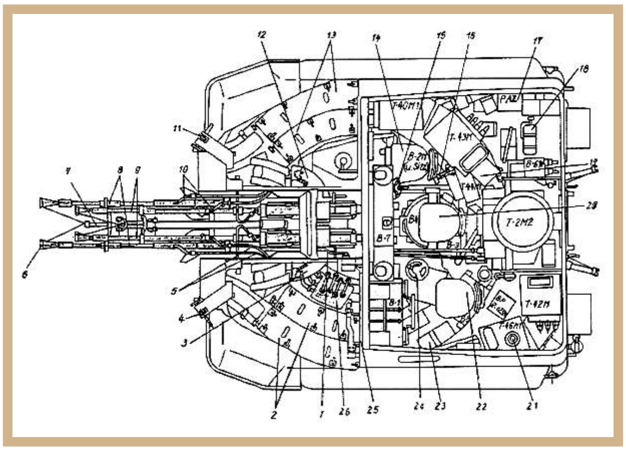
Soviet ZSU-23-4, "Shilka", Part 2

Picture 1:
This is the second part of a three-part series exploring the interior of the Soviet/Russian ZSU-23-4 Shilka. The photo shows the rear of the vehicle and the large radar dish on the turret. The turret houses three crewmen seated across its width, the commander on the left, search radar operator/gunner, and range operator on the right, along with their radar sets, fire control computers and gun stabilizers. The RPK-2 radar system is code named "Gun Dish" by NATO, and utilizes a circular antenna dish mounted on the rear of the turret. The data derived from the radar enables target aircraft to be identified as friendly or foe and provides target tracking parameters. It is also used to determine range and angle of engagement when optical sights are used. Roughly half a minute is required from radar target acquisition to gun engagement in automatic mode. The gunner can also engage targets using the optical sights mounted on the roof, and although the vehicle can fire on the move using its gun stabilisation system, it is far more accurate when stationary. Initial gun cooling systems were inadequate with the result of runaway guns, caused by overheated barrels cooking off ammunition prematurely. Improvements early in the development cycle of the vehicle reportedly cured this problem.

But there has been another cooling problem, this one caused by the large number of electrical systems packed inside the turret. As a matter of fact, the different models of Shilka manufactured over the years can be identified by the changes made to the turret and hull cooling louvers and vents. At the time the Shilka was first produced, the Soviets were not as advanced in solid-state electronic circuitry as the West, and most of their electrical components relied on older vacuum tubes. Vacuum tubes produce a tremendous amount of heat during operation, and cooling the numerous racks of electronics in the turret became a vexing problem for the designers.

The original series production ZSU-23-4 that exhibited the greatest number of cooling problems can be identified by the small air vent covers mounted on the sides of the turret. The ZSU-23-4V Model 1968 that came next was the first to be manufactured in significant numbers, but there were very few of these exported. The air circulation covers on the turret sides of the -4V were enlarged and extended down the length of the turret walls. The ZSU-23-4V1 was the first version to be significantly exported, and the first to be license manufactured outside the USSR, in Poland. Production of the -4V1 Model 1972 began in the early 1970s and continued through the 1980s, and more of this type were manufactured than any of the others. In this type, the vent covers were changed to large bulged panniers that included new vents as well as stowage bins. The large panniers cover most of the length of both turret sides, making these Shilkas easily recognizable.

The final versions of the vehicle were supplied with a revised electronics suite of mostly solid-state design (transistor based), and they are called the -4M. The ZSU-23-4M entered production in the late 1970s and has been exported widely, but not as widely as the earlier ZSU-23-4V1. The vehicle in our photos from the TTF is one of these 4M types, recognized by the large NBC (Nuclear Biological Chemical) air filter box on the right turret roof as well as other detail changes.



