A VISUAL GUIDE TO THE S-CLASS SUBMARINES 1918-1945
PART 2: THE GOVERNMENT BOATS

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BY

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Of the three Fiscal Year 1917 800-ton submarines, Electric Boat's *S-1* and the Government's (the Bureau of Construction & Repair, aka C&R) *S-3* were continued with series production. The Navy strongly desired an in-house design and construction capability, and the workers at Portsmouth were eager to show what they could do. The yard promptly continued with *S-3* follow-on units. The first group consisted of *S-4* through *S-9* and they were all built on large covered building ways along the Piscataqua River in Kittery, Maine. They were near copies of the *S-3* pathfinder. *S-4* through *S-8* were laid down before *S-3* was even launched, with *S-9*'s keel following shortly thereafter.

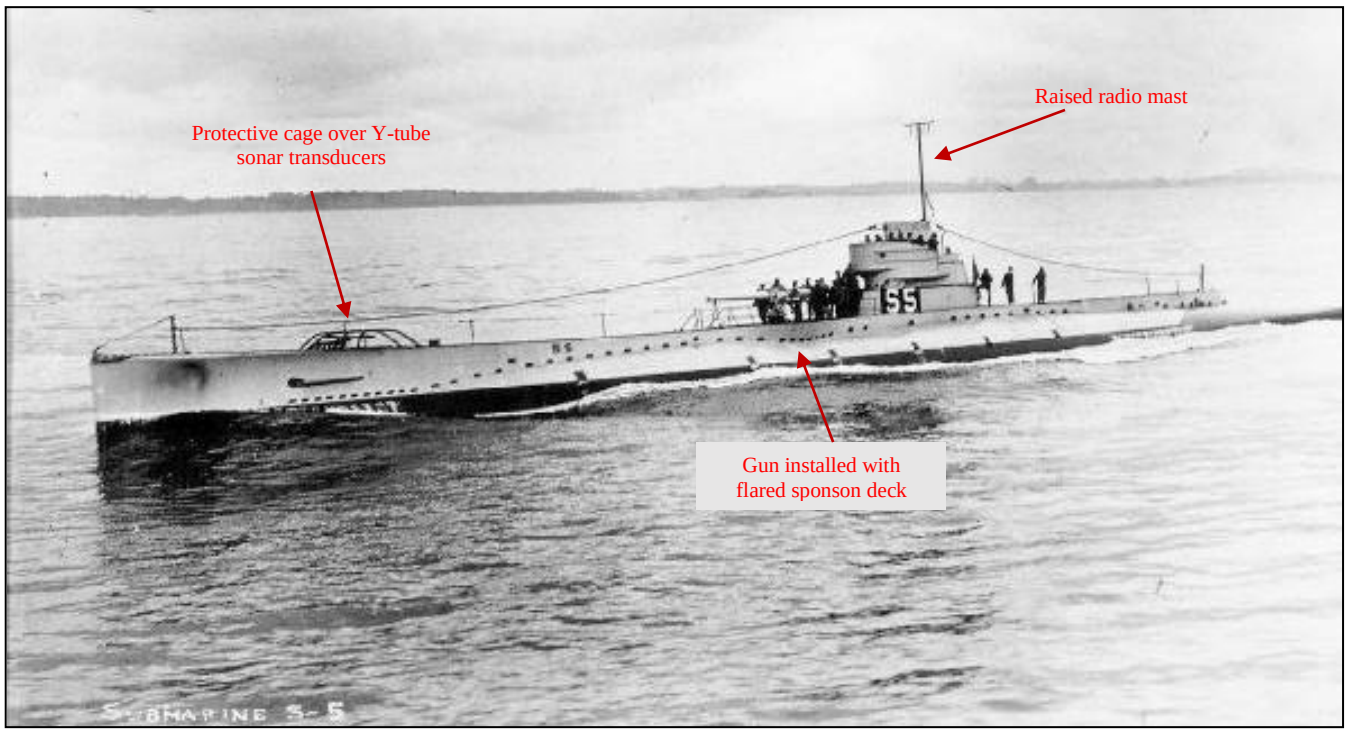

Fig. 1. S-5 on trials, early 1920. Photo courtesy of the Milne Special Collection, Univ. of New Hampshire Library via PigBoats.COM.

Figure 1 is an excellent shot of the ill-fated *S-5*, probably while on trials in early 1920. Unlike the prototype *S-3*, all of the follow-on boats were built with the gun mount foundation already installed and the deck sponsons flared out around the mount, although several boats did not actually have their 4"/50 caliber Mk 9 gun installed until after commissioning. The cage structure on her forward deck protected the three conical rubber diaphragm "rats" of her early Y-tube sonar. Sonar installations were somewhat inconsistent as the Navy experimented with different types.

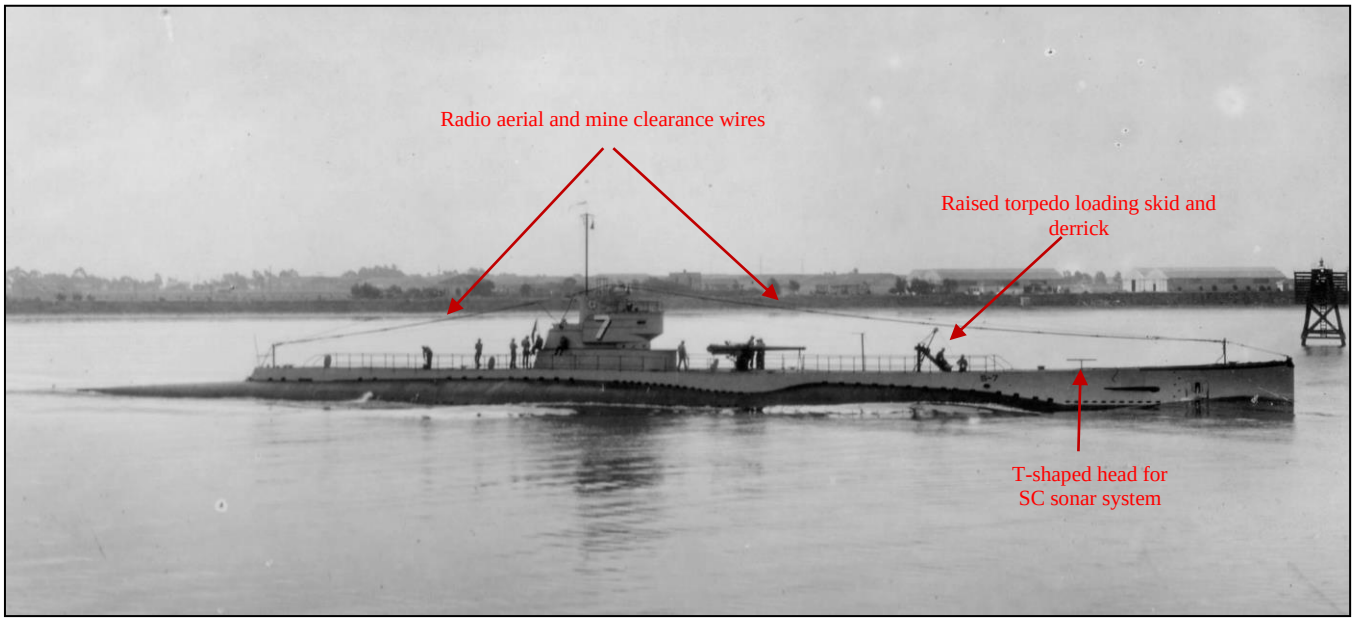

Fig. 2. S-7 returning to port after a torpedo exercise, mid 1920s. NARA photo 19-N-20291 via Navsource.

S-7 is shown in Figure 2 returning to port after a torpedo exercise. At this point the Y-tube sonar had been replaced with a T-shaped rotatable head for the SC sonar. This gave the boat the ability to determine a reasonably accurate bearing to the target. Note also that the torpedo loading skid has been erected on the forward deck, with the torpedo retrieval derrick next to it. Exercise torpedoes were fired with a non-explosive warhead and the expensive weapons were retrieved by the boat after the shot and re-used. The wires running from the bow up and over the conning tower fairwater were combination long range radio aerial and mine clearance wires.

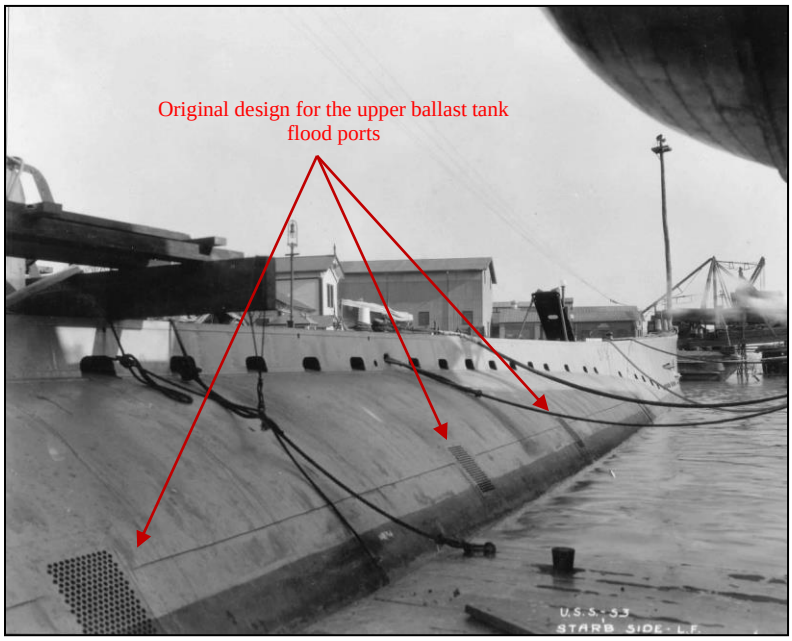

Fig. 3. Original design for the upper ballast tank flood ports. NARA photo 19-N-2676 via Navsource.

In an effort to preserve surface buoyancy, the Government design split the main ballast tanks into upper and lower sections, each with their own vents and flood ports. This had the unfortunate side effect of making the Government design very slow divers. The upper tanks would not begin to flood until the boat had settled enough to submerge the upper flood ports (Figure 3). This was an often criticized feature of the Government design which couldn't be changed. In an attempt to overcome this issue, a revised upper flood port arrangement was developed and retrofitted to the boats in subsequent overhauls. It reduced the size of the ports, but greatly increased their number. Figure 4 shows a port side shot of *S-6* and these new flood ports can be easily seen. The new ports did not fully alleviate the problem and only slightly reduced dive times. The Government boats were rated at 100 seconds from fully surfaced to periscope depth, as compared to the EB boats at 75 seconds.

