NAVSHIPS TECH DIVING

Chapter 9940 (Sec. II)

Salvage

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CHAPTER 9940–SALVAGE
SECTION II. DIVING

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Part 1. Diving Equipment

A. Standard Diving Outfits

9940.541. DETERMINING FACTORS IN DIVING

To a considerable extent, diving has been thought of primarily in terms of depth–shallow water and deep sea. These two terms have been used so frequently that the whole subject of diving has become divided unconsciously into these two categories. Shallow water diving has come to imply diving to less than 36 feet, and deep-sea diving to mean diving in excess of 36 feet. This distinction has led many individuals to erroneously consider depth to be the primary consideration in diving. Strictly speaking, in terms of diving where the only consideration is descending to some depth and returning to the surface, depth is the primary consideration. However, diving must be associated with accomplishing particular tasks under varying conditions. It is true that diving in excess of 250–300 feet causes a reduction in mental alertness that greatly increases the hazards of diving. However, in ordinary diving, other than diving to extreme depths, the type of work to be undertaken, location of the work, the extent of the operations, and the climatic conditions, in addition to depths, should be the determining factors in deciding the personnel and type of equipment to be used and the method of accomplishing the task.

9940.542. DEEP-SEA DIVING OUTFIT

1. **The Deep-Sea Diving Outfit** consists essentially of a helmet and dress which provides watertightness, weighted belt and shoes used for overcoming positive buoyancy gained by the volume of the helmet and inflated dress, the hose and control valve whereby air is furnished and the quantity of air required is controlled, and the nonreturn valve which is used to prevent air escaping from the dress in the event of an accidental rupturing of the air hose. (See fig. 9940–31.)

2. The deep-sea outfit has been used for a considerable number of years with remarkable success. In addition to all submarine rescue and salvage work undertaken in peacetime, practically all salvage work of any magnitude undertaken during the war was accomplished using this equipment. The outfit is designed for doing extensive rugged diving work and provides the diver with the maximum physical protection. It is intended that the deep-sea diving equipment be used for the following general types of work: Submarine salvage–initial inspection, handling rescue chamber, placing slings for pontoons, handling pontoons, attaching hose for blowing and venting; ship salvage–internal inspection, internal repairs, installations of large patches on ship hulls, construction of cofferdams; harbor work–where visibility is poor, working around stone walls, pilings, or where there may be sharp projections; general–diving to depths requiring decompression and working in heavy tideways. The above are merely illustrations of the type of work undertaken using the deep-sea diving outfit; they are not intended to be all-inclusive or specific. It will be noted that there are many diving operations involving the above conditions which are undertaken in shallow depths but require the use of the rugged deep-sea equipment regardless of the depth at which the work is being done.

3. There are two deep-sea diving outfits, the No. 1, and No. 3. The No. 1 outfit is a heavy-duty outfit and contains all the material required for two divers plus additional spares to keep the outfit in repair for approximately 1 year. The outfit is issued only to vessels and shore activities that are called upon to undertake extensive diving operations–repair ships, tenders, salvage vessels, tugs, diving boats, etc.

4. The No. 3 outfit is a special outfit issued only to submarine rescue vessels. This outfit, in conjunction with the helium-oxygen equipment, is sufficient to undertake the diving necessary to effect the rescue of personnel from sunken submarines and the salvaging of a submarine.

9940.543. LIGHTWEIGHT DIVING OUTFIT

1. **The Lightweight Diving Outfit** consists essentially of a dress, mask, hose, belt, shoes, control and nonreturn valves. The outfit is designed with view of maintaining to some extent the advantages of the skin diving attained with

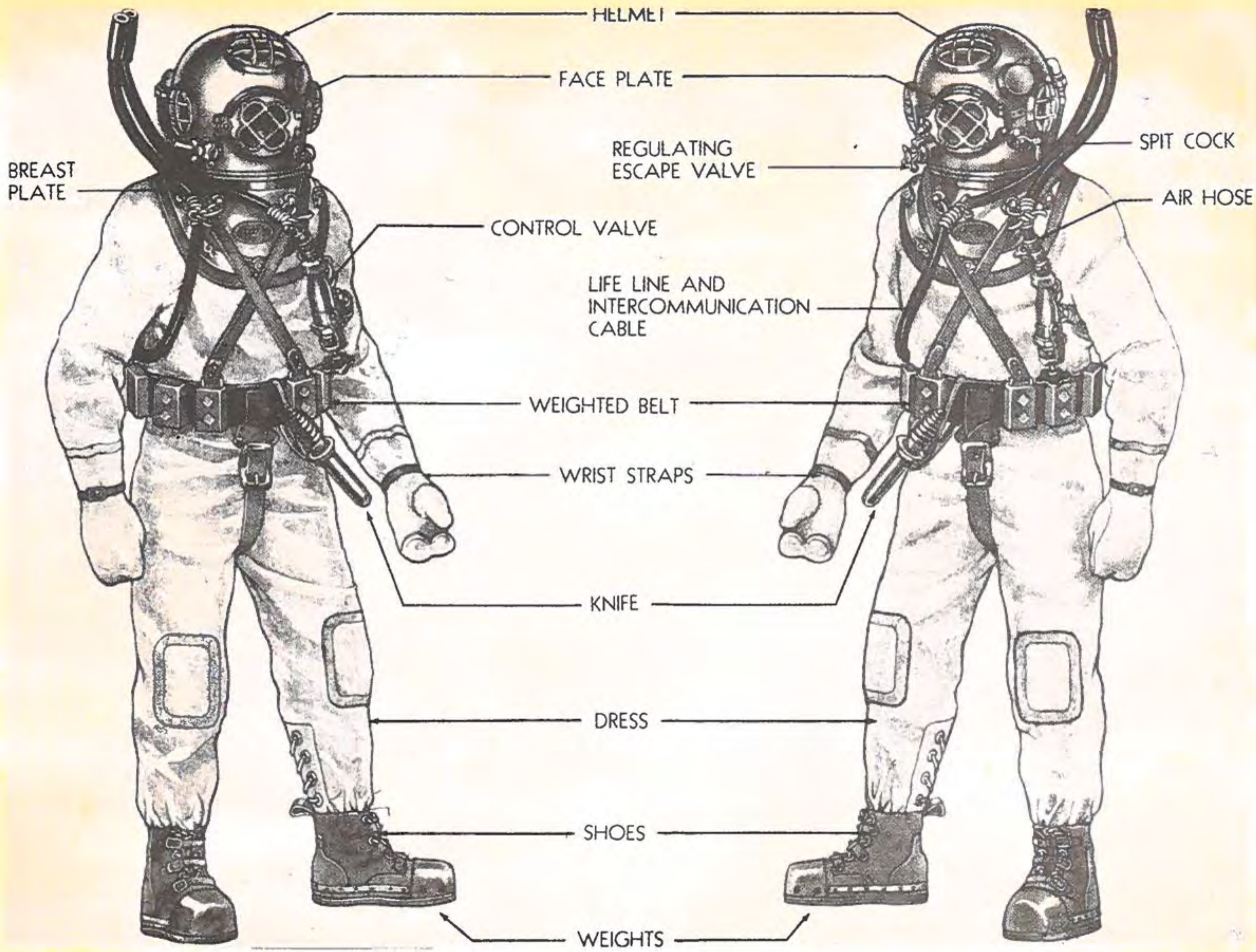


FIGURE 9940–31.

the shallow water outfit and eliminating the bulkiness and weight of the deep-sea outfit which is due to the positive buoyancy created by the volume of the helmet and the inflated dress. This is accomplished by combining a diving dress and mask so that the air enters and exhausts direct from the mask without entering the dress, which results in the dress collapsing completely against the body. In this manner, the weight required is reduced considerably.

2. The lightweight outfit can be used to accomplish a considerable number of jobs where the working and diving conditions are not severe and access to the work is relatively unrestricted, such as inspection, searching, clearing lines, minor external ship repairs, etc. This type of work does not require the use of the heavy deep-sea equipment but could not in many instances be accomplished with the shallow water outfit due to water and temperature conditions. The lightweight outfit can be used in either of two ways depending on the conditions–using the mask alone, or using the mask with the dress.

3. The lightweight diving outfit contains sufficient equipment for two divers and spares to maintain the outfit in repair for a reasonable length of time. This outfit is furnished mainly to vessels–mine craft, patrol craft, auxiliaries, combatant vessels, and landing craft–whose functions are not primarily concerned with diving but may find it necessary to do minor diving jobs of the type listed above at infrequent intervals. Only in extreme emergencies should diving be conducted below 130 feet or in any location that does not permit direct ascent to the surface.

9940.544. DIVING MANUAL

The information included in this chapter of the Bureau of Ships Technical Manual covers only the Standard Deep-Sea and Lightweight Diving Equipment, and decompression table. A complete diving manual (NAVSHIPS 250–538) is now available. In addition to the information given in this chapter of the Manual, the Diving Manual also contains information on the physics and physiology of diving, diving accidents, and a discussion of helium-oxygen equipment and procedures.

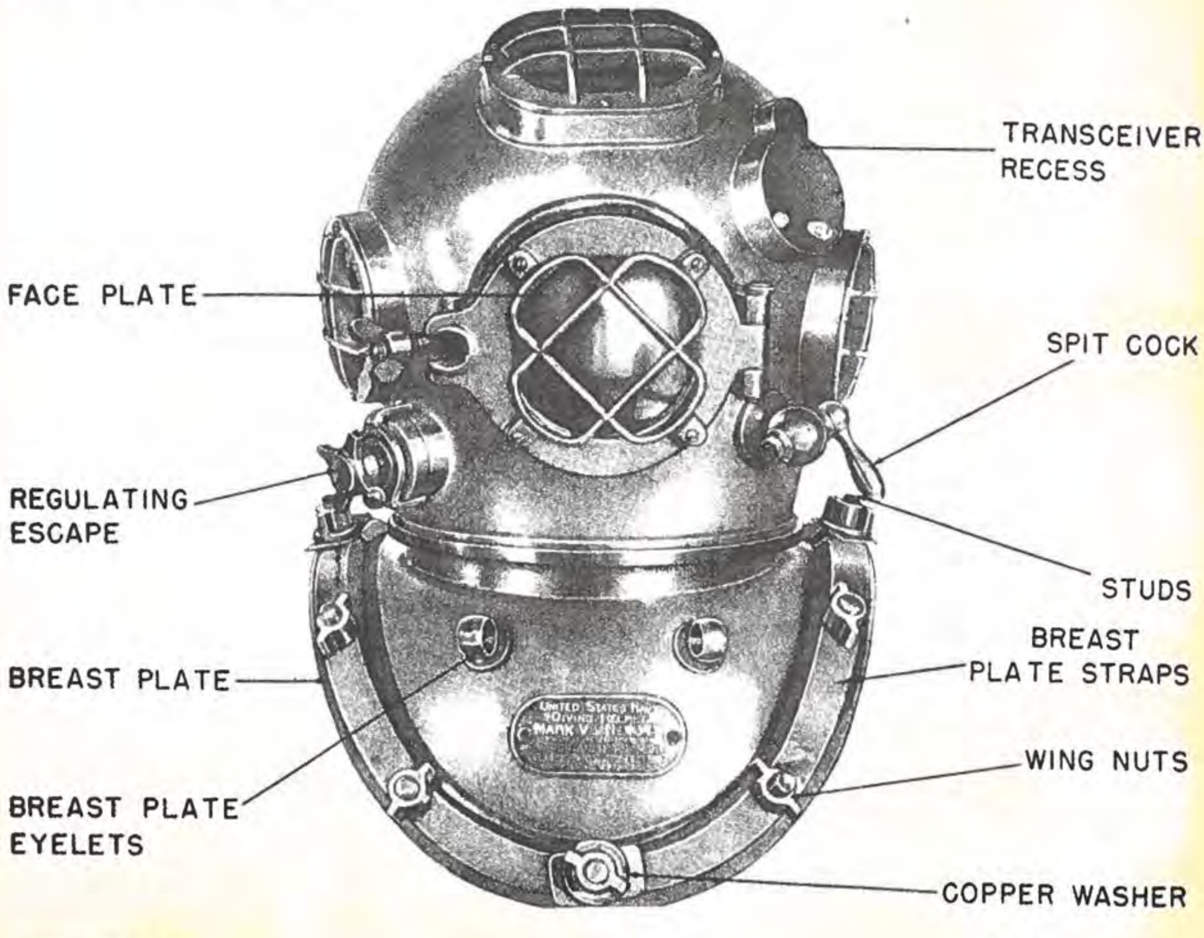


FIGURE 9940–32.

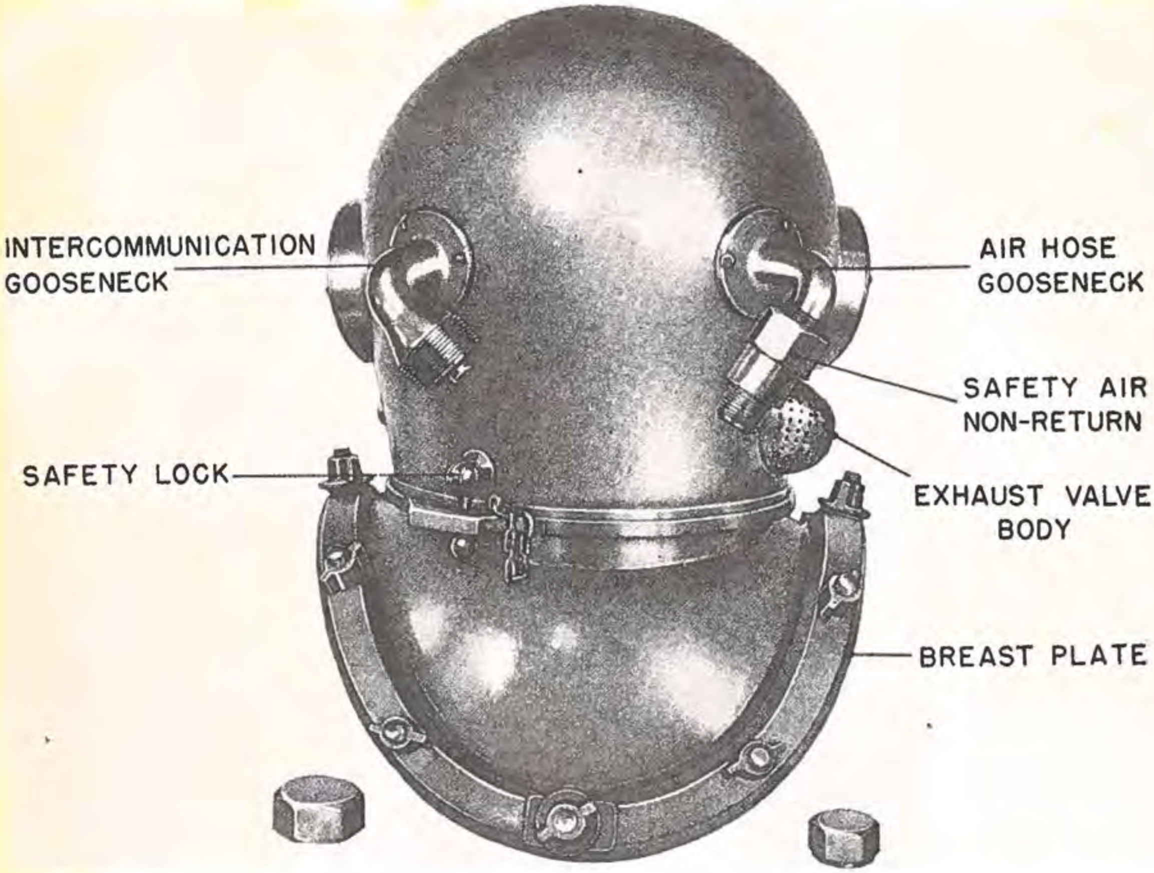


FIGURE 9940–33.

9940.545. COMPONENT PARTS

The component parts of the deep-sea and lightweight diving outfits, with the appropriate stock numbers, can be found in part 5.

B. Description and Care of Standard Diving Equipment

9940.551. EQUIPMENT USED IN DEEP-SEA DIVING

In general, the items comprising the deep-sea diving outfit can be divided into three categories: First, those items used in dressing the divers; second, the items that are used by the diver to reach his task; and, third, the auxiliary equipment to maintain the previously mentioned types of material.

