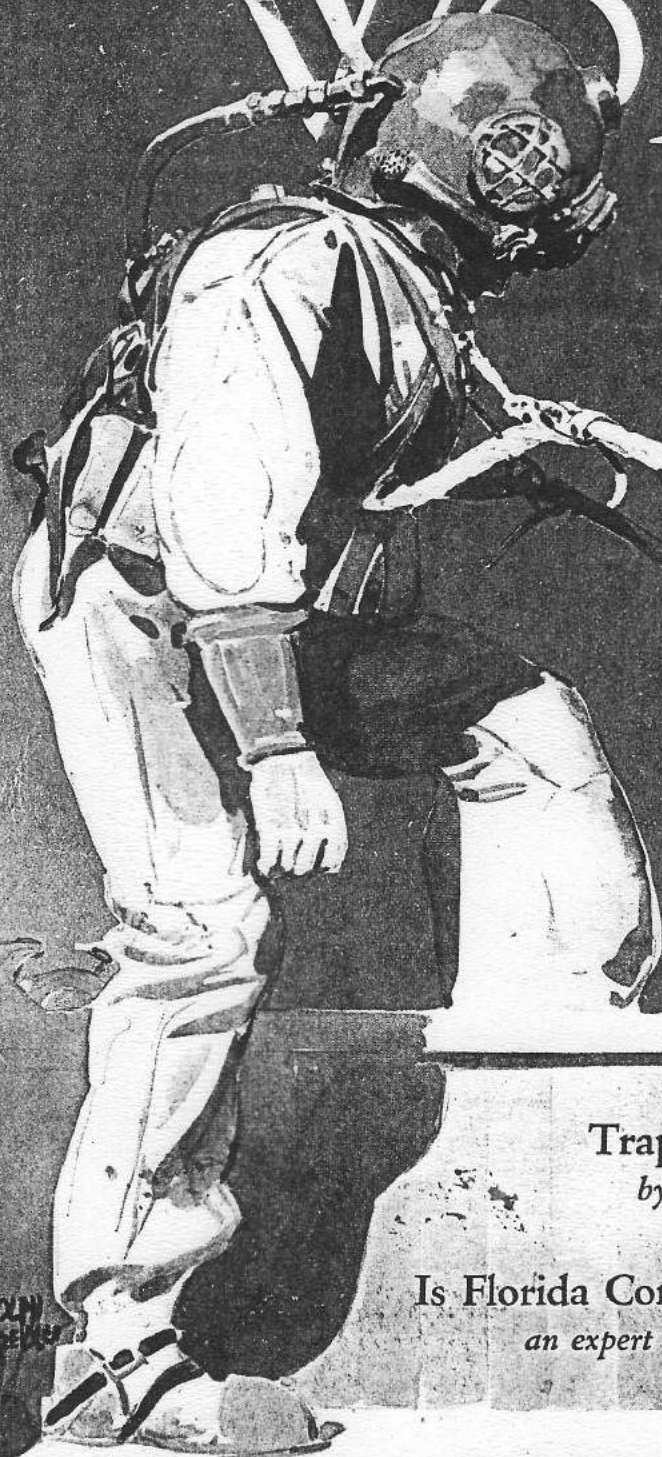


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Deep sea Divers

A THOUSAND NARROW ESCAPES

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Is Florida Coming Back?  
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# THE WORLD'S WORK

