THE STORY OF THE S-4 (SS-109)

BY

JIM CHRISTLEY

Cape Cod Disaster: S-4's Loss

The waters off Provincetown, Massachusetts, at the tip of Cape Cod, are shallow and have a relatively hard sandy bottom. They are also busy. On the afternoon of Saturday, 27 December 1927, the U.S. Coast Guard Cutter Paulding was heading into the sheltered waters of Provincetown Harbor after finishing her assigned patrol in the Atlantic. She was a four stacker destroyer (ex DD-22) which had been transferred to the Coast Guard on 28 April 1924. Several such transfers were made to boost the power of the Coast Guard using existing ships. Commissioned in 1910, this ship had seen service in Queenstown during World War I.

The USS S-4 was in the area just to the northwest of the very hook of Cape Cod. Provincetown Harbor is situated along the south coast, or the bay side of the cape. It is protected from the Atlantic swells by the sandy structure of the cape's tip and by sandy spits which curl around like a semi-closed right hand. Along the outer northwest knuckle are two lights between which are marker buoys which delineate a measured mile. Long Point Light and End Light show mariners where the spits are and a ship moving toward Provincetown from the sea would put Long Point Light and End Light on the port side while steering south east. Paulding doing just that.

S-4 was on an engineering test. At various intervals during a ship's life, the overseeing organization tests the ship to determine if it is performing as expected. The testing organization might be the Bureau of Construction and Repair (its present day counterpart being Naval Sea Systems Command); it might be the type commander such as Commander Submarine Force Atlantic (ComSubLant) or another supervisory group. These groups plan contingencies and uses for the fleet in peacetime and must understand and be able to depend on the capabilities of the units of the fleet. This meant that the ships must be tested in gunnery, maneuvering ability, and engineering. The ship must be tested and along with that, the crew is tested. The crew's ability to operate the ship properly and excel is a direct reflection on the Commanding Officer's ability in leadership.

An engineering trial or test demonstrates the submarine's ability to operated both surfaced and submerged in a carefully controlled set of circumstances. The maximum speed the ship is capable of is measured by using a buoyed measured mile. The maximum sustainable speed is performed by a timed test, normally four to 24 hours in length. On this December day, S-4 was running the measured mile between Long Point Light and End Light just to the southwest of

Provincetown Harbor. During the submerged runs on the measured mile, the boat would take periscope bearings on the known landmarks, determine its position, and steer a course that would take it close aboard the measured mile buoys on one end of the course and directly toward the buoys at the other end of the mile. After passing the buoys on the other end of the course, the ship would continue along that course for a bit then turn to seaward and line up for a return run.

Upon completion of several runs along the course in each direction, the speeds would be averaged for inclusion in the final test report. Runs along the course would be made under various engine/battery combinations, both surfaced and submerged, to determine the exact capabilities of the ship.

S-4 was fairly new, having been launched in 1919. She was then the second production model of a new type of submarine. Her design was the result of the government taking over the task of designing and constructing submarines.

The submarine force wanted larger submarines than the N boats which were primarily for coastal defense. Their idea was to have an 800-ton boat of about 250 feet in length with the ability to transit the Atlantic and Pacific oceans unassisted.

The General Board which determined specifications to which the Bureau of Construction and Repair was to build, made a set of specifications that gave a great deal of latitude to three existing design houses. Electric Boat Company and Lake Torpedo Boat Company would each build one boat, the Bureau would design and build the third in a Navy shipyard. Portsmouth Navy Yard in Kittery, Maine would get the nod to build the boat as they were the only east coast government yard with experience building modern submarines.

The specifications show that the boat design was to be able to sail 3,400 nm at 11 kts and if ballast tanks were to be used for fuel at the start of a voyage, to steam 8400 nm. Their displacement was to be nearly 800 tons and they were to be about 250 feet long. Both EB and Lake scaled up their versions of the O-Class and R-Class and started construction on their own versions of the new "S" Class.

S-1 was built by Electric Boat. It was a single hull type with ballast tanks inside the pressure hull. The NELSECO engines built by a wholly owned subsidiary of Electric Boat were to be installed in the EB boats. These had serious torsional vibration problems which were not well understood at the time. The shaft extended from the engine to the screw with a clutch and a dynamo as integral parts of the arrangement. Even though supported by bearings at the shaft penetration, motors and engine, the shaft tended to be somewhat flexible. At certain speeds called critical speeds, the small vibrations of the shaft sections between the bearings tended to amplify and increase the forces felt by the bearings. This in turn caused the bearings to wipe at alarming rates. In addition, the main engine bearings, foundations, and supports were light and structurally insufficient to take the stresses brought on by the vibration at these critical speeds. The small distortions expected with the shaft weights and forces were good enough, but with the critical speed vibration the supports flexed, cracked and added to bearing difficulties.