9940.552. NAVY STANDARD DIVING HELMET

1. The Navy Standard Diving Helmet, figs. 9940–32 and 9940–33, designated as the Mark V, Mod. I, consists of a spun copper helmet with fittings and breastplate. The connection between the helmet and the breastplate is made by an interrupted-screw joint. Fitted into the recess of the threaded breastplate ring is a leather helmet gasket that serves a twofold purpose of making a watertight seal between the helmet and breastplate and controlling the distance that the helmet rotates. If the helmet gasket is of proper thickness, a moderate amount of force will line up the marks on the front of the helmet and breastplate within a reasonable distance and provide the necessary seal.

2. There are a number of attachments to the helmet to provide the diver with necessary safety devices, sight, communication, air supply, and exhaust. To prevent the helmet from being accidentally disconnected from the breastplate, a safety lock, fig. 9940–33, is attached to the back of the helmet. The ball lever that is secured to the helmet fits into the safety lock recess cut in the breastplate and prevents the helmet from moving more than the length of the recess opening. To prevent the ball lever from falling out of place, there is a safety latch secured to one end of the recess which fits over the ball lever and is secured to the other side of the recess by means of a brass split cotter pin. This device is called a dumbell.

3. There are four windows on the helmet. The one directly in front of the diver's face is called the faceplate, fig. 9940–32. The faceplate is hinged and is held in a closed position by means of a swing bolt and wing nut se-

cured to the helmet and acting through two lugs on the faceplate. The wing nut of the bolt when screwed down fits into a countersunk recess in the two lugs of the faceplate, thereby preventing slippage or accidental displacement of the bolt from the faceplate. The joint made by the faceplate and the helmet is made watertight by a rubber gasket. The other three windows are located as follows: one on each side of the helmet, on the same level of the faceplate, to enable the diver to see laterally; and the third on the midline of the helmet above the faceplate to allow upward vision. All four windows are protected from breakage by brass guards. However, spare glasses are supplied in the event the glasses are accidentally broken.

4. On the back of the helmet are located two goosenecks, fig. 9940–33. The one on the right side of the helmet is for attaching the safety air nonreturn valve to which in turn is secured the diver's air hose, and the one on the left side is for attaching the amplifier and life line cable. The goosenecks are placed at an angle so that the air-hose and life-line fittings will not interfere with each other when secured to the goosenecks.

9940.553. SAFETY AIR NONRETURN VALVE

1. The **safety air nonreturn valve,** fig. 9940–34, is one of the most important safety devices supplied the diver. Its purpose is to prevent the diver from being injured by "squeeze" in the event that his air hose bursts, or the air supply system becomes so seriously damaged as to fail to maintain an air pressure sufficient to counteract the external water pressure. Under either of these conditions the air pressure in the hose would fall suddenly. If the compressed air in the helmet and dress should escape through the air hose, the pressure within the helmet and dress would become less than the external water pressure. The helmet being rigid and the dress being flexible, the effect of the greater external pressure would be to squeeze the diver's body into his helmet in the same manner as a cork is forced into any empty bottle when lowered into deep water.

2. It can readily be seen that the proper functioning of the safety (nonreturn) valve is most important, and it must always be carefully tested before a diver is permitted to descend. It should be examined frequently, disassembled, and cleaned. The leather valve seat washer should be inspected for wear and tear, cleaned, and given a coating of neat's-foot oil. The valve spring and valve stem should also be given a light coat of oil. To test the valve after assembly, screw it in the reverse manner to the end of a length of air hose, attach the hose to the air supply, and apply pressure.

3. In this connection, the pressure applied should be over a range beginning with one-half to three-fourths of 1 psi. The lower pressures are more likely to be vital in that the higher pressure will tend to seat the valve and assist in making an airtight seal. In actual diving the internal pressure is not likely to exceed the external pressure by more than 1 psi. The valve should be immersed in water to see if any bubbles of air come from it. If none appear, the valve is tight; if not tight, a new valve leather or spring, or both, should be installed and the test repeated. When screwed in place on the air connection of the helmet, the valve should be tried to see that it works freely and seats smartly on release of pressure. Verdigris sometimes causes the valve to be sluggish in its action, the spring may be weak, or the follower nut may not be screwed all the way down. The inside diameter of the gasket between the valve and gooseneck should be checked, as it is possible, by setting up tight on the valve, to spread the gasket so that its edge is forced into the air passage, thereby greatly restricting the flow of air to the diver. If these precautions are carefully observed, the safety valve can be depended upon absolutely in an emergency; if neglected, the safety valve may fail at a critical time with disastrous results.

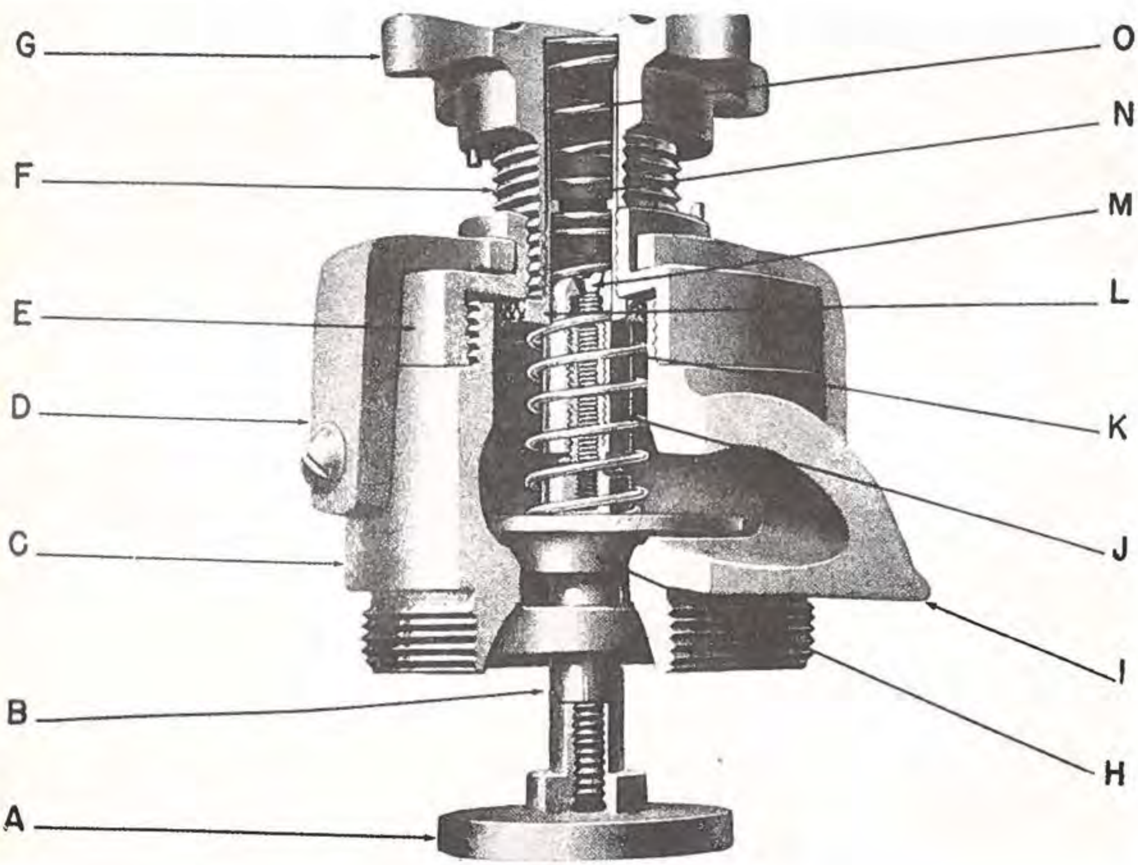
FIGURE 9940–34.

9940.554. AIR-REGULATING ESCAPE VALVE

1. **The air-regulating escape valve,** fig. 9940–35, is located below the window along the right side of the helmet, together with the escape channel, so that the point of exhaust is toward the rear of the helmet. The position of the exhaust prevents air bubbles from passing in front of the faceplate and obstructing the diver's view. The purpose of the air-regulating escape valve is to maintain automatically an air pressure in the diving helmet slightly in excess of the outside water pressure and to provide a means whereby the diver can regulate the inflation of his dress and consequently his buoyancy. This valve is commonly called the exhaust valve.

2. As the diver enters the water, the diving dress is subjected to an external pressure which tends to force the air in the dress up into the helmet and then out of the air-regulating escape valve. If the escape of this air is not retarded, or if the air supply is inadequate, the dress will collapse and the diver's breathing will be retarded. With a normal air supply and no means to regulate its flow properly from the helmet, too great an inflation of the dress will result and be followed by an excess of positive buoyancy.

3. If a diver finds it necessary to provide increased buoyancy, it is accomplished by closing the air-regulating escape valve the necessary amount, thus allowing the dress to inflate. If the danger of overinflating becomes evident, the buoyancy is decreased by opening the valve which causes the dress to deflate. The throw of the stem,



A - CHIN BUTTON
B - VALVE STEM
C - VALVE BODY
D - BONNET GUARD
E - BONNET
F - ADJUSTING SCREW
G - ADJUSTING HAND WHEEL
H - STEM VALVE DISC
I - AIR ESCAPE CHANNEL
J - ADJUSTING SLEEVE
K - PRIMARY VALVE SPRING
L - RETAINER RING
M - ADJUSTING SLEEVE SET SCREW
N - SECONDARY SPRING FOLLOWER DISC.
O - SECONDARY SPRING

FIGURE 9940–35.

through the medium of the chin button, provides a means of rapid release of all excess air.

4. It is obvious from the foregoing that the air-regulating escape valve is one of the most important features of the diving helmet. The principles of operation are as follows: The internal pressure in the diving dress is normally maintained at about one-half psi in excess of the external water pressure. As the pressure builds up in the suit, it is exerted against the stem valve disc (H), which is closed against the air pressure by the primary spring (K). When the internal pressure is one-half psi in excess of the external pressure, the valve stem is unseated, allowing air to escape. The valve stem continues to move forward, increasing the exhaust opening until the valve stem adjusting sleeve (J) comes in contact with the secondary spring follower disc (N), one end of which fits into the secondary spring (O). This secondary spring is designed and constructed to maintain 2 psi internal pressure over the external pressure when the valve is fully closed, a condition which exists when the regulating screw (F) is screwed until the follower disk (N) bears directly against the valve stem adjusting sleeve.

5. The exhaust opening desired is obtained by regulating the distance that the valve stem travels before coming in contact with the secondary valve spring. This distance is controlled by the valve stem adjusting sleeve *(J)* that screws on the valve stem *(B)* and its longitudinal travels in either direction to give the desired setting for length. When the proper setting is obtained, the sleeve is locked in place by the setscrew *(M)* which screws into a threaded hole in the end of the valve stem. The initial setting should be made so that the secondary valve spring follower disk *(N)* comes in contact with the sleeve when the adjusting wheel *(G)* is about one eighth of a turn short of the fully closed position. The diver then is able to produce any desired air flow by manipulation of the handwheel. Regardless of the setting, it always is possible to obtain full opening immediately by manually depressing the chin button (A) because after the one-half psi spring is compressed until the setscrew (M) brings it up against the disk (N), the longitudinal motion of the valve stem may be continued to the maximum degree of travel by compressing the secondary spring (O). When the valve is fully opened, the shoulder on the under side of the chin button strikes the valve stem lightly oiled, that the exhaust tube is clean, and that the valve seat is tight. The primary spring should be activated when the pressure on the seat exceeds the outside pressure by one-half psi and the secondary spring should be activated when the internal pressure exceeds external pressure by 2 psi. A failure of the air-regulating escape valve might result in "blowing up" of the diver.

9940.555. OTHER ATTACHMENTS TO HELMET

1. Directly opposite the regulating escape valve is a supplementary relief valve called the "Spit Cock," fig. 9940–32. The valve is operated by means of a lever-type handle and, when used in conjunction with the regulating escape valve, permits a fine adjustment of the diver's buoyancy.

2. On the inside of the helmet an air channel is sweated to the top of the helmet, with branches leading to and terminating just over the top and side windows to deflect incoming air away from the diver's head and over the window glasses.

3. The necessary screw, bolts, and clips are located inside the helmet for securing the diver's reproducer and to hold the electrical wires in place.

9940.556. BREASTPLATE

The breastplate, fig. 9940–36, is shaped so that it fits comfortably over the shoulders, chest, and back. The neck portion of the breastplate has a threaded ring that screws into the ring on the helmet. Around the edge of the breastplate is soldered a heavy shoulder collar through which are secured 12 equally spaced studs that fit into the holes that are molded into the diving dress gasket. A watertight seal is made by placing the dress gasket over the studs and then placing four removable breastplate straps over the dress gasket. Copper washers are placed under the removable breastplate straps at the junction to assist in making a seal at these points. The breastplate straps are then clamped in place by wing nuts, flanged wing nuts being used at the junction of the breastplate strap. On the left side of the breastplate is one long stud used for securing the link of the air control valve. The two eyelets on the front of the breastplate are used for securing the life line and air hose.
guide and this prevents the chin button from partly closing off the air passage, with consequent restriction of the air flow.

6. The regulating screw (F) is provided with a handwheel *(G)* of improved design which permits a diver who is wearing gloves to grasp it more easily and to estimate the degree of turn more readily than with wheels of conventional type. A dowel pin on the underside of the handwheel strikes against another dowel pin on the bonnet *(E)* when the valve is in the fully closed position and thus prevents the wheel from continuing its travel until it becomes jammed against the bonnet. The bonnet guard *(D)* prevents the bonnet from backing off the exhaust valve body *(C)*.

7. The air-regulating exhaust valve should be inspected prior to each period of diving, after prolonged inactivity, and weekly while diving to ensure that it is clean and

9940.557. FACEPLATE

The **welding faceplate**, fig. 9940–37, consists of a metal frame with an open section for inserting the welding lens, and is attached to the helmet by means of the helmet faceplate hinge bolt. The diving helmet has spring clips for holding the welding faceplate in an open or closed position.

9940.558. WELDING LENSES

The **welding lenses** are furnished in three shades, No. 4, No. 6, and No. 8. The shade number signifies the visible rays transmitted through the lens—the amount of light transmitted through the lens decreases as the shade number increases. The lens that are to be used for an underwater welding job will depend on the turbid conditions of the wa-

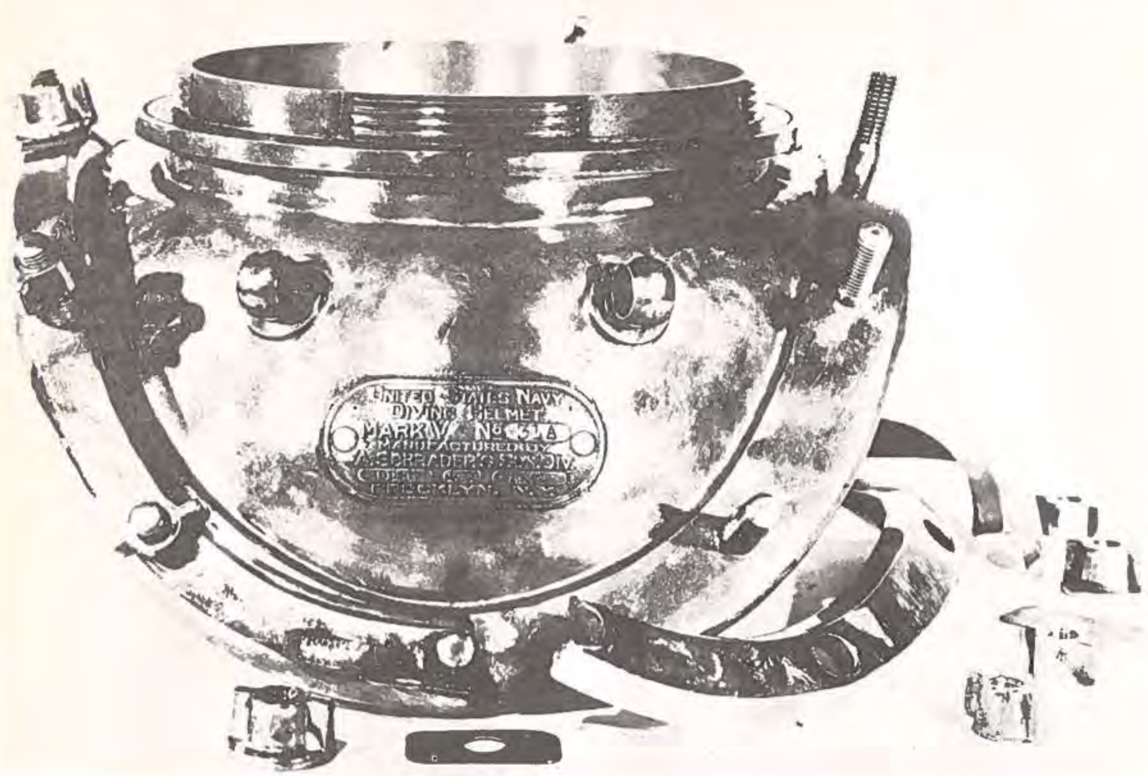


FIGURE 9940–36.

ter. In muddy water the No. 4 should be used and, as the water becomes clearer, the No. 6 or No. 8 lenses should be used.