CARL C. DICKEY, EDITOR

MARCH, 1928

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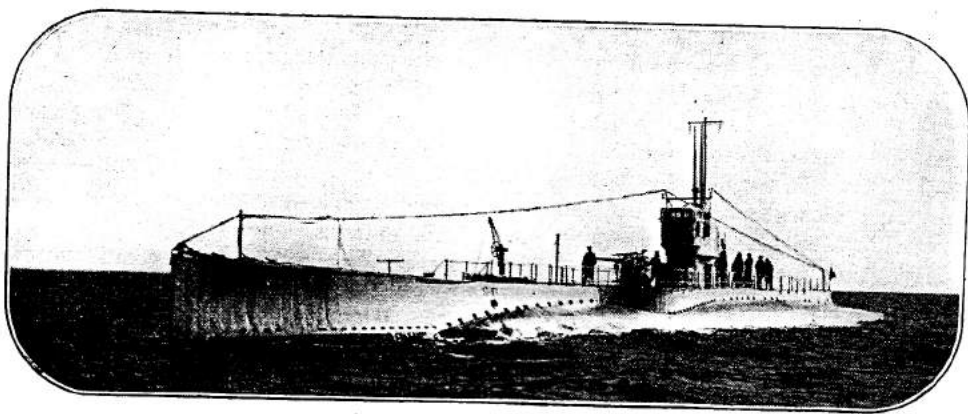
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THE "s-8," SISTER SHIP OF THE LOST "s-4"

## Safety for Our Submarines

*What We Must Have—Better Mechanics, More Caution*

EDWARD ELLSBERG

LIEUTENANT-COMMANDER, U. S. N. (Retired)

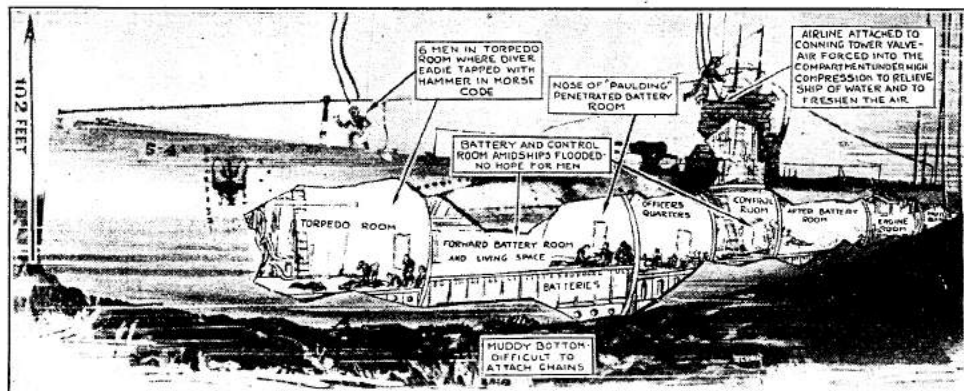
*Commander Ellsberg won the Distinguished Service Medal for his work in raising the wrecked S-51 and took an active part in the early steps to rescue the living on the S-4. Therefore, he writes with authority on the question of salvaging disabled under-sea boats. At Annapolis he won the highest scholastic honors in the class of 1914.*

THE LOSS of the S-4 and the lingering death of Lieutenant. Fitch and his five companions trapped in her torpedo room have driven home to the country what may come in the wake of a submarine disaster. The S-4 is merely the latest in a long string of submarine disasters both in our own and in foreign navies. I still vividly remember the day, thirteen years ago, in the mess-room of the *Texas*, when our radio officer burst in and announced breathlessly: "The Navy has lost its first submarine!" The F-4 had just vanished while submerged off Honolulu. She was the first, but in her wake have gone, among others, R-6, O-5, S-5, S-48, S-51, and S-4. In other navies, a similar story.

Submarines are sunk for the same reasons that trains are wrecked—carelessness, defective machinery, and collision. Submarines are far more dangerous to their

crews than are ordinary vessels. This results from the fact that, to permit submerged operation, they must be packed with special machinery and literally lined with pipes and valves. If something goes wrong with any of this mass of machinery and piping, the boat may never rise again.

The submarine designer is faced with a hard problem. In the given tonnage assigned for the boat, he must include a specially strong and reinforced hull to withstand crushing when submerged; he must provide one kind of engines, Deisels, for propulsion on the surface and carry the fuel oil for them; he must then provide a different type of power, electric motors, for underwater propulsion and install 220 huge storage batteries to supply the current; he must include tanks for filling with water for submerging and a heavy bank of compressed-air tanks for expelling the



A GRAPH OF THE INTERIOR OF THE WRECKED "S-4"

and easy. Several of the crew, including the commander, were still alive in the control room. In spite of this ideal situation for salvage work and the supposedly large number of safety devices in German submarine boats, the men were all dead long before the *Vulcan* succeeded in getting sufficient lines attached to try a lift. Shortly after this occurred, German submarines outgrew the *Vulcan* altogether; the Germans showed what they really thought of the design of such a vessel by not repeating the type in a larger ship.