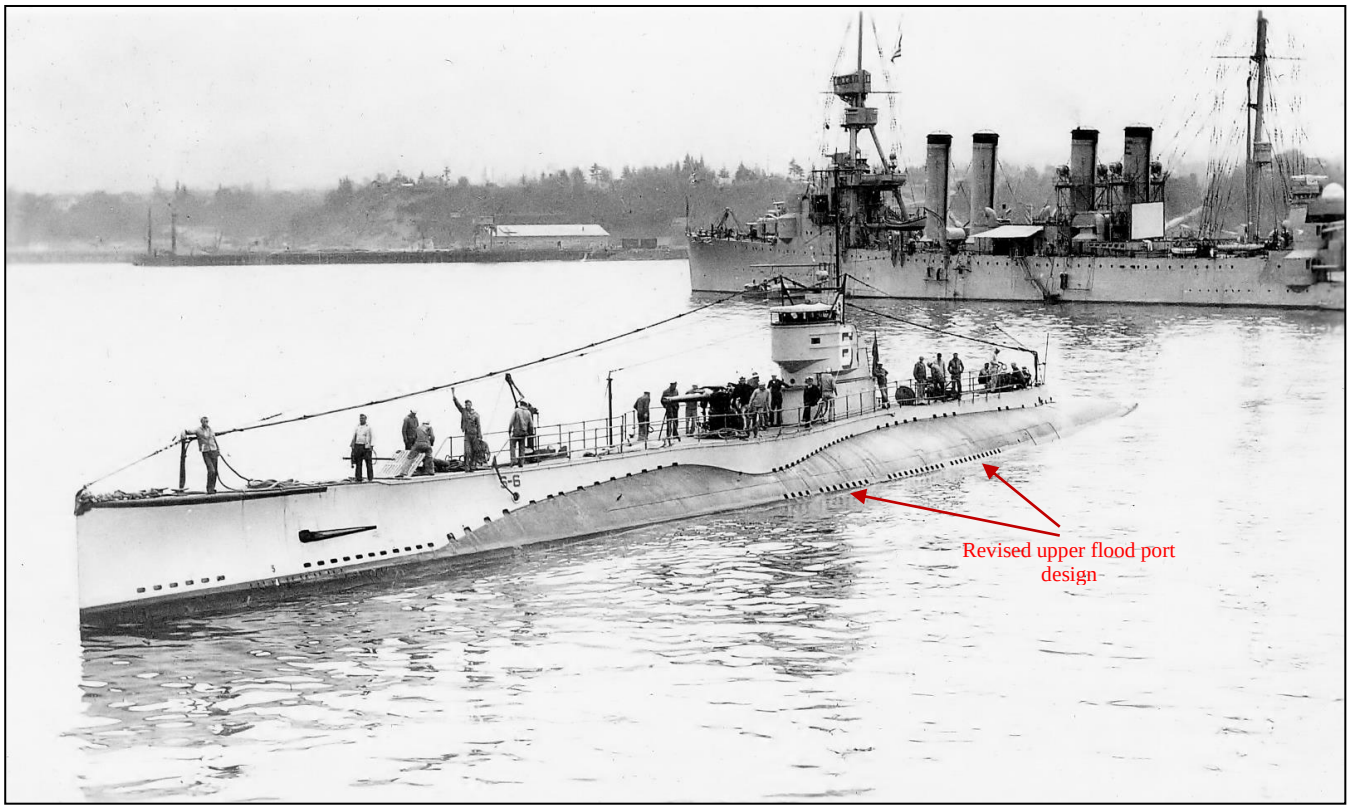

Fig. 4. S-6 with an Omaha-class light cruiser, mid 1920s. USN photo via Navsource.

In an attempt to further alleviate this problem and speed dive times, *S-8* and *S-9* were modified during construction, moving the bow diving planes below the water line and making them non-retractable. An angle iron guard was built around the planes to prevent them from being damaged by tugs or by contact with the pier. Figure 5 shows *S-9* alongside *S-7* and *S-3*. The absence of the bow plane slit in the forward superstructure is readily apparent when compared to the *S-7*. Note also the notation "Bow Planes Keep Clear" on the *S-9's* forward superstructure warning tugs and other craft of the bow

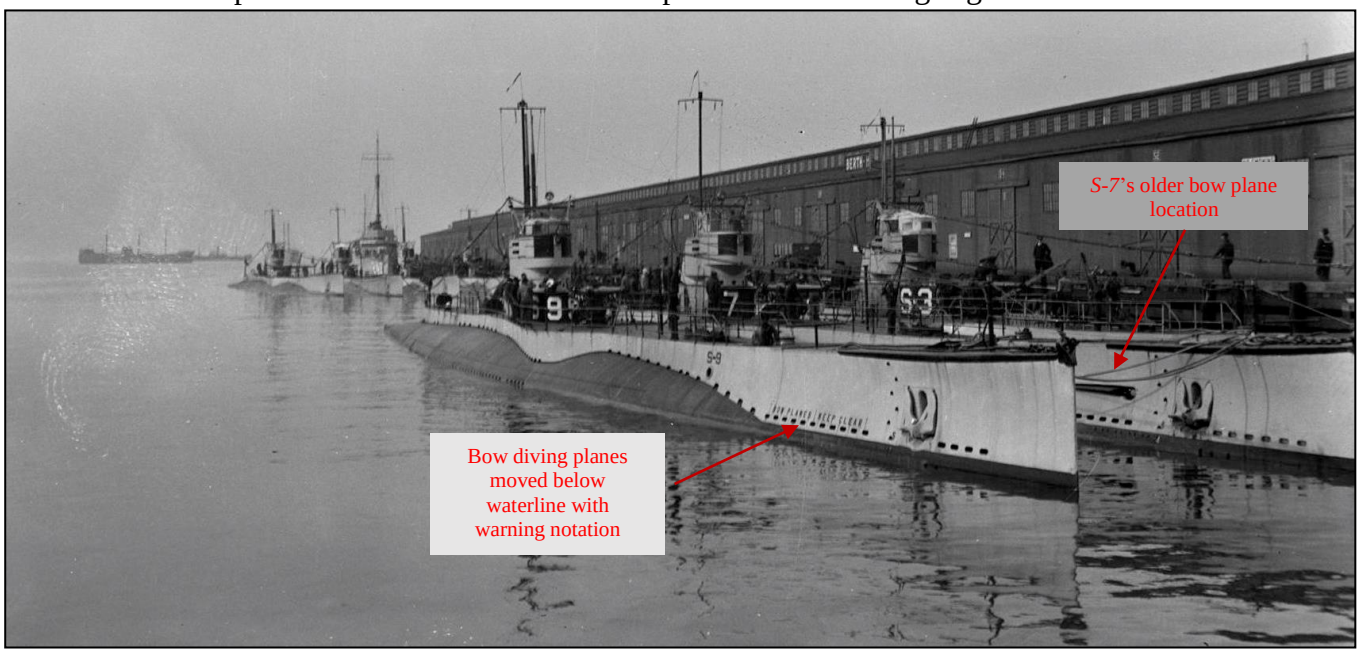

Fig. 5. S-9 with other Government design S-boats, mid 1920s. Photo courtesy of texashistory.unt.edu via Navsource.

planes below the waterline. This configuration became the preferred one for the Government design boats, with eight additional submarines built with below water bow planes.

Figure 6 is a close-up of *S-8* pulling up to the pier at a chilly Charlestown Navy Yard in Boston, 01 March 1928. This photo gives a good view of details of the deck gun, the conning tower fairwater, and the new design of the upper ballast tank flood ports. The circular "deadlight" viewports in the

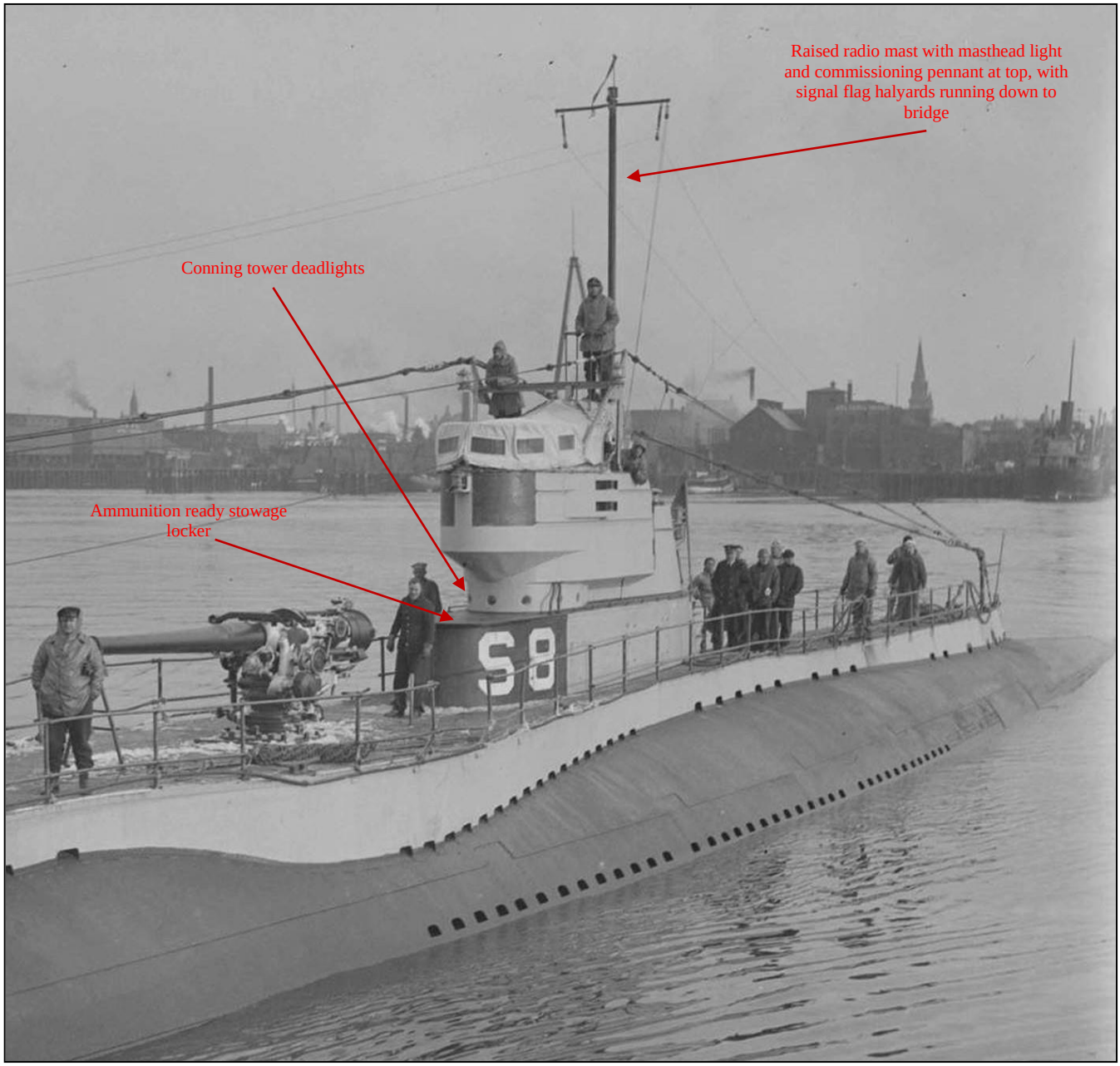

Fig. 6. S-8 entering port at Charlestown, Mass. on 01 March 1928. Photo courtesy of the Boston Public Library, Leslie Jones Collection via Navsource.

