Tankograd

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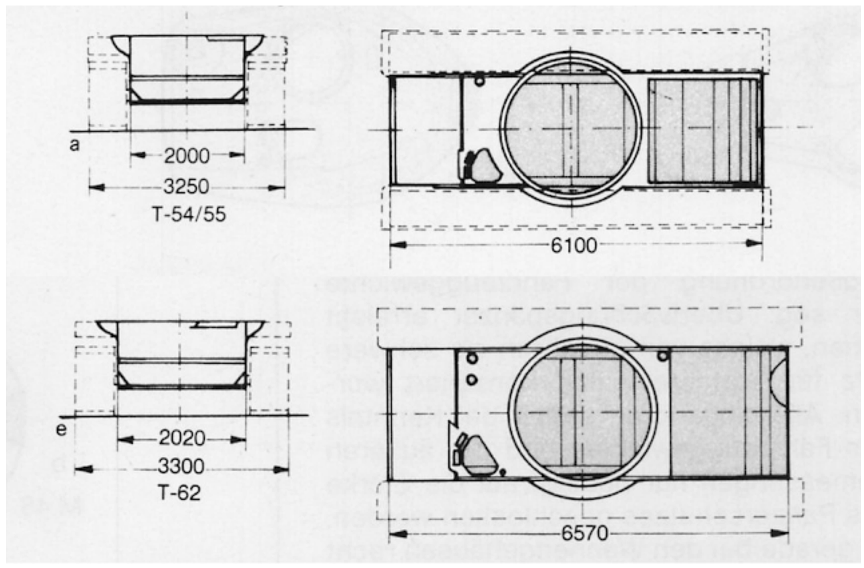
T-62

Today, the T-62 (Object 166) is undeniably the least remembered among large number of tanks deployed by the Soviet Union during the Cold War. Its predecessor, the T-54/55, is known for being the so-called "Kalashnikov of tanks", having seen action in virtually every major military conflict on the planet during the past half century, and its successor, the T-72, has a similar level of fame for having participated in almost as many conflicts. The T-62, on the other hand, lies in an indeterminate gray area. It is usually sidelined as an oddity, sometimes accused of being a failure, and sometimes (bizarrely) criticized for having a smoothbore gun. In the West, the T-62 is best remembered by those who served in NATO armies in the 1973-1980 time frame, especially those stationed in West Germany. Publicly available TRADOC documents and training films show that the U.S Army emphasized the T-62 as a foil to their own M60A1. When more information on the T-64 and T-72 became available in the early to mid 1980's, all attention was shifted towards these two models and lesson plans focused on training soldiers to defeat an enemy tank that had composite armour.

However, even after the T-62 was eclipsed by newer and more threatening tank models in the eyes of the enemy, it still formed a significant portion of the Soviet Army tank fleet until the collapse of the Soviet empire, and its relevance on the battlefield was certainly undeniable for the better part of two decades.

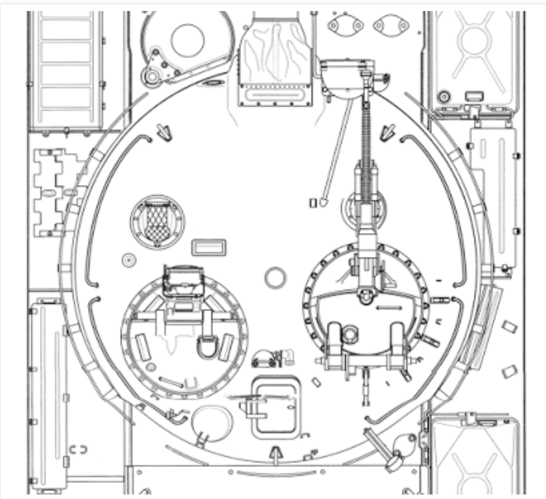
The sentiment among the few tank enthusiasts that haven't forgotten the T-62's existence is that it was a highly mediocre modification of the T-54/55 with a whopping gun that was fraught with design flaws, one of which was (purportedly) the automatic cartridge casing ejection system. This perception will be tackled throughout the article, but the topic of differentiating the T-62 from the T-54/55 can be addressed quite easily as there were a myriad of differences that distinguished the T-62 from the T-54. The enlarged turret, now completely round, is the most major external difference between the two tanks, but the hull was also changed, as you can see in the diagram below. Diagram taken from "*Kampfpanzer: Die Entwicklungen der Nachkriegszeit*" by German author and military expert Rolf Hilmes.

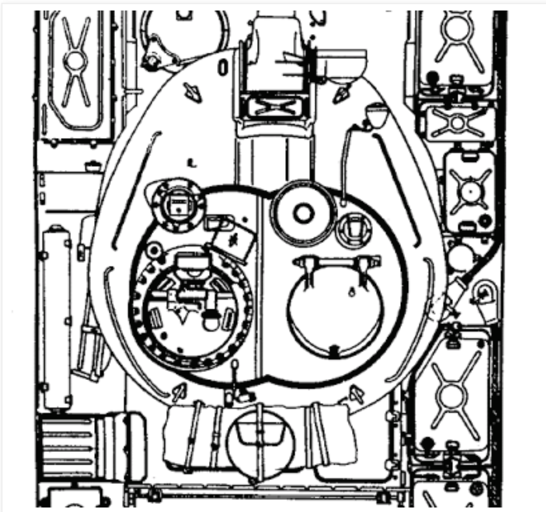


The widened turret ring did not directly affect the width of the hull, but the length of the hull had to be increased by a small amount in order to accommodate its increased diameter. The arrangement of the roadwheels and the torsion bar suspension was also revised in accordance with the redistribution of weight towards the front, thus removing the famous gap between the first and second roadwheels on the T-54 that is often used as an identification feature. Instead, the T-62 suspension has its three front roadwheels densely packed together with larger gaps between the last two roadwheels. The weight of the tank was slightly increased to 37 tons, but of this weight, only 400 kg comes from the upgrade to the 115mm U-5TS smoothbore gun. The remainder is from the new hull and turret.

However, that was not the entire extent of the changes made to the hull and chassis. Compared to the T-54/55, the maximum height of the hull was increased from 977mm to 1,036mm and the maximum internal height of the fighting compartment (from the rotating turret floor to the turret ceiling) went up very slightly from 1,600mm to 1,610mm. The suspension of the T-62 was fundamentally identical to the T-54 suspension, but it incorporated small improvements such as an increased ground clearance of 450mm instead of 440mm and it provided a slightly smoother ride. At first glance, it seems that the T-62 is both wider and taller the T-54/55 by a few inches but surprisingly, the height of the T-62 up to its turret roof almost did not change at all compared to the T-54 - it increased only negligibly from 2,235mm to 2,240mm. Like the T-54, the total height of the tank up to the top of the commander's cupola is 2,400mm.

The internal volume of a T-62 was larger compared to a T-54 or T-55 chiefly due to the need to accommodate the bigger U-5TS gun, but due to the increase in the turret ring diameter and the rearrangement of the internal equipment in the tank, it was possible to allocate more room to the crew. Although the T-62 superficially resembles the T-54 from many angles, the dome-shaped turret is significantly larger and noticeably more spacious, even with the larger cannon. This can be largely attributed to the 2,245mm diameter turret ring, which was a big improvement over the 1.825-meter one of the T-54. The turret ring of the T-62 is much wider than the one on the Leopard 1 (1,980mm) and wider than one on the M48 and M60, which had the widest turret ring (2,160mm) among all Western tanks in service at the time. This is partially offset by the larger cannon breech of the U-5TS cannon compared to the smaller 90mm gun of most M48 models and the 105mm M68 cannon used by the M60 series. However, the turret of the T-62 dispensed with the egg-shaped curvature of the T-54 turret in favour of a simpler hemispherical turret. This contributed to a modest increase in the amount of habitable room inside the turret, mainly for the loader. The difference in the turret shapes can be seen in the two drawings below, with the T-62 on the left and the T-54 on the right.





Nevertheless, having a larger turret ring than the M48 and M60 does not mean that the T-62 is more spacious, as the hulls of the two aforementioned tanks are wider. The M48 and M60 both have turret baskets which are mounted to the turret ring, thus giving a direct correlation between turret ring diameter and crew compartment diameter. For both the Leopard 1 and M48 or M60, the turret basket mount occupies some space and reduces the diameter of the crew compartment by a few centimeters. It would be safe to assume that the diameter of the crew compartment is approximately 1,900mm for the Leopard 1 and approximately 2,040mm for the M48 and M60 (due to hull width constraints). On the other hand, the T-62 lacks a turret basket so the width of the crew compartment is determined entirely by the internal width of the hull, which is 1,860mm. This is close to the Leopard 1 but significantly less than the M48 and M60. On the other hand, the exceptionally large turret ring and correspondingly wide turret grants more room above the waistline. The length of the crew compartment is also larger, but even so, the commander and gunner in the T-62 are still seated rather closely. The main improvement is seen in the loader's station, who also benefited from the relocation of several pieces of equipment. The seating arrangement in the T-62 turret is shown in the drawing below.

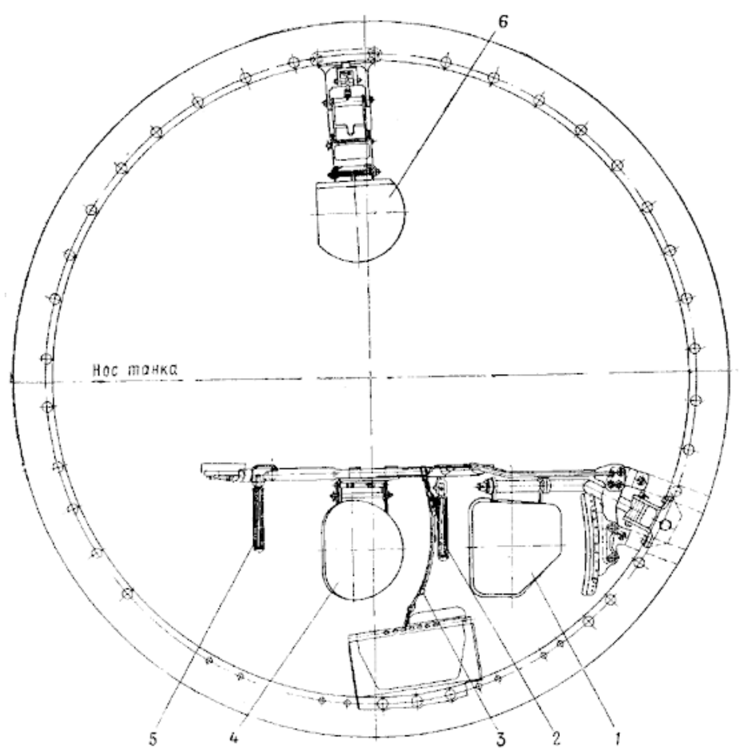


Рис. 31. Расположение сидений в башне:
1 — сиденье командира танка; 2 — подножка командира танка; 3 — опорный ремень; 4 — сиденье наводчика; 5 — подножка наводчика; 6 — сиденье заряжающего

The total internal volume of the T-54/55 is 11.4 cubic meters whereas the total internal volume of a T-62 is 12.5 cubic meters. Of that, the volume of the crew compartment is 8.05 cubic meters and 9.23 cubic meters for the T-54/55 and the T-62 respectively. After taking the internal equipment into consideration, the T-62 is the roomier of the two models by a small margin. The engine compartment of the T-62 is also slightly larger, but only by an insignificant amount compared to the increase in the volume of the crew compartment. For comparison, the massive M60A1 had a total internal volume of 18 cubic meters and the volume of its crew compartment was 11.17 cubic meters. This is offset to some extent by the considerably larger 63-round main gun ammunition capacity of the M60A1, but even so, it is clear that the T-62 does not match the M60A1 in the amount of space allocated for the crew.

In terms of crew space, the T-62 is much closer to the "Patton" tank models that came before the M60A1 such as the M46, M47 and M48. For reference, the crew compartment of the M47 had a volume of 9.06 cubic meters and the M48 had a crew compartment volume of 10.48 cubic meters. After taking the internal equipment into account, the T-62 is on par or marginally superior to the M47 but slightly inferior to later models. In terms of proportions, the crew compartment of a T-54/55 occupies 71.25% of the total volume of the tank and the crew compartment of the T-62 occupies 73.8% of the total volume of the tank, making the T-62 a more volumetrically efficient design. The share of the crew compartment volume of both the T-54/55 and the T-62 is much higher than the 60.4% of the M47 Patton, 59.2% of the M48 Patton and 60.7% of the M60A1 thanks to the uniquely compact engine compartment design pioneered by the T-54. Like the T-54, each crew member in the T-62 was allotted some space for personal equipment and each crew member was provided with a two-liter aluminium bottle which would be stowed in a special holder near their respective stations, among other rations.

Although woefully obsolete as of today, it could at least boast of having the one of the most powerful tank cannons in the world for the better part of the 1960's before being usurped by the T-64A. Indeed, the sole reason of the T-62's existence was its pioneering smoothbore cannon. Tactically speaking, there were very few differences between it and its predecessor the T-54 in the mobility and armour protection departments, and indeed, the T-62 inherited much of its internal equipment from the T-54, thus simplifying both production and logistics to a certain extent. Even many of the newer devices were functionally similar, making the transition from a T-54 or T-55 to the T-62 wonderfully seamless for the crew. In fact, it is stated in a 1981 Soviet essay titled "*Из Опыта Совершенствования Основных Танков В Ходе Серийного Производства*" that 65% of the parts and assemblies in the T-62 were standardized with the T-55 tank. Most interestingly, the transmission, chassis, engine assembly, viewing devices and communication systems were completely interchangeable between the two contemporary tanks. Operationally, this made it extremely simple to supply spare parts and carry out repairs in the field. The non-interchangeable components such as the turret and hull are irrelevant as these items would never require a replacement. Rather, if a tank were knocked out by having its armour breached, it is much more likely to be salvaged for spare parts to support other tanks rather than be repaired, as that is much more expedient in actual wartime conditions.

That said, the high degree of commonality was not entirely positive, because this meant that the rate of progress in tank technology had begun to slow down in critical areas. In other words, the T-62 was only an iterative improvement that still belonged in the same generation as its predecessors. It was generally considered to be no more than a stopgap solution until a new and radically superior tank arrived on the scene, but despite this, the T-62 could be rightfully considered to be the one of the most powerful medium tanks fielded by the Soviet Army. It would be a mistake to say that the T-62 was a poor product for its time. Furthermore, the rate of progress in the advancement of tank technology was still quite reasonable if compared to the state of affairs in the United States where total stagnation could be found with the M60A1 being the de facto main battle tank for two decades until the M1 Abrams supplanted it in the early 1980's.

Being a mere evolutionary stepping stone, we can observe the way Soviet school of thought on mechanized warfare evolved with it. In the early 60's, tank riding infantry was still considered a core part of mechanized warfare. The armoured APC had arrived on the scene in the form of the wheeled BTR-152 and tracked BTR-50, but infantry were sometimes obliged to move and fight as one with a tank, and so to that end, the T-62 had handrails over the circumference of the turret for tank riders to hold on to. When the BMP-1 was introduced in 1966, it drove a major revision of contemporary tank tactics, and the shift in paradigm can be very well seen in the T-62's successors. The T-64A did not have any handrails, nor did the T-72, and the T-62M introduced in the 80's abolished them too.

The changes to the T-62 dutifully followed international trends as well, most notably the global shift to jet power in the aviation industry. Too fast to be harmed by machine gun fire, the ground attack jet rendered the normally obligatory DShKM machine gun obsolete. The birth of the AH-1 Huey Cobra and the subsequent heavy use of helicopters for fire support and landing missions during the American intervention (or invasion, if you prefer) in Vietnam permanently shifted the conventional ideals of armoured warfare, and the men and women at the No. 183 plant at Nizhny Tagil (now Uralvagonzavod) obeyed; the DShKM was back by 1972.

The first pre-production models of the T-62 appeared in 1961. In the Soviet Union, the T-62 was mass-produced from 1963 to 1975, making it the direct contemporary of NATO tanks like the M60A1, Leopard 1 and Chieftain which appeared in 1962, 1965 and 1966 respectively. After 1975, all "new" T-62s are actually simply upgraded, modified, or otherwise overhauled versions from the original production run. By then, production at the No. 183 factory had irreversibly shifted to T-72 production.

Like the M60A1, Leopard 1 and Chieftain, the T-62 was a completely different tank than its predecessor, but unlike these three foreign tanks, it did not represent a major change in mobility or protection. Technically speaking, the only difference was in its firepower. Nevertheless, the inherently good tactical-technical characteristics of the basic T-54 were so good and the original design was so solid that the T-62 could still be considered an equal among these main battle tanks.

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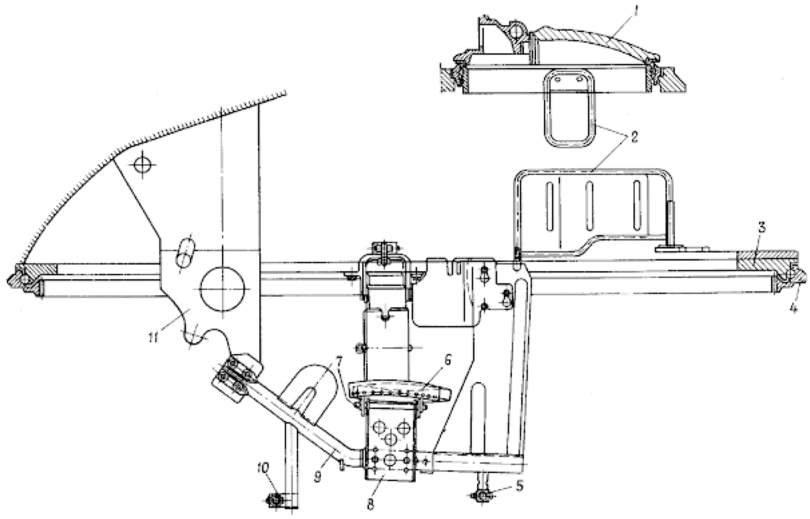
COMMANDER'S STATION

The commander is seated on the left side of the turret, directly behind the gunner. The commander is responsible for observing the tank's surroundings, searching for targets during combat, coordinating the crew or coordinating other tanks in the platoon or company, operating the R-113 radio transceiver set, and more. Unlike the rest of the dome-shaped turret of the T-62, the casting around the commander's station was shaped in such a way that it is devoid of any vertical sloping or curving whatsoever besides maintaining the circular shape of the turret. This was necessary to enable the commander's rotating cupola to be installed. This also meant that any debilitating effects of the shaping of turret (lack of headroom, for instance) do not apply to him as the cupola is raised above the level of the turret roof and the hatch is dome-shaped to further increase the available headroom.

The commander's seat is thickly padded and he has a backrest as well as a footrest. He has access to a communications relay box that enables him to switch between the radio and intercom. There are a few metal loops for strapping on personal effects, his binoculars (in its pouch), his personal sidearm (in its holster), and anything else that might need to be secured such as a documents case. He also has access to the turret traverse lock. Underneath his seat on the hull floor is the tank's heater unit. The commander's two-liter aluminium bottle can be seen secured to its holder. Unlike in the T-54, the radio is installed below the turret ring and next to the gunner which frees up a lot of horizontal space for the commander above the level of his midriff at the expense of the gunner. On the T-54/55, there is a padded knee rest attached to the turret ring where the radio is located in the T-62. All of this can be seen in the two photos below.

The photo on the right (from Aleksey Kotov) shows the backrest of his seat and a few pieces of equipment. The turret traverse lock is just underneath the communications relay box. Besides these two components, there is very little else, and thanks to this, the commander has much more elbow room than a T-54/55 commander who is practically squeezed between the recoil guard on his right and the radio set on his left with enough space to only operate the radio and rotate the cupola with his hands on the handles. Overall, the amount of space for the T-62 commander is noticeably larger compared to the T-54/55 and it is entirely due to the very large turret diameter of 2,245mm. The screenshot below, taken from the video "The Beasts of Kabul: Inside the Afghan Army's Soviet Tanks" by the Stars and Stripes news organization, gives a relatively good perspective of this space.

Still, it's worth noting that in all of the images shown so far, the recoil guard between the commander and the U-5TS gun on his right has been removed. When installed, the recoil guard ensures that the commander's shoulder and arms do not enter the recoil path of the gun or get caught by any of its moving parts but allows him to see over its edge to communicate with the loader.



However, the larger turret ring diameter of the T-62 had much less effect on the space between the commander and gunner. This can be seen in the drawing above. The commander sits directly underneath his cupola and his footrest is just behind the gunner's seat, so unless the commander keeps his legs spread, his knees will be pushing into the gunner's back. The close proximity between the two crew members makes the internal climate hotter and more humid, contributing to the overall discomfort in summer. It may not be as bad in the winter, but still, this is not a positive trait of the tank. The small space between the two men is compounded by the fact that the crew isn't provided with directional ventilation devices such as blowers, fans or directed air vents, so it can get quite stuffy inside. However, both the commander and loader are seated next to the NBC ventilator blower air outlet in the turret, which is installed underneath the spent shell casing ejection port at the back of the turret. Besides the roomy loader's station, the commander's seat is one of the better places to be in the very spartan T-62.

COMMUNICATIONS

The R-113 radio operates in the 20.00 to 22.375 MHz range and has a range of 10 to 20 km with its 4 m-long antenna. It could be tuned into 96 frequencies within the limits of its frequency range.

In 1965, the radio was swapped out for a newer and much more advanced R-123 radio. The R-123 radio had a frequency range of between 20 MHZ to 51.5 MHZ. It could be tuned to any frequency within those limits via a knob, or the commander could instantly switch between four preset frequencies for communications within a platoon. It had a range of between 16km to 50km. The R-123 had a novel, but rather redundant frosted glass prism window at the top of the apparatus that displayed the operating frequency. An internal bulb illuminated a dial, imposing it onto the prism where it is displayed. The R-123 had a modular design that enabled it to be repaired quickly by simply swapping out individual modules.

The commander's cupola superstructure is secured to the turret with screws rather than bolts like on the T-54, but a new bolted cupola superstructure was implemented in the T-62 obr. 1972 model. The cupola is mounted on a race ring. The fixed part constitutes just under half of the total size of the cupola, while the other half is occupied by the semicircular hatch. The hatch opens forward, which is quite convenient for when the commander wants to survey the landscape from outside - perhaps with a pair of binoculars - because the thickness of the hatch makes it a superb bulletproof shield to protect the commander from sniper fire. The hatch has a thickness of 30mm and is curved.

There is also a small porthole in the hatch. It is meant for a panoramic periscope tube for indirect fire, but it can be opened to provide ventilation when the tank is fording a moderately deep river (1.8 meters) with the hatches closed. It is necessary to open the port when doing this as the external engine air intake must be shut off and rerouted to the internal air intake. If the porthole is not opened, the engine will deplete the air inside the crew compartment faster than air can enter through the various small gaps in the tank and eventually asphyxiate the crew.

As befitting his tactical role, the commander's general visibility is facilitated by two TNPO-170 periscopes on either side of the primary surveillance periscope in the fixed forward half of the cupola, further augmented by two more 54-36-318-R periscopes embedded in the hatch, aimed to either side for additional situational awareness. Overall, this scheme could be considered more than adequate.

The TNPO-170 periscope has a total range of vision of 94° in the horizontal plane and 23° in the vertical plane. The four periscopes in addition to the TKN-type periscope aimed directly forward gives the commander a good view of the battlefield in an arc spanning the 4 o'clock position to the 8 o'clock position. There is no rearward-facing periscope, but the commander can look backward by simply turning the cupola to one side and looking back through one of the 54-36-318-R periscopes.

TKN-2 "Karmin"

The original 1961 model of the T-62 featured the TKN-2 surveillance device mounted in the rotating cupola. It had a fixed 5x magnification with an angular field of view of 10° in the daytime channel, allowing a nominal maximum detection range of a tank-sized target of approximately 3 km, though this was greatly dependent on geography as well as weather conditions. The periscope could be manually elevated upwards by +10° and downwards by -5°, and the cupola would have to be manually spun to scan horizontally.

Work on "Karmin" began in 1956 at the Zagorsk Optical and Mechanical Plant. In 1957, the TKN-2 was tested in an experimental T-55 test bed at the testing grounds of factory No. 183, now known as Uralvagonzavod. TKN-2 later went on to be installed on the original T-62 upon its introduction in 1961, thus becoming the first combined day/night periscope to be installed in a Soviet tank.

Due to the combination of nightvision equipment with regular daytime functionality, there had to be two separate optical channels in the periscope. In the daytime channel, the two eyepieces lead to separate apertures to provide stereoscopic vision, thus providing depth perception. For the night channel, the optical channel from the two eyepieces were merged to view from a single aperture lens. This means that the periscope is not truly binocular, but pseudo-binocular.

With only one aperture, the user has very little depth perception. This makes it rather difficult to estimate the distance to a target by eye, but the commander has a stadia rangefinder for that anyway.

The TKN-2 had an active night channel relying on the infrared light emitted from the OU-3 IR spotlight attached to the periscope aperture to provide a limited degree of night vision to the commander. With a nominal viewing range of only about 300 to 400 m, the TKN-2 was all but useless for serious target acquisition at night, serving only to give away the tank's position the moment the spotlight was turned on. Performance could be improved with mortar-delivered IR flares, of course, but that doesn't count as an intrinsic merit of the device itself.

It is not known what the TKN-2 looks like, but this unidentified periscope could be it. Photo from apexgunparts.com. The best evidence that this is the TKN-2 is shape of the housing, which bears a striking resemblance to the TKN-3, the power cables, and the single aperture lens, seen in this photo. All of these evidences point to the unidentified periscope being a combined day/night optic, and we already know for sure what the TKN-1 and TKN-3 look like. Therefore, it must be a TKN-2.

Due to the fact that the periscope is unstabilized, identifying a tank type target at a distance is very difficult while on the move over very rough terrain. However, the commander is meant to bear down and brace against the handles of the periscope for a modicum of improvised stabilization, which is adequate for when cruising at a moderate speed (about 20 km/h to 30 km/h) over a dirt road, but not when traversing over rougher ground.

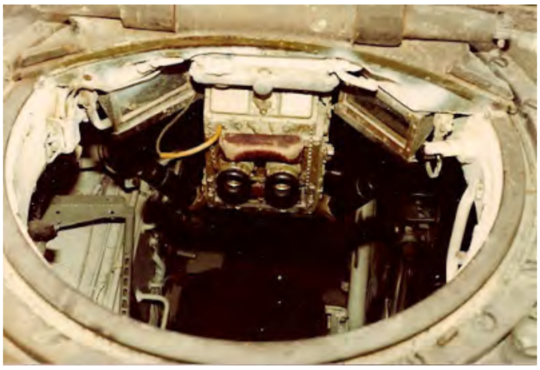
The left handle has a thumb button for activating the OU-3 spotlight. The thumb button must be held to keep the light on. This allows the commander to illuminate his target intermittently or to flash friendly forces. To toggle the spotlight on or off, the commander must flip a toggle switch on the cupola race ring.

The OU-3 has an incandescent lamp with a removable IR filter. The filter isn't totally opaque, of course, so the spotlight will glow faintly red when activated. It is linked to the periscope by mechanical linkages so that it elevates together with the TKN-2.

OU-3 IR spotlight with the IR filter removed to transform it into a regular white light spotlight

The OU-3 spotlight operates on 110 W of power. This is not much compared to the L-2 "Luna" spotlight used for the TPN-1-41-11 night sight, and it is extremely weak compared to most Western IR spotlights. Considering that the Chieftain tank was introduced only six years after the T-62 and came equipped with a higher powered IR spotlight for its commander, the low power of the OU-3 spotlight may have made it a liability in real combat. In a scenario where both sides are actively searching for targets using IR spotlights but fail to find each other by seeing the light sources, the longer-ranged spotlight on the Chieftain enables it to spot a T-62 more quickly. Despite this, the fact that the commander has his own IR spotlight and a night vision sight of his own is still useful, so the commander of a T-62 cannot be considered too deficient in this department. Even if he cannot rely on his own OU-3 spotlight at long distances, the TKN-2 still gives him the ability to survey the battlefield under the light of artillery-launched illumination flares and find enemy light sources without using his own illumination sources.

TKN-3 "Kristal"



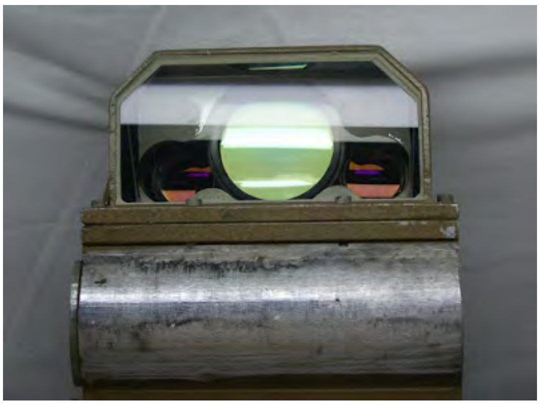
In 1964, new batches of T-62 tanks began to be equipped with the new TKN-3 combined periscope, a direct descendant of the TKN-2. One of the biggest improvements of the TKN-3 over the TKN-2 is the use of coated lenses for the daytime optical channel. This reportedly provided twice as much light transmittance, thus substantially improving the brightness and contrast of the image and consequently increasing the commander's practical viewing range and also improving his ability to see camouflaged objects at long distances.

The periscope has a fixed 5x magnification in the day channel with an angular field of view of 10° and a fixed 4.2x magnification in the night channel with an angular field of view of 8°. The TKN-3 was a sufficiently modern surveillance device for its time. It had a standard target cuing feature, was very compact, and had a relatively advanced passive light intensification system. On the other hand, it wasn't stabilized and featured only rudimentary rangefinding capabilities.

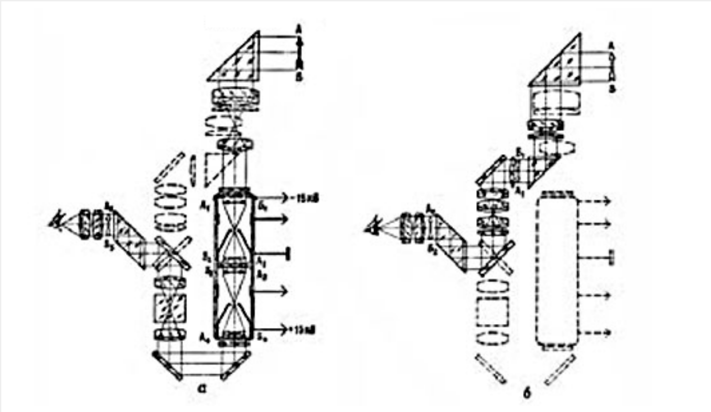
TKN-3 offered night vision in two flavours; passive light intensification or active infrared. In the passive mode of operation, the TKN-3 intensifies ambient light to produce a more legible image. This mode is useful down to ambient lighting conditions of at least 0.005 lux, which would be equivalent to an overcast, moonless and starless night. In these conditions, the TKN-3 can be used to identify a tank-type target at a nominal distance of 400 m, but as the amount of ambient light increases such as on starlit or moonlit nights, the distance at which a tank-sized target is discernible can be extended by around twice the normal range, but the viewing distance is still limited by the low resolution image. Using the image intensifier under increasingly bright conditions may not be so beneficial since the image will be oversaturated and unintelligible, making the low resolution image even more difficult to view.

The active mode requires the use of the OU-3GK IR spotlight. Activating the OU-3GK is done the same way as with the TKN-2. With active infrared imaging, the commander can identify a tank at arund 400 m or potentially more if the opposing side is also using IR spotlights, in which case, the TKN-3 can be set to the active mode but without turning on the IR spotlight. This way, the commander can see enemy tanks from many kilometers away at night. Without the infrared filter, the spotlight emits white light at 240 candlepower.

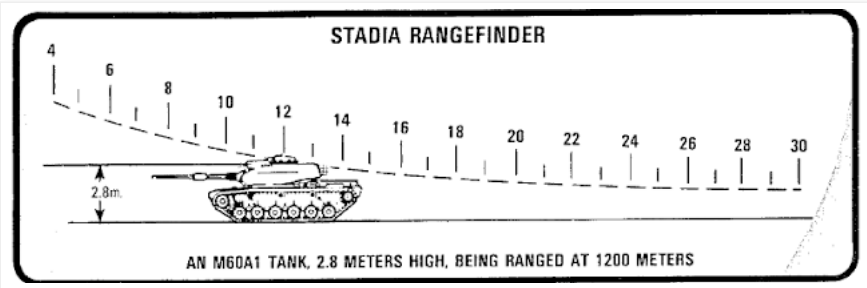
Like the TKN-2, the TKN-3 had separate optical channels for the night and day viewing modes. In the daytime channel, the two eyepieces lead to separate apertures to provide stereoscopic vision, thus providing depth perception. For the night channel, the optical channel from the two eyepieces were merged to view from a single aperture lens.



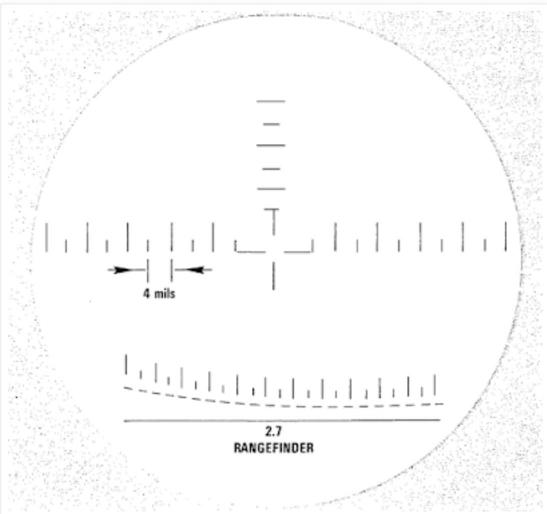
To switch between the day and night channels, the user simply rotates a dial on the right side of the periscope housing by 90 degrees. This flips an internal mirror by 90 degrees, thus changing the optical path between the night vision unit and the regular daytime optical channel. The diagram below shows the two choices. Diagram (a) on the left shows the path of the light from the aperture through the night vision system and into the eyepiece, while diagram (b) on the right shows the mirror flipped 90 degrees and the light from the aperture passing through the normal optical channel for daytime use.



Rangefinding is accomplished through the use of a stadiametric scale calibrated for a target with a height of 2.7 m, which is the average height of the average NATO tank. The ranging error margin is negligible at distances of around a kilometer, but at distances exceeding approximately 1.6 km, it becomes difficult to accurately find the range of the target due to a multitude of factors, including weather conditions, limited magnification power, mirages (a big problem in deserts), and obstruction of parts of the tank (tall grass can hide the lower part of the hull). At long distances, contrast between the target tank and the background is also often very poor, since there is usually some modicum of camouflage to conceal the tank.



It is also possible to find the distance to the target tank by using the windage and elevation scales beside and above the central reticle in the TKN-3 viewfinder. Knowing the width of any Patton tank to be around 3.6 meters, the commander will know that the distance to the tank is exactly 900 meters if the tank can be bracketing it exactly between any two vertical lines on the windage scale (4 mils). If the commander sees a Patton tank presenting its profile, he can assume that its length is 7 meters, and he can place estimate the range to the tank by bracketing it between two of the long vertical lines on the windage scale (8 mils). If it fits perfectly, then the distance is just slightly under 900 meters, but can be rounded up to 900 meters with a negligible margin of error.



TKN-3 viewfinder

Like the TKN-2 and other previous binocular sights for the commander, the TKN-3 is not stabilized, making it exceedingly difficult to reliably identify enemy tanks or other vehicles at extended distances while the tank is travelling over rough terrain, let alone determine the range. On a related note, the lack of stabilization would have made it equally difficult to operate an optical coincidence or stereoscopic rangefinder, especially one with a high magnification. The M17 rangefinder used in M60A1, for example, would have been next to useless if the tank was in motion over rough terrain since the rangefinder had a fixed 10x magnification, so the oscillations from the movement of the tank could cause too much jolting for the commander to keep the target focused. This means that the rangefinder is only useful when the tank is static, which may have been perfectly fine for the M60A1 and its contemporaries if the situation consistently permitted the tank to remain static. The T-62, on the other hand, is an offensive tank designed to fulfill specific tactical-technical requirements while remaining affordable, and high-precision optical instruments did not necessarily fit into this plan.

Optical rangefinders were therefore understandably absent from Soviet medium and heavy tanks, but not from Soviet tank destroyers and assault guns. Case in point: the SU-122-54 and experimental Object 268 both had stereoscopic rangefinders installed on the commander's cupola as a technical requirement. However, Object 268 was deemed superfluous and the need for the SU-122-54 evaporated fairly quickly after it was accepted into service, not least because problems were encountered with the rangefinder. Optical rangefinders only found their way into Soviet tanks on a large scale with the advent of the T-64; the first tank to have an independently stabilized primary gunsight, and also the first tank to have an integrated optical coincidence rangefinder installed in said gunsight.

The left thumb button initiates turret traverse for target cuing, and the right thumb button turns the OU-3GK spotlight on or off, but the button must be held to keep the spotlight on. The spotlight should not be turned on for more than 20 seconds, as it will overheat without periodic cooling. A toggle switch on the race ring of the cupola enables the commander to keep the spotlight on or off. The range of elevation is +10° to -5°. The OU-3GK spotlight is mechanically linked to the TKN-3 by a pushrod to enable it to elevate and depress with the periscope.

Target cuing is done by placing the crosshair in the viewfinder of the TKN-3 over the intended target and pressing the left thumb button. The system only accounts for the cupola's orientation, and not the periscope's elevation, so the the turret will traverse to meet the target, but not the cannon. This was not an issue, since the gunner needs to manually elevate the cannon to place the crosshair on target anyway (explained later in the Sights segment). The wide field of view offered by the gunner's sight made it impossible for the gunner to miss a target even if the turret was imperfectly aligned with the commander's periscope.

The target designation system is practically the same as the one used in the T-54. A direction sensor is installed at around the 3 o'clock position of the cupola, and has the function of determining the deflection of the TKN-3 relative to the longitudinal axis of the turret. The direction sensor consists of a roller placed in permanent contact with the cupola race ring, a cam attached to the roller and two switches. The roller is recessed into a notch in the cupola race ring when the cupola is turned to the 0 o'clock position relative to the turret - refer to the diagram in the middle.

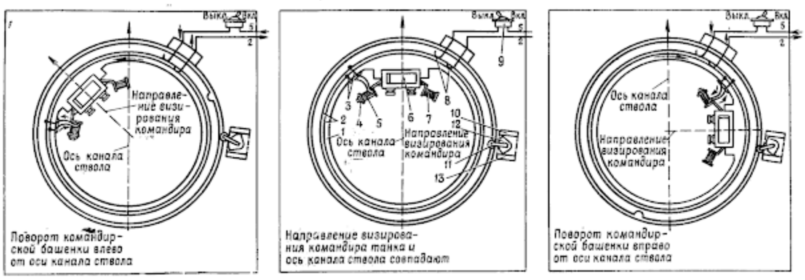


Рис. 88. Устройство и схема работы приборов целеуказания:
1 — погон; *2* — контактные кольца; *3* — контакты; *4* — кнопка целеуказания; *5* — левая рукоятка прибора; *6* — командирский прибор наблюдения ТКН-3; *7* — правая рукоятка прибора; *8* — щетки; *9* — выключатель командирского целеуказания; *10* — переключатель П-60; *11* — ролик кулачка; *12* — кулачок; *13* — переключатель П-60

When the cupola is turned to the right (see diagram on the right), the motion of the cupola race ring dislodges the roller from the notch and causes the roller to be deflected to the left by friction. The cam attached to the roller also rotates left, causing it to touch the switch on the right, but no action is taken until the target designator button is pressed. When the target designator button is pressed, and electric signal is sent from the button to the direction sensor via a conductor track on the cupola race ring. The depression of the right switch by the cam then triggers the turret rotation motor to turn the turret to the right until the roller returns to the notch, whereby the cam is no longer in contact with the right switch and no action is taken even if the commander keeps his thumb on the target designator button. The same mechanism is repeated in reverse when the cupola turns to the left. Since the direction sensor is composed of two switches which can only be either on or off, the command to initiate turret rotation is binary. This means that the turret is either turning, or it is not. For that reason, the turret always rotates at maximum speed when the target designation system is activated. This ensures that the gunner is cued to the target as quickly as possible. The the gun-laying precision of the turret at its maximum traverse speed is low, but that is irrelevant as the final lay is conducted by the gunner.

Because the cupola does not counter rotate as turret traverse is initiated, it may spin along with the turret as it rotates to meet the target cued by the commander, potentially causing him to lose his bearings. To prevent this, there is a simple U-shaped steel rung for him to brace with his right arm as he uses his left hand to designate the target. This wasn't as convenient as a counter rotating motor, of course, but it was better than nothing. The photo below shows the steel rung, as well as the toggle switch for the cupola's electrical systems (turns on power to TKN-3 and OU-3GK) next to the right part of the steel rung. The direction sensor is visible next to the left part of the steel ring.

Overall, the commander's facilities, furnished with the TKN-3, might be considered better than most Western tanks when it comes to target finding. As far as the author knows, the M60A1 and the Leopard 1 to 1A2 didn't have anything even approaching the TKN-3. In 1973, the TKN-3 was soundly outmatched by the new and quite excellent TRP 2A sight installed on Leopard 1A3s, and by the highly advanced PERI-R12 panoramic sighting system for the Leopard 1A4 in 1974. However, it should be mentioned that the Leopard 1A3 was only produced from between May 1973 and November 1973, and that only 110 examples were built, and only 250 units of the Leopard 1A4 model were produced. The Leopard 1A4 was the last major Leopard 1 variant and the most advanced operated by the Bundeswehr until the end of the Cold War. The rest of the Leopard fleet was less advanced.

Sometime during the 1970's, a select number of tanks received a face shield over the commander's hatch. It is a sheet steel face shield with a canvas skirt draping down. Being so thin, the face shield is ***not*** bulletproof.

Since it does not serve as ballistic protection, the main function of the shield appears to be to conceal the opening of the commander's hatch to disguise his exit from the prying eyes of snipers, and to shield the commander from dust and bugs if he feels like sitting outside during road marches. Either way, not many T-62s received the addition, though almost all T-72s did. The reason for this is unclear.

GUNNER'S STATION

A T-55 gunner will find himself in familiar territory upon sitting on the gunner's seat in a T-62. The gunner's thickly padded seat is not adjustable in height but it can be folded flush against the U-5TS gun assembly to enable both the gunner and commander to move to the driver's compartment or exit through the escape hatch in the tank belly, which is behind the driver's seat. The turret of the T-62 does not have a turret basket with a safety cage to isolate the turret crew from the hull, but the rotating floor has a short fence on its perimeter in front of the gunner's seat. When the gunner's feet are placed on the rotating floor, the fence serves to ensure that his feet do not slip off the edge. Overall, the gunner's station is quite spartan - other than these features, there is no other furniture.

When both the gunner and commander are seated, there is so little space between the two men that the commander must partially wrap his knees around the gunner, though it isn't quite as bad as in the T-55 thanks to the larger turret ring diameter. On the one hand, the gunner is seated close to the lateral axis of the turret ring and as such, he gets to enjoy the full width of the turret ring, but on the other hand, the placement of the radio set below the turret ring (as opposed to the turret shelf next to the commander like in the T-54/55) takes up a large amount of horizontal space. This can be seen in the drawing below.

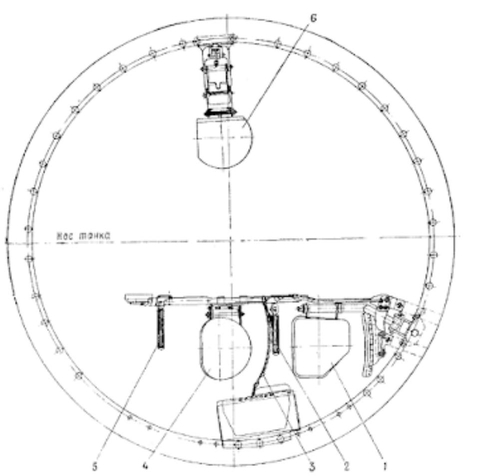
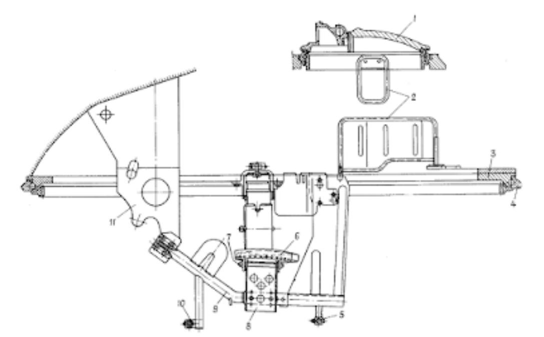


Рис. 31. Расположение сидений в башне:
1 — сиденье командира танка; 2 — подножка командира танка; 3 — опорный ремень; 4 — сиденье наводчика; 5 — подножка наводчика; 6 — сиденье заряжающего

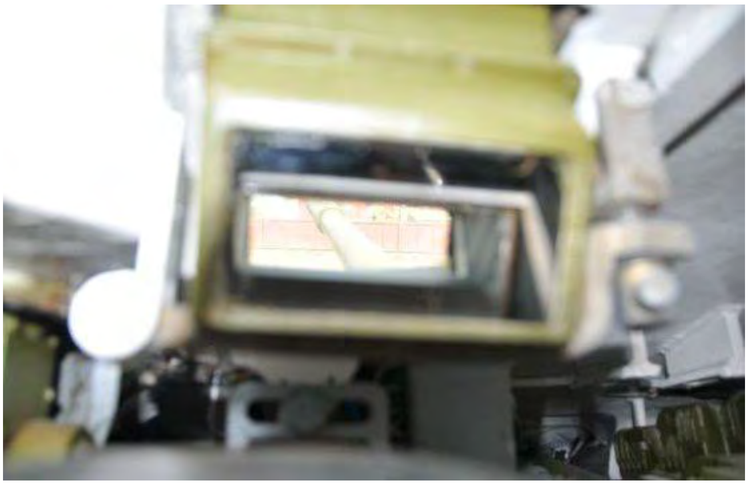
As was, and still is common among manually loaded tanks, the gunner does not have a hatch of his own. Instead, he must ingress and egress through the commander's hatch. The biggest flaw with this layout is that if the commander is unconscious, incapacitated or killed, then the gunner will suddenly find it extremely difficult to leave the tank unless the commander was somehow completely vaporized. Even worse, if the tank has been struck, there is a very distinct possibility that the interior is catching fire.

