taking possession of his most important regions and objects and reaching the targets with attack operations in a short period of time. In connection with this, when conducting attack operations, it is assumed that it will be necessary to determine the direction of the main strike and other strikes representing the combination of nuclear blows and precipitous attack of infantry units, especially tank units, in all directions.

It is thought that the direction of the main strike will be selected with consideration of the most expedient use of nuclear weapons and the utilization of the results of nuclear strikes with attacking tanks to quickly destroy the basic enemy groups. It must permit precipitous forward movement of attacking troops over the entire depth, their rapid entry into that region subjected to nuclear weapons to achieve defeat of the enemy and to seize his important regions and objects.

It is generally known that a superiority in forces and facilities is created and constantly maintained in the direction of the main strike, especially with nuclear weapons. This is achieved with the concentration of basic rocket and aviation forces to destroy his means for nuclear attack and to destroy basic enemy groups, with the creation of striking forces, composed preferably of tanks, well-timed accumulation of forces by conducting wide maneuvers of tanks and other facilities in the course of attack operations.

It is pointed out that guiding the attack operations in the absence of a continuous front, in separate directions and at the same time at different depths will be characteristic for tank attacks. The character of such tank operations will depend on the possibility of destroying the enemy with nuclear weapons, making it possible to put out of commission not only his individual units, but his large groups, as well as a high degree of tank maneuverability.

It is pointed out that the principle of concentrating tank forces in decisive directions is just as important for modern combat operations. However, the conditions and the order of tank concentrations will essentially differ from similar operations in the past. Under the new conditions, there is no necessity for dense formations of troops. This is explained by the decisive importance combat activities acquire for achieving victory, primarily the massive use of nuclear weapons and other destructive means in basic directions for the destruction of main enemy groupings and important enemy objects as well as maneuvers and precipitous operations of tanks following behind these strikes for maximum dispersion of heavy strikes of troop groups. It is pointed out that tight formations and heavy accumulations of troops is not expedient. Forces and facilities may decentralize as much as is permitted for successful conduct of combat operations and above all in order to create favorable conditions for their rapid use in decisive directions and on main objectives.

A high degree of maneuverability for tanks is now its characteristic feature in contemporary attack. Highly maneuvering operations of tanks is based on well-timed and full use of the forces and long-range features of rocket-nuclear weapons and conventional destructive means, as well as on a high degree of maneuverability of rocket subdivisions and aviation, anti-aircraft troops and other forces and means conducting the attack.

It is assumed that highly-maneuvering, dynamic operations guarantee the continuous nature and high attack speed. They will be more fully manifested in operations of tanks in motion.

It must be kept in mind that the combat operations of tanks will be conducted uninterruptedly, in the day time and at night.

The short duration of battles is predetermined by the possibility of using modern combat means, chiefly nuclear weapons, almost instantaneously inflicting massive destruction on the enemy and putting out of commission all combat rank elements and important objects, and also by the capability of infantry troops as a whole, especially their striking force, tanks, utilizing the results of nuclear strikes in a short period of time and achieving victory over resisting enemy forces.

Modern tank attack operations will be characterized by an increased element of surprise and struggle for initiative in all types of combat operations. Contemporary means of armed struggle, and especially rocket-nuclear weapons, not only make it possible to inflict decisive destruction on the enemy, but increases the possibility of using sudden troop operations. Tanks, using a large destructive force and the element of surprise with modern destructive means, make it possible to achieve destruction of the enemy and inflict great losses on him in a short period of time, rapidly changing the relationship of forces and facilities to his own advantage, paralyzing the will of the enemy, exhausting his ability to offer organized resistance and thus seizing and maintaining the initiative.

Successful conduct of modern attack operations and achieving the intended toal in a short period of time is unthinkable without organized, continuous and resolute command of troops. To what extent decisions are taken and tasks are presented to the troops, in many cases decides the outcome of the struggle to seize the initiative and achieve victory. In connection with this, leadership of combat operations requires all degrees of exceptionally high operational capability, fast reaction to sudden changes in conditions, making simultaneous decisions, bringing up problems to them and constantly checking up on their activities.

2. Methods for Proceeding to the Attack

Foreign combat specialists believe that the methods for tanks to proceed to the attack depend on the conditions, and each concrete situation will determine, from one side, the degree of enemy suppression and the character of the activities of his troops, and from the other side, the condition and the position of one's own tanks at the moment of proceeding to the attack.

Judging from the foreign military press it can be said that the methods for troops, especially for armored forces, to proceed to the attack may be many in number. However, the most expedient method seems to be the one which guarantees sudden and massive destruction of enemy resistance with fire, and simultaneous use of the results of tank fire for the purpose of precipitous penetration into the depths of enemy deployment.

In the opinion of foreign authors, the methods for proceeding to the attack must first guarantee well-timed use of the results of nuclear strikes inflicted on the enemy, decisive defeat of resisting enemy forces a short time after the start of combat operations. They also must facilitate the creation of conditions favorable for precipitous forward movement of tanks into the depths, destruction of rocket-nuclear facilities, and of approaching enemy reserves.

Under modern conditions, obviously both sides will not always be able to take an advantageous position for a direct attack on the enemy. Thus the attacking side will provide for destruction of the enemy during forward movement into the region of combat operations and will anticipate him in deployment and in organized transition to combat operations. Obviously, all this will require not only intelligent and decisive suppression of the enemy with fire, but the use of all methods for tanks to proceed to the attack, which would guarantee suddenness of operations, well-timed use of the results of one's own nuclear strikes, and seizure of the more advantageous position with relation to resisting enemy forces. Obviously, these requirement to a large measure correspond with the transition of tank units to the attack after nuclear strikes are inflicted. Moreover, the tanks will proceed to the attack in all directions in which the enemy has been damaged by nuclear strikes, and where their firing facilities are maximum. The transition of tanks to the attack in all directions guarantees their rapid departure from the region where basic enemy nuclear attack facilities are deployed and guarantees their precipitous surge into his rear area.

It must be kept in mind that the possibility of inflicting damaging fire on the enemy at the start of combat operations sometimes makes it possible to guarantee situations for tanks to proceed to the attack which would not be possible if they were deployed in combat ranks. In order to proceed to the attack, the tanks, in columns without deployment into combat ranks, will of course make wide use of breaks and disruptions between enemy troops involved in the operation.

If for any reason reliable destruction of the enemy turns out to be impossible for one reason or another in certain directions, tanks will obviously proceed to the attack deployed in combat ranks.

The use of such principles of tank operation makes it possible to quickly seize and keep the initiative right from the beginning of combat operations. Tanks may cut off enemy attack in a given direction; they may destroy or seize his bases, disrupt operations in the rear; they may destroy enemy reserves interacting with rocket troops, aircraft, motorized troops and air drops; they may disrupt deployment of enemy forces and may guarantee that all the attacking troops reach their target in a short period of time.

All this requires from tanks those methods of proceeding to the attack which would permit undelayed continuous forward movement at maximum speeds right from the start of combat operations.

Under conditions where the enemy has been suppressed with sufficient reliability and there turns out to be no great amount of resistance, it would hardly be expedient to spent time in deployment of tanks into combat ranks. Under these considerations, the tanks which are able to will successfully attack in columns or in pre-combat ranks.

It is pointed out in the foreign military press that in those situations when the enemy, although suppressed in large measure, still offers resistance and thus poses a threat to the attacking troops, in order to localize this threat, part of the first tank echelons will advantageously be deployed in combat ranks, leading the second echelon in columns or in deployed formations.

In conditions where the resisting enemy has not been suppressed and offers considerable opposition, the attacking tanks will be forced to deploy into combat ranks and attack the enemy after carrying out firing preparations.

It is thought that in a rocket-nuclear war, tanks will proceed to the attack using the following methods:

-after nuclear strikes in columns or in pre-combat ranks without deploying their basic groups in combat ranks;

-after nuclear strikes with a combined method, when some part of the tanks proceed to the attack in columns or in precombat ranks and another part deploys in order to proceed to the attack in combat ranks;

-after nuclear strikes with deployment of basic tank groups in combat ranks and carrying out firing preparedness using conventional destructive facilities.

When tanks proceed to the attack in columns or in pre-combat ranks, they have the possibility of utilizing the results of nuclear strikes, precipitously moving short distances into the depth, conducting fire from the tanks (directly from columns) and only in case of need assuming combat ranks to destroy remaining focal points of resistance.

Transition of tanks to the attack with deployment of main forces in combat ranks will be necessary in the case of insufficient destruction of the resisting enemy with nuclear weapons or when only conventional combat means are used.

3. Methods for Conducting an Attack

In various military literature it is pointed out that methods for conducting attack operations are determined by ideas of combat plans and a combination of methods used to fulfill tasks to destroy the enemy and reach attack objectives in a short period of time.

In selecting the methods for leading the attack, evaluate the strong and weak sides of the enemy and take into account the real combat capabilities of his troops. As a result of such an analysis, those methods will be selected which to a large degree will guarantee effective application of nuclear weapons and precipitous attack to achieve the goals of combat operations in a short period of time.

Under contemporary conditions, according to the decisive circumstances when selecting one means or another for conducting the combat operations, we will obviously assume the possibility for rapid destruction of the enemy's nuclear attack facilities.

Different methods of leading attack operations may be taken, depending on the situation. Moreover, wide use will be made of disruptions and weak protection in the directions of enemy combat ranks, bypassing and seizure will be completed to discharge tanks onto the flanks and rear of the enemy basic forces in order to destroy them.

It is noted that for tanks, wider use can be found for those methods in which the basic plan is to inflict strikes in a few short directions in order to disperse (break down) the main forces and other enemy groups and destroy them individually. This method makes it possible to destroy the enemy quickly, undertake operations and take possession of regions and objects with relation to problems and the purpose of the attack.

Dispersing (breaking down) enemy groups and destroying them separately creates the most favorable conditions for rapidly disrupting enemy stability, developing an attack over a wide range and decentralized formation of attacking tanks. In a given situation, the attention of the enemy will be diverted and its strength will be weakened; it will be difficult for him to select objects for inflicting nuclear strikes and for his own troop operations.

In addition, under determined conditions, on the basis of the plan, the tank operations may be to inflict strikes from convergent directions in order to surround enemy groups and destroy them at the same time. However, it is thought that in order to counteract his being surrounded, the enemy may use nuclear weapons utilizing the high maneuvering capabilities of his own troops and also diverting basic forces over large areas. Under such conditions, the operations of surrounding and destroying the enemy may weld considerable forces and deprive the tanks of the chance to develop an attack in the depths in a short period of time.

Obviously, in order to rapidly surround and destroy the enemy, nuclear weapons will first destroy his nuclear facilities and will surprise troops which are situated in directions of tank attack, completing surrounding maneuvers. Together with this, strikes will be inflicted on the enemy with nuclear and conventional means and attacking operations will be conducted from the front against surrounded enemy groups in order to break them up and destroy them in parts.

Any method of destroying the enemy in an attack would probably involve their decisive defeat with nuclear strikes and precipitous and deep forward movement of tanks behind them; air drops will be made behind the enemy whenever this is possible.

It must be kept in mind that when conducting an attack, tanks must often struggle with enemy reserve groups. Moreover, it is important to correctly determine the means for defeating the enemy reserves, guaranteeing their decisive defeat and creating favorable conditions for additional attack developments.

Judging by the foreign military press, under modern conditions many methods may be used to destroy the enemy reserves. Depending on the conditions in the course of attack operations, the enemy reserves may be destroyed simultaneously or in succession in one of several directions, then in the other direction.

It is thought that for tanks, the basic operational method against enemy reserves in the course of an attack is to inflict massive nuclear strikes on them in conjunction with precipitous tank operations, destroying these reserves.

It is pointed out that defeat of enemy reserves may be accomplished either directly following the nuclear strikes or in the course of an attack, when part of the tanks are directed forward into regions of the nuclear blows inflicted in the rear parts, and part of them will complete destruction of the remaining enemy with the aid of the motorized infantry. Moreover, depending on the results of the nuclear strikes, complete destruction of the enemy reserves may be achieved with the use of nuclear weapons or with only conventional means.

Troops operations may be different to complete destruction of the enemy, depending on the degree of his destruction with nuclear weapons. In the case of a high degree of enemy destruction as a result of nuclear strikes, his complete destruction may be achieved with a small number of forces, while the main forces are developing an attack in the rear. In the case of a small degree of enemy destruction with nuclear strikes, his defeat may be achieved with part of the forces, while the other part may be developing an attack in the depths.

4. Pursuit

It is generally known that pursuit takes the form of an attack operation applied by one side when the troops of the other side withdraw. In pursuit, more than in any kind of combat operation, the tanks can make use of one of their basic characteristics, maneuverability.

During the Second World War, pursuit was basically entrusted to mobile units. It was conducted on a tactical as well as on an operational scale.

The foreign military press asserts that under modern conditions the role, character and amplitude of pursuit has essentially changed. Organizing and performing pursuit must be done in a new way, applicable to the conditions for conducting combat operations in a nuclear war.

It is thought that, unlike the past, under modern conditions a situation is not excluded when, as a result of massive use of nuclear weapons and other destructive facilities, decisive tank operations, motorized infantry, aircraft and air drops, the basic forces of the enemy will probe to be almost completely destroyed. Moreover, organized groups of his troops will not begin to withdraw, but its remnants will retreat separately, not able to greatly influence the course of combat operations. Under these conditions, attacking tanks will, in fact, combine pursuit of the enemy with precipitous forward movement into his territory, making use of the results of nuclear strikes.

Analyzing the conditions for executing modern attack operations and the character of such operations, we may come to the conclusion that their pursuit will carry more specific weight than in the past. In cases of the use of nuclear weapons by both warring sides, this will depend on whether each of them has a greater chance than in the past to conduct decisive attack operations in a short period of time, over a broad area and with precipitous strikes forces enemy troops to withdraw. The defenders may use maneuvers for the purpose of premeditated retreat more often that in the past, conducting his troops out of the way of strikes by attacking troops.

It is pointed out in the foreign military press that in the last war, aviation and artillery preparation guaranteed suppression of the enemy defenses in conducting an attack and guaranteed destruction of its system within the limits of the tactical zone, and guaranteed creation of favorable conditions for a breakthrough. Now a massive nuclear strike can lead to a breakthrough of the entire depth of enemy defenses. And the more effective this strike, the less able the defenders are to struggle for a given defensive line. Consequently, pursuit may now be started even with the beginning of attack operations. In the course of an attack, the inflicting of nuclear strikes and precipitous forward movement of troops by one side will obviously force the other side to withdraw his troops. This is more the case now than in the past.

Thus, in many cases, pursuit may be the basic content in the development of an attack.

Wide use of nuclear weapons and, consequently, principal changes in goals and the character of modern attack operations may not have an influence on the goals or character of pursuit, or its essential nature. If before pursuit fundamentally consisted in the operationsof land troops when supported from the air, then it now includes a new, important element, inflicting nuclear strikes with nuclear facilities on remaining enemy troops and reserves. Air drop operations are now an inherent component part of pursuit, and in maratime directions, shore landings with the participation of tanks.

Along with this, the importance of pursuit has steadily increased. Under modern conditions, the presence of nuclear weapons and other destructive means makes it possible to inflict decisive destruction on the enemy and complete his defeat in the course of pursuit. Consequently, the purpose of pursuit may include not only the creation of prerequisites for final defeat of the remaining enemy, but the defeat itself.

Already in past wars, rather large and maneuverable groups, for example tank units, attempted to use pursuit so as not to get involved in lingering battles with surviving enemy troops and move to a line, the seizure of which was the ultimate object of the attack. But this was difficult to achieve; the pursuit troops often got involved in combat with remaining enemy forces.

Under present conditions, tanks have a much greater chance not to get involved in a drawn-out battle. Thus, now the purpose of pursuit may be not only to forestall the remaining enemy troops, but rapid advancement of tanks to regions and objectives, the seizure of which constituted the ultimate purpose of the attack.

An analysis of the foreign military press shows that pursuit may be instituted and carried out in two basic situations: first, under constraint and, second, in the case of premeditated withdrawal of the enemy. Constrained pursuit of remaining enemy forces will be instituted and carried out under very different situations. The defenders may be forced to begin retreat already as a result of the effective application of nuclear weapons by the attacking side, i.e. right from the very start of attack operations.

Making the transition to pursuit is not included during the development of an attack with the successful application of nuclear weapons when enemy reserves move up from the rear, with successful disruption of hig counterattack and counterstrike if his encounter combat fails. Pursuit, begun as a result of the successful outcome of encounter combat, will become more characteristic, since the encounter combat itself will take place more often than in the past.

Thus, analyzing what has been said in the foreign military press by combat specialists it is possible to say that pursuit can begin in very different situations. The conditions for carrying out pursuit will be different depending on the physical-geographical and economic features of a given direction, the makeup and character of remaining enemy troop operations and the possibility of using nuclear weapons. In their opinion, the presence of a sufficient number of tanks, nuclear weapons and delivery means, motorized and mechanized infantry, a sufficient number of armored vehicles, the use of air drops and the possibility of transferring troops with their equipment by air, the presence of reconnaissance facilities, all this makes it possible to conduct pursuit with definite goals in mind, over a wide front and more rapidly than in the past.

The problem of pursuit time is especially important. Since a large part of attack operations may consist of pursuit, the general time for conducting it will in large measure depend on pursuit time.

A short pursuit time will make it possible to disrupt the rest time of the enemy and capture them before they have time to prepare defensive lines, to regroup reserves and prepare and counterattack and, consequently, will facilitate achievement of the final goal in the shortest period of time--defeat of the enemy. This circumstance, a high pursuit speed, which makes inflicting nuclear blows very difficult for the enemy, is very important because frequent changes are required in rocket position, reconnaissance is made more difficult as is commanding the troops.

Thus, under modern conditions, pursuit acquires an important character in the scheme of things. However, it would not be right to ignore the increasing chances of the other side.

The retreating enemy may also use nuclear weapons and other destructive means to inflict blows on pursuing troops from the depths of his own position. In addition, for the purpose of delaying the pursuers, the retreating troops may create a wide zone of destruction in the path of their movement, flooding and radioactive contamination of the terrain.

It must be pointed out that a very large number of different enemy facilities, and a sharp increase in their effectiveness, as well as widespread use of various engineering obstacles and destruction by the enemy during retreat, seriously complicate tank operations during pursuit. In addition, the retreating troops may use well-timed means of reconnaissance, which would make it difficult for the pursuing tanks to achieve the element of surprise. Strong counterattacks and inflicting counterstrikes on pursuing tanks by retreating and approaching troops should also not be ruled out, especially when the retreat is carried out in a premeditated manner.

All this permits us to maintain that in the performance of contemporary tank operations, pursuit will be conducted under more complicated conditions than in past wars.

One of the special features of contemporary attack operations is diversity and rapidity in the absence of a continuous front. This is characteristic for pursuit.

It is pointed out in the foreign literature that the retreat of all resisting enemy troops is possible with the start or in the course of attack, and pursuit of them is possible with all available tanks. In other situations, only part of the enemy forces may retreat, then the remaining ones conduct other operations; for example, defensive operations, counterattack and counterstrikes. In accordance with this, pursuit will be conducted only with part of the tanks, the remaining tanks will attack the defending enemy or repel their counterstrike. In other directions, tanks will keep up the pursuit, in others they will have to alternate pursuit with other kinds of operations. Moreover, all these operations may be carried out simultaneously at a different depth, among them finding tank divisions which are cut off from the remaining troops.

It must be assumed that under contemporary conditions, those tank subdivisions may operate during cut-off which attack in directions where the enemy has been subjected to nuclear strikes, as a result of which favorable conditions have been created for maneuvers and rapid forward movement into the depths.

According to the experience of past wars, two methods of pursuit are known: frontal and parallel. Parallel pursuit is most frequently used with forward-moving troops, armored forces and mechanized troops. The main forces of the attacking troops, utilizing the result of the operations of forward-moving troops, push forward behind them and carry out frontal pursuit, although they sometimes withdraw part of the forces for parallel pursuit. Experience has shown that only one frontal pursuit can be carried out with decisive results, since it leads to "expulsion" and not to defeat of the enemy. It has been shown that parallel pursuit, in which the attacking tanks overtake the retreating enemy, using parallel march routes, permits them to penetrate the depths more rapidly, cut off the retreat routes of the main enemy forces, isolate them from their reserves, break them up into parts and create favorable conditions for achieving their defeat. It is pointed out that for pursuing tanks it is important not only to defeat retreating enemy forces, but to take possession of regions and objectives as quickly as possible, which are the ultimate objects of the attack. All this is more possible as a result of parellel pursuit.

Thus, it is believed abroad that under contemporary conditions parallel pursuit is the most effective, basic form of tank operation. However, in order for parallel pursuit to be effective, it is very important to dislodge the retreating enemy from the front. That is why, in their opinion, under contemporary conditions, parallel pursuit will be combined with frontal pursuit. With this it is necessary to take into account that nuclear weapons and other contemporary means of combat permit units and sections conducting pursuit from the front to freely surmount resistance of enemy units under cover, defeat their retreating troops, force their deployment and slow down the pace of their retreat. Moreover, frontal pursuit will not lead to a frontal strikes. In the course of its pursuit, troops will apply maneuvers widely, carry out flank strikes interacting with troops conducting parallel pursuit, surround the enemy and destroy him.

It is noted that forward brigades will be widely used in pursuit, capable of operating independently when cut off from remaining forces and will be able to utilize the results of nuclear strikes more quickly than main forces, advancing to lines and into regions having great tactical and sometimes operational importance, and seizing them.

The most important task for forward-moving sections will be their entry into regions of enemy rocket and airfield positions and seizing or destroying its lanuching equipment and aircraft.

It is maintained that forward brigades often will be sent out from troops conducting parallel pursuit because in this case favorable conditions are created for their entry into the rear of remaining enemy forces at great speed and at great depth.

It is assumed that wide use will be made of air drops for different purposes in the course of pursuit in order to disrupt planned enemy retreats, destroy their nuclear weapons capabilities, detain forward-moving reserves, facilitate their own troops in surmounting defended enemy lines, water obstacles, regions of difficult accessibility, etc. Moreover, evidently some drops will be made simultaneously, some in succession, according to the number of pursuit tanks. If necessary, the air drop forces may increase in size as the forward brigades more forward to them precipitously, and then front tank echelons.

It is noted that the element of surprise is very important in successful pursuit. Under contemporary conditions, each side has great possibilities of quickly taking up defense during retreat, re-establishing the combat capabilities of his troops, inflicting great losses and even converting to active attack operations after inflicting nuclear strikes on pursuing troops. In the course of pursuit it is very important not to give the retreating troops any rest. Persistent, continuous pursuit demoralizes retreating troops and facilitates their defeat.

In connection with uninterrupted pursuit at high speed, over a wide range, during the day and at night, under any conditions the problem often arises of accumulated effect on the enemy. Primarily, a cumulative effect will be achieved on the enemy by the use of nuclear weapons and inflicting air strikes.