The British, meanwhile, from 1900 onward, were losing more submarines than any one else. They had the *Vulcan* and its prototypes under their noses, but with their usual respect for the practical in ship design, they decided to build no Vulcans and depended for lifting on surface pontoons or scows. Some of their disabled submarines were recovered, and others were lost with their entire crews, but on the whole the British record was better in rescue and salvage than that of their Continental neighbors. The best British performance was in the case of the *K-13*, a large boat that went down with a flooded engine room, but with the control room and the whole forward half of the boat dry and light. Here the water was but ninety feet deep and remained calm; the light bow being up about twenty feet off the bottom. In this case, divers were able to work continuously, attached a pipe to a valve on the hull, and sent down food and air. Steel cables were passed under the

bow, this being rendered easy since the bow was well clear of the ocean floor. Meanwhile, all ballast tanks forward were blown dry by air supplied from above, and surface pontoons lifted the lightened bow enough after fifty-seven hours to cut a hole in it and release about half the crew who were still alive. The bow then slipped out of the slings and sank again.

Carelessness is a major cause of submarine accidents. It takes practically every man in the crew while diving or running submerged to operate the intricate machinery and valves. The failure of only one man to perform his part properly may lead to disaster and the deaths of the whole crew. In the case of the British *K-13* just mentioned, which was a steam-driven boat, a fireman forgot to close the valve on the smokestack when the boat dived. Half the crew, including the forgetful fireman, were promptly drowned. Carelessness or oversight in handling vents caused the accidents to the American submarines *F-4*, *R-6*, *S-5*, and *S-48*. The *S-5* and *S-48* are two outstanding instances of how our sailors in half-flooded but otherwise undamaged submarines have by their own efforts raised one end of their craft above the surface to allow their escape. In a number of other instances, where the boat was disabled but not partly flooded, the crews have managed to raise the whole boat themselves, and thereby have done unaided what the Germans with their *Vulcan* have considered quite a feat.

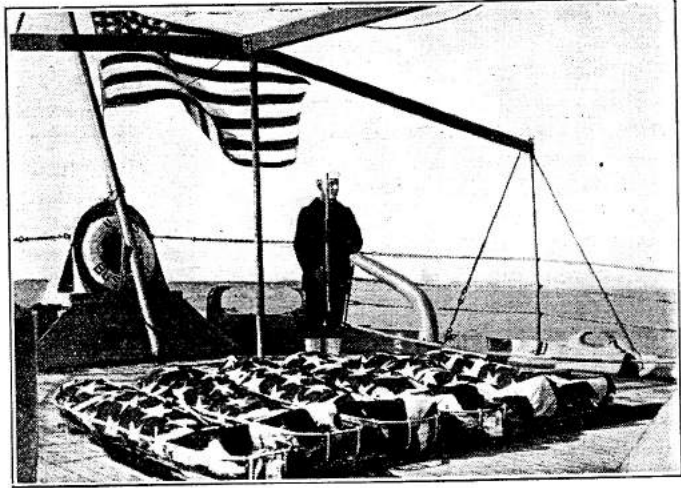
Aside from sinkings due to carelessness

there will be submarine accidents. And if this is so, it is necessary to consider the submarines themselves to make it possible for the crew to save themselves and as much of the boat as they can from flooding in case of an accident; then to make it possible for them to breathe while they try to raise their boat; to include means of providing air, food, and heat from the outside while

the rescue efforts proceed; to render lifting the boat by surface help as quick and sure as humanly possible; and lastly, to provide a means of escape should lifting be impossible. (Such escape is extremely hazardous to the crew and should be attempted only as a last resort.)