Nevertheless, Nicholas "The Chieftain" Moran commented that the gunner's station in the T-55 is very well laid out, and overall quite satisfactory. The T-62 should offer a slightly better experience thanks to the more voluminous turret. The mounting frame for the gunner's seat, gunner's footrest, commander's footrest and the recoil guard is shown in the drawing on the right below. From the close proximity between the commander's footrest and the gunner's seat, it can be seen that the commander's knees would be pressed into the gunner's back unless the commander had his legs wrapped around the gunner. The gunner has no backrest, but a leather belt can be attached to the turret ring and a special attachment point behind the seat to be stretched behind the gunner's back to form a rudimentary backrest. However, it is not used often because it is not particularly comfortable and it can impede a quick exit through the commander's hatch.



For extra visibility, the gunner has a single TNP-165 periscope pointed forward. The field of view from the periscope is 70 degrees. This periscope gives the gunner some additional awareness of the immediate area in front of the turret which can be important as the gunner is responsible for preventing the gun barrel from knocking into obstacles or digging into the ground. However, the TNP-165 for the gunner is more of a bonus than a necessity since the gunner's telescopic sight is installed on the same level as the axis of the gun barrel, so it is not difficult for him to see and control the gun to avoid damage. Rather, the TNP-165 periscope may be more useful for allowing the tank to be used more effectively in a turret-down position thanks to its high location on the turret roof. Having a telescopic primary sight mounted on the same level as the gun barrel means that the gunner cannot aim over the crest of a berm or hill when the tank is parked behind it, but by having a periscope on the turret roof just in front of the commander's cupola, the gunner is essentially given the same elevated view as the commander when the tank is in a turret-down position. The commander can use the target designation function of his TKN-3 optic when he sees a target, and the turret will be automatically traversed to face it and the gunner will be able to see it through the forward-facing TNP-165. After the gunner confirms visual contact with the target, he can look through his telescopic sight and wait until the commander gives the order for the driver to move forward. When the muzzle of the gun clears the crest of the berm or hill in front of the tank, the gunner can immediately acquire the target through his sight and open fire.

The periscope is also useful when the tank is not in combat as it gives the gunner some spatial awareness. Considering that the gunner does not have a hatch of his own, he is essentially stuck in his corner of the turret for the duration of any march which can quickly become tiresome.



In addition to all of the necessary switches and toggle buttons to activate this and that, there are also some other odds and ends at his station, including a turret azimuth indicator, which is used to orient the turret for indirect fire. It is akin to a clock, having two hands - the hour hand for general indication measured in 6000 mils, and the minute hand in 100 mil increments for precise turret traverse. Combined with the gunner's quadrant, the T-62 can conduct indirect fire.

The azimuth indicator has an internal bulb that can be turned on to allow the gunner to read it at night.

SIGHTS

Telescopic sight aperture port, with nuclear attack seal in place

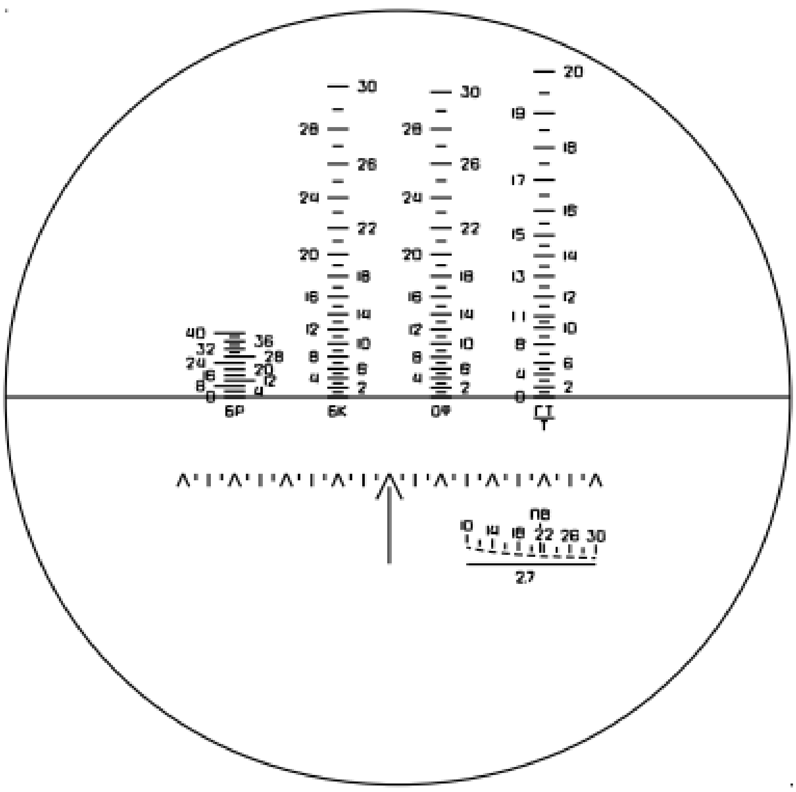
The gunner is provided with either a monocular TSh2B-41 or a TSh2B-41U (in later models) articulated telescopic primary sight and a TPN-1-41-11 night sight.

TSh2B-41

The TSh2B-41 is a monocular telescopic sight that functions as the gunner's primary sight for direct fire purposes. It has two magnification settings, 3.5x or 7x, and an angular field of view of 18° in the former setting and 9° in the latter setting. It comes with a small wiper on the aperture to clean off moisture and dust, and it comes with an integrated heater for defrosting. The sight has an internal light bulb that when turned on, illuminates the reticle for easier aiming in poor lighting conditions such as during twilight hours or dawn. There is an anti-glare filter inside the telescope housing that can be toggled. The anti-glare filter should only be used when looking directly at the sun, otherwise the filter washes out most of the colour and contrast, and darkens the image considerably, thus making it much harder to make out the shape of a camouflaged tank at long distance. All of these features are activated manually by the gunner via toggle switches on the telescope itself.

Like most other tanks of its time, the T-62 lacked a ballistic computer. It had no FCS, only this sight. As the tank lacked a stereoscopic rangefinder like the M48, it was also deficient in the rangefinding department. For rangefinding, the gunner had to make use of a stadiametric ranging scale embossed on the sight aperture. Compared to a good optical coincidence rangefinder with a wide base length, stadia rangefinding was terribly imprecise but also vastly more economical. However, by sticking with the stadia rangefinder, ranging errors of up to several hundred meters was often the norm, especially if some of the lower part of the target vehicle is obscured behind vegetation or other terrain features. It isn't uncommon for the first shot on faraway tank-sized targets to fall woefully short or fly clear over when using low velocity ammunition like HEAT rounds. As such, APFSDS was the primary anti-tank round for the T-62.

Below is the viewfinder of the sight:



Range scales from left to right: APFSDS, HEAT, HE-Frag, Co-Axial Machine Gun

When the gunner has obtained range data, he manually enters the necessary correction into the sighting system by turning a dial. The dial adjusts the sight to calibrate it for that range.

Calibration is when the chevron is elevated or depressed to account for range. If the target is very far away, for example, then the chevron will be dropped significantly, forcing the gunner to sharply elevate the gun to line up the target with the chevron, thus forming a ballistic solution. If the target is closer, the chevron will only drop a little. Because APFSDS, HEAT and HE-Frag shells all have different ballistic characteristics, the gunner must refer to a set of range scales drawn on the upper half of the sight in order to get the proper gun elevation. For instance, if the target is 1.6 km away, and the gunner wishes to engage it with high explosive shells, then he must turn the dial so that the notch marked "16" on the range scale for "OF" (refer to diagram above) lines up with the fixed horizontal line (all of the range scales will drop, so HEAT rounds will also be calibrated at 1.6 km and the co-axial will be calibrated for 2.0 km (refer to diagram), but the gunner ignores that). The chevron will drop by the same amount as the range scale, the gunner will then lay the chevron on the target and open fire. If the gunner wishes to use APFSDS instead, then he need only line up the horizontal bar with the "16" notch on the "BR" scale. The chevron will drop a little, and the ballistic solution for APFSDS at 1.6 km will be obtained. The gunner will then lay the chevron on the target and open fire.

It is more difficult hitting targets with lower velocity ammunition like HE-Frag and HEAT shells, and even harder for moving targets. However, the inclusion of near-hypersonic APFSDS ammunition in the loadout of the T-62 greatly helped counterbalance this issue, making it markedly easier for the gunner to hit both stationary and moving tank-type targets, while most targets requiring HE-Frag shells like machine gun nests and pillboxes and other fortifications would be stationary anyway, thus making pinpoint accuracy much less of a priority. On account of the extremely high speed of the APFSDS rounds fired from the 2A20 gun, the sight can be battlesighted at a very generous 1000 m, allowing the gunner to confidently hit a tank of NATO-type dimensions in the open at any distance between 200 to 1600 m by aiming at center mass without needing to ascertain the range beforehand. If the target is closer to 200 meters, the shot will land above center mass, i.e the turret. If the target is closer to 1600 meters, the shot will land below center mass, i.e the lower hull.

However, one inescapable flaw of the TSh2B-41 was that it lacked independent vertical stabilization. The movable aperture assembly of the sight is directly linked to the 2A20 cannon via a pair of rods. Due to the "loader assist" function of the "Meteor" stabilizer (referred to as the "autoblock"), the aperture of the sight will raise along with the cannon when the loading procedure is underway. This can cause the gunner to (very annoyingly) lose sight of anything he is aiming at at the moment, thereby making the commander's the only pair of eyes to observe the 'splash' and give corrections or search for new targets. However, this can be bypassed if the gunner switched to the 3.5x magnification mode, whereby he will still be able to observe the 'splash' at the bottom part of the sight picture. He might also be able to get a glimpse at the bottom edge of his sight at 7x magnification, but this depends on the elevation of the cannon. On flat ground, this might be possible, but this will be impossible if the tank is peeking over a reverse slope. These complications led to the development of the independently stabilized TSh2B-41U.

But since we are on this topic, we cannot neglect to mention that it is very difficult to observe the fall of a shot when high velocity APFSDS rounds are being used. For one, the flash, smoke and fumes from ejected from the gun barrel will immediately block out any attempts to find the point of impact. Secondly, the shock and vibration from firing the cannon does not leave enough time for the gunner to recover and visually reacquire the target. These two factors are extremely relevant for any tank, but the T-62 suffers since the sight aperture is very close to the ground when the tank is hull-down, so dust from the ground is an even bigger issue. Even if a tank had a thermal sight, it is not possible to escape this phenomenon.

The video below shows a Chieftain tank firing at a target on what appears to be sheep grazing on a grassy field. Due to the clean environment, the amount of dust kicked up by the muzzle blast is very minimal. The target is visible in a mere two seconds after firing.

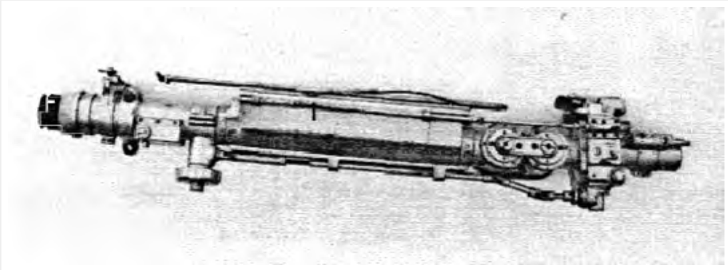
Video from here (link)

The GIF below shows the view from the thermal sight of an Iraqi Abrams firing at ISIS fighters. The dusty environment obscures the gunner's vision for around five to six seconds immediately after firing. See the difference between this and the clean, grassy environment of the Chieftain before. Both examples show the difficulty of maintaining visual contact with the target immediately after firing, and a comparison between the examples show the importance of the dustiness of the environment.


Video from here (link)

Nevertheless, even if the gunner's view is not obstructed by dust or sand, it is still possible to see the target through the TSh2B-41 at the bottom part of the viewfinder. When on flat ground, the 9° field of view of the sight on 7x magnification is almost always sufficient to maintain visual contact with a target. Assuming that the target is placed near the center of the viewfinder where the aiming chevron would be, the raising of the cannon by 3° after firing. This is immediately apparent if we split the 9° field of view into two parts: 4.5° degrees above the center point, and 4.5° below. Raising the sight by 3° leaves 1.5° for the gunner to see the target with. If the 7x magnification setting is too high, the gunner can simply switch to the 3.5x setting with its 18° field of view.

TSh2B-41U

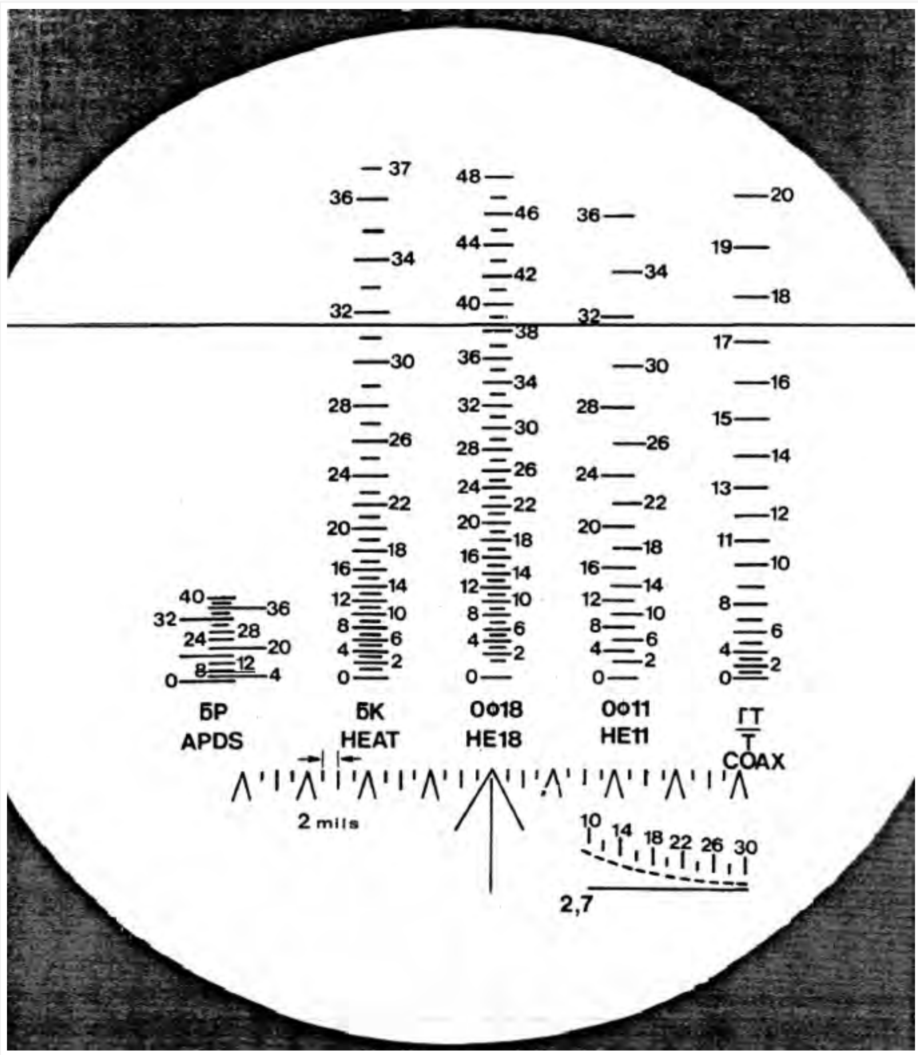


In the 1972 modification of the T-62, it was given the upgraded TSh2B-41U sight with independent vertical stabilization as a transient solution. It lacks the usual components of a true stabilization system, like its own gyrostabilizer system, so its performance is highly unimpressive. The sight has a mean vertical stabilization accuracy of 3 mils - meaning that it has an accuracy of 3 meters at 1000 m, or a maximum deviation of up to 1.5 m, which would incredibly inadequate for anything other than just general observation. Fortunately enough, that's all that it is meant for, as the sight is only stabilized when the cannon is elevated during the loading procedure. When the cannon elevates, the sight does not follow, allowing the gunner to use his handgrips to manipulate the elevation of the sight. Once the cannon is ready to fire again, the "Meteor" stabilizer reengages and "catches up" to the sight, whereby the sight's stabilizer deactivates and defers its work to Meteor once again. This is different from true independent stabilization where the sight's stabilizer can be as precise or more precise than the stabilizer for thecannon, and the stabilizer for the cannon is perpetually slaved to the sight.

One tangible benefit of the independent vertical stabilization of the sight is that the gunner will be able to survey the landscape if the tank is on the move after firing from a short halt or crawl, or if the tank is firing on the move.

The stabilization system of the sight enabled the aperture lens to elevate as high as the cannon, but it could only depress by -5 degrees. Because of this, T-62s from 1972 and onwards have a reduced gun depression of -5 degrees as compared to the -6 degrees afforded by the original TSh2B-41.

Another modification was the addition of a range scale for the new and improved 3UOF18 HE-Frag shell, and the separation of it from the scale of the older 3UOF11. The aiming distance of HEAT ammunition was increased to 3.7 km and the aiming distance for OF-18 and OF-11 shells are listed as 4.8 km and 3.6 km respectively.



TSh2B-41U suffered from poor performance. Even if it did offer a modicum of independent vertical stabilization, it was not useful enough. TSh2B-41U was was not installed on many tanks.

Because the sight aperture is just left of the gun barrel, there is a very high likelihood that it will be rendered inoperable if the turret takes a hit anywhere near it. A very close miss may create a big enough shock to knock the sight out of alignment or even crack the lenses, not to mention the disastrous effects of a direct hit on the aperture itself. But for all of its inherent flaws, the TSh-2B-41 should not be seen as anything less than an extremely high quality product of its time. Lack of independent vertical stabilization notwithstanding, the glass was of superb quality and the insulation and shockproofing of the sight unit was sturdy enough to survive the blast wave of a nuclear explosion and ambient temperatures of over 200° C. Nevertheless, whereupon the TSh2B-41 is out of service, the gunner will have no choice but to rely on the TPN-1-41-11 night sight.

TPN-1-41-11

The TPN-1-41-11 is a monocular periscopic night sight located on the turret roof just in front of the commander's cupola. The TPN-1-41-11 has a fixed magnification of x5.5 and a field of view of 6°. It could operate in the active infrared imaging mode or the passive light intensifying mode, but in either case it must be powered on to be used at night as the night vision system for both modes rely on light intensification with an extremely high voltage to amplify the image to visible levels. Powering on the sight is done by flipping a toggle switch on the BT-6-26 power supply unit on the turret wall, above the manual traverse flywheel. In the active mode, the TPN-1 works in tandem with the L-2 "Luna" IR spotlight which is coaxially linked to the cannon via a mechanical linkage. The infrared light supplied by the spotlight is picked up by the sight, which allows the gunner to identify a tank-type target at distance of around 800m, which is only just decent, but not worse than its immediate counterparts'. In the passive mode, it employs light intensification for a nominal maximum identification distance of 400m for a tank-type target under lighting conditions of no less than 0.005 lux. The intensity of the image can be adjusted by changing the voltage, which can be done by turning a dial on the sight. When in use, the gunner turns the dial until the image he sees has maximum contrast. As with the TKN-3, and indeed any optronics using light intensification, the viewing distance and resolution increases as ambient light intensity increases, but only up to a certain point before the sight is oversaturated and can no longer produce a legible image.

The diagram below, taken from the U.S Army Operator's Manual for the T-62, shows the reticle for TPN-1-41-11. Note that the tip of the top vertical bar is calibrated for 800 meters for APFSDS (marked 'APDS' in the diagram) This is the nominal maximum viewing distance afforded by the sight in the active infrared mode, and is also a convenient battlesight distance. The gunner can use this aiming point to engage any target he sees through this sight in the active infrared mode and be assured that the shot will definitely hit.

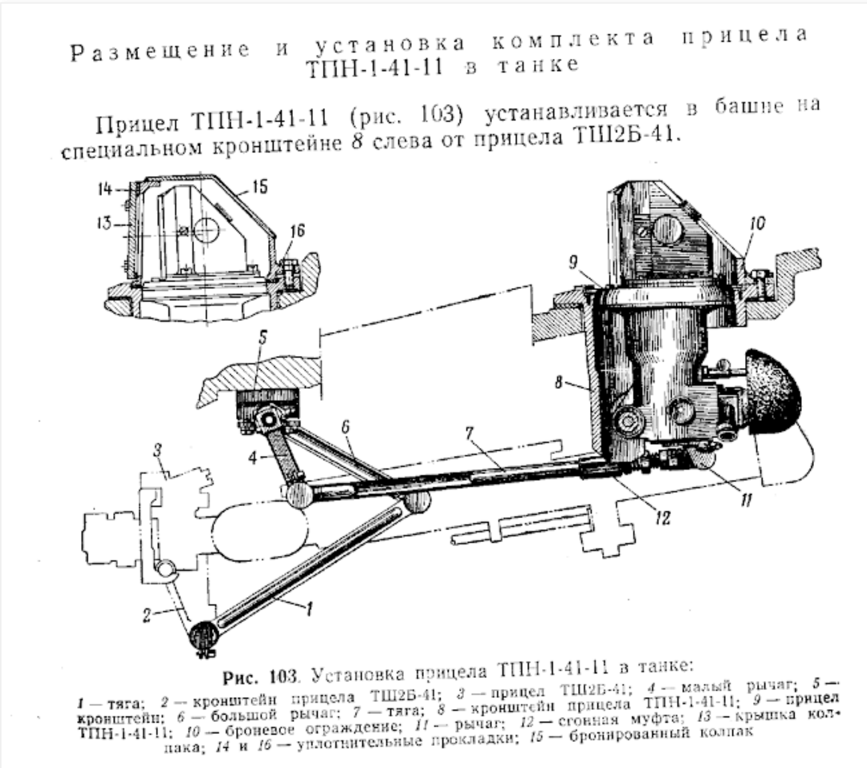
CHART FROM TPN1-41-11 PERISCOPE

APDS	HEAT HE 11		HE 18	COAX
8	1	I	1	1
14	3	I	2	2
19	5	Λ	4	3.5
30	9	I	7	6

Turning on the L-2 IR spotlight will also turn on a red tinted light bulb near the roof of the turret. This gives the gunner's station an ominous red glow and informs him of the activation of the spotlight. The sight has an internal lightbulb which facilitates aiming at night.

The mounting frame for the L-2 spotlight for a Tiran 6 is shown in the photo on the left below (credit to Carl Dennis from Prime Portal). The spotlight is affixed to the frame at the four corners with bolts, and the large hole in the middle of the frame is for the power cable for the spotlight. The back of a partially dismantled L-2 spotlight can be seen in the photo on the right below.

TPN-1-41-11 is mechanically linked to the TSh2B-41, and does not have independent stabilization. As such, just like the TSh2B-41, its range of vertical motion is limited and depends on the range of elevation afforded by the cannon, which is -6° to +16°. The picture below shows the system of linkages that connect the sight to the TSh2B-41, which in turn is connected to the cannon.



Размещение и установка комплекта прицела ТПН-1-41-11 в танке

Прицел ТПН-1-41-11 (рис. 103) устанавливается в башне на специальном кронштейне 8 слева от прицела ТШ2Б-41.

Рис. 103. Установка прицела ТПН-1-41-11 в танке:

1 — тяга; 2 — кронштейн прицела ТШ2Б-41; 3 — прицел ТШ2Б-41; 4 — малый рычаг; 5 — кронштейн; 6 — большой рычаг; 7 — тяга; 8 — кронштейн прицела ТПН-1-41-11; 9 — прицел ТПН-1-41-11; 10 — броневое ограждение; 11 — рычаг; 12 — сгонная муфта; 13 — крышка колпака; 14 и 16 — уплотнительные прокладки; 15 — бронированный колпак

LASER RANGEFINDER

As part of the overall effort to bring the T-62 series up to modern levels of technology, the T-62 began to be fitted with the KDT-1 laser rangefinder in 1974 to 1975, coinciding with the decision to replace optical coincidence sights on the T-72 Ural with a laser rangefinder in the T-72 Ural-1 modernization project. The exact date of the beginning of the modernization programme is unclear, but Mikhail Baryatinsky writes in "*T-62: Убийца «Центурионов» и «Олифантов»*" ("*T-62: Killer of Centurions and Olifants*") that the installation of the KDT-1 on some tanks began in 1975. The KDT-1 was mounted directly atop the barrel of the 2A20 cannon. This sort of arrangement can be encountered on legacy tank designs, but some examples like the Chieftain, which also did not originally have a laser rangefinder and had one retrofitted as well, had it installed under armour by replacing the ranging machine gun. Having the rangefinder exposed outside the turret is no doubt a minor drawback, since it then becomes vulnerable to airbursting artillery shells or even the blast and frag of a direct hit on the armour. The rangefinder is housed in an armoured box, and the armoured box offers protection against artillery and mortar splinters and small arms fire, but nothing more.
The KTD-1 had a maximum measuring distance of 4,000 meters and a minimum of 400 meters. The maximum margin of error in the measurement was 20 m and the average error was 10 meters. According to a 1981 Soviet essay titled "*Из Опыта Совершенствования Основных Танков В Ходе Серийного Производства*", the installation of the KTD-1 on the T-55A obr. 1975 resulted in an increase in the effective range of subcaliber and HEAT rounds by 10% and 15% respectively. Also, the time needed to fire the first shot was decreased 10%, or in other words, the reaction time of the tank was shortened by 10%. The same level of quantitative improvement should be expected for the T-62 as its fire control system is functionally the same as that of a T-55A.

KTD-1 does not directly interface with the existing fire control system primarily because there is no system to compute a ballistic solution in the basic tank model. There is a control panel for the rangefinder system mounted in its own special corner and the original control handgrips were replaced with a new type from the "Meteor-M" stabilizer that had an additional trigger button for firing off the rangefinder. To use the KTD-1, the gunner would lase the target using his sights, remove himself from the eyepiece of the sight to read the range measurement shown in the digital readout on the control panel, return to the eyepiece and then manually apply the data into the sight by adjusting the range dial to the appropriate number. Needless to say, this was not as quick as the system in the TPD-K1 sight which automatically computed the ballistic solution and made the appropriate adjustments for the gunner.

Having a laser rangefinder in 1974 was quite a big deal at the time. The best that the Leopard 1 had at the time was the EMES 12A1 with a stereoscopic rangefinder which could be found on the Leopard 1A4 model built in 1974, although it is understood that this does not mean that the shortcomings of the T-62's fire control system had simply vanished. Rangefinding with the KTD-1 was fast, but the additional hassle of inputting the range data is a cumbersome chore that takes valuable seconds, especially since the readout is separate from the gunsight so the gunner must momentarily break visual contact with the target. The presence of the rangefinder is most helpful when firing on non-tank targets like bunkers and fixed fortifications including machine gun nests and anti-tank weapon emplacements, as these targets cannot be ranged with a stadiametric rangefinder, yet they comprise the majority of the targets that a tank would be called upon to eliminate. Additionally, the T-62's APFSDS ammunition makes up for the lack of rangefinder in the fire control system at short to medium ranges, but not so much at longer ranges. The presence of a laser rangefinder further improves the accuracy of the tank at medium ranges, and greatly fortifies long range accuracy, making it possible to confidently engage tank-type targets at distances greater than two kilometers.

VOLNA FIRE CONTROL SYSTEM (T-62M)

The T-62M introduced in 1983 came with an entirely new "Volna" fire control system. "Volna" is a comprehensive fire control system overhaul. All of the original components of the T-62's fire control system have been replaced, and some new technology has been added, including the KTD-2 laser rangefinder, the BV-62 analog ballistic computer, and the new TShS-41U sight, purpose-built for "Volna", plus all of the necessary electrical equipment like the 9S831 transformer to adapt the new technology to the tank's electrical system.

The addition of the BV-62 ballistic computer vastly reduces the amount of guesswork involved in the gunnery process. The gunner can input five ballistic variables, which are: the gun chamber temperature, ambient temperature, crosswind speed, atmospheric pressure, and the amount of barrel wear. The gunner may set the ballistic computer to operate in either the automatic mode or the semi-automatic mode. BV-62 operates in the automatic mode by default. In this mode, it uses range information from the laser rangefinder and takes calculates a ballistic solution using all five ballistic variables. To switch the ballistic computer to the semi-automatic mode, the gunner turns the dial switch (marked '5' in the drawing below) from the "AVT" position to any of the other positions. This manually sets the range in 1000-meter increments from 0 meters to 3000 meters, and the potentiometer (marked '4') sets the range in 100-meter increments up to 1000 m. The ballistic computer does not accept data on the ambient temperature and atmospheric pressure when operating in the semi-automatic mode. The semi-automatic mode is only used in emergencies, like if the laser rangefinder stops working.

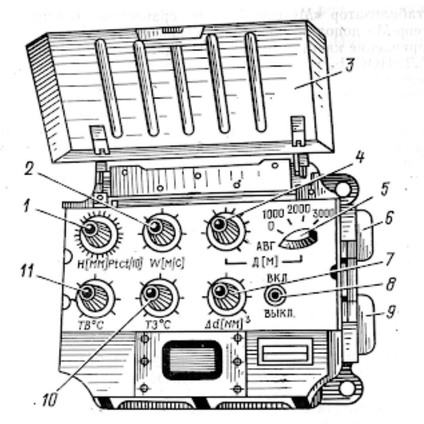


Рис. 22. Баллистический вычислитель БВ-62:

1 — потенциометр ввода величины атмосферного давления; 2 — потенциометр ввода скорости бокового ветра; 3 — крышка; 4, 5 — переключатели ручного ввода дальности; 6, 9 — электрические соединители; 7 — потенциометр ввода величины износа канала ствола; 8 — выключатель питания; 10 — потенциометр ввода температуры заряда; 11 — потенциометр ввода температуры воздуха

The limitations of the system are numerous, the most obvious one being the need to manual input all of the aforementioned ballistic variables. The T-62M was not equipped with wind, temperature and atmospheric pressure sensors, nor was it equipped with sensors to determine gun chamber temperature or an electronic recording system to automatically calculate barrel wear. Environmental conditions have to be communicated to the gunner by the commander, who has to obtain the information from the platoon leader in the command tank (a T-62MK or T-62K), who in turn obtains the information from reconnaissance units. The amount of barrel wear can be estimated by meticulously recording the number of shots fired through the barrel, but exact information can only be known when the barrel is serviced using special instrumentation that is not carried in the tank.

Overall, "Volna" cannot be considered a cutting edge product for the 80's. Rather, it could be considered a cost effective modernization to raise the fighting capabilities of an old and outdated tank up to the level of the T-72B, although this is not entirely accurate either as some of its systems were developed in parallel with the 1A40-1 FCS. For instance, the "Svir" missile system installed in the 1A40-1 FCS of the T-72B was developed from the "Bastion" system for the T-55 and T-62, and shares the same technology as well as the same guidance equipment in the form of the 1K13 sight. The night fighting capabilities of a T-62M would also be on par with a T-72B thanks to the inclusion of the 1K13 sight.

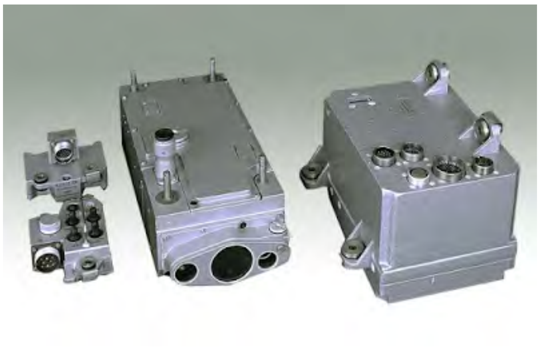
TShS-41U

TShS-41U can be described as a transition model in terms of capabilities as it is superior to TSh2B-41U, yet it does not quite reach the level of the 1A40-1 sighting complex used in the T-72 since 1976. The new vertical stabilizer has an accuracy of up to 0.3 mrad, translating to an error margin of 0.15 meters at 1000 m. This is good by 80's standards for the USSR. However, the sight-gun stabilizer interface was still mechanical, and the sight was still slaved to the gun.

Laser rangefinding had become standard worldwide by 1983, so it was only natural that TShS was fully adapted to the new add-on rangefinder system. The viewfinder had an internal digital readout to display the range data along with a rotating scale in the same layout as the TPD-2-49 and TPD-K1. Besides that, the viewfinder included signal lights to alert the gunner of the readiness of the sight, the readiness of the rangefinder, and also the indicator for the integrated target leading system. Since this could all be seen from the viewfinder, the gunner can maintain visual contact with the target throughout the engagement process. Many T-62M tanks came with the the KTD-1 laser rangefinder, but some were outfitted with the more advanced KTD-2.

KTD-2

The KTD-2 laser rangefinder has a minimum measuring distance of between 500 to 4000 meters under clear meteorological conditions. The armoured cover on the aperture of the rangefinder is opened automatically when the gunner presses the trigger button to lase his first target. The cover remains open until manually closed. KDT-2 requires around 6 seconds between each lasing to prevent overheating. Range data is displayed inside the TShS-41U sight, but there is a separate digital display on the rangefinder control panel, seen in the screenshot below (taken from this video by RedcarUSSR channel).



The gun laying system is semi-automatic, similar to the TPD-K1 sight, meaning that the aiming chevron drops vertically when a ballistic solution is obtained. KTD-2 sends range information to the BV-62 ballistic computer, which then calculates a firing solution. The ammunition type is selected by the gunner, and the selection will influence the amount of drop for the chevron to match the ballistic profile of the ammunition selected. If the target is moving, the system will calculate the necessary amount of lateral correction - i.e windage and lead - depending on the angular velocity of the target measured from the rotation of the turret as the gunner tracks the target. To apply the ballistic solution, the gunner must raise appropriate chevron on the target - thus raising the cannon to the appropriate superelevation - and open fire.

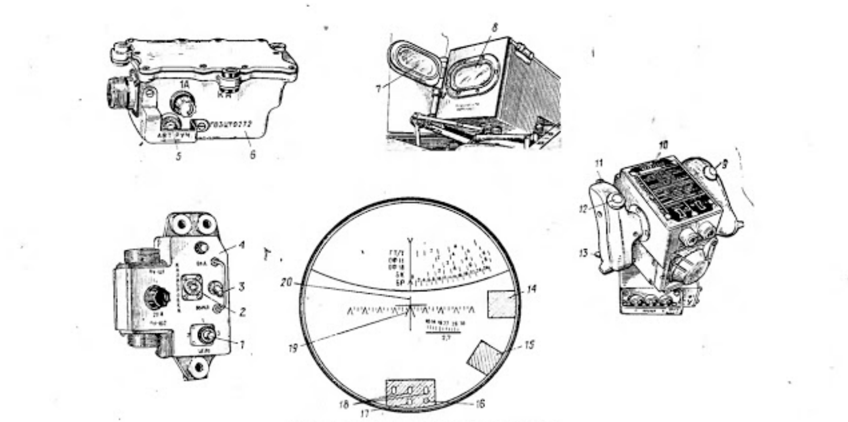


Рис. 1. Подготовка дальномера к работе:
1 — переключатель ЦЕЛЬ; *2* — кнопка КАЛИБРОВКА; *3* — выключатель ПИТАНИЕ; *4* — пульт управления дальномером; *5* — переключатель АВТ. — РУЧ.; *6* — коробка автоматики; *7* — броневая крышка; *8* — защитное стекло приемопередатчика дальномера; *9* — кнопка ПУШКА; *10* — пульт управления стабилизатора; *11* — кнопка ДАЛЬНОСТЬ; *12* — кнопка ПУЛЕМЕТ; *13* — кнопка ПУСК; *14* — сигнал «Прицел готов»; *15* — сигнал бокового упреждения; *16* — сигнал «Дальномер готов»; *17* — индикатор счетчика целей; *18* — индикатор дальности; *19* — прицельная марка; *20* — перекрестие для наведения дальномера на цель

The aiming point for the laser rangefinder is just slightly above the aiming chevron, which is a little inconvenient. Besides the laser rangefinder interface and the overhauled viewfinder picture, TShS-41U features a greatly improved vertical stabilizer, much more precise than the vertical stabilizer of the Meteor-M.

TShSM-41U

TShSM-41U features an electronic interface with the updated Meteor-M1 stabilizer. With Meteor-M1, the gun stabilization arrangement was changed from a sight-follow-gun regime to a gun-follow-sight configuration. This promoted better firing accuracy. The sight could now be aimed vertically using the gunner's handgrips with total independence thanks to the use of Meteor-M1.

TShSM-41U also introduced a target leading system. A secondary chevron (secondary chevrons are the small chevrons on either side of the center chevron) paired with the central chevron to allows lateral lead to be calculated as long as the distance to the target is within the limitations of the KDT-2 laser rangefinder.

AUXILIARY SIGHTS

All T-62M tanks received the 1K13-2 to replace the TPN-1-41-11 except those built without a missile launching capability. These variants are known as T-62M1 tanks.

1K13-2

The 1K13-2 is a combined monocular auxiliary sight which introduced the ability to guide new 115mm GLATGMs like the 9K116-1 "Sheksna", among other things.

The sight has a nominal maximum identification range of 5000 m on a tank-type target in the daytime mode under a maximum 8x magnification, though the actual distance depends on meteorological and geographical conditions more than anything. Like with the previous auxiliary sighting complexes, the 1K13-2 has two modes; passive and active, both of which operate under a 5x magnification. The sight enables the gunner to detect a tank-type target at nominal maximum range of 800 m in the passive mode under lighting conditions of no less than 0.005 lux. Alternatively, the identification distance can be as high as 1100 m in the active mode under illumination from the L-2G IR spotlight. The sight has an internal lightbulb that illuminates the reticle to facilitate aiming at night.

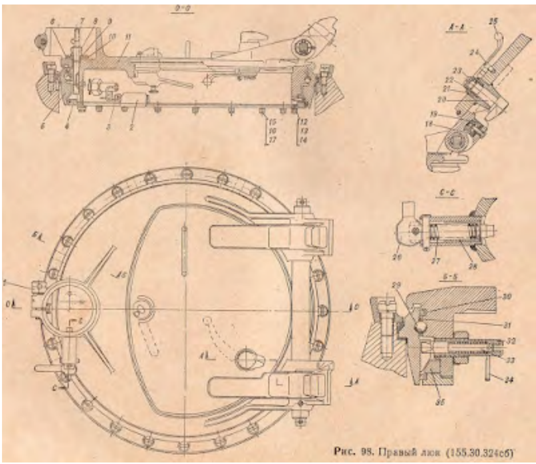
In contrast to all of the previous sighting complexes, the 1K13-2 sight has two-plane stabilization. The accuracy of stabilization while the tank is on the move at 15 km/h is 0.15 mrad in the vertical plane and 0.2 mrad in the horizontal plane, translating to a maximum stabilization error of 0.4 meters at 1000 m vertically and 0.3 meters horizontally. The presence of independent stabilization means that the gunner maintains visual contact with his target when the gun is elevated by +3.5° during the loading process.

The sight can only be used to guide GLATGMs in the daytime mode.

Overall, the analog systems of the "Volna" FCS are easily better than the basic fire control system of the basic T-62 model, but the abilities of "Volna" inherently do not exceed the capabilities of the TPD-K1 laser rangefinding sight installed on the T-72A and late T-64A models. However, even with "Volna", one cannot seriously consider the fire control system of the T-62M to be superior to the Leopard 1A4 (built from August 1974 to March 1976) or any contemporary tank from the early 1980's. Again, it should be reiterated that the T-62M modernization was only a cost effective measure to bring the fighting capabilities of an obsolescent tank up to a useful level, and it is a complete success in that regard.

LOADER'S STATION

From 1961 to 1971, the loader's hatch was large and circular in shape. It was slanted so that it followed the curving contours of the turret roof. In 1972, a DShKM anti-aircraft machine gun began to be installed on the loader's hatch. This required a level circular ring mount to operate, so the loader's part of the turret was renovated completely and a rotatable cupola was added. The area of the turret around the loader's station lost its dome shape to accommodate this new cupola. The loader's new hatch was around half the size of the old type and became an irregular semicircle, making it half as easy for the loader to enter or exit the tank, especially with bulky winter clothing.



There are two variations of the same type of cupola. Early model T-62s upgraded to obr. 1972 standard have a separately cast cupola welded onto the original turret, whereas newly built T-62 obr. 1972 tanks have a one-piece turret with the the loader's cupola cast together with the turret. The thickness of the hatch is 25mm on the original T-62 turret and remained the same thickness when the cupola was added.

To conserve space inside the tank, the ammunition boxes for the external DShKM machine gun are stowed externally on the side of the turret with clips. This also makes it easier for the loader to reload the machine gun as he can simply reach down to retrieve a fresh box instead of going back inside the tank and it is not easy to come out of the hatch with a large box of 12.7mm rounds (which weigh 11 kg each) as the hatch is rather small. The disadvantage is that the boxes can be damaged by artillery splinters and gunfire.

For general observation purposes, the loader is provided with a single MK-4S periscope with a rear view feature. It can be elevated and depressed or rotated 360 degrees for all-round vision, although the geometry of the turret and position of the L-2 spotlight blocks out a large portion of the loader's field of vision. Officially, the total field of view from the MK-4S periscope is 250 degrees measured from the 9 o'clock position to the 5 o'clock position, which is quite good. However, granting forward vision to the loader is often considered superfluous given that both the gunner and commander would be looking forward and observing the target anyway. As such, the loader should be focused on scanning the right side of the turret instead. Even so, a periscope is generally not very useful in combat as the loader must concentrate on his loading duties, and in the case of the T-62 as well as all other Soviet tanks, the loader must also occasionally reload the co-axial machine gun as it is fed from individual 250-round boxes instead of a large container with a continuous belt. Nevertheless, there is reason to believe that furnishing the loader with a periscope not only has a positive psychological effect, but may be intermittently useful under certain circumstances. In theory, a fully rotating periscope for the loader gives the tank an extra pair of eyes to help ascertain the direction of enemy fire in an ambush during the first few seconds of the attack, which can prove critical to the tank's survival and prompt destruction of hostile forces. Of course, this is purely theoretical as it is not possible to verify the actual effectiveness of such measures. The loader would generally be much more useful if he spent his spare time to rearrange the ammunition supply of the tank into the ready racks instead.

The loader's spring-loaded seat can be installed on one of two possible positions on the turret ring. It is adjustable for height in three positions and the spring-loaded hinge automatically folds up the seat when the loader is not sitting on it. Furthermore, the entire seat frame can be folded up and fixed to the turret wall with a wing bolt. If it is still in the way, the loader can simply remove the seat and stow it away somewhere non-intrusive. The seat provided for the loader is meant for marches only as he performs his duties standing. The loader can choose to be seated facing forward or facing the cannon breech. The former option is the most comfortable as the loader can stretch his legs for long journeys and the loader can stand on his seat to peek out of his hatch or use the external anti-aircraft machine gun, and the latter option allows him to load the cannon with the two rounds stowed in the turret or service the cannon while seated but prevents him from exiting his hatch as the seat is not underneath the loader's hatch. The drawing below shows the design of the loader's seat and how it appears when folded against the turret wall. The loader is also provided with a fixed handgrip on the turret wall to hold himself steady as the vehicle is traveling, or as the gun is firing.

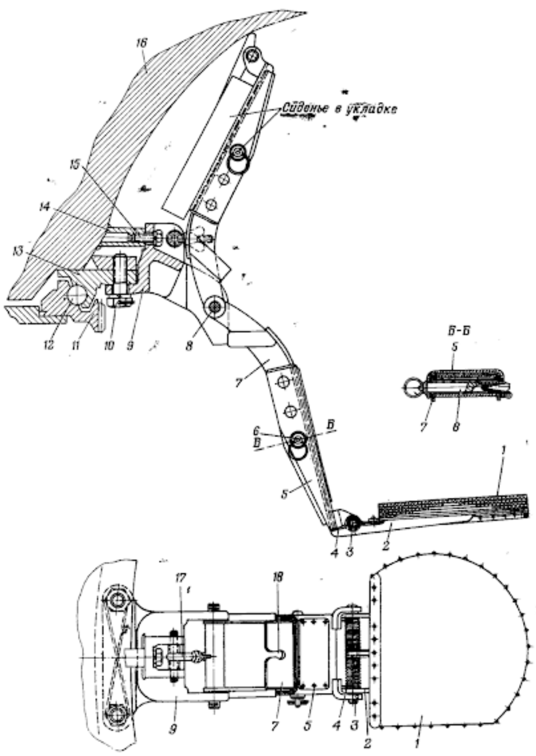


Рис. 34. Сиденье заряжающего:
1 — подушка сиденья; 2 — каркас подушки сиденья; 3 — ось; 4 — пружина; 5, 7 и 9 — кронштейны; 6 — палец; 8 — ось; 10 и 15 — болты; 11 — нижний погон башни; 12 — шарик; 13 — верхний погон башни; 14 — бонка; 16 — башня; 17 — задрайка; 18 — прорезь

When not seated, the loader stands on the rotating floor which has a diameter of 1,370mm, the same as the T-54B and T-55 series. The rotating floor is rather narrow since it does not reach the sides of the hull. Practically speaking, the loader may not always be standing on the rotating floor while carrying out his duties since the "Meteor" stabilizer blocks the rotation of the turret after every shot from the main gun until the loader's safety switch is pressed. Thanks to this feature, the loader does not need to ensure that his feet are strictly planted on the rotating floor itself when taking ammunition from the hull racks.