It is emphasized that over a wide area and at high pursuit speeds, it is very difficult to command the pursuing troops. In order to fulfill this requirement, it is very important to achieve high maneuverability of command points. Radio is the basic method for commanding in the course of pursuit; in addition, mobile means of communication may be widely used, especially airplanes and helicopters.

5. Conducting Combat Operations on Water Boundaries

It is pointed out in the foreign press that in the course of development of tank attacks, often operating when they are cut off, it is necessary to surmount enemy resistance on many water obstacles. Conducting combat operations on water boundaries is given great importance in foreign armies. Water obstacles will be used primarily by defending forces as an advantageous boundary at which the opportunity is presented them to force the attackers to regroup and destroy them with the extensive use of nuclear weapons. In order to prevent this, the attacking side will attempt to destroy the enemy at a water obstacle primarily by inflicing rocket-nuclear strikes and with tank operations without reducing the rate of attack.

Basic situations facilitating defeat of the enemy at water obstacles and forcing their tanks to move include the following: well-timed organization of reconnaissance of the enemy and the terrain near it around the water obstacle; destroying their means of nuclear attack and inflicting defeat on enemy forces at water obstacles; forestalling the enemy from seizing important regions, objects and crossing over the water obstacle; well-timed forward movement of fording facilities to the water obstacle and their intelligent use; rapidly surmounting water obstacles with all accessible tanks and continuous development of attacks on the opposite shore.

As is pointed out in the foreign press, successful defeat of the enemy at water obstacles and forcing their tanks to move will primarily be determined by the firing capabilities of the tanks themselves, the forced obstacle and the effectiveness of reconnaissance operations. It is thought that in foreseeing combat operations at a water obstacle, the basic reconnaissance forces will be directed toward exposing rocket attack facilities, enemy troop groupings and the character of their operations at the water obstacle, the presence of nuclear land mines on the river bottom, and bridges laid along river bottoms to ford tanks.

The operational methods of tank units in destroying the enemy at a water barrier will largely depend on their composition and the operational methods on the original and opposite-lying shores.

The most important water obstacles will usually be prepared for defense beforehand and will be occupied by reserves moving forward from the rear, and by retreating troops as attacking troops move toward them.

In making the transition to defense at a water obstacle, the enemy may have the least requirement for forces and facilities right at the shore of the water obstacle; the basic forces and facilities are in the rear, and primarily tanks, in order to conduct counterattack for the purpose of destroying the main attacking forces after inflicting nuclear strikes.

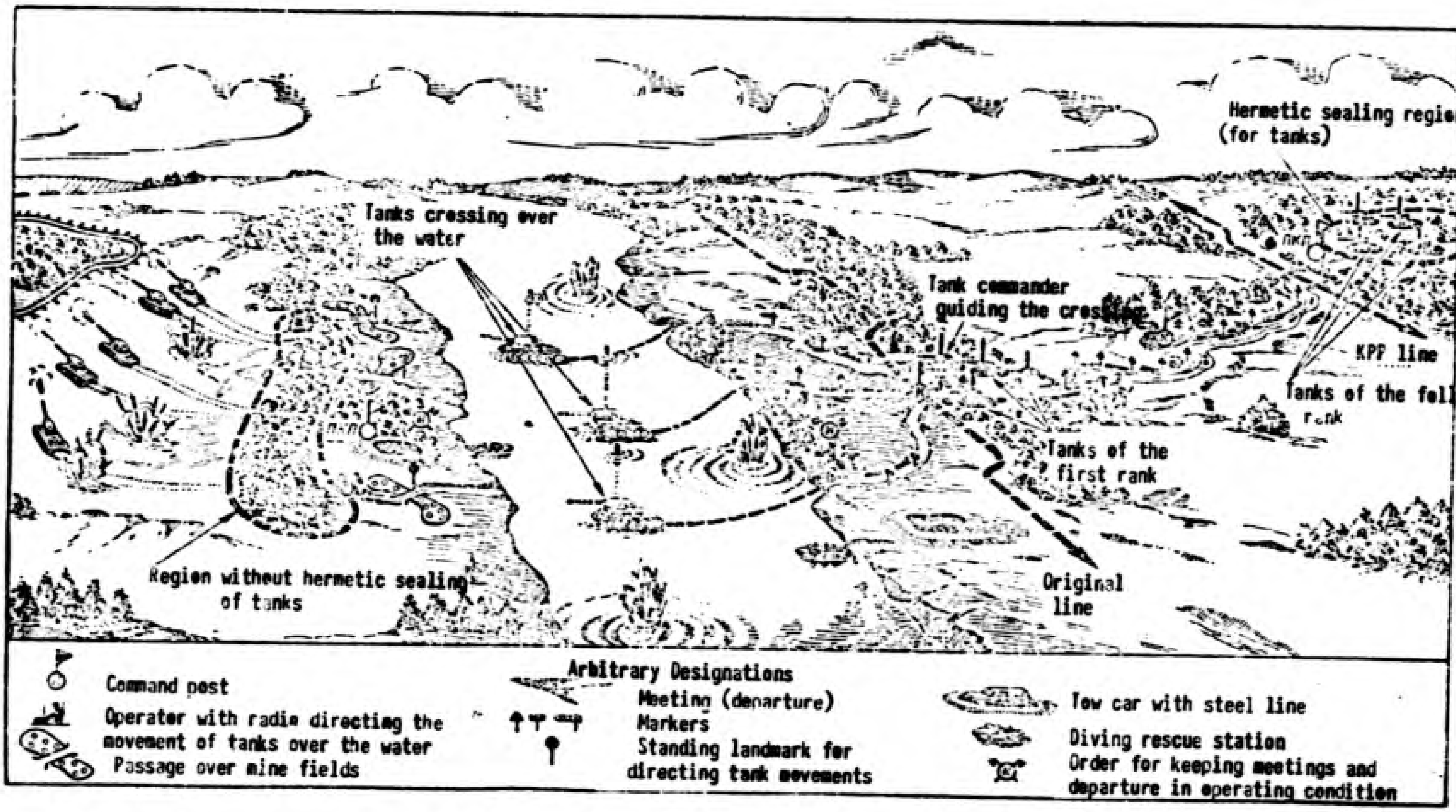


Fig. 125.--Panorama of tanks moving over the water.

At the approaches to water obstacles, resistance to attacking tanks may turn out to come from troops under cover or from retreating troops. At the same time, for the purpose of forcing tanks from the obstacle, the enemy on the original shore may prepare and carry out a powerful counterattack on one or both flanks of troops moving forward to the water obstacle.

It is pointed out in such situations the attacker still moving tanks forward to the water obstacle will inflict rocket-nuclear destruction on main enemy groups on the original and opposite-lying shore in order to preclude the possibility of massive application of nuclear weapons by the defending side, and to guarantee the approach or the attacking troops to the water obstacle, force them to move and quickly achieve defeat of basic enemy forces on the opposite-lying shore.

In order to repel the counterattacking enemy forces operating on the original shore, the minimum number of tanks are precipitated which is necessary to accomplish this; along with their own active operations after a nuclear strike, they must fully complete defeat of the counterattacking enemy troops in the shortest possible time and liquidate the threat of the flank of attacking tanks.

Main tank forces operating under cut-off conditions in this case in a very rapid time will direct themselves to the water obstacle, knocking out enemy cover with powerful forward divisions, equipped with power-driven fording facilities. Moreover, fording facilities will evidently move to the water obstacle, evidently over a wide front from separate directions, moving behind forward divisions. With the arrival of tank units of the first echelon at the river, repeated strikes may be carried out with nuclear weapons or conventional ones on enemy nuclear attack facilities and enemy ground troops situated on the opposite shore.

After arriving at the water obstacle behind the nuclear strikes, the tanks will cross over using ferries, bridges and other fording equipment, crossing in the day and developing in their own directions with attack into the depths. Obviously, defeat of the enemy remaining on the flanks and in the rear will be achieved by forces of the second echelons and reserves.

Considering the high degree of vulnerability of fording facilities, tank units must orient themselves to crossing rivers in the daytime with tanks under their own power (Fig. 125), but artillery and autotransport equipment will be brought over on amphibious transports (Fig. 126).

In the course of attack developments, as a result of precipitous tank operations, the defending side may not be able to unleash its own reserves to the water obstacle in time for its defense, and they find themselves in a situation where they would move to the river with attacking tanks. Thus in order to set up favorable conditions for their own reserves to enter into combat at the water obstacle, the defending enemy may try to slow down the approach of attacking troops to the river, offering them resistance with retreating troops.

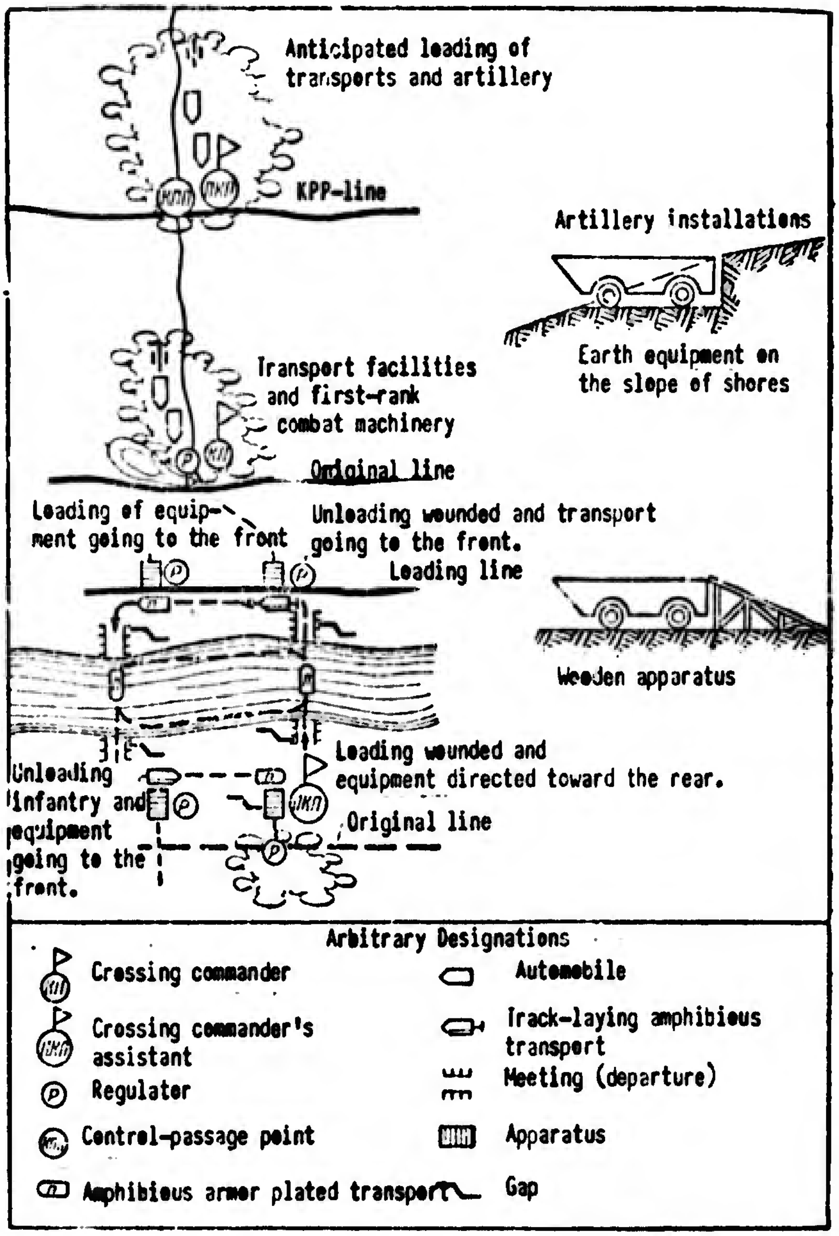


Fig. 126.--Landing-crossing on self-propelled crossing-landing facilities.

It is noted that in such a situation, the attacking troops, still in the process of moving forward to the water obstacle, will try to destroy the enemy nuclear attack facilities with maximum destruction of its approaching reserves, making it impossible for them to approach the water obstacle and to a large measure reducing their combat capability.

Under these conditions, the tanks will go straight to the river in their own directions, preferably operating in columns and deploying only part of their forces for quickly destroying the retreating enemy forces. With the arrival of units of the first echelon at the river, the rocket facilities and the enemy troops successful in getting to the opposite shore and capable of offering resistance, will destroy the attacking subdivisions with all their firing facilities. The water obstacle will be crossed by the divisions and main forces using all available fording facilities and methods.

According to the crossing onto the opposite-lying shore, the tank units of the first echelon will develop a precipitous attack into the depths and defeat th surviving enemy.

Sometimes in the course of developing an attack, the situation may become more complex in that the defenders will offer a high degree of defense on the original shore. Having withdrawn behind the water obstacle with rockets and aircraft, he may inflict a strike on troops approaching the water line and may create a zone of radioactive contamination directly in front of the river so as to gain time to withdraw his own troops to the other side of the river and transfer reserves from behind. It has been said that in this situation the attackers will take measures to quickly destroy the enemy behind the zone of radioactive contamination on the opposite shore and will attempt to overcome the zone in all directions having a lower level of radiation, with a move to overcome the water obstacle over a wide front and developing an attack by quickly transferring forces from the rear to destroy the approaching enemy reserves.

Thus it is asserted in all cases that water obstacles will be surmounted by tanks without delaying and accumulating troops on the original shore, and without reducing the general rate of attack. Water obstacles will be overcome simultaneously, if possible, with a large number of tanks using all possible facilities and fording means over a wide front, after inflicting maximum damage on the enemy with rocket-nuclear weapons and conventional weapons.

6. Surmounting Zones of Radioactive Contamination and Regions with a High Degree of Destruction

The use by both sides of nuclear weapons leads in large degree to the formation of a large number of zones and regions having a high degree of nuclear contamination and destruction, which tanks and tank units will be forced to overcome in the development of an attack, or bypass or conduct combat operations in them. In addition, the defending side may intentionally create zones with high levels of contamination and a high degree of destruction in the directions of basic attacking forces. It is thought that the reason for setting up such a zone may be as follows: to destroy attacking tanks, operating when cut off, detain their forward movement and gain time to concentrate on the operations of their reserves; to create conditions for repeated strikes on tanks which have broken through with their own nuclear facilities when they are overcoming these zones; forging the operations of attacking tanks so inflict strikes with reserves in directions guaranteeing the most success; to guarantee the conditions necessary to deploy and make the transition to the attack.

The character of the zone and regions of contamination and destruction will largely depend on the purposes for which they were set up. In the series of events, obviously such zones may run several tens of kilometers along the front and rear.

When conducting combat operations in zones and regions of strong radioactive contaminations, the personnel of units and of armored forces may receive a considerable irradiation dose and may practically lose their combat capabilities. In order to avoid this, the methods and character of tank operations in contaminated zones will obviously be quite different from operations in ordinary zones. When conducting combat operations in contaminated zones, all tank forces will be directed at decisive, multi-maneuvering and rapid operations to solve problems confronting them and to exit from the contaminated zone in a short period of time and with the minimum degree of radioactive contamination. Zones of radioactive contamination usually will also be surmounted with consideration of the personnel receiving the minimum dose of radiation and maintaining their combat capability in order to conduct combat operations with the strong and active enemy when they exit from the zone. In general, it is assumed that a zone of strong radiation will be passed through only in the case of utmost necessity and only with those units and sections which find themselves in the zone or directly in front of it.

The methods for overcoming zones and regions with radioactive contamination and a high degree of destruction will probably be determined primarily by tactical and meteorological conditions, radiation levels, the degree and character of the destruction on selected directions of movement, the presence of focal points of fires, rubble, as well as the character of enemy operations directly behind the zone and in it.

It is pointed out in the foreign military press that, depending on these factors, tanks will overcome zones of radioactive contamination with different means: moving out, not waiting for a drop in the radiation level; going around parts with a high level of radiation; after a drop of the high radiation levels; combined means.

When surmounting the zones of radioactive contamination, obviously tanks will be at the column heads, behind them the motorized infantry and other units. Moreover, the zones will probably be surmounted on march routes and in directions with the lowest radiation level, and the troops are moving at top speed increasing the distances between the vehicles and units, using individual defensive means.

Bypassing zones, sections or regions with high radiation levels will be used if, when bypassing the zone, moving according to directions of the operation, the personnel may receive a radiation dose exceeding the allowable one. Evidently, the direction for bypassing will be selected on the basis of reliable and full data concerning the radiation levels in sections and directions received from all types of reconnaissance and as a result of prognosis of the radioactive conditions.

It is pointed out that if it is impossible to surmount the zone by moving from very high radiation levels, and in the absence of data making it possible to select the direction with the least radiation levels, the tanks may surmount the zone after the radiation level has dropped. In this case, they will disperse in front of the zone and safely take cover from air strikes. However, it is assumed that tanks will take recourse to this method only in exceptional situations, since its use would lead to slowing down the attack rate.

In these situations, the methods tanks use for overcoming the zones of radioactive contamination and a high degree of destruction will be selected on the basis of the concrete situation.

7. Special Features of Tank Operations on Mountainous-Desert and Desert-Steppe Terrain

In the course of an attack, troops must overcome level desert-steppe terrain or difficultly accessible mountainous regions in operations of varying difficulty according to soil-ground conditions (sand dunes, saline soil, granite-rocky ground) and with a different climate. The habitability of the territory, the limited number and the poor quality of the roads, the lack of local building materials, supplies and water all exert an influence on combat operations.

The complex and varied conditions of the terrain may differently influence maneuverability and the rate of tank operations. So, in desert-steppe terrain, where usually wide dispersion of troops is possible along with free deployment, in many cases widespread maneuvers without roads and where defended borders may often be far apart by even ten or a hundred kilometers, rather favorable conditions are created for maneuvers and conducting precipitous attack operations.

On the other hand, in mountainous regions with their sharp, broken relief, as well as in regions with sand dunes, the time for developing an attack may be less than planned under ordinary conditions.

In view of the great diversity in the relief of terrain, and the special characteristics of enemy defense, combat operations will be just as varied under the considered conditions. For example, desert-steppe conditions facilitate maneuvering and precipitous tank operations over a wide front. At the same time, in mountainous-desert regions, where it is especially favorable for the defense of all sections and lines, but the possibility for maneuvers is extremely limited, it is often necessary to conduct an attack when the lines have been broken through.

One of the most important conditions for successfully solving the problems of defeating the enemy, who is on the defensive in mountains and deserts, is the entry of attacking tanks into the rear of the enemy and onto its basic communication routes for the purpose of seizing their water supply sources, rear bases, supply routes, and important road connections. Obviously, during an attack it must be taken into account that the more powerful and active the defense, the greater the mass of forces and facilities the defenders will have to set up at approaches to important objectives, along basic roads and in the most accessible directions. There will often not be a continuous defensive front.

It is pointed out that in mountainous regions, wider use is made of combining the operations of main forces along a broken-through line from the front when the defending forces pass through less accessible sections in order to inflict accessory strikes on them from the rear and in order to seize the most important rear objectives.

The basic strike in a mountainous region is usually inflicted along a road, a path and along valleys combined with operations of individual motorized or mountain units on difficultly-accessible terrain. Moreover, more time than usual is required to set up the necessary groups and to prepare them for operations. It is especially difficult to spread out and position the necessary amount of artillery in directions of the main strike. Thus, destroying and suppressing the enemy before the start of an attack will often primarily be entrusted to nuclear weapons and planes.

The indigenous conditions of mountain-desert and desert-steppe terrain will be taken into consideration in selecting the time for the start of an attack. It is generally known that movement from regions of concentration along sandy ground in the daytime results in a thick and high curtain of dust being created on the strip along which the tank units are moving, which will be seen for many tens of kilometers and gives the enemy a chance to find out the direction the attacking tanks are moving. In order to achieve the element of surprise, it will be started at dawn, and sometimes in the second half of the night so that the approach of tanks is completed at night.

It is pointed out that in order to achieve great secrecy in using tanks, the favorable conditions of the terrain will be used for movements, wide dispersion, breaking up and rapid regrouping and forward movement in a short time and over broad distances. On deserts and in the steppes it is quite possible to place tank units at a great distance from each other like along a front as well as in the depths and in an area greatly exceeding the dimensions of the dispersion region, designated under usual conditions. In mountains, the possibility for dispersion of tanks along a front is extremely limited, since spreading out is mainly achieved by echeloning in the depths.

In principle, combat ranks of units will include the same elements as in conventional situations. There may be a series of special characteristics only in the makeup and distribution of some elements. In all conditions, it is necessary to have strong reserves, capable of fulfilling tasks arising suddenly under difficult conditions.

In order to achieve bypassing through difficultly accessible terrain in combat ranks, the attacking side may include special preparation for this unit.

In determining the setup of troops in mountains, it is more necessary then in usual situations to take into account such factors as the accessibility to roads for troops; the large depth of the column and all formations due to increasing distances; the necessity of dispersing facilities for the purpose of increasing the independence of the units, moving in columns and in separate directions; increasing time in deployment from field columns into combat ranks.

On broad and open expanses, deserts and steppes, the clear interaction of tanks with aircraft is especially important as well as in mountains with air drops. The importance of forward units is increasing.

In order to be successful, tanks must often hastily break through the occupied enemy defense. In mountain conditions, they have an especially good chance to quickly occupy such defenses.

Foreign combat specialists believe that a rapid breakthrough of an occupied defense, depending on the terrain conditions, may require the use of various methods of tank operations. In desert-steppe regions, it is more advantageous to bypass a defending enemy in order to inflict a blow from the flank or from the rear. If this is impossible or if bypassing is not advantageous, the defense will be broken through simultaneously in several directions. The attack of tanks moving behind nuclear strikes at high speed correlating with the technical capabilities of tanks under the given terrain conditions, will facilitate destruction of the defending groups and enemy reserves, and make it possible to hamper counteraction measures taken by troops attacking in the rear of the defense.

With successful breakthrough of an occupied defense in a mountainous-desert region, the directions for the attack will be selected along a road and in sections facilitating the tanks being able to penetrate the enemy combat ranks and conduct massive tank attacks without complex regrouping. It is also important to prepare and guarantee the attack with artillery fire and air strikes. It is pointed out that air drops will be launched for strikes on the enemy from the rear in directions of tank attacks.

In the course of tank development in desert-steppe regions, tank units will often have to overcome natural various obstacles and artificial hydrostructures in mountains as well as on rivers. Thus, special measures will be planned in advance to guarnatee unhindered forward movement of tanks in regions irrigated with a network of canals with various widths as well as overcoming mountain rivers.

The successful use of tanks in mountainous and desert-steppe regions involves the necessity, much greater than under ordinary conditions, of strengthening their units with engineering troops capable of securing tank operations under difficult conditions.

