7. Submarine External Lift

7.1. The Need for External Lift

External lift must be provided when:

1. It is not possible to provide enough self-lift to raise both ends of the submarine.

2. The submarine is to be lifted a distance which is less than the distance to the surface.

3. The submarine is statically unstable or may become statically unstable at anytime during the salvage operation. This is most likely to occur when one end has been raised and the other end is resting heavily on the bottom.

Even if none of the above factors are present, external lift may be desirable because it happens to be easier than obtaining self-lift.

7.2. Providing External Lift

Sources of external lift include surface vessels (such as lift ships and barges), floating cranes, and submersible pontoons. Lift ships such as the ARS or ATS described in Chapter 2 have sheaves at the bow through which the lift cables are led to winches on deck. These lifting cables are hauled in by the winches or with a block and tackle purchase arrangement.

Lift barges (YMLC) have several lift stations in each side and are generally used in pairs. The wire cable slings are rigged between them and hoisting is accomplished by block and tackle power on deck. Lift ships and barges have floodable spaces permitting large changes in draft, in combination with tidal action, to make lifts. The procedure is for the vessel to flood down the ballast tanks at low tide and take a strain on the lifting cables. As the tide comes in, the ballast tanks are pumped out, lifting the submarine. It is then towed into shallower water until the submarine grounds; the operation is then repeated, as necessary, until the submarine reaches shoal water; it is then made watertight and dewatered. The amount of lift obtained on each side or over the bow is reduced by the stretch of the slings and the sinkage of the lifting vessel. Thus, such lifts are not very effective except in areas where there is an appreciable rise and fall of tide.

Floating cranes are generally less seaworthy than other lifting vessels because of the height of the crane boom.

However, floating cranes have an advantage in boom reach, and, thus, need not be positioned directly over the submarine.

Submersible structural pontoons can furnish a major external lift force of pre-calculated amounts. Once attachment is made, the pontoon is a valuable tool to the Salvage Officer. When it is in position over the submarine, prior to the actual lift, the pontoon is not affected by sea state and can be left for long periods while other pontoons are being rigged. Rigid submersible pontoons have proven useful on four actual submarine salvage jobs, as reported in the Appendices.

Collapsible pontoons of rubber and fabric have been used on a test and evaluation basis only. They were used in a salvage exercise involving the ex-German submarines U-1105 and U-3008 after the ships had been sunk by explosive charges. The advantages of collapsible pontoons lie in the ease of transporting them to the salvage site and of handling them during placement. Experience with the collapsible pontoons in these cases revealed them to be vulnerable to damage and unreliable as designed. In spite of ideal weather conditions, a great deal of trouble was encountered; seams gave way or the fabric was punctured, causing subsequent loss of lift. Pontoons of various lift capacities, up to 50 tons each, were used during these tests. There is some promise that collapsible pontoons of multi-ply construction, such as are used in commercial containers, may prove to be satisfactory. These containers consist of high strength, tire cord fabric and sheets of molded synthetic rubber. Many of these containers have been in use for ten years during which time they have been subjected to rough handling. They were effectively used in salvage of the drydock AFDM 2 in the Mississippi River off New Orleans which was completed in August of 1966.

7.3. Attachments to the Hull

The attachment of slings for applying external lift to the submarine may be the most difficult and time-consuming part of the salvage operation, particularly in water which is of such depth that only a limited amount of work can be performed by divers. In past submarine salvage operations, the slings were placed under the bottom of the submarine since there were no appendages strong enough for heavy lifts.

7.3.1. Attachment Points

In the case of the 585, 593, 598 and later classes of submarines, the fairwater planes, as well as the stern planes, can withstand an applied load of approximately 700 tons on each side if the load is applied within 2 feet of the superstructure (Figure 7-1). The shape of the planes is not favorable to the attachment of slings, however, and if so used, would probably result in the slings becoming jammed between the planes and the permanent structure. Access hatches of the type having a bayonet joint locking device may be removed and replaced by fittings suitable for the attachment of slings. Each dummy hatch in this case would have an approximate lift capacity of 300 tons. Such devices should be considered only for compartments that are known to be flooded. There are no other appendages or features on U.S. submarines suitable for the attachment of slings.

