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FWS

SALVAGING THE U.S.S. S-51

The U.S.S. S-51, a submarine of post-war construction, with a surface displacement of 1000 tons and a submerged displacement of 1250 tons, was sunk on the night of September 25, 1926 about fifteen miles east of Block Island in a surface collision with the merchant steamer CITY OF ROME. A large gash in the port side of the S-51, about thirty feet forward of the conning tower, was made by the bow of the CITY OF ROME, this opening coming into the battery room, the second main compartment from the bow. The S-51 sank in less than one minute with the loss of thirty three of her officers and crew, there being only three survivors picked up by the CITY OF ROME'S boat.

The wreck was located next morning by an oil and air slick. Divers went down and found the boat in 132 feet of water heeled over 11° to port, heading about 350° true. No signs of life inside were apparent then or later, but as a rescue measure for about five days an endeavor was made to lift the stern with derricks. This failed.

After thorough consideration of all offers by commercial concerns, the Navy Department decided to undertake the work itself. Lieutenant Commander E. Ellsberg, Construction Corps, U.S. Navy, was placed in charge of the technical operations and the diving personnel.

A study of the wreck lead to the conclusion that the battery room and the torpedo room forward were damaged by the collision and by the impact with the bottom, to such an extent as to make their buoyancy irretrievable. It was decided to make the other compartments, which were found undamaged, watertight and thus obtain an internal buoyancy of about 450 tons, making reasonable allowances for bilge water. To make up the remainder of the buoyancy required, together with a safe margin for a reserve, eight pontoons with a net lift of 30 tons each, were to be employed. Two such pontoons, once used on the F-4, eleven years ago, were available at the Norfolk Navy Yard. The New York Navy Yard immediately commenced construction of the six additional pontoons required.

As the initial engineering problem, it was necessary to design the pontoons to withstand the pressures they were to work against. The water pressure at the depth of 132 feet was about 58 pounds per sq.in. It was realized that the pontoons might be exposed to this as an internal bursting pressure in case of a rapid rise to the surface. They were therefore built to resist this pressure, and the two F-4 pontoons were given additional internal stiffening, as they were originally built for use in only 45 feet of water. As an additional safeguard, all pontoons were fitted at the bottom with a simple spring loaded relief valve, 6 inches in diameter, set to lift at an excess pressure of 5 pounds.

The pontoons were steel cylinders, 32 feet long, 12 feet, 6 inches in diameter, sheathed with 4 inches of wood to take ex-

ternal chafing. Each pontoon was in itself practically a section of a submarine, with internal frames, longitudinal stiffeners and heavy reinforced bulkheads at the ends and in the middle. A 12 inch hawse pipe ran vertically through each half of the pontoon 8 feet from the end, through which the chains which formed the cradle slings were passed.

While the pontoons were under construction, the salvage expedition sailed for Block Island and active work commenced about the middle of October. The first efforts were to cut away the rigging and radio antennae to avoid fouling the divers. That completed, the salvage work began.

The U.S.S. FALCON, a minesweeper fitted with extra air compressors, a recompression chamber for divers, and some other special apparatus, was the diving vessel. She first planted seven anchors in a circle about the wreck, each secured to a surface mooring buoy, to which buoys the FALCON thereafter moored herself before diving.

The U.S.S. S-50, a sister of the S-51, was present for some time as a rehearsal vessel on which the divers practised before entering the S-51.

The preliminary rehearsals over, the divers entered the engine room and proceeded to close all valves inside needed to make this compartment airtight. Some thirty valves were closed on the first dive, but trouble immediately developed. The largest valve, the main engine air induction, 25 inches in diameter, would close only about three quarters of the way.

After several dives on this valve, it was concluded that something had washed under the valve disk and was lodged there, preventing the valve from closing. The fight with the S-51 had begun.

To clear this obstruction, it was necessary to remove the superstructure deck over the valve body and lift the valve bonnet. The bonnet weighed 300 pounds, was 39 inches in diameter, and was secured by 40 bolts and nuts. It can be imagined what a task this presented to the divers. The work was immediately started however and proceeded for five days at the end of which time the bonnet was lifted and a piece of one inch steel pipe about two feet long was found under the valve disk. This was removed, and the valve then closed easily.

The above instance, in which it took five days to close a valve which we might confidently have expected to close in five minutes was an example of what we found thereafter in the prosecution of the job.

