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ALFA CLASS—THE 1960'S DREAM MACHINE

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The work on then Project 705 submarine (also known as the Alfa class) began in the Leningrad-based Specialist Design Bureau No. 143 (SKB-143, referred to since the 1970s as the *Malakhit* Design Bureau) in late 1958-early 1959. At that time the idea appeared to design a small displacement, high-underwater speed submarine optimized for ASW purposes. The idea was in general similar to that of Rickover's early 1950s SSKN—a light submarine, limited in displacement to about 1500 tons. The goal for full underwater speed was 40 knots.

The proposed submarine was to have single hull architecture with a titanium pressure hull, a single reactor/single shaft power plant and full automatization of all ship control functions. This would permit a corresponding dramatic reduction of the crew size—to just 9 officers and 3 warrant officers.

However, it became clear at the preliminary design stage that, at the targeted 1500 ton displacement, it would be technically unrealistic to reach the design speed and achieve a reasonable level of technical reliability. It was necessary to increase the displacement to 2300 tons. To save the situation, the SKB-143 designers studied several measures, one of which was to eventually cancel the full shielding of the power plant and instead to use lightweight *shade* shielding installed between the reactor and the crew spaces (the forward compartment). That was a very unpopular move, taking into consideration the problem posed by the accumulation of highly radioactive Polonium-210 in the irradiated reactor lead-bismuth coolant.

Nevertheless, even those measures did not allow a decrease of the displacement below 1900 tons. Moreover it was too difficult for the Navy at that time to accept the idea of a single hull submarine, since it was to operate from bases located beyond the Polar Ring, (i.e., the Arctic Circle) and in the absence of rear support at or near probable distant operational areas. Hence after the preliminary Project 705 design had been presented by the SKB-143 on December 31, 1960, a new Council of Ministers' decree was issued on May 27, 1961 requesting serious changes in the design—first of all a transition to double hull architecture, with a corresponding increase of the light ship displacement. Reassessed

estimates of the workload aboard the highly automated submarine led to an increase of the crew size to 18 men. (It was later increased once again to 27 men, and this became the crew of the first Alfa.)

The corrected design was prepared by June 1961, and became the basis for the technical design issued on December 11, 1961. The lead ship of the class (the original Project 705 ship) was laid down at the Admiralty Yard in Leningrad on June 2, 1968. Work on the long-lead components had begun in 1964. The lead Project 705K ship was laid down at the Northern Mashinbuilding Plant in Severodvinsk on November 12, 1967. (It is worth mentioning that the Project 705K lead ship did not enter service until September 1981!) There were seven Alfas built, including the lead ship, though the lead ship was retired in 1972 after less than a year of service as the result of a serious power plant incident.

The Technical Project 705 ship is a highly streamlined Albacore-type, all titanium, double hulled submarine; its pressure hull is made of titanium alloy with a yield of 70 kgf/sq.mm (100 thousand psi, i.e., equivalent to an HY-100 steel). The length of the submarine is 79.5 meters and the beam is 9.5 meters. The submarine's operational depth is 320-350 meters and its test depth is 400 meters. (Hence Alfas were never intended and/or able to operate at depths down to 700 and even 900 meters as was widely believed in the West.) The submarine's surface displacement is 2310 tons and the full submerged displacement is 3980 tons (3120 tons not counting water encased in the outer hull).

The escape chamber (the VSK) for the whole crew was installed in the sail and was a unique feature of Alfas in the 1960s. It had been tested with men aboard during a real surfacing from the submarine's test depth in the early 1970s.

There are two variants of the Alfas' main power plant: the BM-40A and the OK-550. Both use the same FEI's basic design with lead bismuth eutectic as the coolant in the first loop.[1] (Consideration of a gas-cooled reactor studied in the earlier stages of design work was dropped.) The design of the first loop constitutes the difference between the two reactors: the more densely packed BM-

[1] *Eutectic*: Of the greatest fusibility, that is, an alloy or mixture whose melting point is lower than that of any other alloy or mixture of the same ingredients.

40A had two much higher power loaded steam generators and main coolant pumps and very short piping in the first loop. The OK-550 had three steam generators and coolant pumps with more traditional (for the period) long pipes connecting the reactor with steam generators and the latter with the turbine. The design of both power plants was being done in parallel in the Podolsk-based *Gidropress* Design Bureau (BM-40A) and Gorkiy based OKBM (OK-550) to assure against the failure of the more promising but much more difficult to realize BM-40A.

The BM-40A is used aboard the Severodvinsk-built Project 705K ship while the OK-550 is the power plant of Admiralty built Project 705 ship. (The ZhMT index frequently associated with Project 705 submarines—as Project 705ZhMT—is the Russian acronym for *liquid metal coolant*. Both reactors have thermal power of 155 MW and produce superheated steam with temperatures in the range of 790 to 1000 degrees Fahrenheit. The single Kaluga built OK-7 combined turbine/reduction gearing turns a single shaft with a small diameter high rate-of-turn propeller. The 38,000 shp output of the Alfa's power plant provides it a full underwater speed of 41 knots (14 knots while surfaced). Two 136 shp electric motors mounted on the aft horizontal planes are the emergency propulsion and maneuvering aid. Two 1500 kW autonomous turbine alternators provide the power supply. A diesel generator set and a battery are the backup sources.