7.3.2. Methods of Placing Slings

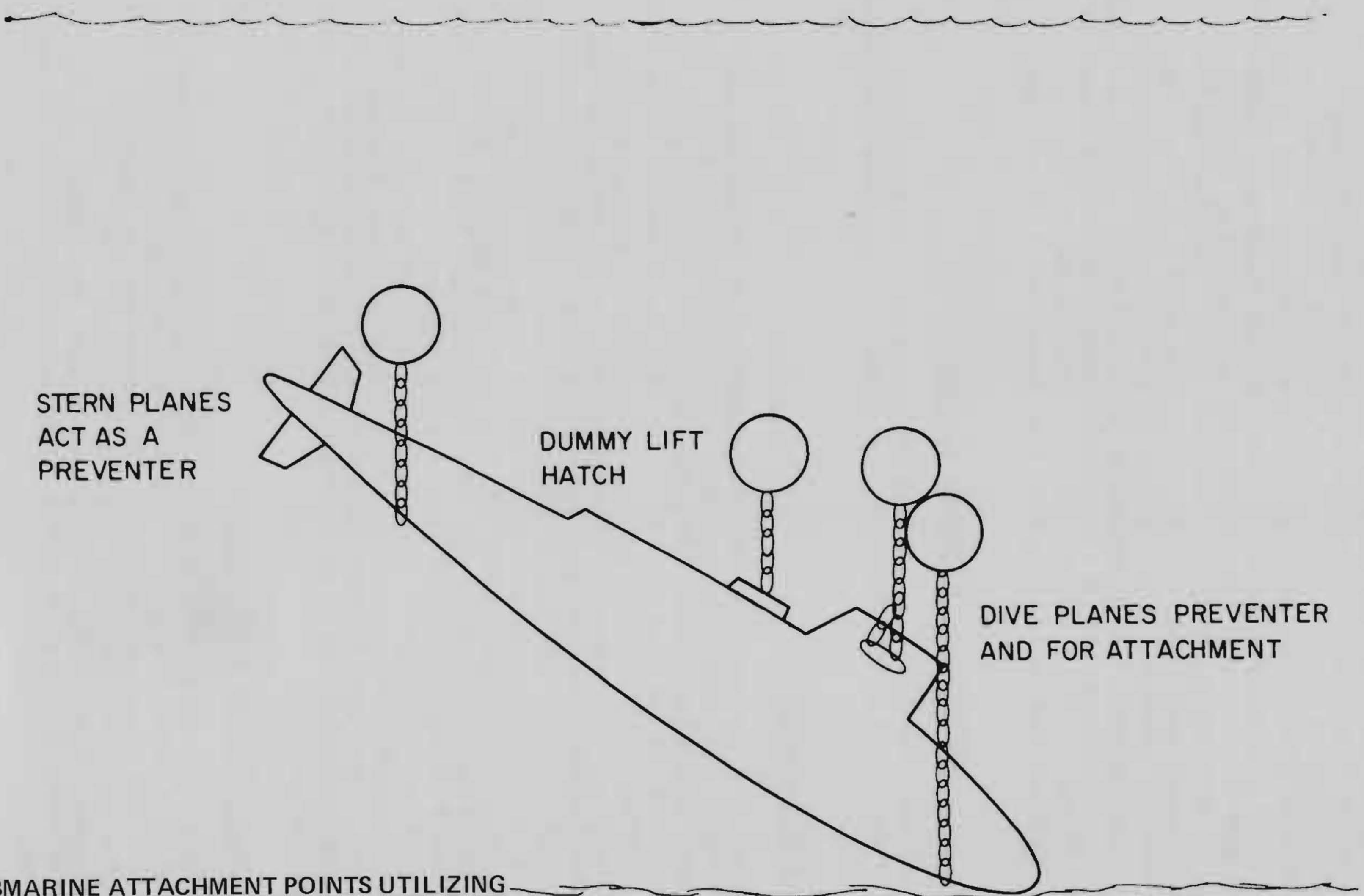
Three methods successfully used in the past for placing slings under sunken submarines are discussed in the following paragraphs.

Sweeping of Slings

The rudder and propellers at the stern of a submarine may make it very difficult to sweep a sling or even a messenger wire under the stern from aft, particularly if the stern is partially buried in the bottom. In the deep-water phase of the F-4 salvage, however, it was possible to sweep slings under the stern on some occasions. When this could not be done, the forward end of the submarine was lifted and held clear of the bottom by means of the forward slings while the after slings were swept from bow to stern. During that salvage operation, most of the lifting slings were placed by sweeping them under the submarine. This involved a great deal of handling of heavy wire and chain. During the salvage of subsequent U.S. submarines, messenger wires were passed under the submarine and used to haul slings into place. The use of messenger lines removed some of the difficulties connected with the handling of heavy and awkward slings.

Tunneling under the Submarine

In the final phase of the F-4 salvage, tunnels for three of the slings were dug under the submarine through coral and sand. The shallow depth of 48 feet made it possible for divers to work for long periods of time. The tunnels were dug with fire hoses and crowbars and the coral debris was washed away by use of water pressure pumped down through fire hoses.



SUBMARINE ATTACHMENT POINTS UTILIZING EXISTING APPENDAGES.
FIGURE 7-1

For the later salvage operations on S-51 and S-4, the tunnels had to be cut through mud, clay and sand. The balanced washing nozzle, described in Chapter 2, was developed during the S-51 salvage after the divers encountered difficulty in handling the standard 2-1/2-inch fire hose nozzle using pressure high enough to cut through the hard clay. The tunnels were dug from both sides so as to join under the centerline of the submarine.