9940.559. MAINTENANCE OF HELMET

1. After use the helmet should be wiped inside and out with a dry cloth to remove any accumulation of moisture. When the helmet is used frequently, it is recommended that a permanent rack with an electric light bulb that fits inside the helmet be made for holding the helmet. This will assist in keeping the helmet dry and keep the diver's reproducer in good working condition. If the helmet is not to be used for some time, it should be dried thoroughly, preferably by using the light bulb method, and then stowed in the helmet chest.

2. Inspect the gooseneck washers and see that the telephone connections are made watertight. Any time the air hose or life line and telephone cable are not attached to the helmet, the blank caps should be screwed on the goosenecks to protect the threads. Examine the faceplate hinge, hinge pin, rubber gasket, and wing nut for possible defects. See that the helmet and screw ring threads are free of all burrs and other defects.

3. Inspect the breastplate stud for defects and tightness and see that the nuts turn freely on them. Special care should be taken to see that the breastplate straps do not become bent or injured, thus saving an endless amount of trouble in making a tight joint at the junction of the diving dress and breastplate. The straps should be put in place and the wing nuts lightly screwed onto the studs to prevent damage to the threads.

4. Check the leather helmet gasket to see that it seats evenly all around, and see that it is treated with neat's-foot oil occasionally. If, as a result of wear, the helmet when screwed onto its breastplate will turn so far that the safety lock at the back is past its recess, and the faceplate is not directly in front of the diver's face, one or more paper washers should be cut and inserted under the helmet gasket on the breastplate, or a new gasket should be fitted. See that all metal parts are free from verdigris and corrosion.

9940.560. DIVING DRESS

1. **The diving dress,** fig. 9940–38, is so constructed that it encloses the entire body with the exception of the head and hands, and, when used in conjunction with the

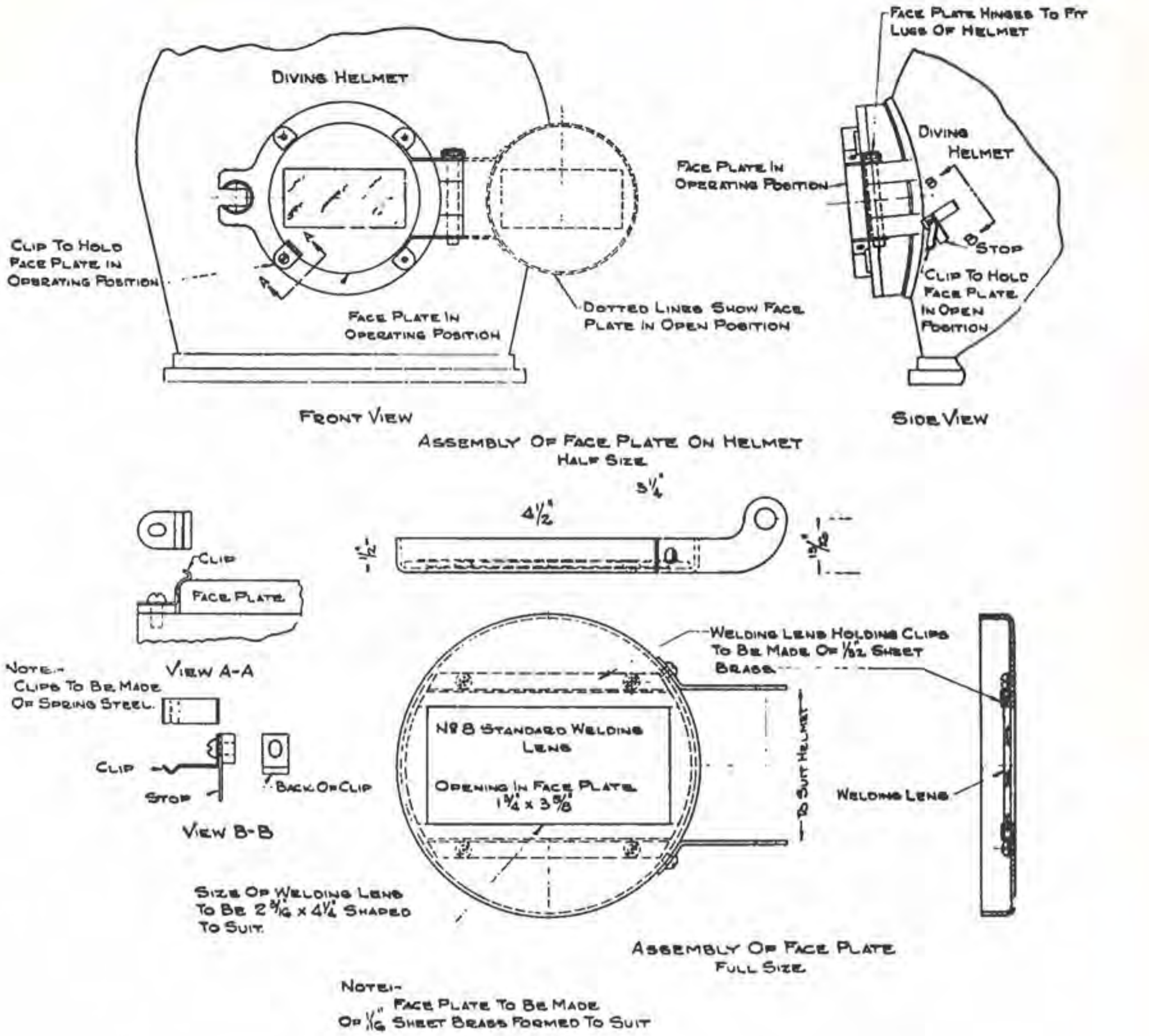


FIGURE 9940–37.

diving helmet and gloves, provides the diver with a complete watertight covering. The dress is made of vulcanized sheet rubber between layers of cotton twill. Around the neck of the dress is fitted a heavy rubber gasket through which reinforced holes are molded to fit the studs of the helmet breastplate. On the inside of the dress around the neck is a fitted dress fabric called the bib. The bib is in the form of a cylinder that fits loosely and comes up well around the diver's neck and serves to trap any water that may enter the helmet through the valves.

2. To prevent an accumulation of air in the lower portion of the dress, flaps for lacing are provided over the rear portion of both legs of the dress. The lacing of the lower part of the dress lessens the danger of accidental "blowup" and risks incident to capsizing. A diver should not be put into the water unless the flaps are snugly laced.

3. Navy diving dresses are designed especially to fit the Mark V, Mod. 1 helmet and are furnished in three sizes: No. 1, small; No. 2, medium; and No. 3, large. The No. 1 dress is designed to fit divers 5 feet 7 inches to 5 feet 9 inches tall; the No. 2 dress for divers 5 feet 9 inches to 5 feet 11 inches tall; the No. 3 dress is for divers 5 feet 11 inches to 6 feet 2 inches tall.

4. To lengthen the life of the diving dress, chafing patches have been cemented to the dress at the points which are most likely to be subjected to the greatest amount of wear - elbow, knees, crotch, and toe. Repair cloth of

FIGURE 9940–38.

rubberized twill is furnished for making any repairs to the dress. To patch a diving dress:

a. Remove loose fabric or other material and old cement from the dress with benzine or trichloroethylene. These and most other solvents and cements are toxic and/or flammable in various degrees. For this reason, the use of these substances should be restricted to well ventilated spaces having an airflow to the outside atmosphere. Containers should be kept tightly sealed and should be stowed only in authorized spaces when not in use.

b. Roughen the area with sandpaper and clean with one of the above-named cleaning fluids.

c. Cut a piece of patching cloth of the desired size and shape, rounding all corners.

d. Strip protective cloth from patch and clamp it flat to a board with the heads of thumb tacks so that the tacks do not pierce the patch.

e. Apply at least three coats of rubber cement to both the dress and patch, allowing each coat to dry until it is tacky, approximately 45 minutes, before applying the succeeding coat. The cement should be applied with a brush.

f. When the last coat of cement is dry enough, lay the patch on the dress and press down firmly or tap with a wooden mallet, working from center to edge, to remove all air bubbles and wrinkles.

g. If any part of the edge of the patch does not adhere thoroughly and is inclined to curl, trim loose parts with sharp scissors.

h. Do not use the dress, if possible, for 24 hours.

Tears in the collars of diving dresses are usually confined to the vicinity of the stud bolt holes. Tears should be sewed together with herringbone stitches, the needle holes filled with cement and allowed to dry, after which a patch should be cemented around the damaged hole on each side of the collar.

5. After using the diving dress, it should be washed inside and out with clean fresh water. Turn the dress inside out and hang it in the shade to dry, then turn it right side out. Repair the dress if necessary. An easy and efficient mode of drying the dress is to take two wooden battens about 8 feet long and secure them together, and place them inside the dress. Pass another straight piece of wood through the arms so they are extended. The dress should be thoroughly dry inside and out before storing; otherwise it will mildew and rot. The dress should not be folded during storage but should be hung on a hanger or left on the wooden batten.

9940.561. RUBBER CUFFS

1. To enclose the hands or make a watertight seal at the wrist, either divers-tenders gloves or rubber cuffs can be used, depending on the water temperature and type of work to be undertaken.

FIGURE 9940–39.

2. The rubber cuffs, fig. 9940–39, are used where conditions are such that it is desirable and feasible to have the hands exposed. The cuff is designed so that one end is equal to the diameter of the lower part of the dress sleeve, and the other end is about equal to the size of the average diver's wrist. In the case of divers having large wrists the cuff will interfere with circulation of blood to the hands. In such cases the remedy is to cut a little off the small ends of the cuffs until a comfortable fit is obtained. If the wrist end of the cuff is too large, a piece of

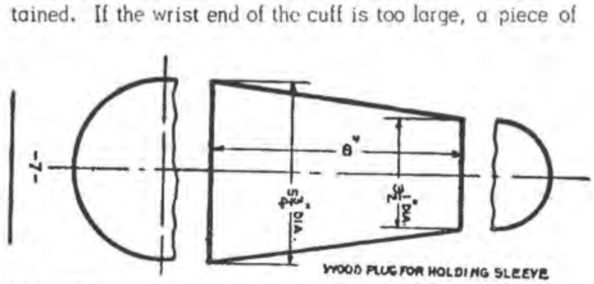


FIGURE 9940–40.

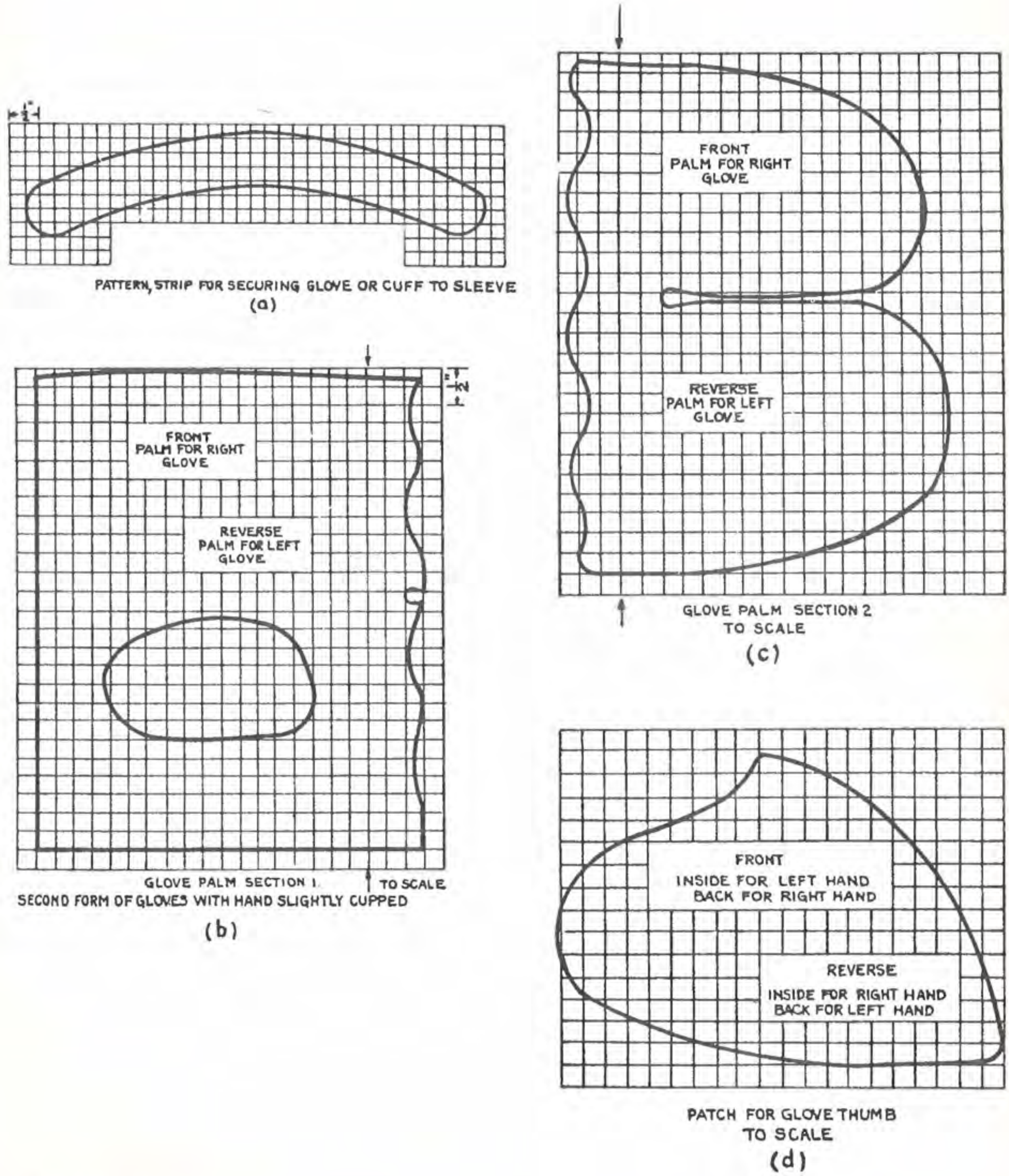


FIGURE 9940–41.

elastic tubing is used to make a watertight seal between the the diver's wrist and the cuff. The elastic tubing is made of pure rubber with an inside diameter of 1½ inches and is furnished in 3-foot lengths. The length of tubing used is generally between 1 to 2 inches. However, the length will depend on the individual diver's preference.

3. The following method of attaching the cuff to the dress is recommended:

a. Make a tapered wooden plug, fig. 9940–40, that will fit tightly into the sleeve of the dress and extend past the sleeve edge about 4 inches.

b. Roughen the outside of the sleeve edge about 3 inches from the edge with sandpaper.

c. Turn the sleeve edge of the cuff back about 2½ inches and roughen.

d. Slip the cuff over the small end of the wooden plug until it touches the sleeve edge.

e. Apply at least three coats of rubber cement to the sleeve and turned back portion of the cuff, allowing each coat to dry until it is tacky, approximately 45 minutes, before applying the succeeding coats.

f. Roll the turned back part of the cuff up over the sleeve and press down firmly.

g. Cut two curved strips of patching cloth in accordance with fig. 9940–41 (a). Roughen with sandpaper and apply three coats of cement in the same manner as the cuff and dress.

h. Apply one strip evenly over the joint between the cuff and the sleeve.

i. Turn the dress sleeve inside out and apply a strip between the cuff and the sleeve joint.

j. The dress should not be used for 24 hours, if possible, to permit the rubber cement to dry thoroughly.