Most submarines are divided into five water-tight compartments—torpedo room, battery room, control room, engine room, and motor room. Hinged water-tight doors with heavy dogs to hold them closed are provided in each bulkhead. These doors are habitually open for purposes of access and communication while submerged. It is of the utmost importance that the doors be quickly closed in case of trouble, and that the bulkheads hold tight against leakage. On the majority of our submarines, this is not now possible. On the *S-51*, rammed while on the surface, the crew was not able to close a single door against the volume of water that rushed in through the hole in the battery room made by the *City of Rome's* bow. Every one inside quickly drowned.

On the *S-4*, the hole made by the *Pauld- ing* was much smaller, the water entered the battery room less quickly. The six men in the torpedo room managed to close the door at the forward end of the battery room, while the men in the control room succeeded in shutting the after door to the same compartment. The damaged com-



WHAT PRICE, SUBMARINES?

partment was thus isolated and the remainder of the ship should have stayed dry and in the hands of the crew. Under such circumstances, Lieutenant-Commander Jones, left in possession of the control room, should have been as well off as either *S-5* or *S-48*. But he was unable to remain. Chlorine gas or water (probably both) leaking in through the forward bulkhead, which is pierced by numerous cables and lines, soon forced the captain and crew to leave the control room and take refuge aft, where they closed and dogged down tight the door leading to the control room.

Had Lieutenant-Commander Jones been able to retain possession of his control room, the history of the *S-4* would have been vastly different. This room is the heart of the ship. Here are the connections to the compressed air banks with which he could have expelled all his fuel oil and all the water from his undamaged ballast tanks; he could certainly have brought the stern of his boat to the surface, if not the whole boat; and in any case so lightened up the bow that a slight pull from the special lifting cable in the *Bushnell's* stern would have brought up the *S-4's* bow. He could have fed air gradually from the banks to his own men and to the six men forward; and finally, had it been necessary, the thirty-three men with him could have passed up one by one through the escape trunk, to be assisted to the surface by

divers. All this could have happened had the forward bulkhead of this room stayed tight against gas and water. It was possession of the control room that allowed the crews of the *S-5* and the *S-48* to lift their boats and save themselves; and it was the loss of the control room that meant death to the crews of the *S-51* and the *S-4*.

Consequently, the type of door on a submarine bulkhead and the tightness of the stuffing boxes around the numerous electric cables, pipes, and rods going through the bulkheads are of primary importance. The control room doors, at least, should be of the sliding "long-arm type," which require no releasing of catches, and which will cut through a heavy stream of water and still close. Leakage of chlorine gas through supposedly tight bulkheads nearly killed the crew of the *S-5*; fortunately, they got the stern of their boat up before chlorine forced them to abandon the control room. The crew of the *S-4* were apparently not so lucky.

A trapped submarine crew needs both a supply of fresh oxygen and the removal of the carbon dioxide from the foul air to live very long. Fresh oxygen can be obtained either from the compressed air in the ship's banks (provided the crew has access to the control room) or from oxygen flasks stored in each compartment. The *S-4* had one such flask in each compartment—with the men evenly distributed through the boat this should suffice for about seventy-two hours. But fresh oxygen is not enough. If the quantity of carbon dioxide generated by breathing rises to 7 per cent., unconsciousness and death quickly follow. Consequently, if nothing is done to remove the foul air from the compartment, the results are fatal.

For purification purposes, all submarines should (and most of ours during the war did) carry a supply of soda lime in each compartment. When this is exposed, it absorbs the carbon dioxide, and a moderate quantity will purify the air for several days. The *S-4* had no soda lime aboard, though it appears that her commanding officer had previously asked for it. Soda lime in the after compartments might have prolonged life till after the divers came on

Sunday; forward it might well have prolonged life till the weather moderated and diving was again possible on Wednesday.