One of the most important tasks for successful troop operations is their intelligent administration. Thus, organizing this administration requires providing for more frequent and full orientation of commanders at all levels and more generally confronting them with problems. The independence and initiative of commanders has special importance.

8. Outlooks for Future Development of the Means of Guiding Attack Operations

Combat equipment and destruction means are some of the most important factors exerting important influence on the methods for conducting combat operations. The development of combat equipment and destructive means, as well as the appearance of new combat methods, unavoidably involves a change in the character of combat, as well as the means of using different kinds of troops in combat, amount them tanks.

Success in modern combat absolutely will depend on the ability of troops to make maximum use of the results of nuclear strikes and at the same time to resist enemy nuclear attacks. This ability is assumed to be possessed by troops whose basis is tanks.

The achievement of armored-tank equipment and the organization of armored forces, as well as the broadened possibility of using nuclear weapons in combat, makes it necessary to look for newer, more perfected means for using tank operations in modern combat.

In cases of wide application of nuclear weapons from tank units, evidently will demand the use of new methods of concentration on the battlefield, deployment and entry into combat, creating strike groups to break through defenses and destroy defending reserves on the move, continuous development of attack over a wide depth and at high rates and constantly maintaining combat preparedness. Evidently, there is more chance for achieving surprise and seizing the initiative in a maneuver.

On the basis of tank operations in the depth, the dispositions of the defending side will have the tendency to anticipate the enemy in maneuvers, deployment and inflicting counterblows, so that his reserves will not be able to organize a counterattack, inflict strikes and stabilize the situation to defend advantageous lines. The threat of massive use of nuclear weapons by the enemy will probably require intelligent and precipitous completion of maneuvers from tanks, rapid concentration of forces and facilities to inflict a high-power strike in the selected direction, and rapidly dispersal after doing the job.

Defeat of enemy reserves, the presence and conditions of which depend on the stability of his defense, will be achieved in the course of encounter combat which will take place in conditions which are changing more abruptly and rapidly than before, and will bear an especially embittered character.

The necessity of conducting decisive combat operations under special physical-geographical conditions may require the wider use of tanks.

Air drops will find wide use in contemporary combat. The character of their operations in the depths at the rear of the enemy will require them to have tanks. This doubtlessly increases stability, striking force and mobility of air drops and permits them to fulfill combat tasks of different dimensions and character.

Section 6

Nuclear Weapons and Defense

1. The Role and Place of Tanks in Defense

In rocket-nuclear combat, each of the sides will attempt to achieve their goals with active attack operations. Together with this, defensive operations may be necessary for armored forces.

It is known that temporary transition to defense in one direction creates conditions for accumulating forces and facilities in other, more important directions, for the purpose of making a transition to the attack. At the same time, the defending troops have the chance to repel the superior enemy forces, inflicting great losses on them, holding important regions and key positions of the territory while creating advantageous conditions for decisively making the transition to the attack .

It is pointed out in the foreign military press that although armored forces are the attacking means, th y can be successfully used on defense. Tanks can be successfully used to set up defensive units. Together with this, they can be used as a maneuvering means to carry out a counterattack against the attacking enemy. The presence of tanks in the defending troops increases their activityand the insurmountability of the defending side.

The main task of the defense will not be to repulse the attacking enemy at any line, but to rapidly destroy or suppress him in a determined area by means of a sudden use of nuclear weapons combined with active tank operations and other facilities.

The presence of nuclear weapons, as well as tanks in the makeup of the defending troops creates conditions for carrying out defense with active methods, including high-power fire strikes and maneuvers for the purpose of carrying out decisive counterattack and inflicting counterstrikes.

It is pointed out that in speaking of methods for conducting modern defensive combat, successful resistance lies in positions in combination with maneuvers of firing, forces and facilities. Thus, in modern defense of tank units, linearity, even distribution of forces and facilities disappear on a continuous front, without gaps, attachment of tanks to determined positions and lines. Unchanging forms of conducting defensive combat lose their force, its essence becomes the maneuver.

The decisive goals of the attacking side are opposed by the no less decisive goals and operational methods of the defending side; in the contrasting case, they will be defeated. Thus the necessity arises of decisively destroying the attacking side with high-powered strikes of all facilities in combination with striking troops in the presence of unyielding containment of important territory. Conducting active and maneuvering defense creates conditions for transition of defending troops to the attack.

An important method for destroying the attacking side is nuclear weapons. From this comes one of the tasks of defending tanks--well-timed detection and destruction of these enemy facilities.

For the purpose of reducing the effectiveness of enemy nuclear weapons, the defending side will be forced to utilize the conditions of the terrain and camouflaging and quickly take measures to equip for defense. The advantage of the defending side includes the fact that it has a chance to choose the region and the position for the battle, he can choose the operational methods and the time for maneuvering fire, forces and facilities. An unyielding and active defense will be set up not only with relation to the enemy, but an antinuclear defense, i.e. to the maximum degree capable of withstanding strikes of enemy nuclear weapons.

It is generally known that in defense, the force is determined by expert organization of the firing system, especially the anti-tank system, wise use of the terrain and engineering equipment, firing maneuvers and personnel.

Since they are highly mobile and maneuverable, tanks are capable of setting up the remaining and deep-echelon defense, even under conditions of direct contact with the enemy. The role of tanks in defense has greatly increased due to their high combat characteristics which permit them not only to resist high-powered enemy strikes, but to make maximum use of the results of the use of nuclear weapons against the defending side, and inflict high-power counterstrikes in order to decisively defeat the attacking side, and create favorable conditions for making the transition to the attack.

The experience of the Great Patrician War has shown how the successful and heroic operations of armored forces in defensive operations creates favorable conditions for defeating the enemy and making the transition of our troops to the attack, for example below Moscow, Stalingrad and in the Kurskoi region. About five thousand tanks and self-propelled artillery installations took part in the defense below Kurskom. All four tank armies (1,2,3 and 5 TA) and six separate tank corps participated in the defeat of the attacking enemy in the Kurskoi battle.

Thus, tanks increase antitank capabilities, stability of the defense, the activeness and the maneuverability of defensive combat.

On defense, tanks will enter into the makeup of the first as well as of the second echelon (reserves). In the makeup of the second echelon (reserves), they often will be designated for conducting the counterattack.

2. Conditions for Tanks Making the Transition to Defense

It is pointed out in foreign literature that the transition of tanks to the defense may be achieved in the most different conditions, while these conditions may be different for each troops organism. However, in the majority of cases, tanks will obviously make the transition to the defense in the case of direct contact with the enemy.

Tanks may make the transition to the defense for the purpose of securing an entrapped line, to protect flanks and the rear from attacking main groups and also on sea coasts to repel enemy air and sea landings (Fig. 127).

The transition of tanks to the defense will also be possible as a result of an unsuccessful outcome for them in encounter combat. It is thought that in isolated directions tanks will be forced to repel the strikes of superior forces from the attacking side, in the performance of defensive operations.

During the last war, the transition of tanks from the attack to defense was often carried out for the purpose of fortifying an entrapped line when the attacking troops had spent their own attacking capabilities and required preparation for the ensuing attack operations. In other words, as a rule tanks make the transition to the defense in the final stage of an operation. An example for such a defense is the operation of the 5th TA and 6 TA in the Korsun-Shevchenkovskoi operation in February 1944; 10 and 29 tk 5 gv TA in the Eastern Prussia operation on the 24-26th January 1945; the 3 and 8th tk 3 gv TA in the White Russia operation after seizing the outskirts of the Warsaw-Prague district in August 1944. Often, tanke make the transition to the defense while being subjected to high-power enemy counterstrikes or being forced to repel his initial counterattack. The 12 and 15 tk TA took recourse to such operations in the Xar'knovskoi operation in February of 1943 and the 18 tk in the Baltic operation in March of 1945.

There are also many examples of tanks making the transition to the defense in areas of concentration entrapped during the course of an attack (Pulavskom--11 tk and Candomirskom-6 and 2 tk 3 gv TA and others).

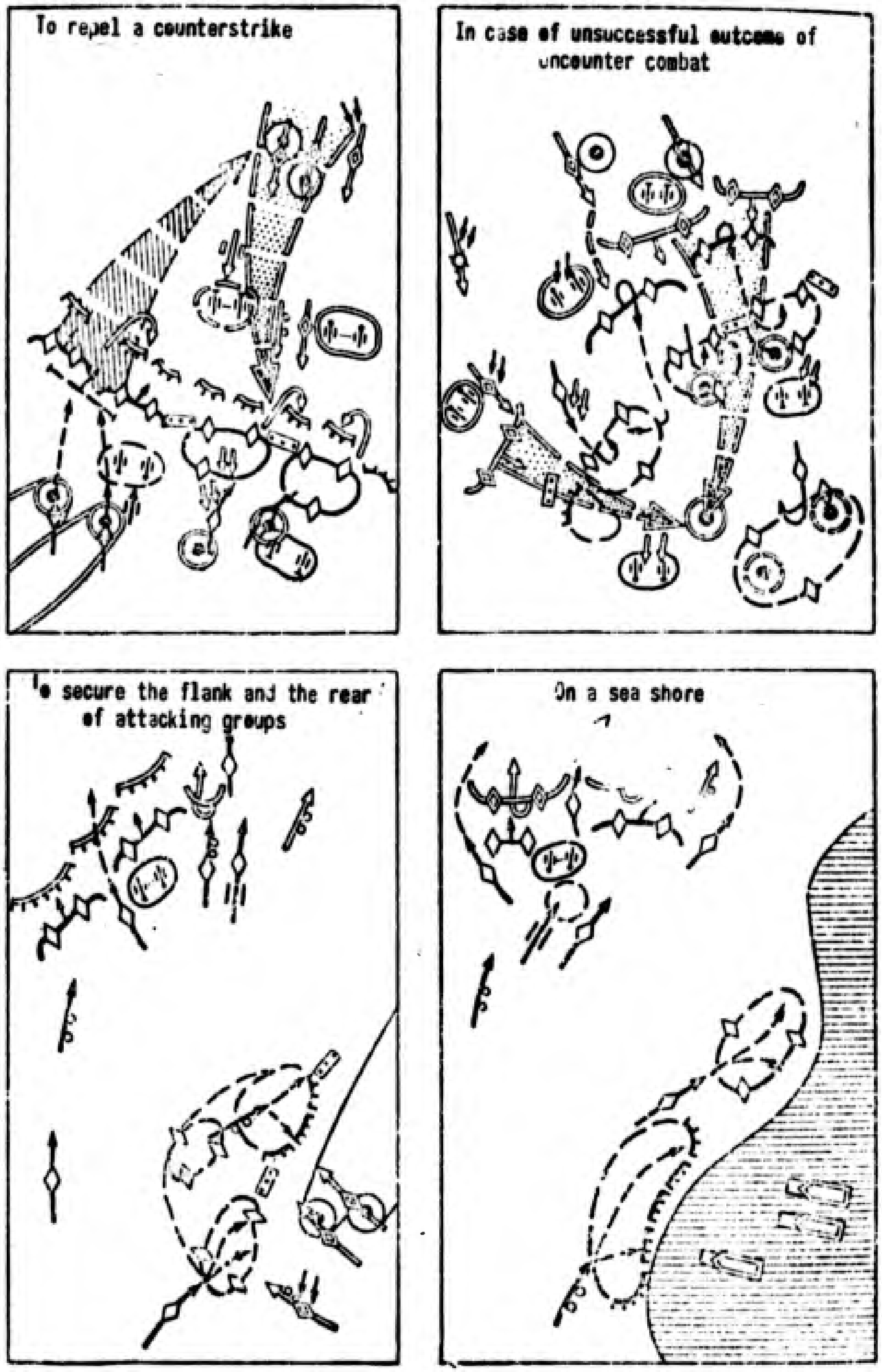


Fig. 127.--Possible conditions for tanks making the transition to the defense (variations).

Defense is used to protect a threatened flank fro a basic strike group. An example for this may be the combat operations of the 16 tk in the defense of Demblin for the purpose of securing the flank and the rear of the 2 gv TA; the operations of the 65 gv tbr with 1493 sap [sic.] in the Sedletz region to protect the right flank of the 3 gv tk in the second half of July 1944 in the White Russia operation as well as the operations of the 3rd gv tk in the same operation to secure the right flank of the 2nd gv TA in its attack in the liberation of Warsaw.

In addition to this, tanks may complete an attack on a sea shore. In case of the thread of a landing from the sea or the air in one direction and a strike of enemy tank groups from the other direction, tanks will obviously make the transition to defend the sea coast and important directions adjoining the sea coast.

Temporary transition to the defense of forward brigades and the avantbuard of the attacking side on the opposite-lying shores of large water obstacles obviously may be necessary in order to secure forcing of the main forces.

It is thought that tanks will also be forced to make the transition to the defense due to a sharp decline or a considerable loss of their attack capabilities.

Such a situation may be created not only in the course of attack operations, but at the start of them, as a result of massive nuclear strikes by the enemy if he is forestalled in the deployment of attacking tanks.

It is pointed out that defense by means of tanks may be used when troops do not have nuclear ammunition available or if they have it in limited amounts.

From what has been stated it is obvious that the transition of tanks to defense is a necessary phenomenon; they will make the transition to the defense, as a rule, in extremely tense situations, under strikes from superior enemy forces.

Of course, the enemy will attempt to disrupt the planned transition of tanks to the defense with all his forces and facilities and make it difficult for them to regroup, and successfully carry out their defensive tasks. In the case of nuclear strikes are inflicted by the enemy, a part of them may be ground blasts, as a result of which zones of high radioactive contamination are developed at individual sites along with regions of great destruction, and tanks will be forced to make the transition to the defense. Part of the tanks may lose their combat capabilities from the nuclear strikes, which requires the introduction of essential changes in the transition to defense and the practice of this transition. Transition of tanks to the defense may also be forced by air drop operations carried out by the enemy for the purpose of seizing and destroying nuclear weapons facilities, creating a diversion, destroying the troop command or the operations at the rear.

Without doubt, the transition of tanks to the defense will be carried out under the most complex conditions, requiring maximum exertion of physical and moral forces on the part of all personnel, initiative, boldness and persistence on the part of commanders at all levels, intelligently commanding units and detachments in order to guarantee quick transition to the defense and successfully carry out the tasks confronting them.

In the transition to the defense for the purpose of economizing forces and facilities, the business of defense will obviously be carried out under conditions of direct contact with the enemy as well as outside of this. In the first case, it will be organized in extremely limited time, in the second case, in advance under more favorable circumstances.

3. Formation of Tank Defense

Formation of tank defense includes creation and disposition of forces and facilities groups on terrain, organizing fire and maneuvers in accordance with the defense plan.

It will be noted that in conditions when nuclear weapons are used, defense will not be continuous since this leads to great losses; it will be organized individually, but in connection with a single system of regional and support points, and echeloned in the depths. Only under this conditions is it possible to achieve stability in modern defense. In connection with this, the question arises about the width and depth of defense. This will depend on many factors, for example, on the presence of nuclear weapons and other destructive means, troop replacement, and on counteroperations of the enemy as well as on the character of the terrain.

Tank units will usually defend one object or region which is important in a tactical sense. The supporting points of the infantry constitute the basic position of a batallion (Fig. 128).

The depth of defensive formation must secure the incremental counteroperations of the attacking side, the freedom of maneuver of the defending troops and decentralization of their positions to defend against enemy weapons of mass destruction. According to the data of the foreign military press, allocation of positions and support points on terrain is more advantageous at a distance, not exceeding the distance of effective tank firing, i.e. so that the terrain between the positions and the support points is shot through with effective tank fire. However, it is assumed that the depth of defense will fit together not only with the distance of tank and artillery fire, but with the enormous long-range nature of rockets and the maneuvering capabilities of the second echelon (reserve). Thus, under conditions of nuclear war, the depth of the defense is one of the decisive factors of its stability.

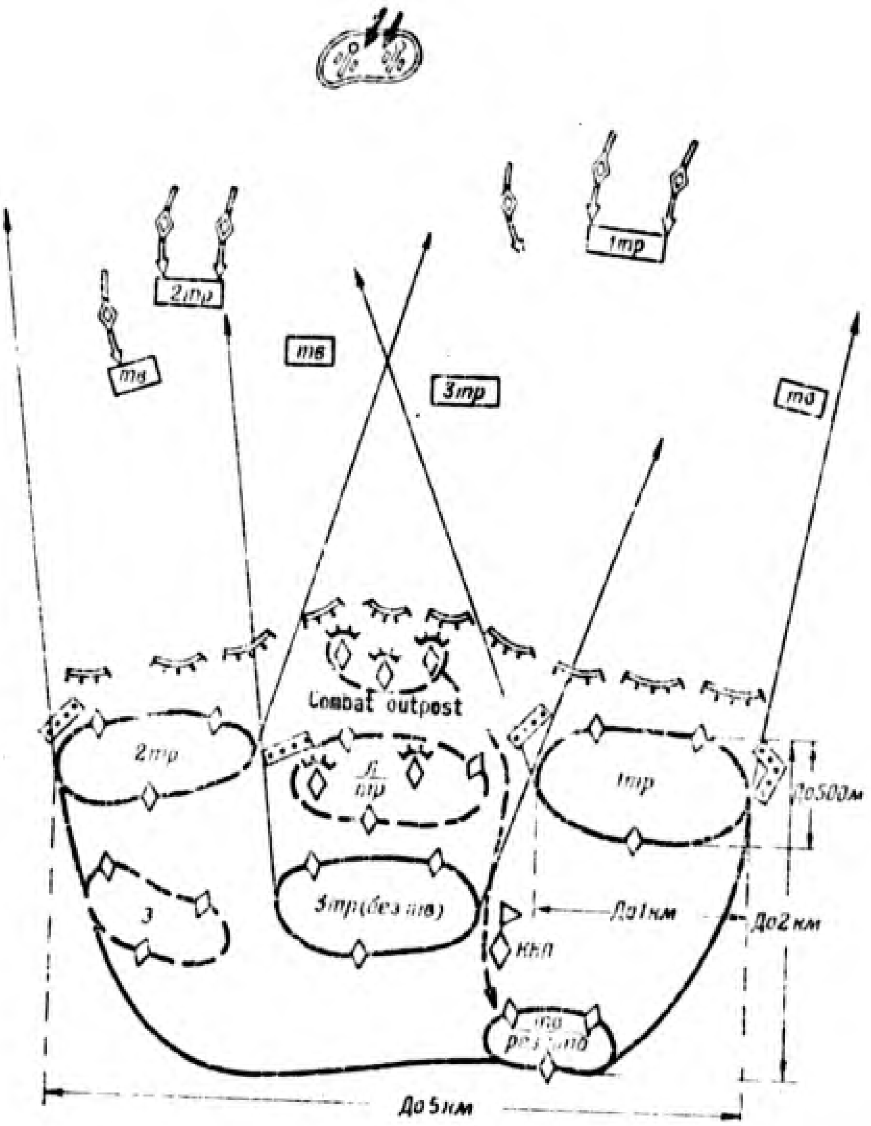


Fig. 128.--Defensive region of a tank batallion (variation).

When tanks make the transition to the defense with direct contact with the enemy, in the course of a determined time they evidently will be forced to carry out defensive tasks in groups, set up to lead the attack. The experience of the Great Patrician War bore witness to this. So, for example, the 5th and 6th tank army and corps entering into their makeup, with the transition to the defense in the final stage of the Korsun-Shevchenskovskoi operation originally had a single echelon formation and a second echelon was created only later. A similar example is the transition of the 5th army to the defense in the Eastern Prussia operation in January 1945, on their entry to the shore of the Frisches Chaff gulf.

It is thought that under conditions of nuclear war, in the course of attack, tanks may be cut off from their own main forces at the moment of transition to the defense. It is obviously expedient to use them for inflicting counterstrikes on enemy columns moving ahead, disrupting their advance systematically and gaining time to seize the defense with basic forces. Similar operations are especially important when they include the use of nuclear facilities and aircraft for inflicting strikes on basic enemy counterattacking groups. However, if the situation permits the attacking groups to regroup its forces, then tanks making the transition to the defense probably will be led out of the second echelon or the reserves. As is pointed out in the foreign press, they will be needed not only for accumulation in the depths, but in the capacity of the main striking force when conducting a counterattack and renewing an attack. The attacking side must meet the ever-increasing resistance of the attacking side. Thus, naturally, combat ranks of tanks on the defense advantageously have echelons in the rear.

Groupings of troops in defensive operations is not an elementary phenomenon, but the result of profound considerations and combat knowledge on the part of commanders at all levels. Its main feature is conformity to the plan of conducting the defense, i.e. it must be such that it facilitates defeat of the attacker with the least expenditure of forces and facilities.

In setting up groups, of course, it must be taken into account that it is not possible to be strong everywhere. Thus, try to secure the stability and activity of the defense in the important directions, not only stationary disposition of combat facilities at positions, but with wide maneuvers of forces along the front, as well as in the depths, as well as with maximum use of combat capacities, all kinds of troops. Reliable cover of the flanks, junctions and gaps between defending troops is important, as is the possibility of engaging in combat with enemy air drops.

It is emphasized that depending on the situation, tank combat ranks may consist of one or two echelons, rockets, artillery, antiaircraft facilities and reserves of different designations.

Foreign combat specialists believe that, depending on the problem at hand, the character of the terrain and the conditions for making the transition to defense, smaller or larger parts of forces and facilities should be included in the makeup of the first echelon. Moreover, it is expedient to precipitate the smaller part of the forces in the makeup of the first echelon, when the enemy has freedom of maneuver, and it is difficult to determine in advance the direction of his main strike. Such a situation will often become more complex with the transition of tanks to the defense when cut off from the basic forces or with open flanks. In these situations the pattern is destroyed, since evidently the forces and facilities will be distributed between elements of combat ranks with consideration of the determined influence of groups put together beforehand. Moreover, the basic forces will be concentrated in important retained regions and terrain boundaries on which the stability of the entire defense will depend.

It is acknowledged that defense must guarantee repulsion of massive enemy tank attacks, i.e. it must be antitank in nature. However, under conditions of nuclear war it will be difficult to achieve a high degree of compactness of forces and facilities. Thus, a high degree of compactness of antitank facilities in threatened directions evidently will not be created in advance, but in the course of combat operations, unexpected for the enemy, and above all at the expense of tank maneuvers. For this purpose, tanks in the reserves (second echelons) in tank-dangerous directions obviously will be assigned to fire lines when they are put forward on the threat of a breakthrough by enemy tanks. One of the main advantages of tanks may be used here too, their maneuverability.

It is thought that in order to deliver nuclear weapons, the attacking side will make wide use of airplanes, and the defense will be set up so that it can resist air strikes.