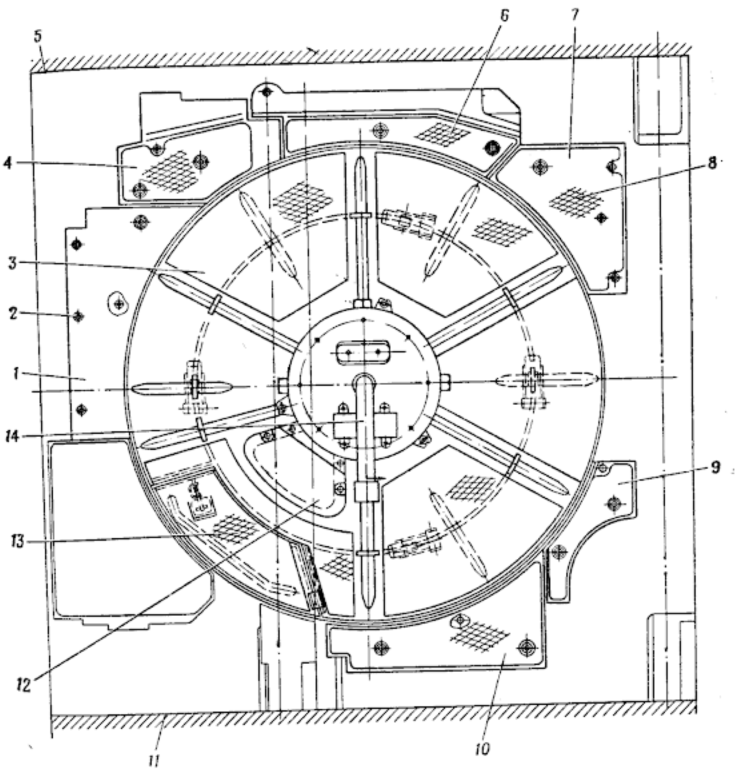


Рис. 29. Вращающийся пол боевого отделения:
1, 4, 6, 7, 9 и 10 — неподвижные листы пола; 2 — болт; 3 — лист вращающегося пола; 5 — правый борт корпуса; 8 — резиновый коврик; 11 — левый борт корпуса; 12 — крышка люка; 13 — резиновый коврик; 14 — труба поводка пола; 15 — стойка; 16 — кронштейн; 17 — ролик; 18 — платформа пола; 19 — торсионные валы; 20 — ось ролика; 21 — днище корпуса; 22 —

The main drawback of the dome-shaped turret is that the loader hardly has any headroom while standing compared to a contemporary Western tank like the M60A1 or the Chieftain. The loader's station in the T-62 has 1,600mm (5'4") of vertical space from the rotating turret floor to the turret ceiling. The amount of vertical room is comparable to tanks like the M46 and M47, but not when compared to a tank like the Chieftain which allocates 1,730mm of vertical space for the loader, allowing a man of average height to stand completely upright inside the tank. This is the same as the T-54, which may be somewhat surprising since the T-62 appears squatter than a T-54. That is evidently an optical illusion caused by the much, much wider turret. The vertical space was increased in the 1972 model of the T-62 by slightly raising the ceiling and by adding a new cupola to the loader's side of the turret. Now, a loader of average height could stand up straighter when ramming shells into the breech, and a shorter loader could stand completely straight as long as he is underneath his cupola.

On the whole, the loader does not have very much room to work with compared to capacious tanks like the M60A1, but he has much more shoulder room than the loader of a T-54 and even the loader of a Leopard 1 or a Centurion as the width of the T-62 turret is simply immense. The two photos below show the loader's station in a Leopard C2 tank (Canadian Leopard 1). Even when the maximum space is created by emptying the vertical ammunition racks next to the loader, the teeth of the racks restrict the width of the station and pose a snagging and injury hazard.

Above the waist, the loader in a T-62 is quite well accommodated. The T-62 has a turret ring diameter of 2,245mm and the gun breech assembly of the U-5TS gun has a width of around 520mm. The gun is installed inline with the longitudinal axis of the turret, so the loader's station has a maximum width of 862mm when measured from the gun to the turret ring. Below the waist, however, the width of the loader's station is only comparable to the T-54 because the width of the hull is practically identical. However, it should be noted that the T-62 only stows a single 115mm cartridge on the floor next to the loader's foot whereas the T-54 stows four rounds on the hull wall. When loading, the single cartridge on the floor can be quickly transferred to the front hull ready racks to free up space on the turret floor while a T-54 loader would need to transfer all four rounds to free up the same space. As such, the available width of the floor for the loader of a T-54 tends to be 147mm narrower (diameter of 100mm cartridge casing) compared to the T-62.

Besides the size of the loader's station, it is also necessary to take the ammunition itself into consideration and not just the amount of working space, and having said that, it will be surprising to many to know that 115mm cartridges are surprisingly lightweight. The T-62 has taken a lot of flak for its lack of amenities, especially for the loader, and there is even an apocryphal story about an Israeli loader being hospitalized for spinal injuries while evaluating a captured T-62. However, the fact of the matter is that Soviet 115mm rounds were quite efficiently designed compared to previous artillery and tank gun rounds. 115mm APFSDS rounds weigh only around 22 kg, lighter than 100mm steel AP rounds by an entire 8 kg, and the 115mm 3UOF1 HE-Frag rounds are lighter than 100mm UOF-412 by 2 kg despite launching a projectile of similar mass at a similar velocity.
The HEAT ammunition for both calibers weigh the same, but 115mm HEAT shells are much more powerful and possess significantly better armour penetration. Only 100mm APDS and APFSDS is outright lighter than 115mm APFSDS ammunition, but they are less powerful and they only became available in the laet 1960's and early 1970's. On the whole, the T-62 had the advantage in the ease of handling its ammunition.

In terms of size, 115mm ammunition is not significantly larger or more difficult to handle than 100mm ammunition within the confines of a tank turret, despite being wider. Shell casings for the 115mm caliber are larger, of course. To be more specific, 115mm caliber cartridge cases have a length of 727mm and a maximum diameter of 165mm, and 100 x 692mm caliber cartridge cases are 692mm in length and have a base diameter of 147.32mm. However, 100mm casings are 147mm in diameter for most of its length and only neck down to around 100mm near the very end of the case whereas 115mm casings are only 165mm in diameter at the lower half of the case, so being wider does not necessarily make them harder to handle. Case in point:

Also, the fact that the shell casings of 115mm ammo are longer than the ones for 100mm ammo does not really matter, because most 115mm cartridges are still shorter overall. The 3UBM-5 APFSDS cartridge, for instance, has a total length of only 950mm. The 100mm UBR-412B cartridge with an APBC shell measures 962mm in length, and the 100mm 3UBM-11 APFSDS cartridge is 978mm in length, so generic 115mm APFSDS ammunition is actually shorter than its generic 100mm counterparts. Only 100mm APDS is significantly shorter than any 115mm round due to the low elongation of its core. As for HEAT rounds, the 100mm UBK-4 cartridge measures 1,094mm in length, and the 115mm UBK-3 measures 1,052mm in length, so once again, the 115mm caliber shows its relative merit. The same relationship exists for the HE-Frag ammunition of the two calibers. Overall, 115mm ammunition is not only shorter than 100mm ammunition but also lighter, and the larger case diameter makes little difference.

Compared to 105mm ammunition, however, a generic 115mm APFSDS round weighs about 4 kg more than a generic 105mm APDS or APFSDS round, and all 115mm ammunition types are longer and wider than their 105mm counterpats. Still, the 115mm rounds are more powerful than their 105mm counterparts, so there is at least a good excuse for the added bulk. In the same working space, a loader should find it most difficult to handle 100 x 692mm cartridges, easier to handle 115 x 727mm cartridges, and easiest to handle 105 x 617mm cartridges, with all else being equal.

Loading the U-5TS is no different than loading any other tank gun. After a shot is fired with the stabilizer in the "automatic" mode, the loader assist function of the stabilizer (referred to as the "autoblock") prompts the cannon to automatically elevate by +3.5 degrees and fixes it in place by hydrolock and engages the turret traverse drive brake; the weapons are automatically blocked. When the breech block opens to eject the spent shell casing, it trips a circuit breaker and opens the electrical firing circuit and the blocks the backup mechanical firing pin mechanism, rendering the gun safe. While the auto-ejector is ejecting the spent shell casing, the loader extracts a fresh cartridge from one of the tank's ammunition racks, brings it up behind the breech, and rams it in. The breech block automatically seals the breech, and the loader presses his safety button to close the electrical firing circuit and remove the autoblock. This arms the gun and returns it to a stabilized status.

The loader assist function allows the loader to load the cannon quicker when travelling on the move. This feature is almost always misunderstood and comes across as self-defeating, but it is a known method of improving the rate of fire. The Leopard 2 has the same feature, as demonstrated in this video clip (link). In the video, you can clearly see the breech rising slightly after the loader presses the loader's safety button, which deactivates the safety measures and the loader's assist function, and clears the gunner to open fire. Some other tanks like the Abrams do not have this feature, making it more difficult for the loader to insert rounds into the chamber while the tank is on the move, as the position of the cannon breech is constantly being adjusted by the vertical stabilizer as demonstrated in this video clip (link). Having a loader's assist function is particularly important when firing on the move, because advancing tanks usually slow to a crawl or halt to fire in order to maximize accuracy, and then immediately accelerate to a high speed to perform evasive maneuvers in between shots to minimize vulnerability to counter fire. The stressful period between shots would be when the loader is obligated to perform, and the loader's assist function is meant to aid him. It is worth mentioning that the T-55A has the same feature, and should not be a factor when comparing the rates of fire between it and the T-62.

If the situation demands that the gunner retains full control, then he can simply inform the loader to disable the loader assist system. The technical manual for the T-62 gives these instructions in pages 97 and 98.

> "*Заряжание пушки. Перед заряжанием пушки необходимо убедиться в том, что цепи стрельбы в приборе автоблокировки выключены.*
>
> *Для заряжания пушки необходимо:*
>
> - *открыть затвор вручную; вынуть поддон и положить его на пол боевого отделения или в свободное гнездо бака-стеллажа;*
> - *извлечь из боеукладки выстрел соответственно поданной команде о снаряде и установить взрыватель;*
> - *вложить выстрел в патронник и энергичным движением дслать его вперед, при этом затвор автоматически закроется;*
> - *разблокировать цепь электрической блокировки спуска (одновременно выключается механическая блокировка), для чего заряжающему нажать левой рукой на рычаг включения цепи спуска прибора автоблокировки и доложить о готовности.*
>
> ***Если после выстрела до последующего заряжания пушка должна быть в стабилизированном положении, то по требованию наводчика заряжающий включает цепь электроспуска, нажав на рычаг включения цепей стрельбы прибора автоблокировки. При этом пушка, снятая с гидростопора, автоматически занимает стабилизированное положение.***
>
> *Для последующего заряжания пушки необходимо снова разомкнуть цепь электроспуска (выключается механическая блокировка), нажав на кнопку выключения цепей стрельбы прибора автоблокировки.*"

Translated:

> "*Loading a gun. Before loading the gun it is necessary to make sure that the firing circuit in the automatic blocking device is turned off.*
>
> *To load the gun it is necessary to:*
>
> - *open the breech block manually; remove the shell casing and place it on the floor of the fighting compartment or in an empty slot in a storage rack;*
> - *take from the ammo rack a round according to the command given on the shell type and set the fuse;*
> - *put the cartridge into the gun chamber and vigorously push it forward, with the breech block automatically closing;*
> - *unlock the gun elevation lock (at the same time the mechanical lock is turned off), for which the loader presses the switch on the left of the device to release the autoblock and reports on the readiness.*
>
> ***If, after firing, the gun must be in a stabilized position before loading the next round, then at the gunner's request, the loader switches on the electric firing circuit by pressing the button for turning on the firing circuit of the autoblocker. In this case, the gun, removed from hydrolock, automatically enters a stabilized state.***
>
> *For the subsequent loading of the gun, it is necessary to again open the electrical firing circuit (turns off the mechanical interlock) by pressing the button for turning off the firing circuits of the autoblocker.*"

In other words, the gunner simply informs the loader to disable the system. The loader does this by pressing his safety switch. This turns off the turret traverse lock and returns the gun to a stabilized status, but also closes the electrical firing circuit so that it can be fired as soon as the breech block closes. Because the loader's safety switch is pressed before the gun is loaded, the safety switch remains off (electrical circuit remains closed) for every shot thereafter. The gun is essentially rendered unsafe. To reactivate the loader's assist feature, the loader simply presses his safety switch after a shot is fired. This opens the electrical firing circuit, rendering the gun safe, and activates the autoblock: the turret traverse system is locked and the gun is hydrolocked in its programmed elevation angle. The loading process then proceeds as normal. After the loader has loaded a round, he presses the safety button and the gun returns to a stabilized status and is ready to fire.

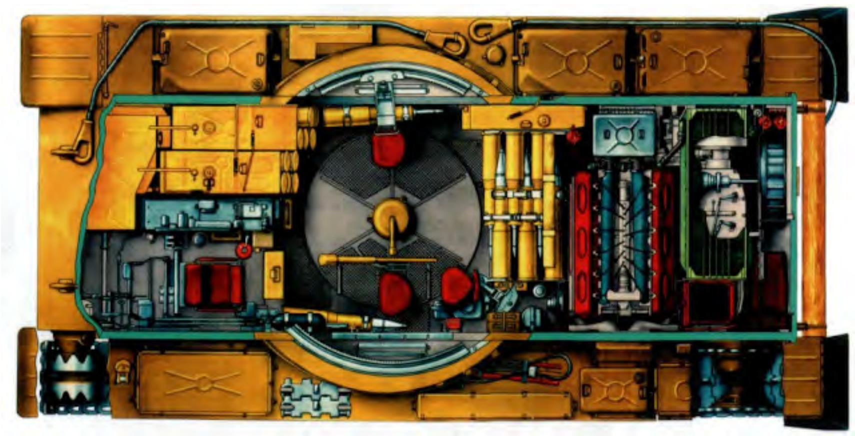
AMMUNITION STOWAGE

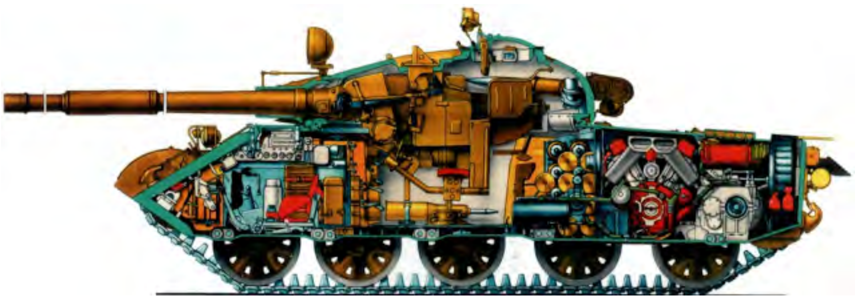
The T-62 can carry a total of 40 rounds of ammunition. The two sets of front hull stowage racks (both are conformal fuel tanks) hold 8 rounds each, for a total of 16 rounds of ammunition. These racks are pictured below. Another 20 rounds are stowed in the very back of the hull on the partition between the engine compartment and the fighting compartment. The loader has 2 rounds in a ready rack on the turret wall directly behind him for convenient loading, and single round secured by tension latches in a rack near his feet on the floor of the hull side wall. There is another round stowed in the same way near the commander's feet.

The 16 rounds in the front hull racks are the most convenient for the loader, second to the rack of two behind him. The rounds are held in place by simple hinged handles, which can be easily flicked up to let the loader pull the round out, as you can see below:

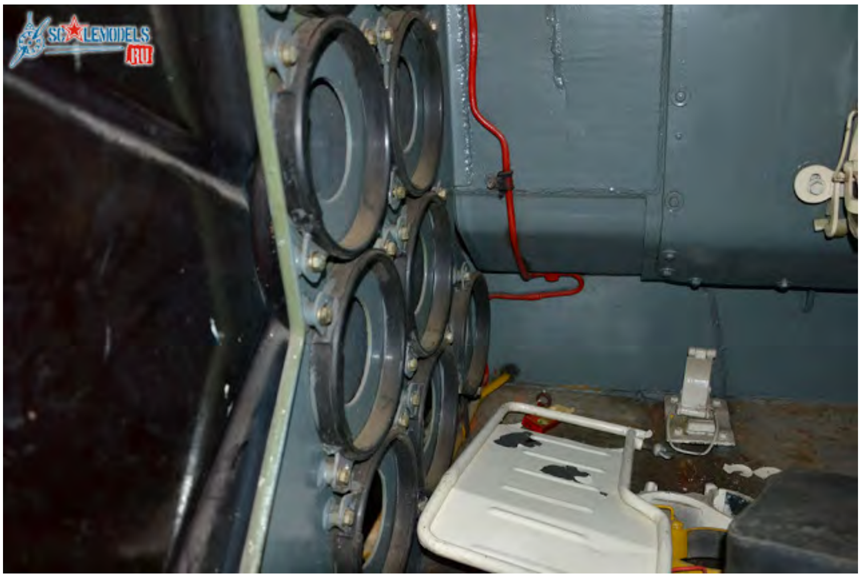
The loader must squat down to access these rounds. These racks are principally identical to the ones found on the T-54, only slightly modified for the different dimensions of 115mm rounds. These racks are one of the most convenient ones for the loader, second only to the rack on the turret wall. Once the loader has pulled a cartridge out of its slot, he can stand up and immediately ram the round into the chamber. There is no need to manhandle or maneuver the shells around to fit them into breech. The loader can be expected to load within 6 seconds using these racks.

As mentioned before, there are 20 rounds stowed in the rear of the fighting compartment, just ahead of the fireproof bulkhead that separates the fighting compartment from the engine compartment. These rounds are stowed crosswise to make the most out of the limited space. The two illustrations below (taken from an Osprey book) show the location of these rounds.

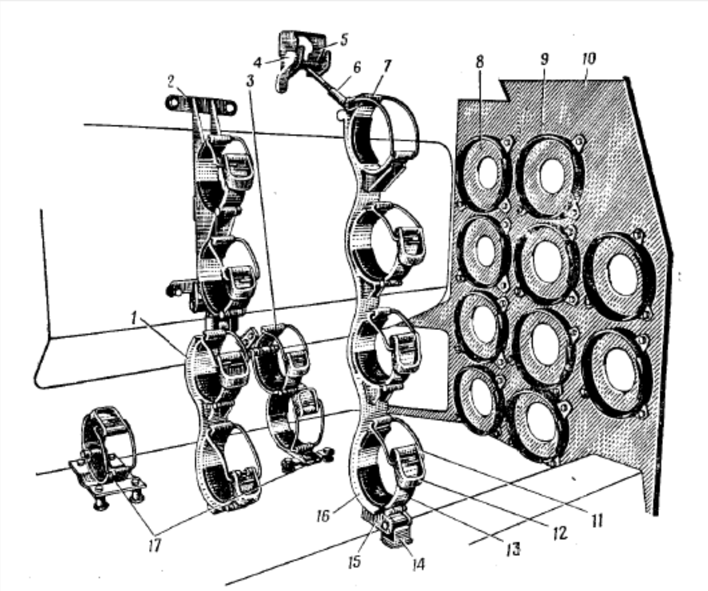




The cartridges are held in that position by rubber cups holding the base of each shell casing and metal frames to prop them up. The photo below shows the rubber coasters for the right side of the racks.



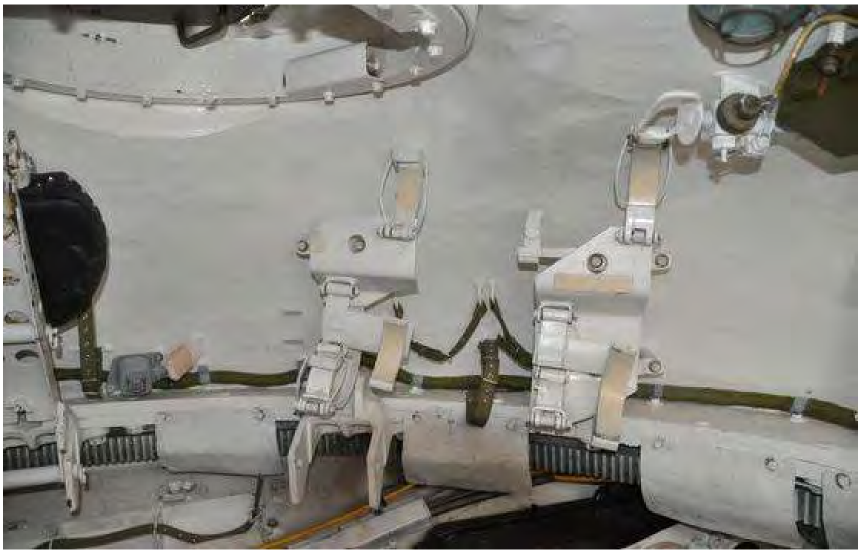
This diagram from the T-62 technical manual gives a better idea of how the metal frames are supposed to look like supposed to look. It only shows the rubber coasters for the left side of the racks. The loader can extract cartridges from these racks by first unclipping the tension latch on the metal rack before carrying it up to the cannon breech. Since the rounds are stowed in a double stack, it is only possible to access the rounds at the back after depleting the rounds in the front and after folding the metal frame away (you can see the hinge, marked *14* at the bottom of the diagram below).



The photo below shows the same rubber coasters seen in the diagram above. The metal frame has been dismantled entirely.

The loader is not able to easily access the rear hull racks compared to the other racks in the tank. It is particularly difficult to access the ammunition stowed at the very back of the racks. Despite this, it appears that a good loader can be expected to load a round in a respectably short time even from the rear hull racks from what we see in this video (link). As the video shows, a motivated loader can pick up a shell from the bottom of the rear racks and pass it out of the hatch within 5 seconds after passing out the first one. It is not advised to use circumstantial evidence such as a video clip, but this gives us a decent idea of the working conditions for the loader.

Last but not least is the ready rack on the turret wall next to the loader, just behind his cupola. It holds two rounds, mounted crosswise. Being located directly behind the loader if he was facing the breech, these are the most easily accessible to him. To load, he must unlatch a round from a rack first, grab it and turn to face the cannon breech, then ram it in. This can be easily done even when the loader is seated. The ready rack can be seen in the photo below.



RATE OF FIRE

The theoretical absolute maximum rate of fire should be around 8 to 10 rounds per minute using the front shell racks and the ready racks only, which is very reasonable. During live fire trials at a firing range, it was recorded that the average loading speed was 6.5 seconds when the tank was static and 7.0 seconds when the tank was moving. For comparison, a report from a Soviet evaluation of the M60A1 published in 1976 found that the loader could load in 7 seconds.

However, the incorrect perception that the loading speed of the T-62 was excruciatingly slow still persists, helped in part by this TRADOC video. The short clip below shows the loader of a T-62 demonstrating the loading process. In this particular instance, the video clip takes a total of only 6.5 seconds. From this demonstration alone, it is abundantly clear that a loading speed of 15 seconds is completely divorced from reality and is nothing but the fabrication of wargamers working from extremely limited information.

In reality, the actual time between shots tends to be much longer than the loading speed as the gunner typically takes longer to find a target and acquire a firing solution than it does for the loader to load. In any given situation where the cannon will be fired as quickly as the loader can load it, then the maximum rate of fire can potentially be as high as 10 rounds per minute. The T-62 might be able to achieve something close to its theoretical maximum rate of fire if the commander and gunner forego the range finding procedure altogether and instead engage using battlesighting as mentioned in an earlier section of this article. This is a big advantage to the T-62 as the margin of error is negligible thanks to the high velocity of its APFSDS ammunition. In the average European battlefield, the gunner will often only need to point and shoot. Nevertheless, the realistic rate of fire will always be much lower than the loader's rate of loading due to the many secondary factors that arise during real combat.

The T-62 technical manual lists the aimed rate of fire of the tank from a stationary position as 4 rounds per minute and supplementary documents state that the rate of fire is 4-5 rounds per minute. These figures do not represent the maximum rate of fire and generally should not be taken at face value because the testing committee usually presents the loading rate as an average value when using ***all*** ammunition stores, including the least convenient ones. Evidence of this practice is provided by Peter Samsonov in his article here (link). In other words, the listed rate of fire is the practical average sustained rate of fire, and is much lower than the maximum aimed rate of fire. Part of the huge discrepancy between the practical average sustained rate of fire and the actual maximum aimed rate of fire comes from the obligations of the commander and gunner to carry out the entire formalized firing procedure during such tests, whereas the crew of a tank in real combat conditions may choose to use faster methods or simply require less time because of experience. These technicalities are specifically mentioned in the book "Tank" published in 1954 by the Military Publishing House of the Ministry of Defense of the USSR:

"*Техническая скорострельность определяется числом снарядов, которое можно выпустить за единицу времени, если считать, что пушка наводится в цель и заряжается мгновенно. Практическая скорострельность, т. е. число прицельных выстрелов в единицу времени, зависит от весьма большого числа обстоятельств (многие из них уже упоминались выше) и всегда бывает во много раз меньше технической.*"

The translation:

"*The technical rate of fire is determined by the number of shells which can be fired per unit of time, if we assume that the gun is aimed at the target and is loaded instantly. The practical rate of fire - that is, the number of aim shots per unit of time - depends on a very large number of circumstances (many of them have already been mentioned previously) and are always many times less than the technical rate.*"

In other words, the so-called "technical" rate of fire is defined as the rate of fire based purely on the time needed for the loader to load the cannon and can be considered the same as the maximum rate of fire. The "practical" rate of fire is the estimated rate of fire during combat and is dependent on factors such as the convenience of the fire control system, visual clarity of the optics, clemency of the weather, distance to the target, the skill of the gunner and commander, and so on. In this case, the loss of visual contact with the target due to the dependent stabilization of the TSh2B-41 sight is definitely a huge factor in the reduced practical rate of fire of the T-62, but more importantly, the practical rate of fire has little to do with the time spent loading the cannon by the loader. This is a well-documented fact that is often obscured or misunderstood due to the way reload speeds are represented in tank games and even in some simulators. This is proven by data from military trials of the Strv 103 conducted in the United States in 1976-1977 as recorded in this document shared by renhanxue, owner of the tanks.mod16 website. When averaging between 400 shots taken against different types of targets from between 500 to 2,000 meters under various simulated scenarios (page 11 of the PDF), the M60A1 took 12.7 seconds between each shot and the Strv 103 took 13.1 seconds. This means that the actual rate of fire of the M60A1 is only 5 rounds per minute despite the fact that M60A1 loaders are required to load in 7 seconds or less to earn their qualification, thus contradicting the notion that the loading speed of the loader directly translates to the rate of fire. This is further reinforced by an independent Soviet evaluation of an M60A1 where it was found that the average time taken to open fire while static was 14 seconds. As such, the actual combat rate of fire of the M60A1 is 4-5 rounds per minute which is exactly the same as the T-62.

Indeed, the minimum loading speed demanded from trained loaders is often very similar across all tanks including Eastern models like the T-62, so the ever-so-common anecdotal claim from former tank loaders of being able to load a gun in 3 seconds and therefore being able to annihilate Soviet tanks have very little value. Indeed, the Strv 103 has an autoloader that reloads the gun in around 3 seconds, but the average time between shots is still 0.4 seconds longer than the M60A1.

Instead, there should be no question that the claimed rate of fire of 4-5 rounds per minute represents the most conservative estimate where the entire formal process of acquiring, ranging and engaging targets is strictly followed and the loader takes ammunition from all ammunition racks in the tank, including the least convenient ones.

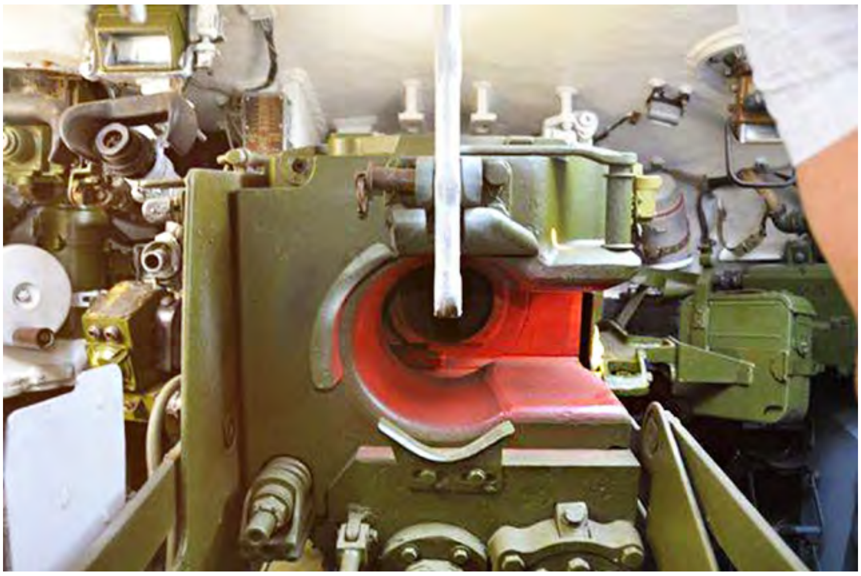
With that said, this also raises an important question. If 115mm ammunition is lighter than 100mm ammunition and both the T-62 and T-54/55 are Soviet tanks that were evaluated by the same standards, why does the T-55A manual state that the rate of fire of the T-55A is 7 rounds per minute when stationary? The T-55A has a dual-axis stabilizer with a "loader's assist" feature like the T-62, but its average rate of fire is ostensibly higher. There are a few possible explanations. One important factor to consider is that the T-55A carries 25 ready rounds, out of a total capacity of 43 rounds. There are 18 ready rounds in the front hull racks, and 7 ready rounds in the turret. For the T-62, there are only 18 ready rounds - 2 in the turret and 16 in the front hull racks - out of a total capacity of 40 rounds. Expressed as a percentage, ready ammunition makes up 58% of the ammunition in a T-55A and 45% of the ammunition in a T-62. Additionally, the T-55A stores another 4 rounds on the side wall of the hull on the loader's side. These rounds are easier to access than the ones in the racks at the back of the fighting compartment, next to the engine compartment bulkhead. Furthermore, the rate of fire figure of 4-5 rounds per minute given in the manual is a single figure unlike the T-55A manual which lists separate firing rates for a stationary and moving tank, so some discrepancies in the criteria seem to exist and may possibly account for the unexplained differences in the claimed firing rates.

A reasonable estimate of the T-62's average rate of fire in combat while firing on short halts or on a slow crawl should be around 4 rounds per minute, as the loader is inconvenienced whenever the turret needs to turn when the tank is moving because of the narrow turret floor and the potential loss of access to his most convenient store of ammunition. How long the loader can maintain his speed under the most optimal conditions (fatigue notwithstanding) is a different matter entirely, of course, and this is a universal issue with *all* manually loaded tanks. The T-62 loses out in pure loading speed since the ammunition is far inferior to contemporaries that have a bustle, as the bustle stays put when the turret spins, unlike ammo in the hull like the T-62's front hull racks, but even though it's not the most optimal configuration, it is still acceptable. The loader has access to all of the ammunition in the tank from his station regardless of the turret orientation. Plus, the ability to access all of the tank's ammunition from the loader's station counts for something during lulls in combat, namely that the commander can continue to do his duties on standby.

In terms of ammunition sustainability, the T-62 cannot hold a candle to its NATO counterparts. Counting the turret ready racks and the front hull racks, the T-62 has 18 ready rounds. The Leopard 1 must be considered excellent in that all of its ammunition is in convenient reach of the loader. The M60A1 is also quite good as the loader has access to up to 37 rounds in the turret. With only 18 ready rounds, the T-62 should not be able to stay in continuous combat for as long as these tanks if we assume that tanks regularly expend dozens of rounds in most engagements. In some cases, stationary tanks used as defensive weapons are obligated to hold a position for long periods under intense attacks so a large amount of ready ammunition is essential. The best example would be the Israeli experience during the Yom Kippur war. However, the combat history of tanks under the European powers during WWII paints a different picture and legitimizes the path taken by Soviet engineers.

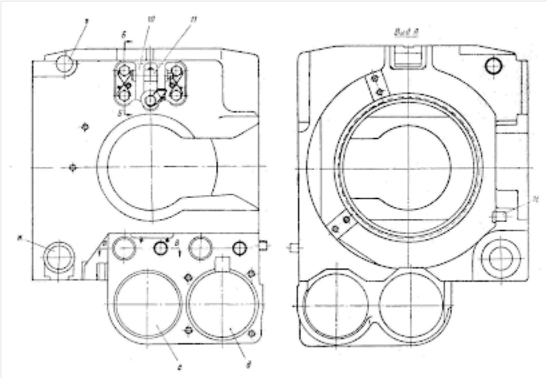
Besides the ammunition for the main gun, the loader is also responsible for reloading the co-axial machine gun. Three ammunition boxes are stowed in simple sheet metal containers mounted on the turret ring bulge recess, and two more boxes are mounted on the turret rear. More boxes can be tucked away on the hull floor.

CANNON



The chief justification for the existence of the T-62 was the U-5TS smoothbore cannon, which bears the GRAU designation of 2A20. The U-5TS was a modification of the 100mm D-54TS cannon (U-8TS) and it differs only in the gun tube. The gun breech assembly, gun cradle, recoil system, and all other components are shared with the D-54TS.

The barrel is 49.5 calibers long, or 5,700 mm, and the total length of the cannon is 6,050 mm. Having a length of only 1,222mm from the gun trunnions to the rear of the gun breech, the U-5TS occupies relatively little space in depth. However, the breech assembly has a maximum width of 520mm, making it wider than even the 122mm D-25T cannon. The maximum safe chamber pressure is 366.8 MPa. Performance wise, the U-5TS was significantly more powerful than the 100mm D-10T and the 105mm L7, although it apparently had slightly poorer accuracy at very long ranges compared to the L7 depending on the ammunition. However, the difference was minor enough to be irrelevant at combat ranges and NATO tanks were relatively big targets anyway. Compared to the D-10T on the T-55, it was a vastly superior product in every conceivable way, although the U-5TS was not without its own small shortcomings. The recoil buffer in the U-5TS was installed asymmetrically from the breech, and the recoil recuperator was installed underneath the breech with a small offset to the left. The asymmetric placement of the recoil buffer lead to an uneven distribution of the recoil force as a fired shot traveled through the barrel, creating a larger moment of force during the recoil stroke of the cannon. Consequently, increased oscillations at the muzzle were generated while the projectile was still traveling down the barrel which result in an increase in shot dispersion compared to a cannon with symmetrically mounted recoil buffers. However, placing the recoil buffer in this location reduced the width of the cannon assembly and the height of the breech above the bore axis, which enabled the T-62 turret with the same height as the turret of the T-54 to accommodate a gun depression angle of -6 degrees instead of -5 degrees despite the increased caliber of the U-5TS compared to the D-10T. The drawback is that the increased height of the breech below the bore axis decreased the maximum gun elevation angle to 16.5 degrees.



The British 105mm L7 cannon also had an asymmetric recoil buffer layout with one recoil buffer on the left of the breech and one on the top right of the breech with a recuperator installed on the right of the breech just underneath the top right recoil buffer. By not having any recoil buffers above or below the breech, this freed up the space directly above and below the gun breech and helped to facilitate larger vertical aiming angles, but the downside is that the width of the cannon was increased. This reduced the available width of space available to the crew in the turret and the design of the recoil mechanism itself forced tank designers to use a wide and more vulnerable gun mantlet as exemplified by the Centurion and Leopard 1 turrets. The M60 and M60A1 turrets avoided the use of such a gun mantlet design thanks to the more compact concentric recoil mechanism of the M68.

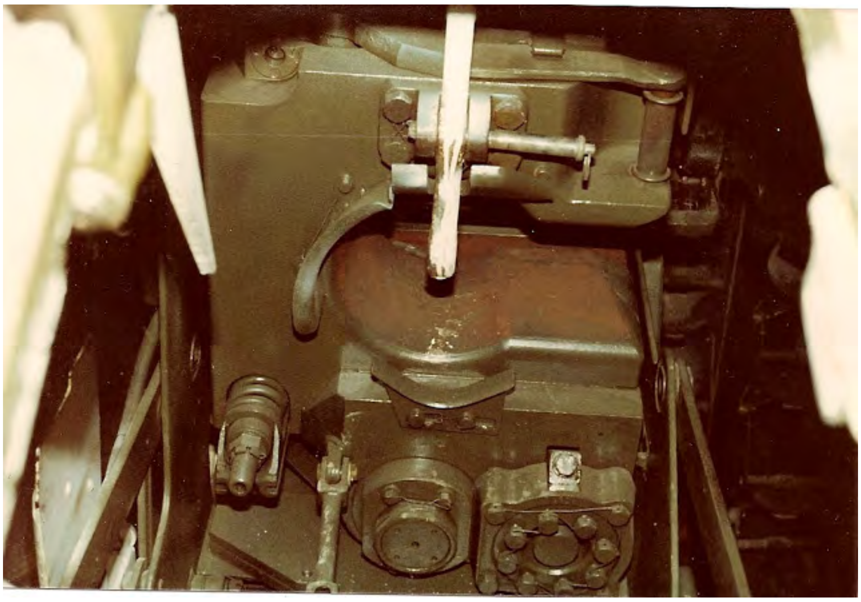
The recoil mechanism of the U-5TS was never changed during its production run, and the asymmetric layout of the mechanism was carried over to the 125mm D-81T (2A26) cannon on the T-64A with a few minor modifications.

Despite the relatively poor gun depression of the T-62 compared to typical NATO tanks like the M60A1 or the Chieftain, a gun depression limit of -6 degrees is enough to allow the tank to aim and fire while on the move over uneven terrain and take up positions behind most forms of natural cover. The inability to fire from a hull-down position from the reverse slope of some hills or ridges is only a partial drawback, because not all hills are shaped perfectly for tanks with a gun depression limit of -9 or -10 degrees to exploit. Some hills are too steep for even a tank with -10 degrees of gun depression to exploit, and other hills are gentle enough that the T-62 can be completely hull-down.

Compared to its predecessor the D-10T, the U-5TS is much more powerful but also heavier. A complete U-5TS gun assembly including the gun cradle weighs 2,350 kg, compared to just 1,950 kg for the D-10T, but the U-5TS also had a maximum chamber pressure of 366 MPa which was higher than the 320 MPa maximum chamber pressure of the 120mm L11 rifled cannon of the Chieftain main battle tank and much higher than the 289 MPa maximum pressure of the D-10T. The maximum chamber pressure of the U-5TS approaches the level of the 122mm M62-T2 which was rated for 392 MPa. The height of the bore of the U-5TS from ground level is very low - only 1,758mm.

Based on the limited information available, the U-5TS appears to have had an acceptable level of durability. It has an EFC rating of 450 shots. This means that the cannon should be able to safely shoot off at least 450 lower pressure rounds like HE-Frag and HEAT, or perhaps around 200 to 150 APFSDS rounds, which operate at a much higher pressure. With a standard mix of HE-Frag, HEAT and APFSDS, around 300 shots can be safely fired through the barrel. As usual, firing a cannon with an excessively eroded bore raises the danger of a catastrophic failure which can result in the destruction of the barrel. The cannon has a recoil stroke of between 350 mm and 415 mm, depending on the power of the ammunition used. The recoiling mechanism has a hard stop at 430 mm.

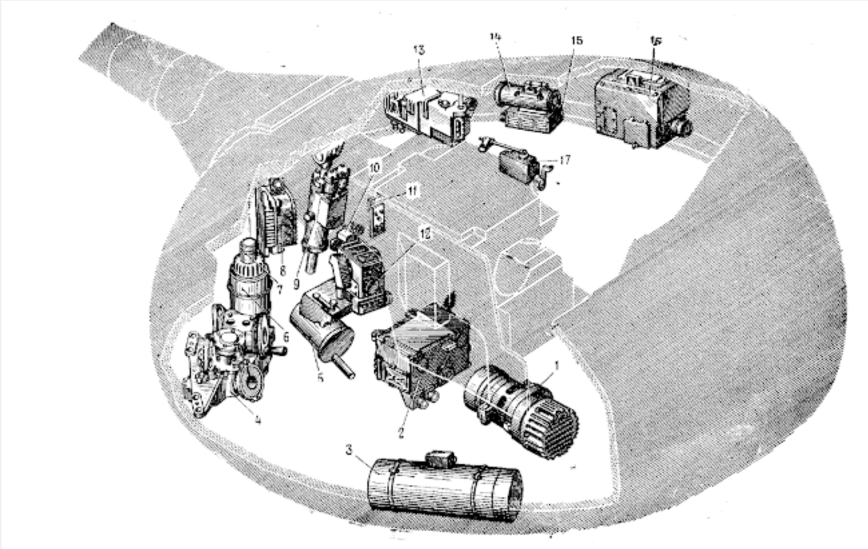
There are three methods of firing the cannon - the electric button trigger on the gunner's right hand grip, the solenoid button on the manual elevation flywheel, and the manual trigger on the breech itself. The electrical primer ignition system is installed in the lower right corner of the breech block, and is visible from behind the cannon breech as the photo below shows. Interestingly enough, the photo is from a series showing a captured T-62 in the possession of the U.S Army.



The U-5TS was completely unchanged throughout the service career of the T-62 in the Soviet Army until 1983 in the T-62M modernization when the barrel received a plastic thermal sleeve with a design shared with the 125mm 2A46 cannon. The sleeve was divided into four sections, enshrouding the entire barrel along its entire length with a gap at the base of the barrel to account for the recoil stroke. Plastic was used in order to keep the sleeve as light as possible so as not to interfere with the delicate balancing of the cannon.

By adding a thermal sleeve, the accuracy and consistency of fire could be increased at minimal cost. Together with the "Volna" fire control system which included a laser rangefinder and the smoother ride with the improved suspension of the T-62M, the thermal sleeve helped to increase the first-round hit probability when firing at point targets, especially in rainy weather. According to the article "Barrel Distortion and First-Round Hits" by Lieutenant Colonel David Eshel published in the January-February 1985 issue of the Armor magazine, firing in the rain has resulted in errors of up to 7 mils from barrel distortion, and by contrast, the maximum barrel distortion from solar heating occurs at 10 a.m in the morning and 4 p.m in the afternoon and the errors from heating and other external factors cumulatively induce an error of up to 1 mil. The installation of a thermal sleeve over the gun barrel will reduce the error when firing in the rain down to only 0.25 mils.

STABILIZER



The diagram above shows all of the components related to "Meteor".

Even as the first pre-production T-62 tanks rolled off the factory gates in 1961, it was already fitted with the advanced 2E15 "Meteor" 2-plane stabilizer. This was not a common practice in the West at the time, not even in the U.S Army which was a pioneer in the large scale implementation of gun stabilizers before WWII. The Leopard 1 caught up to the T-62 in 1970 with the Leopard 1A1 upgrade when it received a new Cadillac-Gage two-plane stabilizer, which was a modification of a stabilizer designed for "Patton" tanks created in 1964-1965. Before this, it only had powered traverse and gun elevation, and most Leopard 1 tanks retained this gun laying system as the 1A1 model was only produced in limited numbers. The M60A1 - which was essentially the most closely comparable nemesis to the T-62 - had just powered traverse and gun elevation like the Leopard 1 and only received a serious two-plane stabilizer in 1972 in the form of the AOS (Add-On Stabilizer) system retrofit using a Cadillac-Gage two-plane stabilizer derived from the system developed for the Leopard 1. Even then was not noticeably more useful; although it was technically more advanced, it appears that the AOS system had a range of issues, including the tendency to sometimes spin the turret uncontrollably. It also did not generate higher hit probabilities when M60A1 AOS tanks fired on the move.

"Meteor" was not a new development at the time. It was assembled and adapted for the T-62 from two previous stabilizer projects; the STP-2 "Tsyklon" from the T-54B and 2E12 "Liven" from the T-10M. To be specific, "Meteor" used This greatly reduced the financial and time costs. "Meteor" gave the T-62 a fire-on-the-move capability which was excellent for the time, granting it a necessary advantage over contemporary Western tanks in highly mobile meeting engagements, which was considered the main format of tank combat by Soviet and Western experts. This also meant that the T-62 was more flexible on the dynamic battlefield, being nearly equally adept on the defensive as on the offensive.

"Meteor" has two modes of operation: Automatic and Semi-automatic. In the automatic mode, the stabilizers operate at full capacity and work to keep the gun oriented at the point of aim set by the gunner using his sight. In the semi-automatic mode, the gyrostabilizer system suspends operation, but not the horizontal and vertical drives. In effect, the gunner is left with power traverse and elevation but no stabilization. The semi-automatic mode is used when the tank is used defensively in a fixed position and when travelling in anticipation of imminent combat, the reason being that keeping the system in the semi-automatic mode improves the lifespan of the stabilizer system by reducing the wear of sensitive devices. Switching from semi-automatic to automatic is very quick. The semi-automatic mode is also used as a backup if a failure of the stabilizer system occurs.

Control of gun elevation and turret traverse is conducted using the Meteor control handgrips. The right thumb trigger fires the main cannon and the left thumb trigger fires the co-axial.

In case of a total failure of the electrical systems or some other malfunction, the gunner must use hand cranked flywheels located directly behind the handgrips. The gearbox on the manual elevation and traverse mechanisms both have buttons for disengaging the powered actuators and engaging the manual drive gears. The elevation flywheel handle has a solenoid trigger for firing the cannon.

As the years went by, the T-62 received continuously updated versions of the Meteor, but these updates did not change the operating characteristics of the system. The "Meteor-M1" was installed in the T-62M, but was only an adaptation of the original stabilizer for working with the new "Volna" fire control system. There were no changes in the performance of the stabilizer itself.

2E15 "Meteor" Hydroelectric Stabilizer

Turret traverse at the maximum rate is quite slow. According to a T-62 manual, it takes 22.5 seconds to make a full revolution, or 16° per second, although this figure is disputed by some sources. The figure given in the manual is slow compared to NATO tanks which tended to be about twice as fast. The somewhat underwhelming turret rotation speed is largely inconsequential during long to medium range engagements, but the T-62 suffers in non-linear combat where targets may appear suddenly from unexpected directions. The slower reaction time of the T-62 is typical of many Soviet tanks, and is partially remedied when the tank is deployed as part of a platoon.