The divers continued with the work of closing interior valves and doors and finally succeeded in closing all valves in the motor room aft as well as the door leading to that compartment. Compressed air was put on that compartment to force the water out, but the air was found to be escaping through a valve which was known to have been closed. Inquiry of the survivors showed this valve to have been defective. Nothing remained but to reopen the motor room, remove the defective valve and plug the pipe. More work and more delay.

Meanwhile it was necessary to supplant the regular hatches to the intact compartments with special salvage hatches. The

regular hatches were designed to seat under an external pressure only; even a light internal pressure would blow them open. In addition it was necessary to provide spill pipes reaching to the bottoms of the compartments to discharge the water, and air connections for blowing. These pipes and valves were made a part of the new salvage hatches, which were provided with strongbacks to keep them seated against a heavy inside pressure. These hatches were heavy, about 700 pounds each, and the long spill pipe attached made them cumbersome to handle but there was no easier method. Two hatches of this type were installed during the fall operations, one without pipes over the conning tower hatch, and one with pipes and valves over the gun access hatch, both leading to the central operating compartment under the conning tower.

To secure the pontoons to the submarine, it was necessary to run tunnels under her for the chain cables, about seventy feet from the bow and about one hundred and ten feet from the bow. In both these locations, the submarine was buried about seven feet deep in hard clay and sand. Tunneling was started immediately, using a fire hose to cut through the clay but progress was slow, was interrupted by storms, and after each enforced departure, we came back to find the tunnel filled up again during our absence, and we had to start afresh after each storm.

Meanwhile the weather was getting steadily worse and November was passing away. Storms increased in frequency and in intensity.

The water grew colder and we ran into a stretch of weather which allowed only one working day out of fifteen consecutive days.

Under these conditions work became impossible and operations were suspended until spring.

During the winter, a class for training new divers was started, experiments were undertaken with an underwater cutting torch which was developed into a successful instrument, and the necessary equipment was carefully overhauled.

Diving operations were resumed on April 26, 1926 with a greatly augmented crew of divers, twenty four men being available including Lieutenant Commander E. Ellsberg, (CC), U.S.N., who had also qualified as a deep sea diver during the winter.

The first problem attacked was the proper method of lowering the pontoons. As this involved handling a bulky and heavy weight and correctly locating it 132 feet down, several rehearsals were carried out in deep water, but well clear of the submarine. It was finally determined that the only safe method was to flood the pontoon down until it just submerged, supporting each end of it on a 12 inch manila hawser. In its awash condition it was held with flood valves and vents open until it had reached a negative weight of about eight tons, when the flood valves and vents were closed. This negative weight was found to be the minimum which would ensure longitudinal stability and prevent the pontoon from standing on end on its way down. With the valves closed, the pontoon was then lowered, its weight remaining constant all the way down.

Having made sure that the pontoons could be safely handled, the FALCON commenced securing pontoons to the stern which was clear of the bottom and required no tunneling. Two manila reeving lines were run under the stern and on these a pair of one inch wire lines was hauled through, from port to starboard. These wires were attached to the chains suspended through the hawsepipes of the first pontoon and were to be used to guide the pontoon down to its position. The pontoon was flooded as in rehearsal, but just as it went awash a one inch wire strap holding the after 12 inch hawser to the pontoon, pulled apart in the splice and the pontoon tore away and sank, after end first. Fortunately the FALCON was holding this pontoon somewhat to port and it landed about twenty feet away from the submarine's stern.

An examination of the splice in the strap showed it had opened up without any special strain, but to prevent a recurrence, forged steel links were substituted and no more pontoons broke away in the lowering process.

The first pontoon was dragged over to the side of the submarine by hauling on the guide wires, after which these wires were threaded through the hawsepipes of the second pontoon. The second pontoon was successfully lowered to about 90 feet, held there while a diver checked its position, and then carefully lowered into position alongside the submarine. The chains from the opposite pontoon were hauled through the hawsepipes in this process. With the second pontoon on the bottom, the divers with the underwater torch burned out a stud in the chain link just

above the top of the hawsepipe and inserted a 4" x 4" nickel steel toggle bar to lock the chain in position and take the load. These bars had previously been tested to a load of 235 tons over a span of 18 inches which was the distance across the top of the hawsepipe castings.

Having secured the first pair of pontoons, work was resumed on the tunnel at frame 46. After two weeks of dangerous and arduous work, the divers completed this tunnel and two manila reeving lines were run through it, followed by two 1 inch wire lines.