The Alfas are equipped with the MF/LF/*Kerch* integrated sonar, which included passive and active detection, sonar intercept, and underwater telephone subsystems. *Kerch* utilizes a single 4.85 meter diameter, 1.45 meter high cylindrical array. Combined with the HF active *Zhgut* (Mouse Roar; mine avoidance), *Tissa* (acoustic log), *Luch* (sound velocity meter), *Rosa* (navigation), and *Vint* (self noise measurement) sonars, the *Kerch* constitutes the larger MGK-100 *Enisey* sonar suite.

Six 21 inch torpedo tubes with rapid loading systems (the UBZ) are the main armament of Project 705 submarines. Each hydraulically actuated UBZ is a pair of torpedo racks joined together. They are able to move across the torpedo tube's longitudinal axis with subsequent loading of a torpedo into the tube by a hydraulic ram. The process is fully automated, but a petty officer—a torpedoman—is present in the torpedo room to monitor the system and intervene in case of a serious system failure. The maximum

combat load of Alfa is 18 torpedoes/anti-submarine rockets, providing that the tubes are loaded. The air hydraulic ejection system makes it possible to fire torpedoes at any depth down to the test one.

A novelty of the Project 705 submarine in the 1960s was in her being armed with the RPK-2 *Viyuga* (SS-N-15) ASW missile system with 81R torpedo tube-launched rockets. The submarine's *Akkord* FCS permits firing both self-homing and wire guided torpedoes as well as straight runners.

The crew of Project 705/705K submarines was originally 27 men (24 commissioned officers and 3 warrant officers). The experience gained during the testing of the K-377 prototype Project 705 submarine led to a decision to add three warrant officers (for sounding patrol purposes) and one petty officer (torpedoman), thus increasing the crew to 31.

The original design of the Project 705 submarine included only three compartments, but the Navy intervened when the lead ship had already been laid down and requested increased compartmentalization. Thus three additional bulkheads were installed. The Navy's intervention was so late it made it impossible to change the locations of some big pieces of equipment, and this has led to probably the most unusual bulkhead design in all the world's submarines. Indeed, to go around equipment, the bulkhead between the Alfa's first and second compartments not only has a very complex shape, but moreover at some places constitutes some parts of the first compartment's decks!

The bulkheads of the third (originally the second) compartment are concave and are designed to withstand an over pressure of 40 kgf/sq.sm (i.e., a depth of 400 meters).

The six compartments of the Project 705/705K submarines (see Figure 1) are: (I) the torpedo room and sonar equipment room, (II) the battery and auxiliary diesel generator set, (III) the control room and living spaces, (IV) the reactor room, (V) the turbine and main gear compartment, and (VI) the auxiliary machinery room.

The Alfa's control room—probably the most spectacular part of this early 1960s vintage submarine—is designed on the basis of the same approach as was proposed in the United States in 1958-1965 under the SUBIC program: the real SUBmarine Integrated Control. All (sic!) Control stations of the submarine are placed on the upper deck of the 3rd compartment. The *Malakhit* designers went along

the SUBIC concept even further than their U.S. counterparts: the maneuvering and automated damage control consoles are also located in the control room.

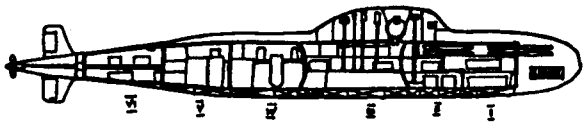

Figure 1

The highly compact (about 10 feet wide, 25 feet long) control room of the Alfa is organized as two functionally separated areas—the alley of ship control stations on the port side and the attack center to starboard, with the command station located aft to make all stations visible to the CO. (See Figure 2.)

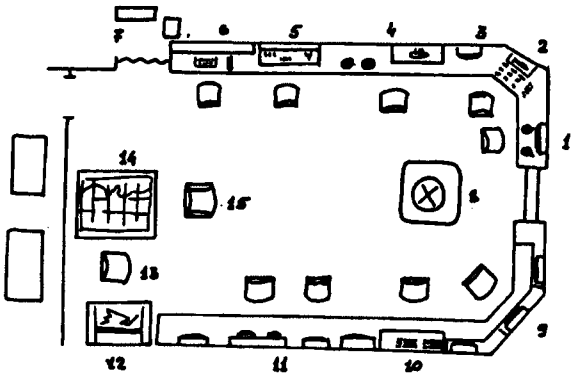

Figure 2

Legend:

1. Ship-control station
2. Ballast control
3. Damage control
4. EOOW
5. Electric power supply control
6. Communications
7. Bulava consoles
8. Periscope stand
9. FCS displays
10. Weapons control
11. Sonar displays
12. Automatic plotter
13. Navigator's seat
14. Plotting table
15. CO's chair

The single man ship control station is at the foremost part of the portside control consoles, to the port of the passageway which leads to an airlock connecting the control room with the second compartment and the exit to the escape chamber. A helmsman (usually a warrant officer, although some submarines had a Captain 3rd Rank, i.e, an O-4, at the helm) controls the submarine with two joysticks (instead of one, as in the FY 65 US SUBIC proposal). Nevertheless, all the controls can be connected to one of the joysticks in the most complex situations.