T-62 Manual:

Minimum Traverse Speed: 0.07 deg/sec
Maximum Traverse Speed: 16 deg/sec

Minimum Gun Elevation Speed: 0.07 deg/sec
Maximum Gun Elevation Speed: 4.5 deg/sec

"*Техника и Вооружение*" Magazine:

Automatic Mode:

Minimum Traverse Speed: 0.07 deg/sec
Maximum Traverse Speed: 17-19.6 deg/sec

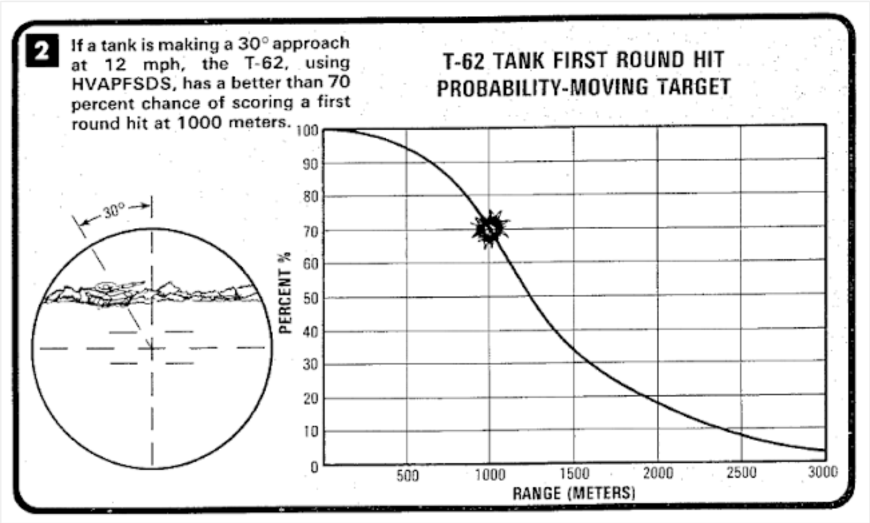
Minimum Gun Elevation Speed: 0.07 deg/sec
Maximum Gun Elevation Speed: 4.5 deg/sec

Semi-Automatic Mode:

Minimum Traverse Speed: 0.07 deg/sec
Maximum Traverse Speed: 20-25.7 deg/sec

Minimum Gun Elevation Speed: 0.07 deg/sec
Maximum Gun Elevation Speed: 4.5 deg/sec

"Meteor" is not precise enough to be used for engaging targets on the move at long distances, but it must be reinforced that it was still quite advanced for its time. The mean deviation in the vertical plane is 1 mil and the mean deviation in the horizontal plane is 3 mils when the tank is in motion, meaning that the cannon shifts by an average of 1 meter at 1 km from the aiming point in the vertical plane, and 3 meters at 1 km in the vertical plane. Firing while stationary is much more accurate, of course. The system is accurate enough for a stationary T-62 to achieve a greater than 70% hit rate at 1,000 meters on a tank-type target moving at 20 km/h at a relative angle of approach of 30°, according to a U.S TRADOC bulletin, pictured below.



Considering that the tank lacks an optical coincidence rangefinder, this result is remarkably similar to the M60A1 AOS. This can be seen in the data from military trials of the Strv 103 conducted in the United States in 1976-1977, as recorded in this document shared by renhanxue, owner of the tanks.mod16 website. When averaging between 400 shots taken against different types of tank targets (head-on silhouette, oblique silhouette, full side profile silhouette) from between 500 to 2,000 meters under various simulated scenarios (page 11 of the PDF), the M60A1 AOS has a hit rate of 72% and the Strv 103 has a hit rate of 77%. Bearing in mind that moving targets are the most difficult type of target to hit (especially for earlier Cold War era tanks that lacked automatic target leading systems), the "*better than 70 percent chance of scoring a first round hit at 1,000 meters*" achieved by the T-62 can be interpreted to mean that its accuracy is generally on par with its Swedish and American counterparts.

However, this is only an indication of the accuracy of the T-62 when firing from a standstill. The primary value of the stabilizer is derived from the ability to fire with reasonable accuracy while the tank is on the move or on short halts. Movement makes it considerably more difficult for an enemy tank to successfully score a hit, and even simple maneuvers performed by a novice driver can make it even more difficult to score a hit.

According to calculated data, the probability of achieving a hit (using APFSDS) on a static tank profile silhouette target with the dimensions of 2.8 x 6.9 meters while the T-62 is moving at a speed of 20-25 km/h is 65.5% at a distance of 1.0 km, 38.5% at a distance of 1.5 km, and 24.0% at a distance of 2.0 km. By comparison, the probability of hitting the same target under the same conditions but with the stabilizer disabled is 2.6%, 1.15% and 0.65% respectively. When firing at a tank front silhouette target while moving at 20-25 km/h, the probability of hit is 47% at 1.0 km, 25.8% at 1.5 km, and 15.7% at 2.0 km.

According to the May 2012 issue of the "*Техника и Вооружение*" magazine, the "effectiveness" of firing on a static "tank" type target while on the move at a distance of 1,000-1,500 meters is 50%, and at 1,500-2,000 meters and 2,000-2,500 meters the "effectiveness" is 37.5% and 30% respectively. It is unclear what the author means by "effectiveness", but the comparatively high figures imply that more than one shot was taken.

Generally speaking, the basic criteria for evaluating the maximum effective range of a tank is the range at which a 50% probability of hit can be achieved. Based on these test results, the maximum effective range of the T-62 when firing on the move is greater than 1 kilometer but less than 1.5 kilometers if the target presents its profile. When firing at the front of a tank-type target, the maximum effective range is just under a kilometer. Such results are unimpressive by modern standards, but for 1961, it was excellent. Furthermore, it was already sufficient because the average combat distance for a major war in Europe is between 1 kilometer to 1.5 kilometers. For instance, during the course of the Hunfeld II study that was carried out in the early 1970's in the Hünfeld region of Fulda, Germany, it was found that the average engagement range for M60A1 tanks was 1,130 meters.

On paper, "Meteor" was technically outclassed by the M60A1 stabilizer from the M60A1 AOS (Add-On Stabilizer) of 1972. According to *Direct support and general support maintenance manual: turret for tank, combat, full-tracked, 105-mm gun, M60A1 (2350-00-756-8497) and M60A1 (AOS) (2350-01-058-9487)*, the AOS system offered better gun laying precision, having a minimum traverse speed of 0.5 mils per second or 0.028 degrees per second, and an equal minimum elevation speed. The horizontal drive of the AOS system also offered a vastly superior maximum turret traverse speed. Theoretically, the accuracy of stabilization should also be somewhat better when the tank was in motion. However, real test results do not appear to actually support the superiority of the AOS system - Hunnicutt reports in page 200 of "*Patton: A History of the American Main Battle Tank, volume 1*" that test results from Aberdeen showed that the hit probabilities from a moving M60A1 with a Cadillac-Gage add-on stabilizer were "better than 50%" at "short to medium ranges". Needless to say, these figures are extremely vague but they are still comparable (more or less) to the results obtained from the T-62 depending on how "short to medium ranges" is interpreted.

Most interestingly, brigade commander Colonel Thomas E. Carpenter states on page 48 of the July-August 1977 issue of "ARMOR" Magazine that the M60A1 was considered by USAREUR to have a 70% chance of "winning an engagement" against a T-62 at 1,000 meters provided that the M60A1 fired first. As such, tank gunners were trained to engage a tank with the battlesight gunnery technique in 5 seconds after visual contact. Battlesight gunnery is used because the speed in firing the first shot is critical, but with this technique, the advantage of the M60A1 in having an optical rangefinder is irrelevant whereas the higher speed and flatter trajectory of the APFSDS ammunition of the T-62 gives it the advantage when using the battlesight gunnery technique, and the presence of gun stabilization on the T-62 gives it an overwhelming advantage when firing from the move or from short halts. The advantages of the T-62 are only partly negated by the M60A1 AOS modification, but from a cost-benefit perspective, it must be emphasized that the fact that the M60A1 AOS and T-62 achieve such similar results despite the lack of an optical coincidence rangefinder or a ballistic computer on the latter is very interesting.

Overall, "Meteor" was quite good for 1961 and it was certainly much better than the stabilizer of the Centurion Mk.3 and its later variants. It was also unquestionably better than having no stabilization at all, which was the case for the entire line of "Patton" medium tanks and for early Leopard 1 tanks, although the Leopard 1 could still be used effectively if care is taken in tactical planning as it had a vastly more sophisticated fire control system. "Meteor" could still be considered adequate during the 1970's and the relevance of the T-62 during that decade was reinforced when it began to be retrofitted with the KTD-1 laser rangefinder during the early 1970's.

There are various methods to improve firing accuracy when firing on the move. The crew is primarily trained to fire on short halts and on slow crawls, which is a process that must be coordinated by the commander. For either methods, the process is as follows: The commander spots a target, designates it for the gunner and cues the loader to load an appropriate round, while simultaneously using the stadia rangefinder in his periscope to determine the distance to the target as accurately as he can. The gunner then inputs the range data from the commander, lays the gun on target, and the driver is ordered to either stop or slow down the tank. If the gun is to be fired while the tank is cruising or moving at a slow crawl, it is important that the driver does not change gears. Once stopped or slowed down, the gunner fires. If at all possible, the tank approaches the target straight ahead. This minimizes the stabilization error in the horizontal plane which tends to be relatively high. After hearing the shot, the driver immediately speeds up the tank and performs evasive maneuvers until ordered to prepare for the next shot by the commander.

However, that is not to say that the stabilization system was insufficiently accurate for firing on the move. With a mean vertical deviation of 1 mil, a T-62 could aim at the center mass of an M60A1 and expect to hit it at 1 km if the tank is moving straight towards it, as the body of the M60A1 measures around 2.5 meters tall, not including ground clearance or the large commander's cupola. The shot could be fall short by 1 meter and still hit the lower glacis, or go over by 1 meter and still hit the upper part of the gun mantlet. On the other hand, the low accuracy of the horizontal stabilizer makes it improbable for the T-62 to score a hit at long range while moving at an angle to the target, or while performing zig-zagging maneuvers.

As mentioned before in the "Sighting complexes" section of this article, "Meteor" features a Loader Assist function where it raises the cannon by about +3.5° and holds it in place by hydrolock. This is the optimal position for loader access to the gun breech, and it also prevents the cannon from undulating while the tank is moving. Turret traverse is automatically suspended by the system disengaging the friction clutch electronically. It was extremely important that the turret traverse was suspended as almost all of the ammunition in the T-62 is stored in the hull. If the turret suddenly started rotating while the loader was still in the midst of extricating a round from one of the hull ammunition racks, the unsuspecting loader might be caught off balance or even hit by the moving cannon assembly.

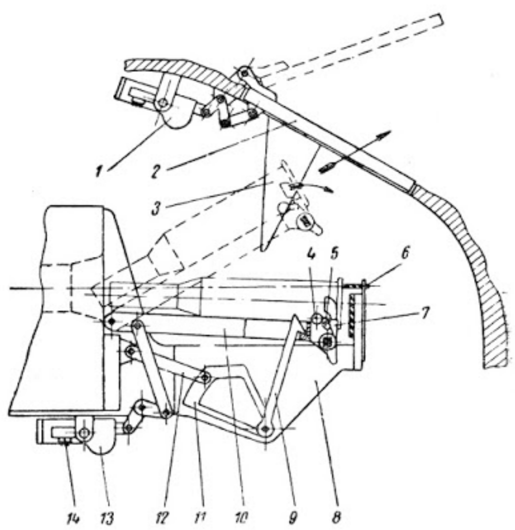
Pressing the "Ready" button on the loader's safety control box will arm the cannon and bring the system out of the Loader Assist status. This system is integral to "Meteor" and is active in both the automatic and semi-automatic operating modes of the stabilizer. It does not function when the stabilizer is turned off entirely. The auto-ejector system is independent of the Loader Assist system, so turning off either one will not affect the other. The Loader Assist system is primarily intended to help the loader carry out his duties while the tank is on the move, as fixing the breech of the gun at the most optimal position and keeping the turret fixed makes it easier for the loader to ram a round into the gun chamber while the tank is moving. However, the system is also enabled when the stabilizer is used in the semi-automatic mode so it also reduces loading time when the tank is firing from a stationary position. The stabilizer system of the Leopard 2 features the same Loader Assist function.

There is an EMU-12PM amplidyne amplifier for the stabilizer system located at the very rear of the turret, just behind the commander's backrest. It takes the electrical signals from the "Meteor" control handles and amplifies the voltage to direct the gun elevation and turret traverse drives, thus translating minute gun laying inputs from the gunner into the movement of the gun and turret.

There is a gyroscopic tachometer for measuring the angular velocity of the turret and tank in relation to the intended target. The tachometer is installed at the very front of the gunner's station, behind the sighting complexes. The gyro-tachometer was taken from the STP-2 two-plane stabilizer system for the T-54B.

Gyroscopic tachometer for Meteor-M1

AUTO-EJECTOR



The T-62 has a nifty automatic shell casing ejection system. The main impetus for the development of such a system was the insufficient maturity of fully-combustible propellant charges (caseless ammunition) and the greater expediency of incorporating such a device given the time constraints for putting a tank with a 115mm gun into production using existing cased ammunition. As mentioned before, the interior of the tank hull is quite cramped since only the turret ring was widened, so the floor space in the fighting compartment remains the same as in the T-54. Having a few spent shell casings rolling around the floor was not desirable, to put it mildly. Apparently, during early testing of the Object 166, cannon fumes accumulating in the fighting compartment were twice higher than the acceptable standard even though the cannon had a fume extractor. The culprit was the spent shell casings, as the unburnt propellant residue inside the casings became a source of these fumes and as the number of shots increased, the number of spent casings accumulated and so did the fumes. When ejected from the tank immediately after firing, the concentration of fumes was reportedly slashed by half, with the added bonus of the loader being saved the trouble of periodically removing the spent shell casings by hand. The ejector mechanism is automatic and has a manual setting that will deactivate the ejection system. In the manual mode, the gunner must manually pick up the spent shell casing from the lifting tray, open the ejection port by pressing the "Open" button on the ejector system control box, and throw the casing out. He can also throw it out of his own hatch if he prefers.

The auto-ejector mechanism does not interfere with the loader in any way as it is installed far from the cannon breech and is in a slightly lower position (to compensate for gravity as shell casings are extracted after firing), so it is completely out of the way when the loader is ramming a shell into the chamber. The T-62 is greatly superior to the T-54 in this regard because there is much more space between the cannon breech and the rear wall of the turret thanks to the large turret ring diameter, so there was room for the auto-ejector. In addition to that, the unusually long neck of 115mm cartridges makes it easier for the loader to insert them into the cannon chamber, as it allows him to insert them with a sideways angle.

The auto-ejector functions independently from the loader's assist function because its components are not logically linked to anything other than its own control system. If the loader's assist function is turned off by the loader, the auto-ejector will continue to function. It can dynamically detect the position of the ejection port relative to the gun at any elevation angle since its control system works using the input of limit switches rather than relying on a fixed set of programmed commands. It will also not proceed with ejecting a shell casing if it does not detect that a shell casing is caught in its tray. As such, low-pressure rounds such as blanks can be fired without needing to turn off the auto-ejector.

Underneath the loader's handgrip is the ejection system control box. The ejection mechanism can be set to either the automatic mode or the manual mode by flipping a toggle switch. Two push-buttons on the control box are used to open and close the ejection port in a semi-automatic mode. The ejection port can be opened and closed independently of the rest of the ejection system and this may need to be done if the system experiences a failure. If the tank is fighting in a heavily NBC-contaminated environment, then the auto-ejection system should be set to manual mode. The mechanism does not work without electrical power.

If the lifting frame of the ejection mechanism is jammed in at its maximum elevation, the loader can rectify the issue by disengaging the worm gear of the rack-and-pinion mechanism in the lifting motor installed underneath the gun breech and then manually ensuring that the motor is cleared of jams by actuating the piston by working a small handle. Once the cause of the jam is removed, the worm gear is reengaged. When the worm gear of the actuator motor is disengaged, the entire ejection mechanism will be able to freely move up and down within the limits of its range of elevation angles. The same procedure can be done with the ejection port motor.

The diagram below shows the sequence of ejection. The order of the sequence goes clockwise from the top left. Viewing the diagram in its original size is recommended.

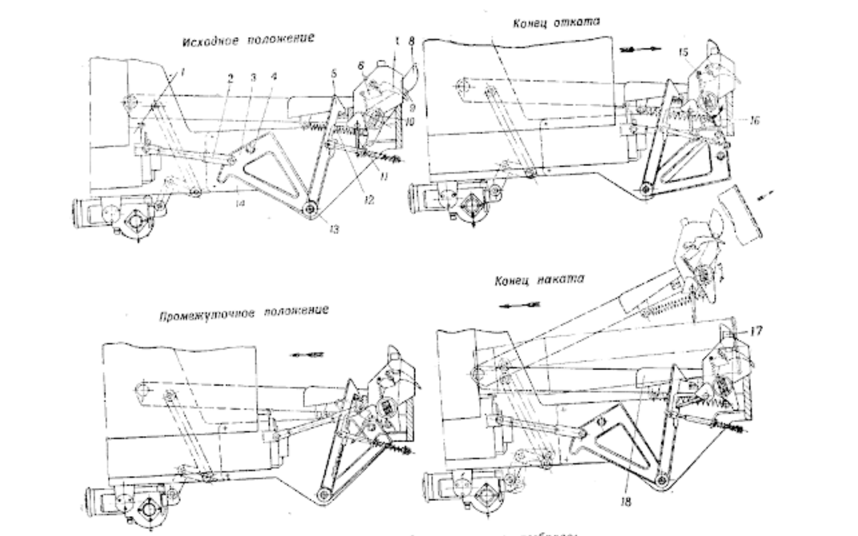
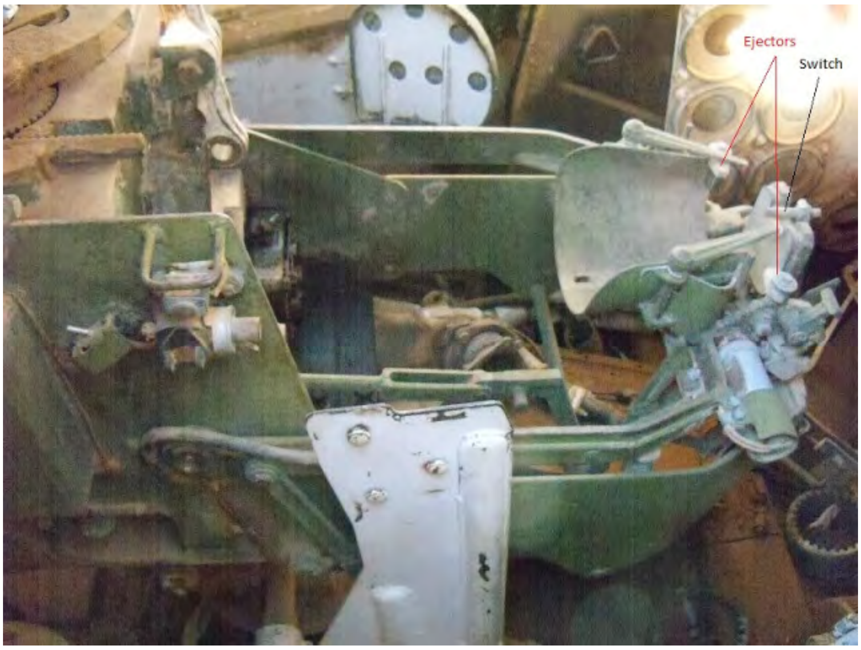


Рис. 44. Схема работы механизма выброса:
1 — казенник пушки; 2 — тяга; 3 — копир; 4 — штифт; 5 — зацеп рамки; 6 — коромысло; 7 — защелка; 8 — зацеп захвата; 9 — зуб кронштейна захвата; 10 — торсион; 11 — створка; 12 — пружина; 13 — вал; 14 — ограждение; 15 — палец электромагнита; 16 — кулак захвата; 17 — буфер; 18 — лоток

When the shell casing is ejected from the breech from the recoiling cycle, it is caught by the lifting tray which is a shallow 'U'-shaped tray affixed to the lifting mechanism. The shell casing is held in place by its rim by two spring-loaded grippers on either side of the tray, which you can see in the photo below next to the ejectors. A rubber-padded plate on the arm guard placed just behind the lifting tray prevents the casing from hitting the rear wall of the turret and helps to soften the noise. The ejector mechanism is triggered when the base of the spent shell casing striking a switch located above the rear plate behind the lifting tray. The act of ejection itself is done by a spring-loaded ejector with two ejector hooks that maintain two points of contact with the rim of the shell casing (refer to picture below). The ejector spring is cocked by the recoil force of the gun via the octant-shaped reciprocating levers shown in the drawing above, and the ejector is held in place by a locking pin actuated by a solenoid.



When the presence of a spent shell casing is detected by the switch, the ejection port automatically begins to open so that it is fully opened by the time the ejector mechanism has aligned the ejection tray with the port opening. The ejector mechanism is lifted up to the ejection port and the control system halts the mechanism when a cam comes into contact with the triangular contact plate on the left of the ejection port. The contact plate is shown in the photo below. It is the sharp triangular plate bolted to a protrusion welded to the turret roof between the commander's cupola and the ejection port. It is separated from the commander when the recoil guard is installed.

Upon touching the contact plate, the cam closes a limit switch. This verifies that the ejection mechanism is aligned with the ejection port and it sends a signal to the ejector lock solenoid. The solenoid retracts, removing the locking pin and releasing the ejector arm and the shell casing is thrown out very forcefully by the force of its spring, whereupon the ejection port closes and the mechanism returns to its original position. As you can see in the photo below, the ejection port is operated by a servo motor and there is a handle to lock it and unlock it manually.

The ejection process is explained in detail in the T-62 technical manual. These are the relevant paragraphs from the manual (pp. 89-90):

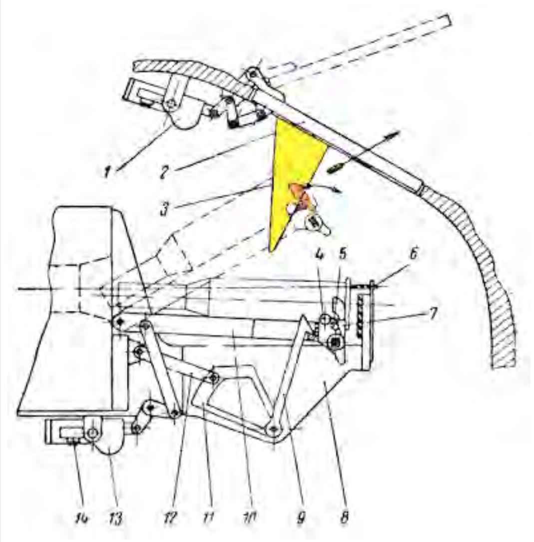
> "*При ударе фланцем о заднюю стенку ограждения гильза включает кнопку запуска электрической схемы. Происходит открывание люка в башне и подъем рамки на линию выброса. При подъеме рамки створка выходит из зацепления с зацепом, который возвратиться в исходное положение.*
>
> *Подъем рамки с гильзой происходит до тех пор, пока кулачок не коснется плоскости копира и не включить переключатели ограничения подъема рамки. Переключатели включается в положении рамки с гильзой против люка в башне. С включением переключателя подается напряжение на электромагнит сброса, который пальцем освобождает захват с зацепами от удержания его защелкой. Силой взведенного торсиона и пружин гильза выбрасывается через люк наружу.*
>
> *После выброса гильзы рамка опускается в исходное положение и закрывается люк в башне. При опускании рамка воздействует на скос зацепа и входит с ним в зацепление. После опускания рамки и закрытия люка все механизма выброса занимают исходное положение.* "

Translated into English:

> "*When the base of the spent shell casing strikes against the rear wall of the lifting tray, the casing trips a start button for the electrical circuit. The ejection port is opened and the frame is lifted to the ejection position. When the frame is lifted, the leaf is disengaged from the hook, which returns to its original position.*
>
> *The lifting frame with the spent casing rises until a cam touches the surface of the kopira* and presses the frame lifting limit switches. The switches are positioned so the shell casing is aligned with the ejection port in the turret. With the pressing of the switch, voltage is applied to the ejector solenoid, which frees the ejector from the hooks holding it. With the force of the cocked torsion bar spring, the ejector throws the shell casing out through the ejection port.*
>
> *After the ejection of the casing the lifting frame is lowered to its original position and the ejection port in the turret is closed. When the frame is lowered, it acts against the bevel of the hook and is locked in place. After the frame is lowered and the ejection hatch is closed, all of the ejection mechanism will be in its original position.*"

**"kopira" is the provisional term for the triangular contact plate used in the manual and in other documents*

The the triangular contact plate (yellow), the cam that contacts the triangular contact plate (red), and the ejector (orange) are shown in the drawing below.



According to the 1963 report "Автоматизация Удаления Гильз Из Боевого Отделения Танка" by Engineer-Colonel Kipnis-Kovalev et al., the entire ejection process takes 2-3 seconds in total. The exact time depends on the elevation angle of the gun - if the gun is fully elevated, the ejection mechanism must be lifted higher to reach the ejection port; if the gun is fully depressed, the ejection mechanism has to travel a much shorter distance. This is verified by this video of a Vietnamese T-62 with a working ejector (link). The ejection cycle starts by the opening of the ejection port and ends when it is fully closed. The quick action of the ejector mechanism means that the loader will never have to wait for it to finish before loading the cannon, so the system does not interfere with the loading procedure in any way. In fact, the two or three seconds spent by the auto-ejector should be over before a loader is even able to retrieve a round from any of the ammo racks in the tank. By the time the lifting frame has lowered back to its original position, the loader should not yet be ready to ram a fresh round into the cannon.

By ejecting spent shell casings from the tank automatically, the loader's working conditions are greatly improved. The large shell casings have no more uses other than to trip the loader after they have been fired, and the unburnt propellant residue inside the casings emit large volumes of noxious fumes. Without an automatic ejector, the carbon dioxide and carbon monoxide concentration inside an enclosed tank invariably accumulates to an unacceptable level after multiple rounds have been fired in a short period. A high concentration of fumes affects all the crew members, but the loader is the most adversely affected since his duties are much more physically demanding than the others. In this context, the primary benefit of the auto-ejector system is that the working conditions of the crew as a whole are improved, especially the loader's, so that the rate of fire may be improved in the long term.

Contrary to popular belief, shell casings can never bounce off the back of the turret and injure crew members because of "misalignment". The lifting frame elevates right up to the ejection port, and even if by pure chance a shell casing does somehow miss the gaping ejection port opening, it will ***not*** bounce back and hit anyone, because there is no space for a shell casing to go between the lifting tray and the ejection port because the sides of the U-shaped tray physically prevent the casing from being deflected towards the crew members seated on the left and right of the gun; the casing can only rebound forward, slide down the tray and drop to the floor (the grippers that hold on to the rim are disengaged during the ejection). This redundancy feature also means that if the ejection mechanism were to fail this way, the loader can simply pick up the shell casing from the floor and throw it away by hand or retain it by placing it back in the ammunition rack slot he took it from. The latter method may be necessary if the tank is used in an NBC contaminated environment.

Of course, the commander is physically separated by a recoil guard and the gunner is seated next to the cannon breech, in front of the commander. The loader would be the only crew member to be hit by a flying shell casing, but again, it must be emphasized that the ejector mechanism is well-proofed against such a contingency.

This persistent myth seems to have originated or at least evolved from an article titled "*The Soviet Tank Mystique*" by Major Raphael A. Riccio published in the November-December 1982 edition of ARMOR magazine. The relevant paragraphs of the article from page 33 of the magazine are shown below.

In addition, the *T-62* incorporated what can best be described as "gadgetry" in the form of some rather complicated mechanical arrangements with its cannon, one of these being an automatic ejection system for spent shell casings. As soon as the main gun fires, it automatically depresses to its maximum limit, lining up the breechblock with an ejection port in the rear of the turret. When the breechblock opens, the casing is ejected through the open port.

This is a good system on paper, but has a few major drawbacks, aside from the complexity that it adds to the main gun system. First, the time needed to depress the gun and then to elevate it back to the proper firing attitude decreases the rate of fire, even though the procedure is automatic. Second, if the system is out of register, the spent casing will not clear the port and will ricochet violently about the cramped confines of the crew compartment and will probably cause equipment damage or personnel injury.

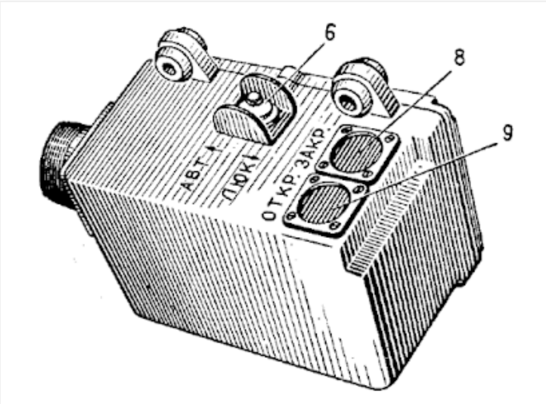
Surely, if such a system had been adopted on a U.S. tank, Congress and other assorted critics would have had a field day. Because the Soviets have done it, however, there are apologists who describe such lunacy as "technical innovation" or "advanced design."

In this case, it appears that Major Riccio incorrectly believed that the ejection of spent shell casings from the turret was accomplished purely with the built-in ejector in the cannon breech itself rather than with a special powered ejector mechanism placed behind the breech assembly of the cannon, but all of the usual criticisms of the ejection system are present. Over time, it became known that the casing ejection was carried out with a special mechanism instead of the built-in ejector of the gun itself, but the so-called "lunacy" associated with the system borne out of ignorance - even in 1982, almost a decade after the U.S Army acquired captured T-62 tanks and examined them in detail - still remained with the T-62. Furthermore, the ejection system did not depress the gun when beginning the ejection procedure, and it was never necessary anyway since the ejection mechanism could automatically detect if it was aligned with the ejection port regardless of the elevation angle of the gun. This myth seems to be connected with Major Riccio's belief that the gun had to depressed so that the breech opening would be elevated into alignment with the ejection port. Unfortunately, this falsehood is still frequently repeated, even in books published by highly respected authors like Steven Zaloga ("*T-62 Main Battle Tank 1965–2005*", published in 2011). As stated before, the auto-ejector mechanism in the T-62 was designed to work at any gun elevation angle.

Interestingly enough, the method of shell ejection described by Major Riccio was implemented only once, in the Object 430 medium tank prototype, and it was specifically rejected in the 1963 report "Автоматизация Удаления Гильз Из Боевого Отделения Танка" because such as system created too many issues, one of which was the inability to have the ejection mechanism work at all elevation angles, for obvious reasons. Another was that placing the ejection port in the turret rear rather than in the rear part of the turret roof significantly weakened the armour protection, and having the ejection mechanism depend on the elevation mechanism of the cannon would cause the gunner to lose visual contact of the target as he must relinquish control over the elevation of the gun. Also, the need to delay the ejection of the spent casing after each shot in order to raise the gun to the correct elevation for ejection would interfere with the fume extractor, thus allowing more fumes to enter the fighting compartment. In other words, such an ejection scheme proved to be too intrusive into the normal operation of the tank, hence the more complex but much more effective auto-ejector design implemented in the T-62.

Another misconception is that the autoejection system compromises the NBC system of the tank because the opening of the ejection port allows airborne contaminants to enter the tank. While this may be true to some extent, the amount of contaminants ingressing the tank would be extremely tiny, because the ventilation system maintains an overpressure inside the tank when the NBC system is activated. The opening of the ejection port would allow more air to rush out rather than into the tank, and indeed, it was found that the autoejection system had a very minimal effect on the amount of radiation exposure suffered by the crew. It was proven during testing that the radiation dosage measured in the fighting compartment increased after firing thirty shots from the main cannon, but the increase was negligible compared to the radiation dosage from background radiation from operating in a site contaminated by a recent nuclear detonation. The combined dosage from radioactive particles and background radiation would not be enough to harm the crew. Nevertheless, it would definitely be safer for the crew to don their gas masks and refrain from firing the main cannon when passing an area known to be contaminated with deadly chemical weapons. It's worth noting that the most common - and also the most dangerous - chemical threat at the time was Sarin gas, which was far too lethal for the crew to rely entirely on the imperfect NBC protection suite anyway, with or without the auto-ejector mechanism. After all, the filtration system for the ventilator cannot guarantee 100% air purity, even in low dust conditions.

The entire system is centered on the KV2 control box, which coordinates the timing and execution of all of the actions of the auto-ejector.



Inside the KV2 control box are five relays. One relay controls the raising of the auto-ejector to the ejection position, one controls the lowering of the auto-ejector to the original position, one controls the opening of the ejection port hatch, and one controls the closing of the hatch. These four relays are coordinated by a time delay relay.

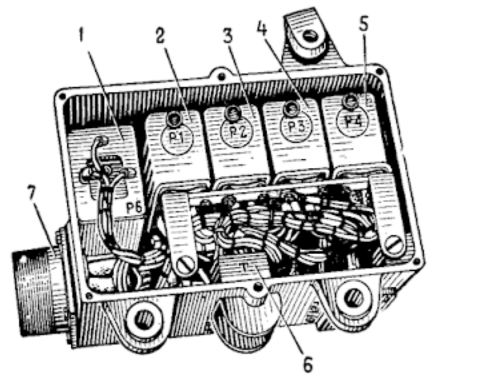


Рис. 43. Коробка выброса КВ2:
1 — реле времени (ТВЕ-101Б); 2 — реле подъема рамки (8Э11); 3 — реле опускания рамки (8Э11); 4 — реле открывания люка (8Э11); 5 — реле закрывания люка (8Э11); 6 — переключатель; 7 — штепсельный разъем ШР40; 8 — кнопка закрытия люка; 9 — кнопка открытия люка

Using the toggle switch labeled (6) on the diagram above, the loader can either set the system to the "Automatic" mode or the "hatch control" mode, which is essentially the manual mode. When the toggle switch is set to the "Automatic" mode, the auto-ejection system works automatically as we have already examined. When set to the "hatch control" mode, the loader can press the "Open" button to manually open the ejection port. Pressing the "Close" button closes the ejection port. As the opening and closing of the ejection port hatch is no longer controlled by the system, auto-ejection is therefore suspended. This mode can be used in NBC conditions to suspend the operation of the auto-ejector and thus ensure that absolutely no contaminated particles can enter through the ejection port despite the positive pressure inside the tank. The ability to open the ejection port hatch is sometimes exploited by leaving it open for for extra ventilation in non-combat conditions or to turn the ejection port into convenient loading hatch if needed, as demonstrated in the two photos below.

When the auto-ejector system is suspended in the "hatch control" mode, the loader must manually remove shells from the lifting tray at the back of the ejector. He can then throw it out of the ejection port or his own hatch above him. Alternatively, he could place the empty casing into its original slot in an ammo rack. This conveniently solves the issue of empty shell casings rolling around the floor of the tank but at the cost of increased loading time.

115mm VS 120mm

The size difference between 115mm cartridges and 120mm cartridges is minimal. In terms of heft and dimensions, 115mm ammunition was bigger than NATO 105mm and Soviet 100mm ammuniton, but essentially identical to NATO 120mm ammunition (not British 120mm). In order to truly appreciate the burden on the loader, here's a photo comparison between a 120mm cartridge and a 115mm equivalent:

M829 compared to 3UB56

The similarities in the sizes of 115mm and 120mm ammunition can be proven by the T-62AG variant, a modernization package offered by the KMDB, which you can read about here (link). Looking past the fact that they managed to fit a 120mm tank gun (in reality a domestic production version of the French CN120 called the KBM2) into the T-62, it must be noted that the total amount of ammunition carried by the tank did not change. The T-62AG carries a total of 40 rounds of 120mm ammunition, stowed in the same positions as the 115mm cartridges it replaced, with only minor modifications to better fit the new ammunition.

115mm rounds are simply much bigger than 105mm rounds. Even though they are both given approximately the same width of space, the T-62 loader is fatigued more easily than an M60 loader or a Leopard 1 loader, even more so since a ride in the T-62 isn't quite as smooth.

And of course, a T-62 loader didn't have nearly the same amount of space that loaders in NATO tanks sporting 120mm guns did. Here's another photo, this time of a 115mm cartridge container held up by what appears to be a Siberian tanker.

However, it must be reiterated that loading the U-5TS was still an easier task than loading the D-10T in a T-54 due to the smaller mass and shorter length of 115mm unitary cartridges.

AMMUNITION

The two biggest assets of the U-5TS cannon were the 3UBM-3 shell - the first ever APFSDS tank shell to enter service - and the 3UBK-3 shell, which was a conventional HEAT shell.

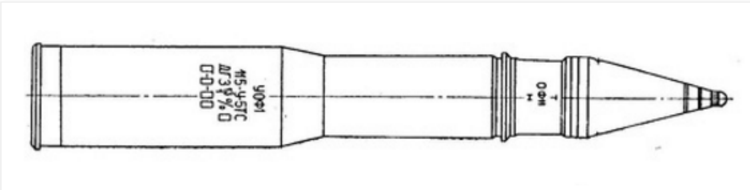
Shell casings had an atypical form that is readily identified by a greatly elongated bottlenecked front section, which was necessary for properly seating the APFSDS shells for which the casings were specially designed for. The 100mm T-12 gun used ammunition that had the same case design. There are two types of casings; steel 4G9 cases and brass 4G10A cases. Steel 4G9 cases cost less to manufacture, while the brass 4G10A cases cost more but improve overall performance. Steel cases were used HE-Frag ammunition, for which accuracy was of less importance while the higher quality brass cases were used for APFSDS and HEAT-FS.

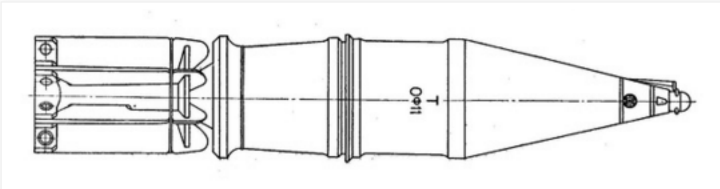
Depending on the source, the standard combat loadout for a Soviet T-62 was 12 APFSDS rounds, 6 HEAT rounds and 22 HE-Frag rounds. According to the September issue of the 2008 edition of the "*Техника и вооружение*" magazine, a Soviet T-62 carried 16 APFSDS rounds, 8 HEAT rounds and 16 HE-Frag rounds. As usual, the loadout changes based on necessity, but generally speaking, APFSDS was preferred over HEAT. The armour piercing ammunition (APFSDS and HEAT) are stowed in the front hull racks for maximum ease of access to minimize the reaction time of the T-62 to an enemy tank in a duel scenario.

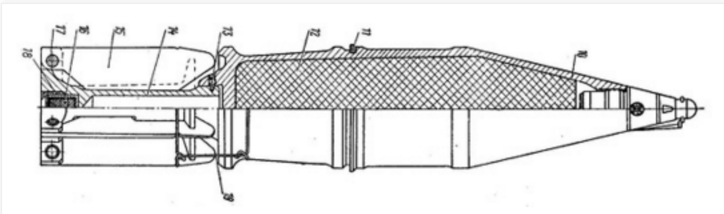
HE-Frag

High-explosive fragmentation shells are arguably the most important ammunition type for the T-62, given the expected tactical contributions of a Soviet tank to combined arms combat. Though tanks are obviously a major threat, the vast majority of the vehicular targets that a tank would encounter on the battlefield are thin-skinned APCs, IFVs and utility trucks, and the tank will always be called upon by infantry for fire support against bunkers, machine gun nests, and other garrisoned troops. HE-Frag shells may be used as a last resort against enemy tanks as well, serving to knock out various essential components for anything from a mobility kill to a firepower kill (though obviously rooting for the latter). The 2A20's selection of HE-Frag shells are characterized by very thick steel walls and a relatively high muzzle velocity. However, the stabilizer fins are a major source of drag. This means that 115mm HE-Frag shells tend to slow down considerably at long range.

3UOF1
OF11







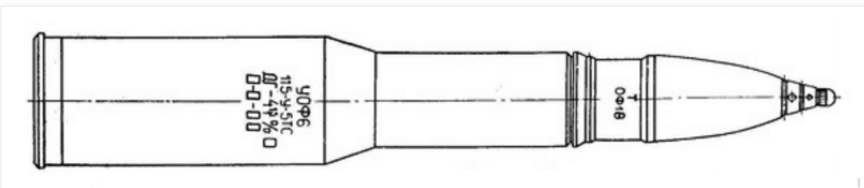
First HE-Frag shell available to the 2A20 cannon in 1961. The body of the shell has a polygonal shape. Its thin steel walls are suitable for fragmentation and splintering, but the bulk of the damage done by this shell is caused by blast. The propellant charge used is 4AD11 stick powder. The explosive compound used is TNT. The use of TNT can only be described as traditional, since RDX (also known as Hexogen) is clearly a superior choice as it is much more powerful. The only plausible explanation is that perhaps TNT was much cheaper and the expenditure of HE-Frag shells in times of war was expected to be so high that the cost efficiency of using TNT outweighed the drawbacks.

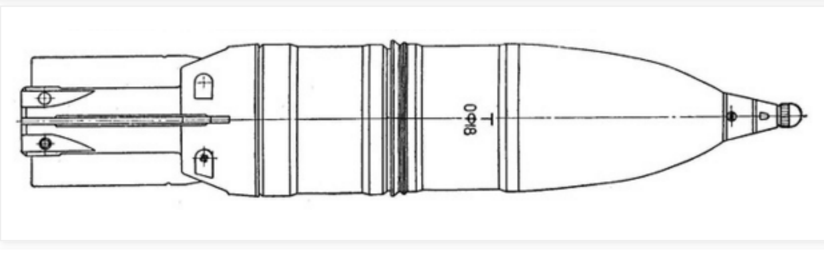
Muzzle Velocity: 905 m/s

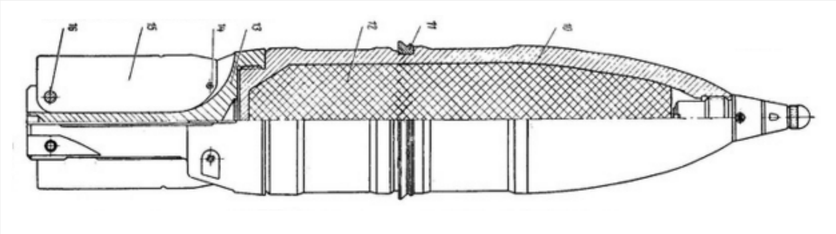
Maximum Direct Fire Range: 3600 m

Mass of Complete Round: 28.1 kg
Total Mass of Projectile: 14.86 kg
Mass of Explosive Charge: 2.695 kg

3UOF6
OF18







Improved shell with an ogived nose and much thicker shell body for greater fragmentation mass and volume as well as a better optimized spray pattern for increased casualties. The shell also boasts an extended firing range despite a 20.1% increase in mass over the OF-11 thanks to better ballistic properties and a more powerful propellant charge taken from the 3UBK3 HEAT cartridge. The new 4AD20 stick powder propellant boosts the muzzle velocity of the shell to 940 m/s, at the cost of increased chamber pressure and also a slightly higher rate of barrel wear. Because of the increased muzzle velocity, this shell is slightly more accurate than the 3OF11 at all distances. The explosive charge is still TNT.

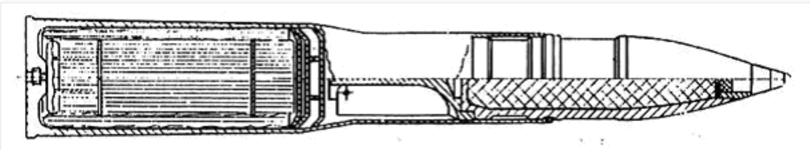
The V-429E variable sensitivity fuse was available later on.

Muzzle Velocity: 940 m/s

Maximum Direct Fire Range: 4800 m

Mass of Complete Round: 30.8 kg
Total mass of Projectile: 17.86 kg
Mass of Explosive Charge: 2.8 kg

3UOF37
3OF27



Newer shell that is largely similar to the 3OF18, but with an A-IX-2 explosive charge replacing the traditional TNT. Like the 3UOF6, 4AD20 propellant is used. The reason why the mass of the A-IX-2 explosive charge is greater than the mass of TNT available in previous shells although the walls of the 3OF27 shell are only slightly thinner is because A-IX-2 is slightly more dense. Why they decided to use A-IX-2 in this shell is not clear.

Muzzle Velocity: 940 m/s

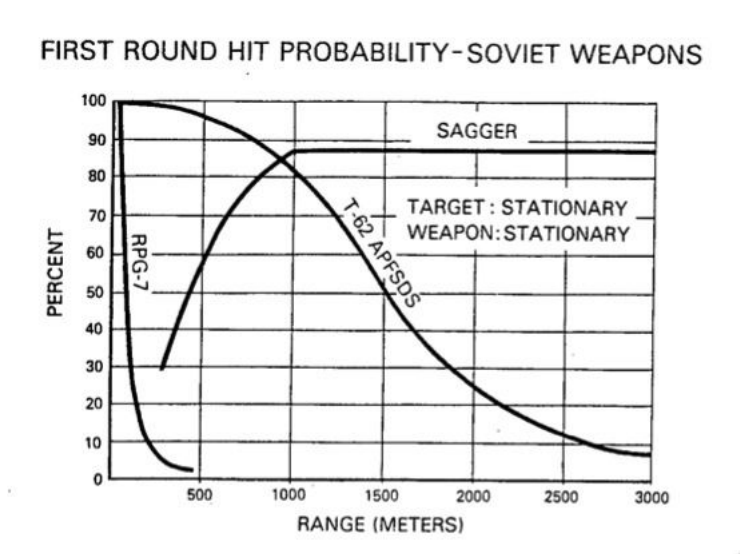
Maximum Direct Fire Range: 4800 m

Mass of Complete Round: 30.75 kg
Total mass of Projectile: 17.82 kg
Mass of Explosive Charge: 3.13 kg

APFSDS

Being widely considered to be a pioneer on the introduction APFSDS technology into widespread service, the T-62 essentially relies on it as its main selling point, and for good reason. Because of the remarkably high velocity of the T-62's APFSDS ammunition, their ballistic trajectory was essentially flat up to 1600m - quite different from APDS shells. This meant that in typical tank-on-tank combat scenarios, the T-62 gunner would only need to put the sight chevron on target and fire without even needing to determine the range. The extremely high velocity also meant that engaging moving targets was a lot easier, since it would tend to take less than a second for the shell to reach its target in normal European battlefields where combat distances typically don't exceed 1500m. This almost entirely negated the need for calculated target leading, even against relatively fast-moving vehicles. APFSDS shells would also be very useful against vehicles moving at irregular speeds, again because the gunner does not need to apply much lead. This greatly helped offset the retarded engagement time caused by limitations of the targeting system and increased first-round hit probability significantly.

According to this TRADOC graph, a stationary T-62 had a 50% chance to hit an exposed stationary M60A1 tank with its APFSDS rounds on the first try at 1500 m. The shots were conducted using 3UBM5 rounds - pure steel rounds.



It must be noted that the large, bore-riding stabilizing fins at the tail end of the projectile produced a great deal of aerodynamic drag. According to V.A Grigoryan in "Защита танков" (Download), 115mm fin stabilized projectiles had a muzzle velocity of 1615 m/s, and a velocity of 1358 m/s at 2 kilometers. This translates to a rate of speed loss of up to 128.5 m/s per kilometer of travel. BM8 APDS, on the other hand, loses 106.5 m/s per kilometer of travel.

The 2A20 "Molot" cannot be considered a "bad" gun, but it had one major drawback related to the Iranian Chieftain in the photo below.