conning tower can be clearly seen. The black painted forward extension of the fairwater contains a ready-use ammunition stowage locker. This locker would be replaced in the *S-48* group by a full gun access trunk leading to the control room below. To help protect the bridge watchstanders from the cold Massachusetts air a temporary canvas awning has been erected on the top of the bridge. The T-shaped radio mast has been fully raised and good details of the radio aerial and mine clearance wires can be seen. Two thin lines run from the tips of the T to the bridge. These are halyards for signal flag hoists.

In Part One it was shown that the Government design had a highly tapered stern that ended in a sharp vertical “chisel”. The rudder, stern diving planes, and the propeller shafts were mounted ventrally, underneath the stern, as opposed to the Electric Boat style axial mounted arrangement. Figure 7 shows the aft end of *S-8* in drydock and gives a good view of the characteristic stern of this group. You can also see the unusual arrangement of the stern diving planes, one large plate suspended on its own pivot posts above the rudder, supported by the propeller guards.

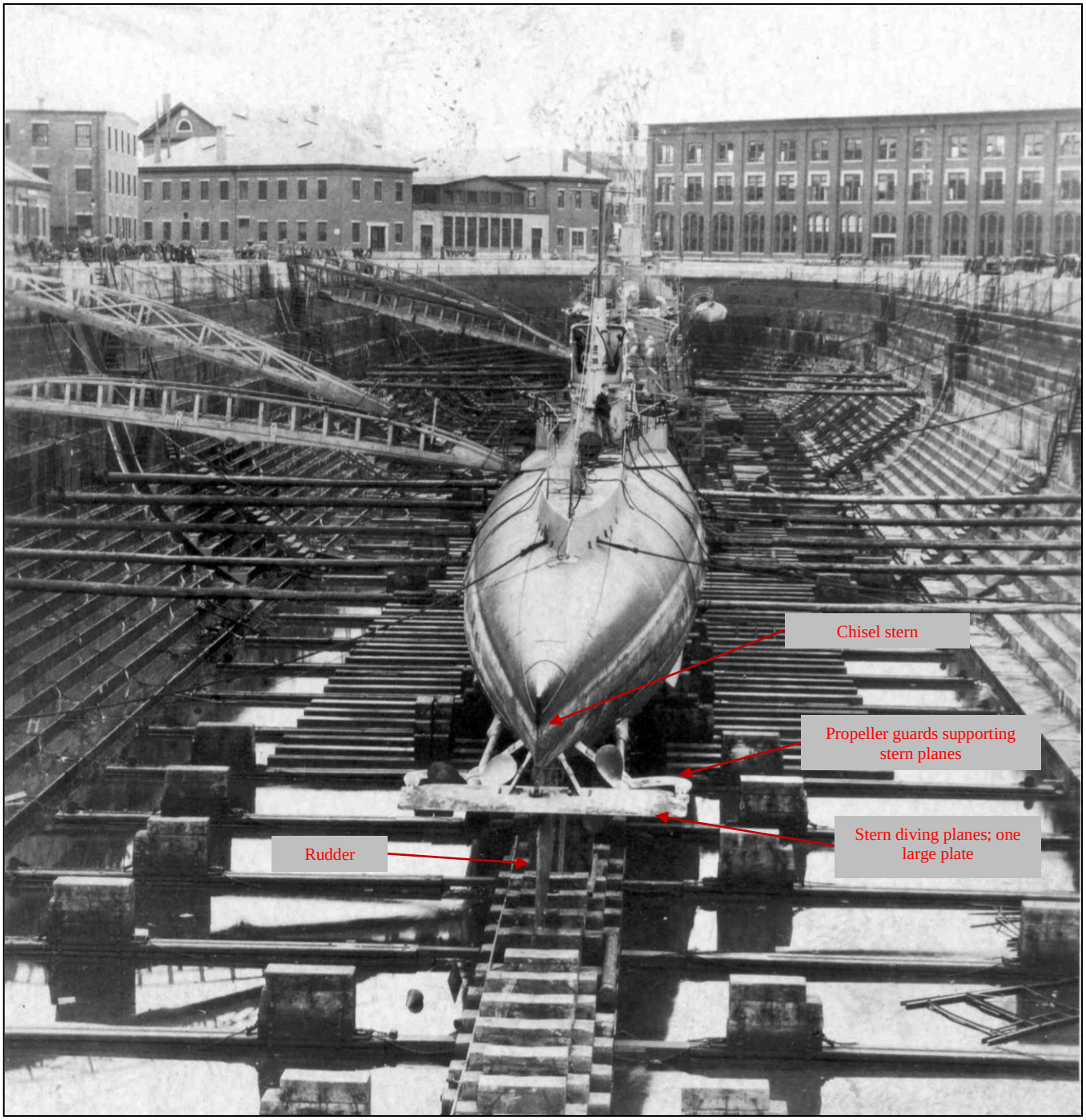

Fig. 7. S-8 in drydock, mid 1920s. USN Photo courtesy of Charles Hinman via Navsource.

Just as the Government design for the *S-3* group was being put into production, intelligence reports from the war zone in Europe left the Navy's General Board and the C&R designers in Portsmouth deeply impressed with the tactical advantage enjoyed by German U-boats with a stern torpedo tube. They immediately set to work to revise the design for the 2nd group of boats. *S-10* through *S-13* had their construction delayed while the revision was finalized and worked into the production

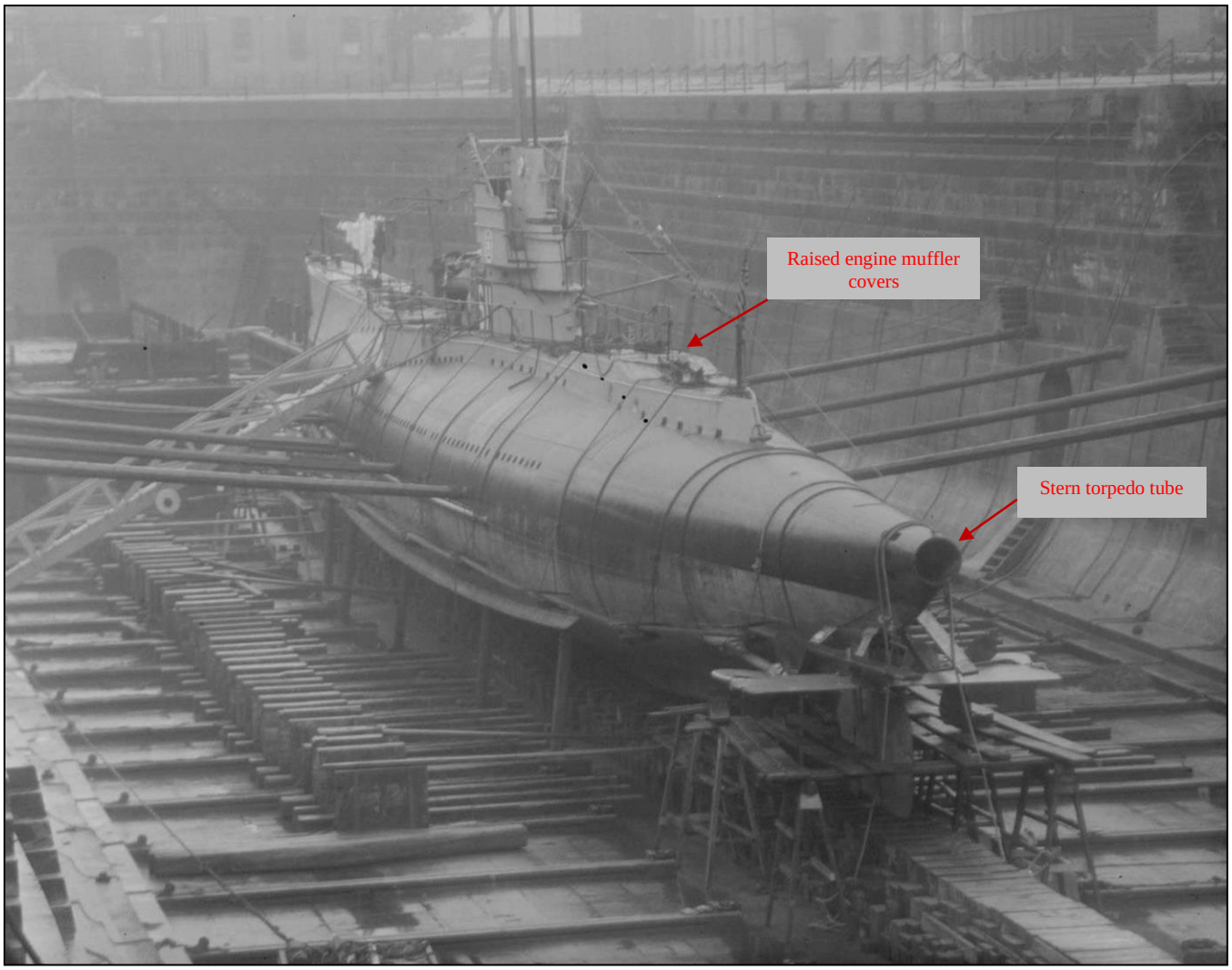

Fig. 8. S-11 in drydock at the Charlestown Navy Yard, Boston, mid 1920s. Photo Courtesy of the Boston Public Library, Leslie Jones Collection via PigBoats.COM.

schedule. The revision gave these boats a single aft 21-inch tube, with the breech letting into the large motor room that this design already had; no separate torpedo room was provided. Two weapons could be carried, one in the tube and one slung from the overhead, with space beneath the reload weapon that would allow the tube loaded weapon to be removed from the tube for maintenance. This also necessitated extensive modifications to the tiller room at the very stern, a separate watertight compartment that housed the rudder operating gear. The tube greatly altered the characteristic chisel stern giving these boats a unique stern silhouette. *S-11* is shown in drydock in Figure 8 with her stern torpedo tube prominently visible. The chisel was gone, replaced by a finely tapering stern surrounding the round tube. The outer muzzle door of the tube was actually *inside* the aft superstructure, just forward of a set of free flooding vents, with the door opening downwards. These vents can be seen in Figure 9, which is a shot of *S-10*'s stern. This photo also provides a good view of the propeller, rudder, and stern diving plane configuration.