It is maintained that the activity and stability of tank defense will be based on widespread maneuvers of forces and facilities and on conducting decisive counterattacks. For this purpose, a strong second echelon will be set up (reserves). Tanks of the second echelon (reserves) with decisive execution of counterattack after the application of nuclear weapons will form the activity for the defense. Part of the forces and facilities may be used to hold important regions in the rear, and to destroy air drops of the attackers. The activity of the defense will be expressed mainly with the appearance and destruction of enemy nuclear facilities at distant approaches to the defending line. Aviation plans an important role in fulfilling this task, which is capable of reconnoitering and simultaneously suppressing and destroying the more important enemy objects. Tanks will fulfill this main task, as well as the task of cutting off the organized advance of the attack striking group and reducing it to a maximum degree when these same tanks are cut off from the basic defense forces.

The total of all this will make it easier to create a stable and insurmountable defense.

The basic operation of tanks in defense is inflicting high power firing strikes on the attacker with all available means. A system of firing has been set up for this purpose. This is the most important and most responsible measure for commanders at all levels when making the transition from the attack to the defense. Under contemporary conditions, when organizing a system of fire, the first thing to consider is the presence and the capability of nuclear weapons. A system of fire on the defense is included in the preparation of fire strikes on approaches to the defense and in setting up a zone of continuous, multiple fire of all types in front of the forward region, on flanks and in the depths of defense, as well as in securing the possibility of concentrating fire in a short period of time, primarily antitank fire, in any threatened direction as part of the defense.

The basic firing system of tanks on the defense is evidently their fire in combination with nuclear weapons strikes, aircraft and artillery fire.

In connection with changes in the firing system, there is increasing importance in the wise selection of a forward line, a plan for the following position and disposition on them of tank support points. At first glance, a significant advantage of the defending side would be obtained by occupying a predominant height and incline turned toward the attacker.

This wasy always attempted in the past. Under contemporary conditions, the defense on the crest of hills and slopes turned toward the enemy has a greater shortcoming than an advantage. As a rule, the side prevailing on a height is looked upon by the attacker as an object to be destroyed by fire. In addition, and this, if you please, is the main point, tanks on slopes facing the enemy cannot be camouflaged or entrenched. They will be easily spotted by the enemy and destroyed. Thus, obviously the back side of slopes will be used. Moreover, on the tops of slopes and other sharply expressed places, it is possible to set up false defensive installations.

The defenders will set up the defense so that the attackers can be destroyed from any direction. It follows from this that tanks disposed in support points must have the capability of conducting a circular defense. Thus, all subdivisions will be assigned supplementary firing sectors, preparing reserve positions for conducting fire on the flanks or in the rear.

Engineering provisions are very important for stability of the defense. This is inseparably connected with the firing system. The experience of the Great Patrician War bears witness to this. It is known that an entrenched tank successfully conducted combat with two or three attacking enemy tanks. Mechanized operational means were applied for the entrenched tank with a limited time to organize a defense, as well as explosive substances. However, this did not guarantee the simultaneous start and finish of engineering work. In connection with this, all the engineering work will be carried out in succession, guaranteeing constant preparedness of tanks to repulse the enemy and defend themselves against nuclear weapons. This work will be carried out by the troops themselves and by engineering detachments. A great deal of attention will be devoted to wise use of the natural defensive features of the terrain. It is generally known that adaptation to the defense of trenches, channels, ravines and other natural features and local objects greatly reduces the volume and time of engineering work.

Anti-tank mine fields will be set up before the front lines, in gaps and on flanks, in basic directions which might be threatened by tanks, at the same time as shelters are erected for personnel, preparing the way for maneuvers and equipping command points.

For organizing defense from the engineering standpoint, the first thing will be to solve the organizational problems for defense against nuclear weapons. The relief of the terrain will be widely utilized to secure protection from nuclear strikes; radiation and chemical reconnaissance will be conducted without interruption; the support points and defense regions will be equipped with a view to antinuclear stability; the disposition of reserves will be changed periodically as will the artillery firing positions; measures will be taken to guarantee the conduct of combat operations under conditions of radioactive and chemical contamination of the terrain, and in case the troops are defeated with nuclear weapons, rapid restauration of their combat effectiveness.

4. Defensive Tank Operations

The character of defensive tank operations depends on the conditions under which it made the transition to the defense. If defense was taken up in direct contact with the enemy under strikes from his superior force, then the defensive operations will obviously begin with securing advantageous lines in the course of attack. Under these conditions, successful conduct of defense will depend on well-timed detection of advancing enemy groups and primarily on preparing nuclear attack facilities. It is thought that air strikes will first be made on the advancing enemy with nuclear weapons. Moreover, it is assumed that strikes with nuclear weapons will be carried out with ground blasts for the purpose of setting up a zone of radioactive contamination and a region of destruction in the paths of approaching enemy forces.

It is pointed out in the foreign press that in order to destroy nuclear facilities, the attackers may also use special groups which will be launched in advance against the defenders, while the attackers are advancing their own nuclear facilities. Tactical air drops may be used for this purpose. Finally, in order to destroy the nuclear capability of the enemy, special units may be sent out, along with reinforced engineers and other means. These divisions will enter the rocket launching facilities of the enemy and seize or destroy them.

It is emphasized that the attackers, for their part, so as not to be subjected to the danger of destruction by nuclear weapons, will attempt to go to the attack from regions far removed from the defenders front line, but their stay in these regions is limited to a few hours. Using modern means of advancing, having a high degree of maneuverability, the attackers attempt to surmount the region where they are apt to be hurt by nuclear weapons as quickly as possible. If after the first nuclear strikes on approaching columns the defenders spot enemy concentrations in regions or accumulations on roads, which is quite possible in this period, then the use of nuclear weapons on the attacking groups will cause them great losses. They may detect the attacking groups in populated points and in forests. The basic task of the defending armored forces is to inflict a destructive nuclear strike on the attacker before he begins his attack.

The most readily available means will be used in the struggle with the attacking group, according to his approach, artillery and tanks. Fire will usually be conducted from reserve firing positions.

Defensive combat will be characterized by the effort of combat operations in the air as well. For the purpose of securing successful forward movement of their groups still in the course of advancing, the attackers will take all measures to obtain superiority in the air. Thus, together with destroying approaching enemy reserves, the defending side will be engaged in an active struggle with his aircraft.

Thus, in order to defeat an approaching attack force, all means of firing effect will be used to disrupt the organized transition to the attack or their ability to inflict counterstrikes.

Right from the time the attacking troops begin deployment, the commanders at all levels of the defending side will specify the tasks for defeating the attacking forces. Countermeasures may be the most successful if they are begun unexpectedly and if they forestall nuclear and air preparations of the enemy.

After the counterpreparations, strikes may be inflicted from tanks in order to complete the defeat of the attacking group before he reaches the front line of defense.

Tank operations under similar conditions are shown in Fig. 129.

Conducting defensive measures by defeating the enemy with fire does not always lead to the desired results, and the enemy, forming his own troops into rank, may proceed to the attack.

The attack will usually be preceded by strikes from nuclear weapons. This makes it necessary for the defenders to take measures to protect personnel. During firing preparations, the nuclear facilities, the artillery and tanks will carry on fire strikes on nuclear facilities, artillery, tanks and enemy infantry. As a result of nuclear strikes, the enemy may put all units out of commission, as a result of which gaps may develop in the defense. To close them up, of course, reserves will have to be moved up.

During the attack, the firing may reach its maximum intensity. The tanks will direct sighting, the artillery with mobile barriers and concentration of fire will inflict damage on the first line of attacking tanks. As a rule, the tanks will open fire from a distance.

In case the enemy wedges in, the defending side may take all measures to prevent his propagation along the front and in the depths in order to fortify flanks where the wedging in took place and to overwhelm the enemy with fire from tanks and artillery. Tanks and armored transports breaking through into the depths of the defense will be destroyed by direct fire from tanks, antitank facilities and artillery. If necessary, counterattacks will be made.

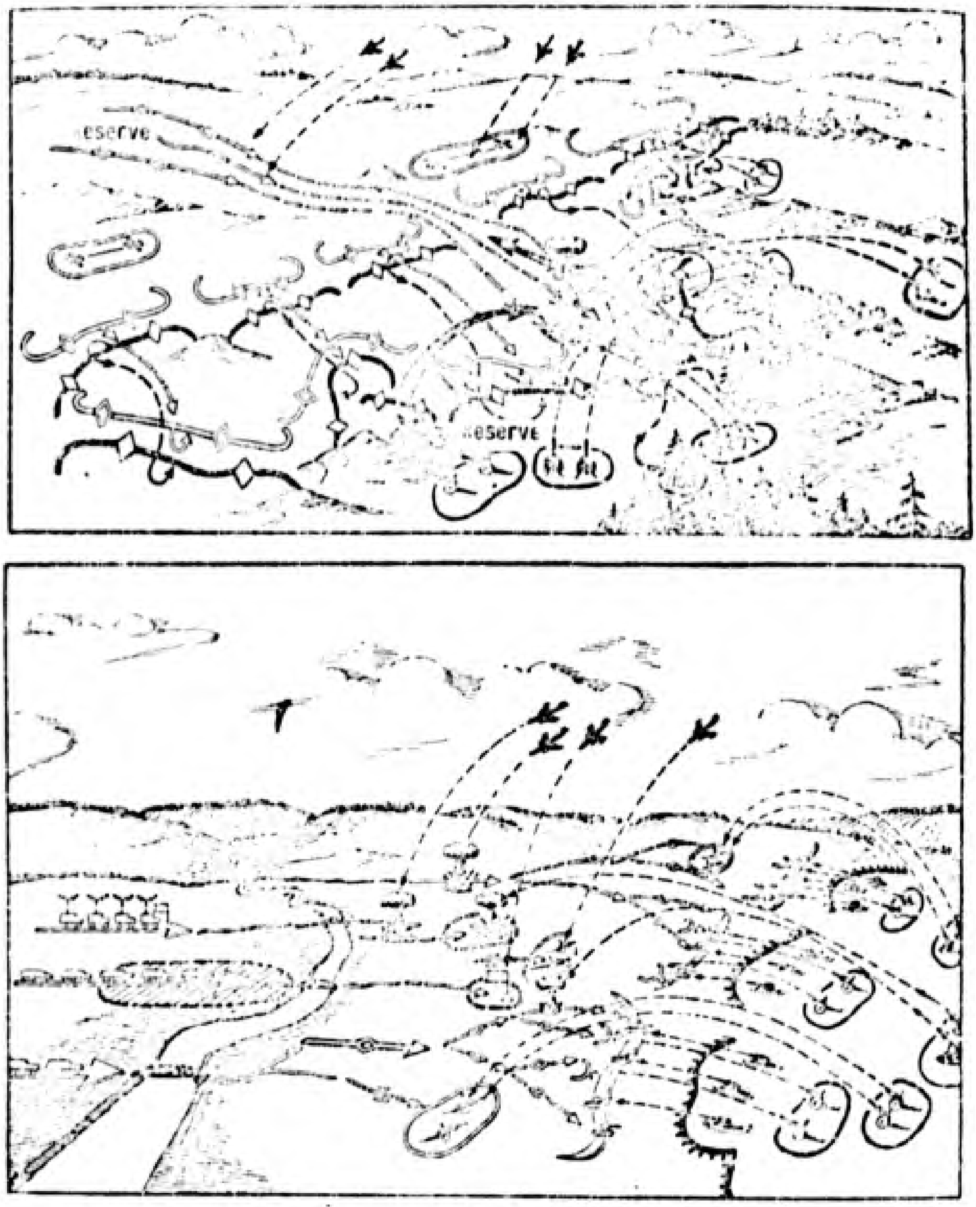


Fig. 129.--Conducting defensive combat.

Counterattacks are carried out precipitously and, as a rule, when the enemy breaks through on a flank or in the rear. The counterattack probably will be carried out the moment the attacking side is detained from the front and the enemy brings his reserves into the battle. The operation of tanks when a counterattack is being conducted may be different and may depend to a large part on the strength and makeup of the enemy. If the enemy has a large number of tanks in the direction of the counterattack, then damage is first inflicted on enemy tanks by firing from place, then precipitous strikes complete the defeat. If the enemy groups breaking through undergo great losses as a result of the nuclear strike of the defenders, then the counterattack will be conducted from movement.

The second echelon (reserves) may be involved in the counterattack. Besides this, in order to inflict the most high-powered strike, tanks and components of the first echelon may be involved from sections where the offensive side is not attacking.

The counterattack may be preceded by a nuclear strike, strikes from the air and artillery strikes on the enemy who has broken through.

It is generally known that the attacking side always has definite goals and thus, having broken through into the depths of the defense, will attempt to introduce fresh forces into the battle to develop the attack. Primarily, the defending side will conduct an active defense and select the advantageous moment to lead a counterattack for the purpose of defeating the enemy who has broken through. Under such conditions, the counterattack may begin with an encounter. An example of this is the operations of the 5th tank army in the Kurskoi battle below Proxorvkoi, the counterattack of which was carried out in an encounter with large tank groups of the enemy.

If not successful in defeating the attacking side, and he is successful in continuing the move forward, then the troops conducting the counterattack will attempt to defend their lines and will not try to prevent further penetration of the enemy into the depths.

An example of this is the defensive operations of units and sections of the 2 TA in the Kurskoi arch. On July 5, 1943, the German troops, at the price of great losses below Ol'xovatkoi at the central front, succeeded in penetrating our defense at 6-8 km. The decision was made by the frontal commander on the morning of July 6 to carry out a strong counterstrike on the enemy groups which had broken through. The 2nd TA carried off a basic role in this; they were situated in the second echelon 30-35 km from the front line. The 2nd TA with forces of the 3rd gv tk moved to the defense in the Goryainovo-Gorodishch section and carried out the counterstrike with two other tank corps.

In order to achieve the goals of the counterattack, the tanks may continue the attack until the enemy is complete defeated in this direction, or with an exit to a specified line move to fortify it and prepare to repulse advancing fresh reserves of the attacking side.

Thus, as a result of active and decisive tank operations in the course of defense, advantageous conditions are created to renew the attack.

An accumulation of forces and facilities takes place in the course of defense, a supplement of personnel and material parts, an accumulation of all kinds of reserves and also regrouping is accomplished.

5. Tank Defense in Special Situations

In the case of tank defense in the city, usually small units are used, attacked to motorized units. In this case, the tanks will often be used in ambush and in support points of the motorized company. Tank firing positions are set up behind stone fences and walls in which embrasures are made. The experience of past wars in this regard may offer a valuable lesson. So, for example, tank detachments entering into the makeup of the 62nd army in the defense of Stalingrad in street battles were used in a dispersed manner, in small groups of 2-5 vehicles in important defensive regions. As a rule, tanks are positioned at crossroads and in front of squares in order to have a large firing sector. These tanks are usually expected to destroy the enemy tanks and also lead the counterattack jointly with rifle divisions. Part of the tanks, mainly the damaged ones, dig in and become high-power immobile firing points around which the infantry firing facilities group.

Defensive combat in the city is conducted by retaining every building when surrounded. Thus it is expedient to prepare some positions for each tank. Counterattacks may be made to recover support points (buildings) seized by the enemy, but with limited forces. In this case, tanks usually operate as reinforcements for motorized battalions and enter into their combat ranks. Squares, vacant land and wide streets are often used to conduct a counter-attack.

Defense in the mountains also has its own specifics. In the Great Patrician War, armored forces successfully engaged in combat with German-fascist invaders in mountainous terrain. An example of this is the heroic exploits of tanks of the 52nd tbr, 44th, 75th, 249th and 258th otb of the 9th army whose active defense in September 1942 stopped part of the enemy in the Malgobek region and didn't allow them to reach Groznomy.

Defense in the mountains is preferably organized in directions accessible for enemy attack. Tank units can defend themselves either independently or combined with motorized units. In addition, tanks usually defend tank-accessible directions. Under mountainous conditions, the maneuver of tank units if made more difficult along the front as well as in the rear because the second echelon (reserves) is positioned closer to the front line in directions threatened by tanks. In connection with this, the defense depth in mountains may be less than under ordinary conditions.

Combat ranks in mountain defense are characterized by dispersed basic forces in individual tank-accessible directions and stretched out along the front in parts difficultly or not accessible for the attackers. Thus defense may be set up with infantry or platoon support points which must be arc-shaped. This makes it possible for smaller forces to hold a wider territory.

Tank ambushes, reconnaissance and patrols are organized in gaps between the support points and mined obstacles are set up while the counterattack is being prepared. The tank units will be reinforced with motorized and sapper units or else motorized units are attached.

Positions and support points are selected with consideration of the terrain. All defensive positions are selected with a view to securing the largest possible area for firing and, if possible, with the smallest amount of dead territory and secret approaches. In organizing the system of fire, provision is made for creation of a multistage crossfire and flank fire, in which there is no dead territory. The firing positions of tanks are laid out in stages; this makes it possible to defeat the enemy with long-range fire.

In narrow mountain valleys, tanks are set up so that the valley is struck by crossfire over the entire depth of the defense. Howitzer artillery and mortars are used to strike the enemy on the back of slopes and in ravines.

When organizing defense in mountainous areas, it is very important to take into account a sudden change in the meteorological conditions, rock slides and avalanches, flooding of high river channels, gorges and ravines during heavy rains and ice melts.

Tanks will conduct defensive combat in mountains, not along the entire front, but in individual directions or at individual sections. When defending in the mountains, conducting a counterattack on enemy groups which have broken through is often carried out with small forces, but precipitously and suddenly. The counterattack is conducted along amountain ridges, along valleys and, as a rule, in the flank and rear of the enemy who has penetrated the defense.

When defending in the desert, counterreactions to bypass and envelopment are very important, since the support points and defense areas of tank units in mountains prepare for a circular defense, and gaps between them are dependably secured with artillery fire, and engineer-mined obstructions.

It is pointed out in the foreign press that on open terrain, tanks have the chance to take up defense on a wider front. At the same time, more favorable conditions are created for surrounding the enemy flanks, which creates the necessity for setting up deeper defenses than under normal conditions. For this purpose it is considered expedient to have a stronger second echelon (reserves), and position them at a greater depth.

A regular water supply is very important for keeping troops in combat readiness. In order to preserve water supply points, it is expedient to assign special units. In order to preserve a high degree of independence and combat preparedness in the support points and in defensive zones, if possible set up supplies of ammunition, water, food and fuel.

During defense in the desert, the basic forces are concentrated on important roads, water supply points which are held, i.e. regions which are important for life.

When determining the order of nuclear weapons to be used in the desert, take into account the possibility of a high degree of long-term contamination of the water and the terrain with radioactive substances from dust formation, and its propagation together with shifting sands.

Defense in northern regions will be constructed in held directions threatened by tanks, on roads and other life-vital junctions. Tank units will be reinforced by motorized units and their defense will be built up on individual support points. Gaps between the support points may be greater than under normal conditions.

Support points are selected in those sections which would require the enemy to conduct his attack along deep, snowy cover or in the mountains.

When defending in the polar night, the firing system is organized with extensive use of night viewing equipment and illumination facilities.

Counteractive diversions and seizures are very important. For this purpose, evidently, reserves are set up in the units and parts which will be positioned nearer the threatened directions. The limited number of roads creates the necessity of preparing in time for tanks approaching the line for counterattack.

When organizing the rear security, it is necessary to take into account the low air temperature. This is very important for protecting personnel from freezing and preventing freezing up of tank engines, armored vehicle engines and automobile engines.

When defending sea shores, tanks will proceed with the threat of a landing of large enemy forces. When this condition prevails, the crossovers may be very different.

Approaching a sea shore, tank units may carry out defensive operations independently or in cooperation with ships in the fleet. Moreover, ships are used to support tanks and defeat enemy landings.

It is thought that the width of a defensive front of tank units will be somewhat greater than under normal conditions. Since the defensive front of tanks will be wider, the second echelon (reserves) will be positioned in several places, prepared to move to counterattack with part or all of the forces in the most important directions. The second echelon (reserves), is positioned away from the shore at a distance to assure its secret positioning, maneuvers in any direction and well-timed leading of the counterattack, while the enemy landing has not succeeded in fortifying itself on the shore.

Setting up tank defenses on seashores is somewhat unusual and must guarantee destruction of sea landings on the shore with all firing facilities of the first echelon, and counterattack of the second echelon. For this purpose, the front edge of the defense is selected as close as possible to the water's edge, and on the base of the shore it may be moved into the depths to the natural advantageous line.

The defense is organized more substantially and deeper in directions accessible to tanks and convenient for landings. Counterattacks and forward movement of reserves is forestalled in these same directions.

In difficultly-accessible parts, it is customary to separate out the insignificant forces and facilities.

It is thought that in organizing the defense, provision is made for the use of nuclear weapons in order to destroy ships and transports during sea landings, as well as to destroy landings from ambush in the course of combat on shore.

The firing system is organized with consideration of the possibility of defeating the enemy on the water as well as on the shore with flank crossfire.

At parts where landing of amphibious tanks is possible, tank ambushes should be organized to fortify the antitank firing and obstacle system.

When organizing the engineering security, in addition to the usual measures, landing-preventing obstacles should be set up at places accessible for enemy landings, and mines should be laid in the direction of those operations.

Destruction of the enemy begins already in the sea with long-range facilities and aircraft as well as with ships from the fleet. As the landing approaches the shore to engage in combat with the enemy, artillery and tanks enter, directing fire at great distances.

Summing up what has been said, we may come to the conclusion that under modern conditions tanks will be forced to proceed to the defense. However, their defensive operations will usually be brief.

Further improvement in the means for equipping for combat and methods for conducting combat operations evidently will not exclude defense in future nuclear wars. However, in accordance with the general tendency to conduct highly-maneuvering combat operations, defense has taken on a high degree of activeness as well as anti-nuclear and anti-tank stability.

Since defense will be temporary in nature, but the defending troops must be ready for subsequent tank operations, it can be assumed that in defense, the positioning of tanks will be such as to permit rapid transition to the attack without much regrouping.

Section 7

Directing the Troops

1. General Problems in Directing Troop Combat Operations

By directing we mean conscious and organized influence on any object by a man or a group of people in order to achieve desired goals. Consequently, in order to achieve this directing, it is necessary to have a command organ, the object of the command, and communications back and forth between them. The basic operation of this system is: selection and analysis of data concerning the object of the command and conditions which influence it; the command organ making the appropriate decision; the object of the command confronting the problem; control of the command organ after acting on the object of the command and receiving from it (or from them) new data on the situation for the following specification of the decision, or making a new decision.

Thus, there are presently three continuously repeated operations: selection and processing information concerning the situation and condition of the object of the command, taking or clarifying a decision by the command organ, bringing up the problem to the object of the command, and appropriately putting together the situation.

However, the process for commanding troops under combat conditions is many-sided.

Commanding combat operations includes: maintaining high politico-morale conditions of the troops and keeping them constantly prepared for combat to fulfill the problems confronting them; continuous gathering and study of data on the situation; making the decision and presenting the problem to subordinates; preparing troops for combat operations and constantly securind their combat operations; organizing and maintaining continuous interaction; continuously checking whether orders and decrees have been carried out and giving aid to the troops.