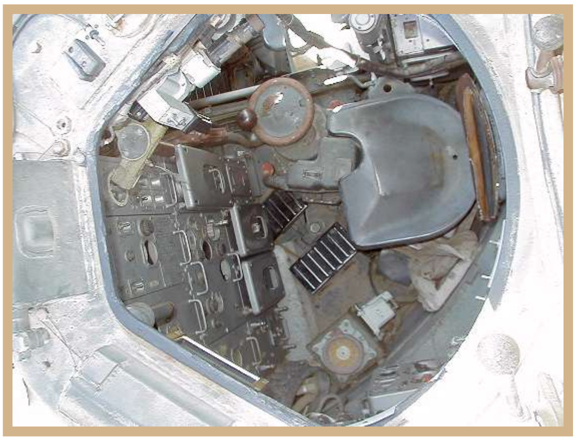
Picture 2:
This is a drawing from an East German manual of the turret interior components. You can clearly see the three seats aligned across the center of the turret, the gunner's in the center, the commander's to the left (bottom) and the range operator's to the right (top). Each seat is surrounded by a bewildering array of equipment and electronics. Directly in front of the gunner is the T-36M radar unit and screen, with the B-7 optical aiming periscope system mounted above. Although not seen here, directly in front of the gunner's seat, and below the radar screen, is his powered hand grip controls for elevation and traverse. To the right is his manual gun elevation handle (number 15). To his left is a hand wheel for manual turret traverse (24) the wheel located so both the gunner and commander can use it. The commander sits elevated above the other two seats and his seat can be further elevated on its base to allow him to sit head-out of his over-head cupola. To his immediate left is the navigation system (23) found in later Shilkas while in front of his position is the large B-1 electronics unit. Stepping over to the range-finder's seat to the right, we see the T-40M1 ranging computer to his right and the T-43M system behind him.

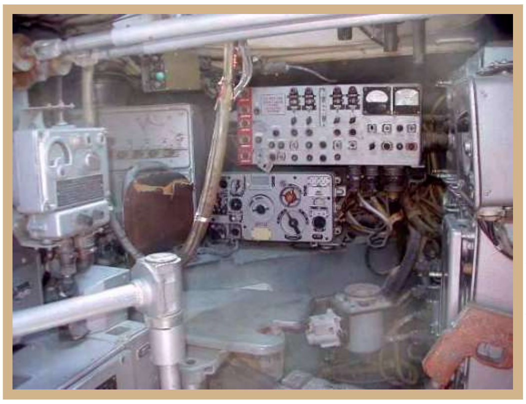
Forward of the center bulkhead are the four AZP-23 guns with ammo storage bins to either side. Each of these side bins is accessible via a large cover on the top of the turret, and once the cover is raised the individual magazines (13 and 2) are accessible. There are two curved rows of magazines on each side, and in the drawing you can see both the right and left side ammo feed chutes (3 and 12) leading from the ammo magazines to the receivers of the weapons. Part of the gun cooling system is seen on the left side of the guns' receivers (26) and some of the individual cooling tubes are identified (10). Both sets of top gun barrels (9) and bottom barrels (8) are visible here as well as the barrel covers (6) at the ends of the four tubes. Let's climb up on top of the turret and see what some of these components look like from inside.

Picture 3:
We have climbed up on top of the turret now and are looking toward the rear and down at the two open crew hatches. The base of the radar dish is to the upper left, the dish centered on the rear of the turret roof. The commander's cupola is to our right and has a simple hinged cover with a couple of latching handles and a rubber gasket around both the hatch and the cupola opening to make a water and air-tight seal. There are two periscopes mounted on the commander's cupola, one daylight TPKU-2 for forward viewing and one BM-190 for viewing off to the left-front, as you see here. The forward facing TPKU-2 day periscope can be replaced with an TKN-1T infrared night viewer with a visibility range of between 200 and 250 meters when using the FG-125 vehicle infrared lights to bathe the area in front of the Shilka with IR.

At one time there was another plain BM-190 angled off to the right of the central periscope, but it has been replaced with a mount for a small commander's auxiliary sight system on this and most other -4M vehicles. This commander's sight is a simple optical lens system that allows the commander to roughly orient the guns toward a potential target. Unfortunately, we do not have an illustration of this small sight system at this time. Behind the cupola, and slightly to our right, is the radio antenna base, the R-123 radio being located down in the commander's area on this left side of the turret. The hatch to our left is the larger gunner's and range-finder's hatch that we will see more of later. Notice at the bottom of the photo a portion of the optical periscope sight and its opened cover. There is another of these on the roof in front of the second hatch, out of view to our left.