All our submarines have what is known as the compartment salvage air line; this starts from an external valve in the side of the conning tower and runs the length of the boat, with a branch leading into each compartment and discharging into it through a non-return valve and a gag valve. The intention is that the gag valves shall be left open so that, in case of accident, air can be supplied from the outside. In the flooded compartments, this air is supposed to enter and expel the water, but, as it is practically certain that the damage that caused the flooding will extend to the top of the compartment, any air entering such a compartment will promptly escape and do no good.

In the compartments where men are alive, if the outside air line is connected up, the men are supposed to take air when they want it and then close the valve in their room. However, the non-return valve prevents bad air from leaving the room, and it shortly happens that if the men take air this way, they will build up a pressure in their room that will soon equal the outside water pressure. The trapped men will then be subjected continuously to the same pressure as the diver; the latter can stand it only a few hours; the submarine survivors will probably not be able to stand it that long before they contract severe pneumonia from the heavy pressure and very quickly die.

I cannot recollect a case in the history of our submarine disasters where the compartment salvage air line has ever been of use. On the *S-51* it was cut in half by the stem of the *City of Rome*; on the *S-4* the survivors also reported it flooded on Sunday night. The compartment salvage air line should be removed immediately from all submarines, and replaced by either one or two valves attached directly to the hull in way of every room on the ship. In this way, even with one valve per compartment, fresh air could be supplied by a hose from the surface, bad air could be vented out, and the men in the room subjected only to a little above atmos-

pheric pressure, under which they could survive indefinitely. Hot soup for food could be run through the same hose. Such an arrangement was urged on the Navy Department after the *S-51* disaster by at least one inventor. It was not then adopted, but no more time should now be lost.

Quick lifting of the boat is the most important feature in rescue work. Derricks and salvage ships are useless in such cases as *S-51* and *S-4*, where rough water and deep water prevail. As an instance of this, when the *S-51* sank off Block Island, the weather was good enough for divers to work steadily for the next five days, passing heavy wire slings under the *S-51*'s stern, which was just clear of the mud. Nevertheless, the commercial salvage company that was hired at that time, and had its two largest derricks at Point Judith, fifteen miles away, considered the weather too bad for derricks and refused to send the derricks out to the wreck until the fifth day, by which time it was certain all hands were dead.

Pontoons can be used in any weather in which diving is possible. Derricks require that the water be smooth, or they will probably carry away their booms if they do not capsize. Pontoons are the quickest and surest method. After the *S-51* job, we designed a new type of pontoon that can be lowered and secured in less than an hour. (Most of the Navy pontoons have since been converted to this type.) It is possible for the *Falcon* to lower and secure a pontoon in less than an hour; six pontoons can be secured in less than twelve hours, and are enough to lift half of a completely flooded *S* boat; twelve pontoons can be secured in twenty-four hours and will lift the entire boat, even if completely flooded. But to do this requires twenty experienced divers, a well-drilled crew on the *Falcon*, and a quick means of attaching chains.

In using any external lifting means, attachments to the submarine are necessary. Our boats have none. On the *S-51*, it was necessary to dig tunnels under the boat to get the lifting chains under. With the ordinary means (a fire hose), our first tunnel took several weeks to dig, and several

divers nearly lost their lives when the tunnel caved in on them. We then employed an improved nozzle, which allowed us to cut tunnels faster; the time was reduced to two days for a moderate length tunnel under the *S-4*. But even with this nozzle, tunnelling is still slow and dangerous, and I marvel that men can be found who in cold blood will hazard the perils of burrowing in the darkness and the cold at the bottom of the sea through sand and mud beneath a buried submarine. For salvage work, this method, while slow and dangerous, is at least feasible. For rescue work, when the lives of a trapped crew may depend on a quick lift, it is ridiculous.

The strain in lifting on each chain of a pontoon is only forty tons. It is easy to provide permanent padeyes on the side of every submarine, properly spaced to take pontoon chains. For an *S* boat twelve such padeyes on each side will permit attaching twelve pontoons in twenty-four hours; the weight of all the padeyes is less than six tons. The need for tunnelling is eliminated; the divers can quickly shackle the pontoon chains to the submarine and with a proper salvage crew and twenty-four hours of moderate weather, the boat will be afloat again. But it must be remembered that to do this requires sufficient divers, a salvage ship well-drilled and not too far away, and a set of pontoons somewhere in the vicinity.