From this complex of measures it is possible to separate out a basic component: continuous gathering of information on the situation and its analysis; making a decision and presenting it to subordinates.

The experience of past wars and what was learned following the war asserts that if the commander always is aware of the real situation, makes a decision in time and clarifies the decision with relation to this situation and rapidly places the problem before subordinates, then as a rule success of the troops is facilitated and, as a result, they achieve victory over the enemy. This situation is correct for past wars and for future wars. However, the conditions for fulfilling the requirements for commanding troops have essentially changed. Basic changes in the equipment organization and the character of operations have had an especially strong influence on commanding troops, all of which took place in the past few years.

The appearance of nuclear weapons and new combat methods lends modern combat a decisive character and combat operations themselves begin to be distinguished by a high rate of speed, surprise, frequent and sudden changes in the situation and continuity. All this has only complicated the situations in which it is necessary to command troops.

Especially complex situations arise in commanding tank units. They are distinguished from units of other types of troops not only in their capability for greater effectiveness in resisting enemy nuclear weapons and immediately using nuclear strikes of their own troops, but in greater impetus and high maneuverability.

In connection with this, increased demands are made on the commander and staff officers. Their activity must be creative. In addition, they must be fast in making decisions, resolute and flexible in carrying them out, skillful and lucid in presenting combat tasks to subordinates according to technical means of communication, always try to stay in touch with subordinates, display independence and initiative in carrying out the plans of the commander, improve their knowledge of enemy tactics, facilities and combat capabilities of both their own troops and those of the enemy. The degree of preparedness of commanders and their staffs may depend on their ability to fulfill modern requirements set forth in commanding troops.

In the process of command, the commander and staff officers have very concrete problems as a part of their function.

2. The Role of the Commander and Staff in Commanding Troops

The value of the commander is measured by his ability to organize his own activities and the work of subordinates in order to gather and correlate important data concerning the situation, rapidly make sound decisions and bring them to his troops and then check up on subordinates, helping them consistently and flexibly to carry out his decisions to achieve complete defeat over the enemy.

The commander in charge has full responsibility for directing his subordinates in carrying out the problems confronting them. The commander personelly makes the decision, and the decision, as is well known, is the basis of command. However, making decisions is not the only activity of the commander, his activity is much more extensive and many-sided. After making a decision, the commander determines the sequence and times for placing the combat tasks before his subordinates, organizes interaction and gives instructions for securing the combat operations of the troops. Always and everywhere the commander must instruct his subordinates in the fulfillment of their duties in connection with the requirements for conducting teneral troop combat. For this the commander himself must have a many-sided knowledge and specific practical experience in carrying out the tasks delegated by him to officers. In instructing others, the commander must not ignore the experience and knowledge of his own subordinates. Together with the subordinates he bears all the burdens of combat life. The duties of the commander must not be discharged in the form of trivial custory to inferiors. He commands only those forces and facilities which are directly delegated to him.

Modern combat takes place at a very fast rate, thus great speed in making decisions is required from commanders at all levels. This requirement applies in a larger sense to tank commanders. Persistence in carrying out decisions, daring and resoluteness, manifesting initiative and creativeness as well as readiness to take an intelligent risk, all this must be shown by a tank commander.

The conditions for conducting modern combat operations are much more complex. In connection with this, the number of measures for leading troops continues to increase, and the time for developing them and carrying them out continues to decrease. Thus, to a greater degree than was the case before, the commander needs assistance from his subordinate officers. They must guarantee him, if possible, favorable conditions for creative operations in commanding the troops, relieving the commander to a maximum degree from decisions of a technical and second rate nature.

It is generally known that the staff is the basic organ for commanding troops.

It falls to the staff and its chief to direct the preparation of data which the commander needs to make decisions, correlate the work of all officers and check whether orders have been carried out. All the work of the staff is organized on the basis of the commander's decision as indicated to the higher-ups on the staff.

The importance of the staff work is understandable if we enumerate all the problems which it solves. These problems, according to the information of the foreign press, may be as follows: to organize reconnaissance of the enemy and of the terrain; to organize radiation and chemical reconnaissance; to evaluate the radiation, chemical and bacteriological conditions, to continuously gather data on the enemy by all available means, their troops, location, meteorological conditions, radiation, chemical and bacteriological conditions, evaluate and determine their influence on the fulfillment of combat duties; work out necessary command operational-tactical calculations; issue preliminary orders and battle orders; record and work out combat duties; work out and bring up to subordinates and cooperating troops problems of reciprocal action and maintaining it during the course of the battle; organizing detailed security of combat operations, command points, communications and command duties; presenting dispatches to the higherups on the staff and information to subordinates, neighboring and cooperating troops concerning complexities of the situation, checking up on and helping subordinates in fulfillment of their duties.

In solving these problems, a special responsibility of the staff is always knowing the true situation and the state of combat readiness of their own troops, constantly obtaining data on the enemy and discovering their plans, and also informing themselves about the course of the fulfillment of combat tasks given to the troops by subordinates.

It is thought that the circle of duty which the staff fulfills is very large. And consulting about the solution of the enumerated problems may only be done by a staff which has good operational ability. Each man on the staff must be at his place. Thus, the commander always tries to have carefully selected personnel on the staff and takes responsibility for their preparation.

What characterizes modern methods of troop command? This question may be answered by the copious experience of tank troops with consideration of the views which are included in the other modern armies of the world.

It is emphasized that modern methods of troops command are characterized by: the least expenditure of time in gathering and processing information, decision-making by the commander and presenting the problems to subordinates; centralization of command and broad initiative of subordinate officers in carrying out the plan decided upon by the commander; the possibility of commanding troops in movement; the abrupt abbreviation of workable combat documents; tendency toward active leadership; intelligent application of measures for mechanizing the automated command.

3. Organization of Combat Operations under Difficult Conditions

It is pointed out in the foreign press that the process of commanding troops in combat operations includes a large number of measures and problems. Disregarding any of them may lead to an undesired result in preparing for combat operations and during combat operations.

The most important measures for commanding troops can basically be broken down into those concerning the gathering and evaluation of data concerning the situation; measures connected with making a decision by the commander, putting it into official form; measures for presenting the combat tasks to troops and problems of interaction; measures for checking up on and helping subordinates carry out the tasks given them.

Let us examine these groups of command measures in more detail.

Gathering and correlating data on the situation. Data concerning the situation which is necessary for the commander to make his decision may be classified into the following groups: the enemy, his troops, neighbors, radiation, chemical and bacteriological conditions, terrain, meteorological conditions, time of year and time of day. In addition, the commander needs such information as, the economic condition of the area of combat operations and the social-political makeup of the population.

The volume of information on each group which is needed by the commander may be different in each concrete situation. So, for example, if the batallion commander receives a problem concerning completion of a maneuver in the rear of his own troops in a new region, then he is not likely to need detailed data about the enemy; on the other hand, to a large degree he needs data about the condition of his own units, concerning radiation and chemical conditions and the nature of the terrain, especially road networks.

To gather and process all data on a situation in a short time, even part of it, is a very complex business; successful completion of this task largely depends on precise organization of the commander's work and that of his staff.

The commander, along with the chief of staff, explaining the task which has been received, usually determine the measures which must be carried out to best prepare for the imminent operations. In addition, they will determine what data they will need concerning the situation and when they will need it in order to make operational-tactical calculations. Bringing the tasks to the subordinates in time permits them to purposefully organize their own work in gathering and processing data concerning the situation and conducting calculations.

In order to avoid overlapping and parallelism in the selection of data concerning the situation and, consequently, to shorten the time for this step, the work of the staff officers is usually set up according to the principle of specialization. A clear allotment of duties between the officers, specialization and, at the same time, their interaction is one of the most important conditions in a troops command organ.

In the view of combat specialists abroad, the centers where the data concerning the situation is correlated and measures are worked out to guarantee that decisions are made and carried out, should be operational and reconnaissance parts of the staff. For this reason, all the command officers, including the troop chiefs of all kinds, will inform the operational and reconnaissance sections about data obtained by them concerning the situation. Doubtlessly the import important information will be reported directly to the commander.

The methods for the commander and the staff receiving information concerning the situation may be different. The following is most characteristic for the staff of armored forces: private observations of the commander and staff officers on the battlefield with mobile observation points; reports of subordinates and information from senior staff officers concerning the technical means of communication; receiving information on the situation from one's own troops and on the enemy from air reconnaissance with the aid of various technical communication means; personel contact with subordinates on the departure (flying out) of staff officers.

As seen from the enumerated methods of receiving data concerning the situation, use of technical means of communication is very important. Thus, the tank officers must know how to operate with means of communication.

The possibility of receiving data concerning the situation from subordinates two steps below is very important under present conditions, since this saves a great deal of time.

Characteristic for work of commanders and staff officers under modern conditions is commanding the troops with the aid of radio signals worked out shortly beforehand. For the experience of the Great Patrician War, it is known that subordinate commanders usually report to the chief commander concerning any events with numerical signals or with conventional words, and the staff transmits to the senior officers the radiogram developed with the necessary details.

All the processed data is expeditiously reported to the commander personally on his work sheet. Only in this case may he quickly assimilate and analyze the situation in depth. In addition, the generalized situation is preferably plotted on the map of the chief of staff.

The gathering and correlation of data concerning the situation as well as operational-tactical calculations connected with this, necessary for making a decision by the commander, occupy an important place in the work of the staff. In order to hasten this process, the commander and the staff use various standard documents under modern conditions.

Thus, the making of a decision by the commander and its validity depend on how quickly and fully data on the situation are gathered and correlated and operational-tactical calculations are made.

<u>Decision making by the commander and putting it into official form</u>. The decision of the commander is the basis of all measures in commanding troops. In consists of the combat operational plan, determining combat problems by subordinates, organizational problems and interaction and organization of command. The amount of problems in the decision of a commander depends on the tasks presented to him and the conditions of the situation. It is noted that in in contemporary combat a decision will be made in the minimum amount of time. Thus, the methods for making a decision by the commander must guarantee not only its reliability, but required speed, because an ill-timed, late decision, even a very well-founded opinion, will not lead to success in battle.

The conditions under which the data reach the commander and his staff can be very different. In each concrete situation the commander usually selects the main information from all that collected. The main link in the chain of events is found, it is evaluated and the most expedient decision is made--a very important task, requiring great mental effort, broad combat knowledge and practical experience.

To make a decision means to determine the goal of the battle and the most expedient means for achieving it. The goal of the battle is contained in the problem posed by the commander in chief and the method for achieving it is determined by evaluating the situation. Thus, making a decision must be preceded by clarification of the combat problem and evaluation of the situation.

How to clarify problems and evaluate situations. This is generally known since here we are studying only the methods for conducting such work.

The most characteristic conditions in which command of tank operations is carried out is rapid and frequent transfer of the commander and his staff. Thus, frequently the tank commander is forced to make a decision while moving. Consequently, as a rule he has to clarify the combat problems and evaluate the situation having a very limited number of aids around him. Moreover, data concerning special problems which require more specifics for the commander with clarification of the problem and evaluation of the situation, must be received by personal contact with appropriate staff officers.

This is very important in order for the commander, clarifying problems received by the chief, to be able to determine a plan of action. In such a situation the commander or the chief of staff, following the commander, may familiarize certain staff officers with the plan of combat operations. This will more purposefully facilitate their activities in guaranteeing that the commander makes a decision and various measures are worked out.

After that, since the combat operational plan has been presented to the subordinates, and they will have been given the appropriate orders, the commander will evaluate the situation with his closest aids, when necessary he will specify the scheme of his decision, determine the combat problems, the basic questions of interaction and command organization.

Simultaneously with making a decision, he will put it into official form, i.e. it will be reflected in a written or graphic document. It is also possible to record the decision on tape or on dictaphone.

It is most characteristic for the tank commander to plot his decision on a map with the necessary text on the legend. As experience has shown, such a method requires less of an expenditure of time. As a rule, the decision is put into official form on the working map of the commander, and copies of his decision must be on the working maps of people in official positions who, according to their duties, must have complete data on the situation. In some cases, if the combat orders have arrived from the commander in the form of graphic documents, to save time it is expedient that the decision be put in official form right on the map received. Then the situation of the subordinate troops can be plotted on this map, as well as basic information concerning the enemy, radio and chemical conditions, as well as other data necessary according to the situation.

Presenting the tasks and problems of interaction to the troops. Well-timed presentation of the decision to subordinates means to give them the necessary time to prepare to carry out their combat tasks.

Secrecy in presenting the decision to executives, as well as command of units in general must be guaranteed so that combat operations and combat tasks will be kept secret. This is usually achieved with wise use of various technical means, certain command documents and personel contact of staff officers with subordinates. Moreover, not the entirety of the decision made by the commander is brought up to the executive officers, but only that which they require in order to best carry out their combat tasks.

The decision of the commander when organizing combat operations up to their beginning is usually presented to subordinates personelly by the commander or by staff officers in the form of oral or written combat orders, or commands to guarantee combat operations. As a result, in the course of combat operations, the new or specified decision of the commander is presented to subordinates in combat edicts by means of technical communication facilities and may be duplicated by transmission of written or graphical combat documents through staff officers.

When bringing up the decision to units, we usually operate according to the following principle: the combat problems are first presented to the executives whose operations depend on changes in conditions.

A more intelligible method for delivering combat tasks to subordinates is by personal contact with them by the commander. In this case, if the combat operations are still only being organized, the subordinate officers may be called to the commander in chief to listen to oral combat orders. In the course of combat, as a rule the commander or the staff officer does not call subordinate commdners to himself, but rather they come to him to receive their combat assignments. In this or in the other case, it is obviously expedient before verbally presenting the order to deliver the map to the subordinate commander with the combat assignments plotted beforehand.

The most widespread means for armored forces to place combat problems in the course of battle is to issue combat orders by radio. This method makes it possible to bring the combat problems to subordinates comparatively rapidly, which is very important under modern conditions. Each tank officer must know how to conduct conversations by communication facilities, especially by radio.

For transmitting combat tasks by technical means of communication, in order to save time, typed documents are widely used as well as command signals worked out beforehand.

Written combat documents and edicts at the present time are confirmations of earlier-presented combat problems. In addition, they make it possible to understand the plan of the commander-in-chief more fully as well as calls to increase the responsibility of subordinates and precise fulfillment of their combat tasks.

In armored forces, written combat orders and edicts will be worked out in the organization of combat operations, as well as in the course of combat, if change to a new type of combat operation is imminent.

A combat order or edict may be worked out on a map or else recorded on a tape (dictaphone).

At the same time, the combat tasks are being presented, troop interaction is being organized, because the coordination of unit forces of various kinds of troops and special troops among one another as to tasks, lines (regions, objectives), directions according to times and operational methods are some of the basic methods for achieving success in battle.

The basic problems of interaction (where, what, who and when they must be carried out) are usually determined by the decision of the commander and are brought to subordinates when giving them their combat tasks. Thus under conditions of tank combat operation, when the tank commander frequently does not have time to organize interaction, he limits formulation of the combat problems. The same questions of interaction which were not reflected in formulating combat tasks will be brought up in carefully supplemented combat edicts.

It is thought that sustaining continuous interaction in the course of combat is impossible without mutual knowledge of the commander and staffs of the interacting troops, giving them their tasks and informing them of the conditions. The staff must play a large role in solving those problems.

It is pointed out that problems of interaction must occupy the commander and the staff continuously, starting from the moment they receive their combat tasks and ending when they are carried out. In other words, the commander and the staff determine and give instructions concerning reciprocal action and when the received tasks are explained, when the situation is evaluated, when the combat tasks are placed before subordinates and when commanding troops in the course of combat. Moreover, to solve the problems of reciprocal action in the case of a high degree of maneuverability of the troops and the impetuous nature of their combat operations, it will not be possible to do work on the spot. For this purpose, it is often necessary to use working or specially prepared maps, aerophotographs and also helicopters.

In all cases, when organizing the reciprocal action, the commanders and the staffs must pay special attention to guaranteeing the maximum effective use of nuclear weapons and immediately utilizing the results of their application.

Checking up on and helping subordinates to fulfill the combat tasks given them. In the single process of managing the organization of stable and continuous communication between executive officers and command organs, there are important measures without the fulfillment of which the success of combat would be in great doubt. It is impossible to command if the commander does not know the situation, the character of the operations, the safety of subordinates, to whom his orders have been given. For this purpose, the commander and staff check up on their activities. Checking up is necessary on the part of the commander, on the activities of his immediate subordinates and their functionaries, but also on the part of the commander and the staff on the operations of the troops subordinated to them.

The commander checks up on the work of the staff so far as planning and securing combat operations, well-timed placement of the combat tasks to subordinates and presenting them with problems of reciprocal action, organizing command and communication points, organizing aid for subordinates and carrying out the tasks given them, etc.

The commander and the staff constantly follow up the combat tasks and their well-timed reception by subordinates, that they are correctly clarified, that the plan of the commander is appropriately solved by executive officers, the detailed security of combat operations, effectiveness and opportuneness of utilizing strikes by nuclear weapons made on the enemy, etc.

In the case of a high degree of maneuverability and impetus of the combat operations of armored forces, it is very important to check up on shifts and locations of subordinate command points. In order for communication between command points to be stable, the commander in chief will often point out to the staff the direction in shifts of command points, the place and time of their interruption (deployment), and the sequence of the shifts.

An important place in the control system of modern armies is given to organization of the command service, because it is called upon to secure the organization and rapid shift of troops to the region of combat operations as well as to the field of battle.

Checking up is accomplished with various methods.

The most effective means of checking up is an excursion (departure) of the commander or the responsible staff officers to check up on accomplishments directly with subordinates. However, the conditions of tank combat operations hardly will permit frequent association with subordinate commanders.

Checking up on the operations of tanks may also be accomplished by direct conversations with commanders or staff officers using technical means of communication. But this method may be used only to a limited extent since it may be used, with consideration of secrecy, only for solving simple problems.

It is assumed that in modern combat wide use will be made of the method of receiving data of interest to the commander from conversations overheard with subordinates. For this it is necessary to include communication facilities of the commander-in-chief in radio networks of subordinate instances [sic.].

Only by combining various methods of checking up with consideration of the concrete situation is it possible to achieve effective control of subordinate operations and provide them with help in time to fulfill the tasks given them.

Securing the combat operations of troops. This work occupies an important place with the commander and the staff. In order to organize combat operations, it is sufficient to make a decision on the battle, bring it up to subordinates and organize their reciprocal action. In addition, in order to achieve success, the commander and the staff must generally secure combat operations. It is generally known that the basic measures, securing combat operations, include reconnaissance, military outposts, defense against weapons of mass destruction, camouflage, engineering, material, technical and medical provisions, etc.

It is thought that the commander will give his order to the staff personally according to the detailed securing of combat operations, i.e. determine the security problems and releasing the forces and facilities necessary for this. On the basis of the commander's decision, his orders and edicts, the staff will plan, organize and check up on the securing of combat operations. However, the staff officers will not always be bale to receive instructions from the commander on these problems. In these cases, based on the decision of the commander, they must opportunely and correctly organize the general security of troop operations.

4. Command Points and Requirements made for them.

The commander and his staff will command subordinate units and sections from command points.

A command-observation point is usually set up in the tank batallion in which the commander of the batallion and the staff are located.

As attested by the foreign military press, several command points are usually organized in the troops of modern armies. This is dictated by the complexity in commanding troops and the necessity of echeloning command points in order to increase reliability and stability of command. In addition, one of the created command points is the basic one which is located along with rear units at the rear command point.

In addition, mobile observation points may be precipitated from the basic command point. However, it is assumed that if there is a commander at that or at any command point, then at any given moment this is the basic one from which subordinate troops are commanded which are conducting combat operations. Proceeding on this basis, it can be concluded that the command points will be created such that from them it is possible to maintain continuous and reliable communications with subordinates and interacting units, sections (units) and higherups on the staff. Evidently, a large part of the command organs and technical facilities will be at the basic command point. Thus, as a rule, the commander will be at the basic command point and will leave it only when circumstances so require.

In addition to the basic command and rear command points, it is possible to set up a forward command point which is usually organized during the course of combat operations to command troops operating in the main directions. It is pointed out that it will be equipped with better protected and more mobile vehicles than the other command points. Under modern conditions, the forward command point will be shifted and will also operate from helicopters.

The rear command point is organized to command rear units and sections. However, the necessary facilities will be provided so that, in the case of need, it will have the possibility of taking over command of the troops.

It is pointed out in the foreign combat press that in modern warfare the command points are one of the first objects of strikes by nuclear weapons, thus they will not be able to stay at one place for any length of time. This requirement is fulfilled in the organization of combat operations when the troops have not yet started them in the course of combat. Thus, the transport facilities of command points evidently must have a high degree of mobility and speed, and they must guarantee the fulfillment of functional duties by the staff personnel, their protection from weapons of mass destruction and necessary rest.

The shift of command points into a new region is usually preceded by careful reconnaissance of the terrain by special reconnaissance groups. The region for these points will be selected primarily so as to guarantee reliable maintenance of communication with troops, so that they have natural cover and available means of camouflage. As a rule, the reconnaissance group is headed by a staff officer. The makeup of the group includes specialists of different kinds of troops and units for equipping and guarding the region of the command point.

The order of position for vehicles and personnel in column from the command point when changing places is determined by the commander and the chief of staff. This is necessary in order to guarantee mobility and operational smoothness in the work of the staff officers.

The high degree of maneuverability and the precipitous operations of tanks in attack predetermine the necessity of commanding troops from mobile command points. In addition, it will be noted that the smaller the scale of troop instances, the longer the time the command point will be in motion, but work at individual places will be carried out with brief stops. Together with this, it is pointed out that if several command points are set up, then to move one of them is done such that its movement does not coincide with the change of place of another. This increases the reliability of troop command.

It is pointed out that in the new region, the command point is usually changed with the authorization of senior staff officers. The command points are often changed with dispersions and along different march routes. This is necessary to prevent the chance of their being destroyed simultaneously with one nuclear blast.

On defense, the command points will also not stay long in one place, because they can be quickly spotted and destroyed by the enemy.

With disposition, a command service is set up at command point sites which organizes military outposts and maintains a strict order of transport movement and movement of personnel, illumination, heating the working places and resting places.

5. Technical Means for Commanding the Troops

It is pointed out abroad that the use of electronics exerts a tremendous influence on the character of combat operations under modern conditions, together with the use of rocket-nuclear weapons and other new combat means. Direction of rocket-nuclear facilities, forces, antiaircraft defense, aviation, tank troops, motorized infantry, etc. is accomplished with the aid of electronic devices.

It is pointed out in the foreign press that to command armored forces, use is made of communication facilities and the staff-command machinery, reconnaissance facilities, processing, documentation of information and reflecting conditions.

In order to continuously guide the troops strictly, and yet flexibly, the command must always be aware of the troops under him, he must immediately react to all changes in the situation, report these to the commander in chief and present tasks to subordinates in a well-timed manner. In order to fulfill this entire complex of measures, of course is only possible for the commander and the staff in the presence of well-organized and continuously operating communications, which is the basic means of command.