Tunneling with a Lance

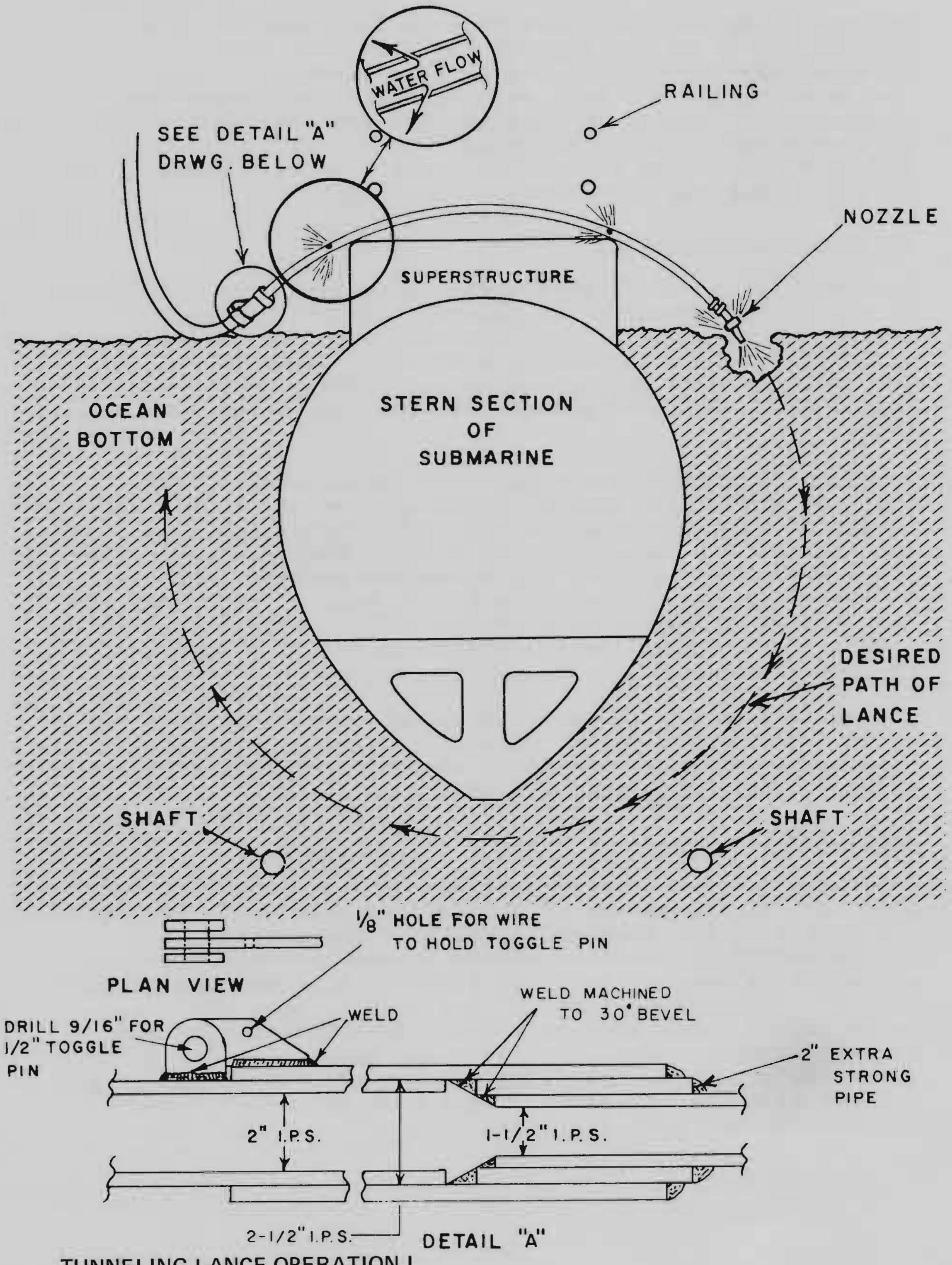
The depth of 240 feet in the SQUALUS salvage was sufficient to discourage tunneling by divers. Bottom-time in such depths was very short, and there was a danger of the tunnel walls collapsing, entrapping a diver. Also, the hull at the stern of SQUALUS was buried quite deep, which meant that a diver would be working several feet below the sea floor.

In order to reeve a messenger wire for a sling at the stern of SQUALUS, a special lance was devised. This consisted of pipe sections that could be fitted together from the deck of the submarine by a diver. Each section of the lance was curved so that the assembled sections would tend to tunnel following the shape of the hull. The tunnel was cut so that it passed between the hull and the propeller shafts. This permitted the shafts to act as preventers for the slings.

Any lance that may be used for tunneling will need to be designed according to the particular salvage problem. However, a review of the lance operation on SQUALUS might be useful to the Salvage Officer.

Operation 1

The first section of the lance was of 1-1/2-inch diameter pipe bent to the radius of the desired path which was below the bottom of the ship and inboard of the shafts. Its length permitted it to be placed across the deck of the submarine (a span of about 15 feet) by a diver, and to be in contact with both sides of the deck to more accurately guide it, as shown in Figure 7-2. In this position and pointing athwartships, the lance was pushed around the submarine's side by the diver, who at all times kept it in contact with the two sides of the deck as water pressure cut through the sand and clay.



TUNNELING LANCE OPERATION I.

FIGURE 7-2

Operation 2

When the first section of the lance had advanced to the position shown in Figure 7-3, pumping was stopped, and the hose disconnected and hauled to the surface. There, a shorter 7-foot section was attached and sent down to the diver to be joined to the first section, after which, pumping was resumed. In this manner, four of the short sections were added and the lance was advanced to the position shown in Figure 7-4. The inside of the nozzle and the joints in the nozzle were beveled so that a 1/4-inch diameter rod could be passed through the lance without encountering obstructions.