Fig. 9. Stern of S-10, 20 February 1922. NARA photo 19-N-9134 via Navsource.

The *S-8/S-9* bow plane modification was well liked so it was continued on these boats. Figure 10 is a launch day photo of *S-10* and it gives a good shot of the bow plane and guard arrangement. To keep the bow at the desired angle once the boat hit the water, a temporary wooden beam and two blocks have been installed and lashed under the plane guard, bracing the plane and holding it in place. This brace would be removed after launch.

Electric Boat had been strongly criticized for the poor performance of the diesel engines made by their subsidiary, the New London Ship & Engine Company (NELSECO). These engines were license-built derivations of the German Maschinenfabrik-Augsberg-Nurnberg

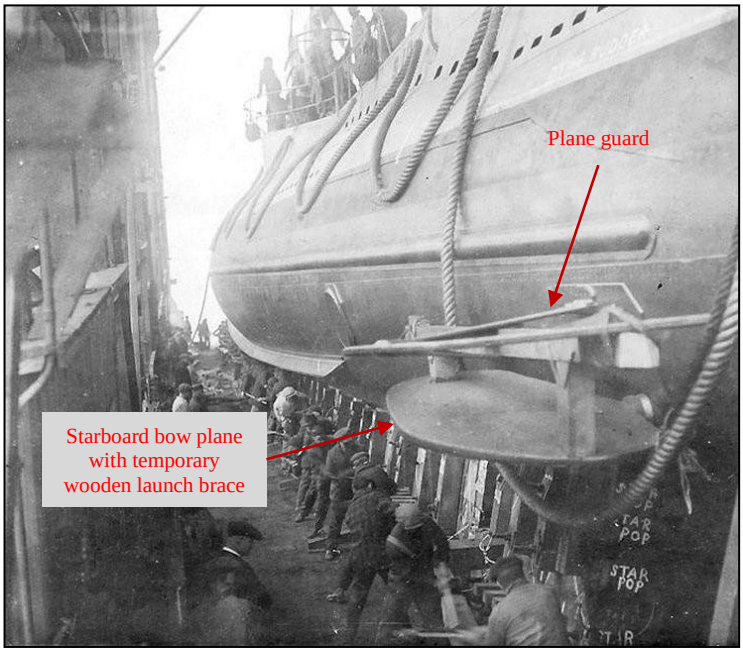

Fig. 10. S-10 on launch day, 09 December 1920. NHHC photo NH 41770 via Navsource.

(MAN) company designs. Inferior American metallurgy and manufacturing processes of the time made these copies less than perfect. They suffered from excessive torsional vibrations that frequently broke crankshafts and destroyed the engine. Unfortunately, at the time the NELSECO engines were the only ones that would provide the necessary horsepower in a package small enough and light enough to fit into a submarine hull. The Bureau was forced to purchase the NELSECO designs and built engines directly from NELSECO plans at the Washington and New York Navy Yards, although with a slightly larger cylinder diameter that seemed to help reduce the vibrations somewhat. These engines were installed in the *S-3* group boats and accordingly they battled engine problems throughout their career, although not nearly to the same extent that the EB design boats did. The NELSECO experience prompted C&R to go in a different direction with the *S-10* group. They were equipped with a six cylinder, 1,000 hp MAN derivative that was built directly from the German MAN plans by the New York Navy Yard, eliminating the NELSECO middleman. These engines, while still not perfect, were tremendous improvements and were considered to be quite reliable. At some point after their commissioning, the four boats of the *S-10* group were given larger mufflers for the engines, necessitating raising the aft deck with a distinctive hump. This hump can be seen in Figure 8, but unfortunately it is not readily visible in most available photographs.

The Navy was keenly interested in maintaining a commercial competitor to Electric Boat, fearing they would gain a monopoly. Unfortunately, Simon Lake and his company were not up to the task. Even though a brilliant engineer, Lake's business sense was terribly lacking; he was chronically under-funded and his yard beset with inefficient management and production processes. As a result, Lake's yard was

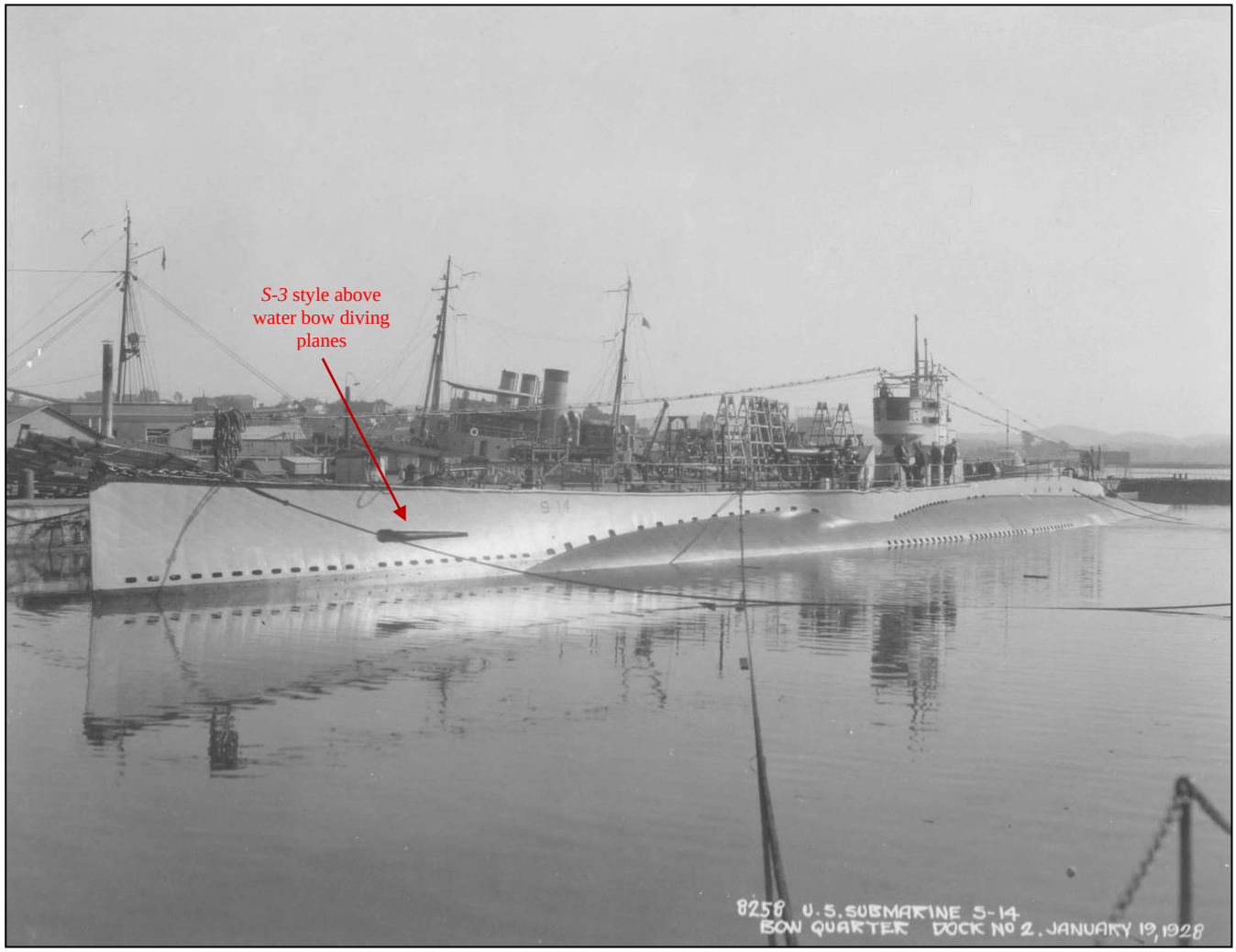

Fig. 11. The Lake built S-14 at the Mare Island Navy Yard, 19 January 1928. NARA photo 19-N-11536 via Navsource.

littered with incomplete *O* and *R*-class submarines as he started construction on *S-2*. When combined with Lake's insistence on including design features that the Navy didn't want (amidship diving planes, watertight superstructures, etc.) the Lake Torpedo Boat Co. had become something of a pariah within the Navy Department. As construction of *S-2* got underway, the Department had already made the decision to not award Lake any more contracts for *S-2* copies. Instead, in order to keep him afloat financially, Lake was offered a contract to build eight copies of the *S-3* design. Lake, his pride stinging from the rejection of *S-2*, took the contract and built *S-14* through *S-17* at his Bridgeport, CT. yard. These boats were straight-forward copies of the *S-3*. With the contract for these first four boats preceding the *S-8* bow plane variation, they were built with above water bow planes similar to *S-3* to *S-7* (Figure 11). In a highly fortuitous decision, C&R ordered Lake to install a six cylinder, four cycle (approximately 700 hp) diesel from the Busch-Sulzer Co. Although considered to be underpowered, these engines proved to be quite reliable and thus these boats avoided the engine problems encountered in the EB and other Government design boats. In a surprisingly nimble move, Lake laid the keel of *S-14* and *S-15* before *S-2* had even been launched. The construction of all four boats went very well, helping to marginally improve Lake's reputation with C&R.