Communications permit the command and his staff to rapidly notify the troops about the threat of combat and guide them in combat preparedness, on march and in the course of combat operations, place tasks before subordinates, secure interaction with neighbors, aviation and sections of other kinds of troops, and also to direct from the rear and inform troops concerning radiation and chemical contamination caused by the enemy.

In order that communications might guarantee continuous and flexible command of the troops, it is organized with consideration of operational-tactical conditions and the possibility of communication with sections and units. To a large degree, the entire complex of operational-tactical conditions in organizing and securing communications influences the character of modern warfare and the possible effect of the enemy.

It is pointed out in foreign combat literature that the use of nuclear weapons and other firing facilities by the enemy may lead to the destruction of individual command points and to all command units being put out of commission. Under these conditions, the main requirement for communications is to guarantee its reliability so as to be able to command the troops from another command point if necessary or to transfer it to a subordinate or to the commander in chief. In order to achieve this, it will obviously be necessary to organize communications with all points while to set it up between the top and the botton, it will also be necessary to protect communications junctions from weapons of mass destruction and radio jamming.

It is noted that in connection with the broad application of nuclear weapons by both sides, as well as other firing means, it will be necessary to operate in zones of radioactive contamination, while surmounting sharply increasing distances between command points. In addition, broad use is required for subsidiary communication junctions, relays and information transmitters. This makes it possible to increase the reliability of communications and in case high-power nuclear blasts are used by the enemy, when short-wave communications are interrupted for an extended period of time.

Judging from the press, in the armies of NATO nations a great deal of attention is being paid to radio waves. Considering the present possibility for radio reconnaissance and setting up radio jamming, appropriate measures will be strictly observed and taken to guarantee reliable communications when radios are jammed, the jamming being created by the enemy. For this, the primary need is for reliable camouflage of command points and the work of communication facilities,rapid exchange of information by communications channels, strict observance of discipline in conversations. It is acknowledged that in contemporary conditions, special attention must be paid to automatically classifying information in communications channels, since this achieves not only secret command of troops, but transmitting instructions and reports by technical means of communication in an abbreviated period of time.

The highly maneuvering, dynamic character of tank combat operations, possibly frequent and abrupt changes in the situation, makes it necessary to arrange timely communications and set up a system of communications to that continuous and flexible command is guaranteed in changing from one type of operation to another, without essential reorganization, since there will often not be enough time for this.

It is pointed out that under modern conditions the factor of time in commanding troops assumes primary importance. The high rate of conducting tank combat operations creates the necessity for the commander and his staff to be in movement for an extended time, to command from moving points. According to the military press, these problems can be successfully solved with the aid of staff command vehicles, equipped with all the necessary means of observation, equipment and which are comfortable to work in. Helicopters may also plan an important role, equipped with radio equipment and other technical means of command.

It is pointed out in the foreign military press that communications problems can be rather completely solved with the presence of individual communications systems, which with the least expenditure of means permits the commander and staff officers to achieve centralized command of troops, materials and security techniques, clear interaction and well-timed transmission of warning signals. And for this, of course, it is necessary to have communications between command points, as well as between officials on them. Moreover the most important type of communication remains the radio, which can secure the command in the most complex situation. Obviously, radiocommunications will be organized by radio networks and radio directions, the quantity and composition of which will be determined on the basis of command requirements and the presence of radio facilities. So, for example, in a tank batallion, radio communication of a batallion commander with a commander-in-chief and his staff is organized according to two radio networks, and with the commander of tank companies, platoons and linear tanks, and also with the chief-of-staff of the batallion and with the technical observations point according to the radio network of the batallion commander.

In order to guarantee the stability of radiocommunications, it is very important to carefully distribute frequencies and distribute radio facilities on command points such that they do not interfere with each other in their operations. In addition, measures will be provided for radio concealment, protecting radiocommunications from jamming and maintaining it in a stable manner at the time when command points are in movement.

Radio relay communications also are finding wide use.

It is pointed out that conducting means of communication will be used in a very limited amount, mainly in regions of dispersion, in defense and in the original position for attack, as well as on command points.

Tanks will use mobile means of communication in all types of combat activities, and signal means will be used in units.

Complex use of all types of communcation permits full use of all the positive qualities of each of them, maximum attenuation of their negative side, which may be utilized by enemy radio reconnaissance, and facilitates increasingly reliable communications in cases of firing and radio interference, created by the enemy. Complex use of all communication means is realized on communication junctions, the assignment and makeup of which is determined by the scale of the unit command.

To defend them from enemy weapons of mass destruction, the communications junctions will be distributed at places having natural cover (in ravines, gulches), and also in shelters; the communications facilities laid out in a dispersed manner and camouflaged from air and ground attacks.

It is emphasized that technical reconnaissance facilities and data information are very important in command. These include observation equipment, radio, radio-locating facilities, chemical and meteorological reconnaissance and other different apparatuses. Data obtained with them will reach the staff by communications channels from the units, and will be used for decision-making by the commander.

Information processing facilities help the commander and the staff officers to quickly correlate data on the situation and make calculations which are necessary for a decision. Such methods include electronic computers, key-punch machines, slide rules, charts, graphs, etc. According to the data of the foreign press, the use of electronic computers makes it possible to almost cut in half the time required to carry out calculations for the use of nuclear weapons, planning regrouping of troops, material and technical security.

It is thought that means for documenting representations of the situation include sound recorders (tapes, dictaphones), means for duplicating text and graphical documents, photo- and blueprinting equipment. Using tapes and dictaphones, it is possible to record combat orders and messages, transmitted by communications channels, and, thanks to this, greatly abbreviate the quantity and volume of written combat documents. Other types of these apparatuses make it possible to rapidly duplicate documents and at the same time to facilitate command of the troops.

It is acknowledged in the foreign press that the enumerated technical facilities greatly aid the commander and the staff in achieving continuous and flexible command of troops. However, they make it possible to solve only individual and frequent problems. It is also acknowledged that under modern conditions the need has grown for using a complex automation of command.

Now in the century of such a turbulent growth of technology, it has become fully evident that old, long-confirmed forms and methods of commanding troops and combat facilities have outlived themselves. Now many complex problems must be solved and presented to executive officers in a very short time, computing minutes, even seconds. Here the machine comes to the aid of the commander and the engineer.

According to the data of the foreign press, electronic means of an automated system for commanding troops make it possible to receive information from subordinates and interacting units on multiple channels of communication in which data information is set up, data concerning the enemy and his troops, and introduce it into staff electronic computers. After correlating the data received with the aid of electronic computers on a screen, the commander and staff officers may be given the following necessary information: concerning the most important enemy objects, relationship of forces, the most expedient directions for overcoming the zone of contamination, etc. On the basis of these data, the commander may quickly make a decision and in minutes and even seconds present the subordinates with their tasks. This makes it possible to sharply increase the effectiveness of using new combat means.

The introduction into armored forces of new methods for command neither diminishes nor increases the role of the commander and staff officers: the electronic computer can operate with large numbers a thousand times faster, but man is the master and sovereign of all technical means, not the servant.

In order to master new techniques, a still higher level of tank officer preparation is required.

Chapter VII

Combat Capabilities of Armored Forces and Determining them by a Mathematical Modeling Method

Section 1

The Need to Study Combat Operations

It is generally believed that qualitative and quantitative changes occurring in technical equipment, armaments and in the organizational structure of modern armies has led to essential changes in the nature of combat in general and the combat operations of armored forces in particular.

Already in the last war, the combat operations of enormous tank masses developed over a large depth and took place at high rates of speed. Under conditions of a rocket-nuclear war, the dimensions of tank combat operations and the speeds at which they occur have increased considerably. Sustaining a large radius of operations with high-powered weapons, they take on an exclusively dynamic character, they are carried out with decisive goals over enormous areas, characterized by impetus and power. Under these conditions, the problems of the commander and of the staff in commanding highly-mobile armored forces have become much more complex. The need has grown as never before for a well-timed, scientific prognosis of the entry and withdrawal from imminent combat activities.

When we speak of scientific investigations this, of course, involves the experimental method. However, carrying out experiments involving the organization and the conduct of troop combat operations is a very difficult business. This difficulty, insurmountable at first glance, is like a stumbling block to the study of combat operations. But fortunately this is far from the case. Modern mathematics makes it possible to set up mathematical models which represent any process. These mathematical models describe the structure of the actual system (object) in qualitative terms. They may be subjected to analysis, and to operate them is much simpler than the real system; thus, in essence they present a possibility for widespread experimentation.

V. I. Lenin wrote "The unity of the nature of finding differential equations in "wonderful analogy" concerns different areas of the phenomenon." [V. I. Lenin: Complete Writings, Vol. 18, p. 306]. This Leninist assumption serves as a methodological starting point for perceiving the phenomena in any area, among them in the conduct of war, with the aid of models of a different physical nature.

In the research it is possible to change some characteristics of the system according to the plan conceived, preserving other constant characteristics, and thus it is possible to determine how these changes influence the system as a whole, if they take place under real conditions. In the studies, we model the actual combat processes and experiment in abstract terms.

Finally, setting up and using the mathematical mode, we carried out symbolic experiments in the course of one day. Very great difficulties may arise in constructing models, and the models present themselves as very complex mathematical expressions.

In the simplest form, all mathematical models are described by equations of the type:

$$W = F(N_i, P_j),$$

where W is the magnitude characterizing the result;
N_i, P_j are the qualitative characteristic combat objectives of one side.

If this would be possible, then any mathematical study of combat operations would include the conducting of experiments in real conditions. But the majority of investigation problems do not permit experiment. Thus it is necessary to find different abstract means of experimentation (models), guaranteeing close coincidence of the conditions of the conducted experiment with real conditions and at the same time not influencing the real system. These methods are called modeling.

It is thought that simultating the combat operations of armored forces presents the possibility of studying a very wide range of their combat activities, finding and analyzing the difficulties which are encountered in combat situations and taking them into account, working out appropriate methods of combat operations. Consequently, using the modeling methods, it is possible to work out tactical operations of armored forces in hypothetical conditions which may come up in combat operations.

Simulating the combat condition in which the decision must be made, it is possible to precisely or approximately determine the values of variables at which the magnitude, characterizing the result, assume an optimum value.

After setting up the models representing the content of the problems, set about finding the solution for which it is necessary to determine the values of variables (N_i and P_j), maximized or minimized, (depending on the significance of the problems) result of solving the problem. The solution may be found by conducting experiments on models, that is modeling or with an analytical method.

When setting up the models it is necessary to indicate which variables are accessible to the commander and which are not accessible. Moreover, the judgment of all commanders are not accepted unconditionally; they are subject to analyses for the purpose of clarifying the conditions. In the course of solving the problems, it may be found that the variables considered beforehand as being random may be controlled, as a result of which it is possible to remove some limits imposed on controllable variables. With such an investigatory method it is possible to arrive at a much better decision, then in the case where such an analysis is not made.

To conduct simulations of combat operations means to know the large number of factores influencing the studied phenomena to each degree, selecting the path to a solution which will lead to the desired result. In this sense, modeling combat operations differs little from other scientific studies and requirement made for this must be the same or even greater.

It must be kept in mind that modeling combat operations on the result of solving a problem may turn out to have a decisive influence on reconnaissance data. Thus, to calculate them in models must be done with extreme care. Only under these conditions does simulation give the desired effect and to a maximum degree will reflect the actual process.

For an objective prognosis of the course and outcome of tank group combat operations, it is very important to work out scientific methods of studying the combat capabilities of these groups and the combat effectiveness of the tanks themselves.

It is acknowledged abroad that one of the promising methods of such investigations in included in modeling tank combat operations using electronic computers.

The experience of using these methods permits us to proceed from studying the individual processes of conducting combat operations by means of partial problems to modeling entire battles. So, for example, it is reported in the foreign press that a group created in 1960 to analyze strategic and tactical operations (CTAG) of the US army unsuccessfully modeled the operations of ground troops. One of the basic problems of this group was working out models of combat operations for the universal electronic computers, intended to check out the operational plans and study complex problems to be solved by the staff. To the number of such problems we may refer to calculations to determine the combat capabilities of troops and finding principles on the basis of which it is possible to predetermine a more rational use of available forces and facilities to achieve victory in combat. It is assumed that the worked-out models of combat operations will embrace all the possible types of ground operations, even of large-scale operations.

Section 2

Determining the Concepts "Combat Capabilities of Tank Groups" and the "Combat Effectiveness of Tanks"

By the term "combat capabilities of tank groups" we mean the combination of indicators characterizing their capability to carry out a determined combat task in a concrete situation.

Proceeding from this determination in the capacity of a criterion for evaluating the combat capabilities of tank groups, it is necessary to assume the probability of fulfilling the combat task laid out for it. This criterion permits us to judge more fully and comprehensively the combat capabilities of any tank group in a concrete fight or battle. It is known that when formulating combat tasks, it is customary to indicate: in an attack--which enemy to destroy (defeat), in which area (line, objective), and how much time it will take; on defense--on which enemy group to inflict losses, what region (line or object), and how long to hold it.

Consequently, every combat problem includes three interacting and interrelated problems: defeating the enemy, seizing or holding territory and the time for fulfilling these tasks. Only when these partial problems have been solved is it possible to assert that the general problems confronting the tank group are solved. Each of the enumerated partial problems has its own criterion: probability of defeating the enemy, i.e. inflicting strikes on it which would lead to complete loss of combat capabilities of its troops: probability of seizing territory occupied by the enemy; probability of fulfilling tasks in a determined time.

Thus, the probability of fulfilling combat tasks, according to which it is possible to evaluate the combat capabilities of tank groups, is a complex criterion, consisting of three separate criteria. Which of them is the main one, the basic one? The experience of many combat operations is convencing witness to the fact that victory may be achieved only by defeating and capturing troops of the opposing side, seizing their equipment and arms.

However, in order to successfully fulfill tasks confronting groups of footsoldiers in general and armored forces in particular, the extent of the loss inflicted on the enemy is important. Primarily, with just this criterion, it is possible to evaluate the combat capabilities of tank groups.

Together with this, in determining the probability of combat tasks being fulfilled and evaluating the combat capabilities of tank troops, it is obligatory to use a second criterion: the probability of seizing (holding) determined regions. This criterion is subordinate in relation to the first, since after defeat of the enemy, inflicting losses on him which turn out to have a decisive influence on the combat capabilities of his troops, as a rule conditions are created for seizing his territory, in order to hold regions defended by tank groups.

The third and not least important criterion for evaluating the combat capabilities is time expended on the fulfillment of combat tasks, or the probability of fulfilling combat tasks in a determined period of time. The time factor always has a very important meaning during the course of combat operations, and in future wars its importance will increase immeasurably. To guarantee the gain factor of time to forestall the enemy operations and in order to make maximum use of the advantage of new combat facilities, primarily rocket-nuclear weapons and tank groups, is the most important problem in organizing combat operations. However, this criterion is subordinate to the basic problem, inflicting maximum losses and destruction on the enemy. The gain factor in time for forestalling enemy operations is not an end in itself, it is one of the most important conditions for inflicting damage on the enemy and destroying his troops.

Thus, from the three basic criteria we have examined, permitting us to judge the probability for fulfilling combat tasks by armored forces and consequently evaluating their combat capabilities, the most important one is to know the losses inflicted on the enemy. The extent of seized (or held) territory and the time to fulfill tasks are secondary criteria which may be taken into account when determining the quantitative magnitudes characterizing the combat capabilities of troops.

The functional dependence of the combat capabilities of tank groups may be written as follows:

$$W = F(N_O, N_K, P_O, P_K, \alpha, t)$$

where N_0 is the initial grouping of one's own troops;

N_K is the final grouping of one's own troops;

P_0 is the initial grouping of enemy troops;

P_K is the final grouping of enemy troops;

α is the parameter characterizing the combat task;

t is the time required to fulfill the combat task.

Thus, in order to study the combat capabilities of armored forces by the modeling method, it is first necessary to have data concerning the qualitative and quantitative make-up of one's own troops and the enemy troops.

These data provide tabular denominations and tabular numbers characterizing the combat and numerical make-up of sides, tactical-technical characteristics of arms and combat technology, training of the troops and the staff, the quality of the command. In addition, it is necessary to observe the following conditions: information concerning one's own troops must be reliable; the character of enemy operations (defense or attack) must be known.

As far as the parameters are concerned determining the combat characteristics of objectives, some of them may be theoretical-probable: the probability of uninterrupted work; the probability of attack, the probability of destruction, etc. The position of enemy objects may also take on probability with the characteristics: for example the probability that the combat object P_j will be located at point ε, equals P.

The final status of combatting groups designated by N_K, P_K is determined by means of realizing models on an electronic computer.

For one's own troops, it may be composed of the following magnitudes:

$$N_K = N_0 - N_1(t) + N_2(t) + N_3(t),$$

where N_0 is the initial grouping of one's own troops;

$N_1(t)$ is the loss after period t;

$N_2(t)$ is the reinforcement of troops and combat technical equipment after period t;

$N_3(t)$ are the groups returned to formation from the number brought out of formation after time t.

For enemy troops we have

$$P_K = P_0 - P_1(t) + P_2(t) + P_3(t).$$

To determine the combat capabilities of tank groups it is necessary to determine the combat effectiveness of tanks as the basic combat means entering into this group. Let us examine this question.

It is known that attempts to determine the effectiveness of tanks with the aid of general reasoning concerning three traditional tank components (fire power, maneuverability and armor plating) in the absence of precise data, evaluations and, as a result, a subjective approach have not yet brought positive results. Evidently, in order to objectively evaluate tank design, it is necessary to hold to a different course--to determine the probability of tanks fulfilling their tasks in combat or else in one of its stages. Such a probability method permits us to evaluate more correctly the tactical-technical indicators of the tank and gives objective quantitative criteria for comparing vehicles of different designs.

It is pointed out in the foreign military press that the combat effectiveness of tanks is understood to be their capability of fulfilling characteristic combat tasks. The most difficult of these tasks is destroying enemy tanks. The in the capacity of a basic criterion of effectiveness we will take the tank's ability to destroy an armor plated enemy vehicle. This criterion may be taken as the basic one, because tanks capable of effectively destroying an enemy tank are capable of operating effectively and fulfilling their other tasks.

For a quantitative analysis of the combat effectiveness of tanks, the criteria may serve as the probability of fulfilling tasks (destroying or not destroying targets), or mathematical expectation of damage inflicted on an enemy object. These criteria may be determined theoretically either experimentally by conducting dual battles, tank against tank, or another combat method. The combat effectiveness of a tank in such instances may be determined by the tactical-technical characteristics of the tank itself and the means with which it conducts combat, as well as the trained crew. The criterion of effectiveness in a given situation will be the probability of destroying the enemy. However, this criterion is insufficient to judge the combat effectiveness of tanks in general.

It is known that the combat operations of tank sections is not dual between individual combat facilities. Units of various kinds of troops participate in battle with various combat techniques interacting with each other. Thus, to judge the combat effectiveness of a tank as a result of dual combat and even as a result of combat with small units would be incorrect. For a general study of combat effectiveness, it is necessary to take into account the relative scales of combat operations in which a large number of tanks is participating. It is known that the basic principle of utilizing tanks is their maneuvering operations. Their combat effectiveness must be studied in just these situations.

However, to find the basic indicators of effectiveness (probability of completing combat tasks with mathematical expectation of enemy losses) is still insufficient to judge the combat effectiveness of tanks. It is also necessary to know the expected (on the average or with determined probability) extent of one's own tank losses. This criterion is very important in those situations when it is necessary to evaluate the combat economy of tanks of one type or another and make a decision concerning the expediency of using any assumption of armaments.

When we speak of such criteria as the probability of fulfilling combat tasks and the mathematical anticipation of damage, we must primarily keep in mind that the tank fulfills its combat tasks with weapons--shooting. But an important influence is exerted on this parameter, as well as such characteristics as operational supplies, maneuverability, protection of the crew from the destructive factors of nuclear blasts, etc. Thus to evaluate the combat effectiveness of tanks is possible only on the basis of complex calculations combined with certain mathematical indicators. As a result of this, the study of combat effectiveness if very complicated.

To study the combat effectiveness of tanks, let us examine some variables in the makeup of initial tank groups N_0, varying the amount of tanks. Such a variation may be produced in the widest possible limits. It is possible to judge the combat effectiveness of tanks according to the extent of changes in the final grouping N_K.

The same method is effective for studying the combat effectiveness of perspective tanks. For this reason, parameters may be included in the composition of initial groups N_0 which are assumed in the make-up of perspective tanks.

Changing the composition of the tank group, not only the quantity of tanks, but the other combat facilities determine the effectiveness of these facilities and a more rational organization of tank groups. In other words, modeling the combat operations of determined troop groupings is attempted in the goals set before us.

Part 3

Methods of Modeling Combat Operations

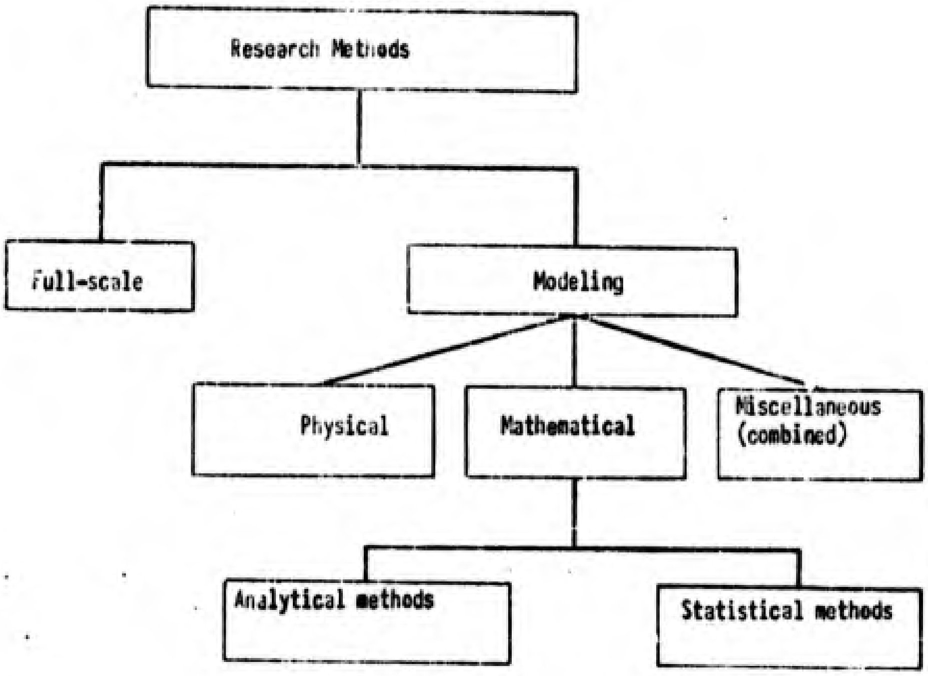


Fig. 130.--Methods for studying operations.