9940.562. DIVERS-TENDERS GLOVES

1. **The gloves** shown in fig. 9940–42, used by both divers and divers' tenders generally are referred to as divers-tenders gloves. The gloves are intended for use in cold

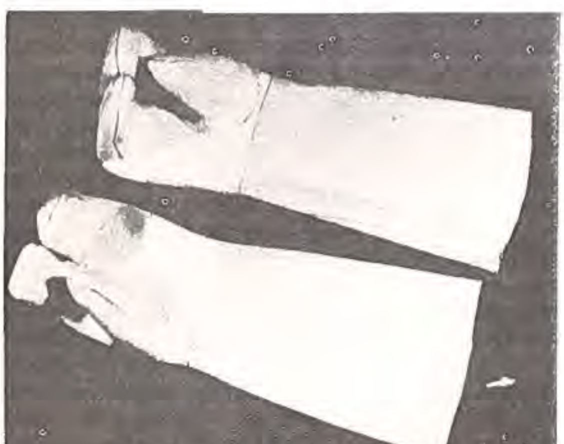


FIGURE 9940–42.

FIGURE 9940–43.

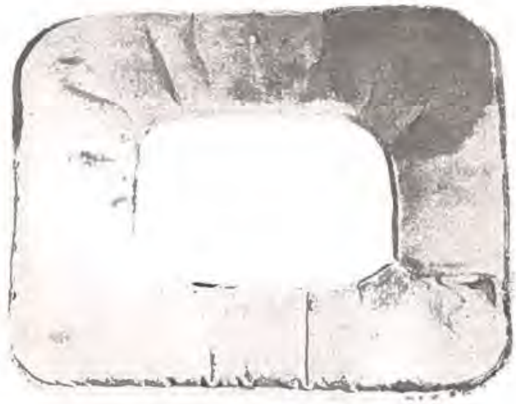


FIGURE 9940–44

water or where the type of work to be done is likely to injure the hands.

2. The divers-tenders glove is a three-fingered glove molded in a semiclosed position so that there will be no strain on the diver's hand when holding a tool. The palm of the glove is shaped so that it still conforms to the shape of the diver's palm when the hand is closed. The arms of the dress with the gloves attached are not adjustable and, because of this, some divers have difficulty keeping the hands all the way in the gloves. To overcome this condition, wrist straps, fig. 9940–43, made of chrome-tanned leather are furnished.

3. To attach the divers-tenders gloves to the diving dress:

a. Insert the wooden plug, fig. 9940–40, into the sleeve of the dress.

b. Loosen the lower part of the elbow patches and fold back.

c. Cut 1 inch off the top (gauntlet) of the glove for attaching to a No. 3 dress; cut 2 inches off for attaching to a No. 2 dress; and 3 inches for attaching to a No. 1 dress.

d. Turn 2 or 3 inches of glove gauntlet back and place glove over the sleeve plug until it touches sleeve.

e. Cut two strips of patching cloth as indicated on fig. 9940–41 (a).

f. Prepare the surfaces of dress sleeve, gauntlet, and strip of patching cloth as indicated in the sections on dresses and cuffs.

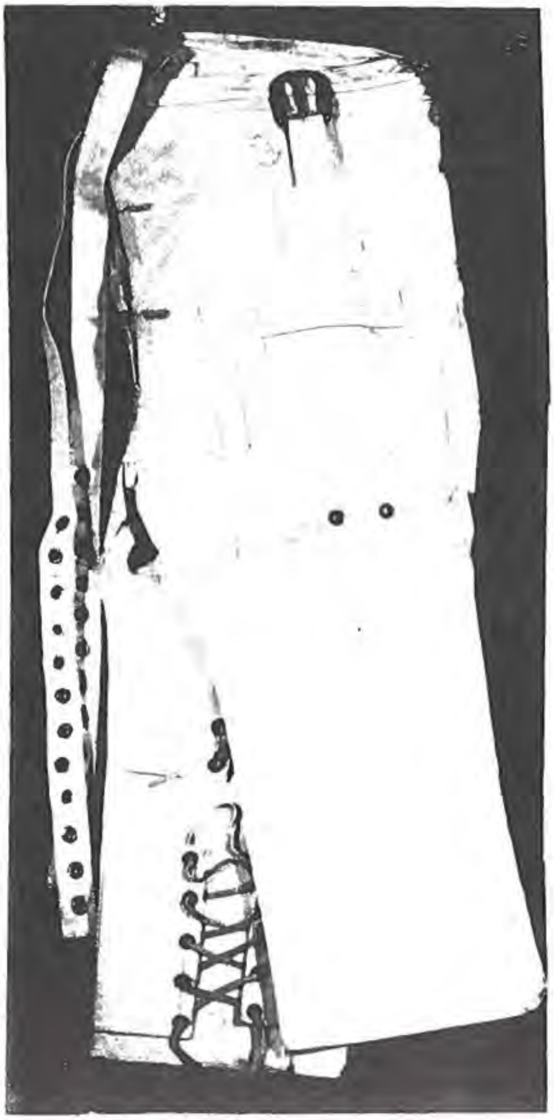


FIGURE 9940–45

g. Have the glove thumb line up with the dress sleeve so that the glove will hang in the natural position of the diver's hand.

h. Roll the turned back section of the glove in place over the prepared section of the dress.

i. Place the patching strip in place.

j. If time permits, allow the cement to dry for 24 hours.

4. The repair of the glove is made similar to the method of repairing the diving dress: Remove work fabric from glove and roughen with sandpaper. Cut patches for the glove according to the patterns shown in fig. 9940–41 (b), (c), and (d). Prepare the patches and glove at the same time. When both are ready, have an assistant put on the glove and half close his hand to conform to the natural curvature of the glove. The thumb patch, fig. 9940–41 (d), is then applied, with care being taken to smooth out all wrinkles. Palm patches, fig. 9940–41 (b) and (c), if necessary, are next applied, and the wrinkles smoothed out along the entire surface of the patch. Clip off rough edges of the patches and remove glove. The glove should be allowed to set, if possible, for 24–48 hours. Before storing, the gloves should be washed with clean water and allowed to dry thoroughly.

9940.563. HELMET CUSHION

The helmet cushion, fig. 9940–44, is worn around the neck under the dress to prevent the helmet and weighted belt from bearing directly on the diver's shoulders when he is out of the water. The cushion is made of canvas padded with hair felt. The cushion should be thoroughly dry before stowing.

9940.564. OVERALLS

The **trousers** (overalls), fig. 9940–45, are made of light canvas and are used to protect the diving dress against wear and chafe. The overalls are secured to the diver by means of cord which is run through the top of the trousers. After use, the trousers should be washed with clean water and allowed to dry thoroughly before storing them.

9940.565. UNDERWEAR

1. The diver's **underwear,** fig. 9940-46, consisting of undershirts, drawers, socks, and gloves, is made of 100 percent pure wool and provides, together with the diving dress, protection against the cold water. Frequently the underwear will be worn over the ordinary working clothes, or several sets of underwear will be worn depending on the temperature and the individual diver's preference. At

FIGURE 9940–46.

least one set of underclothing should be worn to prevent the body from being chafed or bruised from the diving dress. It has been found that when the diver is working moderately hard, one set of underwear will, under average conditions, provide the necessary insulation and warmth. Under more extreme conditions of cold, two sets of underwear will be satisfactory.

2. The underdrawers are furnished in sizes 36, 38, and 40, and the undershirts in sizes 38, 42, and 44. The gloves and socks are furnished in medium sizes. In addition, Sizes 42 and 44 underdrawers and size 36 and 40 undershirts are stocked in limited quantities. The underwear should be washed and allowed to dry thoroughly before storing. As woolens will stretch under their own weight when wet, they should not be hung on a line but should be laid on a flat surface for drying. When not in use, the woolens should be stowed in larvicide, such as napthalene, and kept tightly wrapped in paper.

9940.566. BELT

1. The **weighted belt** fig. 9940–47, provides the necessary negative buoyancy to overcome the positive buoyancy of the helmet and diving dress when it is moderately inflated. The weight of the complete belt is approximately 94 pounds. However, the weight can be varied as desired by adding or removing the individual 7½-pound lead weights. Metal strap fittings are cast in four of the weights and are set at angles to give the proper lead to the shoulder strap which passes over the helmet breastplate and crosses in the back and front so as to counteract any tendency the belt may have to shift.

2. The jock strap is provided for the dual purpose of preventing the helmet from rising over the diver's head as it would if the dress were permitted to elongate due to over-inflation, and to hold the belt in its proper location.

3. To protect the belt leather, it should be given a coat of neat's-foot oil, well rubbed in so that it will not be

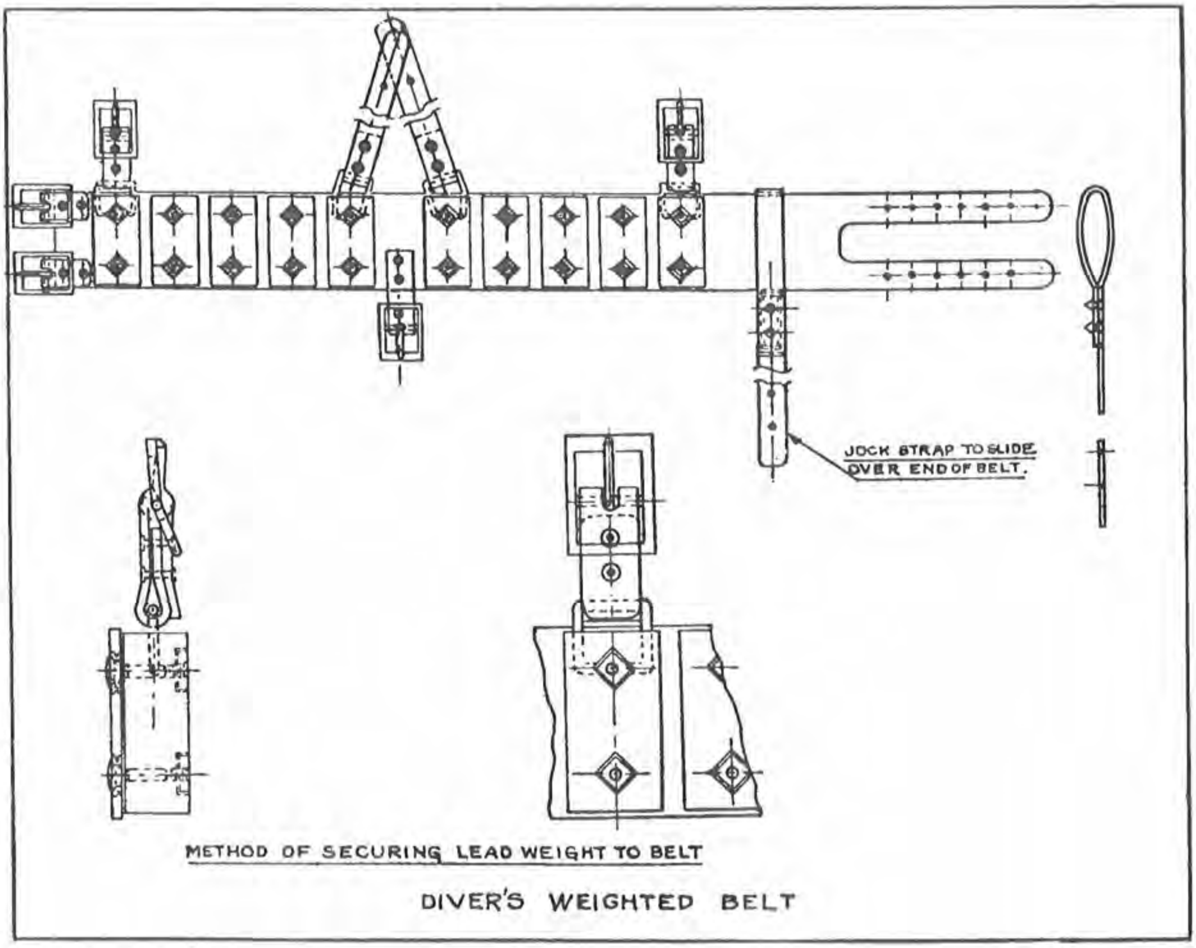


FIGURE 9940–47.

disagreeable to handle. As leather used in water will soon become dry and hard, the frequency of applying oil will depend on how frequently the belt is used. Deterioration of leather is not always discernible from visual examination; consequently, the belt strap including the shoulder and jock straps should be tested for tensile strength. This may be accomplished by securing regular diving belt buckle to the overhead, run the strap to be tested through the buckle; then have a man of about 160 pounds weight gradually put his entire weight on the strap which will withstand the load if in a satisfactory condition.

9940.567. SHOES

1. The **diver's shoes** are used in conjunction with the weighted diving belt to overcome the positive buoyancy of the inflated diving dress and helmet and to give stability to the diver.

2. The standard weighted shoes, fig. 9940–48, consist essentially of a lead sole, hardwood upper sole, either leather or canvas upper, lacing cord and leather straps for holding the shoe in place, and a protective brass toe clip. The shoes weigh approximately 35 pounds per pair.

FIGURE 9940-48.

3. The lightweight diver's shoes, fig. 9940–49, are essentially the same as the standard weighted shoe with the exception that a brass sole is used in lieu of the lead sole, and the weight of a pair is approximately 20 pounds. The use of the lightweight diving shoes will depend on the dress inflation and the individual diver's preference.

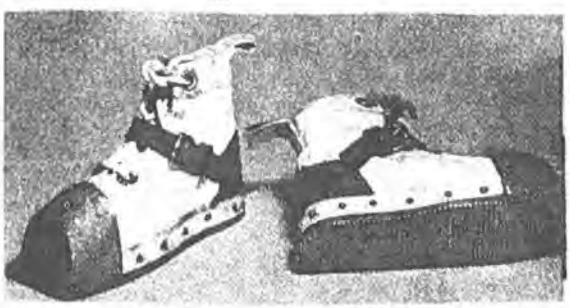


FIGURE 9940-49.

9940.568. KNIFE

1. The **diver's knife**, fig. 9940–50, is made of a tough tool-steel, bayonet-shaped blade with one cutting and one sawedge, a metal sheath, hardwood handle, and a leather strap. The use of the term "knife" is misleading as the instrument actually is a utility tool which is used for prying, hacking, sawing, or cutting such material as wood, wire or manila rope, sheet metal, etc. As such, the knife represents a compromise of the individual features that go to make up the knife.

2. The knife sheath is made of brass, cylindrically shaped with a conical bottom. The top of the sheath has a wide mouth opening to facilitate placing the knife in the sheath. A hole is drilled in the bottom of the sheath to permit drainage. The leather strap is used for securing the sheath to the diver's belt. If the knife is to be stowed for any extended time, the sheath should be filled with grease to

FIGURE 9940-50.

prevent the steel blade from corroding. While the knife is being used frequently, it should be covered with a thin layer of grease.

9940.569. AIR HOSE

1. Diver's air hose, fig. 9940–51, is a sinking type, having an internal diameter of one-half inch and an external diameter of 1 1/16 inches. It is constructed of a vulcanized rubber tube reinforced by three plies of braided cotton laid on the bias to prevent the hose from wriggling, twisting, or turning while under pressure. The hose is furnished in two standard lengths—50-and 3-foot lengths. The 50-foot lengths of hose connect the surface air supply to the air control valve. The 3-foot length of hose connects the air control valve to the air safety nonreturn valve on the diver's helmet. A special 3¾-foot length of hose is used for this purpose when helium-oxygen helmets are being used.

2. Diving hose when manufactured is required to withstand a working pressure of 500 psi and a proof pressure of 1,000 psi held for 30 seconds. In addition, representative lengths are required to withstand a burst pressure of 2,000 psi instantaneously. In connecting up the lengths, it should be remembered that the hose nearest the diver will be subjected to the least difference in pressure and, therefore, if there is any preference, the best hose should be on the end and nearest the surface.