The crankshafts were also prone to cracking. The boat was a good one though and was the basis for much testing and design analysis work including the only sub-borne aircraft design. (As an aside, none of these EB boats were built at the EB facility in Groton. They were built mainly at the Fore River Yard in Quincy MA, NELSECO was located on the present site of the Groton yard)

Simon Lake's shipyard in Bridgeport, CT built the S-2. Some main differences between the EB boat and the Lake design were the placement of the batteries, Lake had his all forward of the control room and EB had theirs split into a forward battery and after battery. For the rudder arrangement, EB had it's characteristic centerline fishtail rudder and Lake's was below the stern. The ballast tank flood and venting arrangement was also vastly different. EB had patented the keel duct which provided water through the hollow keel to the kingston valves under control room, from where it was routed to the ballast tanks. Lake's design used a more complex internal piping arrangement. The upshot of this difference was that Lake boats were generally slower divers. The Busch-Sulzer engines Lake used were generally better, but his electrical arrangements were not as good as EB.

Lake and EB had different philosophies in submarine design and operation. EB's designs derived from the work of John Holland called for dynamic diving and used the ability of the boat to be angled up and down in the water to control depth. The boats were normally ballasted slightly light and would broach when stopped. Lake's design called for his boats to be in a neutral buoyant condition and would change depths with a zero angle (horizontally level) using bow, stern and side mounted hydroplanes. Both groups took out extensive patents to protect elements of their designs, a tactic at which EB was most effective.

Portsmouth Navy Yard built the S-3. In reality, they took the good parts from each of the designs of Lake and EB. The follow-on contracts called for more of this design. Lake's contracts after S-2 required that he build to Government specs and designs rather than his own while EB was left alone to build their own S-design for reasons which are still not clear.

S-4 was the first of the so-called production model Government S-design (the S-3 being a production prototype). The boat was 231 feet long with a beam of 19 feet 8 inches. Its submerged displacement was a bit over 1000 tons and it carried a crew of four officers and thirty seven men. The two 700 horsepower engines could drive the boat at 15 knots and the two 600 horsepower motors gave it a one hour rated speed of 11 kts. Four 21-inch torpedo tubes with a capacity of eight torpedoes in the room and four in the tube and a 4"/50 caliber deck gun comprised its armament suite.

During and after WWI, the boats were equipped with C-Tube and Y-Tube sonars, chariot bridge structures and radios. Quite luxurious for her time, the S-4 had an evaporator to provide fresh water for the battery. It worked off the heat of the engine exhaust and was not terribly efficient. The ship also had a chill box for storing meats and other foodstuffs longer. There were also bunks for everyone.

Divided into six watertight spaces, the boat had a layout similar to a 1950's Skate Class nuclear submarine. Forward of course, was the torpedo room. Next aft was the battery compartment with berthing on the upper deck and battery below. The battery consisted of one

hundred twenty closed ventilated cells divided into two groups of 60. The lead acid battery was not much different than the one used today. The battery was ventilated by four centrifugal fans in two groups of two which pulled a suction on lines that led to each cell. The exhaust of these fans was routed through a ventilation duct, up along the port side in the overhead and aft through control room then to the engine room. The exhaust gasses were then dumped near the engine intakes and were burned by the engines.

Berthing spaces, just above the battery well were rows of stacked canvas bottomed pipe bunks which could be triced up as necessary. The aft end of this space held the officer's bunks and wardroom. The control room was next with the small conning tower above. One periscope was used in the conning tower and the two others were used from the middle part of control room.