Operation 3

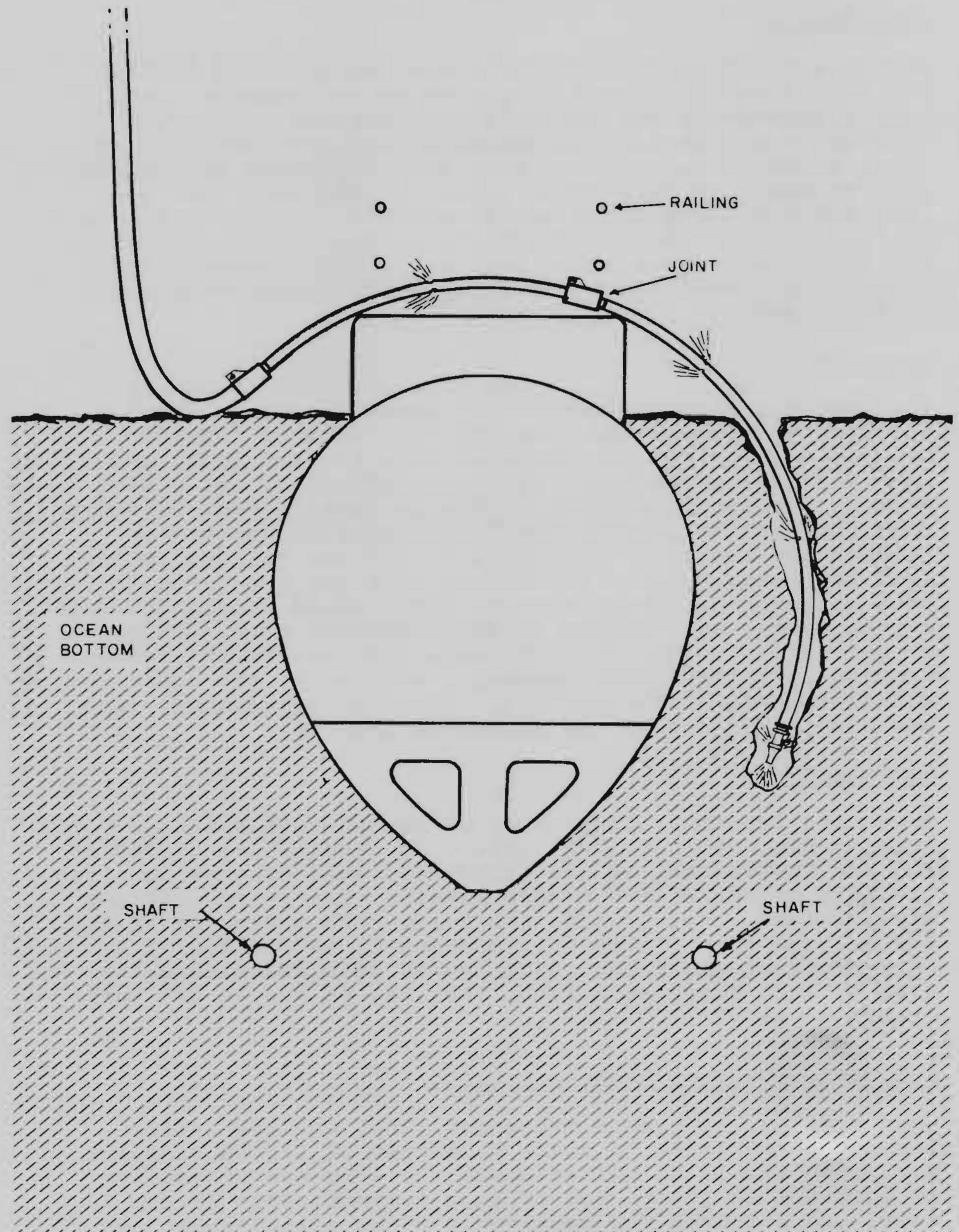
The hose and last section of the lance were then removed and sent to the surface, leaving the lance as shown in Figure 7-4. A 1/4-inch diameter rod, 60 feet long, and with a 3/16-inch diameter wire rope attached, was pushed through the lance and sent to the surface. Then, 7/16-inch wire rope was spliced to the 3/16-inch wire and hauled through the lance. A 1-inch wire rope was spliced to the 7/16-inch wire. Since the 1-inch wire was too large to pass through the lance, a stop, which would engage the end of the lance, was clamped to the 7/16-inch wire just ahead of the splice. The 7/16-inch wire then hauled the lance out and left the 1-inch messenger wire under the submarine with both ends at the surface. The 1-inch messenger line was then used to haul the slings into place.

Operation 4

When more than one sling is to be hauled into place, a reeving plate (Figure 7-5) should be used. During SQUALUS salvage operations, it was found desirable to make up three complete slings of the proper lengths (2-1/2-inch lifting wire, 1-inch reeving wire, and 2-1/2-inch chain) to suit the salvage plan (Table 5-1, Drawing E) and to haul them into place at one time. Once hauled into place, and the ends of each sling equalized, they may be buoyed off until ready for use.