Steel was cheap, plentiful, easy to handle and reasonably strong, but is intrinsically inferior to heavy metals like tungsten and depleted uranium. The high elongation of the steel rod is absolutely critical in counteracting this. In the photo above, an eagle-eyed observer will note that the impact crater on the left shows evidence of deflection. It cannot be part of the channel made by a cumulative jet, because the photograph was taken at eye level with the turret, not at a downward angle, and a cumulative jet does not leave such huge entry holes, so the crater must have been left by an APFSDS round. However, despite whatever deflection occurred on impact, the APFSDS round perforated the turret all the same.

This report provided by Tank-Net and Otvaga2004 member Wiedzmin tells us that Iranian Chieftain tanks were vulnerable to both 115mm APFSDS and HEAT, and that the majority of the hits were achieved by APFSDS rounds. The report notes that:

"*of the eighty eight strikes, seventy one penetrated, many on the relatively vulnerable hull but some in the areas of highest protection on the turret front. The consequences of penetration were:*

a. A 'fireball' of low duration but high intensity surging through the penetrated compartment. The turret padding and any cloth, such as crew clothing, was badly singed and paint was blistered. In many cases the singeing of the padding and its foam lining had caused dense smoke and the production of a noxious gas.

b. A 20° high energy cone of spall was discharged from the point of penetration. Four feet from the penetration the cone was some 600mm in diameter. The internal diameter of the penetration was normally 60 to 80mm."

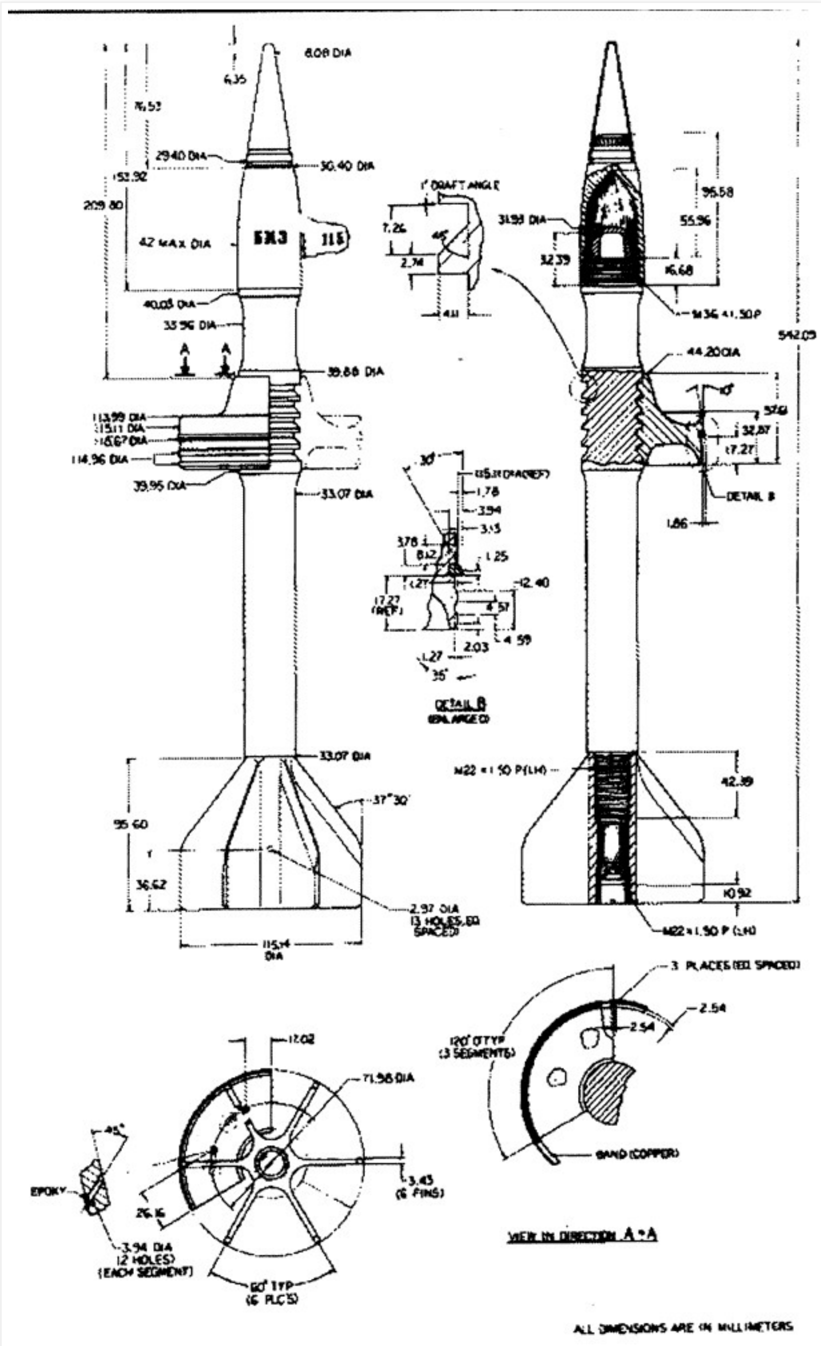
The report also notes that "*by far the majority of the damaged tanks (70%) had been hit by the 115mm long rod penetrator APDSFS T62 tank gun round*", proving that APFSDS rounds were the preferred anti-tank round. From what we see here, it is clear that 115mm APFSDS is highly effective against the Chieftain, providing that penetration occurs. The post-perforation effects of this type of ammunition is proven to be effective at either killing the crew and damaging internal components or at least smoking the crew out of the tank. Unfortunately, the ranges of engagement for any of the damaged Chieftains was not given, and they did not provide a definition for "battle range", so we cannot know the limits of the capabilities of 115mm APFSDS by reading this part of the report. We can, however, make good guesses by taking an in-depth look at 115mm APFSDS ammunition:

3UBM-3

3BM-3

Photo Credit: Stefan Kotsch

Original APFSDS shell made for the 2A20 cannon, first introduced in 1961. It had a tungsten carbide slug in the bulbous region of the projectile at the tip, topped off with a flat steel armour piercing cap to prevent the slug from shattering outright on impact and to improve performance on sloped armour.

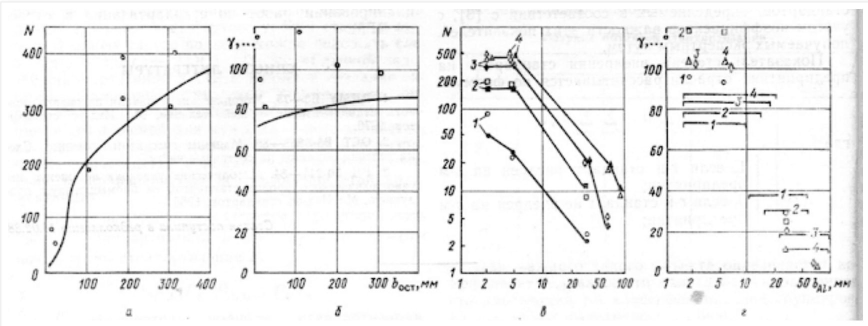


In 1961 terms, the BM3 was vastly superior to contemporary 105mm APDS ammunition such as the L28 and L36A1 and the American M392 derived from it, having *at least* 35% better penetration values at the same distance, accounting for different certification standards and different target steel strength and hardness. BM3 can be placed between 100mm 3BM8 APDS for the D-10T (T-55) and the 122mm 3BM11 APDS for the M-62 (T-10M) in "power" ranking. These two contemporaries were introduced quite a while after BM3 - in 1967 and 1968 respectively. 3BM8 penetrates 190mm at 0 degrees at 1 km, and 3BM11 penetrates 320mm at 0 degrees at 2 km. BM3 is also superior to the L15 APDS shell in terms of penetration on both sloped and unsloped armour, and generates more lethal after-armour effects on significantly overmatched armour as a result of its less optimal design; being much less efficient than a single solid tungsten carbide slug, it would produce a much more massive fragmentation pattern post penetration.

A small part of this is simple extrapolation, since the author hasn't seen any documents pertaining to this matter, but based after-armour lethality reports on extremely similar 125mm tungsten-cored APFSDS, there can be very little doubt about it. This article by Peter Samsonov is mandatory reading. The document featured in the article pertains to a lethality analysis done on 3BM-9, 3BM-15, 3BM-22 and 3BM-26 APFSDS rounds. 3BM-9 is an all-steel "torpedo" APFSDS round. 3BM-15 is the closest representation of BM-3, as both have a tungsten carbide core at the front of the projectile, as opposed to one at the rear, as in 3BM-22 and 3BM-26. All of the shots were for a 60 degree obliquity impact, and the velocity of all of the shells corresponds to their velocities at 2 km.

Assuming that the round overmatches the armour plate by 100mm to 200mm (LOS), then a penetrating 3BM-15 shell will produce 150 to 200 pieces of fragmentation capable of penetrating 3-6mm of aluminium sheeting in a 110 degree cone.

According to graph (b):



The number of lethal fragments increases as the armour overmatch increases. The curve of this graph was drawn based on calculations from the tabulated data of all four APFSDS rounds, so it does not exactly represent any of them, but we know that the late model APFSDS designs with the core at the rear have a greatly improved fragmentation pattern and quantity compared to the earlier designs, so we can assume that 3BM-15 - and by extension, the BM3 - produces somewhat less fragments than listed in graph (b) per 100mm of overmatched armour. If we take 3BM-15 as a surrogate for BM-3, then when BM-3 is fired at the side of an M60A1 (74mm cast side armour) at 60 degrees, it will overmatch by 112mm. This means that it will generate slightly less than 80 lethal fragments (according to graph (b)), but it will also generate around a hundred other fragments that will badly injure the crew, cut electrical wiring, sever hydraulic fluid lines, and so on. Adding on to that, remember that the APFSDS rounds fired in the test had an impact velocity corresponding to their velocity at a distance of 2 km.

Fragments that are capable of penetrating ***at least*** 30mm of aluminium are few and far in between; most of the fragments are only capable of penetrating less than that. While fragments that can penetrate 30mm of aluminium would not be more useful than smaller fragments at harming or killing the crew, they will be capable of detonating ammunition on a direct hit, which is something that the low penetration, low energy fragments cannot readily do.

This would make the BM3 incredibly potent against relatively lightly armoured tanks like the Leopard 1 and AMX-30 appearing in the late 60's. Additional evidence of the high lethality of BM3 comes from U.S Army evaluations, which assign a very high Pk (probability of kill) to BM6 rounds on an M60A1 - 71% - according to the TRADOC bulletin. As shown in the report above, 3BM-9 steel APFSDS produces more fragments post-armour penetration than 3BM-15 cored APFSDS. This relationship should not be different for the BM3 and its all-steel counterparts.

Muzzle Velocity: 1615 m/s

Mass of Complete Round: 22 kg
Projectile Mass: 5.5 kg

Certified Penetration at 1000m:
300mm @ 0°
130mm @ 60°

Certified Penetration at 2000m:
270mm @ 0°
115mm @ 60°

With what we currently know about the armour of the M60A1, BM3 would have been more than sufficient at combat ranges. The cast upper glacis of the M60A1 measures 109mm in thickness, angled at 65 degrees, making for a more formidable target than even the sloped turret cheeks, but even so, most parts of the M60A1 should be vulnerable to BM3 at combat ranges, and that is without taking into account the differences in ballistic standards. The Soviets use V80 ballistic limit, as opposed to V50, meaning that given a data sample of 'x' number of rounds, 80% must penetrate a certain amount of armour within a reasonable range of velocities. Also, the American criteria of what constitutes full armour perforation is based on the recovery of 50% of projectile mass behind the armour plate. The Soviet criteria uses 75%, but 80% is also used. Taken together, all this means that if BM3 can penetrate 300mm at 1 km according to the Soviet penetration criteria, then it could penetrate around 324mm when expressed in the Western penetration criteria, and for every successful armour perforation, the behind-armour effect would also be much stronger.

Knowing the armour thickness of the Chieftain Mk.5 tank from ultrasound measurements, it can be reasonably surmised that the 3BM3 is capable of reliably perforating the turret on any point from at least 1000 m, but probably more, because the Chieftain has cast steel armour and not rolled armour, and we are basing our estimations on Soviet penetration values based on Soviet penetration criteria. The weak lower front plate of the hull can be penetrated from any conceivable distance, but the highly sloped upper front plate is a tougher target than even the turret, since 115mm APFSDS does not handle extreme slope well. It is fortunate for the T-62, then, that the upper front plate of the Chieftain occupies only a very small portion of the total frontal profile of the tank.

The true ingenuity behind the 3UBM3 round wasn't that it was radically more powerful than anything on the planet - it wasn't. The innovation of the BM3 projectile was that the tungsten carbide slug within only only weighed about 300 grams, but could punch through more armour than the 2.82 kg slug in the 100mm BM-8 APDS shell for the T-55. For every BM-8, they could have made almost ten 3BM3 shells that were more powerful and more accurate. This would have been a huge incentive to prioritize the T-62 if a major conflict erupted. Recall that tungsten was very scarce in Nazi Germany in the late war period, making it extremely difficult for the Wehrmacht to procure APCR rounds as the war drew to a close and heavier and heavier Allied tanks started to appear on the frontlines. A similar scenario would be disastrous for the Soviet Union, as the technology for producing depleted uranium ammunition was still decades away, and the only alternative was steel ammunition, which would struggle against the heavily armoured M60A1. For this reason alone, the 3UBM3 round deserves nothing but praise. But let's take a look at that steel ammunition:

3UBM-4
3BM-4

Introduced in 1963 as an even cheaper alternative to the 3UBM3, presumably having the secondary function of a training round. It was basic in construction; It was all-steel, was torpedo-shaped and very cheap to manufacture, but most importantly this shell clocked in at an unheard-of 1,650 m/s at the muzzle, just a fraction above a mile a second.

The entire projectile functions as the penetrator. There is no internal core, only an armour piercing cap at the tip. It is made entirely of solid 60KhNM high carbon steel with a hardness of around 310 BHN, which is strange as earlier steel armour piercing projectiles like the 100mm BR-412B already used steel hardened to 600 BHN and above. It had 6 steel fins, which were of a bore riding type that worked alongside the sabot to stabilize the shell as it travels down the barrel. The ends of the fins have copper lugs embedded in them to minimize abrasive damage to the much tougher chrome lining of the gun barrel. The soft armour piercing cap is made of 35KhGSA steel, built with a flat tip to decrease the likelihood of a ricochet on sloped armour as well as to protect the projectile from shattering upon impact. The necessity of an armour piercing cap despite the relatively low hardness of the steel was due to use of high carbon steel instead of maraging steel, which retains more ductility without compromising strength. For 3BM-4, the steel penetrator lacks hardness, yet brittle. In other words - it was not a very good design.

Nevertheless, the presence of the armour piercing cap protects the round from the effects of simple spaced armour such as the type present on upgraded Leopard 1 turrets. The spaced plate will successfully destroy the armour piercing cap, but the penetrator will be intact, and it will have a high chance of defeating the relatively thin turret armour with ease even at high angles of attack.

Moreover, the after armour effects of BM4 are even greater than BM3, as shown in the comparison between pure-steel BM-9 and BM-15.

The main factors contributing to the penetrating performance of the shell is the relatively high length-to-diameter ratio of 13:1 and the fantastic speed of the projectile, but because it was made entirely from steel, its performance falls short of the BM3. However, that is not the point of the 3UBM4. If the 100mm BM-8 APDS projectile penetrates around 264mm of RHA steel at 0 degrees at 1 km using a 3 kg tungsten carbide slug, then the BM4 projectile can be considered a reasonable alternative, as it is capable of penetrating about 228mm RHA at the same distance, without needing any tungsten or special manufacturing techniques to build. Furthermore, the performance of BM-8 APDS was very underwhelming on sloped targets. As all Cold War era NATO tanks featured heavily sloped armour, BM4 would have been much more useful than BM-8 in practice.

Mass of Complete Round: 22 kg
Projectile Total Mass: 5.5 kg
Penetrator Mass (Without Sabot): 3.196 kg
Armour Piercing Cap Mass: 0.187 kg

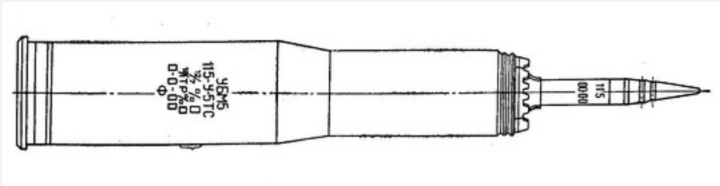
Certified Penetration at 1000 m:
228mm RHA @ 0°
110mm RHA @ 60°

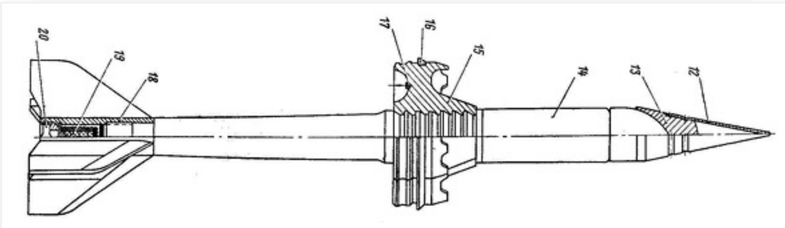
Certified penetration at 2000 m:
200mm RHA @ 0°
100mm RHA @ 60°

Alternate Russian source lists the penetration at 1000 m as:
250mm RHA @ 0°
130mm RHA @ 60°

With this shell, the T-62 had a respectable (but by no means dependable) chance of defeating tougher customers like the M48 or M60 frontally out to more than 2,000 meters, and no trouble at all defeating an AMX 30, Leopard 1 or Centurion frontally out to 2,000 m. The Chieftain's turret is generally immune to this shell at any range, but the prominent lower hull is vulnerable at a distance of up to 1,000 m, but no more.

3UBM-5
3BM-6





Introduced in service in 1970 as a slightly more advanced but similarly cheap alternative to the 3UBM4, although in reality production had already switched over to 3UBM5 from the 3UBM4 between 1966 to 1968.

The stabilizing fins are made from 40KhFA steel alloy with high thermal resilience. The fin assembly weighs a total of 0.651 kg.

Externally identical, the 3BM6 projectile can be distinguished from the 3BM4 by the presence of "teeth" on the edge of the sabot, which are absent from the one on the 3BM4 projectile. Internally, they are quite different. The penetrator is made from 35Kh3NM steel with a hardness of around 600 BHN. The 35Kh3NM steel is a type of steel that had been in use in standard full-caliber armour-piercing shells like the 100mm BR-412B and 122mm BR-471B since their creation in the late stages of WWII. As expected, the hardening of the steel to around 600 BHN is consistent with the hardening of the old full-caliber shells of postwar production. The 3BM6 penetrator had a rounded nose and it had an armour piercing cap made from softer 35KhGS steel. Although still made entirely of steel, this shell offers appreciably higher performance, but still far from being comparable to the 3BM3 on flat targets.

The performance of 3BM-6 on spaced armour is detailed in the table below. In the table below, the first column from the left shows the impact angle and the next three columns from the left list the spaced armour configurations: b_1 and b_2 denote the thickness of the first and second plates in millimeters, and L denotes the size of the air gap in millimeters. The fourth column from the right lists the velocity limit of 3BM6 for the spaced described armour configuration, and the third column from the right lists the velocity limit for a monolithic plate of the same thickness in steel (b1 + b2). The difference in the velocity limit is listed in the second column from the right. The first column on the right shows the difference in the velocity limits between the spaced armour configuration and a monolithic plate in percentage points, and also represents the improvement in mass efficiency.

Фактическая стойкость стальной ДБ с различными соотношениями толщин первой и второй преград и разными МПР по сравнению со стойкостью РМБ при воздействии снарядов 3БМ6 в диапазоне малых углов встречи

Угол встречи, град	Преграда			$V_{ПКП}^{ДБ}$, м/с	$V_{ПКП}^{РМБ}$, м/с	$\Delta V_{ПКП}$, м/с	$\Delta \bar{V}_{ПКП}$, %
	b_1, мм	L, мм	b_2, мм				
0	120	470	120	1460	1470	10	0
	120	1400	120	1460	1470	10	0
	90	330	100	1370	1350	20	1,48
	90	900	100	1390	1350	40	2,96
30	20	350	80	1000	940	60	6,40
	20	850	80	1010	940	70	6,90
	20	500	80	1080	1050	30	2,90
	20	850	80	1100	1050	50	4,80
45	90	500	100	1520	1430	90	6,30
	90	1000	100	1560	1430	130	9,10
	40	500	80	1185	1150	35	3,04
	80	500	40	1140	1150	10	0

As you can see, the maximum improvement in mass efficiency was attained using a 90-1000-100 configuration which was also the toughest target and showed an improvement of 9.1% compared to a monolithic plate of the same physical thickness (190mm). Needless to say, however, the 1.0-meter air gap of this configuration is completely impractical for tank armour, and the total thickness of the array considering its 45 degree angle is huge: 1,683mm thick. The improvement in mass efficiency from the other configurations are all less than around 6 percentage points, so from these results, it can be said that 3BM6 performs well for simple spaced armour with two steel layers within the range of angles of between 0 to 45 degrees. In practice, simple spaced armour such as the type implemented on the turrets of upgraded Leopard 1 tanks would be no challenge for 3BM6 at any plausible combat distance, nor would the spaced armour of the MBT-70 or KPz-70 (had they entered service).

Here is what the penetrator without the armour piercing cap and the windscreen (ballistic cap) looks like:

Projectile Maximum Diameter: 42mm
Diameter of Stabilization Fins: 114mm

Total Projectile Length: 550mm
Total Cartridge Length: 950mm

Mass of Complete Round: 21.66 kg
Total Projectile Mass: 5.34 kg

Projectile Mass In Flight: 4.00 kg

Mass of Penetrator: 3.009 kg
Mass of Armour Piercing Cap: 0.167 kg

Muzzle Velocity: 1680 m/s

Source

Penetration at 1.0 km:
280mm RHA at 0°
135mm RHA at 60°

Penetration at 2.0 km:
240mm RHA at 0°
110mm RHA at 60°

This shell deserves special attention for the huge improvement over the 3BM4. The new armour piercing cap appears to have improved the performance of the projectile on sloped armour to the point where it is superior to the BM3, making this shell even more useful than its predecessor on the heavily sloped armour of contemporary NATO tanks like the Chieftain and the M60A1.

Despite lacking any tungsten component whatsoever, 3BM6 was already enough to defeat the Chieftain at typical combat distances. According to a Soviet analysis of an Iranian Chieftain captured by the Iraqi army during the early part of the Iran-Iraq war, available here on Andrei Tarasenko's website, btvt.info, the frontal armour of the Chieftain Mk.5 could be defeated at a distance of 1600 m. The frontal cheeks of the turret could be pierced at 1,600 m, and the base of the turret could be pierced at 2,300 m. The upper front plate, an 85mm cast armour plate sloped at 70 degrees, could be defeated at 1,600 m, while the lower front plate could be defeated at more than 3 km. The table says 3 kilometers, since they did not bother to conduct testing past that distance but the velocity limit is listed as 1,000 m/s which corresponds to a distance of 5 km. Needless to say, these are excellent results, especially considering that it is achieved without the use of any tungsten at all in the construction of the projectile.

It must also be noted that the all-steel projectile offers better performance than the L28 or M392 APDS shells for the L7 cannon. The L28/M392 had a very substantial tungsten carbide core, larger than the 3 kg slug in the 100mm 3BM8, in fact, but they achieved less penetration (than both the BM-8 and 3BM6) at the same distances; at 1 km distance, the L28/M392 could penetrate 252mm at 0 degrees, and 117mm at 60 degrees. To add insult to injury, combat experience in the 1973 Yom Kippur conflict apparently revealed that these shells could not perform reliably on heavily sloped armour, which was quickly solved with a tungsten tilting cap on the M392A2. However, this upgraded version is still inferior to the 3BM6 in performance on sloped armour.

This round made up the bulk of ammunition exported to client states, making it the most numerous type of APFSDS ammunition available to Egyptian and Syrian tank crews during the Yom Kippur war.

3UBM-9
3BM-21 "Zastup"

A slightly more progressive design derived from the 3BM-15 made for the 2A46 125mm cannon, sporting a tungsten carbide core installed at the front of the penetrator like the BM3, but without the bulb at the front of the projectile. 3BM21 "Zastup" was created alongside the 3BM25 "Izomer" and 3BM22 "Zakolka" in accordance with an order issued in 1972 for the general modernization of anti-tank munitions for anti-tank guns of 100mm to 125mm calibers. However, there designs did not present any huge advance from previously established ammunition technology.

Like with the previous designs, an armour piercing cap with a flat tip is present to reduce the likelihood of a ricochet, and in this case, to protect the tungsten core from shattering upon impact. The difference between 3BM21 and previous models is that this cap is now much bigger. The enlarged cap effectively neutralized any difference in performance on sloped targets compared to flat targets. Here, the armour piercing cap and the tungsten carbide core are clearly visible.

Mass of Complete Round: 23.50 kg
Projectile Mass: 6.26 kg

Propellant Charge Mass: 8.20 kg

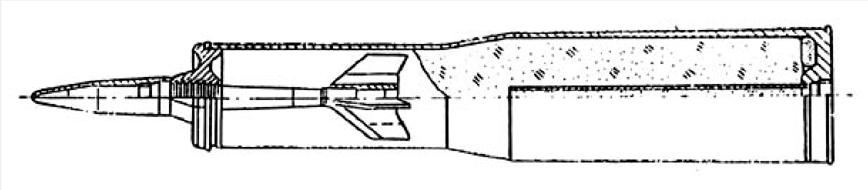
Muzzle Velocity: 1600 m/s

Certified Penetration at 1000 m: (Extrapolated from values at 2 km)
360mm RHA @ 0°
175mm RHA @ 60°

Certified Penetration at 2000 m:
330mm RHA @ 0° *
165mm RHA @ 60° (Inferred)

* From Andrei Tarasenko's site (link), MV Pavlov, IV Pavlov "Domestic armored vehicles 1945-1965". Tiv №9 2008.

3UBM13
3BM-28



Most advanced 115mm APFSDS round of Soviet origin, and also the last APFSDS round developed for the T-62 before it was withdrawn from service. 3BM28 has a sheathed monobloc depleted uranium penetrator with a flat AM6 light alloy armour piercing cap at the tip. The penetrator is made from UTsN uranium-zinc-nickel alloy.

Muzzle Velocity: 1650 m/s

Mass of Penetrator: 4.36 kg
Mass of Armour Piercing Cap: 0.1 kg

Penetration at 2.0 km:
380mm at 0°
200mm at 60° (Inferred)

From Andrei Tarasenko's site (link), quoted from MV Pavlov, IV Pavlov "*Domestic armored vehicles 1945-1965*". TiV magazine September 2008.

Penetration at 2.0 km:
350mm at 0°

From "*Боеприпасы: учебник для вузов*".

HEAT-FS

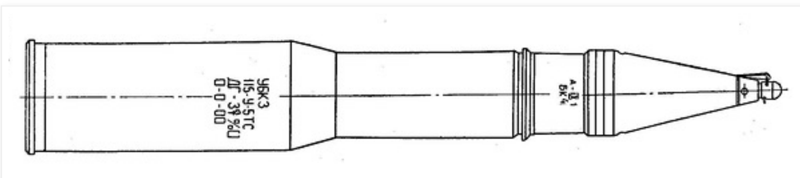
Between the mid-50's to late 60's, shaped charge warheads was widely appraised as being the "great equalizer" of tank warfare. Tube-launched HEAT warheads became popular, being tremendously useful in a variety of roles ranging from general tank-killing to bunker busting or simply as a more flexible alternative to HE-Frag or HESH shells, but because of the immaturity of shaped charge technology in those days, manufacturing a HEAT warhead tended to be costlier than manufacturing a steel full-caliber shell or a HESH shell. HEAT shells also had a lower post-perforation effect on all targets compared to conventional ammunition types - they were not as effective at destroying bunkers compared to HE shells equipped with a delay fuze, and they were not as efficient at destroying lightly armoured vehicles compared to HE and HESH shells. This is due to the limited mass of particles that can be ejected through an armour plate due to the small mass of the shaped charge liner, and of that small mass, 70% to 80% is propelled behind the shaped charge jet as a slug. In many cases, a shaped charge warhead optimized to penetrate a maximum thickness of armour will only produce a slender penetration cavity through which a shaped charge slug cannot pass. If the slug cannot pass, it does not contribute towards the post-perforation effect and will actually plug the breach in the armour from the blast overpressure of the explosion from the detonation of the warhead. As a result, only a modest stream of hypervelocity particles will come out through the exit hole in the armour plate, supplemented by a smattering of armour fragments. Unless the ammunition loadout of a tank was rationalized to the extent that it carried HEAT rounds exclusively, this type of ammunition is best suited to only occupy the niche of defeating exceptionally heavy armour.

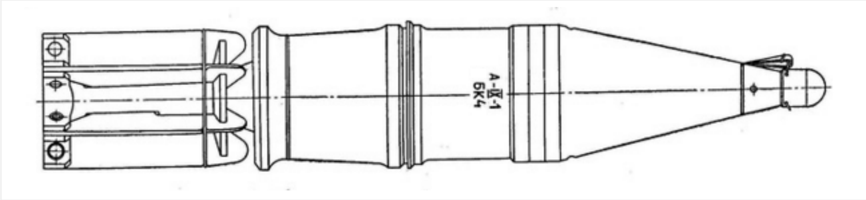
The typical tank-fired HEAT shells developed on both sides of the Iron Curtain were so powerful that they rendered all contemporary tank armour essentially useless in the event of a direct hit. Unfortunately, the post-perforation effects of HEAT rounds do not hold a candle to the power of APFSDS rounds. The report provided by Wiedzmin had this to say about the relationship between HEAT rounds and Iranian Chieftains:

"*There had been forty four HEAT strikes from both 115mm T62 tank gun rounds and TOW [only one TOW strike was recorded]. All but five had achieved some penetration; two Sagger warheads had achieved penetration; seven RPG 7 had struck but none had penetrated. The internal diameter of the 115 and TOW penetration was normally 35mm; penetration led to much less damage than APDSFS and seldom led to fires*"

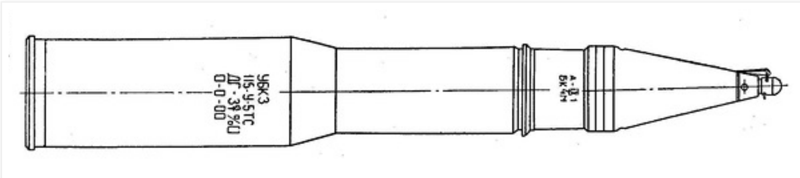
So despite the comparatively high penetration power of HEAT ammunition, it was still not qualified to complete substitute a good KE round. Real combat experience showed that 115mm APFSDS was more lethal than 115mm HEAT when used against tanks that both types could perforate; the Chieftain, in this case. Even abroad, foreign tank crews generally preferred APDS or APFSDS over other ammunition types when targeting tanks. For instance, during the course of the Hunfeld II study that was carried out in the early 1970's in the Hünfeld region of Fulda, Germany, it was found that M60A1 gunners overwhelmingly preferred to use APDS during simulated combat.

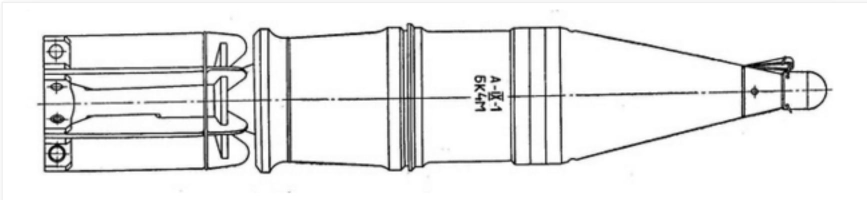
UBK-3, UBK-3M
BK-4, BK-4M





BK-4 was a basic HEAT shell entering service alongside the T-62 in 1961. It had a steel casing with a conventional conical aerodynamic fairing and generally unremarkable ballistic properties. The warhead uses a conical steel shaped charge liner with a squared apex. The explosive compound used in the warhead is A-IX-1, a composition containing 96% RDX and 4% paraffin wax. The BK-4M shell used the same casing as the basic BK-4 but had a copper shaped charge liner of the same diameter. The built-in standoff distance as measured from the base of the shaped charge liner to the tip of the fuze is 238.8mm, which is equal to 2.35 charge diameters (CD).



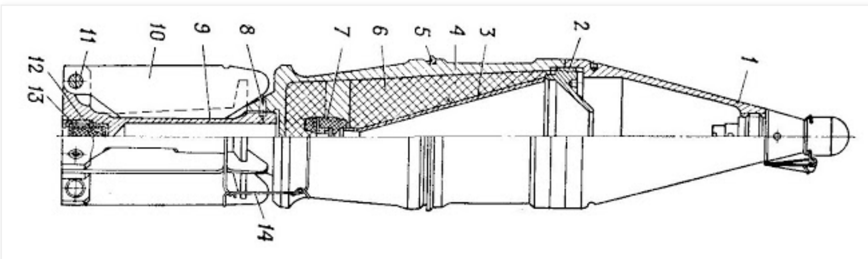


The Soviet approach to the creation of HEAT rounds can be considered quite rational as the focus was placed on maximizing the primary effect of the warhead by sacrificing the muzzle velocity. By having a modest muzzle velocity relative to the pressure of the U-5TS gun, the warhead casing of the BK-4 and BK-4M rounds could be reduced, and in turn, the diameter of the shaped charge liner could be increased. The 105mm M456 round had an exceptionally high muzzle velocity of 1,200 m/s, so it required a thick warhead casing to withstand the stresses of acceleration inside the gun tube. Case in point: the BK-4M warhead casing has a thickness of 8.03mm at the base and a thickness of 5.31mm at the mounting point for the shaped charge liner. This enabled a shaped charge liner with a diameter of 101.6mm to be installed. On the M456 warhead, the casing has a thickness of 10mm at the base and a thickness of 8mm at the mounting point for the shaped charge liner, and because of this, the shaped charge liner has a diameter of only 85mm. The difference in shaped charge liner diameter between the 115mm BK-4 and the 105mm M456 is therefore not 10mm as the calibers imply, but actually around 15mm.

By maximizing the penetration power of the HEAT ammunition at the expense of velocity, the role of HEAT in a mixed ammunition load was intrinsically constricted to the niche of defeating tanks that are too heavily armoured to be handled with APFSDS rounds alone.

The replacement of the steel liner with a copper one was not considered sensitive technology, as there is evidence that these shells were freely exported to the Syrians and Egyptians. It is difficult to imagine that the BK-4M shell was less prolific in the Red Army.

In shells produced from 1961 to 1964, there was a small 20-25 gram charge of A-IX-2 inside the tailboom, between the tracer and the warhead. It has no fuze or detonator - it is detonated by the explosion of the main warhead. The purpose of the small A-IX-2 charge was to increase the total fragmentation effect of the shell, but after several cases of the tailboom rupturing in the cannon barrel when fired, this feature was deleted. All BK-4 shells produced after 1964 have a perforated hollow tailboom.



According to a well-known TRADOC bulletin, the penetration of 3BK-4 is roughly equal to the 105mm M456A1 HEAT round with both having a penetration of 432mm despite the difference in caliber between the two rounds. This may be explained by the use of a steel liner in the BK-4 warhead instead of a copper liner as found in the M456A1, but a more likely explanation is a difference in the criteria. According to a 1979 Soviet report titled "*Выбор Кумулятивных Снарядов Для Испытания Брони*" (*Selection of Cumulative Shells for the Evaluation of Armour*), the average penetration of BK-4M in armour plate is 499mm with a maximum of 559mm and a minimum of 418mm. All of the penetration figures represent the performance at both 0 and 60 degrees. For the sake of comparison, the average penetration of M456A1 in the same targets was found to be 398mm, and the maximum and minimum penetration were 434mm and 355mm respectively. Most interestingly, these figures imply that the TRADOC bulletin and other U.S Army documents are reporting the maximum penetration of M456A1 instead of the average penetration wheras the official Soviet figures represent the maximum perforation limit including an allowance for post-perforation effects. This nuance can also be seen in French literature on the 105mm F1 HEAT shell (Obus-G) which report that the penetration figures are 360mm at 0 degrees and 150mm at 60 degrees, but the Soviet study credits the F1 shell with an average penetration of 388mm.

COMPARATIVE KILL PROBABILITY—T-62 VERSUS M60A1

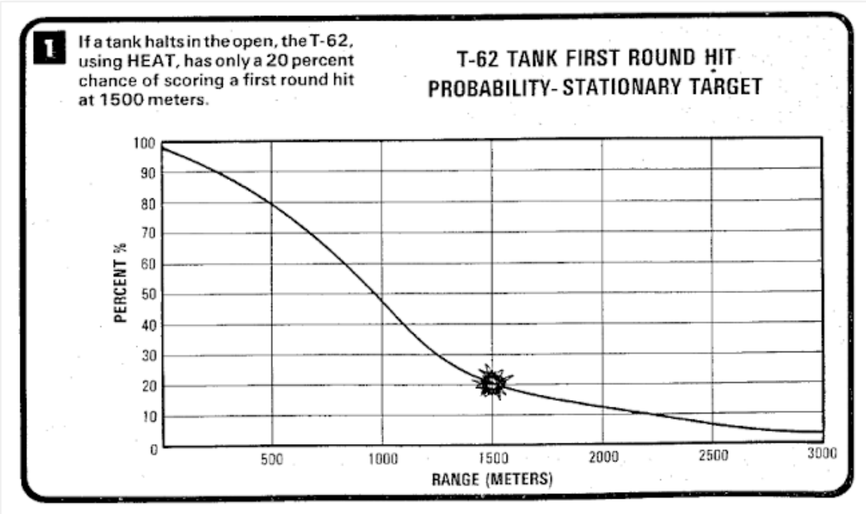
TANK	ROUND	ARMOR PENETRATION (CM)	PROBABILITY OF KILL IF HIT
T-62	HVAPFSDS	33cm	71%
	HEAT	43.2cm	75%
M60A1	APDS	25.4cm	54%
	HEAT	43.2cm	75%

When all of these rounds are normalized according to their average penetration, the 105mm M456A1 round has the lowest performance with a penetration of 398mm. The 115mm BK-4 round penetrates 440mm, and the 115mm BK-4M penetrates 499mm.

Based on this information, BK-4M provided the capability to defeat the most heavily armoured NATO tanks from the front until the emergence of the Leopard 2 and M1 Abrams in 1979. It also permitted the T-62 to defeat the frontal armour of a T-64 or T-72 before these main battle tanks even came into service. However, the armour penetration performance of BK-4 was already enough to greatly overmatch any NATO armour that a T-62 was likely to meet and it was enough to defeat even the most well-protected heavy tanks of its time. The higher the level of overmatch, the more powerful the post-perforation effect will be. Of course, a catch existed - by its nature, the post-perforation effect on tanks protected by thick armour was modest compared to KE ammunition. Main battle tanks like the M60A1 and Chieftain cannot withstand an attack from either BK-4 or BK-4M, but the odds still favour their survival.

However, BK-4 and BK-4M would be very lethal against lightly armoured tanks like the Leopard 1 and older tanks like the M48 and M47 which formed the bulk of the tank fleets of NATO armies. However, APFSDS would be preferred under all circumstances due to its superior first-shot hit probability, sufficient armour penetration performance and superior post-perforation effect. Both HEAT rounds can be used interchangeably in a T-62 as they share the same ballistic characteristics, and they are both capable of defeating the armour of any enemy tank.

Although this round is capable of knocking out an M60A1 or a similar type of tank from the front on the first hit, the chances of scoring a hit with the first shot at normal combat ranges are rather low. At 1,500 meters, the probability of hitting an M60A1-sized target is only 20%, and although this rises to about 48% at 1,000 m, this still only means that just one out of two shots will connect. See the diagram below, taken from the TRADOC bulletin.



This is partially related to the design of the shell itself. 3BK-4 depends entirely on its stabilizer fins for accuracy, whereas M431 (90mm) and M456 (105mm) make use of shape stabilization; the shape of the shell is designed in such a way that the airflow around it keeps it very stable in flight. Additional factors that contribute to the lower accuracy of 3BK-4 are the lower velocity of the shell and the lack of precise rangefinding equipment on the T-62 itself. The M60A1 is more capable of exploiting low and medium velocity ammunition at long ranges because it has an optical coincidence rangefinder.

Both the BK-4 and BK-4M use the GPV-2 piezoelectric fuse. It is the same fuse used in the 100mm 3BK-5 HEAT round for the D-10T.

BK-4 (BK-4M)

Mass of Complete Round: 26.00 kg
Projectile Mass: 12.97 kg
Shaped Charge Liner Mass: 0.706 kg (0.804 kg)
Diameter of Shaped Charge: 101.6mm

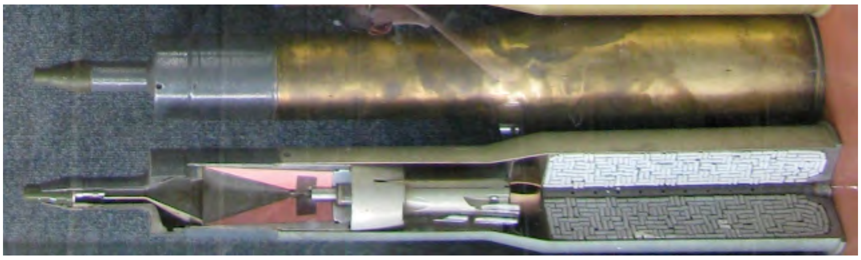
Mass of Explosive Charge: 1.55 kg (1.478 kg)
Explosive Charge Type: A-IX-1

Muzzle Velocity: 950 m/s

Penetration:
440mm at 0° (499mm at 0°)
200mm at 60° (?)

It is strange that 3BK-4 has 440mm of penetration at 0 degrees when the 125mm 3BK-12 has a penetration of only 420mm at the same angle. Given the increased caliber, one would expect the penetration to rise accordingly. The 3BK-4 was introduced in 1961 and the 3BK-12 was introduced experimentally in 1962, so there is no technology gap between them. One possible explanation is that the 0 degree penetration figure for 3BK-12 was created by someone simply converting the 60 degree penetration figure. If that were the case, 3BK-12 would have 210mm penetration at 60 degrees, and more penetration at 0 degrees as well.

3UBK-7
3BK-15, 3BK-15M "Zmeya"

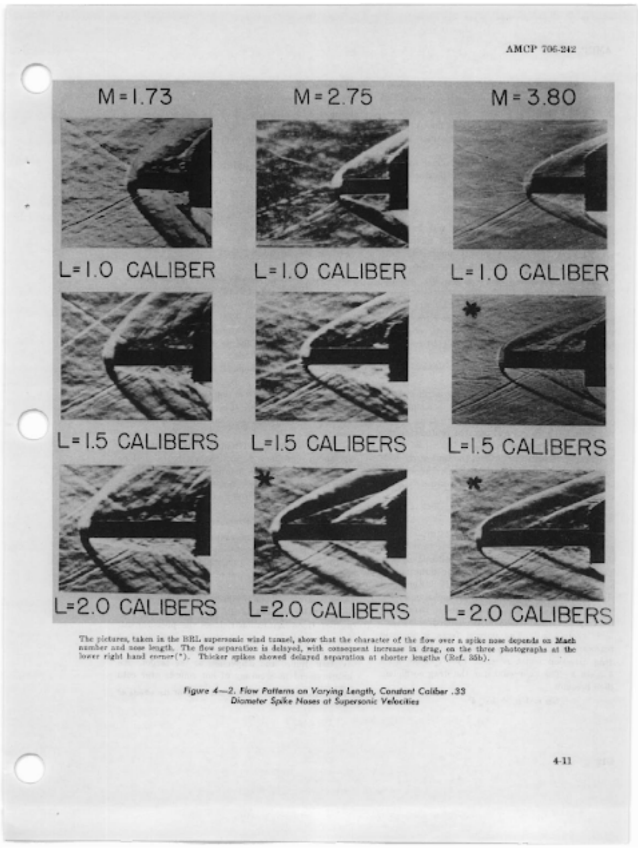


"Zmeya" was developed alongside the 100mm "Ikra" and 125mm "Nadezhda" as part of a modernization program to upgrade the firepower of the Army's cannons in the 100mm to 125mm caliber range. The most notable difference in the new shells was the use of spike tip technology, which was not a new technology by the time 3BK-15 was introduced in 1975. The ballistic peculiarities of spike nosed projectiles were known and had already been used to create tank shells as early as 1962 in the form of the 125mm 3BK-12 round. It is not clear why this technology did not immediately carry over to the ammunition for the 100mm D-10T, 115mm U-5TS and 115mm D-68 when it was first implemented.

Two variants of the new round with steel and copper shaped charge liners were created in accordance with the standard practice of the Soviet Army. The 3BK-15 shell had the warhead using a steel shaped charge liner and the 3BK-15M shell used a copper liner for improved penetration power. Both variants were ballistically matched.

The 3BK-15 had an improved warhead design compared to its predecessors, doing away with the traditional conical or ogived aerodynamic fairings in exchange for a a flat-sided cylindrical body and a spike nose carried over from contemporary 125mm HEAT shells. "*The Engineer's Handbook*" from the U.S Army Materiel Command provides us with a more esoteric examination of spike noses.

The pictures below, taken from page 4-11, show the different airflow characteristics with different lengths of the standoff probe (referred to as the "spike nose") and at different mach numbers.


AMCP 706-242

The pictures, taken in the BRL supersonic wind tunnel, show that the character of the flow over a spike nose depends on Mach number and nose length. The flow separation is delayed, with consequent increase in drag, on the three photographs at the lower right hand corner(*). Thicker spikes showed delayed separation at shorter lengths (Ref. 35b).