Aft on the port side of control was a row of levers similar to those seen in railroad switch houses. These levers, when unlatched and pulled inboard, opened the kingston valves below. If the latches were tripped, the spring and sea pressure slammed the valves shut. Just forward of the kingston valve levers were the diving planes control wheels. In the area between the large handwheels were the switches that controlled the motors in the forward room, with similar switches just aft of the stern plane handwheel for the stern plane motors. These motors moved the planes through gearing. The handwheels were for hand operation only. There were no hydraulic controls. Forward on the starboard side was the main electrical switchboard for the submarine. Nothing like the semi-automated control switchboards of today's Navy, this consisted of an insulated (normally melamine or marble), vertical board on which were mounted open knife switches. The main motor/generator controller was situated in the aft starboard side of the control room. Somewhat more modern, this Woodward controller actuated electromagnetic contactors in the motor room that routed electrical power to the main motors.

Just aft of the control room was the engine room. The two engines took up most of the space in the room. Then, going aft through the water tight door with its eight peripheral dogs (like a surface ship door) was the motor room. In the lower level forward were the two main motors. In the upper level were the controls for auxiliary machinery, the ballast pump, the air compressors, and the ship's lathe. Then just aft of the motor room was another watertight space. It was not normally manned but could be accessed through a bolted manhole. This was the tiller room and extended to the very stern of the ship. The accesses to the ship from the outside world were through a hatch in the motor room, engine room, conning tower, battery compartment, and the torpedo loading hatch.

The boat had finished a submerged run on the measured mile from southwest to northeast by about 3:15 in the afternoon of 27 December 1927. The seas were choppy and there was the threat of a cold front passing which, in this season this might mean a moderate nor'easter was pending. Two observers on the S-4, LCDR Callaway and Mr. Charles Ford, both from the Bureau of Construction and Repair, were conferring and recording the engineering numbers necessary for their report. The boat was coming around to the left and preparing to surface. The last submerged run for the day was finished and it was time to go back to Provincetown Harbor for the night.

Paulding was making nearly eighteen knots when a lookout spotted the periscopes and shears of S-4 coming up close aboard on the port bow. The lookout reported the sighting and the OOD ordered the engines full reverse and the rudder hard to port, hopefully to pass to port over the still submerged stern of S-4. Paulding, however, struck S-4 at nearly the point of max beam half-way between the forward and aft battery compartment bulkheads about two feet above the battery well deck. The blow was somewhat glancing. The forefoot of the cutter telescoped and broke off in the hole torn in S-4[1]s side. The hole in the sub was nearly four feet long and two feet high in the ballast tank and two and a half feet long by a foot high in the battery compartment pressure hull. About three feet of the crumpled forefoot girder was stuck in the hole, not enough to stem the blast of cold water hosing through.

S-4 heeled far to port and started down by the bow. Paulding got on her radio and announced she had just collided with a submerged object, probably a submarine, and gave her position. She then stopped and waited for the sub to surface. It didn't. The men inside the boat were thrown about by the impact. Some in the battery compartment started to jam whatever was handy into the stream of water to stem the flow. The inrush was, however, too great and it was readily obvious that the battery compartment would have to be abandoned. Six men were in the torpedo room and slammed the door shut, dogging it tight. The remainder of the crew that were in the battery compartment made their way up the steepening deck to the control room door and when all had made it through, the door was shut and dogged. The water continued to fill the battery compartment, compressing the air inside. The battery well held tight and did not leak too much. The pressure in the bubble of air in the upper aft end of the space rose to about 50 pounds per square inch.

The boat was not in bad shape at this point. The water was only 110 feet deep. The S-4 had submerged to 170 feet some seven years before and the entire crew survived. Certainly, this depth was not out of the reach of divers and they weren't too far away. Besides, the Paulding had already alerted the world that there was a submarine down. There were 34 men in the control room, engine room, and motor room. They and the six in the torpedo room made up the whole crew. No one was badly hurt.

As the boat settled on the bottom, the ventilation line from the battery exhaust fans to the engine room collapsed over much of its length from the aft set of fans to the control room bulkhead. It was not designed to take the 50 psi pressure that was now in the battery space. Air and water streamed through the torn flange at the control room bulkhead, pressurizing the line through control room. The water also flooded back through the fans into the battery well, flooding the battery space. As soon as the sea water came in contact with the electrolyte, the salt in the seawater decomposed and liberated vast quantities of Chlorine gas. This gas bubbled out of the well and added to the air bubble in the battery space.