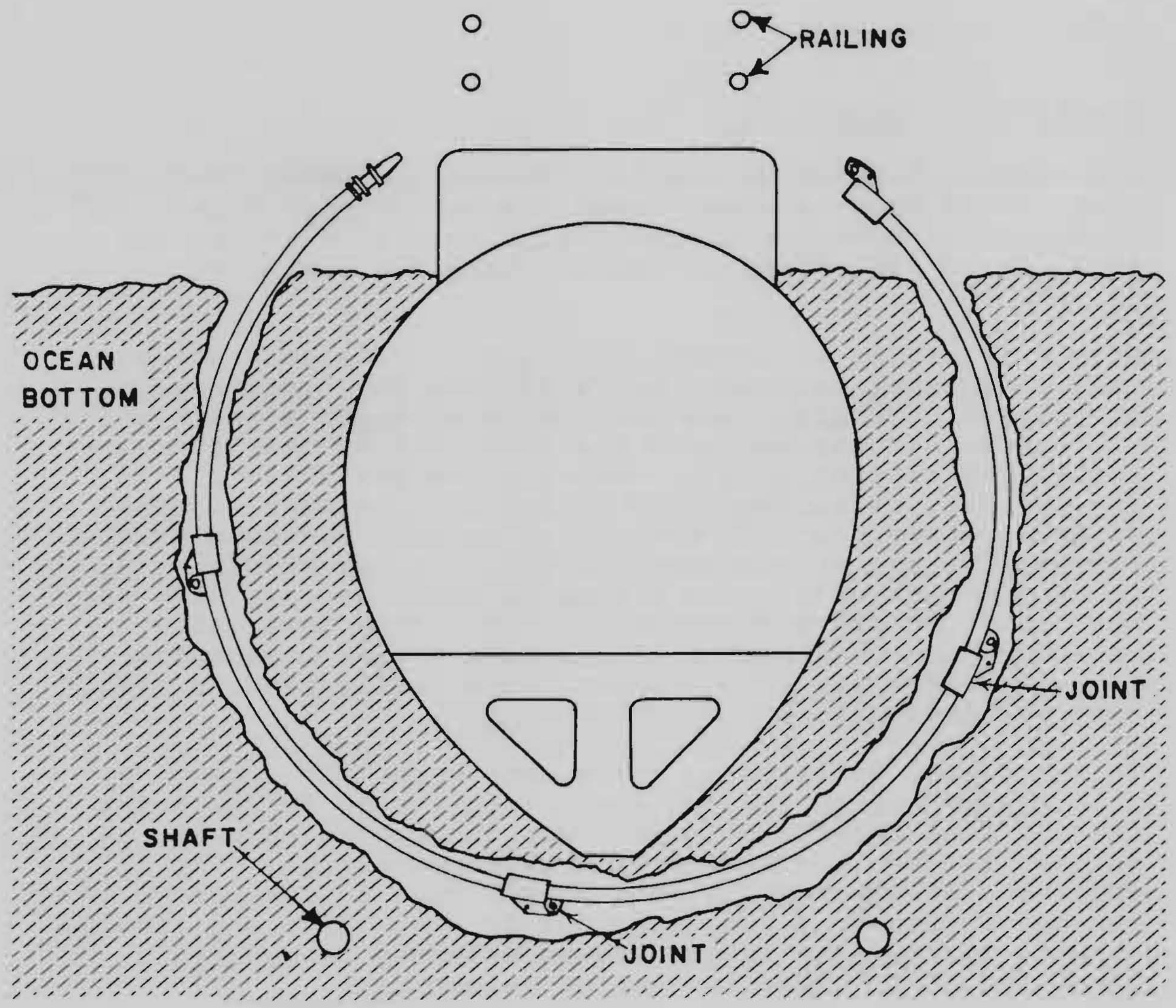
7.3.3. Spare Messenger Lines

Once a sling, or even a messenger line, has been placed under the submarine, a spare messenger of 1-inch diameter wire rope should be pulled under the ship and buoyed off, or laid out on the bottom in such a manner that it can be retrieved and used for hauling in a new sling should one break. This should be accomplished at each position at which slings are to be used.

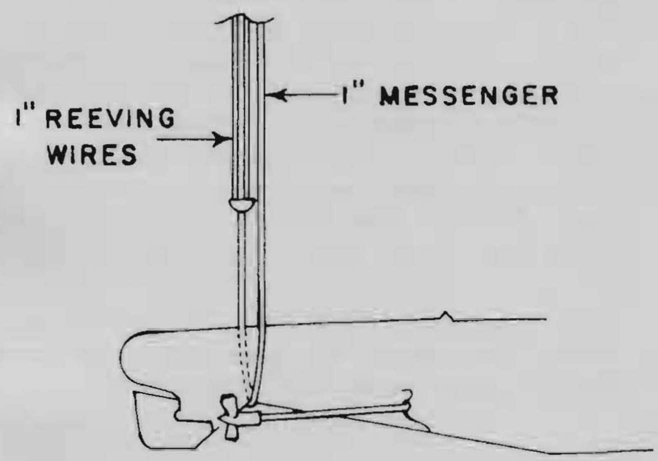


TUNNELING LANCE OPERATION 2.

FIGURE 7-3



TUNNELING LANCE OPERATION 3.
FIGURE 7-4



FINAL ARRANGEMENT OF
REEVING WIRES.
FIGURE 7-5

7.4. Slings

7.4.1. Description

Experience obtained during F-4 salvage indicated that wire rope slings tend to break under the submarine. This prompted the subsequent practice of utilizing chains for that part of the sling in contact with the submarine (Figure 7-1).

Wire rope slings in contact with a submarine hull not only have a tendency to break, but also have the disadvantage of rolling at angles less than those at which a chain sling will slip. If the pontoons are to be placed near the submarine, no lifting wire is needed above the chain slings. If, however, it is desirable to set the pontoons at some distance above the hull for use as control pontoons or to keep the divers at shallower depths, the use of wire rope in conjunction with chain slings is recommended. Wire rope has a greater strength-to-weight ratio than does chain. Extending the length of chains by using wire rope rather than chain results in a lighter, more easily handled sling-pontoon combination.

To facilitate positioning the slings under the submarine, a length of 1-inch reeving line, long enough to reach the surface when the sling is in place, should be shackled or spliced to each end of the wire or chain slings. The upper end of the reeving line should have an eye splice which can be secured to a buoy when not in use. When the reeving line is in use, its length may be extended as desired by shackling it to other lengths of 1-inch wire.

7.4.2. Rigging of Slings

When the first messenger line has been placed under the submarine, it should be used to haul into place under the submarine a 1-inch messenger wire and a spare 1-inch wire. This 1-inch wire is shackled to the reeving line of the sling and used to haul the sling under the submarine. If several slings are to be placed through a single tunnel, all of the slings should be hauled through the tunnel at the same time. Table 5-1, Drawing F, shows a reeving plate suitable for hauling in three slings at one time. The leading end of the chain part of the sling should have a fairing cone such as that also shown in 5-1(F).

The slings are normally made up to suit the salvage operation and then sent to the salvage scene. In SQUALUS salvage, a barge was used to transport the slings to the site.

When the slings were ready to be hauled under the submarine, the barge was brought alongside the salvage vessel. The slings were led across the salvage vessel and shackled to the 1-inch wire under the submarine. They were then paid out under control and kept free of slack while the 1-inch wire was being used to haul them into place.