Figure 12 is a good view of *S-14's* conning tower fairwater, and is typical of most of the Government design boats. Both of her control room periscopes are visible, along with the large telescoping radio aerial mast just aft of the scopes. Just below the bridge and to the right of the Sailor in the black shirt are the circular deadlight windows for the conning tower itself. A short 10 ½ foot periscope was installed in the conning tower, along with a steering station (via electric switches, not the traditional wheel). A tubular framework for a canvas awning is installed on the bridge rail, in addition to a smaller frame installed between the periscopes for a lookout platform. The numerous drilled holes in the top of the periscope shear structure are intended to allow air to vent from this free-flooding space as the boat dives. In addition, there is a large air induction pipe in the space between the periscopes, used to draw in the vast quantities of air needed for the diesel engines. On the aft end of the shears the boat's bell can be seen. Just below this is the mushroom shaped valve for a ventilation line that ran down to the passageway between the radio room and the galley. It was used mostly to vent cooking heat and smoke out of the boat while preparing meals. The dual port side running lights can be seen just forward of the 14, with the Submarine Squadron 18 insignia forward of that. Two large triangular brackets on either side of the bridge form supports for the heavy mine clearance/radio aerial wires. The starboard side wires split off downwards near the ventilation intake and penetrate the fairwater on the starboard side. They are then routed downward with a pressure hull penetration just above the radio room.

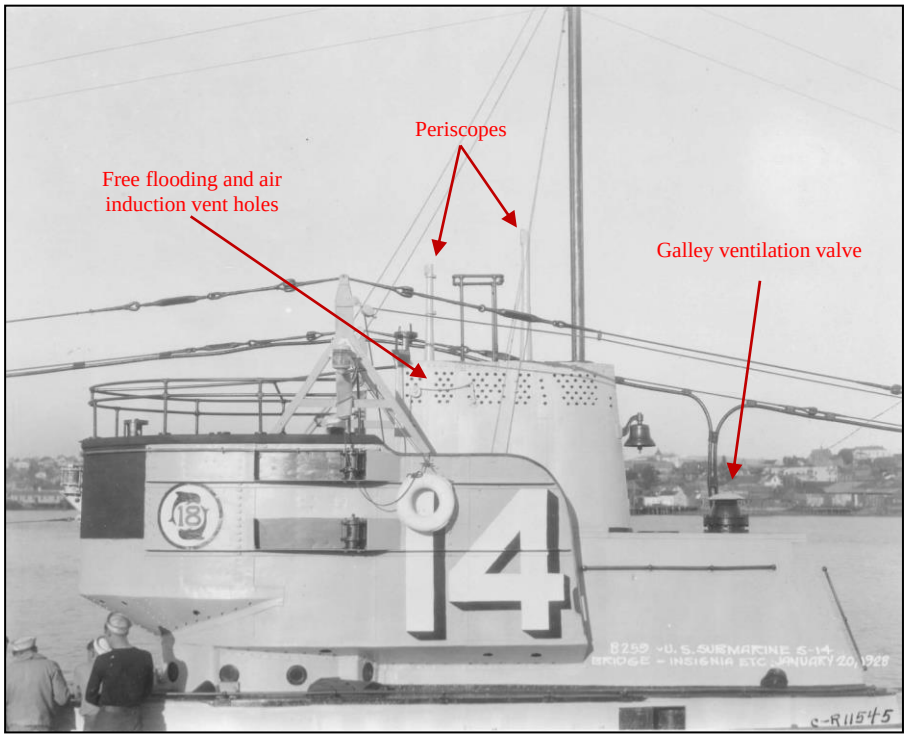

Fig 12. S-14's fairwater while docked at Mare Island, 20 January 1928. NARA photo 19-N-11545 via Navsource.

The second group of four boats that made up the Lake Government design contract was the *S-48* through *51* group. These would be the last submarines built by Lake. The Navy reluctantly allowed the Lake Torpedo Boat Co. to close its doors for good in 1924, after a General Board study showed that the inefficiently run yard was also physically incapable of building the much larger fleet submarines that were then in the planning stages.

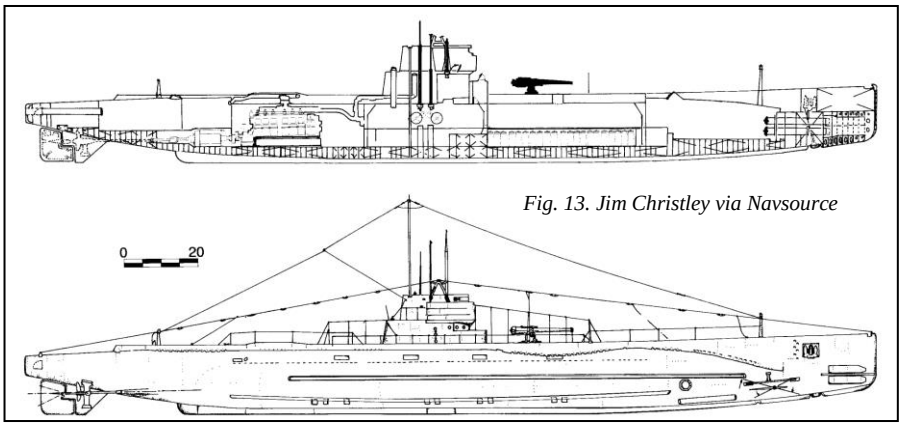

Fig. 13. Jim Christley via Navsource

The *S-48* group design (Figure 13) was a derivative of the *S-10* group, but with some significant differences. These boats reverted to the preferred below water, fixed bow planes with guards as seen on the *S-8* through *S-13*. They also had a different arrangement for the stern planes and rudder, a design that would presage the arrangement on the later fleet submarines. They were powered by a heavier, 2-cycle version of the Busch-Sulzer diesel. Lengthened by 9 feet, they separated the single large Maneuvering/Aft Torpedo Room of the *S-10* group into two

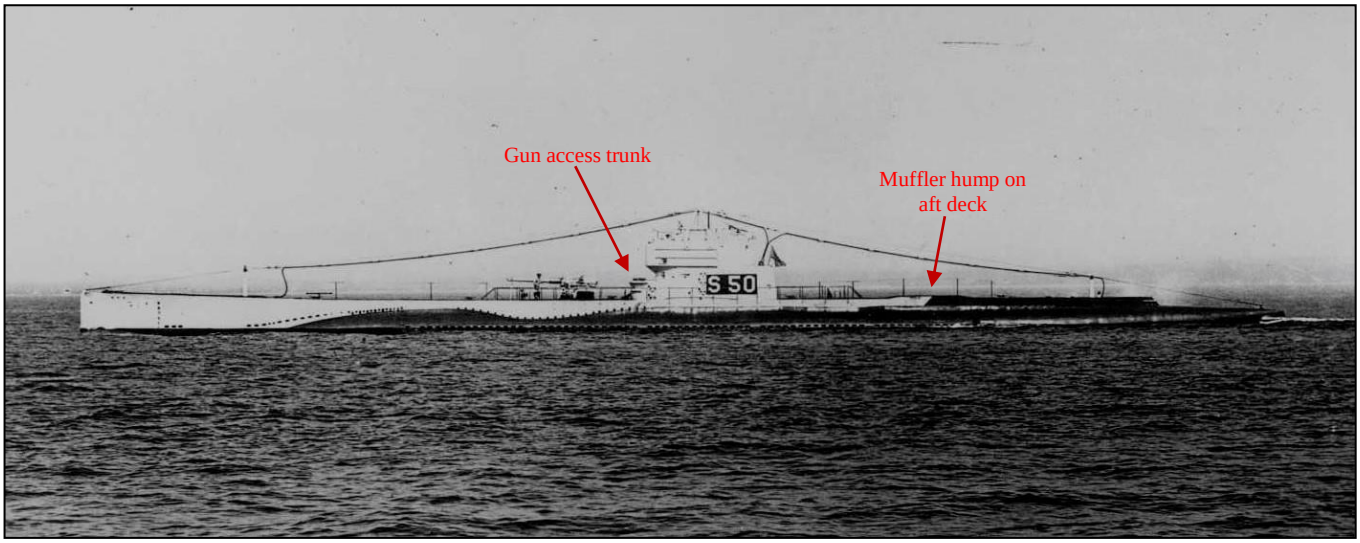

Fig.14. S-50 underway in the mid 1920s. NHHC photo NH 108466 via Navsource.

separate spaces, with the electrical controls for the main motors divided from the torpedo room by a bulkhead. Instead of the *S-10* style finely tapered stern faired around the muzzle end of the tube, the *S-3* style chisel stern returned, with the torpedo tube jutting through the center of the chisel. The nominal 800 tons of the earlier boats had been increased to 903 tons. The larger Busch-Sulzer diesels required a larger muffler, necessitating a hump in the after deck to accommodate them (Figure 14).

The conning tower fairwater was generally similar in appearance to the earlier Government design, but it incorporated several changes. In the earlier boats there was a hatch from the main deck into the battery compartment immediately aft of the deck gun. This hatch proved to be a little too close to the gun and was too low to the deck be safely used in a heavier sea. In the *S-48* group this hatch was eliminated. The former ammunition storage locker on the forward end of the fairwater was replaced with

a full gun access trunk that let into the control room. This bulged the fairwater farther forward. The conning tower cylinder itself was slightly taller and had fewer deadlight windows. The trailing edge of

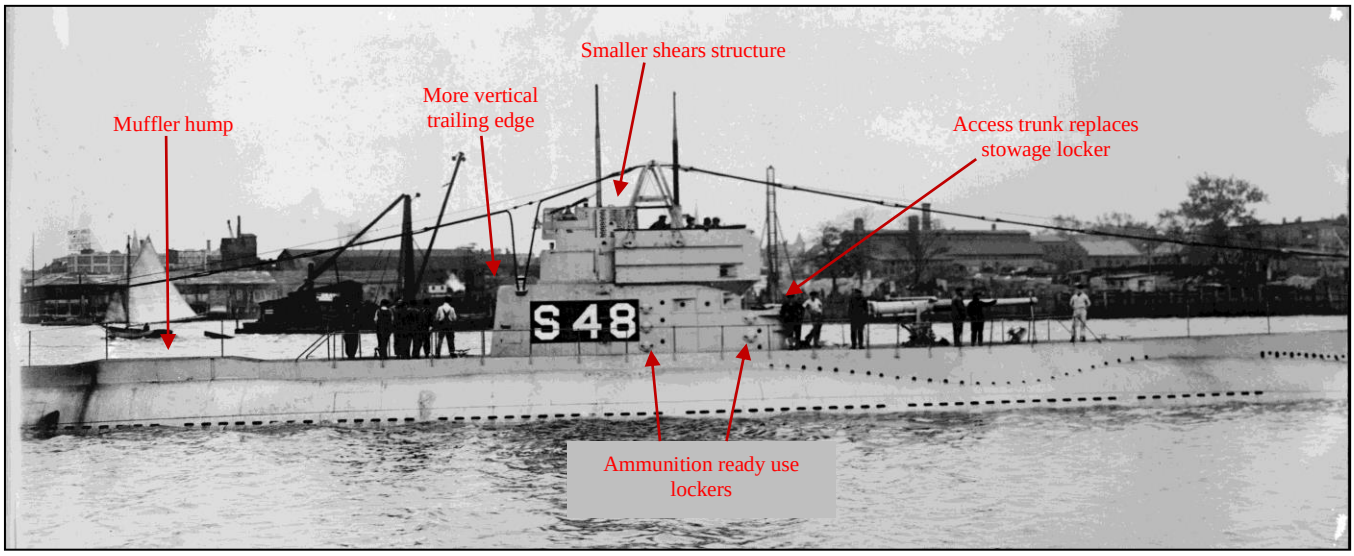

Fig. 15. S-48 from starboard, approximately 1922. Library of Congress photo via Navsource.