The ventilation line in control room was not meant to take the pressure from the inside any more than the line in the battery space was built to withstand it from the outside. Within a few minutes of the boat coming to rest on the bottom, the line in control burst spraying high pressure air water and chlorine gas at the electrical switchboard in control room. The crew rushed to close the bulkhead flapper valve at the forward bulkhead of control to stem the flow of water through

the now destroyed ventilation lines. It would not shut. One of the curtains that closed off the commanding officer's stateroom in the battery compartment had streamed into the ventilation line and prevented the valve from being shut. The air and chlorine burst into the control room, then when the air bubble had gone through the line, water followed, flooding the compartment.

The initial stream of water spray and air had shorted sections of the switchboard throwing the entire boat into the dark. The commanding officer ordered the space evacuated and when all the personnel in control had made their way back to the engine room, he slammed and dogged the door. Now the crew was in serious trouble. There were fourteen men in the engine room with an additional fourteen in the motor room. The air was foul with chlorine, it was dark and getting cold fast. When at last, the noise of rushing water had stopped and the boat got quiet, it was obvious that access to control room was out of the question. There was no way to lift the stern of the boat as S-5 had done. The only thing left was to wait for help.

USS Falcon (ASR-2) got underway from New London two hours after receiving the word that Paulding had hit a sub. By eleven o'clock, the next morning she had moored over the site and had put a diver down. He rapped on the torpedo loading hatch. Slowly, six taps answered. Six men were alive in the torpedo room. The diver moved aft and rapped on the conning tower bulkhead. No answer. He moved further aft and rapped on the engine room hatch then the motor room hatch. No answer at either. The men in these two spaces had already succumbed to the cold, chlorine, lack of air, or all three. It was Sunday afternoon, the boat had been down for 24 hours.

Then as plans were being readied to get air to the crew in the torpedo room, the nor'easter blew up and stopped all diving. It was Monday before the seas had calmed enough to allow a diver to go down again, then it was iffy at best. Still, the divers went down. They rapped again on the torpedo room hatch and received a plaintive reply. "Please hurry". By the next afternoon, they had readied a fitting that would fit onto the C-tube pipe which led to the interior of the torpedo room. The air compressors on Falcon started to force good air into the space. After a bit they were reversed and started to suck air out. This was the only way to renew the air in the room. Put some in, take some out. It was hoped the process of renewing the air would be in time, the tapping from the space had stopped. The air being sucked out of the S-4 was sampled for carbon dioxide. The level was 7%, too high a level for humans. It was decided that the entire crew had died.

The drama of the attempted rescue hit the papers all over the country. The failure was devastating. Then the questions were asked. Just how is it that you rescue submariners who are stuck on the bottom? The answer coming from the Navy was unsatisfactory. We could not rescue our own. The S-4 disaster was to change all that. She was raised the next spring and on 18 March 1928 had been docked in one of the drydocks at the Boston Navy Yard. The bodies were removed and the inquiry board investigated what had happened. S-4 was then sealed, undocked and towed to Portsmouth Navy Yard. There she was stripped and made ready for submarine salvage experimentation. With no engines or propulsion and only half a battery to supply lights and amenities, the boat was towed to a point off Block Island and over the next year used to examine the possibilities for submarine rescue and to practice salvage techniques. The next year she was recommissioned under the command of LT Norman Ives and with a crew of 14, she was towed south to Key West. EB had removed the airplane hangar from S-1 and had used the cylindrical

shell to make a diving bell. Called the Ives Bell or the McCann Rescue Chamber, this device was tested and perfected on S-4 in repeated trials in water from 60 to 300 feet deep off the Florida Keys. In addition, the self-contained breathing lung devised by LT Charles B. Momsen, a buoy that could be released from inside the sunken sub, and a specially built escape lockout chamber were tested over the next several years. These were all back fitted to existing submarines and became standard equipment for future boats. After serving at Key West through the remainder of 1930, the boat returned to New London. Then after overhaul, S-4 transited south through the Panama Canal and out to Pearl Harbor to serve as a training ship for the West Coast rescue forces.

Finally, after having served well in her role as a salvage and rescue pathfinder, USS S-4 was scuttled in deep water off Pearl Harbor on 15 May 1936. The boat was a pivot point in the story of submarine design. Her tragic accident lead to better navigation regulations by setting aside areas for submarine operations and requiring other ships to not transit these places. The death of her crew and the painful inability of the Navy to rescue them became the basis for an effort to make submarine escape and salvage a viable option. Forty men died but the legacy they left saved the life of at least 46 others because they used the devices invented and may have saved an untold number more because of the improved safety and navigation required after the accident. They died, that is indeed tragic. They did not die in vain.