7.4.3. Preventers

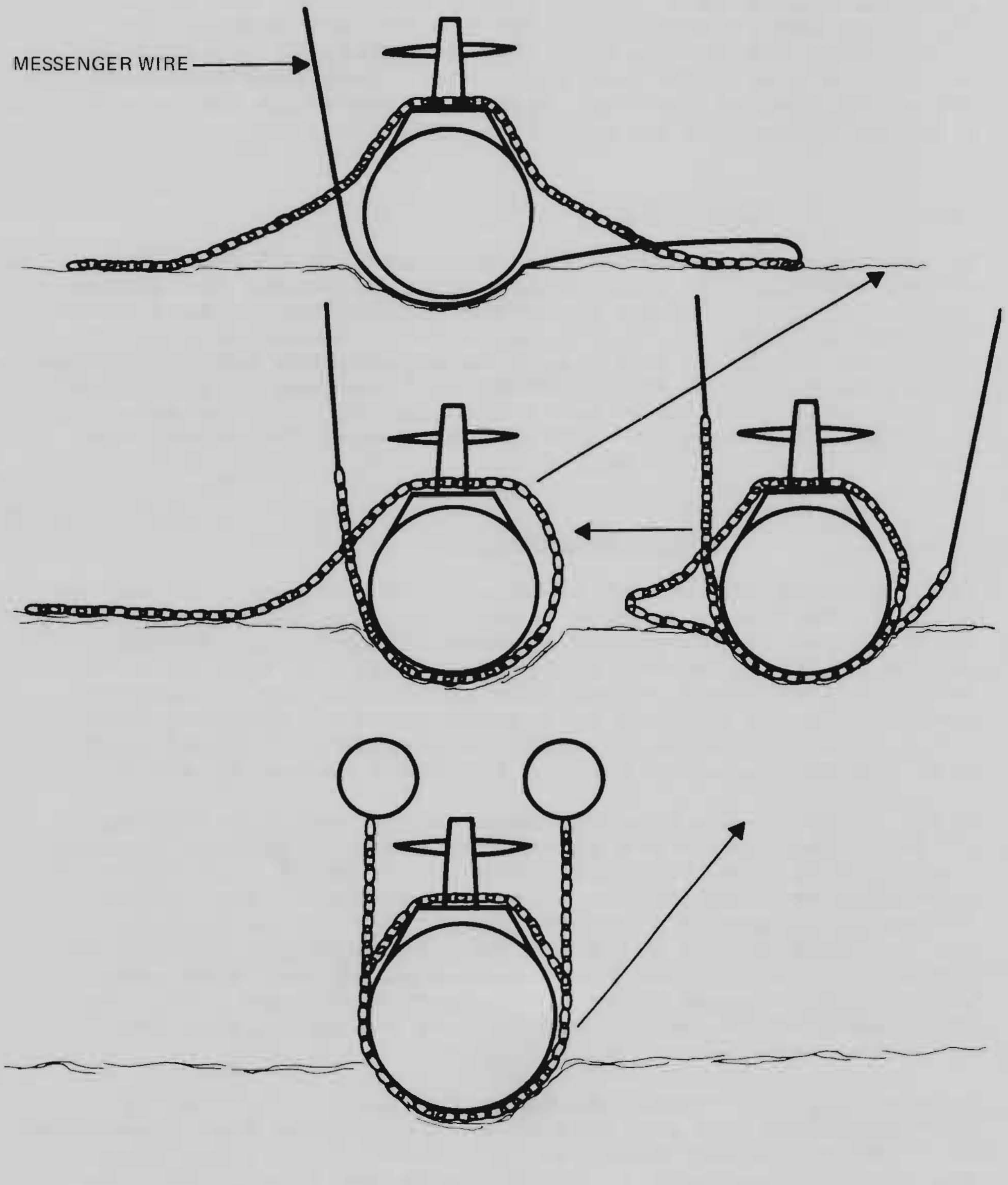
If the horizontal angle of the keel exceeds 10 degrees during breakout, it will be necessary to secure the slings against slipping toward the end which has been raised first. This may be done by rigging preventers between the slings and fixed points on the ship. By raising the same end first each time a lift is made, the preventers need be effective in only one direction. Since the rigging of preventers requires hard, physical work, their use should be weighed against the effort of making additional, shorter lifts.

7.4.4. Temporary Attachments

Temporary attachments of lines will be necessary for various purposes such as measuring aids, lifelines and diver descent. Where ladder rungs, grabs, padeyes, hatch bails, or handwheels, or other suitable appendages are not available for securing such lines, a suitable attachment may be obtained by installing a C-clamp in a superstructure flood or vent hole. Another method would be to install a threaded stud with a power velocity tool or to weld a padeye to the hull.

Sling slippage may also be prevented by taking a full turn of the sling around the submarine. This is done by laying out the full length of the sling across the top of the submarine at right angles to the centerline. The center of the sling should be at the centerline of the submarine. The two ends of the sling are then hauled under the submarine and led to the surface by messenger wires that have previously been rigged under the submarine (Figure 7-6). The chain part of the sling must be long enough so that the ends clear the submarine.

Before rigging preventers, however, the possiblility of placing slings and pontoons in such positions that preventers will not be needed should be considered (Figure 7-1 illustrates an arrangement in which slings are restrained from slipping by the use of fixed parts of the ship).



METHOD OF RIGGING FULL TURN
OF SLING AROUND A HULL.
FIGURE 7-6

7.5. Rigging for Supplemental Surface Lift

If bottom conditions are such that the maximum breakout force can be predicted with confidence, then control pontoons may be eliminated and a lift ship may be used for breakout. Under these circumstances, the lift ship capacity must be well in excess of the breakout force anticipated. It is also feasible to use a lift ship at one end of the submarine and control pontoons at the other end, though a lift ship at each end is more desirable from the standpoint of positive control during breakout. The advantages of using lift ships as the force for breakout lie in the fact that control is available at all stages of the lift and the Salvage Officer may be provided with immediate knowledge of the magnitude of the weight being lifted. In this manner, the Salvage Officer can avoid any major changes of trim angle or unprogrammed depth changes of the submarine. Thus, the problems of free surface and expansion of air in the submarine compartments and tanks may be detected and controlled.