3. The use and stowage of the diver's air hose should be governed by the following:

a. Hose more than 5 years old shall not be used as diving hose. ASR vessels shall not use hose in excess of 3 years old.

b. Diving hose in store more than 2 years should be surface-inspected and hydrostatically tested to 75 percent of the working and the proof pressures listed above for new hose. In addition, one length of hose, selected at random from each lot of the same date of manufacture as representative of the lot, should be subjected to the burst test (75 percent of the 2,000 psi test). The lengths of hose which have been subjected to bursting tests should not again be used for diving purposes.

FIGURE 9940-51.

4. When diving air hose is requested, the issuing activity should furnish the receiving activity with a copy of the report of the last test made on the hose. Hose received from store without this report should not be placed in service until the report is received. If an emergency requires the use of the hose before such report is received, it may be so used provided it is retested by the ship.

5. On receipt, and every 6 months thereafter, diving airhose shall be visually inspected and an inspection made to ensure that the clamps are tight. Diving hose in service shall be hydrostatically tested when it is 3 years old and every 6 months thereafter to 750 psi, with a concurrent elongation load of 250 pounds on the couplings held for a period of one minute. If hydrostatic tests cannot be made, then the hose shall be subjected to a 350 psi air pressure test, with a concurrent elongation load of 250 pounds on the couplings held for a period of one minute. If facilities are not available to conduct the required tests and it is necessary to use the hose, it should be subjected to an air pressure of at least 100 percent greater than the maximum pressure that will be applied to the hose topside and held for 10 minutes. An inspection shall be made to ensure that the clamps are tight.

6. The ends of each length of diving hose are capped with a rubber compound to give the ends a smooth and watertight finish. Except in an emergency, the hose should not be cut as the uncapped sections permit water to permeate along the braid and inner tube of the hose thus forming bubbles which weaken it.

7. When coupling lengths of air hose together, a leather washer should always be placed in each female coupling. Air hose should not be coupled directly to the air supply but to the oil separators. If a long length of air hose has been in use, moisture is sure to have accumulated in it. Therefore, 50-foot sections should be separated and drained before stowing. New hose must be thoroughly cleaned inside by running fresh water through it and then blowing it dry **before** it is put into use. Hose carried on racks also should be blown out periodically and before use to remove soapstone powder and other deposits.

8. The various types of air-hose fittings are shown on fig. 9940–52. The ends of each 50-foot length of hose are fitted alternately with male and female couplings. The ends of the 3-foot length of hose are fitted with female couplings. In fitting the air-hose couplings on the hose, the following procedure is recommended:

a. Slip three clamps over the end of the hose.

b. Coat the shank of the couplings with rubber cement and clamp in a vise. When attaching a female coupling, it should be assembled to a male coupling, rubber-coated, and clamped in a vise.

c. The hose then is forced over the coupling shank until it is against the shoulder of the coupling.

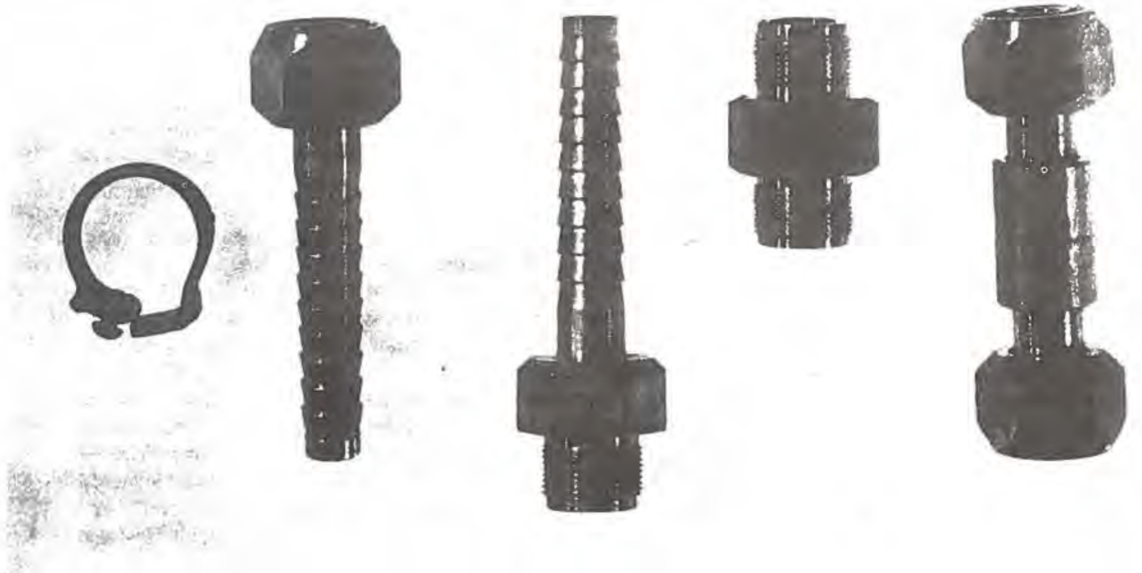


FIGURE 9940–52.

FIGURE 9940–53.

d. The first clamp is placed in position and set into a vise. Screw up on the vise until the clamps are compressed bringing the clamp screw holes in line. The clamp screw is then screwed in place and the operation repeated on the next clamp.

9. As the shank of the coupling is slightly larger in diameter than the bore of the hose and as the clamp is smaller than the external diameter, forcing the hose onto the corrugations of the shank and gripping tightly with the clamps will ensure the coupling a firm hold on the end of the hose. A firm hold is absolutely necessary in view of the serious consequences that would result should a coupling pull out of the hose when a diver is under water. The joints between male and female parts of the hose coupling are made watertight by means of leather washers. Double-male and female standard air-hose couplings are provided for use when it is desired to make a special connection; e. g., when the alternations of male and female connections are not continuous. Wherever special couplings such as double-male or double-female couplings are used, they should be placed in the line of air hose so they will not be under water. Such couplings are intended for use in making surface connections.

10. There are two diving hose **reducers (adapters)** furnished for making special connections, fig. 9940–53. The (S) reducers have a standard ¾-inch pipe thread on one end and a standard diver's air-hose thread–1 1/16-inch–17 threads, and are used for making connections from an air source having a standard pipe thread to a diver's air-hose fitting. The T reducers have a standard diver's air-hose thread cut on one end and a torpedo-air-pipe thread on the opposite end. The T reducers are used for connecting the diver's air hose to the torpedo charging lines when torpedo air flasks are used as a diver's air supply.

9940.570. AIR CONTROL VALVE

1. The **diver's air-control valve,** figs. 9940-54 and 9940–55, is of the needle valve design and is used to control the flow of air to the diver's helmet. The valve consists of the body, valve stem, stuffing box, packing gland, cap nut, handle, and the link and eye pad. The body of the valve is a brass casting with standard made air-hose threaded inlet and exhaust connections. Attached to the lashing eye of the body is a link and eye pad for securing the control valve to the long stud on the left side of the helmet breastplate. The body valve seat and the stem seat are ground at a 60° angle. The valve stem and the stuffing box have a 5/8-inch–8 acme threads of sufficient length so that when the valve is in a completely open or closed position, referring to fig. 9940–55, a minimum of two threads are engaged.

2. The following method of assembling the control valve is recommended:

a. Screw the valve stem into the stuffing box.

b. Place the copper ring washer into the groove on the top of the valve body, and apply red lead to the top surface.

c. Insert the valve stem into the body and screw the stuffing box up tight with a wrench. The valve stem should not be in contact with the body while the stuffing box is being drawn up tight.

d. Insert the first lead packing ring over the valve stem.

e. Take several turns around the valve stem with the flax packing, and insert the second lead packing ring.

f. Insert the stuffing box gland and screw the cap nut into position.

g. The bracket is secured by means of screws to the valve body. The bracket prevents the cap nut from backing off.

h. Place the valve handle, stem nut, and cotter pin in place. The valve handle is designed so that it can be readily grasped when wearing the diver's gloves.

3. The packing of the diver's air-control valve is very important and should be carefully adjusted so that the valve works stiffly enough to prevent its being opened or closed accidentally but it is sufficiently free to be readily manipulated by the diver even though wearing the heavy diverstenders gloves.

FIGURE 9940–54.

C. Diving Communications

9940.581. METHODS OF COMMUNICATION

Communication between the diver and his tender is of the utmost importance to the safety of the diver and to the efficient accomplishment of the work being attempted. In addition, it is desirable to provide adequate communication between divers who are working together so that they may assist each other effectively. To accomplish communication, three basic means are available–mechanical, electrical, and visual.

9940.582. DIVING SIGNALS

1. The three basic means of communication used by divers are visual communications, voice communications, and line pull signals. Visual communications are limited to conditions of good visibility and therfore are most applicable to scuba diving. Visual communication may be accomplished by writing on a slate, by hand signals, or by any easily understandable gesture. A system of hand signals designed for scuba diving is presented in NAVSHIPS 250–538.

2. It is possible for divers to talk to each other directly if they are close enough together, but the conversation is difficult to interpret. Electrical means of voice communication prove more satisfactory, particularly when using deep-sea diving equipment. Electrical means of voice communication are in the process of development for diving in self contained and lightweight equipment. Specific procedures for the use of the divers "intercom" are contained in another section of the manual.

3. Line pull signals remain the basic means of communication whenever the diver is connected to the surface by the lifeline. Line pull signals are not affected by conditions of visibility or by electrical equipment failures and are therefore the most dependable means of communication for any type of diving. Line pull signals have been standardized for the Navy and their use must be understood by

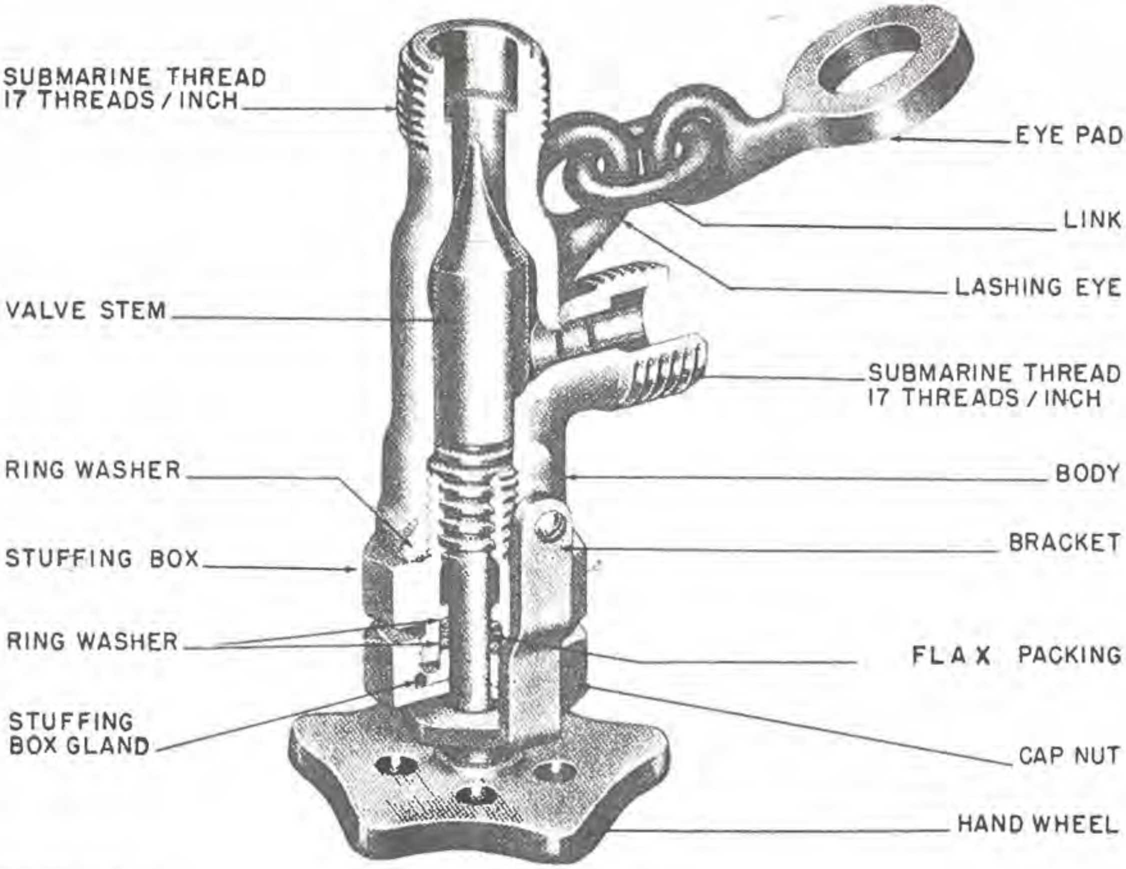


FIGURE 9940–55.

all Navy divers. Special signals for particular operations also may be arranged between the diver and the tender.

4. Line pull signals consist of a series of sharp, distinct pulls, strong enough for the diver or tender to feel but not so strong as to pull the diver away from his work. When sending signals, take all slack out of the line first. Repeat signals until answered. Continued failure to answer a signal may indicate too much slack in the line, a fouled line, or an accident to the diver. Notify the supervisor immediately if the diver fails to respond. The problem of loss of communication is covered in chapter 1.6, para. 16 of NAVSHIPS 250-538. Signals are answered when received with two exceptions. Answering the emergency signal "haul me up" results in too much loss of time. Also the diver will never answer the signal "comeup" until he is ready to leave the bottom. If he is unable to leave the bottom at that time, he should communicate the fact by "intercom" or by use of the "I understand you" signal followed, if necessary, by the applicable emergency signal. Many of the standard line pull signals may be used not only on the lifeline and air hose but also on any other line with which the diver is working.

5. Signals from tender to diver:

Signal	Meaning
1 pull	Are you all right? (When diver is descending, 1 pull means stop.)
2 pulls	Going down. **(During ascent,** you have come up too far. Go back down until I stop you.)
3 pulls	Standby to come up.
4 pulls	Come up.
2-1 pulls	I understand, **or** answer the telephone.

6. Signals from diver to tender:

Signal	Meaning
1 pull	I am all right.
2 pulls	Give me slack, **or** lower me.
3 pulls	Take up my slack.
4 pulls	Haul me up.
2-1 pulls	I understand, **or** answer the telephone.
3-2 pulls	Give me more air.
4-3 pulls	Give me less air.

7. Emergency signals from the diver:

Signal	Meaning
2-2-2 pulls..	I am fouled and need the assistance of another diver.
3-3-3 pulls..	I am fouled but can clear myself.
4-4-4 pulls..	Haul me up immediately.

The diving supervisor must try to find out the nature of the emergency as soon as possible, since in some cases it may be necessary to bring the diver to the surface with decompression.

8. Searching signals are employed so that the tender can direct his diver as he moves along the bottom. A 7-pull signal from the tender to the diver means that the diver will interpret the signals following as searching signals. A 7-pull signal to a diver who is already using searching signals means that these are no longer to be used. Only the tender may originate searching signals. It is not necessary for a diver to take himself off searching signals before originating a signal, as no signal from the diver will be interpreted as a searching signal. In interpreting the direction in which the diver is ordered to move, he will face or assume he is facing his lifeline, or the descending line if he is using a circling line attached to the descending weight. In sending signals to the diver, the tender must take into consideration the diver's position in relation to his lifeline or descending weight:

SEARCHING SIGNALS

Signal	Meaning
1 pull	Stop and search where you are.
2 pulls	Move directly away from the tender if given slack. Move toward the tender if a strain is taken on the lifeline. If using the circling line, move away from the weight.
3 pulls	Move to your right.
4 pulls	Move to your left.

9. Use the following procedure when working with lines on the bottom. To send a relatively light object to the surface, the diver signals 1-2-3 pulls, which means "send me a square mark." The tender bends a short piece of line, about 3 feet long, to the lifeline and then signals 3 pulls meaning "take up the slack." The diver hauls in the slack until he reaches the square mark and then signals 1 pull "stop." After he has attached the object to be lifted to his lifeline with the square mark, he signals 3 pulls meaning "take up the slack." When the object reaches the surface, the tender detaches it from the lifeline and signals 1 pull "are you all right." All signals are answered as sent. The procedure for lifting a heavier object is similar. The diver signals 5 pulls "send me a line." The tender selects a line adequate for the weight to be lifted and bends the bitter end to the lifeline. When the tender signals 3 pulls, the diver takes up the slack until the bitter end of the line is in hand. After signaling 1 pull "stop," he removes the line from his lifeline and signals 3 pulls on his lifeline. When the tender has taken all of the slack out of the lifeline, he signals 1 pull "are you all right." The diver then makes the line fast to the object to be lifted and commences signaling on it. Signals used on the line are: 1 pull "stop lifting," 2 pulls "slack the line," 3 pulls "take up the slack," and 4 pulls "haul it up." All pulls, whether on the lifeline or any other line, are answered as sent.