A pontoon was lowered with chains attached as at the stern, in the first instance, but the chains hung up on the box keel which was one foot lower than the hull, and refused to pull through. Some two weeks were spent in an endeavor to haul these chains through, but the net results were only broken hawsers, as we successively parted a 6-inch manila line, an 8-inch manila line, a 1-inch wire line, and finally tore the stern winch out of its foundations on the seagoing tug IUKA which was being used to haul on the lines.

After this last mishap, it was concluded that the method was wrong and the pontoon was blown free of water by compressed air and brought to the surface, chains and all. The chains were removed from the pontoon, and lowered separately one chain at a time from starboard to port. The divers guided the hauling lines through the tunnel, and by giving enough slack to the chain, it was allowed to drag through the tunnel clear of the box keel and passed through without difficulty.

Having passed a pair of chains through in this manner, the one inch wires attached to the chains on both sides of the submarine were hauled taut and the chains held up vertically. The wires were threaded through the pontoon hawsepipes, and the pontoons lowered, port pontoon first, on the wires as guides. The pontoon was held suspended at a depth of 90 feet, when two divers went down on it, checked its position, and reported everything clear. The pontoon was then slowly lowered with the divers riding down on it, until the chain showed through the hawsepipes, when it was again held and while the divers inserted the toggle bars through the chain links. When this was done, the pontoon with divers aboard was lowered to the bottom, where the divers cast loose the 12 inch manila lowering lines, let go the one inch wire lines to the chains, opened flood valves, saw everything else secured, and came up.

The mate pontoon was lowered in the same manner. The FALCON became so expert in pontoon handling that she was able to run a pair of chains and lower and secure completely a pair of pontoons in about seven hours.

It now became necessary to dig a new tunnel under the submarine amidships. About this time, a machinist's mate on the FALCON who had observed the action of the ordinary fire hose nozzle previously used in tunneling, turned out a new nozzle with balanced jets that enabled the divers to use about five times as much water pressure as formerly. With Waldern's nozzle, the diver could easily hold a 2-1/2" fire hose under a water pressure of 200 pounds per square inch. As a result, the second tunnel was completed in

two days, instead of in the long number of weeks spent on the first one.

The sealing up of the interior and the planting of all pontoons was completed about the middle of June. The next problem was to float up all pontoons alongside the submarine, level them off, and lash them against sliding when the submarine rose. In this operation the cranky nature of the pontoons was demonstrated, because as they became buoyant, one end or the other would always rise first and the pontoon would float on end and hardly ever horizontal. The end which rose first would drag the slack chain through under the submarine from the other side and make the levelling off of both pontoons above the submarine impossible.

After a few such experiences, a different levelling method was used. A one inch wire was attached to each end of the first pontoon of the pair to be levelled, the wires being taken through the bitts to the winches on the FALCON. The pontoon was then lightened by blowing and during this process, a strain was kept on the wires until the weight was so reduced that the winches could haul the load. Blowing was then stopped, and the pontoon, with perhaps twelve to fifteen tons negative weight was lifted from the bottom and hoisted up until it was held above the submarine at the height desired. The opposite pontoon was then blown, and it floated up, and as one pontoon was already in proper position and held there, its mate was unable to run away with any slack chain. By blowing either end of the mate pontoon as necessary it was compelled to float horizontally alongside the first pontoon.

The above process worked very well and was regularly employed. However, owing to the heavy weights handled and the surging on the lines due to the FALCON'S rolling in a seaway, it resulted now and then in breaking the one inch wires or the pelican hooks with which they were secured to the pontoons.

On the night of June 21, 1926, all work was completed, the pontoons partly blown down, and some compartments partly emptied, in readiness for the final blowing the next day.

June 22, 1926, brought a storm which made any attempt to raise the S-51 that day out of the question. Two of the pontoons and the engine room had been refilled the day before to avoid a premature rise, and it was decided to await better weather. However, the storm took charge and rocked the lightened S-51 on the bottom enough to break the suction grip forward and the bow rose. Quick work on the FALCON'S part hauled her clear and prevented a disaster.

The bow and four forward pontoons showed above water. As practically the only thing to do, an attempt was made to lift the stern in spite of the storm, and blowing was commenced on the after compartments and the after pair of pontoons. It should be remembered that it was always intended to raise the vessel stern first and the lashings and pontoon locations were selected with that in mind.