Deep-sea diving is vastly different from diving in shallow water. Our navy has developed the art; practically every deep-water diver in this country was trained in the Navy or by Navy instructors. Except for ex-Navy men, there are probably not half a dozen qualified deep-sea divers in this country. But even in the Navy, such divers are not so common as they should be. For the *S-51* job, it took more than a week to gather up twelve; meanwhile, we could find only four qualified civilians. Trained divers in large numbers constitute a major safety factor for submarines. A salvage ship like the *Falcon* should always carry at least twelve divers in her crew; by constant drill both with divers and pontoons, the captain of the *Falcon* will be able to swing into action when a sub-

marine sinks, with the speed and precision of a battleship going into action against the enemy.

How far the *Falcon* was from this state of readiness can be judged from the fact that on the day the *S-4* sank, there was only one qualified diver attached to her crew—Chief Boatswain's Mate Carr; the *Falcon* had not handled a pontoon since the day the *S-51* came up a year and a half before. The pontoons themselves were scattered—six in New York and four in Norfolk—not enough in either place to raise a submarine. The four in Norfolk had not yet been converted to the new design and were slow and dangerous to handle. For proper preparation, there should be a complete set of twelve pontoons in every major district where submarines operate. Two hundred pontoons, more than sixteen complete sets, can be built for less than the cost of one moderate-sized *Vulcan*. These sixteen sets, scattered over our Atlantic and Pacific coasts, will insure that pontoons are close at hand wherever submarines operate.

The Navy has two salvage ships, the *Falcon* and the *Widgeon*, one in the Atlantic and one in the Pacific. These boats, converted mine-sweepers, are ideal for the purpose, being small enough to handle easily and moor quickly in a seaway; they can hold position when a larger ship would be swept away by the wind, but though much crowded, they can carry all necessary machinery. Under Lieutenant Hartley, the *Falcon* has done wonders; but really to fulfill her purpose, such a ship must be given ample opportunity for drill; in addition, there should be at least four such ships properly to cover the areas where submarines work.

And finally, in case a boat cannot be raised, or the crew must be taken out before the raising equipment can arrive, the last desperate means must be provided to allow the crew to escape from the boat as it lies at the bottom of the sea. An airlock is the answer. This is a small trunk with one hatch below opening to the boat, and another either at the top or side, opening

to the sea. The members of the crew enter the lock from below, one at a time, and close the lower hatch. Then either by compressed air or by admitting water to the lock, they raise the pressure inside till it balances the outer sea pressure, when the hatch to the sea can be opened. The man inside is then supposed to float up with the air released from the lock. The other members of the crew inside then close the outer door by a wire attached to it, drain out the water from the lock, open the lower hatch, and the next man enters.

This is the theory. The practice is far different. In deep water the pressure would so collapse a man's lungs that he would have no buoyancy and would sink instead of rise. In deep water such escape has never been effected. In shallow water, it might be done. The only instance I know of where it was successful, occurred on the British *K-13*, when the captain and first officer attempted to escape to give warning of the loss of the boat and her condition. Here the top of the conning tower was only fifty feet below the surface, and the pressure was not great. One officer rose successfully; the other was killed in the attempt.

Each submarine has an air lock in the conning tower, but it often happens that the crew cannot get to that. In addition, there should be one at each end of the boat, so that a crew forced to get out or die from chlorine or because of lack of air to last them till divers or rescuers can arrive, can at least take this last desperate gamble with death. If divers are at hand but cannot lift the boat, then the locks can be used with comparative safety. In such a case, the diver stands outside the lock, holding an extra diving helmet heavily weighted down and with airhose attached and blowing, ready to slip it over the head of each man as he comes out, before lifting him to the surface. In this way, one at a time, divers can rescue the entire crew of a submarine, provided the crew can get to an airlock. To make this possible, all submarines should have at least three, one at each end as well as the present one in the conning tower.