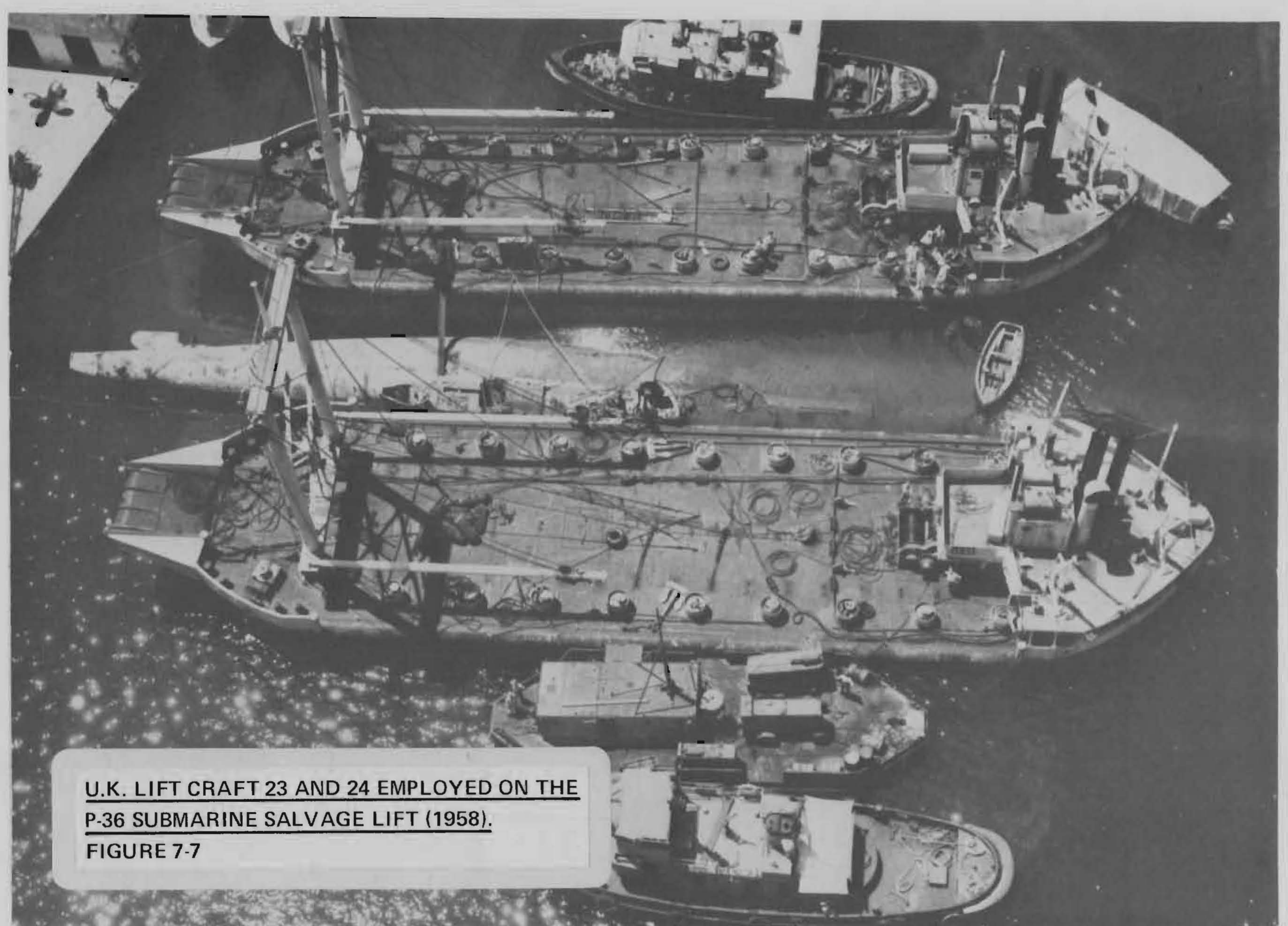
When a surface lift ship is to be used, a separate sling, without pontoons attached, should be available at each lift point. If the surface lift is provided by salvage vessels such as ARS, YMLC, or ATS, the lifting can be continuous except for the short period needed to rig for a new purchase. When the submarine has been lifted clear of the bottom, it should be towed toward shallower water, keeping only a small distance between the submarine and the bottom. The loss due to a broken sling or other mishap will thus be minimized.

If the lifting is done with cranes and the depth of water exceeds the distance they can lift, it will be necessary to place the submarine on the bottom to shorten the slings.

NOTE: Figure 7-9 illustrates a lift situation using submersible pontoons secured close to the submarine's hull, an ATS lift ship, and tidal action.