When the stern pontoons were practically blown, but the after compartments still mostly full of water, the second accident of the day happened. The stern pontoons broke the 2-1/2 inch chain cables holding them to the submarine and floated

to the surface separately. It is now definitely known that they slipped forward bringing their chain cables successively in contact with the point where the vertical keel starts and thus breaking the chains under impact. This accident deprived the stern of its reserve buoyancy. As it further happened that all spill-pipes in hatches were located at the forward or high ends of each compartment, it was impossible to force out more than half the water in each compartment.

Under these circumstances, raising the stern was impossible, and nothing remained but to sink the bow before the stern should carry away the bow pontoons. Under conditions which sound more like fiction than fact, several seamen and officers from the FALCON boarded the pontoons and though many times swept off by heavy seas and thrown off by the erratic and tremendous hammering of the pontoons against each other and the submarine, these men stuck to the job until the flood valves were opened, and the bow with the pontoons still attached sank slowly from view.

The deep gloom which pervaded the salvage party after this accident can well be imagined. It is a high tribute to the spirit of the officers and men of the Navy to know that the next day all hands again turned to with a determination and a vigor far in excess of their previous efforts. The four damaged pontoons at the bow were found standing on end in a tangled heap. These were cast loose and brought to the surface for repairs. At the Harbor of Refuge, Point Judith, the repair

ship VESTAL and a hundred ton crane from the Navy Yard hauled these four and the two stern pontoons out of water, and in seven days had them completely repaired and ready for service again.

The pontoons were returned to the wreck, and the FALCON'S men, working with redoubled energy, lowered and secured completely three pairs of chains and three pairs of pontoons on three successive days. The Fourth of July was celebrated by working all day and nearly all night, and when July Fifth dawned everything was again practically ready, and all vessels took their stations for raising.

At 12:17:30 p.m., Lieutenant Commander E. Ellsberg, (CC), U.S.N., turned the air on the engine room and shortly afterwards on the stern pair of pontoons. At 2:06 p.m., the stern pair of pontoons with the stern rose to the surface. Air was then turned on the forward group of pontoons, and at exactly 3 p.m., the bow rose. All pontoons were noted to be spaced exactly as intended and the submarine's draft was found to be 32 feet as anticipated. There was a list to starboard of about 10°.

At 4 p.m., the tow got underway for New York, 150 miles away. The SAGAMORE and IUKA were towing in tandem ahead, with the FALCON towing 150 feet astern of the S-51 and maintaining a steady supply of air through twenty air leads to all pontoons and all buoyant compartments. The speed of the tow was at first three knots, which the next day was increased to five knots. The tow proceeded smoothly and steadily from the open sea into Long Island Sound and through it into the East River. Hell Gate was safely passed and the tow was within sight of the Navy Yard when the civilian East River pilot

attempted to take it through a narrow passage between two reefs instead of sticking to the deep water channel on the Manhattan side. As a consequence, he stranded the S-51 on Man-of-War Rock at high tide in about 24 feet of water and the impact of the keel with the reef carried away the chain cables of the second pair of pontoons from forward which happened to come where the reef hit the keel.

The S-51 was thus left in a hazardous position, with one quarter of her pontoon buoyancy gone, hard and fast on a reef, and in a very strong tideway. Fortunately for all concerned, the original reserve buoyancy provided as a margin for towing was adequate. Working desperately for the remainder of the day, the salvage crew resank the four remaining forward pontoons until they were wholly awash and resecured the toggle bars. In this manner, the reserve buoyancy of these pontoons was brought into play for lifting purposes, and just overbalanced the effective buoyancy of the lost pair of pontoons.

When the evening high tide arrived, all pontoons were blown down again, and the bow was lifted several feet higher than it had been when it struck. As a result, the S-51 floated clear of the reef, and was then towed stern first, with a list to starboard of about 25°, the remainder of the way to the Yard. Here, after a hard struggle against the tide, she was turned into the Navy Yard basin and the next day was safely landed in the drydock and straightened up.

Thus ended a salvage job which for the size of vessel raised,

✓ the exposed location where the work had to be done, the depth of water worked in, and the distance the submarine had to be ✓ transported, has no parallel in history. As an engineering feat, it is the pride of the officers who took part in it, but far above that in their minds stand the quiet, steadfast, and heroic behavior of the men of the Navy who risked their lives in the depths and on the surface of the sea that the S-51 might rise again.

Of the adequacy of the engineering appliances used, there never was any doubt. That the human element might crack under the strain was the ever present danger and the fact that in spite of peril and discouragement the officers and men involved always came back and fought on until the job was done, will always remain the brightest spot in the salvage history of the S-51.

E. ELLSBERG.