Picture 4:
If we look down into the commander's cupola, we have this view of his seat and the surrounding equipment. The foot pedals on the floor in front of his seat are part of the powered traversing system; the range-finder also has a set of these at his position, while the gunner has handgrip controls. The B-1 computer system is the large array of electronic panels in front of his seat, and it contains a number of individual modules that can be pulled and replaced if malfunctioning or requiring updating. To the commander's left, sitting up on the turret lip, you can see part of his R-123M radio, the same set you find in tanks of this vintage. The horizontal handwheel at the right-front corner of his seat is the manual turret traverse, and his azimuth indicator is the dial in the square box seen at the lower edge of the hatch opening, actually mounted about the same level as his seat bottom.





Picture 5:
This is the view looking across to the commander's position from the range-finder's seat. Just above the turret ring on the left turret wall is the R-123M radio set (near the middle of the picture) and the larger box of the PK commander's electronics module is mounted above. The R-123M radio has a frequency coverage of 20-51.5 MHz in two ranges and an RF output of approximately 20W. The range is up to 28km, modulation is FM R/T only and the unit is powered by 26v DC. The azimuth indicator is seen again, now located below and to the right of the radio.

The box partially hidden behind his seat back (slightly out of focus in this picture) is the T-46M1, and the vehicle radio antenna base connection is directly above. I do not know the function of the two horizontal drive shafts crossing the ceiling, but they may have something to do with the optical sighting aiming system; the left periscopic sight is slaved to the radar, and this may be the mechanical connection between the components.

The smaller box at the far left that is slightly blurry in this photo is a DP-3B Roentgenometer that is a radiation detector and indicator. It is designed exclusively for use in vehicles, or even aircraft, and takes its power from the vehicle batteries. The DP-3B can measure radiation up to 500r/hr. The dial meter you see on the box at the upper left corner is the microammeter and the three buttons along the top of the box (next to the meter) are the illumination button, subrange switch light, and radiation warning light. Below these is a subrange knob which can be turned to a number of different positions. The small panel attached to the bottom of the unit contains the cutout switches and test button. Notice that there are two plugs on the bottom of the unit-- the one on the left is the power cord and the one on the right leads to the remote sensor which is usually mounted fairly close to this box. Notice the red handle of the gun firing trigger at the lower-right corner of the picture.

Picture 6:
Taken from approximately the same location, this photo shows the area below the commander's seat and includes some of the gunner's seat at the far left (missing its seat back cushion). Notice the post underneath and supporting the commander's seat has a height-adjusting lever that allows the seat to be elevated. The manual traverse handwheel is mounted between the gunner's and commander's areas so they can both use it, and you can see one side of the red gunner's power turret control grips at the lower right. These are the standard double handgrip type, in the US called Cadillacs, that provide powered control of both elevation and traverse through large electric motors and gearing systems.

The main armament consists of four belt-fed 23mm L/81 AZP-23 cannons grouped in a quad mounting that occupies the central-front of the large rotating turret, with ammunition bins on either side. Each of the weapons is stated to be able to fire 1,000 rounds per minute, although in practice this appears to be reduced to 200, normally fired in short bursts. Roughly 2,000 rounds can be stored in the turret bins and the cannons have a vertical effective ceiling of 2,500 meters (8,205ft) and horizontal of 7,000m (22,974ft). Elevation of the AZP-23 cannons is from +85 to -4 degrees and both the commander and gunner can engage targets using the power traverse, rotating the turret at a head-spinning speed of 45 degrees per second. Elevation is also powered, and both traverse and elevation have manual backup handwheels. Access to the turret is via two roof hatches, one for the commander and the other for the gunner and range finder, but bulkheads in the front of the turret isolate the weapons with no access from inside.