9940.583. ELECTRICAL COMMUNICATION

In view of the limitations of hand signals, some form of electrical communication that permits the use of voice communication is necessary. By suitable equipment design, it is possible to provide dependable two-way amplified voice communication which will permit talking from the diver to the tender and will not require the person on either end to wear any sort of headband or microphone harness. To provide a convenient term to describe the amplified type of system as compared with the older telephone types, it is recommended that the terminology "Divers' Intercom" be used. To talk on this system would be to talk on the "intercom."

9940.584. DIVING INTERCOMMUNICATION SYSTEM

The diving intercommunication system that has been adopted as the standard for use in the United States Navy consists of the following basic items:

1. The diving amplifier.
2. The diver's reproducer (loudspeaker).
3. The combination diving amplifier and life line cable.

Several different models of diving intercommunication systems exist, but each works basically in the same manner.

9940.585. DIVING AMPLIFIER

1. The diving amplifier is portable and is placed in a convenient location on the tending vessel, barge, or pier. The combination diving amplifier and life line cable plugs into the amplifier and extends from the tender to the diver. The diver's reproducer is mounted in the diver's helmet.

2. Two models of diving amplifiers are now in general use. The following table will serve to identify each model:

Manufacturer	Mfg. model No.	I. C. Instruction Book No.	Number of selector or keys
(a) Guided Radio Corp.	957	82A (NAVSHIPS 3650220).	6
(b) Guided Radio Corp.	H–919	82 (NAVSHIPS 3650288).	3

3. The diving amplifier, fig. 9940.56, is the heart of the system and contains the amplifier, the tender's reproducer, the control switches, the volume controls, the tone controls, the power switch, the power jacks, the diver's jacks, and the grounding binding post. The amplifier is designed to amplify the voice from either the diver or the tender to sufficient volume so that, regardless of the surrounding noise, a message can be transmitted. So that the system can be operated anywhere it is needed, the amplifier is designed to operate from power supplies of 12 volts d-c; 110 volts d-c., or 110 volts, 60 cycles a-c. Details of the amplifier circuits are found in the I.C. Instruction Book furnished with the equipment.

FIGURE 9940–56.

9940.586. TENDER'S REPRODUCER

The tender's reproducer is mounted on the top of the amplifier case; it acts as a loudspeaker when the diver is talking and as a microphone when the tender is talking. Two sets of control switches are used on this model. The three spring-return switches marked "Tender to Diver" provide switching for communication among the tender and any of three divers. In the normal position, the diver's reproducers are acting as microphones and anything any one of the divers says is heard by the tender through his reproducer. When one of the switches is pressed, the tender's reproducer, which corresponds to the switch pressed, acts as a loudspeaker and the tender talks to the diver. At this time the other two divers are disconnected from the circuit. Thus the tender always can hear messages from any of three divers at any time that a switch is not pressed and he can also call individually any one of three divers.

9940.587. COMMUNICATION BETWEEN DIVERS

1. An additional feature especially useful when several divers are working together is provided by a second set of spring-return control switches marked "Diver to Diver." By pressing one of these switches the tender can make the selected diver's reproducer act as a loudspeaker while the other diver's reproducers act as microphones. Thus the diver selected can hear a message from either of the other two divers. Reversing the switching makes a return call possible. At all times, when using this feature, the tender's reproducer is acting as a loudspeaker, thus making it possible for the tender to hear both sides of the conversation. In this manner divers working together can actually talk with one another as they work on the assigned job.

2. To use this feature efficiently requires a certain amount of circuit discipline. All switching is done by the tender to relieve the diver from having to accomplish it. Diver No. 1 wishing to speak with diver No. 2 calls "Diver No. 1 calling diver No. 2." The tender presses the tender-to-diver No. 1 key and says "Go ahead" and immediately releases the tender-to-diver No. 1 key and presses and holds diver-to-diver key No. 2. The tender will hear diver No. 1's message to diver No. 2 and at the end of the message diver No. 1 will say "Over." The tender then releases the diver-to-diver key No. 2 to talk with diver No. 1. At the end of his message diver No. 2 also signals "Over." Thus the call continues until it is completed at which time diver No. 1 says "End of Call." The tender releases all switches and then tells diver No. 1 "O. K."

9940.588. VOLUME CONTROLS

Two volume controls are provided. One control adjusts the volume of sound to the diver and the second adjusts the volume to the tender. In this manner the volume can be varied in each direction separately to provide satisfactory volume for both the diver and the tender. These controls should be adjusted before the diving is begun and as necessary during the dive. The tender should check with the diver to determine whether or not the volume at the diver's end is satisfactory.

9940.589. TONE CONTROLS

Two tone controls are provided. One control adjusts the tone of the sound to the diver and the second adjusts the tone of the sound to the tender. In the center or zero position, normal tone results. The air hiss in the helmet and external noise at the tender's station may make adjustment of these controls necessary to permit maximum intelligibility. These controls are helpful in deep dives and especially when helium-oxygen mixture is used because the voice of the diver changes and adjustment of the tone controls will aid greatly in understanding the messages.

9940.590. POWER SWITCH

The power switch and its associated pilot lamp are used to turn the amplifier on and off. Prior to each dive, operation of the entire intercom system should be checked at the same time that the diver checks his air valves.

9940.591. POWER JACKS

Three power jacks are provided, fig. 9940.57, one for each type of power supply--12 volts d-c., 110 volts d-c., and 110 volts, 60 cycle a-c. Three power cords are provided, each having a different special plug to fit into one

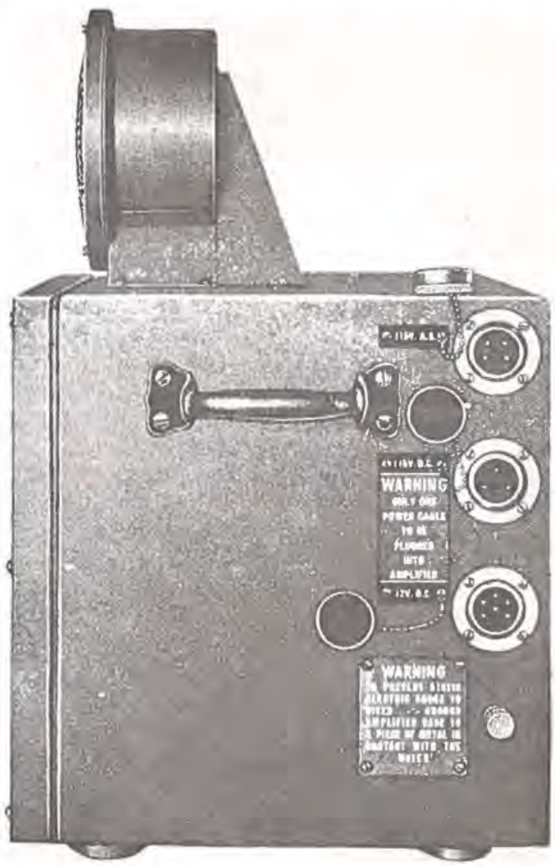


FIGURE 9940–57.

of the three jacks. After determining the type of power supply available, the power cord for that type of supply is selected and the special plug is plugged into the appropriate jack in the amplifier. The special plug automatically makes the necessary connections for operation on the selected power source. WARNING: **Do not plug in more than one cord at a time** for this will cause a direct short circuit of the power supply, with resultant destruction of the plug and jack and may also cause serious electrical shock.

9940.592. DIVER'S JACKS

Three diver's jacks are provided on the side of the amplifier case, fig. 9940–58. Each consists of a special jack manufactured in accordance with Bureau of Ships plan 9000–86502–73015. Each is designed to receive a plug on the end of the diving cable and thus make possible the separate connections to three divers.

9940.593. GROUND POST ON DIVING AMPLIFIER

When diving operations are conducted from wooden rafts, hulls, or docks, the intercom equipment often is insulated from ground. As a result, a static electric charge some-

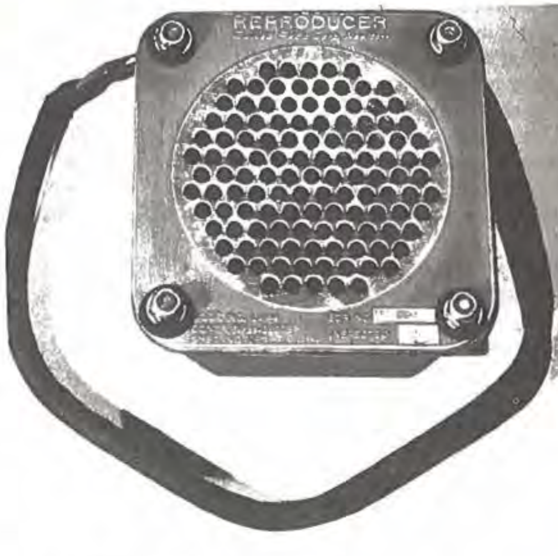


FIGURE 9940–59.

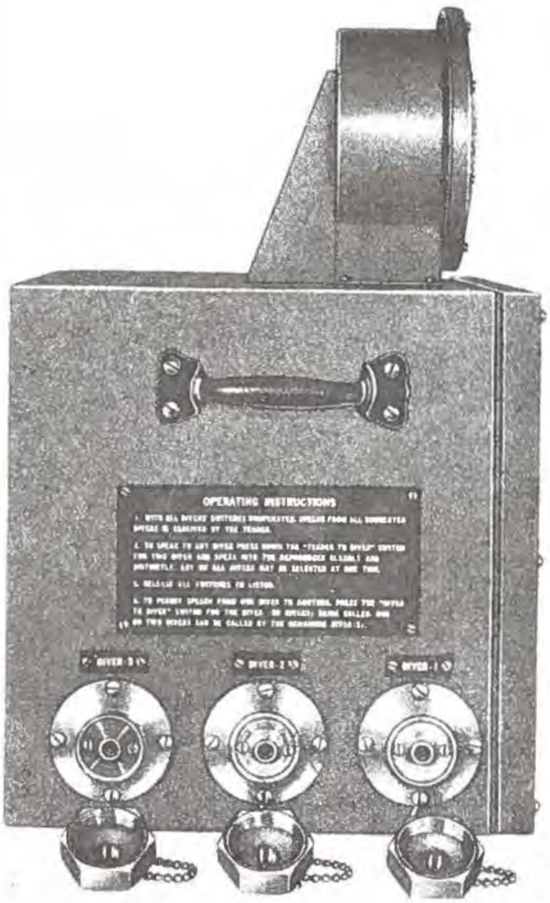


FIGURE 9940–58.

FIGURE 9940–60.

times exists between the equipment and ground and when the helmet is placed on the diver, this charge will discharge through his body and produce electric shock. To prevent electric shock, the diving amplifier is provided with a ground binding post. A copper wire No. 10 B & S gage or larger should be run from this post to any metal that is in continuous contact with the water. The diver's metal ladder will serve as a good grounding point. If any metal-sheathed cable is used to make connection to a shore power supply, the sheath should be grounded in a similar manner.

9940.594. DIVER'S REPRODUCER

The diver's reproducer, fig. 9940-59, is a small permanent magnet, cone type of loudspeaker especially designed to be mounted in the recess of the helmet. It is connected electrically to the diving cable through the helmet gooseneck. The helmet jack assembly (discussed in detail under fittings) is mounted in the outer end of the gooseneck. A pair of wires run from the jack to the reproducer. The excess space in the gooseneck is sealed with melted beeswax to prevent water seepage. The diver's reproducer serves both as a microphone and a loudspeaker as described above.

9940.595. CONNECTING CABLES

Three connecting cables, fig. 9940–60, are provided, each with special plugs to plug into each of the special jacks on the amplifier as described above. These plugs serve to connect the amplifier to the available power supply; and, as they make the connections necessary for the particular supply, only one can be plugged in at once without causing a short circuit. The other end of the 12-volt cable is provided with battery clips. The other two have no plugs so that the activity using the intercom system will attach the standard fittings that match the available receptacles.

9940.596. SPARE PARTS SET

A spare parts set, fig. 9940–61, which includes all parts necessary is provided for the maintenance and repair of the intercom system. To avoid possible delays in the procurement of replacement parts from supply depots, the parts in this set should be kept carefully under lock and key, and should be used only for the repair of this system.

9940.597. INSTRUCTION BOOKS

The detailed information on the maintenance and repair of the diver's intercom system is available in the instruction books that accompany the systems. These books contain detailed mechanical drawings, electrical schematic diagrams, and photographs of the equipment. They are the best source of information on maintenance and repair problems and therefore, should be consulted freely.

9940.598. SIMILAR TYPES OF AMPLIFIER EQUIPMENT

The diving amplifier equipment described above represents the most complex system that has been developed. The Guided Radio Corp. Model H-919 is equivalent to the Model 957 in every respect except that it does not include the "diver-to-diver talk" feature, but it will provide excellent communication and, therefore, except where special justification can be given, will not be replaced by the Model 957. Any equipment not of the types listed above is considered obsolete and should be replaced in any active diving outfits by one of the types described above manufactured by the Guided Radio Corp.

FIGURE 9940–61.

FIGURE 9940–62.

9940.599. COMBINATION DIVING AMPLIFIER AND LIFE-LINE CABLE

1. To carry the wire necessary for using the diving intercommunication system and to eliminate the need for a separate cable containing these wires, a special cable has been developed for use by United States Navy divers. This cable is called the Combination Diving Amplifier and Life-Line Cable, fig. 9940-62. As its name implies, this cable has sufficient mechanical strength to serve as a life line for the diver and at the same time provide the electrical conductors necessary for the operation of the intercommunication system.

2. The cable consists of a stranded steel core which is coated with high-grade rubber. Around this core are wound four rubber-insulated wires. The winding of these wires is spiral, much like a coil spring, so the cable despite its size is fairly flexible. Over these wires is another coat of rubber and then a final coat of tough oil-resisting neoprene. The result of this construction is a tough, high tensile strength (2,500 psi test), water- and pressure-resisting cable that is 5/8 inch in diameter and weighs about 0.35 pound per foot.

3. The cable usually is made up in lengths of 200 or 600 feet. Each length is supplied with the following items:

2 male plugs (attached to cable ends),
1 coupling (for connecting cables together),
1 coupling wrench (for tightening fittings),
2 leather washers (used between plug and couplings), and
1 spanner wrench (for disassembling plug).

The diving cable is plugged into the diving amplifier unit of the intercom system. When more than one length of cable is needed, additional lengths are added by connecting the two male plugs together with a female coupling. The plugs and couplings are constructed heavily enough so that both a strong mechanical connection and a good electrical connection are made. The cable is secured at the diver's end by lashing it to the breastplate. It then passes to the helmet gooseneck where the plug is attached, thus making positive mechanical and electrical connections to the helmet. A leather washer is inserted into each connection to act as a spacer and watertight gasket.

9940.600. CARE TO BE USED IN HANDLING AMPLIFIER EQUIPMENT

1. The diving intercommunication system is designed to be as rugged as possible consistent with the permissible weight. However, it still is fundamentally a piece of electrical equipment. For this reason, care should be used in handling the diving amplifier to avoid dropping. Power cables should be attached only one at a time to avoid the possibility of a short circuit.

2. Every effort should be made to keep water, especially salt water, out of the amplifier and the cable fittings. The helmet reproducer is especially vulnerable to mechanical and water damage, and the helmet always should be handled with consideration for this vital unit. To avoid damage, the male section of the diving cable plug should be suitably protected with a screw cap as shown on Bureau of Ships Plan 9000-S6502-73009. This is especially important on the plugs that have a plastic base on the plug insert assembly.

3. The internal parts of the amplifier should be kept dry at all times. If water does accidentally get into the amplifier, the units should be carefully dried out before the power is connected.

1. If the amplifier becomes inoperative, the power supply should be checked to see if it is energized and, in the case of d-c, of the right polarity. If a storage battery is used as a source of power, the battery voltage should be at least 11.5 volts with the amplifier turned on. If the power circuit is found to be unsatisfactory, remove the fuse posts on the amplifier with a screw driver and examine the fuses for burn-outs. Defective fuses should be replaced with good ones of the rating shown in the instruction book.