Figure 4—2. Flow Patterns on Varying Length, Constant Caliber .33 Diameter Spike Noses at Supersonic Velocities

4-11

The handbook remarks under subheading "*4-7.8.1 Spike-Nosed Projectiles*" in pages 4-10 that: "*These spike-nosed projectiles had higher drag coefficients than the corresponding projectiles with ogival heads*", indicating that 3BK-15 probably has a higher drag coefficient than the rounds it was designed to replace, trading velocity for some other desirable trait of the ballistic shape. Further down the paragraph, the handbook details a phenomenon called "dual flow":

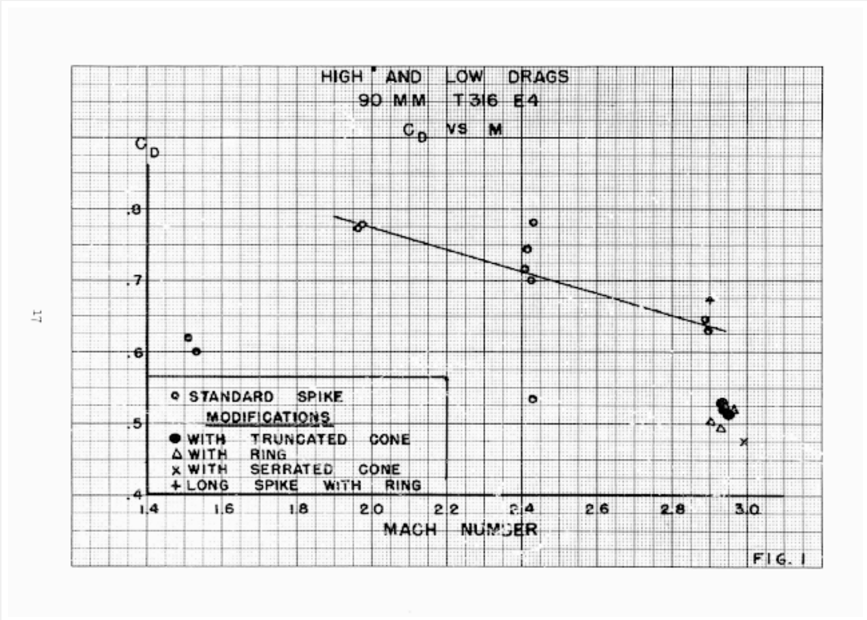
"*Examination of spark photographs showed that the low drag coefficients were associated with rounds on which the airflow separated from the spike at its tip, while on the high-drag rounds the flow separated at a point about half-way down the spike. This phenomenon was called "dual flow"; its* *existence was a function of the geometry of the spike. In order to avoid the occurrence of dual flow, with its serious effect on accuracy, modern spike-nosed rounds arc furnished with a small ring near the tip of the nose which insures the early separation of the flow."*

In other words, a mach cone forms at the tip of the spike, and sometimes separates down the middle of the spike to form a second cone. Projectiles with two mach cones; one at the tip of the spike and one down the middle of the spike experienced higher drag, whereas projectiles with a single mach cone at the tip experienced low drag. A projectile with a simple straight spike could experience both flow configurations, resulting in some shots experiencing higher drag and landing low on the target, while others experience lower drag and land high. The purpose of the ring is to ensure the separation of flow at the tip of the spike, thus ensuring that the second cone down the spike is consistently eliminated leaving a single mach cone at the tip of the spike.

The effects of dual flow on accuracy are further explained in a Ballistics Research Laboratory study on this topic in the paper "*The Effect on Drag of Two Stable Flow Configurations Over The Nose Spike of the 90mm T316 Projectile*" from 1954. Here is an excerpt:

"*Since the occurrence of either type of flow appears to be of a statistical nature, caused by unknown conditions, a given group of rounds fired on a target might contain both species. With markedly different drag characteristics, the two groups will gradually separate, principally in a vertical plane, by as much as three mils at 2000 yards. The vertical target will then contain both high and low rounds thus jeopardizing what otherwise might be a good dispersion pattern. Clearly, it is desirable to fix the flow over the spike in such a way that only one type of flow occurred and preferably of a lower drag type.*"

The lack of a ring similar to the type present on Western spike noses might be because a truncated cone nose already had acceptably low drag, as suggested in the BRL paper. The paper showed that a truncated cone spike nose could reliably achieve stable low drag flow with almost as low of a drag coefficient as that achieved by a ringed spike, with no dual flow. See the table graph below:



The research conducted by the BRL resulted in engineers settling on the now common Western-style spike, with a square spike nose and a small ring. The 90mm M431, for example, perfectly matches this description, having a squared-headed fuse and a small protruding ring around the spike. We can infer that truncated nose cones were perhaps not quite as effective, but then why did Soviet HEAT shells have pronounced conical noses?

A plausible reason could be because the Soviet conical fuse had other, perhaps more important advantages. Yugoslavian testing found that the 100mm BK-5M HEAT shell (with the GPV-2 PIBD fuse, pictured below) worked at slope angles of 65 to 70 degrees, whereas the square-headed (M509A1) fuse on the 90mm M431 HEAT only worked up to 60 degrees.

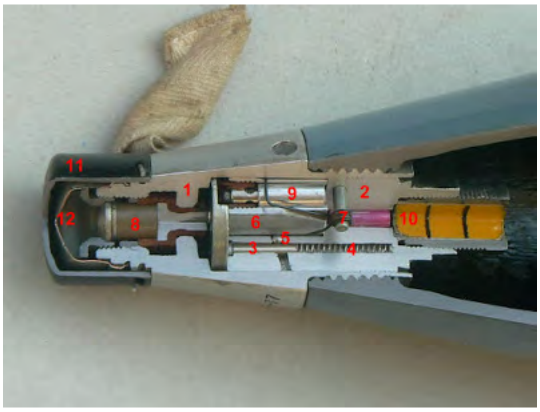


Photo credit to PzGr40 of the wk2ammo site

Therefore, the decision to not use a square-headed fuse might have been a deliberate compromise to trade ballistic performance for more reliable fuzing on very steeply sloped armour plate. Indeed, during the famous Yugo tests, the 90mm M431 had high probability of failing to detonate when it struck the upper glacis of the target (a T-54A tank) when the tank was angled 20 degrees sideways. It would not have been acceptable for a Soviet HEAT shell to exhibit similar limitations, as the upper glacis of an M60A1 tank was already more sloped than 60 degrees (it was sloped at 65 degrees) and the upper glacis of the Chieftain was even more sloped (72 degrees). This might explain why Soviet HEAT shells remained with conical noses despite the USSR obtaining some quantities of captured Western HEAT rounds over the course of the Cold War.

The spike nose of 3BK-15 had a length of 1.4 calibers and a maximum diameter of 0.38 calibers. The warhead also implemented some new old technologies to improve jet formation characteristics, including the use of a slightly tapered cylindrical wave shaper to optimize the propagation directions of the blast waves from the explosive charge. 3BK-15 also has a more precisely drawn shaped charge liner cone and uses compressed explosives to increase the density of the explosive filling.

The use of more energetic 12/7 stick powder boosted the muzzle velocity of 3BK-15 to 1,060 m/s, or Mach 3.11. However, this was only to offset the higher drag of the projectile compared to the conventional BK-4 projectile.

3BK-15 (3BK-15M)

Mass of Complete Round: 26.3 kg
Total Projectile Mass: 12.2 kg

Muzzle Velocity: 1,060 m/s

Penetration: (Unknown, estimated)
460mm at 0° (520mm)
230mm at 60° (260mm)

For some reason, the tracer was not placed at the base of the shell assembly. Instead, it is embedded into the wall of the warhead at the very front. It is possible that this was intended to take advantage of the modest spin rate of the projectile to generate a more distinct tracer signature, which could potentially help the gunner and commander track the fall of the shot more easily in poor weather conditions.

SECONDARY WEAPON

The original T-62 model was armed with the SGMT machine gun chambered for the 7.62x54mmR cartridge as the coaxial machine gun. It had a cyclic rate of fire of 600 rounds per minute. The machine gun is fed from a 250-round box, of which ten more are stowed inside the tank for a total capacity of 2,750 rounds of ammunition. The SGMT can be fired from the trigger button on the gunner's handgrips, the trigger button on the manual elevation handwheel, or with the manual trigger on the back of the machine gun receiver during an emergency situation such as the total loss of electrical power in the tank. The spent casings and emptied links are collected in a metal bin to the left of the machine gun. Light ball rounds and armour-piercing incendiary (AP-I) rounds are linked with armour-piercing incendiary tracer (API-T) rounds in a 4:1 ratio. Both the API and API-T are used for fire correction. Both have an incendiary charge in the tip of their bullet that generate a bright flash on impact and the tracer on the API-T bullet will obviously trace the trajectory of the rounds fired downrange.

Beginning in August 1964, the SGMT was replaced by the new PKT machine gun. The two machine guns were practically indistinguishable in terms of ballistic performance, although it is worth noting that the PKT fires faster at a cyclic rate of 800 rounds per minute. The primary impetus for the change was not to have a better machine gun, but to standardize the PK general purpose machine gun in the Soviet Army.

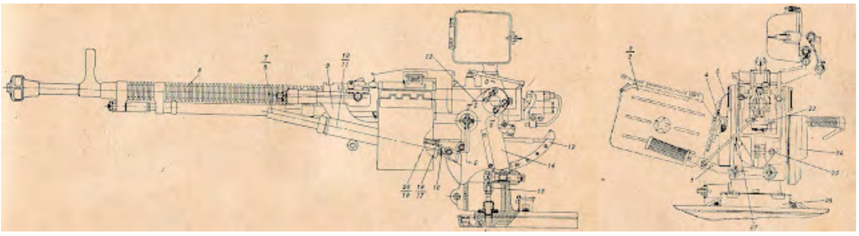
The PKT machine gun is fed from proprietary 250-round boxes of which ten more are stowed, exactly as with the SGMT. Because both machine guns use the same ammunition and have similar barrel lengths and rifling twists, the ballistic trajectory of the shots fired are essentially identical, so there was no need to modify the sights to accommodate the new machine gun. The nominal maximum effective range of both machine guns is around 1,500 m, while the effective range against a running target is reportedly around 650 m.

ANTI-AIRCRAFT MACHINE GUN

The new requirement for an anti-aircraft machine gun meant that the loader was given his own cupola with a race ring and a mount to place the DShKM machine gun. The DShKM was a robust 12.7mm machine gun with a rate of fire of around 600 rounds per minute, but it is unclear why it was retained for the T-62 when the NSV had recently entered service and was replacing the DShKM in all other applications.

The design of the anti-aircraft machine gun mount is distinct from the typical pintle-mount types found on the T-54, T-10 and other armoured combat vehicles. On the T-62, the machine gun is mounted on a cradle that is fixed to the cupola in azimuth, so aiming the machine gun in azimuth is done by turning the entire cupola rather than traversing the machine gun itself by a pair of spade grips. The operator does this by holding on to the fixed handle on the left side of the machine gun cradle and simply turning the cupola with his bodily strength. The DShKM is on a cantilever mount, so the cupola will tend to be slightly front-heavy unless the machine gun is elevated even though the loader's hatch acts as a counterweight when it is opened. The imbalance of the cupola can be a problem if the tank is on a steep incline or a steep side slope, but it is not a major issue. The equilibrium of the DShKM itself is maintained by a pair of equilibrator springs installed underneath the machine gun receiver. These springs ensure that the machine gun can be aimed with a uniform effort throughout its entire range of elevation angles.

Elevation is accomplished by turning a hand wheel which acts on a toothed arc. The elevation hand wheel has a brake lever that releases a simple brake mechanism when grasped, allowing the machine gun operator to aim the gun freely. When firing at a fixed target, the operator can release his grip to activate the brake. This fixes the machine gun rigidly in place, making it more accurate when firing long bursts.

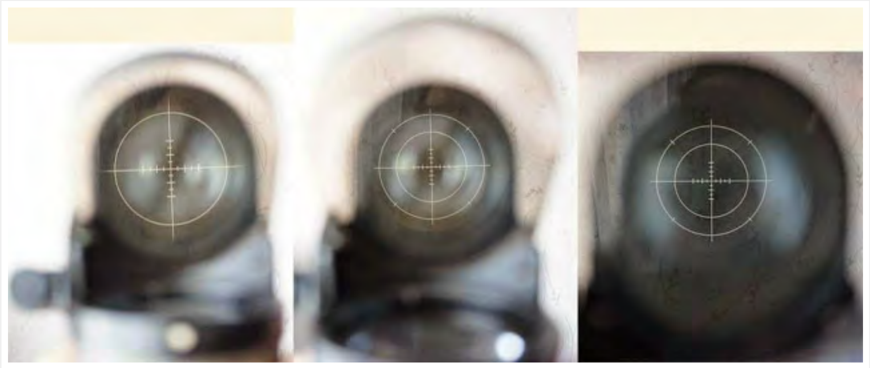


The machine gun cradle allows the gun to be depressed by -5 degrees and elevated by +85 degrees with ease, but there are two caveats: the "Luna" infrared spotlight installed above the coaxial machine gun port is tall enough to obstruct the machine gun from depressing to its full extent when it is aimed directly forward, and the commander's OU-3 spotlight does the same. This minor design flaw is not an issue when firing at aircraft or when firing at ground targets at long range (since superelevation has to be applied anyway), but it can be a nuisance when aiming the machine gun at low-profile targets at short range. The spotlight is positioned in such a way that the muzzle of the DShKM will be blocked when it is depressed instead of allowing it to get behind the spotlight, so there is no chance of the loader accidentally shooting off the spotlight.

The firing mechanism is actuated by a trigger lever on the fixed left handle on the gun cradle. The lever is connected to the trigger of the machine gun via a pull cable.

The DShKM is fed with standard 50-round boxes. Two boxes are stowed inside the tank and another two boxesare stowed to the side of the turret next to the loader's cupola for easy access. The loader only needs only to bend down to reach these boxes, but since the machine gun is fed from the left, it is easiest to reload it by swinging the cupola to the rear. The two boxes were not simply placed on the outside of the turret for the sake of convenience when reloading, but also to save space inside the tank and because it would have been difficult for the loader to extract an ammunition box from inside the tank and exit through his hatch with the large box in his hands. The disadvantage is that the externally stowed ammunition can be easily damaged by bullets, artillery shell splinters, and high explosive autocannon rounds.

Aiming at targets can be done with either the K-10T anti-aircraft collimator sight kept in the raised box mounted to the gun cradle or the classic leaf-type iron sights on the machine gun. The K-10T facilitates accurate aiming at both ground level and high altitude targets, although the leaf sights on the DShKM would be more appropriate for aiming at ground targets. The K-10T sight has a tinted screen in front of the collimator screen to reduce glare when aiming in the direction of the sun.



When not in use, the protective cover is closed over the K-10T, mainly to shelter it from the weather.

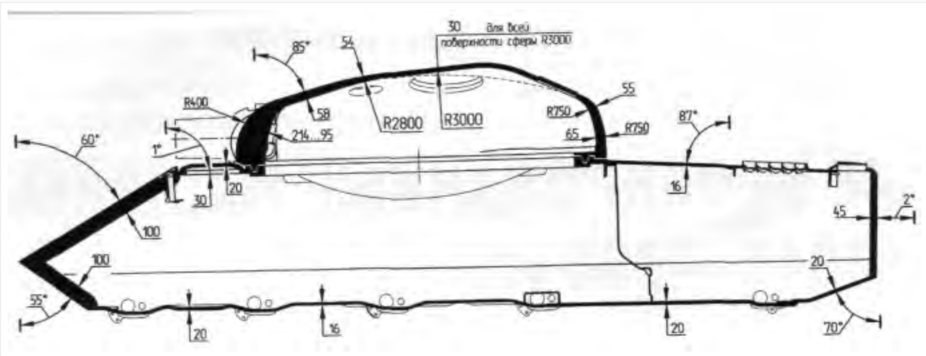
The DShKM was technically sufficient against helicopters and other low-flying aircraft given that common types like the AH-1 Cobra did not have enough cockpit armour to protect the pilot from 12.7mm shots, and the windscreen was only a thin polycarbonate sheet that did not even offer any protection from rifle rounds at hundreds of meters. The rest of the fuselage lacked any meaningful armour protection. The main challenge would be reliably scoring hits on the helicopter. This task becomes even more of an issue if the tank is coming under fire, so the machine gun would probably be more useful as a deterrent against enemy aircraft. Historically, the anti-aircraft machine guns on T-54 and T-62 tanks were hardly ever used against aircraft at all. If used, they were most often aimed at ground targets, and only when the operator had some assurance of safety from enemy snipers.

PROTECTION

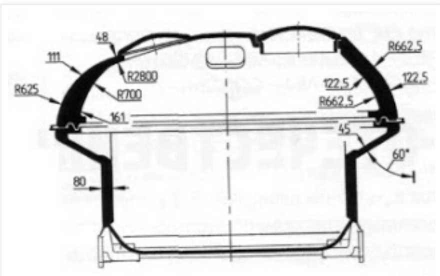
The T-62's hull retains the same general layout as the T-54 but differs in dimensions. The armour thickness remained largely unchanged from its predecessor which could be considered a perpetual liability for the T-62 since the beginning of its service life in contrast to the T-54 which enjoyed a high level of immunity from contemporary anti-tank guns when it achieved initial operating capability (IOC) in the early 1950's. Even so, the design of the T-62 allocates a large proportion of its mass to armour - almost 50%. For a tank weighing only 37 tons, 18.3 tons is from armour alone.

Like the T-55 before it, the upper glacis armour of the T-62 was essentially immune to American 90mm armour-piercing rounds (excluding HEAT to some extent) and somewhat resistant to 20 pdr. APDS (at ranges of 1 km or more). This was due to the original requirement of the T-54 for protection from the Pzgr. 39 round fired from the 8.8cm Pak 43 or KwK 43 at a muzzle velocity of 1,000 m/s. This requirement was created because it was expected that the Pak 43 and KwK 43 or an equivalent cannon would become the standard cannon for future German medium tanks while the existing Tiger II heavy tank would eventually be replaced with a new design equipped with a 10.5cm or 12.8cm cannon. Even though the war ended before this became a reality, the requirement was not reduced to the benefit of the future of Soviet medium tanks as a class.

A German source indicates that the hull of the T-62 can be defeated by 105mm APDS from a distance of 1,800 meters. The front hull armour is composed of an upper and a lower glacis plate. The upper glacis has a thickness of 100mm at a 60° slope for a line-of-sight (LOS) thickness of 200mm, and the lower glacis is the same thickness but with a 55° for a LOS thickness of 178mm. From a head-on attack, the upper glacis is immune to 100mm blunt-nosed armour piercing rounds (BR-412B) from point blank range but the lower glacis can be defeated by BR-412B from a distance of 900 meters. The lower glacis can be considered a weak point, although it is largely inconsequential since the lower glacis is only a third of the height of the upper glacis.



It must be noted that the glacis armour is stronger than the LOS thickness may suggest when attacked with AP and APDS rounds due to the slope of the armour as these two ammunition types have degraded penetration on sloped plate. Overall, the steel used in the T-62 was of a higher quality and of a higher hardness than the steel used in the American Patton series of tanks, though that would not mean much if the difference in thickness is big enough. Still, the glacis should have some chances of resisting M392 at distances of 1.5 km and more, keeping in mind that M392 can penetrate 117mm at 60 degrees at 1 km.



The hull side is 80mm thick. The rounded collars for mounting the turret are cast steel with a thickness of 45mm, angled at 60°. The side armour of the hull is immune to 100mm blunt-tipped armour piercing rounds (BR-412B) at point blank range from a side angle of 22 degrees. The belly of the tank is a pressed 20mm steel plate that was bent up at the edges to join with the side and rear hull plates. The slope of the edges of the hull belly plate is only 33 degrees, creating a minor weakened zone at the bottom part of the side of the hull. From a profile view of the tank, this weakened zone is rather narrow as it is only around 230mm tall and it is additionally protected by the large roadwheels of the tank across most of its length.

Being only 45mm thick, the rear of the hull is weak but well within the normal range. This thickness of armour is enough to provide complete protection from 14.5mm armour-piercing bullets, 20mm AP rounds and 23mm AP rounds at point-blank range.

According to the "A-10 Pilot's Colouring Book", the lower side hull armour of the T-62 can be pierced by the A-10's GAU-8/A 30mm gattling gun at a distance of 2,133 meters, but if the roadwheels are factored in, the maximum range where the armour can be perforated is only 790 meters. Furthermore, the upper side hull armour can only be pierced from a range of 1,500 feet (460 meters) from a normal angle and attack and air speed. If the hull is not perfectly perpendicular to the approach angle of the plane, the chances of piercing the side hull armour drop even further due to the low performance of PGU-14/B AP-I rounds on sloped armour plate. Furthermore, attacking under such conditions forces an A-10 pilot to target individual tanks which greatly increases the number of strafing runs required to disable any given tank unit and vastly increases the chances of the A-10 being shot down itself. The only way to reliably knock out a T-62 with the GAU-8/A of the A-10 would be to approach from behind, but this places the plane in great danger of being shot down almost immediately by anti-aircraft weapon systems marching behind the tank unit.

Overall, the T-62 can be considered quite well protected from air attack from the side, especially compared to a tank like the M47 even though the M47 was considered to be close to the T-54 and T-62 in armour protection in the study "A-10/GAU-8 Low Angle Firings Versus Simulated Soviet Tank Company". Evidently, this is not true and M47 targets were only used for expediency, as the M47 targets were observed to have been pierced from the side through the turret and hull from distances as far as 3,528 feet (1,075 meters) whereas the side of the T-62 turret is fully immune to 30mm PGU-14/B AP-I rounds from any distance and the hull side armour is only vulnerable from 460 meters.

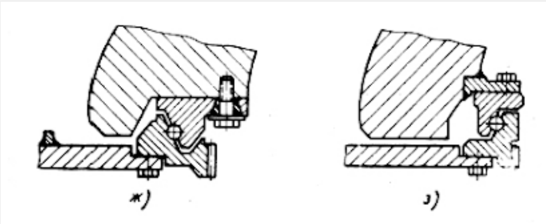
The steel used for the all-welded RHA hull is 42SM armour steel which has a hardness of 280 to 340 BHN - harder for the thinner plates (i.e side hull) and softer for thicker plates (glacis). The difference in hardness is partly due to the difficulty in applying heat treatment to thick steel plates, but this is not the primary reason; there are optimal hardness levels for plates depending on their thickness, slope and the expected type of anti-tank threat. Against AP and APC rounds, the hardness of the 100mm RHA plate grants the optimal level of protection. However, as the type of threat evolved throughout the course of the Cold War, an increase in the hardness of armour of all thicknesses became more desirable. A higher hardness results in increased penetration resistance from all APDS rounds - particularly early generation designs with less developed armour piercing caps - and from APFSDS rounds.

Although the upper glacis armour of the T-62 is nominally thinner than that of an M48 (110mm at 60 degrees) or an M60 (93.2mm at 65 degrees) or an M60A1 (109mm at 65 degrees), the T-62 uses RHA steel instead of cast steel, and not only that, the hardness of its RHA steel was significantly harder than that of American cast steel at the time. The M60's cast glacis armour, for example, was quite soft at only 220 BHN, and because of the lower strength and toughness of cast steel, it was not as effective as the rolled steel on the T-62. One very excellent demonstration of this difference can be found in Yugoslavian testing of T-54A tanks and their own M47s. Both tanks had 100mm of steel glacis armour sloped at 60 degrees, the only difference being that the M47 had a cast hull whereas the T-54 had a rolled and welded hull. It was found that BR-412B blunt-tipped APBC rounds fired from a D-10TG could defeat the upper glacis of an M47 at 750 m, whereas the T-54A was fully immune from any distance down to point blank range.

With those results in mind, the thicker armour of the M60A1 cannot be said to have granted a noticeable advantage over the T-62, especially when considering the context of the period. The 100mm gun of the T-54 and T-55 was still effective against an M48 Patton whereas the reverse was not true. The status quo was therefore in favour of the Soviet medium tank. Ten years after the introduction of the M48, the implementation of the 105mm M68 and APDS rounds on the M60A1 allowed it to defeat the upper glacis armour of the T-62 from a distance of 1,800 meters, but the turret of the T-62 could only be defeated from 400 meters, and in turn, the 115mm gun of the T-62 largely invalidated the armour of the M60A1. The U.S Army rated the probability of kill for a T-62 using 105mm APDS at 54%, but rated the probability of kill for an M60A1 using 115mm APFSDS at 71%. As such, the thinner armour of the T-62 offered a borderline adequate level of protection against the less potent ammunition of the M60A1 whereas the thicker armour of the M60A1 offered insufficient protection against more powerful ammunition of the T-62.

TURRET

The T-62 uses MBL-1 armour grade cast steel for the turret, which has a hardness of 270 to 29BHN. New casting techniques were used in the manufacture of the monolithic turret, granting increased resilience from all angles of attack. Of particular interest is the fact that the T-62 turret is a one-piece casting unlike the T-54 turret which had a separate roof. The use of a one-piece casting allegedly increased the structural rigidity of the turret and improved the resistance of the roof to direct hits. Unlike the turrets of the M47, M60A1 and Leopard 1 - to name just a few - the T-62 turret is an entirely convex shape, i.e it lacks shot traps where an impacting shell may ricochet down into the turret ring or into the hull roof. However, the turret ring of the T-62 turret is somewhat more vulnerable than the turret ring of the T-54 turret due to the change in the location of the ball bearing race ring which reduced the thickness of steel protecting the race ring. This is shown in the drawings below. The drawing on the left shows the layout for the T-62 and the drawing on the right shows the layout for the T-54.



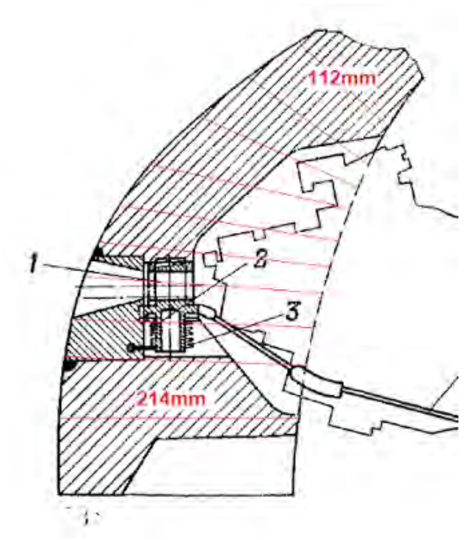
By shifting the race ring forward, the stress on the ball bearings was reduced and the overhang of the turret armour over the turret ring was reduced at the expense of an increased probability of jamming from direct hits. The merits of various turret ring protection methods are examined in the study "*Некоторые Вопросы Проектирования Защиты Стыка Корпуса И Башни*" by O.I Alekseev et al. It was noted that turret ring designs that required a cutout in the lower part of the turret like the T-54 and T-62 turrets was a liability. Conversely, the solution implemented in the M48 Patton, M60 and M103 where the turret ring was installed in a raised flange cast together with the hull was also assessed to be non-ideal solution as it still fails to prevent the turret from being jammed by a hit to the joint between the turret and the hull. The low thickness of the flange also results in a low level of armour protection. The best solution was found on the IS-3, T-10, Chieftain, Leopard 1 and M46 Patton. These tanks had the ball bearing race ring recessed below the hull roof, and in the case of the T-10, M46 and Chieftain, the gap between the turret and the hull roof was covered by raised parts of the hull.

The turret ring of the T-62 is additionally protected by an armoured collar that prevents bullets from slipping into the gap between the turret and the hull roof. The collar is clearly visible in the closeup photo below (credit to Carl Dennis).

Furthermore, the top edge of the upper glacis plate extends slightly above the hull roof to form a lip, as shown in the two photos below. This fulfills the same function as the turret ring collar.

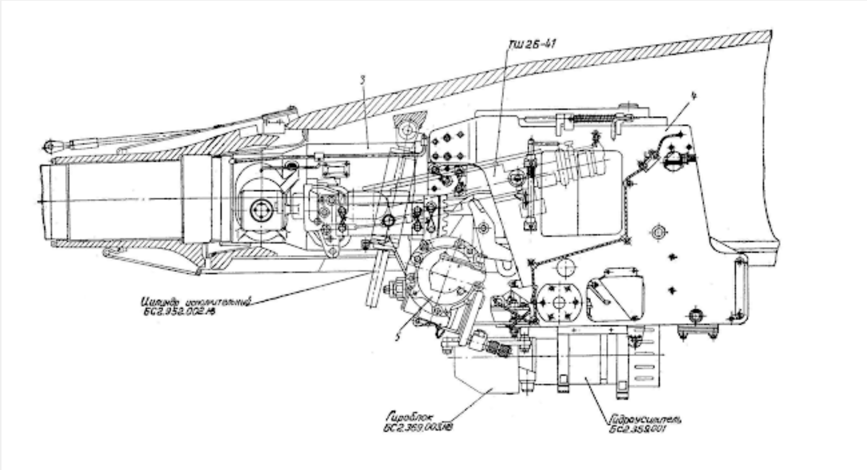
In terms of technical sophistication, the turret ring layout of the T-62 is superior to the M60A1 but inferior to the Leopard 1 and greatly inferior to the Chieftain.

The original production turret had an effective thickness of 214mm throughout the front facing, but only the base of the turret near the turret ring had a physical thickness of 214mm. The rest of the front turret wall thinned down to as little as 95mm as the front turret transitioned into the roof, but the effective thickness of 214mm was maintained due to the use of vertical sloping. 1972 saw the appearance of the up-armoured T-62 obr. 1972 with a new 242mm cast turret. Again, only the base area of the turret has this thickness. A close look at the shape of the front turret wall is available from the T-62 technical manual, on page 560. The reduced thickness of the turret at the lower edge for the turret ring ball bearing race ring is also apparent in the drawing.



In this drawing, the top part of the front turret is as thin as 112mm, but the much higher slope at this part increases the effective thickness to somewhere approaching 200mm, although this estimate is bound to have a large margin of error due to the inherent inaccuracy of photo scaling techniques. Furthermore, the discrepancy in effective thickness compared to the physical thickness at the base of the turret is compensated by the lower effectiveness of APDS ammunition on sloped plate, so it would be favourable to fire at the thicker but less sloped base of the turret. Different ammunition will have different behaviour at certain slopes, so the effective thickness of the sloped portions of the front turret differs from one instance to the next. Using basic trigonometry, the slope of the turret where it is 112mm thick appears to be 33 degrees. If a particular shell is able to penetrate around 115mm at 30 degrees obliquity, then it should be able to defeat that particular part of the turret.

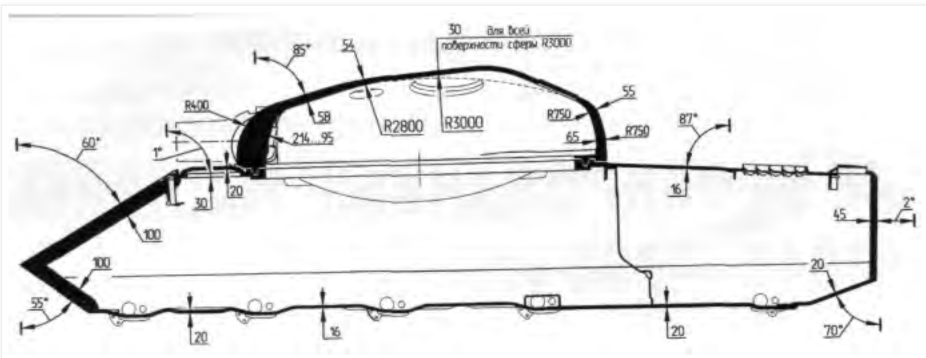
The sloped roof above front turret face is quite resilient despite the much lower thickness, chiefly thanks to the steep angling of the roof. The area of the roof above the cannon a maximum thickness of 58mm sloped at an angle of 80° at the edge of the roof, thinning down very slightly to 54mm at the same angle as it goes further towards the back, and then transitions to 30mm sloped at 83° over the middle and rear portions of the turret roof.



Beginning from the zone just next to the mantlet, the front turret wall gently thins down until it reaches the side of the turret at the commander's cupola, where it is only 122.5mm thick. The left edge of the photo below shows part of the right side of the turret of an early model T-62 (without a loader's cupola). The side of the turret is generally proofed against autocannon fire from short ranges which is normal for a medium tank and very reasonable for a tank weighing 37 tons. For comparison, the side of the Leopard 1 turret was vulnerable to 20x139mm DM43 APCR rounds from a distance of 300-500 meters. This level of protection was only matched by the Leopard 1 when a heavier welded turret was introduced on the Leopard 1A3 and when appliqué spaced armour screens were retrofitted.

From the area around the commander's cupola, the thickness of the armour sharply declines to only around 65mm at the lower half of the rear of the turret, and only about 55mm at the upper half where it just begins to form the roof, below the ejection port and ventilator housing. In West Germany, a number of tests were conducted on a captured T-62 in 1974 to determine its level of protection from a variety of weapons, including small caliber and medium caliber automatic cannons. Among these tests were live fire tests with 20x139mm DM43 APCR rounds with a tungsten carbide core. The base of the rear of the turret (underneath the cartridge casing ejection port) was shot six times. Shots 1 and 2 failed to perforate the armour, shot 3 perforated the armour, and shots 4, 5 and 6 were at the velocity limit. All shots were fired from a distance of 100 meters. According to the analytical breakdown of each shot, the armour thickness at the sectors where shots 4, 5 and 6 landed ranged from 58mm at 17 degrees to 68mm at 15 degrees. The sole case of armour perforation by shot 2 was recorded at a sector where the armour was 72mm thick but sloped at only 7 degrees.

30mm APCR rounds - or HVAP as they are known in the U.S - fired from the GAU-8/A of an A-10 ground attack jet can perforate the rear of the turret from as far as 1.3 kilometers. As mentioned earlier in the article, the turret hatches themselves are respectably thick, with the commander's hatch being 30mm thick and the loader's hatch being 25mm thick. The roof armour is 30mm thick. This is better illustrated by the diagram below.

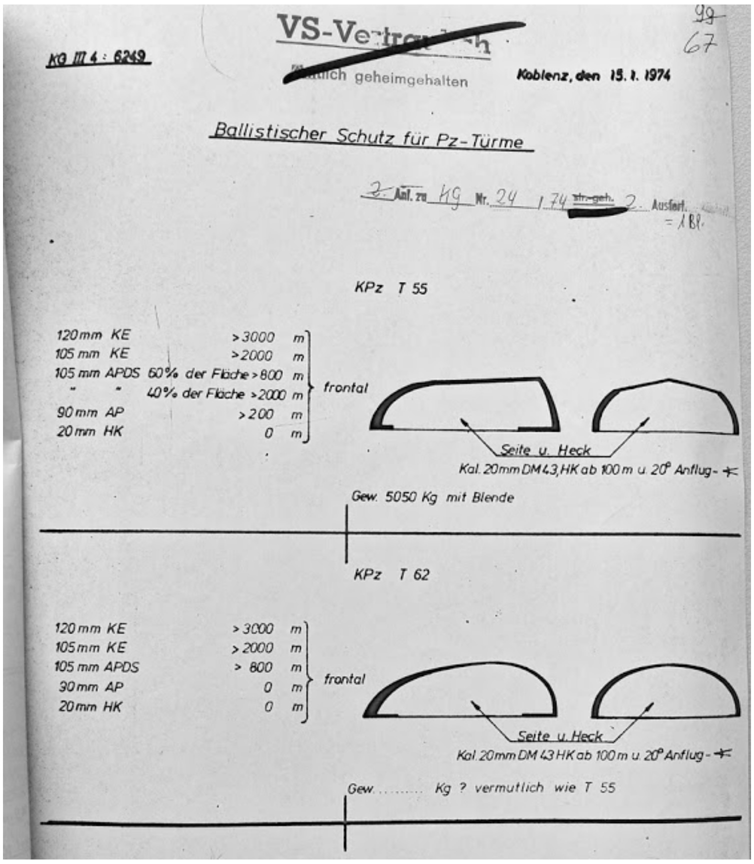


From the 17th of February to the 10th of March 1978, test firings of the GAU-8/A on an A-10 were carried out on two captured T-62 tanks. The report "Combat Damage Assessment Team A-10/GAU-8 Low Angle Firings versus Individual Soviet Tanks" contains most of the important details from this test. Five missions were flown with a total of seven passes at individual tanks. Mission 1 and the first pass of Mission 2 were directed at the rear of a T-62, and in both cases, the rear of the turret was perforated once behind the commander's station, both impacts being very close to each other. It is rather strange, however, that it was reported that ammunition was set off in both cases despite the fact that no ammunition was stowed behind the commander's station in the description of the simulated combat configuration of the target T-62 tank. This seems to indicate that the testers placed additional ammunition where the amplidyne amplifier would be located in a real T-62 as shown in the photo below, and not only that, they placed additional ammunition in the tank without documenting it in the report.

On the second pass of Mission 4, the tank was attacked from the rear offset clockwise by 25 degrees (or 155 degrees from the front), and the rear of the turret again proved vulnerable, with four perforations recorded at the base of the turret directly behind the loader's cupola. This is where two rounds of ready ammunition is stowed and may have caused an ammunition explosion.

Overall, the frontal turret armour appears to be completely insufficient against M392 and L28A1 105mm APDS at even at distances exceeding 2 km. These APDS rounds were introduced at the turn of the decade to complement the upgunned Centurion and the new M60. Later, the Leopard 1 was also armed with an L7 cannon firing the DM13 APDS round, a licence-produced clone of the L28A1. These APDS rounds would have sufficient penetration power to defeat the T-62 turret at the zones on either side of its gun mantlet, only failing at the edges of the turret cheeks and the turret roof which is too steeply sloped for APDS rounds. Considering that the T-62's turret was made of cast steel, the situation was not bright indeed. For all intents and purposes, the T-62 was no better armoured than the T-54, and would have to rely on getting the first shot off to ensure its own survival.

However, a West German evaluation of the T-62 turret detailed in a January 15, 1974 report indicates a significantly higher level of armour protection at its front. While the T-55 turret was rated as being vulnerable to 105mm APDS at 40% of its frontal projection from over 2,000 meters away and 60% of its frontal projection was vulnerable only from over 800 meters. The T-62 turret was only vulnerable to 105mm APDS from over 800 meters over its entire frontal projection. It was also completely immune to 90mm AP rounds which the T-55 turret was not, although the T-55 turret was still tough enough that any enemy 90mm gun would have to be at a suicidal distance in order to defeat its armour. 105mm APFSDS was effective against the T-62 turret from over 2,000 meters.



KG III 4 : 6249

VS-Ve[redacted]h

[redacted]ich geheimgehalten

Koblenz, den 15. 1. 1974

99
67

Ballistischer Schutz für Pz-Türme

2. Anl. zu KG Nr. 24 1.74 str. geh. 2. Ausfert. = 1 Bl.

KPz T 55

120 mm KE	> 3000	m
105 mm KE	> 2000	m
105 mm APDS 60% der Fläche	> 800	m
" " 40% der Fläche	> 2000	m
90 mm AP	> 200	m
20 mm HK	0	m

frontal

Seite u. Heck
Kal. 20mm DM 43, HK ab 100 m u. 20° Anflug

Gew. 5050 Kg mit Blende

KPz T 62

120 mm KE	> 3000	m
105 mm KE	> 2000	m
105 mm APDS	> 800	m
90 mm AP	0	m
20 mm HK	0	m

frontal

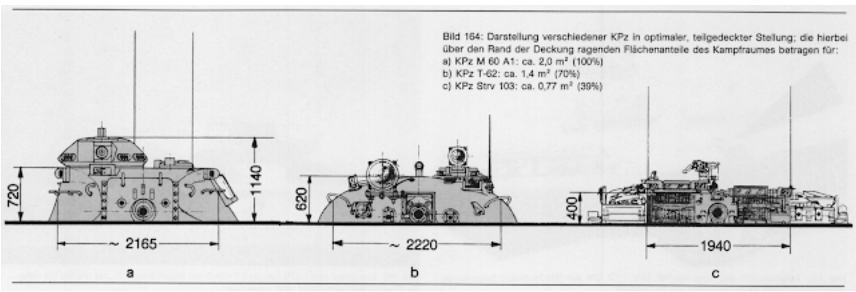
Seite u. Heck
Kal. 20mm DM 43 HK ab 100 m u. 20° Anflug

Gew. .... Kg ? vermutlich wie T 55

These German figures for the T-62 indicate that it is a T-62 obr. 1972 turret with increased armour. The original T-62 turret had the same level of protection as the T-55 turret and should be treated as such. It is reasonable to assume that like the T-55 turret, the T-62 turret was vulnerable to 105mm APDS at 40% of its frontal projection from over 2,000 meters away and 60% of its frontal projection was vulnerable only from over 800 meters.

The turret of the T-62 had a height of just 810mm, equal to the T-54 turret. For comparison, the Centurion Mk.10 turret had a height of 956mm, the Chieftain turret had a height of 975mm, the M60A1 turret had a height of 970mm. The difference is not as large as one might have expected from the difference in the total heights, but this is because the height of the commander's cupola is being ignored. With its cupola included, the total height of the T-62 turret is only 914mm, whereas the total heights of the Centurion Mk.10, Chieftain and M60A1 turrets are 1,295mm, 1,237mm and 1,375mm respectively. The advantage of the T-62 turret in terms of silhouette size is further enhanced by its dome shape, as opposed to the flat roofs of the Centurion, M60A1, Leopard 1 and Chieftain turrets. As such, the perceived height may be smaller than what the actual maximum height implies.

In the event that the T-62 is in a hull-down position behind a hill, berm or in a prepared trench, the primary consideration is the hull-down silhouette of the turrets, and again, the T-62 turret design shows an advantage. This difference is illustrated in the drawing below, taken from "*Kampfpanzer: Die Entwicklungen der Nachkriegszeit*" by Rolf Hilmes



The exposed surface area of the inhabited zone of the M60A1 turret amounts to 2.0 square meters whereas the surface area of the inhabited zone of the T-62 turret is only 1.4 square meters. In other words, the silhouette of the T-62 turret is 30% smaller. Needless to say, one of the factors behind this advantage is the extremely large and conspicuous commander's cupola on the M60A1 turret. The extremely low silhouette of the T-62 turret gives it an edge over the M60A1 when both tanks are hull-down with only the gun exposed over the crest of the hill. Of course, both tanks are soundly beaten by the Strv 103 in this respect, but only in this respect. When the hull sponsons of the Strv 103 are taken into account, the actual exposed surface area of the tank is 1.44 sq.m which is actually larger than the T-62 turret. Damage inflicted to the components housed in the hull sponsons of the Strv 103 can lead to a mobility kill whereas a hit to the edges of the T-62 turret are very unlikely to pierce the armour due to the immense slope and high relative armour thickness.

The difference in the silhouette sizes of the T-62 and its NATO counterparts extends beyond the turret and includes the entire tank.

Although the T-62 was only negligibly narrower and shorter compared to its NATO counterparts, it was significantly shorter at just 2.40 meters tall, which is 0.50 m shorter than the Chieftain, 0.80 m shorter than the M60A1 pictured above, and even slightly shorter compared to the French AMX-30 and German Leopard 1, both of which were designed with more focus on a reduced silhouette size. This is an extremely important aspect to the survivability of the T-62. Getting hit and shrugging it off is one thing, but the ability to avoid getting hit is crucial, so in this sense, the T-62 is arguably on par with NATO tanks in the defensive role while having a distinct, if small advantage in the offensive one chiefly due to its relatively small size.

The advent of mass produced thermal imaging equipment practical for combat use in tanks, the advantage of size as a concealment factor became largely immaterial, and new technologies such as superior sabot designs, highly precise stabilizers and ballistic computer made hitting even small targets a trivial task. However, those innovations only came in the early 80's: years after the T-62 arrived. For its time, the armour protection of the T-62 simply cannot be considered poor, and this can be credited to the sensible requirements that were originally drawn up for the T-54 years before the T-62 itself was even conceived.

SIDE SKIRTS

The T-62 was not originally equipped with side skirts, but many T-62 tanks were retrofitted with steel-reinforced plastic ones (interwoven textile skirt) similar to that of the T-72 beginning in the early 1980's as part of the T-62M modernization programme.

The main function of the side skirts was to reduce the amount of dust kicked up by the tank while travelling, which was highly undesirable because the dust clouds could give away the tank's position, not to mention blinding the vehicles following it if the tank was travelling in a convoy. Of course, the side skirts acted as spaced armour for the hull, but the use of thin skirting in this role is often counterproductive due to the peculiarities of shaped charges. The thickness of the skirts is 10mm and the stiffness is sufficient to ensure that an RPG grenade fuze activates reliably, but not thick enough or strong enough to be of much use against kinetic energy penetrators. The skirts were mounted 610mm away from the hull.

YOM KIPPUR EXPERIENCES

The T-62 had quite a hard time in the 1973 Arab-Israeli war, known to the Syrians and Egyptians as the Ramadan war and to the West as the Yom Kippur war. Hundreds were knocked out in combat, mostly by Israeli Magach (M60A1) and Sh'ot (Centurions) tanks. However, I contend that the T-62 cannot be blamed for its poor showing. One of the more famous tank-on-tank engagements involving the T-62 was the the Battle of The Chinese Farm in October 17.

See this excerpt from Zaloga's "T-62 Main Battle Tank 1965–2005":

"*Egyptian tank column was spotted in advance by the Israelis, and elements of the 217th Armored Brigade were assigned to lay an ambush. The 25th Armored Brigade advanced northward with the Great Bitter Lake on their Western flank.*

Centurion Sh'ot tanks suddenly emerged over the sand dunes of their Eastern flank, initiating a violent engagement around 1445 hours. The Egyptian tank battalions were caught by surprise due to a lack of flank security and began taking heavy losses. The Egyptian column was hemmed in by a large Israeli minefield that had been laid in 1970 during the "War of Attrition". Although the T-62 companies tried to rally and attack the advancing Israeli wave, they were unprepared for the ferocity of the attack and the brigade was decimated.

In his account of the battle, Lieutenant-General Saad el Shazly later wrote: "When our tanks rolled north into the killing ground, they were attacked from three sides and trapped against the lake on the fourth. Our crews fought desperately against the odds. But when night came there were only a few survivors to pull back to the Third Army bridgehead. It was an utter waste."

About 50 to 60 T-62 tanks were destroyed in the attack by the 217th Armored Brigade, and others were lost in the neighboring skirmishes. By day's end, only 10 of 25th Armored Brigade's original 96 T-62 tanks survived; Israeli losses were only four tanks."

An ambush by hidden and hull-down tanks, from three directions! On a column of tanks with no flank protection! Trapped by a minefield! Now, this isn't the whole story. The initial ambush was conducted by Sh'ot tanks, but later on, Magach tanks joined the fight. This is only a short anecdote, and I recommend doing some serious reading of your own. I am confident that you will reach the same conclusions that I have: There was nothing wrong with Arab equipment. They were simply incompetent fighters, and the Israelis were exceedingly competent and well-motivated.