Picture 7:
As I mentioned earlier, the commander has two periscopes in his cupola, and this is the view of one of them. Notice the large wingnut underneath for quick replacement of the glass block if damaged. There is also an electrical connection for the anti-fogging/deicing feature common in Soviet vision blocks. The drive rod rising up to the right is the cupola directional ring rotator. It is connected by gears to the hull, so as the turret rotates, the degree ring you see here counter-rotates, and the commander can then determine how the turret is oriented compared to the hull. This simple system reminds me of the similar system we have seen in German WWII tanks, like Pz.III and IV.

The Shilka does not have deep fording (amphibious) ability. It is only capable of fording water up to one meter in depth. This is surprising, considering the long-standing Soviet interest in amphibious design. It also indicates that the Shilka was not designed to accompany front line armor units, but requires bridging equipment to maintain forward momentum during forward assaults. The armor protection of the Shilka is light, with a maximum thickness 9.4mm in the front hull and 8.9mm in the turret. Heavy machine gun fire, like that from the .50cal Browning M2, can easily penetrate the hull and turret, so again, this is not a vehicle that was designed to face concentrations of frontline enemy fire. As we mentioned previously, there is a collective NBC protection system that includes a PAZ radiation detection and warning system and an air filtration and overpressure system. The PAZ unit location is shown in the earlier turret sketch-- in the right-rear corner.

Picture 8:
As we continue our tour of the turret walls beginning from the commander's position, the next component we find is this box located directly behind the gunner's seat. This is the RPK-2 antenna dish control, raising and lowering the dish and providing control power for rotation. The radar dish, operating in the J-band frequency, is located directly over this area; you can see the indentation on the ceiling for the antenna base mounting. One of the black warning decals on the component box reads "Caution. Check closing of hatch on stern of turret before lower of aerial." By the way, it is common to see English labeling inside Soviet/Russian export vehicles. The rear turret hatch provides access to other electronic systems-- it is not a crew hatch. Notice the characteristic Soviet blue-lens interior light on the ceiling. To the far right of the J-band radar electronics unit is the DP-3B Roentgenometer that we saw earlier in Picture 5.

What is J-band? There are two systems for designating radar frequencies, an old one and a new one. The older or original system is based on wavelength of the emitter wave and the system was created during WWII. The first radar systems used in the war by British and US search radars was 23cm in wavelength, and this radar type became known as L-band (for "Long"). When shorter wavelengths (10cm) were introduced, they became S-band, S for "Short". When very short wave band fire control radars (3cm wavelength) entered service, they were designated as X-band radars because "X marks the spot". When a new intermediate wavelength system was then developed that was to combine the advantages of both long and short wavelengths, this new type was called C-band, C for "Compromise". Okay, then so far we have L-band, S-band, X-band, and C-band.

Picture 9:
The Germans used short wavelength radars and they selected a wavelength of 1.5cm. This became known as K-band, the K standing for "Kurtz", the German word for short. Unfortunately for the German system designers, they had selected the one radar frequency that is absorbed by water vapor, so the K-band radars did not work properly in rain or fog. After the war, this was countered by selecting frequencies either just over K-band ("Ka" or K-above) or just under it ("Ku" or K-under). And lastly, the very first radars that were produced operated with long (meter-long), wavelengths. These were later designated P-band (P standing for "Previous"). So now we have added K-band (including Ka-band and Ku-band) and P-band.

This nomenclature system was disliked by just about everyone who used it, so it was eventually replaced by a rationalized system based on frequency instead of wavelength (the number of times a wave is emitted in a certain time period instead of the length of the wave). The new designations ran from A-band to P-band. Since frequency is generally related the wavelength, the new system worked out this way: the Old P-band became the Modern A/B band, the Old L-band became the Modern C/D-band, the Old S-band became the Modern E/F band, the Old C-band became the Modern G/H band, the Old X-band became the Modern I/J band, and the Old K-band became the Modern K band. The Shilka radar operates in the J-band range, so therefore it produces a wavelength of 3cm or thereabouts, and would have been called a X-band system using the old nomenclature, just like some police speed radar units used in many countries around the world. By the way, most radar warning systems operate in D- to K-bands as these are the most commonly used, and most radar jamming systems operate at H-, I- and J-bands.

This is a good place to pause while we move over to the other side of the turret in Part 3 so we can examine the gunner's and range-finder's equipment in the Shilka.

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