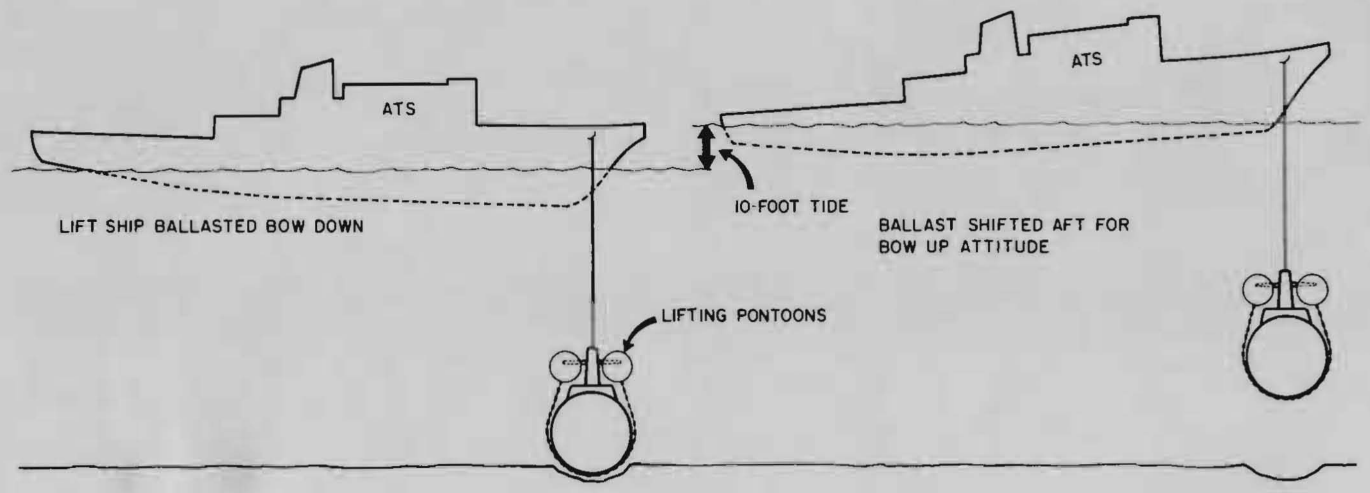
7.6. Air Requirements

A large quantity of air is usually required to blow water from tanks and pontoons while buoyancy is being provided to lift the submarine. The amount of air required depends upon the depth of the pontoon or tank and on the amount of buoyancy needed. The time required to obtain the buoyancy can be shortened greatly if fully charged air banks are available in addition to the air compressors on the salvage ship. If a submarine is assigned to the salvage force, her air banks may be a source of a large amount of high pressure air. In such a case, the submarine would feed her air to the air manifold on the salvage vessel, where regulation of blowing operations will be controlled and monitored. (Figure 7-10 may assist the Salvage Officer in estimating the air requirement for his salvage operation).



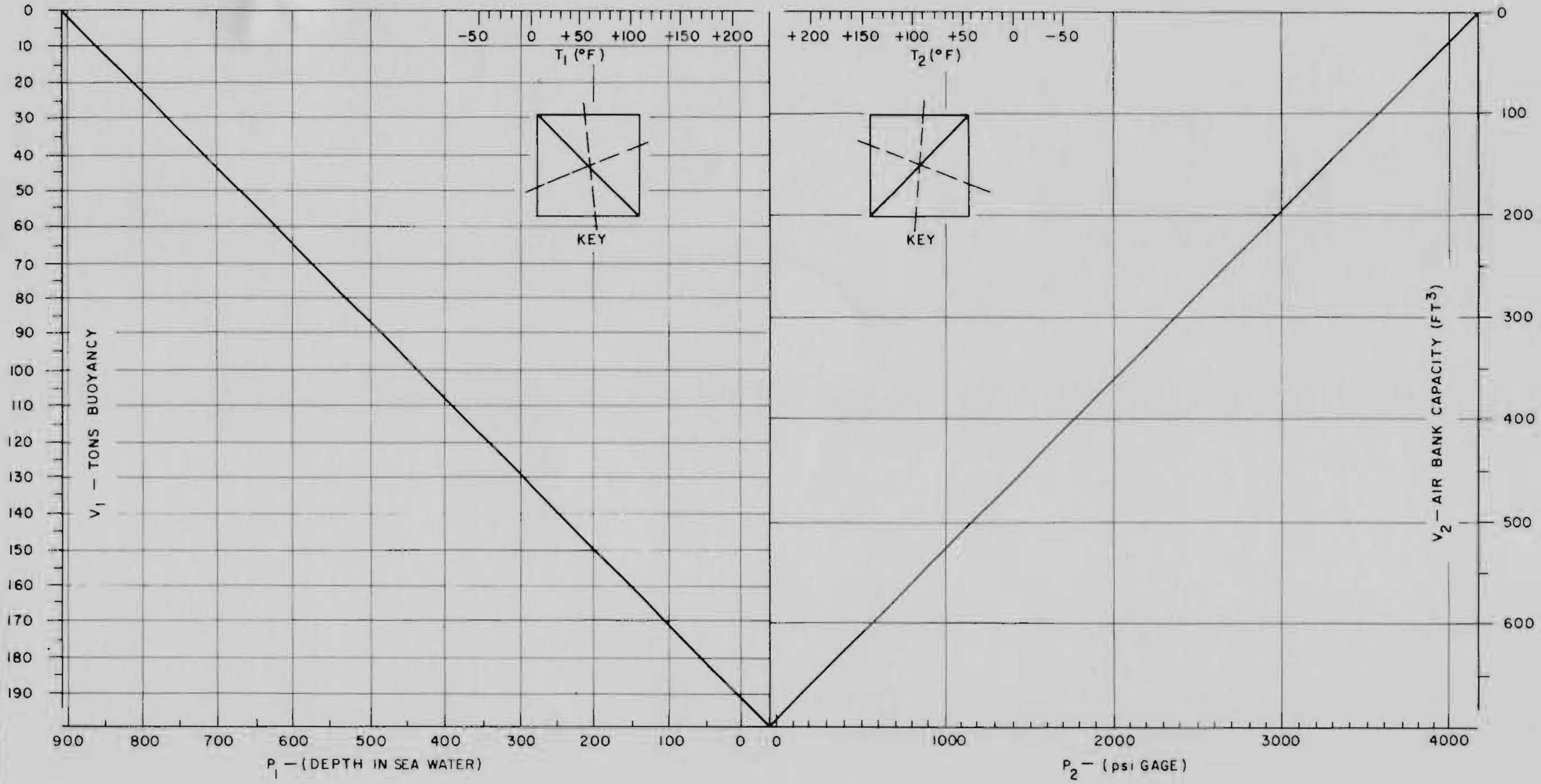
U.K. LIFT CRAFT 23 AND 24 EMPLOYED ON THE P-36 SUBMARINE SALVAGE LIFT (1958).
FIGURE 7-7

BOW LIFT DECK PURCHASE TACKLE USED ON THE HMS TAPIR SALVAGE OPERATION (1966).
FIGURE 7-8



SUBMARINE LIFT BY SURFACE SHIP.

FIGURE 7-9



<u>SALVAGE AIR REQUIREMENT</u>
<u>NOMOGRAM.</u>
FIGURE 7-10