Full-scale methods and modeling methods can be used in studying combat operations. Modeling is classified into physical, mathematical and miscellaneous or quasi-mathematicsl (Fig. 130). Mathematical simulation of troop combat operations includes analytical methods and statistical modeling.

Physical models are those models which according to their nature and forms are similar to original ones and differ from them in dimensions, speed of the process and other parameters. To it we may refer war games, command-staff training, troop training, maneuvers, etc. The merit of this kind of simulation is included in the graphic nature of the models and their results, as well as in man's participation, the description of supposed operations which in concrete situations are an exceedingly difficult business. One of the essential shortcomings of physical models must be recognized in very conditional calculations of enemy counteractions.

Mathematical models of combat operations take the form of a system of mathematical dependences and logistic principles. These models are similar to the originals only in that they describe the same mathematical dependences.

Mathematical models present the possibility of studying the most varied types of troops activities using objectives of calculated technique for this and primarily electronic computers. In addition, they guarantee simplicity of localizing the most optimum solution.

Miscellaneous or quasi-mathematical models present themselves as a combination of physical and mathematical models of troop combat operations. Such a combination of models makes it possible to achieve a high degree of success, since such combinations of models give the possibility of a result of the mathematical model to verify on higher and special students, and then set up a refined mathematical model, etc. In addition, the mathematical model may include man.

Let us examine the methods of modeling enumerated above, in sequence.

<u>The physical modeling method</u> has been known for a long time. In organized and conducted war games, command-staff training and troop training in some approximation produces processes of troop combat operations for the purpose of seeking more rational solutions, prognosing the possible outcome of combat operations, finding optimum methods for utilizing troops and commanding them. organizing general security of combat operations. War games carried out for studied purposes make it possible not only to find the most rational means for conducting combat operations, and using forces and facilities in these operations, but they make it possible to evaluate and study the combat capabilities of troop groups and combat methods and produce arming and troop organization flowing from this requirement for combat technology.

War games played on maps are not only valuable means of studying combat operations, but are different from the method of preparing the commanders and the staffs. Having a series of merits, the war games, conducted on maps, however, have an essential shortcoming. One of them is the insufficient quantitative basis for making decisions. Very often participants in the gams, players as well as intermediaries, when making a decision do not have the opportunity to study the supplementary materials, the complex calculations which have been made, and to give quantitative and qualitative evaluations taking place with the combat process, but must rely on their own knowledge and personel experience. It is quite natural that when making a decision under these conditions, the influence of subjective factors show up. Many examples are known when different people evaluate the situation differently.

<u>The mathematical method</u> is used to study combat operations using electronic computers which make it possible to decrease the role of subjective evaluations and increase the importance of objective factors when making a decision. Conditions are created for organizing a scientific prognosis of combat operations.

As was pointed out before, the mathematical modeling of combat operations is based on describing mathematical methods of basic dependences, characterizing the process of war. These dependences are expressed with a system of equations and logical conditions reflecting these processes.

The methods for mathematical modeling are classified into analytical and statistical.

The analytical modeling method permits us to make a series of assumptions, sometimes very essential ones. Unfortunately, it does not permit a complete and accurate calculation of the enemy.

In principle, such mathematical models may be set up which would reflect the dynamics of combat operations of one side with various magnitudes and variations influencing these factors: the setup of combat ranks, the operations of one side, the organizational structure of the troops and the types of combat technique used. With the aid of such a model it becomes possible to study the combat capabilities of any troop organization, among them tank groups as well as to determine the combat effectiveness of tanks.

The difficulty of setting up such models includes primarily a qualitative evaluation of a large number of different factors exerting an important influence on the combat capabilities of troops and not subjected to mathematical description. In particular, such factors include the polotical-morale conditions of the troops and their training, the quality of troop command, the artistry of the commander, etc. By virtue of the fact that in analytical models it is very difficult to calculate these factors as well as other different chance factors in which combat operations are carried out, the final recommendations for making an optimum decision and to predict the final result of concrete combat cannot be arrived at which such a model.

The statistical modeling method consists in obtaining a series of chance realizations of the criterion and subsequently a statical processing. Statistical modeling, especially with the aid of electronic computers, offers the possibility of a deeper and fuller calculation of all the special features of combat situations, among them the counteraction of the enemy. This modeling method is used in order to determine the regularity of achieving chance events and chance dimensions, which cannot be expressed analytically.

The statistical model is a model which includes probable dependencies and is based on the principle of realizing chance magnitudes and events in concrete situations.

Miscellaneous or quasi-mathematical modeling is a method of modeling combat operations in which human activities (commander) and mathematical models are combined. In studying combat situations and, in particular, in studying the combat capabilities of tank groups and the combat effectiveness of tanks, mathematical models may serve not as a basis for making final recommendations and decisions, but for producing qualitative data necessary for a preliminary qualitative orientation on the basis of which a rational decision may be made with consideration of a series of other factors and reasons.

This method is a prospective one for studying the combat capabilities of tank groups, the combat effectiveness of tanks and giving a prognosis of the results of combat operations. The structural scheme of functioning of quasi-mathematical models is in many ways similar to command activities of a two-sided war game conducted on maps.

In order to condust a war game, it is customary to set up operational-tactical assignments which contain determined quantitative and qualitative characteristics; evaluating them, the trained person makes a decision and reports to the commander. The commander, comparing these decisions, evaluates the possible outcome of combat operations, sends word of the "losses" and the results of the combat. Then the situation is built up by presentation of routine original data (input). In the course of the war game, this process is repeated over and over.

Something similar take place when quasi-mathematical models are used. The original data prepared with consideration of the decision made, in the form of qualitative characteristics, is introduced into the mathematical model. The necessary calculations are made on the model or models (if there are several) which are used by the instructors to evaluate the decisions and the results of the combat. In the capacity of such results, for example, we may use the qualitative indicators characterizing the extent of damage inflicted by one side. When evaluating the decisions and results of the combat, the instructor proceeds not only on the basis of the quantitative indicators, but takes indicators into account which are not subject to qualitative evaluation.

Then a new combat situation is created, showing the consequences of the foregoing, but the qualitative data characterizing the new situation is again introduced into the mathematical model. When an opinion is changed, for example, concerning the makeup of striking groups, concerning the direction of main strikes, concerning the time they are to be inflicted, the original data are changed and obviously different quantitative results are obtained, according to which it is possible to make a judgment concerning any decision. In addition, varying the makeup of tank groups or parameters characterizing tanks, it is possible to determine the combat capabilities of tank groups and the combat effectiveness of tanks.

If the investigation of the process of two-sided combat operations of tank groups is taken as an example, then the scheme of the model will be such as shown in Fig. 131.

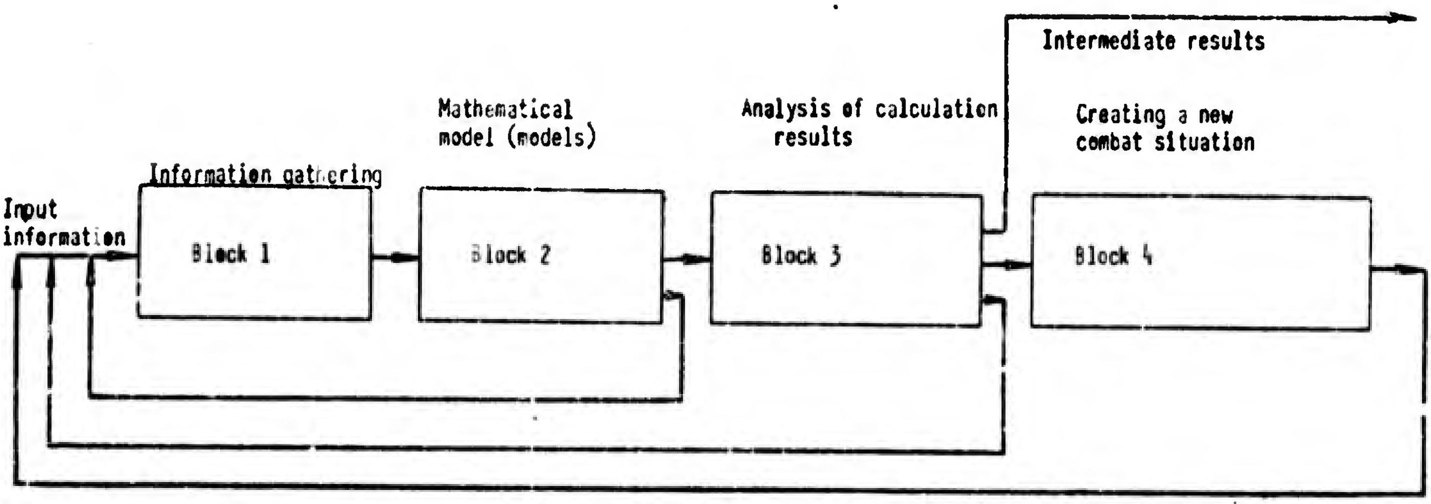


Fig. 131.--Drawing models of combat operations of tank groups.

All the original information is entered into block 1, qualitative and quantitative characterizing the counteractions of enemy troops in concrete conditions.

According to a program fed beforehand into the electronic computer, in block 2 we calculate the following without intervention of the instructor:

-optimum distribution of combat facilities on enemy objectives and extent of inflicted damage (for troops of the same side);

-losses of material parts according to technical causes;

-the amount of technical equipment returned to formation from the number damaged and those put out of commission by technical causes.

In this block there may be one simple mathematical model or a complex one. In the latter case, the problems entering into the complex must be mutually connected with input and output, permitting the possibility of a decision in a different real necessary sequence and making it possible to rely on a continuous single piece of information.

When setting up a complex mathematical model, it is expedient to make provision in order that in the interval between solution of each individual problem, intervention of the instructor was permitted in order to refine the interjacent information before solution of the next partial problem, with consideration of the results of the previous one.

The results obtained on the mathematical models of calculations are entered into unit (block) 3 and simultaneously into block 1.

In block 1, they may be used in the capacity of original information in producing calculations for the following combat situation, if troops participate in it, operating accordingly.

The following takes place in block 3: the instructor analyzes the results of the calculations and makes corrections with consideration of factors not taken into account in the model of block 2, due to the impossibility of quantitative expression. Corrections to the calculations are fed into block 1, and all the calculations, with consideration of the corrections, are printed out in the capacity of intermediate results.

The following takes place in block 4: the instructor sets up a new combat situation as a logical continuation of the preceding one and information characterizing it is fed into block 1. Here, in particular, the instructor makes a decision concerning overall disposition in the broad sense, i.e. which enemy groups must be destroyed with what means. It is difficult to set up a clear mathematical model for this purpose for large groups.

According to completion of the collection, the information in block 1 resumes the work of the model in the stated sequence.

It was already discussed above that when conducting war games without using mathematical models, for evaluating decisions made, the results of the combat and, consequently, the conclusion according to the evaluation of the combat capabilities of one side to a large extent depend on the subjective qualities of the war games leadership.

From examining the scheme of quasi-mathematical modeling, it is clear that it is also not devoid of shortcomings, since final judgments concerning the combat capabilities of tank groups and the effectiveness of tanks when using this model also pertains to the man with his own subjective judgments. However, it can be affirmed with a certain degree of assuredness that using the method of quasi-mathematical modeling allows the role of subjective judgments to be decreased, since investigation is conducted on the basis of objective and rather accurately calculated data obtained on the basis of mathematical models. It must also be noted that according to accumulated experience, the volume of clearly mathematical models in quasi-mathematical models will be expanded.

The good prospects of this method consist in the fact that it makes it possible to greatly shorten the time, the volume and the cost of studying the combat capabilities of tank groups of new organizations as well as the combat effectiveness of existing tanks and those about to be produced. In combination with troop training, this method makes it possible to investigate more rational means of conducting the combat operations of tank groups interacting with other types of troops and with different types of armored forces.

Using the quasi-mathematical method of modeling makes it possible to greatly increase the quality and the consequences of war games, carried out for definite purposes.

The practical realization of this method at the present time depends on scales and levels of working out mathematical models realized on electronic computers.

Finally, let us emphasize once again that the use of the methods of modeling combat operations of armored forces makes it possible to solve a series of complex problems connected with the investigation of combat capabilities of tank groups and the combat effectiveness of tanks.

By means of a multiple playback of various characteristic combat situations on quasi-mathematical models with the use of electronic computers, we are presented with the possibility of obtaining a large number of objective indicators, which the commander needs to determine the combat capabilities of tank groups and to select the optimum variations of their combat operations in concrete situations.

This method makes it possible to evaluate the effectiveness of combat actions of tank groups on enemy objectives with consideration of active counteroperations.

With the aid of quasi-mathematical models it is possible to make well-founded conclusions concerning the advantages and shortcomings of various methods of combat using tank groups, concerning the most advantageous forms of maneuver, concerning the most expeditious attack approach, the defense strip, fording water obstacles and other types of combat operations.

The described method of modeling facilitates development by the commander of habits in the optimum use of tank groups and other combat facilities under various conditions.

The method under consideration makes it possible to obtain statistical material necessary to evaluate the combat effectiveness of existing tanks as well as in working out parameters determining the combat characteristics of prospective tanks.

The stated method of modeling makes it possible to determine a more rational organization of tank groups in a qualitative as well as a quantitative sense.

In addition to this, it must be remembered that the calculated data obtained with the aid of modeling is only of a quantitative character, used by man to analyze a studied process, phenomenon, fact. On the basis of these data, with consideration of factors which cannot be calculated in modeling, the commander makes a decision concerning the question under study.

Chapter VIII

Rear of Armored Forces

Section 1

General Situations

The presence in armored forces of a large quantity of various technical equipment and vehicles of various designations causes a great expenditure of material means in fulfillment of combat tasks. In order that the troops might have a chance to conduct continuous combat operations, they always require that a large quantity of various materials be brought up--ammunition, fuel, combat-technical goods, supplies, etc.

The use of nuclear weapons and other high-power new firing combat means in modern warfare may lead to considerable sanitary losses of personnel and to a large number of combat technical equipment being put out of commission.

According to the evaluation of combat specialists, losses of NATO footsoldiers as a result of initial nuclear strikes could amount to 40% of the general troop strength dispersed in theaters of war operations at the start of the war.

It is thought that the possible large losses of armored forces will demand well-timed qualified medical assistance for treatment of the sick and wounded, rapid restoration of damaged equipment and returning them to operation for the purpose of always maintaining the combat preparedness of troops at a high level.

In connection with this, it is acknowledged that in modern warfare a high level of combat preparedness by armored forces, apart from other factors, obviously will depend in large measure on clear organization and well-coordinated work of the rear with regard to material, technical and medical assistance.

The experience of past wars has graphically illustrated that a constantly high level of troop preparedness, successful fulfillment of the combat tasks given them in large measures depends on the degree of preparedness at the rear, their ability to supply troops with the full measures of required material means, give timely aid to the sick and wounded, and also rapidly restore combat technical equipment put out of commission in the course of troop combat operations.

The increasing role of the rear in guaranteeing a high level of combat preparedness of armored forces is explained by their good technical equipment, fulfilling large and responsible tasks, the successful solution of which makes it possible for troops to carry on continuous combat operations over an extended period of time at great depths without essentially decreasing their combat capabilities.

As is pointed out in the foreign press, the basic task of the rear includes providing the troops with complete and well-timed material, technical and medical assitance in relation to the general situation, the requirements of the troops and the conditions under which they are conducting their combat operations. In their opinion, the successful fulfillment of this task may be achieved only with continuous and strict direction with rear facilities, a high degree of preparedness, correct distribution and well-timed movements after the troops, reliable protection from weapons of mass destruction, defense and rear-guard, continuous transportation of necessary material means to troops, rational use of transportation and well-timed performance of treatment-evacuation measures.

The volume of work of all rear facilities in securing the troops materially, technically and medically may be very great.

The high degree of technical equipment of armored forces when conducting combat operations in modern warfare causes the large requirement in various material means. Foreign combat specialists believe that of the average daily requirements of troops for basic types of material means, more than half will be constituted of fuel and lubrication materials. Fuel has become one of the basic and most decisive forms of supplying armored forces. The large material expenditures of troops require intense work of all types of transportation, especially automobiles and air for quickly replacing material means to troops which have been used by them in combat.

The presence of a large number of armored tank and half-track vehicles in the armored forces and the possibility of them going out of commission in great numbers as a result of damage by various means of warfare used by the enemy, lends an exclusively great importance to technically supplying troops in the course of combat operations.

In order to guarantee a high rate of troop attack, completion of prolonged forward movements with a very limited amount of time to prepare for combat operations, requires maintaining armored tank vehicles in top operational condition, clear organization of the work for quickly restoring vehicles put out of commission directly in the course of combat operations and returning them to action in time. This makes it possible to keep troops prepared for combat at a high level according to the number of armored vehicles in their makeup and at the same time to increase the continuation of uninterrupted combat operations.

The importance of restoring armored tank vehicles in order to sustain the combat preparedness of armored forces is clearly seen in the theater of combat operations, isolated from the rear of the warring region, when the possibility of making up losses in tanks due to their delivery from industrial plants is extremely limited.

Thus, in the battle at Al-Alamein from 23 October to 3 November 1942, losses of German-Italian troops amounted to 450 tanks, the English losses-500 tanks. In the same period of combat operations, thanks to the well-provided work of the English repair-restoration service, the English repaired and restored 337 tanks of the number put out of commission; at the same time, the losses in tanks in the German and Italian divisions by means of restoration were practically not made up, except for the extremely limited capabilities of their repair-restoration services. If at the beginning of the battle of Al-Alamein the 15th and 21st German tank divisions disposed of 230 tanks, then at the end of the battle there were 80 tanks in these two divisions. In this battle, the English repair-restoration service played an important role in changing the relative tank strength in favor of the English. In what followed, the numerical superiority of the English in manpower and technical equipment was one of the main reasons for them defeating the German fascists and the Italian troops in Libya.

The experience of past wars shows that the number of vehicles put out of commission from combat damage may be very large, as a result of which the troops will rapidly lose their combat capabilities. So, for example, in armored forces after 10-15 days of attack, an armored tank put out of commission due to combat damage attained dimensions of its registered makeup at the beginning of combat operations. However, the troops did not lose their own combat capabilities and this was achieved only by the fact that in the course of combat operations their work was clearly organized as far as restoring damaged vehicles with all repair unit facilities, and measures were taken to quickly return the damaged vehicle to operation.

In order to get a picture of the volume of work in restoring vehicles which will be carried out by all repair unit facilities in the course of combat operations, it is sufficient to say that the amount of repairs carried out in the course of past wars exceeded by one and one-half to two times the number of tanks participating in combat operations. In the course of combat operations, some tanks were repaired two to three times and then returned to the line.

As foreign specialists believe, in conducting modern combat operations with the use of nuclear weapons and more powerful antitank weapons than before, a vehicle going out of commission may be a more serious matter than in past wars. In addition, the continuous, uninterrupted combat operations of armored forces under modern-day conditions with the absence of extended pauses in combat operations demands that a complex of measures be carried out directed toward securing reliable and dependable operations of armor-plated tanks for extended periods of time in their combat use. Well-organized technical supply makes it possible to sustain the combat capabilities of armored forces at a high level while conducting combat operations and makes it possible to increase the length of time they can be used in combat without interruption.

In modern warfare, constantly keeping a good supply of tank replacements makes it possible for troops to make deep attacks at high rates of speed over a long period of time.

Under the conditions of modern combat, there may turn out to be a large volume of work with regard to giving medical assistance to the wounded, sick and injured. The use by the enemy of weapons of mass destruction may lead to sharp increases in sanitary losses in comparison with those in past wars. The characteristic special feature of modern warfare may be that personnel simultaneously sustain serious and combined injuries and there is a great inequality of sanitary losses in days of combat operations. Moreover, the greater sanitary losses may be chiefly on the lines of force of combat operations. These lines may be situated quite far from one another, which causes great difficulty in evacuating wounded and evidently requires the widespread use of medical aviation for this purpose.

The high rate of speed and the maneuvering character of armored forces operation, the large-scale use of nuclear weapons and the different combat technology creates great difficulty in the work of the rear, especially the rear of armored forces. It is thought that if a high degree of maneuverability, the possibility of moving behind the troops, to realize their continuous security, is an obligatory requirement of modern rear-guard action, then to the rear guard of tank troops this quality is especially important. The tank rear is required to persistently follow behind troops, attacking at a high rate of speed. It must be in constant readiness to secure troops under any conditions.

The principal feature in the organization and work of the rear guard of armored forces stems from the character of their combat use and their completion of combat tasks. Armored forces, having a highly maneuvering and quickly-moving type of troop, will act in the operational depths of the enemy in different directions. Under these conditions, the rear subdivisions must be located in the direct vicinity of their own troops and persistently follow them in the course of their developing attack.

It is pointed out in the case of armored forces activities in operational depths of the enemy at high rates of speed, the distances of supply and evacuation will greatly increase, in addition to which communication may often be influenced by the enemy. Thus, the conditions of supplying material means and hospital evacuation will be very complicated.

In modern warfare, the rear may successfully fulfill its tasks if its own troops are technically supplied and flexibly organized.

In modern armies, special attention is paid to technical equipment: widespread introduction of air transport facilities, automobiles with large load capacity and high maneuverability, wide use of different mechanisms and automatic equipment for performing loading and unloading work, key punch and electronic calculators for producing large amounts of calculations for materially, technically and medically supplying the troops.

In modern combat, great significance is lent to the question of securing the viability of the rear. The use of nuclear weapons not only on troops, but on objects of the rear may lead to the destruction of supplies, material facilities and objects of the rear as well as to considerable destruction of supply and evacuation paths. Thus, in their distribution, the rear sections will probably be dispersed and reliably protected from the effects of various means of destruction.

The rear of armored forces is organized with relation to the situation and how the commander conducts combat operations. It must be remembered that correct organization of the rear is an important condition for continuously securing troops in the course of their combat operations. The rear objects will be disposed in accordance with the concrete situation, grouping of the troops, fulfillment of tasks by the rear, thus guaranteeing constant readiness for a maneuver, better use of all forces and facilities in the course of combat, and a high degree of viability of the rear.

It is acknowledged that as a rule, the rear facilities fulfill tasks in securing troops in the zone of their operation. The distance of rear regions of disposition from the combat ranks of troops depends on the character of combat operations, the combat tasks and the conditions. Under combat conditions, medical facilities and facilities for evacuating and repairing track-laying vehicles always more forward nearer to the troops. In the course of combat operations, a shift of tank units behind the troops is organized so as not to disturb the continuous security of troops leading the combat operations.

It is asserted that the basis of materially securing troops consists in supplying material means under any conditions.