the fairwater was more vertical and not tapered as much as the earlier boats. Figure 15 shows the *S-48*'s conning tower fairwater, and when compared to the *S-14* photo above the differences can be seen. To make up for the loss of the ready service ammunition locker, five single round watertight lockers were placed on each side of the fairwater. These ten rounds would serve the weapon until a passing train could be set up from the main magazine below the control room. The periscope shears were slightly smaller than the earlier design.

Fig. 16. S-49 beached in Revere, Mass. as a tourist exhibit in 1935. NARA photo via PigBoats.COM.

Figure 16 shows *S-49* after being decommissioned, beached as a tourist exhibit in Revere, Massachusetts in 1935. It is a good shot of the hull below the waterline. On the far left the configuration of the chisel stern and torpedo tube can be seen, and it is apparent how it differed from the *S-10* group. On the right the bow diving planes and plane guard are visible. The small wooden structure on the aft deck is an access point cut into the motor room after the boat had been sold to a civilian interest. It was not part of her operational configuration.

SUBSEQUENT MODIFICATIONS

The four-cycle Busch-Sulzer engines that were installed in the *S-14* group, while well liked, were considered to be underpowered and thus the boats had trouble making their designed speed. In 1926 all four of these boats had their engines replaced with a MAN derivative rated at 1,200 hp. The result was impressive; the boats were now reliably capable of 15.5 knots surfaced. The more powerful engines required a larger muffler with a hump on the after deck similar to the *S-10* and *S-48* group.

By 1925 it was becoming apparent to the Navy Department that the far reaches of the Pacific Ocean would be a prime operating area for our submarines. Unfortunately, the S-boats lacked sufficient range to make adequate patrols in the vast Pacific. Several ideas were bandied about, including the construction of a submarine tanker to refuel S-boats during patrol. However, it was feared that the loss of the tanker sub would seriously hamper operations of the attack boats. The scheme that was decided on was a complete rebuilding of the Government design S-boats (the EB single hull boats were not capable of being heavily modified). This plan called for lengthening the boats by 26 feet to add fuel bunkerage, adding a stern tube to the boats that didn't have them, changing the engines to better MAN derivatives, and a complete redesign and rebuild of the interior. Initially, this plan seemed like a real bargain, as it would cost about a quarter of what a brand-new design 1,250 ton boat would cost.

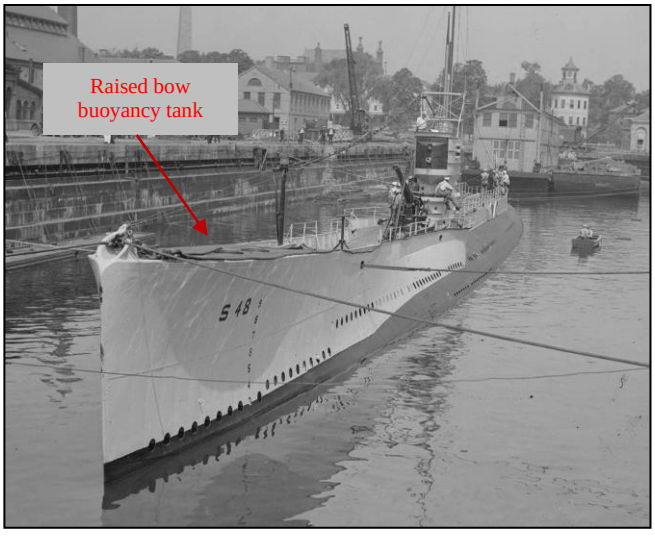

Fig. 17. S-48 at the Charlestown Navy Yard, 1929. Photo courtesy of the Boston Public Library, Leslie Jones Collection via Navsource.

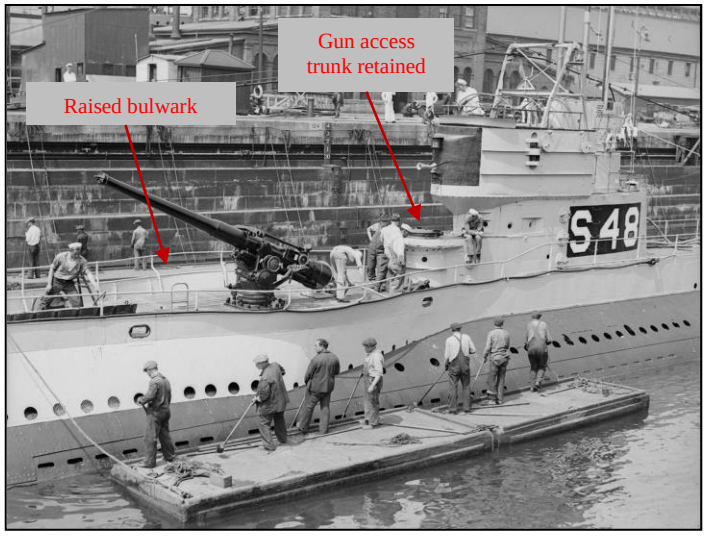

Fig. 18. S-48 post conversion at Charlestown, 1929. Photo courtesy of the Boston Public Library, Leslie Jones Collection via Navsource.

S-48 ran aground in January 1925 and was heavily damaged. She was quickly salvaged, but it was decided to take her in hand and make her the prototype for the General Board's modification scheme. She was lengthened by 25 ft. 6 in. between the control room and engine room, new MAN engines were installed, and she was completely rebuilt internally. Previously, the Government design had the battery all in one large compartment forward of the Control Room. The *S-48* rebuild split the battery into two compartments, forward and aft of the Control Room, with the crew's and officer/chief's

berthing split as well. A bow buoyancy tank was added and a raised bulwark was installed around the gun deck. She received one of the first air conditioning plants installed in USN submarines. In this configuration, she was a precursor to the later fleet submarines (Figures 17, 18, & 19).

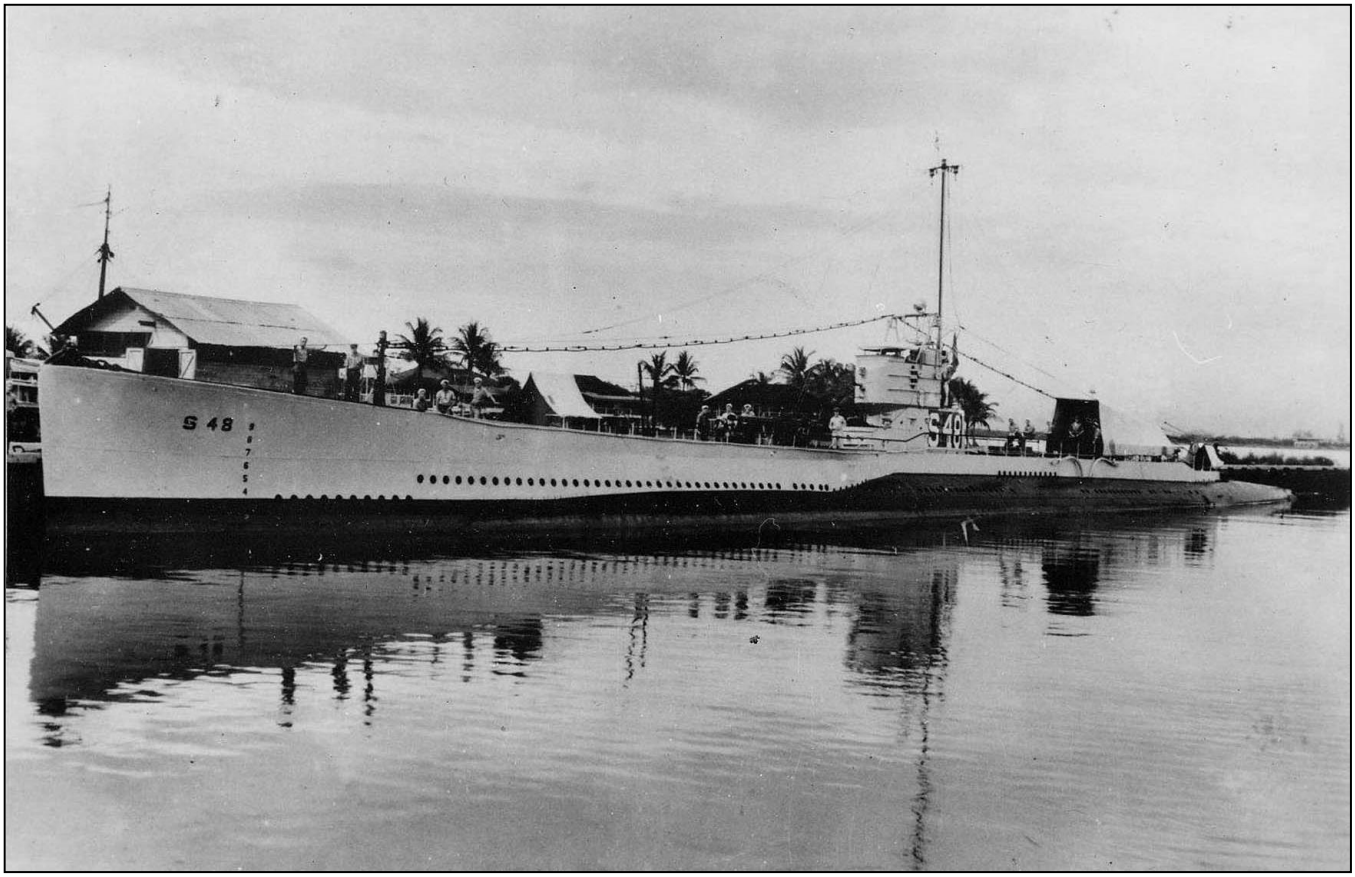

Fig. 19. S-48 post-conversion alongside in Coco Solo, Panama, 1931. The tent like covering on the stern was a temporary shelter to provide relief from the glaring Panamanian sun. NARA photo 80-G-466552 via PigBoats.COM.