2. If the foregoing procedure does not restore operation, the most likely source of trouble is failure of one or more of the vacuum tubes or failure of the power supply vibrator. To check or replace these tubes, the amplifier must be removed from its case by removing the panel screws. This will enable the main amplifier panel, the cover, and the rear panel to be withdrawn from the case as a unit. Before removing the tubes, it is necessary to loosen the locking clamps around the tube bases. Defective tubes and vibrators should be replaced with new ones. Only tubes of the type furnished with the amplifier should be used. The tubes are not interchangeable and replacement tubes should be installed in the sockets marked for the particular type of tube used.

3. If the foregoing check does not disclose the cause of failure, the trouble may be due to an open or short circuit in the amplifier connections or failure of component parts. The circuit may be checked by reference to the respective wiring diagrams and list of parts as shown in the instruction book accompanying the equipment.

9940.602. HANDLING OF COMBINATION DIVING AMPLIFIER AND LIFE-LINE CABLE

1. Care should be exercised in unreeling the combination diving amplifier and life-line cable when received on board. The coil of cable, as received, should be placed on a revolving platform or reel and uncoiled as the platform or reel revolves. The cable should not be pulled from the coil in the manner commonly used with rope as this will twist the cable and cause kinks. Kinks especially should be avoided as they may damage the rubber cover or displace the conductor wires, thus causing early failure of the cable.

2. It is unnecessary to test the cable for strength as the central core, which is the strength member, is of corrosion-resisting steel, has an ample factor of safety, and is not susceptible to deterioration. Unfortunately, however, this is not the case as regards the conductor wires which, being of copper, may in time stretch or break, thus impairing or destroying the electrical circuit. When the breakage occurs, it is usually at the points of greater flexing of the cable. The points of greatest flexing are usually a few inches from either end of the cable due to the bend in the cable at these points when it is under

tension. Care should be taken to prevent the cable from getting a sharp nip or permanent bend at these points. Experience will facilitate the locating of such breaks, and a study of the drawings showing the construction of jack plugs will enable the jack plugs to be assembled and reassembled when removing defective sections of the cable.

3. Continuity of circuit or grounds may be determined by test with a megger, a test lamp, or an ohmmeter, following the same procedure as for determining an open or a ground in any other circuit. In testing the cables, remember there is a complete electrical circuit from the metal sleeve of one amplifier to the other plug through the cable core. If, through any cause, an open or a short circuit develops in the cable and causes failure of the communication circuits, the jack plug at the damaged end of the cable should be removed, and the faulty section of the cable cut off and the jack plug replaced.

4. Referring to fig. 9940-63, the removal of the jack plug involves the following operations:

a. Unscrew the gland nut at rear of plug housing.

b. Remove packing.

c. Remove lock nut at front of plug housing with spanner wrench supplied.

d. Heat plug housing to soften the sealing compound.

e. Slide plug housing back on cable away from plug.

f. Loosen connections to plug terminals and remove plug.

g. Melt solder which secures stainless steel core in the anchor plug, and remove the wood screw wedge and anchor plug.

The cable may now be cut back until it is evident from the appearance of the butt end, that all the damaged cable has been removed, and until the communication lines test through.

5. To reassemble the jack plug the procedure is as follows:

a. Slide gland nut and jack plug housing onto cable.

b. Remove the two outer rubber coverings for a distance of about 4 inches; untwist the four conductors and remove the rubber covering of the stainless-steel core also for about 4 inches.

c. Separate the exposed strands of steel core and tin thoroughly.

d. Slip anchor plug over the tinned strands and bring up as close as possible to rubber covering.

e. Distribute strands around circumference of hole in plug and drive in wood screw wedge.

f. Solder the steel core and wedge securely into anchor plug.

g. Cut off loose ends of steel core even with anchor plug and smooth with file.

h. Bare the ends of the conductors and twist together into two pairs—red with green, black with white. It is very important that this color coding be observed.

i. Form an eye in the end of each pair and solder.

j. Pull plug housing down over anchor, plug as far as possible. Length of conductors should be such that eyes project about one-fourth inch out of plug housing.

k. Several turns of suitable packing material should be inserted in the gland, and the gland nut screwed in and pulled up tight.

l. Place the thin leather washer over conductors and attach conductors to plug terminals making sure that

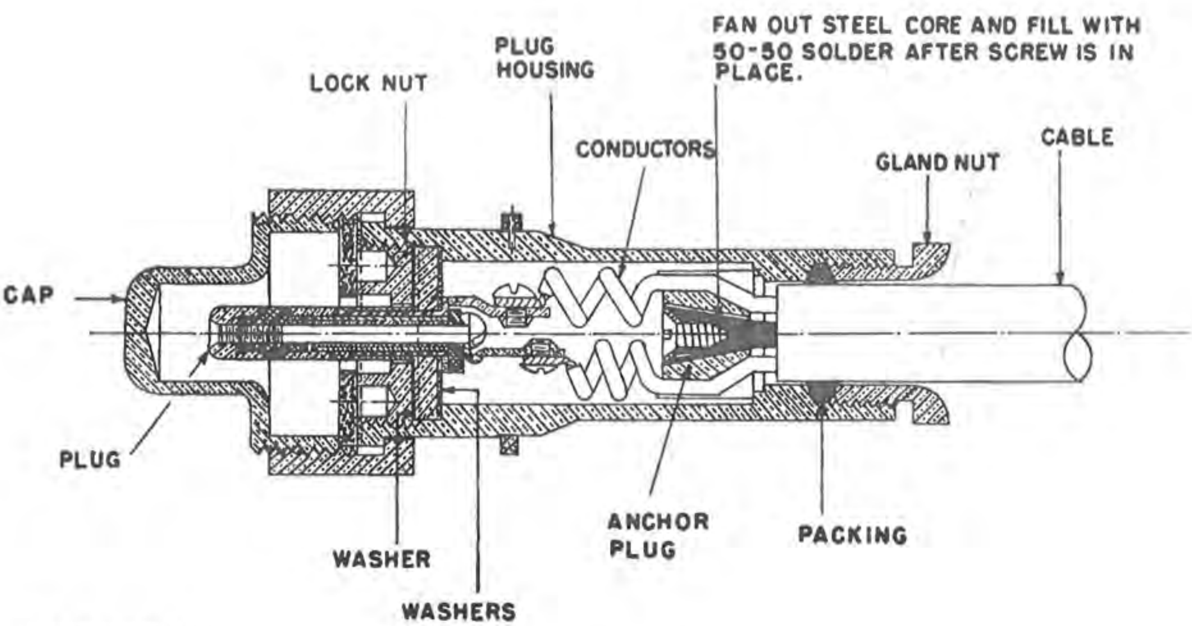


FIGURE 9940-63.

the red and green pair is connected to the side terminal and the black and white pair to the center terminal.

m. Pour melted sealing compound or beeswax into open end of housing to within one-fourth inch of the plug seat.

n. While the sealing compound is still soft, seat the jack plug in plug housing, making certain that thin leather washer is properly situated on seat. Care must be taken to see that all space in the plug housing is filled with the sealing compound.

o. Screw in locking nut and pull up tight to complete the assembly.

6. If a bubble forms in the outer rubber covering of the cable due to leakage of compressed air from the diver's helmet, it is not necessary to cut off the injured section of cable unless the communication circuit is opened. The correct procedure is to puncture the bubble and wrap the puncture with several layers of rubber tape, using plenty of rubber cement between layers. The rubber tape should be covered with one layer of friction tape and the whole patch then thoroughly shellacked. Before returning the cable to service after a repair, it is essential that the cable jack plug be opened and inspected for leaks in the sealing compound. If any are found, the plug should be resealed. A similar inspection should be made of the telephone gooseneck fitting on the helmet, and the necessary repairs made.

9940.603. CARE OF REPRODUCERS

The reproducer units of the standard diving intercom system are exceptionally rugged and unsusceptible to trouble usually experienced from the effect of moisture. Ordinarily no serious damage is caused by short submersion, but continued submersion, continuous exposure to moisture will result in corrosion of the metal parts and the grounding or short circuiting of the coils. If any of the units should accidentally be submerged in salt water, they should be washed out with fresh water and dried out by exposure to heat. Care should be taken, however, that the applied heat is not sufficient to burn the insulation of the wire. If any of the units become inoperative due to collection of dirt, they should be carefully dismantled and cleaned. The diaphragms and pole pieces especially should be kept free

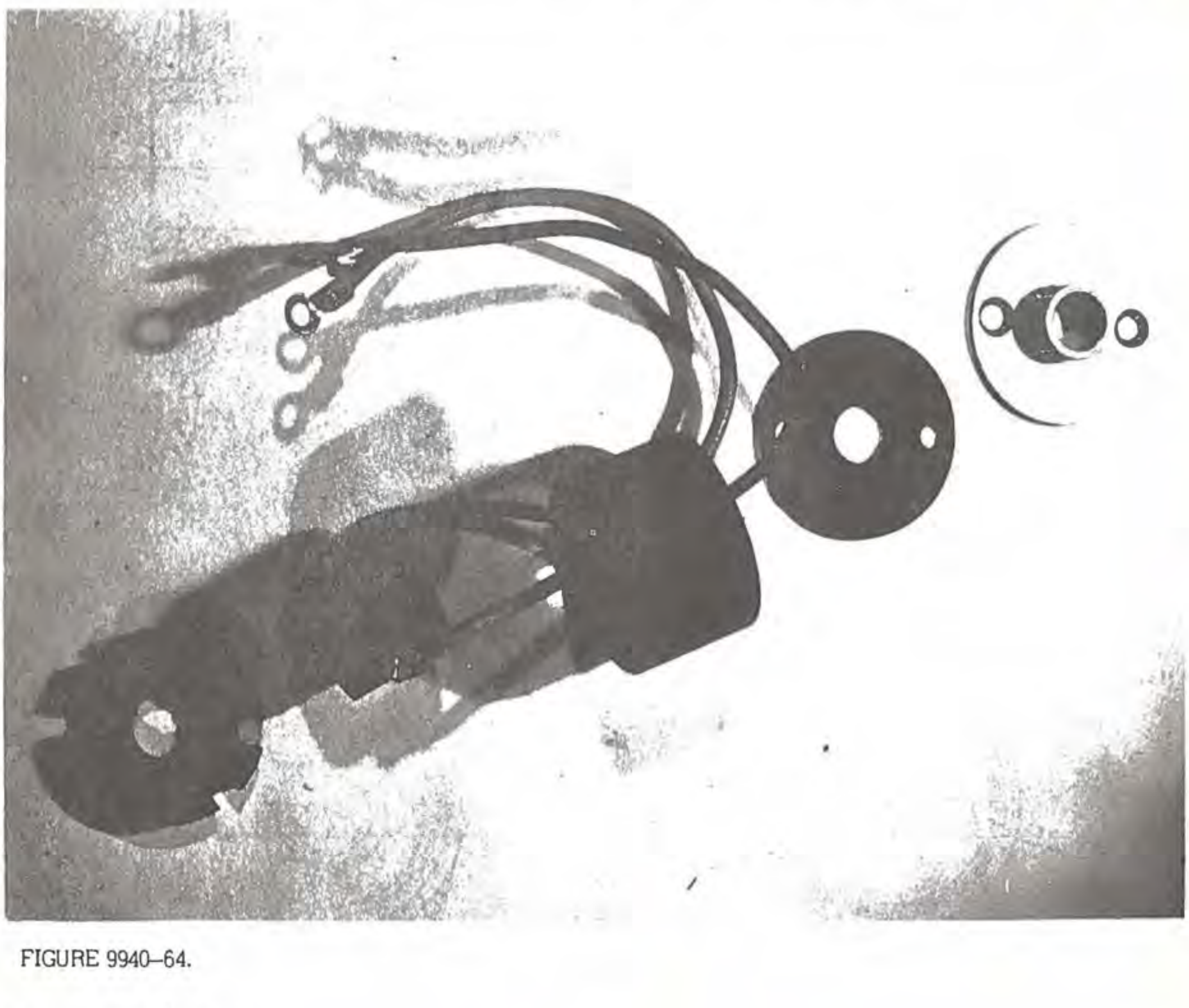
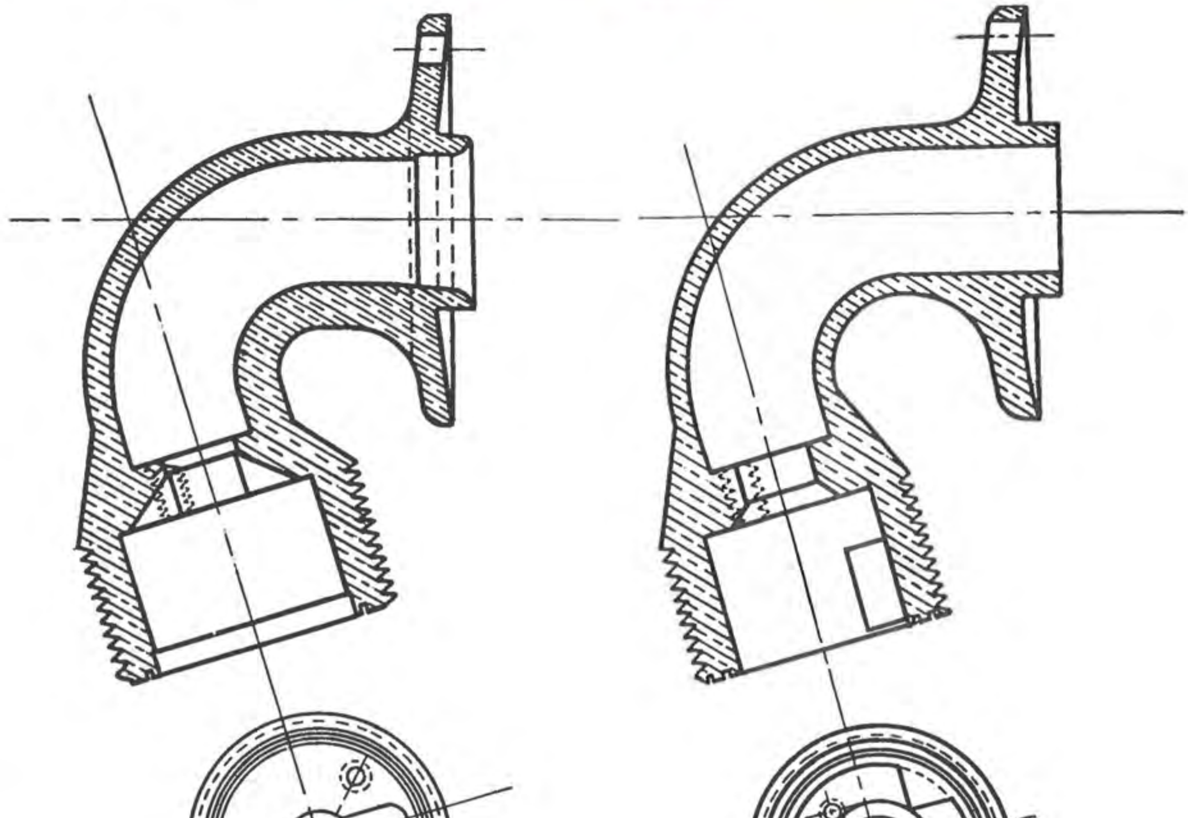


FIGURE 9940–64.

FIGURE 9940–65.



HELMET GOOSENECK REQUIRING USE OF NEW STYLE JACK BOX

HELMET GOOSENECK REQUIRING USE OF OLD STYLE JACK BOX

FIGURE 9940–66.

from dirt and sediment. After use, the units should be wiped dry with a clean rag to remove all moisture before storing.

2. The installation of the helmet gooseneck jack into the gooseneck involves the following steps:

a. If leads are not furnished on the jack unit, solder a 12-inch insulated wire to each of the terminals of the jack.

b. Insert the jack element, wires down, into the gooseneck and secure with two screws.

c. Trim and attach leads to the reproducer unit and secure the reproducer unit in place.

9940-604. ELECTRICAL CONNECTIONS

1. The electrical connections between the diver's reproducer and the amplifier and between cable lengths are made through the jack boxes. The new style jack box is shown in fig. 9940-64 and the old style in fig. 9940-65. The corresponding helmet goosenecks are shown in fig. 9940-66.

d. Pour melted beeswax into the helmet gooseneck from inside the helmet to produce a watertight seal.