The great depth of armored forces operations and the high speed in the development of combat operations brings with it the strain of using armored tanks. This causes intense wear of armored tank parts and requires that effective measures be carried out to keep the tank in combat-ready condition. In view of the possibility of the vehicle going out of commission from combat damage, the necessity arises to organize continuous processes for restoring them and quickly putting them back in order with repairs. All this demands observation of determined principles in organization and performance of their technical security.

It is believed abroad that the basic of these principles includes the following: under combat conditions as well as in peacetime conditions, strictly observe and carry out a planned-anticipatory system of technical maintenance and vehicle repair; give technical maintenance to armored tank vehicles and do this during the course of combat operations directly in the troop combat ranks while the crew and the driver are involved in helping with maintenance means and repair; primarily repair those vehicles which may be restored and returned to service after a short period of time while repair of such vehicles is carried out where they went out of commission or under cover, in which the safety of the work may be guaranteed.

For this purpose, right from the beginning of the combat operations, the evacuation and repair facilities will be situated a short distance from the combat ranks of tank units in order to shorten the time required for them to reach the vehicle gone out of commission. Under war conditions, it is an important factor in guaranteeing a high rate of speed when restoring an armored vehicle; obviously, the aggregate method of repair will be used.

The evaluated importance and specifics of work of the rear under conditions of combat operations, foreign combat specialists point out that to change the tactical plans, to give the troops a new direction and to present new tasks is comparatively simple; it is considerably more difficult to carry out plans of tactical and material supply with changing tactical problems, since this change requires dislocation of material facilities, changes in the order of using forces and facilities and attracting new ones.

Section 2

Organizational Basis of the Rear and Technical Security in Combat

It is acknowledged in all armies the method for organizing the rear, maintenance of measures in material and technical security, do not go unchanging. They change with the change in form and methods of organizing combat, which primarily involves changes of the organizational structure of institutions and facilities of the rear.

The following basic requirements are presented in the organization of the rear with regard to material and technical provisions: well-timed provision of troops with all required material means; always keeping machinery in good condition and ready for use; rapid restoration and repair of damaged vehicles.

1. Rear and Technical Security on the March

It is noted that on the march, the basic question of organizing the rear is preparing rear units for forward movement, determining the setup of rear columns and the place of their succession in field rank, selection and preparation of movement march routes for rear columns, determining the place of disposition of rear facilities in places where stops are made, with entry into the designated region and when deploying for encounter combat, organizing protection, defense and rear guard.

When preparing to march, the rear units complement the personnel, the autotransport, the technical rear, and table property, [sic.] they guarantee the required material means and evacuate surplus property, transfer the wounded to medical institutes of the commander in chief; they organize and conduct pursuits with personnel of rear units, give technical maintenace to autotransports and the technical rear.

The concrete content and organization of the enumerated measures in each case will depend on the make-up of the rear, the time available for preparing to march, tactical conditions and conditions in which completion of the march is imminent.

It is acknowledged that under heavy road conditions, when the wheeled vehicles cannot follow in one column with track-laying vehicles, when completing a march over a long distance, and also in designating individual march routes for wheeled vehicles, all facilities of the rear will follow along the route selected for them in independent columns.

When moving troops forward to the line, leading rear facilities into combat, as pointed out in the foreign press, one or two columns will follow at a distance, guaranteeing well-timed fulfillment of tasks of technical and material supply. The removal of a rear column from the main forces depends on the conditions for completing the march.

It is assumed that on a march completed in the absence of threat of encounter with the enemy, the rear column will usually move behind the main troop forces.

Evidently, the rear column will be set up such that the rear units will be located closer to the head and the supplies of material means which primarily will be required on the march in encounter combat. In training, the tank columns will originate from that, so that in each column there will be the necessary supplies of material means.

In order not to fix the possibilities for maneuvering troops in their deployment for encounter combat and also to decrease the vulnerability of the rear, it is thought that rear columns on the march in anticipation of encounter combat must follow at a much greater distance from the main forces than on a march in the rear of its own troops. The medical and repair facilities in all cases move forward directly behind the main forces, closing off part of the facilities.

Apparently, when linking up in encounter combat with rear facilities, they will enter into a region under the cover of troops, ready to fulfill the task of material, technical and medical provision. The medical and repair facilities are situated closer to the line of encounter with the enemy.

It is noted that under contemporary conditions the march will be characterized by a large expenditure of fuel and lubrication materials as well as anti-aircraft ammunition. Thus when completing a march, especially over a large distance, in parts there will probably be an increase in supplies of all kinds of material means, a decrease of movable supplies of other kinds and a consolidation of the most important means. Primarily due to the supplies of material means, which are in storehouses there, a supplement of supplies will be produced in units consisting of forward detachments.

It is asserted in the foreign press that a supplement of vehicles using fuel on the march is produced usually in halts or with entry into a designated region, and on the march in several daily transitions on halts and in rest areas. When a march is completed over a long distance, in the rest area it is expedient to deploy servicing points beforehand.

Obviously, spent material means will be refilled in regions where long halts are made, in rest areas after a daily transition or in regions of rear disposition when deploying troops for encounter combat from the march when the necessary material means will be brought up.

It is assumed that in conditions when autotransport with supplies of material means cannot accompany tank columns, especially when overcoming a special zone of high levels of radiation, the necessary material means will be conveyed by air.

The success in completing a march in large parts depends on correct organization of technical security.

Foreign combat specialists avow that when preparing for a march, technical preparation of the crew personnel must be provided for as well as the automobile drivers and armored transports, and the repair crews, preparation to march of material parts and technical security facilities, supplment of moving supplies of armored tank and auto transport goods.

Preparation of personnel is organized such that it responds to the goal of securing the safe use of vehicles on the imminent march and high marching speeds are achieved. With a prolonged preparation to march with personnel, pursuits may be carried out to teach the special features of using vehicles under conditions of imminent march. When preparing to march in short periods of time, only instructions are carried out in the course of which the personnel are instructed as to the special features of driving the vehicle in conditions of the imminent march, the volume, place and sequence of technical vehicle maintenance, the order of providing technical assitance to vehicles during the course of the march, the order of checking the operation of aggregates and systems.

The original data for determining the volume of work concerning technical vehicle maintenance may be the following: the availability of time for preparing for the march; the supply of motor resources up to routine laborious technical servicing; the possibility of expending motor resources when the march is completed; technical condition of the vehicle and condition of its use; possible character of combat problems which are coming up after the march.

It is thought that the volume of work in technical vehicle maintenance when preparing for the march is established with such calculations that when approaching the designated line, the vehicles have a supply of motor resources sufficient to carry out a routine, laborious, technical servicing, guaranteeing fulfillment of the given task.

When setting up time periods for completing the work of preparing the vehicle for a march, consideration is taken of their technical state and conditions of use, since the volume of this work will be much greater on vehicles having a smaller supply of motor resources until routine repair, as well as those vehicles used under difficult conditions.

When time is lacking, the most opportune sequence for completing the work is set such that the most important work is done first, that which depends on the combat preparedness of the vehicle. Completion of remaining work is provided for on rests during the course of the march or after its completion.

In the opinion of foreign press specialists, in the period of preparing for march, the tasks with repair facilities will be laid down so that all repair work will be done in the time of preparing for the march. The vehicles which cannot be restored with troop facilities will be repaired with the facilities of the field command technical service.

When preparing for the march, supplies of armored tank and auto-tractor goods are supplemented in the troop storehouses. In addition, the moving conditions and technical state of the vehicle are taken into account, since in many cases the expenditure of spare parts will be determined by these factors.

It is pointed out that technical servicing of vehicles on the march is organized on halts and in rest areas after daily passage. It is carried out in volume guaranteeing reliable operation of the vehicle during the course of the march and their arrival in a designated region in technical working order for further operations. Thus, the duration and the number of halts, and also the duration of stay in rest regions in each case must correspond to the requirements for technically servicing the vehicle.

The fatigue of the mechanical driver of the tank during the course of the march may be great. Thus, with the crew aiding in technical servicing, the vehicle will be drawn to the batallion technical servicing section. On the march, this section will be constantly moving behind the batallions.

It is acknowledged that repair and evacuation work on the march will be carried out by facilities sent out to complete the field column. The completion of the field column is guaranteed by section facilities as well as by facilities of the commander in chief. The makeup of the facilities sent out as completion depends on the presence of repair and evacuation facilities, the assumed volume of repair work on the course of the march and the character of the problems to be confronted. Depending on the enumerated conditions in completing a column, usually up to half of the repair unit is sent out, reinforced special workmen and evacuation facilities.

Restoring damaged track-laying vehicles on the march will be completed where they went out of commission. Depending on the character of the damage, the condition of the road and other conditions, automobiles may be restored directly where they broke down or towed forward into a designated region, and when the march is completed when anticipating encounter combat, on a special prefabricated point.

Armaments, communication means nd other technical equipment are most expeditiously restored preferably at a selected point, since their evacuation would not present difficulties.

It is pointed out that the maximum repair period with means completing a column on a march is set up such that the completion facilities and the repaired vehicles may overtake their own parts in the region of daily rest. In this case, the facilities sent out to complete a column must not break off from the troops completing the march.

On the march, when anticipating encounter combat, the maximum period of repair with completion facilities is determined on the basis of the planned use of these facilities in encounter combat. For the purpose of reducing the number of vehicles simply going out of commission and waiting for repair, the completion column follows directly behind the security troops.

The repair facilities not entering into the makeup of the completion, move along a better march route behind the main forces in preparation to fulfill repair and evacuation work with entry into a new zone or onto the line of encounter with the enemy.

With the presence on march routes of water obstacles or other parts which are difficult to pass, such as mountain crossings, narrow passages for guaranteeing unhampered movement of columns onto these parts, obviously the required number of evacuation means will be sent out.

It is thought that when overcoming a zone of radioactive contamination, depending on the level of radiation and the size of the area, the repair facilities may either follow behind the column in the same formation, or wait for a drop in the radioactivity to a safe level, or move along a new march route. When moving repair facilities and bypassing zones of contamination, behind columns of troops, completions on tow cars will be organized.

2. Rear and Technical Security in Attack

As confirmed in the foreign press, during attack one of the basic requirements for organizing the rear is a correct transfer of the rear behind the troops with its work for continuous and full security of the troops.

Up to the start of an attack, the rear facilities will secure supply and replacement of material means, evacuation of wounded and sick, preparation to autotransport and vehicles in the rear. This work will be conducted in regions of constant dislocation.

Rear units are placed in distant regions in the approximate region of troop placement. If necessary, supply regions are designated and defended for rear units.

For disposition of the rear, it is recommended to designate a region which has natural camouflage and cover for protection from enemy weapons of mass destruction.

It is thought that with forward movement to the attack line, the rear is echeloned in the depths. This is done not only for the purpose of well-timed material and technical assistance for the troops in the course of combat, but for the purpose of dispersing supplies of material means.

Usually, medical facilities, parts of units, designated for repairing armored tanks and automobiles are detached in the first echelon, and the necessary number of subunits with supplies of material means. The second rear echelon consists of the remaining subunits of material and technical maintenance.

Rear columns are basically set up on the same principle as on the march and when anticipating encounter combat.

When disposing and deploying the rear, we use protective and local camouflage facilities, equipped beforehand with armed troops and if possible subunits and rear establishments equipped with their own cover for personnel, transport and material means.

Obviously, further shift of the rear will be accomplished with consideration of the circumstances. Under any circumstances it is considered expedient not to allow a break of the rear from the troops being supplied.

In the course of a successfully deployed attack, the rear units evidently will move forward in the direction of the troop attack, making short stops to transfer and take on supply loads.

It is acknowledged that at the end of the day of combat, and with the escape of troops into the reserve, the rear units must arrive in the place where the troops are disposed and guarantee setting them into rank and preparing them for further operations. The requirement of the troops for material means is determined each time by the character and the depth of the tasks for them to fulfill, the character of the enemy defense and the degree of its suppression, the conditions of the terrain, the time of the year and of the day, and weather conditions.

On the basis of the conditions, the tasks to be fulfilled and the consumption rate, set up by the commander-in-chief for each trop grouping, the commander determines the standard expenditure of ammunition, fuel and lubrication materials.

The replacement of material means in the course of combat takes place on the basis of established norms of consumption and the practical presence of material means. The sequence of the replacement is determined by the commander. Primarily, the material means are supplied by sections and subsections operating in primary directions.

Replacement of tanks and other combat vehicles with ammunition and servicing their fuel and lubrication materials takes place with leading out of the subsection into the reserves, at points designated by the commander. When necessary, the supply of tanks with ammunition and fuel in combat ranks takes place under cover.

Supply of material means in combat conditions takes place on the principle from the top down, i.e. the higher standing rear unit will bring up loads to warehouses of lower-standing units with their own transportation.

In case there is interruption in bringing up goods in the course of an attack, a maneuver may be performed with the supplies of material means, including redistribution of inside subsections as well as intermediate subsections. If the transport guaranteeing the movement of material means turns out not to be capable of taking on the load, the transfer of material means into the transport of the secured troops takes place not once, but several times in the course of a day.

If it is impossible to transport material means along the ground, it may be done by air. In this case, the troops provided for delivering the material means by air prepare the landing area, detach the teams for unloading (taking off) the material means and guarantee delivery to the designated place.

When preparing for attack, technical security is organized on the basis of the character of the combat problems to be faced, the conditions and the period of imminent combat operations. As a rule, it includes measures for technically preparing the personnel, preparing the vehicles for reliable operation in the course of attack, repairing the vehicles which have been damaged in previous combat operations, and transferring unrestored vehicles by means of the commander-in-chief, setting up the required supplies for armored tanks and automobiles. The concrete volume and the content of the work will be determined in each case in the available period for preparation, by the technical state of the vehicle, the presence and state of repair and evacuation facilities, the level of technical knowledge of the personnel, using the tanks and the automobiles.

The basic requirement made for preparing vehicles is to guarantee their reliable operation during extended and intense use. For this purpose, when preparing an armored tank or half-track for attack, service it technically, carefully check the technical conditions of the vehicle and correct any defects. Tanks and armored transports are set up to supply them while moving, which would permit their escape at any stage of imminent operations without performing time-consuming repairs caused by vehicle wear. The vehicle is prepared by replacing or repairing individual components, assemblies and aggregates which, due to their technical condition, would not guarantee extended and reliable vehicle operation. If the conditions do not make it possible to make the needed repairs on all vehicles up to the start of an attack, then it may be possible to provide for repair of such vehicles in the course of combat operations.

At the same time technical servicing is being done to prepare for combat operations, work is organized to set up necessary vehicle repair. All vehicles which cannot be restored and put back into operation when preparing for combat operations are transferred to repair sections of the commander in chief.

The technical security means are prepared in the process of repairing and evacuating the vehicles. However, in order to accomplish the work and check the readiness of technical security means for repair, there must be sufficient time.

It has been pointed out that technical servicing of vehicles during an attack will be carried out during battle pauses and in reserve units (of the second echelon), if possible, and in the course of an attack. Often, technical servicing of a vehicle will be conducted in regions into which the troops have escaped. In the case of escape of troops into the reserves (second echelon), technical servicing may be carried out in the region indicated by the commander. The necessity of conducting vehicle technical servicing to any extent is determined by the work which will be done by the vehicle in the course of combat operations.

To accelerate the completion of technical servicing work in combat ranks, the unit may put forward the means of technical servicing and repair beforehand (technical servicing vehicles, fuel tankers, work shops, and the like) as well as used materials and ammunition necessary to replenish spent material means of supply.

It will be noted that with the forward movement of troops to **the line** of attack, the servicing batallions may move up to join their own batallion.

It will also be noted that the batallion facilities for moving forward to the attack line do not include vehicle repair; their basic task is to complete evacuation and repair work from the start of the battle in the capacity of repair-evacuation batallion groups. During the course of the battle, the work period for the batallion repair-evacuation group is determined by the period of time of leading troops into battle and must be such that the batallion facilities may take part in technically servicing the vehicles when the batallion withdraws into the second echelon or into the reserves. Other repair-evacuation groups fulfill other tasks. From the start of the attack, the repair-evacuation groups are situated directly behind the combat ranks near the technical observation points.

When troops move forward to the attack line, troop repair facilities are confronted with repair problems such as the period of time which would permit them to complete repair of the vehicle. In relation to these requirements, the period of repair time for facilities which have joined on is usually limited to a few hours.

Depending on the place of disposition and the character of the damage, vehicle repair is carried out where the vehicle broke down or near cover.

The period of time of the work of repair facilities at one place and consequently the extent of their delay from combat rank sections depends on the presence of repair facilities, the presence and the character of repair stocks, the rate of troop attack and other conditions.

In order to preclude a long period of lag for the repair crews and to guarantee most important restoration of vehicles with a small volume of repair, and also to guarantee the participation of repair facilities in preparing vehicles for combat operations on the following day, the basic staff of the repair crew is moved nearer the unit when beginning to repair vehicles for the following combat operations.

The maximum repair time, the order and the times for moving the repair crews depends on the situation and on the presence of vehicles requiring repair.

Correct determination of the maximum work time for repair crews greatly influences the effectiveness of their use, and consequently the number of vehicles restored for use. Thus, in each case, when determining the tasks for the repair crews, it is necessary to proceed not only on the basis of the possible break-offs of repair facilities from combat ranks, but primarily on the basis of effectiveness of the work of repair facilities in restoring a vehicle.

When organizing the work of repair facilities in restoring a vehicle in the course of combat, their rapid forward movement to the troops should be provided for, and to vehicles in need of repair to quickly restore their combat capability.

It is emphasized that vehicles damaged in the course of combat are first evacuated to the nearest cover and then the places where repair facilities have been deployed. To facilitate the approach of combat and evacuation facilities to vehicles not restored by troop facilities, to hasten their subsequent transfer, evacuation and repair, it is recommended to disperse these vehicles on evacuation paths. The sequence of evacuation is set up with consideration of the concrete situation, the location and the technical condition of the vehicle.

The auxiliary sections of repair units and sections are guaranteed continuous accessibility to warehouses during the course of combat. Supplies in storehouses are usually replenished at the end of a day of combat operations.

3. The Rear and Technical Security on Defense

It is pointed out in the foreign press that in defense the troop rear is organized such that occasional changes in the condition of the defense strips caused by enemy penetrations do not require significant changes in the setup of the rear, and its frequent shift. On the basis of these requirements, the rear units will be distributed at a great distance from the security troops.

Medical facilites and repair units will be deployed between the first and second echelon or behind the second echelon of the defending troops. Auto transport facilities with supplies will be deployed behind the troop combat ranks at a great distance, determined in each case depending on the tactical situation and local conditions. Moreover, the more deeply echeloned rear will be characteristic for conducting extensive defensive combat.

It is admitted that regions difficult for tanks to reach will be designated for the placement of the rear, having good natural and artificial cover. In the designated regions, the rear subsections will be deployed in a dispersed manner, while the fuel and ammunition supplies will be usually divided into two parts. In the absence of cover, the rear units occupying the regions designated for them will obviously take measures for their own outfitting. In order to guarantee the defense of the rear from the effects of the enemy, defensive regions may be prepared and equipped for deploying the rear.

In defense, special attention is given to preparing and maintaining supply and evacuation routes. Other routes are designated if the usual routes cannot be used.

Rear guard and defense of the rear is usually accomplished by forces and facilites of rear units. In individual cases, combat units may be detached for the rear guard and defense of the deployment region, and also for supply and evacuation routes.

It is pointed out that in comparison with other types of combat troop activity, the characteristic special feature of material supply in defense is the lower expenditure of fuel and the higher expenditure of ammunition, engineering equipment and goods.

When making the transition to the defense, it is acknowledged in many armies, measures will be taken to replenish supplies of material goods, primarily in troops of the first echelon. If there are occasional interruptions in supplying units and subunits of the first echelon, supplementary material supplies may be set up, especially ammunition. These supplies may be laid out on the ground and artillery and tank firing positions.

Technical supply on defense is usually organized under complicated conditions with considerable losses in the course of previous combat operations and with the repair crews very busy restoring this equipment.

It is thought that one of the basic problems of technical supply on defense is to keep the vehicles in combat readiness and to guarantee their reliable operation during defensive battle as well as in the subsequent transition to the attack.

Control inspections of the vehicles will be carried out by subunits designated in those defense regions who will make repairs, replenish ammunition and replace fuel and lubrication materials. The sequence for carrying out the work in technically servicing tanks is arranged so as not to upset the combat preparedness of the troops. When carrying out technical servicing, work will obviously be done in intervals between the battles in combat ranks or in nearby cover. Orderly planned technical servicing of transport automobiles, occupied with transporting material means will be carried out after they have completed their transport work.

It is pointed out in the foreign press that when the troops make the transition to the defense in cases of direct contact with the enemy, one of the main tasks of technical supply is evacuation of vehicles which have broken down in the course of previous operations, under the cover of troops. Moreover, all damaged vehicles, regardless of the character of the damage, will first be evacuated behind the lines of unit defense, and then at selected points the damaged vehicles will be repaired. In the course of defensive combat, the repair-evacuation groups will be under cover behind the combat ranks of the batallions.

In the course of defensive combat, the damaged vehicles are evacuated in two stages. The initially damaged vehicles are evacuated into cover from under enemy fire and then into a further esignated region. From the number of damaged vehicles, the ones are evacuated which due to the damage incurred cannot direct fire on the attacking enemy.

Repair units not a part of the repair-evacuation group restore damaged vehicles during the course of defensive combat at selected points.

In order that occasional changes in the situation in the course of defensive combat, caused by enemy intrusions, do not disturb the normal work of repair facilities and do not cause them to be moved frequently, the place where these facilities are deployed will be selected where they will be under cover of troops of the second echelon or reserve. In order to evacuate damaged track-laying vehicles, from troops of the first echelon onto CPPM, evacuation paths are designated and prepared whenever they are deemed necessary.

The most expedient place for organizing repair of track-laying vehicles is selected in a region located in directions where basic troop forces are dispersed, under the cover of the second echelon or reserves. The place for repairing automobile or other equipment often will be organized behind the defense strip, the region where the the rear is deployed.

It is emphasized that in defending troops on a wide front, in order to reduce the distance of evacuation repair facilities, it is expedient to divide them up into two independent groups, including in each group facilities for repairing armored tanks and automobiles. Each group is deployed for work under the cover of the second echelon or reserves.

When selecting the place for deployment of repair facilities on defense, use is often made of protective and camouflaged places which make it possible to reduce the expenditure of forces and means when equipping the covered camouflage work.

The volume of work which may be done by repair facilities on defense depends on the tactical conditions, the time of the defensive battle, the number of damaged vehicles and their condition. When defensive regions are stably held and the defensive battle lasts for a long time, the repair units may make transitional and even medium repair without limitation. When the defensive combat is short, the volume of repair work may be decreased.

When the enemy penetrates the defense, the repair and evacuation facilities direct their basic forces to repid and well-timed evacuation of damaged vehicles from threatened regions in order to prevent them from being seized and destroyed by the enemy.