These *S-48* modifications, while generally successful, failed to correct the basic deficiencies of the design. The cost of the modifications had spiraled upward, reducing the economic advantages versus a new design, and when compared to the estimated remaining life span for the boats (2-5 years), it was becoming rapidly apparent that the program wouldn't remain viable. The Submarine Officers Conference of 1927 successfully argued against any further modifications of the S-boats and pushed for a new construction program, which would eventually become the Fleet Boats. The *S-48* served well through the end of World War II (although with two periods in decommissioned reserve), providing training services to submarine crews and ASW forces.

SAFETY MODIFICATIONS

The years 1920 to 1927 were not good years for the Submarine Service from the standpoint of safety. *S-5* and *S-48* were lost in diving accidents (*S-48* was recovered and put back into service), *O-5*, *S-51*, and *S-4* were all lost to collisions with heavy loss of life. The inability of the Navy to quickly and effectively rescue crews of sunken submarines was dramatically played out in the press and pressure was put on the service to fix this problem quickly.

S-4 was sunk in a collision with a Coast Guard cutter off Cape Cod in 1927. After a dramatic but ultimately futile attempt to rescue six survivors in the torpedo room, she was subsequently raised,

partially reconditioned, and put back into limited service as a test boat to develop new salvage techniques. Towed to various fleet locations she provided valuable training in submarine salvage techniques and trained numerous submariners in escape procedures from a prototype escape trunk installed on her deck above the engine room.

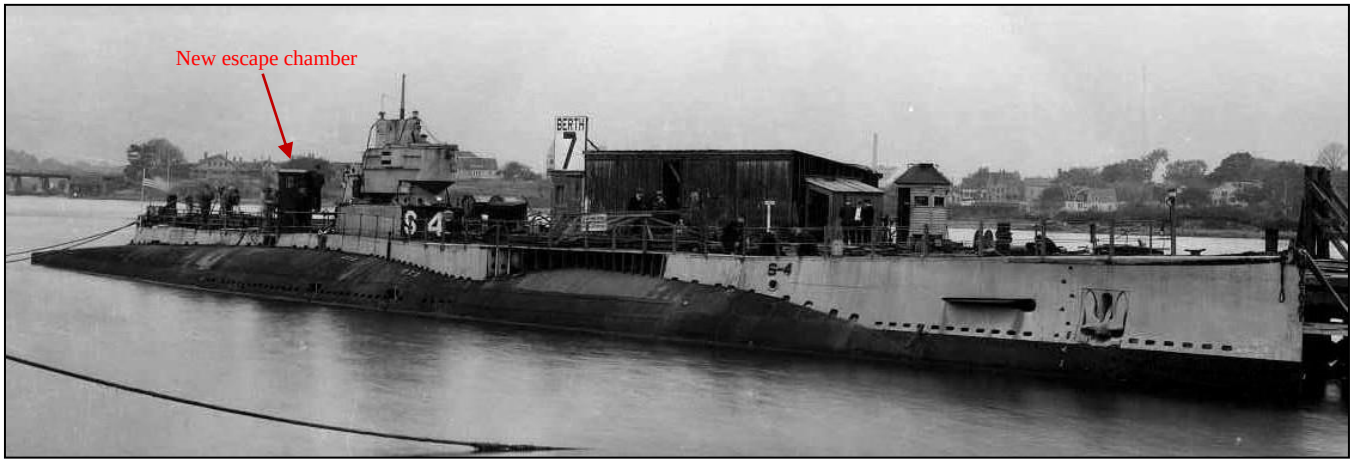

Fig. 20. S-4 after salvage at Submarine Base New London, CT., 16 October 1928. Note the new escape chamber on her after deck. The gap in her superstructure forward of the fairwater is unrepaired damage from her collision. USN photo via Navsource.

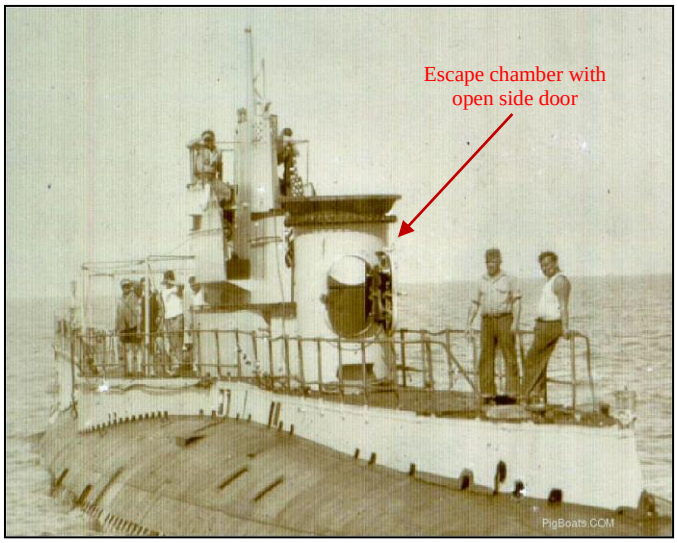

Fig. 21. S-4 and her escape chamber, late 1920s. Photo from the private collection of Ric Hedman via PigBoats.COM.

S-4's prototype chamber is shown in Figure 21. Two to three men could stand up inside, and it is shown with the side escape door open. The top is flared out so that a McCann Rescue Chamber could mate to it (see Part One of this series). The boat also tested rescue marker buoys that could be released after the boat's sinking. Further tests of this equipment were conducted on a heavily modified *S-22* (see Part Three of this series) The tests on *S-4* were entirely successful and they paved the way for safety modifications incorporated into new boats or retrofitted to older ones. The Navy immediately began a program to get this equipment fitted to all submarines and by the end of the 1920s the program was complete.

The chamber was much too big to fit into the confines of the relatively small *O*, *R*, and S-class boats then in service. It would wait for the larger fleet boats to come. An engineering compromise was needed so the side door was eliminated, and the lower skirt portion was made out of collapsible rubberized reinforced canvas. In the event of an escape, the collapsible skirt was pulled down from the overhead and locked in place. The compartment would then be flooded until it was equalized with sea pressure (roughly half full), with the water level well above the bottom of the skirt. The remaining air inside the skirt would be vented off and the upper hatch opened. Sailors would don an escape breathing device, duck under the open bottom of the skirt, and swim out of the open hatch. The process was repeated until all personnel inside that compartment were out.

The alternative and preferred method was to wait for the McCann Rescue Chamber to be brought to the scene. The chamber's size dictated that the top of the hatch be flared out so that the chamber could successfully seal to it. Two rescue buoys, one forward and one aft, would be released to float to the

surface. The line attached to the buoy would serve as the haul-down line for the chamber. These installations are shown in Figures 22 and 23.

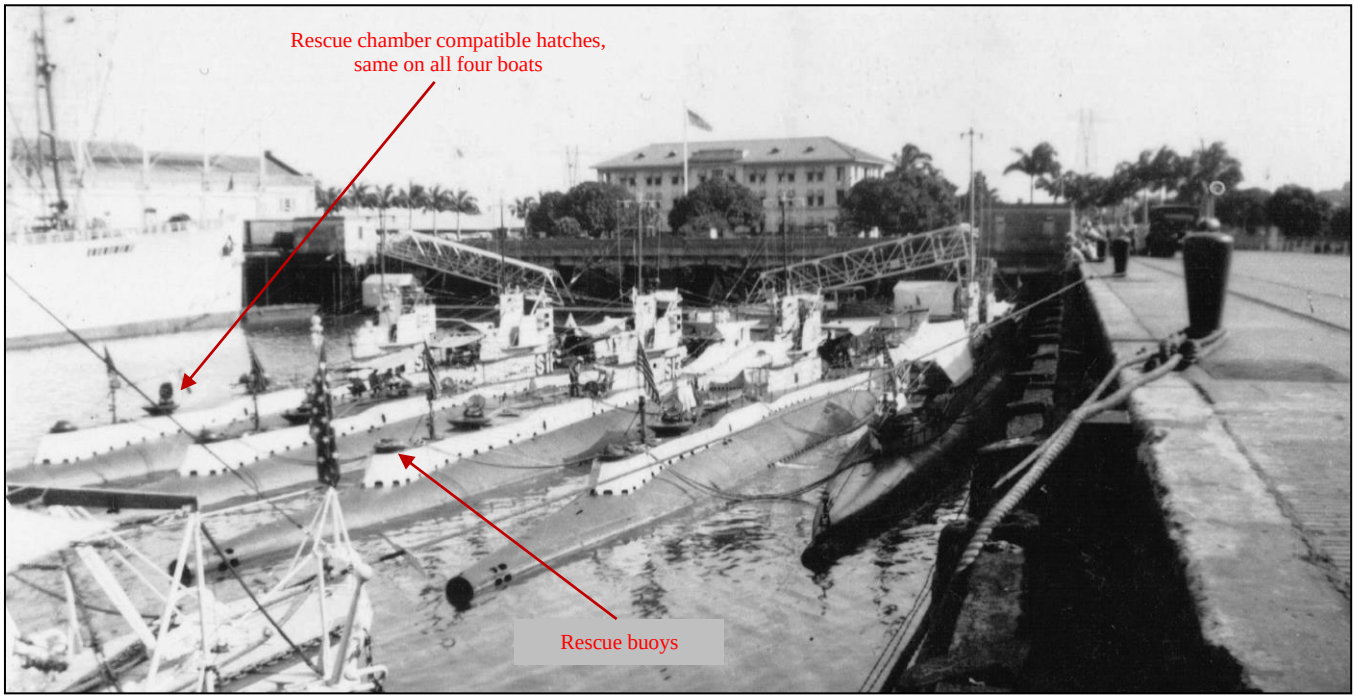

Fig. 22. S-12, S-11, S-13, S-10, and S-48 shown alongside at Coco Solo, Panama, early 1930s. USN photo via Navsource.