Ilyich's Eyebrows

All T-62Ms were equipped with large composite armour blocks on the front of the hull and on the turret, sometimes referred to as "BDD" armour in the West after it was given this name from the late 1990's and early 2000's. It is more popularly known as "Ilyich's Eyebrows" in reference to Soviet Premier Leonid Ilyich Brezhnev:

Officially, the name of the add-on armour is somewhat more descriptive: "metal-polymer block". The add-on armour covers the hull glacis and the turret cheeks, but did not offer any protection for the lower hull area or the turret roof. It is a form of NERA armour, composed of a laminate of alternating steel plates and a polyurethane filling. First entering inventories in 1980, the add-on armour boosted the protection of the T-62 to the level of the T-64A or T-72 Ural, giving it the ability to resist widespread 105mm APDS and APFSDS ammunition as well immunity from lightweight portable anti-tank rockets like the LAW and RPG-7 families. The metal-polymer block armour was developed during the late 1970's as part of ongoing research into reactive armour with a focus on defeating shaped charge weapons.

Older T-62 models could be outfitted with the new armour in the field as long as rudimentary arc welding equipment was available, and indeed, there are multiple documented cases of older model T-62 tanks in Afghanistan with "Brows".

The "Brow" armour blocks only provided coverage for the turret cheeks, and even then, the edges of the blocks lack the metal-polymer composite armour to make room for the large mounting points. On the right side of the turret, the metal-polymer block covers an arc of just under 50 degrees over the turret cheek, while the remainder is covered by the front steel plate. On the left side, the metal-polymer block covers an arc of just under 46 degrees, and the front steel plate of the armour blocks covers the rest. Overall, the "Brow" armour blocks cover the frontal 140-degree arc of the turret with a large gap at the gun mantlet zone. The diagram below shows the mounting points for the armour kit. Note the large size of the connecting bolt and the rubber bushing underneath the washer at the top of the bolt. These help to ensure that the armour blocks stay on the turret when subjected to tremendous shock.

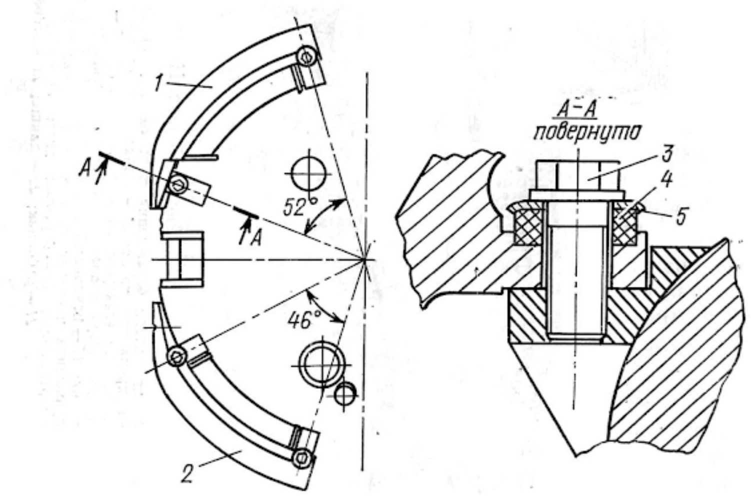


Рис. 4. Установка защиты:
1 — блок защиты правый; 2 — блок защиты левый; 3 — болт; 4 — амортизатор; 5 — шайба

There are two distinct variants of "Brow" armour. One version provides simple spaced steel protection over the machine gun port and the port for the gunner's primary sight, as seen in the photo below. This version appears to be the most common type. Credit for the photo goes to Vitaly Kuzmin.

The second version omits the spaced steel plates and leaves most of the gun mantlet area completely exposed, similar to the "Brow" armour block design for T-55AM and their variants, but this version lacks the distinctive scallop on the left armour block to accommodate the driver's head, so it is clear that it is not simply a transplant from the armour kit for the T-55AM. This version is not rare, but it is not common either.

The metal-polymer armour block on the front of the hull spans the entire upper glacis in height, but leaves two narrow zones on the top edges of the upper glacis uncovered. This is to leave the mine plow mounting points untouched. This is a rather strange design decision, as the metal-polymer armour block is firmly welded to the upper glacis and has no issues bearing heavy loads, as evidenced by the relocation of the towing hooks to the front plate of the armour block. There should be no problems in mounting a mine plow directly on the armour block. Aside from this puzzling feature, the design of the armour is quite rational.

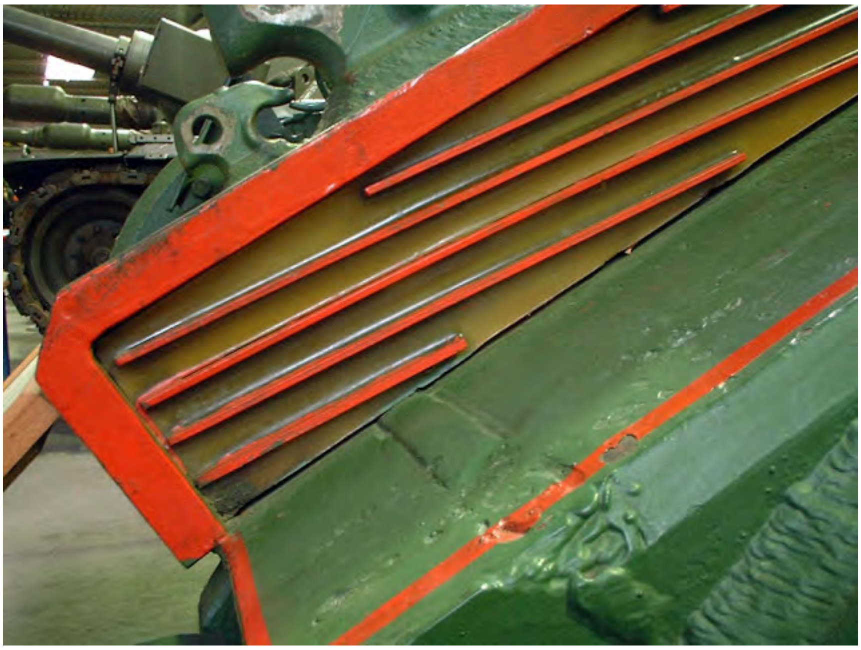
Method Of Operation

The single composite armour block on the upper glacis of the hull is 150mm thick, or 300mm thick when taking the 60° slope of the hull into account. Inside the armor, a pack of thin steel plates is suspended in a plastic filler. Each internal steel plate is just 5mm thick, and the plastic layer fills the gaps in between. The physical thickness of the front plate of the glacis array is 30mm and the LOS thickness is 60mm. The internal steel plates are angled at 65° and the perpendicular spacing between each plate is 30mm. Combined with the 102mm base armour of the upper glacis, the total physical thickness of the upper glacis is 252mm and the LOS thickness is 504mm, of which 264mm is rolled steel. This is close to the 547mm LOS thickness of the T-64A/T-72/T-80 upper glacis armour (of which 267mm is steel), but "Brow" armor is probably more efficient because it uses a newer and more effective composite filler as opposed to a simple glass textolite interlayer.

The turret blocks have a uniform maximum thickness of 296mm across its curved profile, but thickness of the blocks varies considerably in the vertical plane. The composite filler is thinnest near the turret ring and thickest at the top of the armour block, where it measures 210mm in thickness. The turret blocks follow the same layout as the upper glacis block but differs in having a small air gap between the surface of the turret and the metal-polymer block. The front plate is made from cast steel and is divided into top and bottom halves: it is 71mm thick at the top half and 85mm at the bottom half. The top half is angled at 30 degrees and the bottom half is angled at 15 degrees. The metal-polymer block behind the front plate is contained inside a thin steel box with a thickness of around 5mm.

The added thickness compared to the upper glacis plate is probably intended to compensate for the relative weakness of cast steel compared to rolled steel and to compensate for the positive influences of the high slope on the glacis on the breakup of APDS and APFSDS rounds. The internal steel sheets in the turret array are the same thickness as in the upper glacis (5mm) but they are angled horizontally at 50° instead of 65°. However, the direction of the angle is such that a shot fired at the turret from a side angle will meet the internal plates at a greater relative angle. If, for example, a missile was fired at one of the "Brow" blocks on the turret at a side angle of 30°, the internal steel sheets would have a relative angle of 80°. Strangely enough, the internal steel sheets are not angled in the vertical plane even though this would probably have improved the performance of the armour. The layout of both the hull and turret armour modules forces a penetrating projectile to intersect with at least three of the internal steel sheets.

Against shaped charge weapons, "Brow" armour most likely operates on the transfer of kinetic energy from impacting projectiles to the thermoplastic polyurethane (TPU) layer through the propagation of shockwaves from the impact of the attacking penetrator. The TPU itself has some erosive effect against a shaped charge jet, but it should also be violently displaced out of the penetrator's path. However, the function of the thin steel sheets embedded into the TPU layer is not so clear.



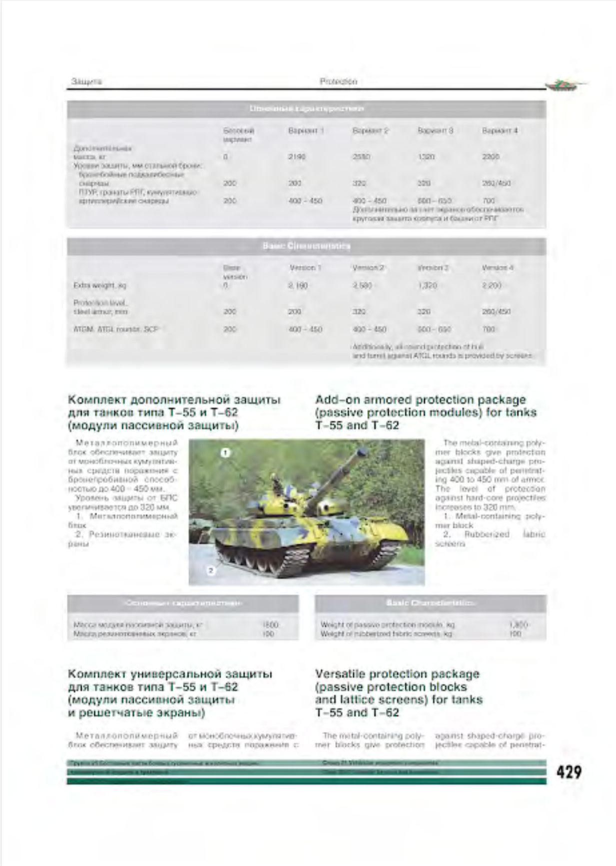
One possible mechanism would involve the reflection of shockwaves from the surface of the thin metal sheets at an oblique angle to the penetrator, thereby pushing a greater mass of TPU into the penetrator. This would be mostly useless against APDS or long rod penetrators, but it should be quite effective against shaped charge jets, as TPU is a low density material suitable as a barrier against shaped charge jets.

The use of a high density front plate paired with a low density filler is principally identical to the original upper glacis armour of the T-64A except that the armour includes internal steel sheets. The high density front plate has the function of not only eroding an attacking shaped charge jet, but also particulating it. A low density filler would perform effectively against a particulated jet, and reducing the density gives better results. For the upper glacis armour of the T-64A, the low density filler is glass textolite, with a density of 1.3 g/cc. TPU has a density of between 1.1 to 1.2 g/cc, making it highly optimal for this application. Coupled with the reflection effect and the additional erosive effect of the steel sheets themselves, the armour kit should be quite effective against shaped charge warheads. However, low density fillers like glass textolite generally do not have much effect against KE penetrators and polyurethane would fare much more poorly than glass textolite due to its worse mechanical properties, so some of the protection from the armour blocks (outside of the thick steel front plate) is very minor or negligible.

Another possibility is that the displacement of the TPU causes the steel sheets to bulge away and downwards laterally against a penetrator. This lateral motion would have the effect of either disturbing the delicate flow of cumulative jets or damaging a kinetic energy penetrator by creating stresses in the body, which are suddenly released, causing the penetrator to fracture. However, the presence of TPU behind each steel sheet would reduce the bulging velocity of the sheets, making them less effective, so the effect of the movement of the plates is probably quite minor compared to its value as a simple spaced barrier. The thickness of the internal sheets (5mm) is very low - less than 0.4 rod diameters of any long rod penetrator ever fielded, so it does not reduce the kinetic energy of a long rod penetrator in any meaningful way on its own unless it works by dynamic movement. Otherwise, the 5mm sheets will be easily perforated and experience plastic failure in the form of petalling and contribute almost nothing to the protection capacity of the armour.

Interestingly enough, one variation of the so-called "Chobham" armour is described as alternating panels made from a plastic plate glued to a steel plate. This type of armour is unequivocally a type of NERA that functions by lateral dynamic plate movement. Unlike the metal-polymer block, however, the "Burlington" armour array uses individual dual-layer panels separated by air gaps instead of steel sheets suspended in a single mass of polymer material. The air gaps behind the panels is likely to enable the steel plates to move backwards ("in pursuit") against a penetrating shaped charge jet, thus disrupting the jet and reducing its effectiveness. The lack of air gaps in the metal-polymer block suggests that this is not the primary operating principle of the armour design, or that it is a less efficient design. Nevertheless, the similarities were not lost on other authors: On page 23 of "*T-62 Main Battle Tank: 1965-2005*", Steven Zaloga notes that the armour is similar to early version of "Chobham" armour. He goes on to state that the armour protection is equivalent to 380mm RHA against KE attack including long rod projectiles and 450mm against shaped charges.

According to the article "*"Ilich's Eyebrows": Soviet BDD Tank Armor and Its Impact on the Battlefield*" by James Warford in the May-June 2002 issue of ARMOR magazine, a marketing pamphlet by NII Stali claims that metal-polymer armour adds the equivalent of 120mm RHA of armour against KE threats and 200-250mm RHA against shaped charges. Depending on how these numbers are interpreted, the approximate level of protection described in both sources is essentially the same. The article appears to be referring to this excerpt from page 429 of a marketing booklet, possibly the very same "*Suggestions on Modernization of MBTs and IFVs*" mentioned by Warford, under Chapter 2 "*Защита*" (*Protection*).



Защита Protection

Основные характеристики	Базовый вариант	Вариант 1	Вариант 2	Вариант 3	Вариант 4
Дополнительная масса, кг	0	2190	2580	1320	2200
Уровни защиты, мм стальной брони:					
Бронебойные подкалиберные снаряды	200	200	320	320	260/450
ПТУР, гранаты РПГ, кумулятивные артиллерийские снаряды	200	400 – 450	400 – 450	500 – 650	700
			Дополнительно за счет экранов обеспечивается круговая защита корпуса и башни от РПГ		

Basic Characteristics	Base version	Version 1	Version 2	Version 3	Version 4
Extra weight, kg	0	2,190	2,580	1,320	2,200
Protection level, steel armor, mm	200	200	320	320	260/450
ATGM, ATGL rounds, SCP	200	400 – 450	400 – 450	500 – 650	700
			Additionally, all-round protection of hull and turret against ATGL rounds is provided by screens		

Комплект дополнительной защиты для танков типа Т–55 и Т–62 (модули пассивной защиты)

Металлополимерный блок обеспечивает защиту от моноблочных кумулятивных средств поражения с бронепробивной способностью до 400 – 450 мм.

Уровень защиты от БПС увеличивается до 320 мм.

1. Металлополимерный блок
2. Резинотканевые экраны

Add–on armored protection package (passive protection modules) for tanks T–55 and T–62

The metal-containing polymer blocks give protection against shaped-charge projectiles capable of penetrating 400 to 450 mm of armor. The level of protection against hard-core projectiles increases to 320 mm.

1. Metal-containing polymer block
2. Rubberized fabric screens

Основные характеристики	
Масса модуля пассивной защиты, кг	1800
Масса резинотканевых экранов, кг	100

Basic Characteristics	
Weight of passive protection module, kg	1,800
Weight of rubberized fabric screens, kg	100

Комплект универсальной защиты для танков типа Т–55 и Т–62 (модули пассивной защиты и решетчатые экраны)

Металлополимерный блок обеспечивает защиту от моноблочных кумулятивных средств поражения с

Versatile protection package (passive protection blocks and lattice screens) for tanks T–55 and T–62

The metal-containing polymer blocks give protection against shaped-charge projectiles capable of penetrat-

429

Against kinetic energy projectiles, the low efficiency of the metal-polymer filler means that the majority (not all) of the burden lies on the heavy steel front plate of the armour block and its spacing from the turret. It may not be too unrealistic to treat the overall armour as a form of dual-layer spaced armour. The photo on the left (credit to Vyacheslav Demchenko) is a profile shot of the armour of a T-62M. The photo on the right (credit to Jarosław Wolski, also known as Militarysta) shows the armour of an a T-55AM2 with the metal-polymer filler removed, leaving only the steel front plate. Note the declining size of the gap between the front plate and the surface of the turret at the base of the turret.

The armour kit offers a good amount of coverage for the upper glacis, but as mentioned before, the turret front is only partially protected by the metal-polymer blocks. The two "Brows" weigh 1.8 tons together, and the upper glacis block alone weighs around 1.5 tons. The additional steel-reinforced plastic side skirts add another 100 kg to the total weight of the tank. Equipped with the additional armour, the weight of a combat-loaded T-62M bloated to 41.5 tons - more than 3 tons greater than the vanilla T-62, and about the same as a T-72A. One issue with this is that all of the additional mass is disproportionately concentrated on the front of the tank, making it nose-heavy. For the turret in particular, the addition of 1.8 tons was especially serious in relative terms, and it made the turret unbalanced. This increased the load on the turret rotation drive, especially if the tank is not on level ground.

Using the information we have gathered so far, it is possible to estimate the areal density of the metal-polymer armour and determine its mass efficiency:

It is known that that the total physical thickness of the armour is 252mm, with the first 30mm being a layer of RHA steel and the last layer being the original 102mm upper glacis armour of the tank. The cavity inside the metal-polymer block is 120mm thick. Inside the metal-polymer block, there are three steel sheets in the path of a penetrating projectile. With a thickness of 5mm each and an angle of 65 degrees, the LOS thickness is 35.5mm. Subtracting this from the cavity thickness, we find that the LOS thickness of the polyurethane filler is 204.5mm. Assuming that the density of the polyurethane used in the armour has a density of between 1,100 to 1,200 kg/m^3, the areal density of the polyurethane should range from 225-245 kg/sq.m, with an average of 235 kg/sq.m. The total LOS thickness of the steel elements of the armour array is calculated by simply adding up the LOS thickness of the three steel sheets at its structural obliquity together with the 30mm front plate and 102mm base armour, all angled at 60 degrees. All in all, it is 300mm thick (rounded up from 299.5mm). Using the known density of RHA steel (7,850 kg/m^3), we find that the areal density of the steel is 2,355 kg/sq.m. Adding up the steel and polyurethane layers, the total areal density is around 2,590 kg/sq.m. This is equivalent in mass to a 330mm homogeneous steel block, so it is lighter than the well-known 80-105-20 armour array by the equivalent mass of 5mm of steel while having an armour protection level of 450mm RHA against shaped charges.

To quantify this, we divide the equivalent thickness of steel against shaped charges (450mm) with the relative mass of armour (330mm) to find that the the armour has a mass efficiency coefficient of 1.36. This is only a 0.01 point improvement over the basic 80-105-20 composite armour array of the T-64/72/80 with glass textolite and does not reach the 1.40 mass efficiency coefficient of the Soviet bulging plate NERA armour used in the T-72B turret. There is some margin of error, of course, but based on all available information, it is completely unsurprising that the efficiency of the metal-polymer block armour lies somewhere between a simple three-layer glass textolite-based composite armour and multilayered NERA armour. Against a KE threat, the claimed protection level of 320mm RHA implies that the mass efficiency coefficient is 0.97, which is less than a solid homogeneous steel plate (1.0) and less than the 80-105-20 armour array (1.0). This is extremely unusual considering that long rod penetrators always perform worse against multilayered targets compared to monolithic targets of the same mass which is reflected in the type of tank armour simulator targets used by NATO. For example, NATO Double Medium is considered a tougher target than NATO Single Medium. Both targets are intended to represent the same type of target (the frontal armour of a Soviet medium tank), but NATO Double Medium is an increased difficulty target despite having the same thickness of steel (130mm) and same slope (60°), differing only in that the armour is split into two layers with a space in between (40-150-90).

By having a very similar distribution of steel plates of the same general properties while also benefiting from a more complex construction including internal steel sheets, it seems to be beyond question that the metal-polymer block on the upper glacis should have a mass efficiency coefficient of more than 1.0. Needless to say, the fact that the 320mm RHA figure contradicts this basic understanding of spaced and composite armour is abnormal and indicates that Zaloga's claim that the armour offers a protection level of 380mm RHA against KE attack is probably closer to the truth. The claim that "metal-polymer block armour adds 120mm against KE attack" from the NII Stali marketing pamphlet can still be true if it is interpreted to refer only to the turret from a 30 degree side angle.


Turret block

On the 5th of February 2017, a video of an SAA T-62M being struck by an ATGM began circulating on Twitter. The T-62M was attacked from the right flank by either a Fagot or Konkurs missile (judging by the tracking flare and flight pattern of the missile). The missile hit the "Brow" armour block on the right side of the turret, but all three crew members survived and evacuated the tank immediately. Watch the video here (Twitter link).

The video cannot affirm or disprove anything, as the missile struck the turret approximately where the gun breech is. There is no way to know if the missile defeated the side armour or not, because even though the loader is fine, this could be because he was seated below his hatch, meaning that he would not have been in the line of fire had the missile perforated the base armour. If the missile did not manage to get through, it is still more than possible that the crew bailed as a matter of principle. In fact, there is a high probability that the armour was defeated by the missile as a very similar scenario was tested during Hungarian trials at the end of the Cold War, where it was revealed that the side of the turret of a T-54 equipped with "Brow" armour (taken from a modernized T-55) could not resist a "Fagot" missile. The results of the test are detailed on this TankNet post. This effectively means that the "Brow" armour for the turret combined with the 140-150mm of cast steel of the T-54 turret itself cannot resist a shaped charge warhead with around 400mm of penetration. The main difference is that the T-62 turret is slightly thicker at that location and the T-62 obr. 1972 turret is significantly thicker, so the claim of 450mm RHA against shaped charges may be true depending on the angle of impact.

However, the armour only covers around half of the surface area of the tank from the front and of that covered area, some parts lack the metal-polymer component, making it nothing more than simple spaced armour at those specific zones. From the front, these parts are the machine gun port on the right side of the turret and the primary sight aperture port on the left side. These areas can be considered to be weakened zones, especially to shaped charge weapons, but they are still highly resilient to APDS attack. The area over the machine gun and gunsight ports is definitely resistant against M392 or L28 as the 71-85mm spaced plate should effectively de-cap the tungsten carbide core and fracture the core, whereby it is broken up in the air gap before it reaches the ~242mm turret front. Even without the spacing, the added thickness of steel is likely to be enough to defeat the shell. In terms of thickness alone, the LOS thickness of these parts are around 313-327mm thick. Using the assumption that M735 penetrates 330mm RHA at a 1 km (based on a report by Jane's that M735A1 penetrates 370mm at 1 km), we can see that the thickness of the steel alone is already straining the capabilities of early 105mm APFSDS. The cast steel of the spaced armour and the base turret armour is worth slightly less than what these LOS thickness figures suggest due to the lower effectiveness of cast steel compared to rolled steel, but after taking the large air gap into consideration, it seems highly unlikely that the armour can be defeated with M735 at a kilometer's distance. 105mm APDS such as the L52 would be hopeless even at a distance of under a kilometer and some 105mm APFSDS rounds like the M111 "Hetz" or DM23 may be stopped by the armour at medium range based on available information. On the other hand, M833 should be more than enough to defeat "Brow" armour depending on the point of impact, but even so, ammunition like DM23 and M735 or M774 would have been the most common threat during the early to mid 80's so they were a more significant threat. With that in mind, it appears that the T-62M would have been quite a tough nut to crack.

The T-62M can be considered on par with or even superior to the T-72A in a few respects, but vastly inferior to the T-72B in armour protection against both KE and CE threats. The largest disadvantage is that the "Brow" armour leaves the mantlet area of the turret uncovered by the metal-polymer armour array, but at least the thick steel front plate forms spaced armour over the machine gun and gunsight ports. With the applique armour, the maximum total thickness of the turret armour of the T-62M is 566mm (296mm armour block plus ~70mm air gap plus 200mm turret) over the areas covered by the metal-polymer armour, though the average thickness should be lower. The total thickness is comparable to the T-72A turret, but needless to say, it should be self evident that the combination of a metal-polymer block and an air gap is more effective than "Kvartz".

Even if the internal armour array is badly damaged by multiple hits, the thick steel front plate of the blocks can still perform as simple spaced armour. In effect, the armour still provides a respectable amount of protection even if it is hit in the same area twice in a row, certainly still enough to immunize the T-62 from the shaped charge warhead of the less advanced versions of LAW rockets to the frontal arc. Going by steel thickness alone, the main armour of the turret together with the front plate of the armour blocks will still be too thick to be defeated by an M72A3 LAW from 1977.

Overall, the "Brow" armour on the T-62M was not cutting edge technology. Portable threats such as the 105mm M40 recoilless rifle (400mm penetration), LAW, Carl Gustav (400mm penetration), and the anaemic M47 Dragon (450mm of penetration) were effectively neutered, and the add-on armour can be considered very successful in that regard. However, the ITOW was just around the corner by the time the T-62M was introduced, and it would have been able to defeat this new armour with relative ease from the front based on available information. "Brow" armour could not change the status quo of the T-62 against opposing tanks given the relatively recent introduction of 105mm APFSDS ammunition, so even if it could offer full protection from 105mm M456 HEAT and M392A2 APDS and possibly earlier APFSDS like the American M735, this was of little importance as the U.S Army had already moved on to the M774 and M833 while the Germans had already armed themselves with the 105mm DM23 and DM33. By achieving a level of protection only equal to the T-64A, the T-62M was only suitable against similarly obsolescent NATO tanks. This, combined with the general obsolescence of the chassis itself, meant that the further upgrading potential for the T-62 was effectively exhausted. Nevertheless, these obsolete tanks reigned supreme in Afghanistan in the absence of the threat of APFSDS rounds, and it was there that "brow" armour proved to be the difference between life and death.

"Brow" armour was not exclusive to Volna-equipped T-62Ms, or even to the T-62M in general. Many T-62s have been seen in Afghanistan with "Brow" armour and sideskirts, but no other upgrades. The lack of a laser rangefinder is a dead giveaway for the tanks below:

This is expected, as "Brow" armour is an applique armour kit that is intrinsically compatible with the T-62. There is nothing to limit the installation of the armour kit to older versions of the T-62. In fact, it was not uncommon to see a pre-1972 model T-62 equipped with "Brow" armour in Afghanistan, as field technicians did the best they could to armour up the army's valuable armoured assets with whatever they had. The photo below shows an early model T-62 (distinguished by the loader's hatch) equipped with "Brow" armour and side skirts leading what appears to be a tank platoon including fully fledged T-62M tanks. The second tank in the line is a T-62M, as we can see by the smoke launchers on the right side of the turret.

The photo below shows another early model T-62 with "Brow" armour.

And the photo below shows another one in a partially hull-down position.

BELLY ARMOUR

But besides the (lack of) additional protection from new NATO weapons, the armour package also came with added belly armour for extra mine protection in light of the tactical situation in Afghanistan at the time. The applique belly armour is quite simple in construction, composed of a large spacer frame, onto which twelve individual steel plates welded on to it, as you can see in the photo above. The escape hatch received an extra welded armour plate as well.

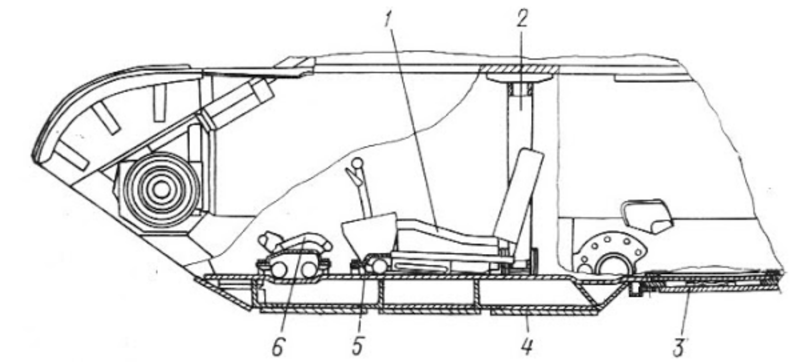


Рис. 3. Противоминное броневое днище:
1 — быстросъемная подушка; *2* — распорная стойка; *3* — броневая крышка люка запасного выхода; *4* — броневой лист днища; *5* — литая скоба крепления кулисы; *6* — амортизационное ограждение передней пары торсионов

The thickness of the welded steel plates is 20mm. The new armour reduced the ground clearance of the T-62M from the original 430mm to 397mm. This affected its ability to drive over some of the larger tree stumps, large rocks and overcome vertical obstacles, but the otherwise, it was business as usual.

SLAT ARMOUR

Slat armour was often used to cover areas unprotected by BDD armour. This was a not an uncommon combination during the Soviet campaign in Afghanistan, where it proved more useful than the basic rubber side skirts originally installed onto the T-62M. The full slat armour set weighs 0.55 tons.

Kontakt-1

Photo from Andrei Tarasenko's website

When Kontakt-1 became available in the early 80's, some T-62s were formally equipped with the armour, but only on an evaluatory capacity. Instead of Kontakt-1, T-62s were invariably given slat armour instead, which could not be often seen on tanks that used Kontakt-1 like the T-64 and T-72. They both had the same basic function, but slat armour was much cheaper and easier to install, and since the T-62 became more or less obsolete by that era, it was only ever given slat armour instead of more effective ERA kits. However, some units in Afghanistan ignored the official regime and retrofitted their T-62s with Kontakt-1 anyway.

Mounting the blocks are easy. Each one is bolted onto a spacer bolted to the surface of the hull and turret. The ease of installing and replacing the blocks meant that the entire modification could be done as part of regular scheduled maintenance. However, simplicity comes at a price in this case. The ERA boxes are somewhat fragile, and can be quite easily knocked off when the tank is travelling through densely wooded areas, or perhaps traversing obstacles in urban sprawl. A great many Syrian T-72s lost their side skirts and all of the Kontakt-1 blocks on them from reckless driving.

Photo from Andrei Tarasenko's website

Each Kontakt-1 block consists of two 4S20 explosive elements - plastic explosives packed into a flat steel plates. Each plate of plastic explosive weighs 260 grams, and have an explosive power equivalent to 280 grams of TNT. The plastic explosives have a very low sensitivity to ensure that they can survive being hit by machine gun fire and even autocannon fire without detonating. The weight of each block is 5.3kg, and a full set covering the entire tank weighs approximately 1.2 tons, meaning that there are around 220 blocks of Kontakt-1.

Method of Operation

A full examination of Kontakt-1 is available on the T-72 article. View it here.

The entire tank is covered in all areas except for the rear half of the side skirts, and rear of the hull and turret, and the turret ring is left exposed. Each Kontakt-1 block can reportedly reduce the penetrating effects of cumulative jets by up to 55% at 0 degrees obliquity, and up to 80% when angled at 60 degrees. The addition of Kontakt-1 would have made the T-62 immune to all handheld anti-tank weaponry, and the vast majority of anti-tank missiles without a tandem warhead.

Since the T-62 is only used for target practice nowadays, there isn't any incentive to give any of them the benefit of increased protection. Even in the 80's, the T-62 was already completely eclipsed by T-64s, T-72s and T-80s. Their use alongside the T-54/55 in Afghanistan is proof that the T-62 was viewed as a second-class tank, suitable only for foreign excursions and not the "big war".

MINE CLEARANCE

Equipment for clearing a path through minefields was issued to tank platoons, one each. One tank in any given platoon would be a model appropriately modified from the factory to mount any mine clearance devices from the early PT-54 all the way up to the KMT-8.

PT-55 Mine Rollers

Mine rollers meant to detonate anti-tank mines before the tracks do. Main disadvantage of mine rollers is that it is not safe for the cannon barrel to be pointing forward, due to the negative effects of the blast on its integrity. They weigh in at a hefty 8.8 tons, and quickly wear out the front suspension of the tank.

Later on, the improved and progressively lighter PT-54M and PT-55 could be mounted. They could not clear as wide a path as the original PT-54, but are more sustainable because of their weight.

KMT-4 Mine Ploughs

Mine ploughs that dig up and shove anti-tank mines out of the way, creating a path just wide enough for the tracks to pass through They weigh 1.2 tons, and are lowered with a hydraulic piston powered by the tank's electrical system. The tank can move at normal speeds with the plough raised, but must slow down to 12 km/h with the plough lowered. The plough is light enough that it will not affect the frontmost torsion bars, which is helped by the better optimized arrangement of roadwheels on the T-62. The large gap between the first and second pair of roadwheels in the T-54 and T-55 designs meant that they would have been placed under excessive strain, possibly breaking them.

Neither of these devices could remove or safely detonate tilt-rod mines, but tank crews could tie a piece of steel wire or cable across the two plows or rollers for a makeshift standoff detonator. Later mine clearance devices like the KMT-5 combined rollers with a plough while weighing less than the original PT-54-type rollers. Later on, the T-62 could mount more sophisticated KMT-6, 7 and 8 devices capable of detonating both tilt-rod mines as well as electromagnetically fused ones. This is mostly thanks to the completely standardized mounting system used for all Soviet mine clearance devices.

NBC PROTECTION

Like any other tank, the T-62 can be decontaminated swiftly by being blasted with jets of hot air to remove chemical and biological agents, which is what is happening to the T-62 below:

Before external decontamination can begin, it must be made sure that NBC contaminants cannot slip through gaps in the tank's armour to incapacitate or even kill the crew, and the effects of a nuclear blast may cause severe illnesses in the long run. To combat all of these effects, the T-62 was furnished with a fairly comprehensive NBC protection suite, something which no other tank in the world except its predecessor had at that time.

Unlike the T-55A, the T-62 lacked a lead impregnated lining to protect the crew, leaving them more vulnerable to gamma and neutron radiation if the tank was caught in a nearby nuclear blast. Although the crew is protected from breathing irradiated dust particles by the filtering system, they are not protected from the burst of initial radiation during the nuclear explosion itself, nor are the protected from the radiation released from irradiated debris and soil, which may penetrate the thin belly of the tank. The crew is also exposed to some gamma radiation from the steel shell of the tank itself, due to induced radioactivity from neutron radiation. Because of this, there is a significant chance that a T-62 tank crew may become too sick to fight or even die in the hours after a nuclear blast from radiation poisoning if they are close to ground zero and do not have the thick frontal armour of the tank facing the explosion. In other words, a T-62 crew has the same chance of surviving a nuclear strike as the crew of a basic T-55 tank (but not a T-55A).

Of course, there was a serious attempt to add the anti-radiation lining to the T-62. In December 1962, two experimental Object 166P (T-62P) tanks were built at the No. 183 Nizhny Tagil plant and subsequently tested at the NIIBT testing grounds in Kubinka from February to March of 1963. Unfortunately, the results of the tests were negative; the addition of thick anti-radiation lining in the driver's compartment significantly reduced the available work space and even interfered with his hands. The amount of work space in the turret was also affected, and the view from the periscopes deteriorated. Because of this, the installation of the anti-radiation lining was rejected, and the T-62 never had one for the entirety of its service in the USSR and abroad. However, the T-62M received an external anti-neutron cladding during the mid-80's as a response to President Reagan's authorization of the production of neutron bombs like the W70-3. Designated "Podboi", this anti-neutron cladding was also installed on the T-64, T-72 and T-80 during the early to mid 1980's. One such T-62M is shown in the photo below (photo credit to Vitaly Kuzmin).

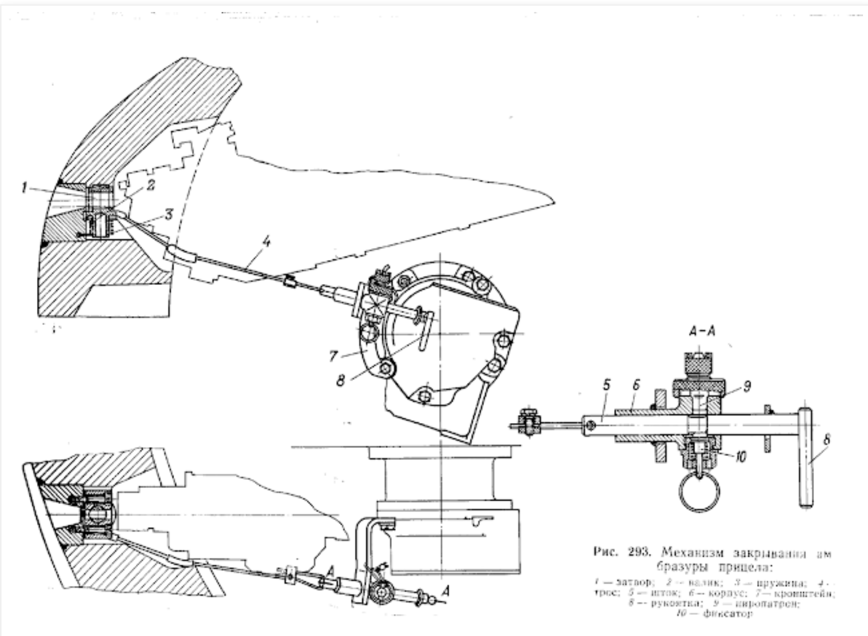
Unfortunately, the coverage of "Podboi" cladding on the T-62 is rather limited. There are large gaps between some of the anti-neutron mats, and the commander's cupola only has cladding on the hatch and not the forward part where the periscopes are situated. It is also the same for the loader's hatch.

ERB-1M

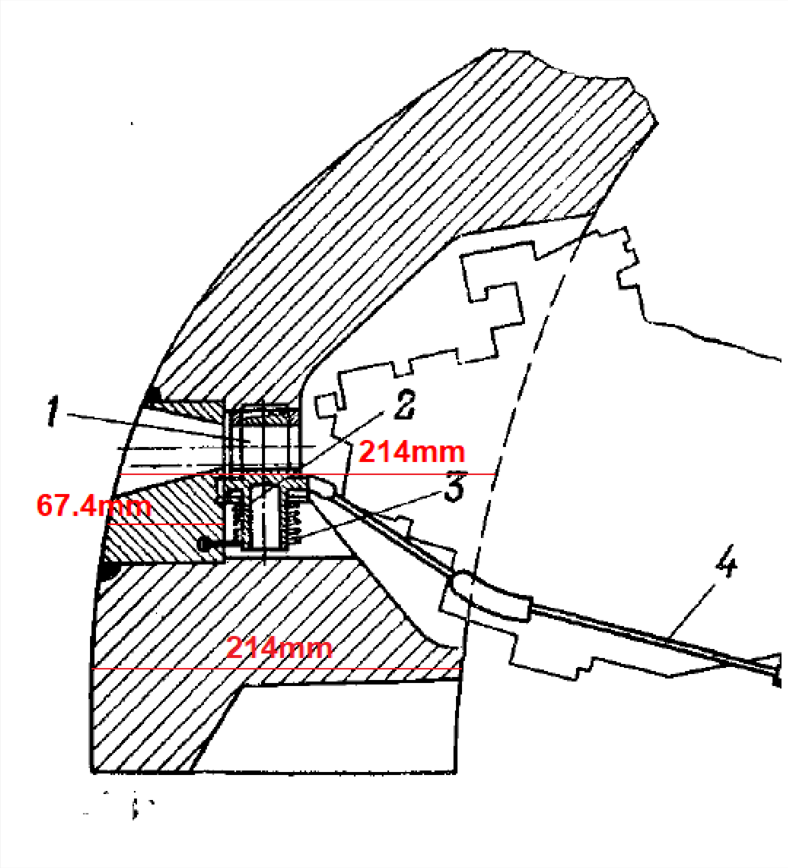
With the need for nuclear protection firmly established with the appearance of tube artillery-delivered tactical nukes, the requirement for such a system remained the same for the T-62 as it did for the T-55, which had the most advanced and comprehensive nuclear protection scheme for any medium tank in the world at the time. For simplicity's sake, the T-62 was equipped with the same ERB-1M system as the T-55. ERB-1M could detect a nuclear explosion through a gamma radiation sensor located in the middle of the hull, just beside the commander's seat (red box), and activate the tank's collective protection suite.

When gamma radiation was detected and determined to be at or above a dosage indicative of a nuclear explosion or leak, all portholes would be automatically sealed to prevent contamination, as the tank was not actually airtight. The seals were applied via small pyrotechnic squibs detonated through an electric impulse sent from the main control unit of the ERB-1M system. The engine would be immediately stopped and the radiator cooling fan suspended. The radiator louvers would be automatically shut closed, and to fully assure the impenetrability of the fighting compartment from radioactive particles, the compressor in the ventilator would be powered up to create a slight overpressure. The driver has manual switches for activating the defensive systems.

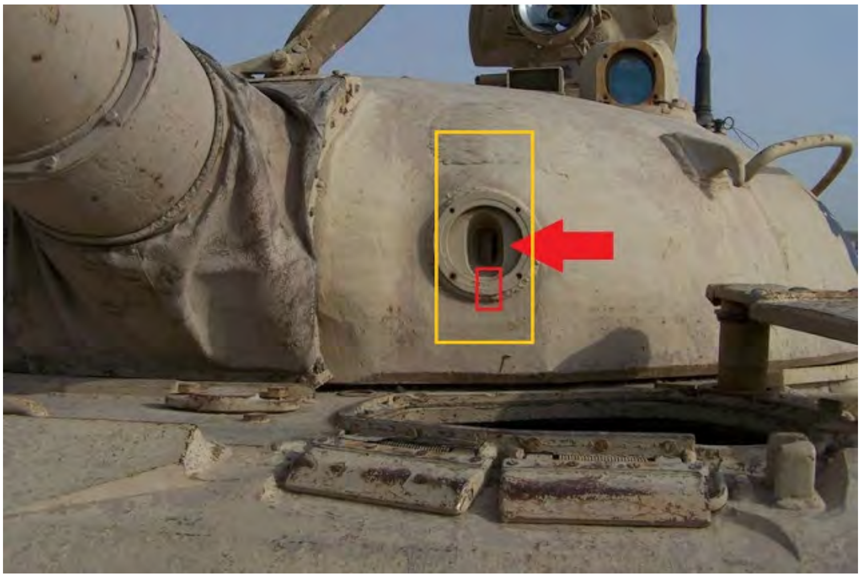
The sealing mechanism for the gunner's telescopic optic is illustrated in the diagram below. The diagram is taken from the T-62 technical manual, page 560. As you can see, the area around the gunner's telescopic sight is a weakened zone due to space concessions required for the fitting of the sight. Based on the diagram at the top left, the thickness of the turret around the optic port was reduced by around 60% at the area above the port, and around 20% below it. The aperture of the telescopic sight peers out from behind a small porthole, under which the seal is installed.



The optic port itself is thinly armoured compared to even the weakened region. By scaling it with the base of the turret wall as depicted in the diagram, it is apparent that the armour is only 67.4mm thick. Note that it is a separate piece of armour made from rolled plate rather than cast steel. This would be enough for virtually any machine gun or autocannon fire, but nothing more. While tall, it is some consolation that the weakened zone is rather narrow, based on the drawing at the lower left corner of the diagram above. The thickness of the optic port armour is shown below:



A sealed optic aperture is shown in the photo below. The red box indicates the location of the seal when retracted. The entirety of the weakened zone is shown by the yellow box.



Ventilation for the crew is facilitated by the KUV-3 ventilator, identifiable on the rear of the turret as a large, overturned frying pan-shaped tumor on the rear of the turret. The "frying pan" is quite thick.

A centrifugal fan inside the ventilator housing sucks in air and performs some low level filtration, ejecting dust and larger particles out of a small slit at the base of the housing (refer to photo above). The filtered air is then released into the crew compartment, passing through a drum-shaped NBC filter unit inside the tank proper. The air can be optionally cleaned of chemical and biological contaminants by the filter in contaminated environments where the centrifugal fan is simply not enough. The filter unit also contains a supercharger to increase the positive pressure inside the tank to produce an overpressure, preventing chemical and biological agents from seeping into the tank. A diagram from the T-62 technical manual may make this information easier to visualize:

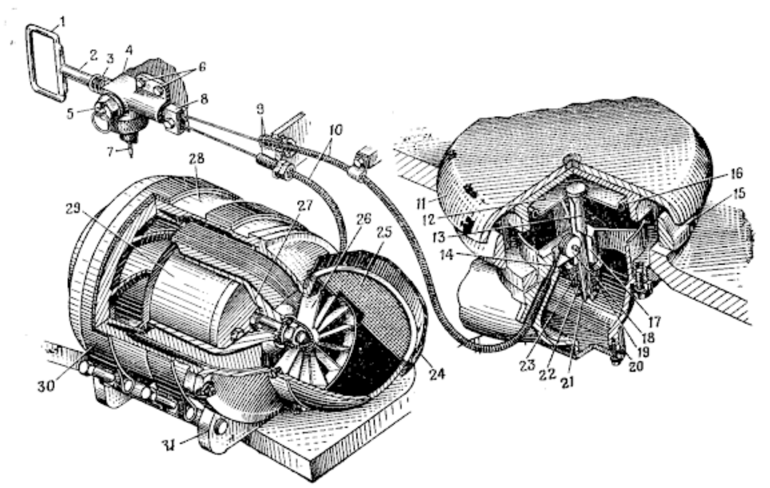
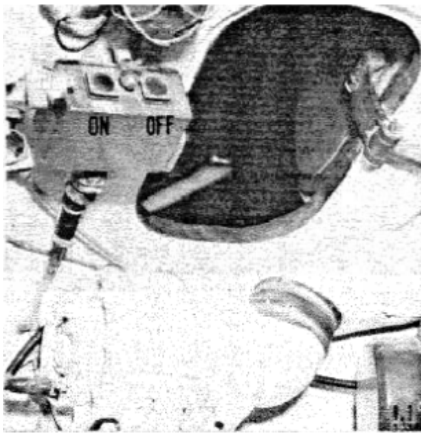


Рис. 297. Нагнетатель:

1 — рукоятка; *2* — шток; *3* — пружина; *4* — корпус штока; *5* — фиксатор; *6* — болты; *7* — провод пиропатрона ПП-3; *8* — планка; *9* — регулировочные втулки; *10* — оплетки тросов клапана и заслонки; *11* — броневой грибок; *12* — клапан; *13* — шток клапана; *14* — трос; *15* — броневое защитное кольцо (раструб); *16* — клапанное кольцо; *17* — направляющий сердечник; *18* — ролик; *19* — пружина; *20* — раструб; *21* — гайка; *22* — пружина; *23* — стакан; *24* — дюритовый шланг; *25* — сетка; *26* — завихритель; *27* — ротор с лопатками; *28* — корпус нагнетателя; *29* — электродвигатель; *30* — металлическая лента; *31* — кронштейн

When activated, whether it be automatically or manually by the driver, the system generates an overpressure of 0.0015 kg/sq.cm, thus preventing irradiated particles or chemical and biological contaminants from entering the tank.