The *Boksit* system—its multi-functional display is installed over the ship control panel—is used as the important piloting aid. The main Boksit regime is a combination of the *road in the sea* display (like in the US CONALOG) and a sort of equivalent to the US SQUIRE display; but it differs from the latter in showing a constantly updated ship's predicted position for the case in which all measures to reverse a maneuver currently underway are undertaken at this specific moment; the SQUIRE system projected ahead the consequences of control plane movements. The *Boksit* display can be also switched to the *Sever* under-ice sonar, or the *Tissa* acoustic log, or the MT-70 underwater television system that is mainly used as an aid during surfacing from under ice. The push button ballast control station is adjacent to the helmsman's position; it is manned by an engineer who also monitors all the submarine's pumps, high- and medium-pressure air systems, and other auxiliary equipment. In case of an emergency or combat damage he also remotely seals the inter-compartment hatches and controls the automated damage control systems from the nearby panel. He can use a closed circuit TV system (its monitor is installed above the damage control panel) to assess the situation; this CCTV is routinely used for remote monitoring of the unmanned compartments.

Next to the damage control watch officer is the EOOW (the VIM, or "watch engineer", in Russian Navy parlance) station. It includes two separate consoles: reactor controls and turbine controls. Both are usually manned in the project 705 submarines by one engineer—the power plant can be controlled by one handwheel-like controller in a wide range of power outputs. Flanking the maneuvering console is one more engineer department console that is used by the third engineer on watch to control the submarine's entire electric power supply system including the work

of the turbo alternators. Auxiliary motors are also controlled from this console.

The integrated communication center (Alfas have the *Molnyay* communication suite) is located immediately aft of the electric systems control console. This combat station is constantly manned by a communication technician of the rank of warrant officer. Also on the portside in the very tight space further aft from the communication center are the *Bulava* ESM consoles and the ship ciphering equipment, hidden from the rest of the control room by a thin wall and a curtain closing the entrance to the ESM space.

All the combat stations, except the *Bulava* consoles combat stations related to sonar operations and fire control, are located on the starboard side of the control room. The *Akkord* operator station with three displays is just across the passageway from the ship control station. The Project 705 submarines were the first Soviet submarine Project (class) to be equipped with a computer based integrated sonar/fire control system—the BIUS *Akkord* (BIUS is the Russian acronym for "combat information and control system"). *Akkord* uses each one of them and prepares presettings for weapons to engage all three targets in rapid sequence (the firing rate of the torpedo tubes is the limitation).

Further aft is the Alfa's *sonar room* with the underwater telephone controls on the foremost console and three side-by-side sonar control consoles for active detection, sonar intercept, and passive detection respectively. The row of the *tactical* combat station is ended by the horizontal automated plotting board. The inertial navigational system of the submarine's *Sozh* navigational suite is situated abaft the control room; three gyros are further aft.

The second deck of the third compartment is occupied by the living spaces for all of the original Alfa's crew (27 men). Everyone has his own bunk—about the size of bunks aboard the U.S. Los Angeles submarines—with the CO having the only private stateroom. A head, two toilets, air conditioning, electrical switches, and the VIPS acoustical decoys ejector are also located on this deck.

The galley with adjacent wardroom with seats for 12 is located on the lower deck. The provisions cisterns flanked by the TDU are across the passageway from the galley. The rest/sporting area with a pair of armchairs and trainers is next to the wardroom. There is also some life support machinery on this deck.

Several modifications of the Project 705 were proposed in the late stages of the design work. The Project 705B SSBN resembled in its general design principles the US interim SCB-180A design. Like the George Washington class—basically the Skipjack with an inserted missile compartment—the Project 705B submarine was to be a 4200 ton high speed submarine with a compartment for a single row of the R-27 SLBMs of the D-5 missile complex inserted into the Project 705 hull. The appearance of the 705B project in 1963-1964 was SKB-143's unsuccessful attempt to participate in the US-style SSBN-design race underway in the Soviet Union at that time between several submarine Design Bureaus.

Another attempted modification of the Project 705 SSN was the mid-1960s preliminary Project 705A SSGN design. It proposed installation of P-120 *Malakhit* (SS-N-9) ASCM tubes in the forward ballast tanks of the lengthened (to compensate for the increased weight at the ship's bow) Project 705 submarine. Like the Project 705B, this design, which at some point had the designation "Technical Project No. 686", was canceled and the less expensive Project 670M (Charley-II) was designed instead of it in the Gorkiy-based *Lazurit* Design Bureau as the modification of the existing Project 670 (Charley-In) SSGN.■

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