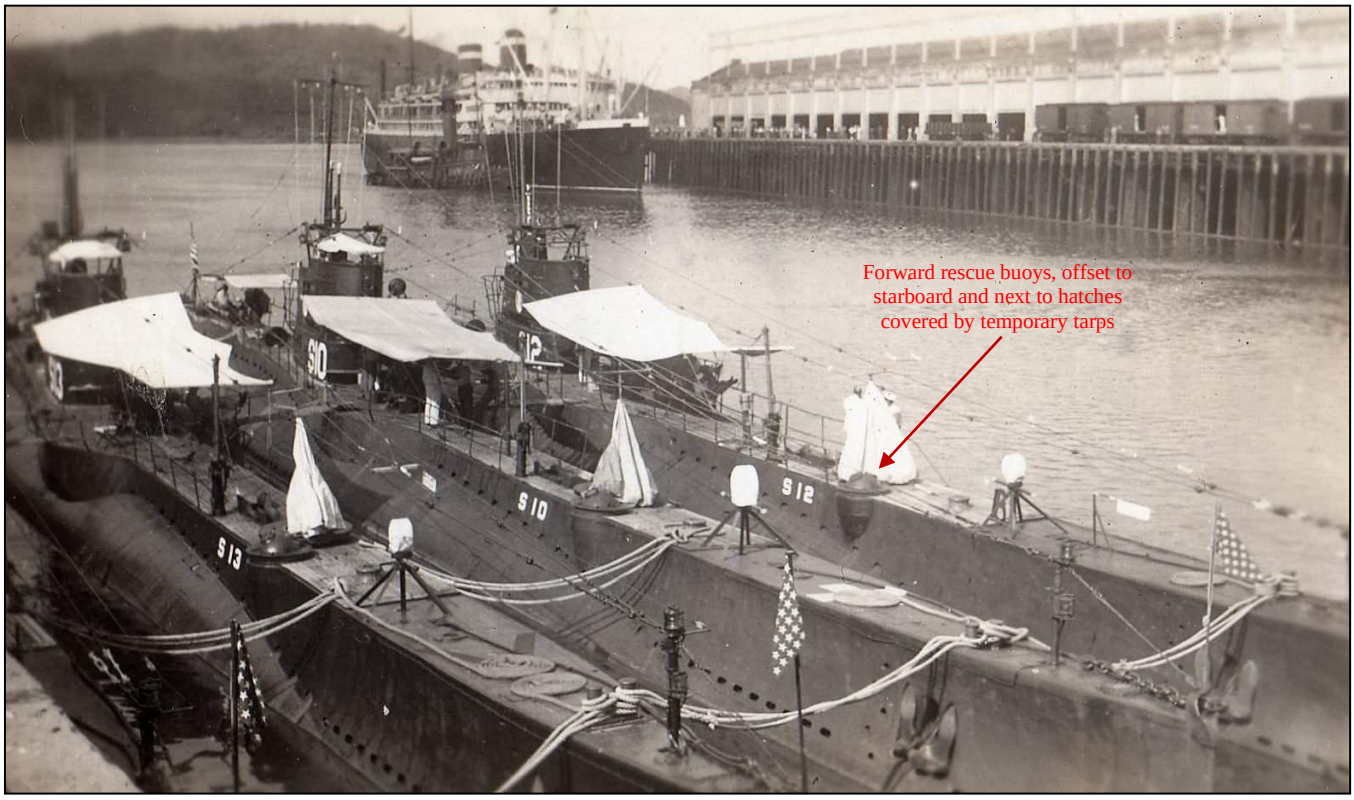

Fig. 23. Black painted S-13, S-10, and S-12 alongside at Balboa, Panama, early 1930s. USN photo via Navsource.

WARTIME MODIFICATIONS

The London Naval Treaty of 1930 placed restrictions on the total submarine tonnage allowed to the U.S. Navy. To stay within treaty limits, the service was forced to decommission and scrap many submarines. Hard decisions needed to be made and after a study was conducted it was decided that the remaining *S-3* series boats, with their ponderous underwater maneuvering and difficult to maintain outer hulls and superstructures would be the first to go. Accordingly, *S-3* and *S-6* through *S-9* were sent to Philadelphia for decommissioning and eventual scrapping. *S-10,* with a badly corroded outer hull and superstructure quickly followed. *S-49* and *S-50,* roundly disliked for even worse submerged performance than the *S-3* group, were sent packing as well. *S-11* through *S-13* with their stern torpedo tubes, better engines, and improved pumping machinery were retained in service along with the heavily modified *S-48. S-14* through *S-17* with their improved engines were retained as well. These eight boats would serve all the way through the end of WWII, but not without receiving some wartime upgrades. They served mostly in stateside training and anti U-boat patrols along the Atlantic coast and in the Caribbean.

Starting in 1933 all USN submarines were painted a flat black, a move prompted by extensive tests conducted in Hawaiian waters. Later pictures of the surviving Government S-boats show this new

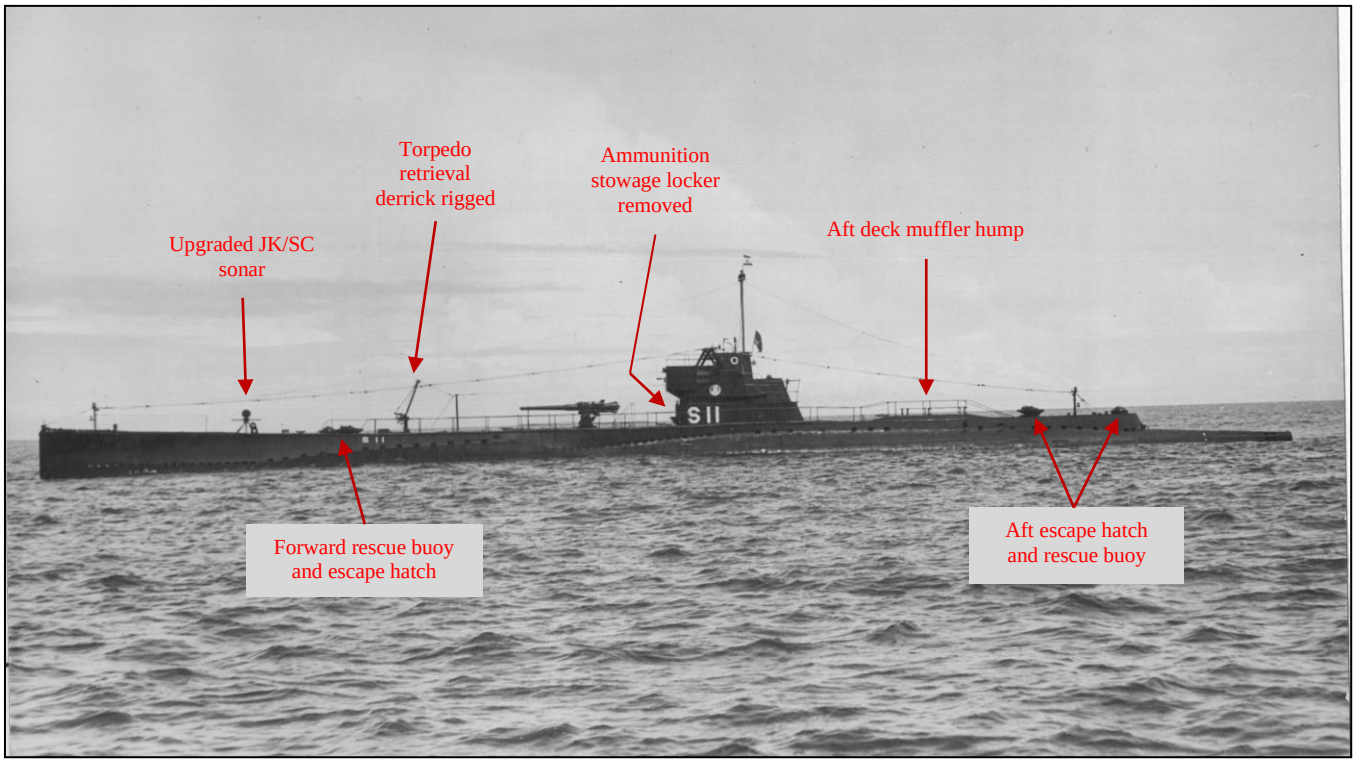

Fig. 24. S-11 shown off Coco Solo, Panama, 04 October 1935. NARA photo 80-G-466177 via Navsource.

look. Figure 24 is a fine shot of *S-11* in the late 1930s. She would enter WWII six years later in much the same configuration. For an unknown reason the ammunition stowage locker at the front end of the fairwater has been removed, perhaps due to a corrosion control issue. Her raised escape hatches and rescue buoys can be seen, along with the characteristic muffler hump on the after deck. She has received a much more capable sonar rig, with the JK high frequency dome sitting on top of the T-shaped low frequency SC array.

Unlike their EB design sisters, the remaining Government design S-boats did not engage in active war patrols in the Pacific. The eight boats spent the war in the Atlantic, Caribbean, and the

Panama Canal area. They were detailed to training duty with the Submarine School in Groton, CT., they conducted ASW exercises with the surface fleet, were engaged in technical development work, and occasionally conducted anti U-boat patrols. Despite this valuable work for the fleet, their missions were considered lower priority and thus they did not receive all of the wartime upgrades that the EB design boats did. At least one boat (*S-17)* received an SD air search radar set, and most of them were retrofitted with air conditioning. Figure 25 is a nice overhead photo of *S-14* in 1943, displaying her wartime

Fig. 25. A fine overhead photo of S-14 on 17 October 1943. NARA photo 80-G-450215 via Navsource.

configuration. All of these boats had their ammunition stowage locker removed from the forward end of the fairwater, although *S-48* did retain her access trunk in that location. She has the JK/SC sonar array on the forward deck; by this time that set had become somewhat dated. Three of her four deck hatches are open, indicating she is close to a pier. Of particular note is the fact that her name has been replaced by her hull number, a move to standardize the convention throughout the force. USN submarines during the war years only carried their hull number while stateside. Boats headed to the war zone in the Pacific had the numbers painted out until their return.

Final honors go to the USS *S-15* (SS-120). She was the last operational Government design S-boat, serving the Navy well until 11 June 1946, when she was finally decommissioned and her name struck from the Navy register. This closed the book on an elegant and iconic, albeit flawed chapter in our submarine history.

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