Although the T-62 did not have equipment capable of detecting chemical and biological agents, the supercharged filter-ventilator can be manually activated from a control box near the shell casing ejection port. The control box is easily within the loader's reach (red box below in the photo below). If the crew notices clouds of suspicious smoke or have been informed of contaminated sectors, they have the opportunity to safeguard themselves on their own initiative by activating the supercharged filter-ventilator to produce an overpressure to prevent the ingress of any such contaminants.



Compared to a plug-in system where crew members must plug in their gas masks into the tank's air filter unit - a system that is very commonly found in American armoured vehicles - the collective-type protection suite of the T-62 is ergonomically superior by far. The crew does not need to wear masks that obturates their vision, and they can breath without restrictions. This was not the case in tanks like the M48A2, which was the first American tank with a filtered ventilation system but lacked an overpressure generator.

SMOKESCREEN

Like the T-54, the T-62 has an on-board smokescreen generation system known as a TDA, which stands for "Thermal Smoke Apparatus". Diesel fuel is injected into the exhaust manifolds, vaporizing it with the heat and expelling the resultant mist out of the exhaust. Upon exiting the exhaust manifolds, the mist condenses immediately in the cold environment and turns into white, opaque smoke. The rate of smoke production depends largely on the load on the engine, so the tank will produce more smoke when it is travelling over rough ground at high speed than when it is parked and idling.

902V "Tucha" Smoke Grenade System

The T-62M was outfitted with the "Tucha" smoke grenade system to supplement the built-in TDA exhaust smokescreening system included since the original T-62 model.

3D6

The 3D6 smoke grenade is a caseless grenade weighing 2.34 kg. The propulsion charge is located in the base of the grenade and the expanding propellant gasses exit the grenade and enter the smoke grenade launcher through twelve small vent holes around the circumference of the base and six holes on the end of the base. The grenade has a conventional smoke-producing element based on hexachloroethane, zinc oxide and aluminium, and the smoke emitted from the grenade is toxic to humans through skin absorption. The smoke is only partly opaque to far-infrared light, so it is only partly effective against thermal imaging devices but it is completely ineffective at scattering lasers from laser rangefinders. The grenades will travel anywhere from 200 meters to 350 meters after launch, and it takes between 7 to 12 seconds to produce a full smokescreen measuring 10 m to 30 m in width and 3 m to 10 m in height depending on various environmental factors like wind speed, humidity, altitude, and so on. According to the manual, the average width of the smokescreen is 27 meters and the average height is 8 meters. This does not include the time of flight which can take around 8 to 10 seconds, so the total time between the moment of launching the grenade and the formation of a full smokescreen may be up to 22 seconds. The smokescreen can last as long as 2 minutes, depending on environmental factors.

The launching distance was designed to work with assault tactics where tanks advance and maneuver behind a continual wall of smoke generated in 300-meter increments until reaching enemy positions. It was also designed so that tanks could launch smoke grenades into enemy positions to obstruct their vision without affecting the vision of the launching tank and other friendly tanks in the vicinity. Naturally, this also made them useful as a signalling device for other tanks and for friendly troops, especially when radio silence is mandatory. Conversely, the smoke grenade launching systems of most NATO tanks are designed to generate a smokescreen at close range to screen the host tank in order to cover a hasty retreat. The response time of such a system is much quicker due to the short time of flight and air-bursting mode of detonation. This is perhaps the most clear-cut example of the differences in tactical doctrine between Soviet tanks and NATO tanks.

FIREFIGHTING

The T-62 is furnished with the "Rosa-2" automatic firefighting system inherited from the T-55. It is responsible for the engine compartment only, and can be activated from the driver's station. "Rosa" employs a halocarbon fire extinguishing agent designated "3.5"; a pressurized combination of ethyl bromide and carbon dioxide. The mixture is very effective, but also highly poisonous and carcinogenic. A drawing of one of the three fire extinguisher bottles containing the "3.5" halocarbon agent is shown below. The "Rosa" system employs TD-1 temperature sensors strategically positioned around the inside of the engine compartment to give the best chance of detecting both fuel and electrical fires. "Rosa-2" reacts to a rise in temperature to 180°C.

The system can operate in either 'automatic' or 'semi-automatic' modes. In the 'automatic' mode, the system alerts the driver of the source of the fire and immediately closes all of the radiator louvers, shuts off the engine, cuts off the engine air intake and shuts down the radiator fan to deprive the fire of air. Then, the fire extinguishers are activated and the entire compartment is flooded with the extinguishing agent. In the 'semi-automatic' mode, the system alerts the driver of the presence of a fire via an alarm and a signal light, but does not intervene on its own. The driver can then choose whatever action he deems most suitable at the moment. He can control the deployment of the fire extinguishers from his station and the commander has a master switch for deploying the fire extinguishers as well.

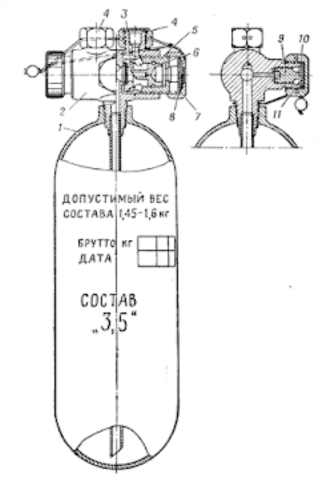


Рис. 304. Баллон для состава 3,5:
1 — баллон; 2 — корпус головки с сифонной трубкой; 3 — шайба с мембраной; 4 — заглушка; 5 — пробка; 6 — поршень с фиксирующим кольцом и пробойником; 7 — накидная гайка; 8 — прокладка; 9 — пробка; 10 — заглушка; 11 — прокладка

In addition to the automatic fire extinguishing system, the driver is supplied with a single manual OU-2 carbon dioxide fire extinguisher. Carbon dioxide is suitable against Class B and C fires, namely fuel and electrical fires, which are the predominant causes of fire in a tank. The OU-2 is the only means of extinguishing fires in the fighting compartment.

ESCAPE HATCH

The T-62 features an escape hatch to enable the crew to exit the tank in the very worst of emergencies. It is located directly behind the driver's seat and in front of the gunner. All of the turret's inhabitants can (relatively) easily swing down and out, but for the driver to exit, he must first fold his seat backwards, enter the turret, and then fold his seat forwards (the driver must fold as well) before he can egress.

(The one at the bottom of the photo)

Though small as always, the hatch is distinguished from escape hatches found on most Western tanks in that is that it is opened inwards on a hinge as opposed to dropping out of the bottom of the tank. Not only does this practically eliminate any potential concerns of the hatch dropping out on its own accord from vibrations and shock, it also means that it can be opened if the tank is submerged. The main disadvantage is that this type of hatch is less resistant to mine attack.

DRIVER-MECHANIC'S STATION

The driver's station is practically identical to the one in the T-54, with only very minor differences. It is located at the front left quadrant of the hull, and the driver absconds through an armoured hatch. When the hatch is opened, the turret traverse mechanism is automatically locked as a built-in safety mechanism. A small indicator light connected to the turret traverse system is installed next to the hatch to alert the driver if the gun is directly over the hatch. The thickness of the hatch is not uniform, as shown in the photo above. The rear part of the hatch which connects with the hatch opening mechanism has a thickness of only 20mm which is thinner than the hull roof (30mm), but the actual thickness of the hatch that fits into the hatch hole is 50mm. The increased thickness of the hatch protects the driver from the blast and fragmentation of explosive shells impacting the surface of the turret as well as from the splinters of artillery shells airbursting over the tank.

The driver's station is exactly identical to the one in the T-55. Steering is accomplished using the obligatory pair of tiller levers. To save legroom for the driver, the instrument panel is moved to the right. The speedometer is placed on a pedestal to the driver's left, and the gear shift is placed to his right. The driver is also in charge of the tank's automatic firefighting system. Two 5-liter compressed air tanks for cold weather engine starting are located just behind the driver on the left wall. They are replenished by an engine-driven AK-150SV air compressor. The compressed air reserves are also used for the pneumatic clutch assist, but the air compressor can be used with a pneumatic hose and used as a pneumatic washer for detailed cleaning of the more sensitive parts of the tank. The driver's left periscope also has an air nozzle to blast away dirt and debris, which is around as effective as a traditional wiper. It takes about an hour to refill both air tanks using the AK-150SV air compressor if the tanks are empty. The AK-150SV is powered by the engine, so that a continuous supply of air is provided the moment the engine is started.

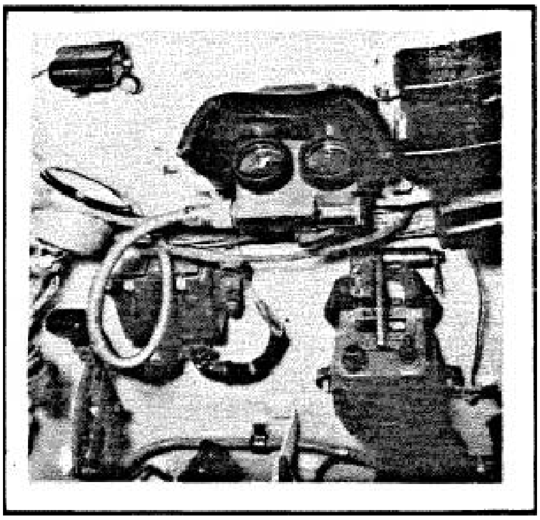
Starting the engine is done with the VB 404 ignition device. You can find out how it works by watching Nicholas "The Chieftain" Moran's video on the T-55.

For daytime driving, the driver is provided with two 54-36-317-R periscopes. To remove them, the driver can loosen its clamp by turning a nut on the side of the periscope and pull it straight down by its handle. This causes spring-loaded armoured shutters to flip down and shut the periscope port from gunfire and irradiated particles. The 54-36-317-R periscope has 1 x magnification. The periscopes have special K-108 windows infused with cerium. When the windows are blasted with gamma radiation from a nuclear explosion, they will begin to darken to protect the driver's eyes from the intensity of the visible light and infrared and UV radiation emitted from the explosion. They will return to their original undarkened state under daylight within several hours, depending on the time of day (intensity of sunlight). Just like the periscopes everywhere else on the tank, the 54-36-317-R periscopes are heated through the RTS electrical heating system to prevent fogging. The cable for the internal heater can be found on the bottom right of the periscope.

Visibility from the 54-36-317-R periscopes is best described as "average". There is absolutely nothing wrong with it, but also nothing exceptional. The periscopes are slightly wider than the periscopes on the T-34, but the field of vision offered by the 54-36-317 periscope is similar. The main difference is the vastly improved quality of the glass, as with the T-54. As he is provided with one fewer periscope, the driver of a T-62 has inferior visibility compared to the driver of any Patton tank or a Leopard 1. The GIF below shows the view from the left periscope. Unfortunately, the view to the right side is partially obscured by a canvas bag, possibly a sandbag.

For nighttime driving, the driver is equipped with the TVN-2 binocular infrared nightvision periscope. It has a fixed 1x magnification and a 30° field of view. The left periscope can be replaced with the TVN-2. The driver must then connect the TVN-2 to a special cable from BT-6-26 power supply box. Infrared light is sourced from the single IR headlamp on the hull glacis and another similar lamp on the turret, installed just underneath the L-2G Luna spotlight. The range of vision is limited to 60 meters and the field of view is rather constricted compared to the daytime periscope, so the speed of the tank must be carefully controlled when driving in unpaved or otherwise unfamiliar terrain. It is not possible to navigate at night using only the TVN-2, as the driver will be unable to see the landscape and recognize landmarks.

The photo on the right below - taken from the U.S Army Operator's Manual for the T-62 - shows the TVN-2 as it looks when installed in the T-62. The screenshot shown on the left below shows the TVN-2 installed in a T-54.



Navigation is facilitated by a simple GPK-48 gyrocompass located near the driver's feet. The main function of the gyrocompass is to let the crew know which direction they are travelling in, but it is particularly useful when driving underwater or when driving at night. With the GPK-48, it is possible for the driver to perform maneuvers when driving underwater (provided that certain conditions are met, including riverbed integrity and so on) and at night, with assistance from the commander. It would also be helpful when driving in poor weather conditions.

Photo credit: mashpriborintorg from flikr

In 1966, the T-62 received the GPK-59 gyrocompass, which had more knobs and dials.

The use of gyrocompasses can perhaps be labeled as a rudimentary form of an Inertial Navigation System (INS), advanced versions of which are often present in modern combat vehicles due to their independence from outside input contrary to a GPS-based navigation system.

MOBILITY

The tactical mobility of the T-62 - that is, its ability to maneuver under its own initiative as opposed to being carried on transporters like by lorry, rail, by plane or by ship - was only average for a tank of its time. One of the T-62's main grievances, though minor, is that it is slightly underpowered compared to its predecessor the T-55, mainly because it uses the same V-55 diesel engine and the same transmission but is heavier by a ton. Thus, the mobility characteristics of the T-62 are just between the level of the T-55 and the T-54. However, the power to weight ratio of a basic T-62 is equal a T-55A which has the same weight of 36.5 tons, and in fact, the T-62 surpasses the T-55A in cross-country driving thanks to its improved suspension with an increased range of roadwheel travel.

As such, the level of tactical mobility achieved by the T-62 was certainly the highest among all available Soviet medium tanks at the time, and it was still quite competitive when placed in the international arena. For reference, the T-54 requires 18 seconds to reach 32 km/h on a paved road, whereas it is reported on page 12 of the May-June 1977 issue of "ARMOR" magazine that the M60A1 or M60A3 accelerates to 32 km/h in 16 seconds on a paved road.

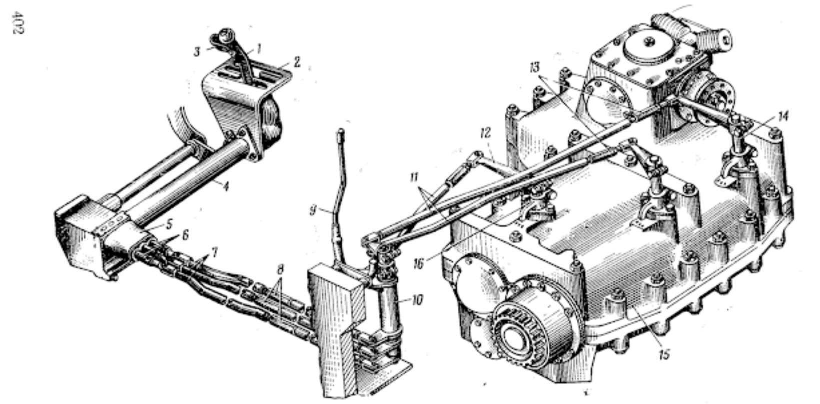


Рис. 216. Привод управления коробкой передач:
1 — рычаг кулисы; 2 — козырек кулисы; 3 — рукоятка; 4 — труба; 5 — поводковая коробка; 6 — поводки; 7 — продольные тяги; 8 — стяжные муфты; 9 — трубка; 10 — вертикальный валик; 11 — поперечные тяги; 12 — рычаг валика переключения; 13 — муфты; 14 — валик переключения; 15 — коробка передач; 16 — стрелка-указатель

The five-speed transmission is of a planetary type, with dry friction clutches. There is one reverse gear. The transmission and the mechanical linkages linking it to the gear stick can be seen in the picture above, taken from the T-62 technical manual. According to the technical manual, the speed of the tank for each gear at 1,800 RPM is as follows:

- 1st Gear: 6.85 km/h
- 2nd Gear: 14.66 km/h
- 3rd Gear: 20.21 km/h
- 4th Gear: 28.99 km/h
- 5th Gear: 45.48 km/h
- Reverse: 6.85 km/h

The T-62 manual states that the average speed of the tank on a dirt road is 22 to 27 km/h, while the average speed on a paved road is 32 to 35 km/h. The maximum attainable speed on a highway is given as 50 km/h. These simplified figures are by no means compatible with any available information for contemporary Western tanks due to the simple fact that the testing conditions tend to be different, sometimes vastly so. Only the figures given for the average speed of the T-62 on a paved road can be directly compared, and even then, roads in the Soviet Union were notoriously bad and are still subpar to this very day.

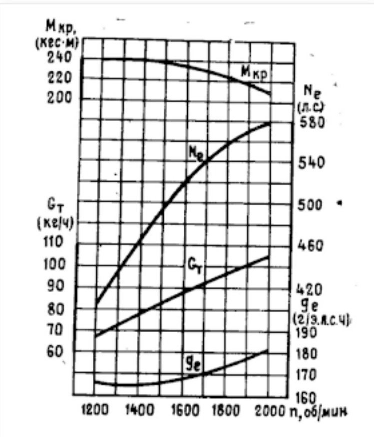
The T-62 uses an dual geared steering system - otherwise simply known as a geared steering system - of the exact same design as the T-55, with an auxiliary clutch-and-brake steering system for tight turns at any gear and in neutral. A similar steering system was employed on the IS-1 heavy tank. Steering is achieved by having two separate final drives with separate gear boxes connected to a common transmission. This design is extremely compact and highly durable. Unlike a (very outdated) single differential or a clutch and brake steering system, full power is sent to both tracks while steering. By manipulating the gear ratio, either the left or right track can be slowed down incrementally rather than braked for smoother and more precise steering. This is done by stepping down the gear box of the inside track to a higher gear ratio (more torque, less speed), thus creating a difference in speed, causing the tank to turn. However, this system will have the same fixed turning radius regardless of which gear you are in when driving.

The driving tillers (or levers) each control the track on its side. Each tiller has three positions, the first (1) for full forward, the second (2) for engaging the planetary mechanism to reduce speed for that track, and the third (3) to engage the brake. Each gear had a fixed (but not the same) turn radius, except the first gear, where steering can only be done by clutch and brake. The T-62's geared steering system was capable of a form of neutral steering called pivot turning, but not true neutral steering. The turning radius when pivoting the tank on the spot in neutral is 2.64 m.

By the early 1960's, this method of steering could still be considered relatively modern, but it had been surpassed by more advanced Western designs. Many Western tanks already had double differential or triple differential transmissions that were capable of true neutral steering and were additive in addition to being regenerative. It is worth mentioning that while the geared steering system of the T-62 was a regenerative system and just as efficient as the triple and double differential steering systems used by the M60A1 and Leopard 1 respectively, it was not additive, and this is important. It means that in addition to being regenerative, the outside track of an M60A1 or Leopard 1 will gain power. The steering systems for the M60A1 and Leopard 1 also have multiple turn radii, so that steering precision is higher for any given gear setting. It does not need to be said that the Leopard 1 is faster and more agile than the T-62, of course, but when comparing the M60A1 with the T-62, the additive feature of the steering system of the M60A1 may be enough to nullify whatever advantages the T-62 may have with its higher power-to-weight ratio and manual gear shifting system.

V-55V

The T-62 uses the same V-55 engine as the T-55, only slightly modified in the form of the V-55V. It is a traditional V-12 engine with a displacement of 38.88 liters and weight of 920 kg.



The V-55V engine puts out 580 hp at 2,000 RPM with a maximum torque of 2,354 N.m at an engine speed of 1,200 to 1,250 RPM. Like the ancestral V-2 engine developed during the 1930's, the V-55V has a bore diameter of 150mm and a piston stroke length of 180mm. It has a specific fuel consumption of 180 g/hp.h, which is reasonable for an engine of its size. The average fuel consumption per 100 km of travel is 190-210 liters on paved roads, and 300-330 liters on dirt roads. This is confirmed by West German testing conducted in 1974 using a captured T-62 from the Yom Kippur war of 1973. According to the German results, the T-62 consumes 165 liters per 100 km on a paved road and 339 liters per 100 km when traveling on a "field", which appears to be equivalent to what the Russians considered a "dirt road".

With this engine, a typical T-62 weighing up to 37.5 tons when combat loaded would have a nominal power to weight ratio of just 15.46 hp/ton. This placed the T-62 firmly in the category of contemporary medium tanks like the M48 Patton and the Centurion, but slightly better than the then-brand new Chieftain Mk. 3, and only slightly better than the M60A1. The T-62 could attain a top speed of 50 km/h on paved roads, and the average speed when going cross country was around half of that at 25 km/h, which was more or less the same as the M60A1. The reverse speed, however, was quite bad by Western standards at just 6.8 km/h. According to the Polish study "*Propozycja Poprawy Manewrowości Czołgu Twardy*" *(Proposal to Improve Maneuverability of the "Twardy" Tank*) from the University of Technology in Szczecin, the T-54 requires 18 seconds to reach 32 km/h on a paved road. As the T-62 uses the same tracks, transmission and has the same power to weight ratio as a T-54, the acceleration characteristics should also be the same. For comparison, Paul-Werner Krapke states in "*Leopard 2: Sein Werden und seine Leistung*" that the Leopard 1 accelerates to 32 km/h in 10 seconds on a paved street.

According to West German testing conducted in 1974, the T-62 takes 22.75 seconds to reach 40 km/h. For comparison, the same document states that the Leopard 1 reaches this speed in just 14.2 seconds, which is completely consistent with the information published in Paul-Werner Krapke's book. The gap between these two tanks is hardly surprising given that the T-62 retained the mobility characteristics of the T-54 - a classic medium tank designed in the immediate postwar period. The main factor in this large difference is the much more powerful engine MB 838 engine, more than powerful enough to offset the fact that the Leopard 1 is actually somewhat heavier than the T-62 (830 hp vs 580 hp). However, the rolling resistance of the T-62 is good. The German testing found that the rolling resistance of the T-62 was 237 N/ton whereas the rolling resistance of the Leopard 1 was 313 N/ton, illustrating at least one benefit to the large-diameter roadwheels inherited from the T-54 suspension.

The T-62 could traverse difficult terrain as well as any other tank. It could climb vertical obstacles up to 0.8 meters tall, climb a 32° slope and drive on a side slope of 30°. With the mudguards removed, the tank can climb a taller vertical obstacle. The tank can cross trenches 2.85 meters wide at low speeds, but it is possible to jump the tank over wider trenches provided that it travels fast enough.

The engine could be started either electrically, pneumatically or by a combination of air pressure and electricity in extremely cold weather, as mentioned before. Electric starting is done with the ST-16M electric starter and the air for pneumatic starting is supplied by the compressed air tanks. When starting the engine pneumatically, the two 5-liter air tanks mounted in the driver's station inject air into the cylinders of the engine, forcing the pistons into motion. This method is somewhat harsh on the engine, but it is dependable. Starting the engine in the summer is usually done electrically, but in the wintertime, the electric starting system may not be reliable due to piston lockup, so having the pneumatic option gives the tank more flexibility. In the harshest weather conditions, with the most poorly maintained tanks, starting the engine may require a combination of both methods simultaneously. Of course, the engine and engine oil must be preheated during cold weather conditions.

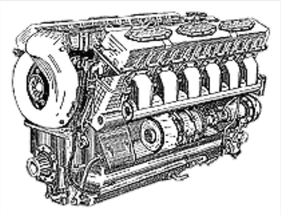
Like the T-55, the compressed air tanks are refilled during normal driving by an AK-150 air compressor, powered by the engine. AK-150 is a typical V-shaped reciprocating compressor. It runs on power supplied via an input shaft from the engine and uses pistons (operating essentially like a reverse order piston engine) to compress air drawn from the engine compartment, which it then routes directly to the air tanks.

The F-6.5 generator is attached to the engine and is supplied with power from the driveshaft by a power takeoff belt. The generator produces 6.5 kW of electricity for the tank's electrical system.

V-55U

This engine was fitted to the T-62M. Thanks to a more optimized direct fuel injection system, it had a slightly increased output of 620 hp to compensate for the added weight of "Brow" armour on the T-62M, but was identical to the V-55V in every other way. The small increase in power does not adequately balance out the gain in weight, so the T-62M has noticeably poorer acceleration.

V-46-5M



The V-46-5M engine was derived from the V-46-6 engine developed for the T-72 and was mechanically identical except for the various modifications made to the driveshaft, the exhaust manifolds and the air intake system. The installation of the V-46-5M was made possible by the fact that it has the same displacement of 38.88 liters as the V-55 series of engines, which is thanks to the shared lineage of the two engines. The bore diameter and piston stroke length are also identical, but the running components were reinforced to deal with the higher power output. The V-46-5M was de-tuned from the V-46-6 to generate 690 hp at 2,000 RPM instead of the normal 780 hp when configured for the T-72. Keeping in mind the fact that the appliqué metal-polymer armour increased the combat weight of the T-62M to 42 tons which is very close to a T-72A, the installation of the V-46-5M gave the T-62M-1 a power to weight ratio of only 16.4 hp/ton - significantly less than any T-72 variant. The sole advantage is that the engine has a longer lifespan and has better fuel economy. The maximum torque output of the engine is 2,844 N.m at an engine speed of 1,200 to 1,400 RPM.

Instead of the F-6.5 generator, the V-46-5M is equipped with the G-6.5 model with the same output, differing only in the method of installation and the input capacity. It is not entirely clear if the gearboxes were changed when the V-46-5M was installed, but it is very likely due to the large increase in the input power.

SUSPENSION

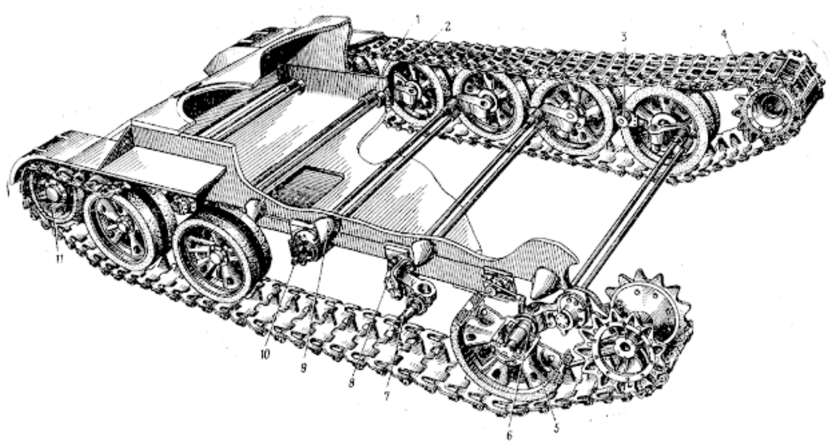
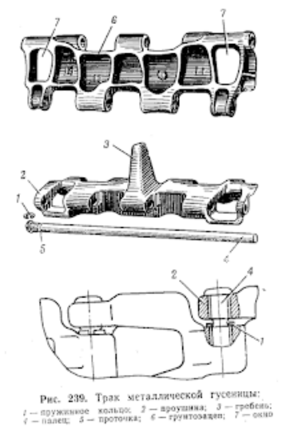


Рис. 238. Ходовая часть:
1 — кронштейн балансира; 2 — гусеница; 3 — амортизатор; 4 — ведущее колесо; 5 — опорный каток; 6 — буфер; 7 — балансир; 8 — опора балансира; 9 — упор; 10 — торсионный вал; 11 — направляющее колесо

Like the T-55 before it, the T-62 had individual torsion bar suspension and five hollow die-cast aluminium alloy roadwheels with a thick rubber rim. The T-62's suspension is aesthetically similar to that of the T-54 and T-55, but it can be differentiated by the even spacing between the three roadwheels at the front of the tank and the wider space between the two at the rear. This was done due to the shifted center of gravity of the tank due to the new enlarged turret, making it more front heavy than the T-55, thus necessitating more suspension elements at the front to ensure better load distribution for a longer lasting suspension as well as a smoother ride across bumpy terrain. The diameter of the roadwheels is 810 mm. They have a standard layout with a central channel for guide horns on the tracks to pass through. The same 5-spoked wheel was kept throughout the T-62's service life. The tank had 450mm of ground clearance.

The frontmost and rearmost roadwheels were fitted with rotary shock absorbers, identical to the type installed in the T-55. The range of vertical travel of the roadwheels is quite limited at only 160mm to 162mm, but this was already an improvement over the torsion bars of the T-55 which had a vertical range of travel of only 142mm. Compared to the 407mm of the Leopard 1 or even the 241mm of the Chieftain, the T-62 is clearly worse off for having inherited the suspension of the T-54. This issue could have been solved had the Object 167 been introduced into service instead, but the political climate in the Red Army leadership at the time was not conducive to such changes.

The T-62 used OMSh single pin tracks, carried over from the T-54/55. A full set of 96 links weighs 1,386 kg for one side of the hull. The combined weight of both sets of tracks is 2,772 kg, which is equal to only 7.2% of the total weight of the tank. The tracks are of a simple hinged type with no inner rubber padding or rubber bushings, nor were there any rubber track pads available for this type of track during the T-62's years of service, so travelling on paved roads was not very good for the asphalt. The track retention pins were not held in place so they could wriggle out of their slots from the vibration of the tracks over time. To prevent this, a steel bump was added to the side of the hull near the drive sprocket where it could knock any loose pins back into their slots. The tracks are 580mm wide with standard centered guide horns.



The idler wheel is of a skeletal design with 10 spokes. The drive sprocket has 4 spokes.

Despite the slight increase in weight compared to the T-55, the lengthened contact length of the tracks helped reduce the ground pressure to such an extent that it is actually marginally less than the T-55. For comparison, the specific ground pressure of the T-55 is 8.04 N/sq.cm whereas the specific ground pressure of the T-62 is 7.95 N/sq.cm. In fact, the ground pressure of the T-62 could be considered to be on the lower end of the spectrum for medium and main battle tanks.

Exerting a nominal ground pressure of only 7.95 N/sq.cm, the T-62 was identical to the M60A1 (7.95 N/sq.cm) which was heavier by 12 tons but also much wider and longer. The T-62 was certainly better than the common M48A1 or M48A2 (8.24 N/sq.cm), and it was rather light-footed compared to tanks like the Centurions (around 0.95 kg/sq.cm for Mk. 3 and above) and the Chieftain (9.12 N/sq.cm), both of which are rather heavy tanks. Surprisingly, the specific ground pressure of the T-62 is slightly less than the Leopard 1 (8.44 N/sq.cm) although this does not really make much of a difference when all the other mobility factors are considered.

To improve the lifespan of the tracks, a new RMSh track design was developed by the Omsk Transport Engineering Plant with development concluding in 1962. Beginning in 1966, these new RMSh tracks were fitted to new-production T-62 tanks. The RMSh is a rubber-lined metal track design and is considerably more durable thanks to larger and tougher connecting pins and internal rubber bushings round each pin. A set of 97 links weighs 1,655 kg and the combined weight of two sets of tracks is 3,310 kg. All T-62M variants are fitted with the RMSh tracks as a standard component of the modernization. The installation of RMSh tracks increased the ground pressure (it is not wider than OMSh tracks), increased the load on the engine and thus decreased the power-to-weight ratio of the tank to 15.4 hp/ton.

The easiest way to tell apart an OMSh track from an RMSh track is to observe the ends of a track link. The older OMSh track has an open loop at the ends of the track links whereas an RMSh track doesn't.

ENGINE DECK

The engine deck was renovated twice since the original iteration in 1961. The original engine deck had maintenance hatches to allow easier inspection of the engine and air cleaner without removal of the engine deck. The hatches aren't very large, though, so doing any sort of detailed repairs will be difficult.

Replacing the engine or doing more extensive maintenance can only be done with the removal of the entire deck.

The T-62M brought with it a revised deck design with a large T-72-style engine access hatch, giving a clear, unobstructed view of the innards of the engine compartment.

Photo credit: Andrei Tarasenko's website

Based on the known armour thicknesses, none of the engine deck designs have enough armour to resist 30mm DU rounds from the legendary A-10 Warthog's GAU-8 cannon except on a very low angle of attack, but it is still strong enough stop the extremely anaemic 20x102mm cartridge, which isn't saying much, but very relevant given that the A-10 did not even exist until the T-62 was already well on its way out of Soviet frontline units.

COOLING AND HEATING SYSTEM

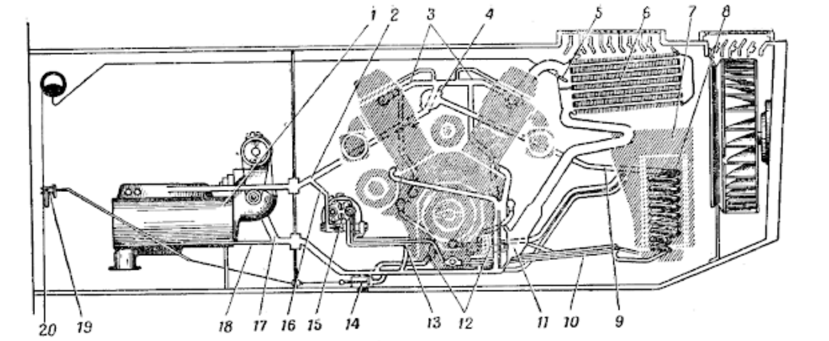
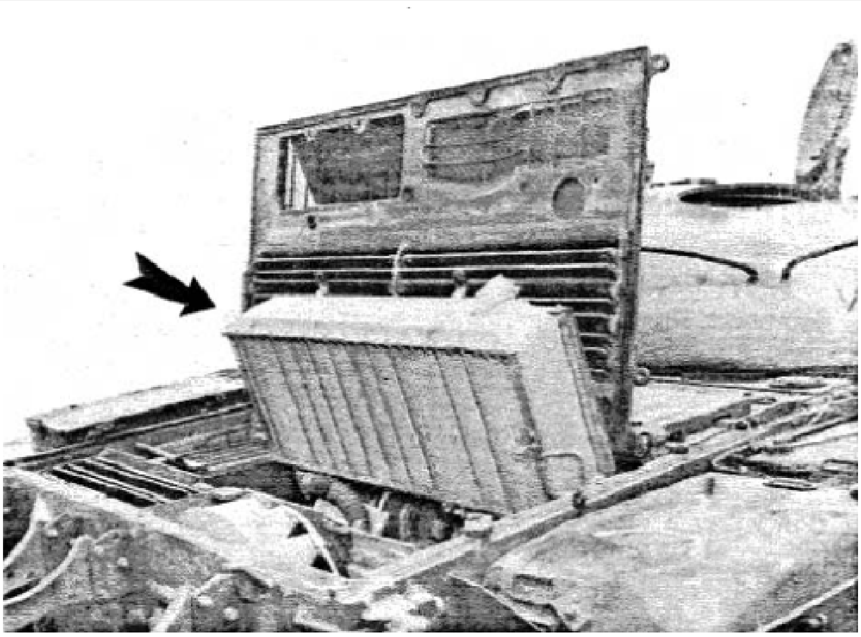


Рис. 163. Схема работы систем охлаждения и подогрева двигателя:

1 — котел подогревателя; 2 — трубопровод отвода нагретой жидкости; 3 — трубопроводы подвода нагретой жидкости в двигатель; 4 — кран отключения подогревателя; 5 — датчик термометра; 6 — радиатор; 7 — масляный бак; 8 — змеевик масляного бака; 9 — трубопровод подвода нагретой жидкости к змеевику масляного бака; 10 — кожух заборного трубопровода; 11 — водяной насос; 12 — трубопроводы подвода нагретой жидкости к нижней половине картера; 13 — кожух заборного маслопровода МЗН-2; 14 — сливной кран; 15 — маслозакачивающий насос МЗН-2; 16 — трубка подвода нагретой жидкости к маслозакачивающему насосу; 17 — трубопровод подвода жидкости к насосу подогревателя; 18 — трубопровод слива охлаждающей жидкости из котла подогревателя; 19 — рукоятка крана слива охлаждающей жидкости; 20 — термометр

The cooling and heating system of the T-62 is largely the same as the T-55 tank. The engine pre-heater is also the fighting compartment heater, and is located underneath the commander's seat in the fighting compartment. The cooling system is identical to the T-55, featuring a radiator in the engine deck and a centrifugal fan to circulate air through the radiator and out the tank.

The radiator can be accessed by lifting the hinged armoured radiator access panel. Directly underneath the radiator unit is the cooling pack into which coolant carries heat from the engine to be dissipated by air sucked in through the radiator unit and out the rear of the engine compartment via a centrifugal fan. Armoured louvers in the radiator access panel protect the cooling pack from damage.

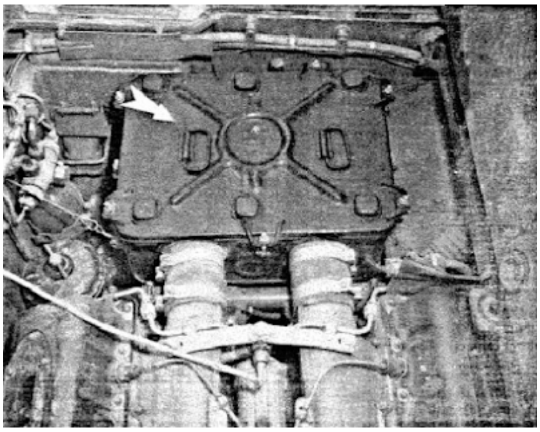


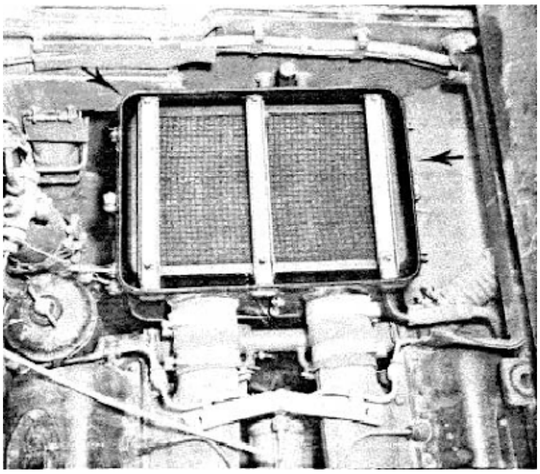
The fan is powered by the engine via a drive shaft connected to the gearbox, thus allowing the fan to meet the engine's cooling needs following its power output which is proportional to its heat output. The fan housing has its own armoured cover. When closed, the rubber seals around the edges of the cover prevent water ingress, allowing the tank to drive under water.

As mentioned before, the radiator access panel includes armoured louvers. These protect from air burst artillery and mortar shells or even molotov incendiary bombs, and they are further augmented by auxiliary armoured covers which must be manually closed, but can be sprung open with the press of a button in the driver's station. They add some protection from air attack but their main function is to seal the radiator from the ingress of water when fording deep rivers or snorkeling.

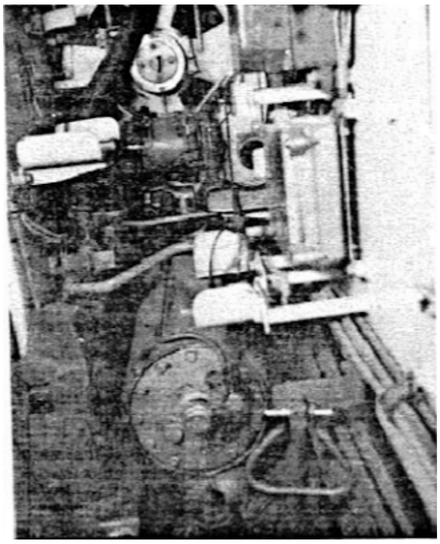

Engine air intake (Photo Credit: Alex Chung)

The VTI-4 engine air intake filter is located the beside the engine, just under the air intake grille. It is a dual-stage fabric-type filter, good for many hours of operation under highly dusty conditions. Dust is filtered out from the air to ensure that the engine is not clogged up and has sufficient oxygen to run at normal rates. Larger pollutant particles are ejected from the filters using the dust ejector, via compressed air.





When the engine air intake is sealed and the vehicle is underwater, the engine draws air from inside the hull via a respirator fan located just behind the commander's seat, on the partition between the engine compartment and fighting compartment. There is no filter in the respirator fan.


(Notice the fan duct at the top of the photo)

There is an electric air heater just in front of the fan duct and under the commander's seat (cylindrical tank in photo below). It supplies hot air to warm up the engine during cold weather, and it also functions as the heater for the crew compartment.

The tank's electrical supply needs are handled by four 6-STEN-140 accumulators located at the front of the hull, adjacent to the driver's station. These are lead acid batteries with a voltage rating of 12 V and an amperage rating of 140 Ah each. The four batteries are divided into two pairs connected in series and the two pairs are connected in parallel to double the operating voltage and amperage rating to 24 V and 280 Ah respectively. The batteries supply 24 volts when the engine is turned off, and the G-6.5 electric generator supplies 28 volts when the engine is running.

ROAD ENDURANCE

Fuel storage is divided between 3 internal tanks and 3 external tanks for a sum total of 960 liters. Two of the internal fuel tanks are also the two front hull shell stowage racks (as seen previously) and the other fuel tank is located at the starboard side of the hull, at the very rear of the fighting compartment, right next to the partition between the engine compartment and the fighting one. The two front hull fuel tanks hold 280 liters each, and the solitary fuel tank at the rear of the fighting compartment in front of the engine compartment partition holds 115 liters

Since all of the fuel tanks are interconnected, the driver-mechanic only has to top up the tank from one fuel filler port. There is one at the rear of the hull leading to the rear fuel tank:

(Photo credit: Evgeny Starobinets)

And another two for the pair of conformal front hull fuel tanks at the front of the hull:

The three external fuel tanks are mounted atop the starboard fenders, each with their own fuel filler caps. These external fuel tanks are part of the fuel system.

Here you can see how the fuel tanks are connected

Total internal fuel capacity is 675 liters, plus another 285 liters carried on the external fender tanks. An additional 400 liters of fuel is carried in two 200-liter auxiliary fuel tanks mounted on brackets at the rear of the tank to augment the tank's operational range. With all fuel tanks filled, the tank carries a sum total of 1360 liters of fuel. With auxiliary fuel tanks, the T-62 has a highway cruising range of about 650 km, or 450 km without. The cruising range on dirt roads with auxiliary fuel tanks is 450 km, and 320 km without.

As mentioned before, all of the fuel tanks are interconnected. The driver has a control knob located beside the right steering lever to select which set of fuel tanks he wants to draw from, choosing between the internal fuel tanks only, external and the auxiliary drums only, or all together, or the driver may cut off all fuel flow entirely. This is quite helpful if one of the tanks were to be compromised, because by shutting off a set of fuel tanks, the rate of leakage can be greatly reduced and this may even help control a potentially catastrophic internal fire if the driver reacts promptly.

WATER OBSTACLES

In the same pattern as the T-54 and T-55 preceding it, the T-62 was made to snorkel across large bodies of water down to 5 meters deep, or ford shallow waters as deep as 1.2 meters. Driving endurance under water was about 1 km, which meant that tank units could potentially disappear in one part of a river, snorkel down or upriver and appear in a totally different location to mount a surprise attack. The photo below shows a platoon of T-62s travelling down a river (though they are not snorkeling).

There are certain procedures that need to be followed prior to snorkeling, however. In order to prevent water from entering the engine air intake and radiators, they must all be sealed by locking their armoured covers down, and the bilge pump should be activated, which can be done with a switch on the driver's instrument panel. It is only necessary to close the armoured louvers for both the radiators and the air intakes when fording. Once the engine air intake is shut off, however, the engine must draw air from inside the tank through a respirator fan located just behind the commander's seat.

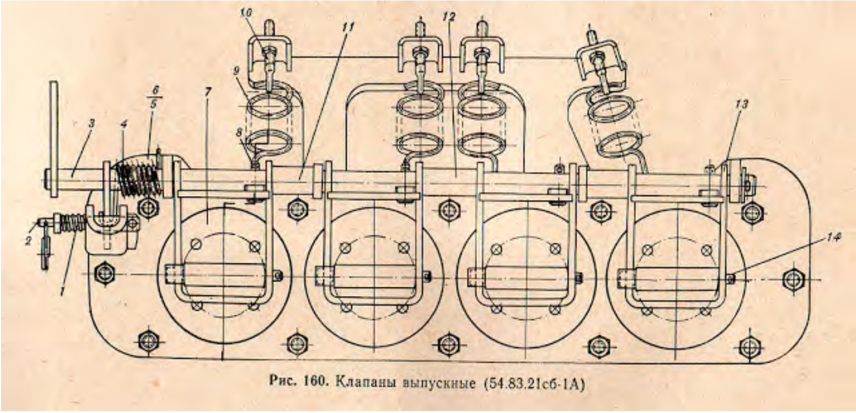


Рис. 160. Клапаны выпускные (54.83.21сб-1А)

When snorkeling, it is also necessary for the exhaust outlet to be sealed with a valve bank, which is a bolt-on cover for the exhaust outlet equipped with four spring-loaded circular exhaust ports that prevents exhaust gasses from being released until they can build enough pressure to blow out forcefully enough that water will not have a chance to leak in.

If the tank is to be snorkeling deeper than three meters, the last step is to seal all of the hatch gaps with a waterproof paste, which has the consistency of clay. The entire preparation process takes around 30 minutes for snorkeling, but the tank can readily ford across any stream without any preparations whatsoever.

The air supply for both the crew and engine is provided by the single snorkel erected from the turret roof.

The snorkel is broken down into three parts and latched onto the rear of the turret and under the auxiliary fuel tanks for convenient stowage during road marches and combat. The snorkel must be assembled on site by the crew before it can be used. It is possible to install only one or two of the three parts depending on the depth of the body of water to be crossed. The snorkel is installed in a small port in the turret roof, just in front of the loader's hatch. Once the tank resurfaces and drives off, it is not necessary to remove any of the snorkeling accessories except the snorkel (for obvious reasons), which can be simply cast away by pushing on it from the inside.

The porthole plug has a thick rubber seal to prevent rainwater from dripping into the tank, as do all of the hatches.

A wider type of snorkel is used during training. This type of snorkel fits over the commander's hatch, and is large enough to allow crew members to escape from the tank via an internal ladder. This is to help ensure that the crew does not drown underwater. These snorkels are not used in combat.

DISTRIBUTION

All in all, the Soviet Union churned out a total of about 20,000 T-62s. By the early 1980's, their numbers had dwindled down to around 14,000 T-62s in Red Army inventories, most in reserve, but many on active combat duty in Afghanistan. In Europe, the T-62 became an extinct species. By the year 1990, there were only 1,300 units left, and by 2013, the T-62 was completely erased from Russian warehouses and poligons alike. Besides the preserved examples in museums, the T-62 now litters the shooting range as hard targets.

When it was at its peak, however, the T-62 was not to be taken lightly on the battlefield. The T-62 could only be counted among the most advanced tanks in the world for a short period of time before it was surpassed by newer Soviet developments, but it still retained some parity with the best Western counterparts for some part of the two decades after 1961.