9940.605. SIGNAL HALYARD

One-inch cotton braided signal halyard, fig. 9940–67, is used for securing the hose and amplifier and life-line cable to the eyelets on the helmet breastplate.

9940.606. SOUNDING LINE AND LEAD

The sounding line and lead, fig. 9940–68, are provided for determining the depth to which the diver must descend. It is important that this depth be determined with reasonable accuracy in order to anticipate the diving conditions, type of equipment, and personnel to be used, and to ensure proper decompression.

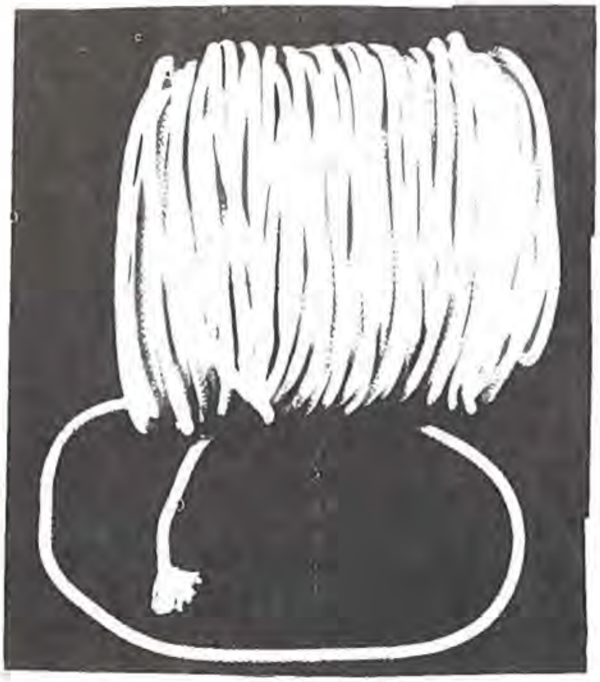


FIGURE 9940–67.

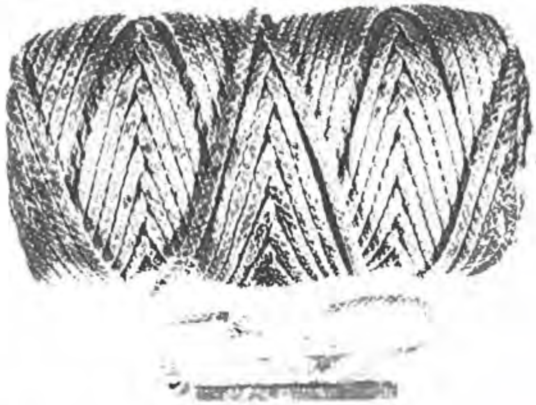


FIGURE 9940–68.

9940.607. DESCENDING LINE

The descending line, fig. 9940–69, is the means of guiding the diver to the bottom and for lowering tools and equipment. The line is made of 3-inch circumference manila rope, and cable-laid to prevent twisting and to make identification by the diver easy. In rescue and salvage work, after the sunken vessel has been located, a line usually is attached to the wreck by the diver. In subsequent dives the diver slides down the line to reach the desired point on the wreck. In diving operation requiring searching or observations, etc., the descending line is lowered direct to the bottom by shackling its end to the eye of a 100-pound weight. In strong tide ways, should the 100-pound weight not remain on the bottom, additional weight may be added.

FIGURE 9940–69.

9940.608. DISTANCE LINE

A distance line, fig. 9940–69, made of 15-thread cable-laid manila, 60 feet long, is attached to the descending line above the weight. This line is used by the diver in rotary searching and as a guide for relocating the descending line when he is ready to ascend.

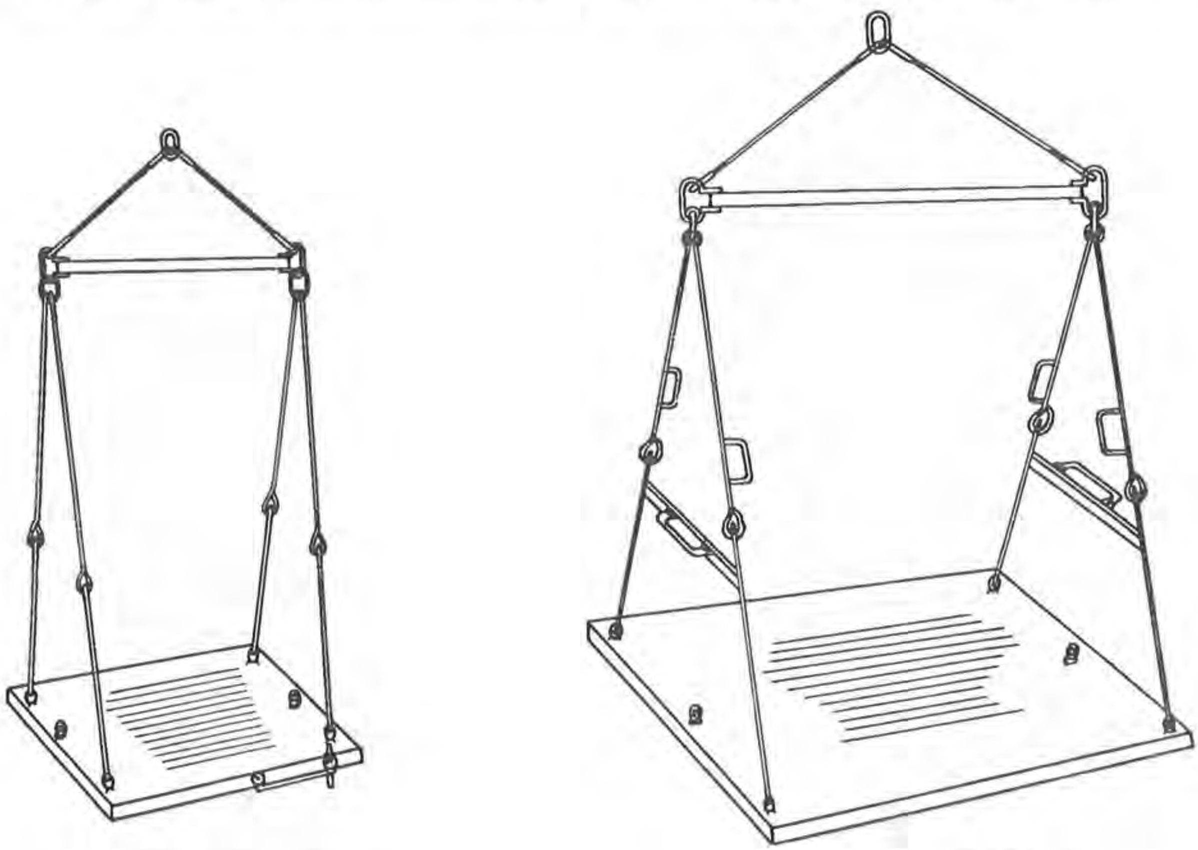
9940.609. DECOMPRESSION STAGES

1. The divers' decompression stages, fig. 9940–70, are used for putting one or two divers over the side and for bringing the divers to the surface in accordance with the decompression tables. The single-diver stage is 3 feet in length and 18 inches wide; the two-diver stage is 5 by 4 feet. The stage platform is made of flat cross-bars spaced about 1 inch apart to permit it to pass through the water with a minimum of resistance. The platform is mounted on two wooden skids for deck protection. Eye bolts approximately 1 3/8 inches inside diameter are welded to the middle of each end of the platform for attaching guy ropes for steadying the stage, suspending weights, or permitting the diver to brace himself. On the front of the single-stage platform and on the side frame of the two-diver stage is secured a guide through which the descending line is passed when lowering the stage to the diver. The bails of both stages are made in two sections to permit the stage to collapse for ready stowage. At the top of the stage is a 2½-inch inside diameter ring for securing the stage lines.

2. **Stage lines** are not furnished with the stage but should be made up on board to suit the particular needs of the vessel. The lines are made of 3- or 4-inch manila rope with marks made 10 feet apart, corresponding to the decompression stops. As the decompression tables are prepared on the basis of the entire body being below that required by the decompression stop, the depth of each decompression stop is measured from the surface of the water to the midpoint of the diver's body. As individuals vary in height, it is necessary to use an average distance in determining the location of the first marker.

3. **The diving ladder,** fig. 9940–71, is used for entering and leaving the water when diving over the side of a motor launch. The struts that give the correct inclination of the ladder when in use may be folded against the frame after removing the securing bolt to facilitate stowage. The ladder is made of medium steel and is heavily galvanized.

4. **Cast-iron weights** are provided in two sizes, 50 and 100 pounds. The 50-pound weights generally are used with



SINGLE DIVER TWO DIVERS

FIGURE 9940–70.

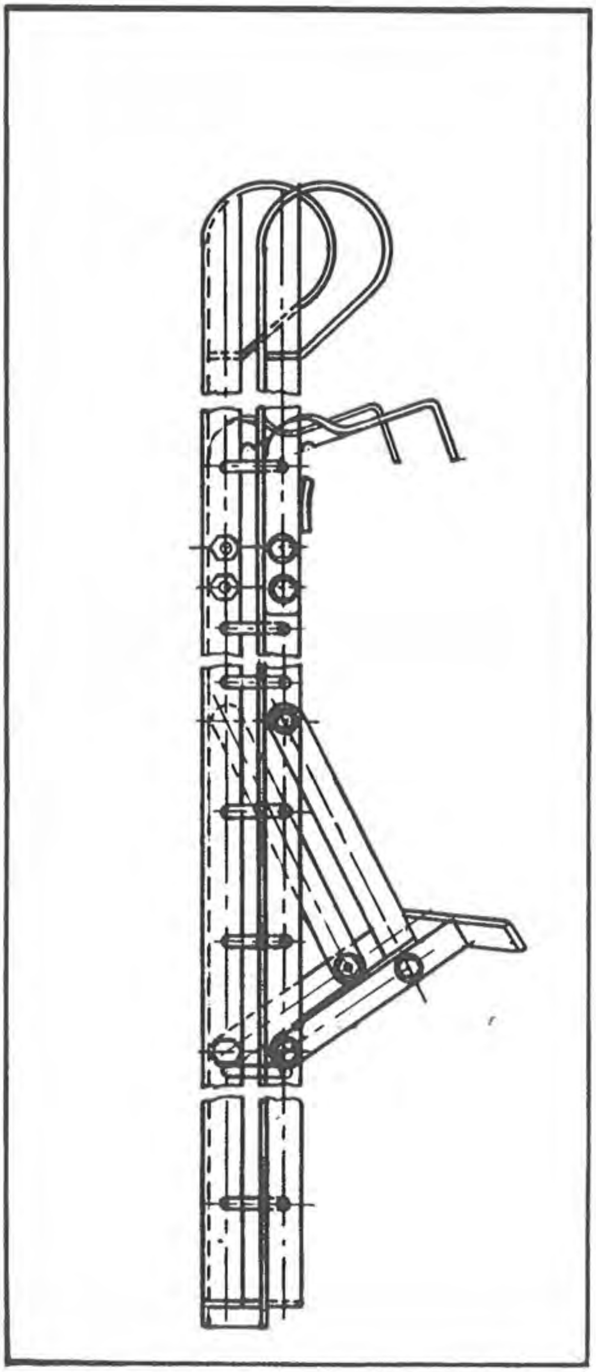


FIGURE 9940–71.

the decompression stage or as marker-buoy weights, and the 100-pound weights are descending line weights.

5. The **tool bag,** fig. 9940–72, is used for carrying any tools that may be required by the diver for doing a job.

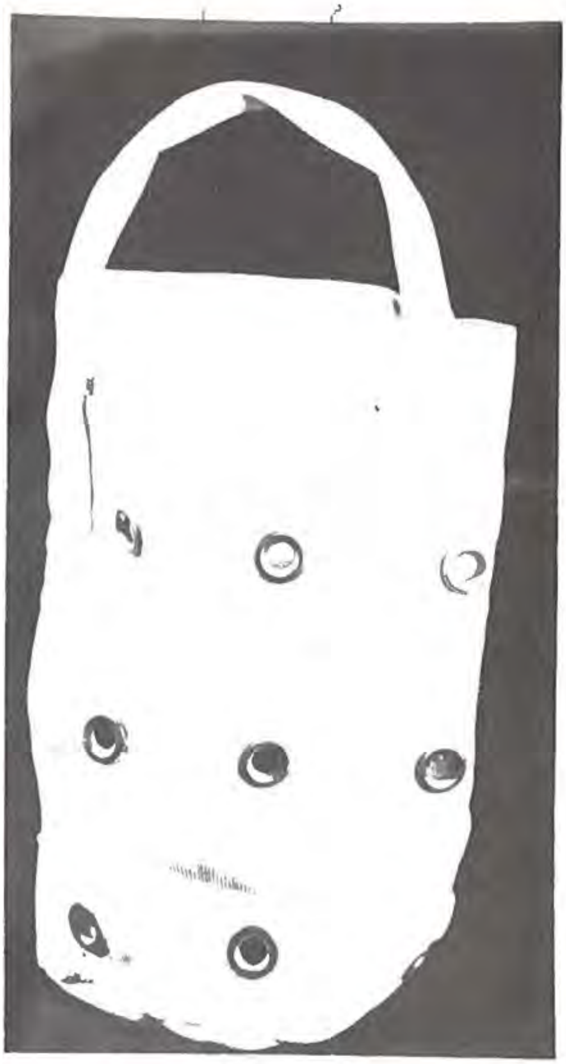


FIGURE 9940–72.

Usually the tool bag, if not too heavily loaded, will be looped over the diver's right arm while he is on the ladder, just before entering the water. If it is heavily loaded, it should be sent down the descending line. The bag is made of heavy canvas and perforated with grommets, for easy drainage and for securing tools. After use, the bag should be washed with clean water and allowed to dry thoroughly before stowing.

6. **Lights.**

a. One of the greatest handicaps experienced by divers is reduced vision under water which may range from 0-100 percent of normal, depending on the turbidity of the water. In many instances the diver working on muddy bottoms has to depend entirely on his sense of touch to accomplish a job. The value of underwater lights will

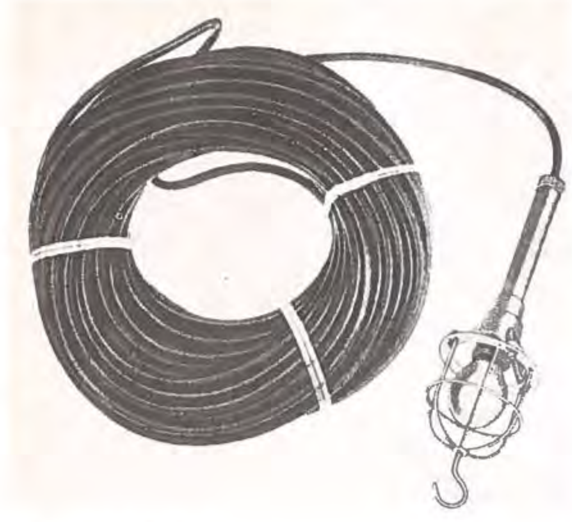


FIGURE 9940-73.

FIGURE 9940-74.

FIGURE 9940-75.

FIGURE 9940-76.

depend on the water conditions. The extent of light penetration or diffusion of light under water depends principally on the amount of opaque matter suspended in the water inasmuch as the opaque matter scatters the light, creating a haze. Increasing the power of the light increases the intensity of illumination but does not materially increase the radius of diffusion, nor does the use of reflectors to project the rays contribute materially to greater penetration.

FIGURE 9940–77.

Reflectors are useful in protecting the diver's eyes from the glare of the light at its source.

b. To provide light where it may be feasible, two underwater lights have been develo:ed. The medium pressure underwater light, fig. 9940–73, consists of the lamp with a rubber socket for making a watertight seal with a commercial 100-watt photo flood bulb (any commercial medium base bulb may be used), and 200 feet of cable. The light has been found satisfactory for use in moderate depths-down to 150 feet. The second light, fig. 9940–74, consists of a 1,000-watt lamp, lamp holder of seamless brass tubing, and a chromium-plated copper reflector fitted with a wire mesh guard. This light is designed to withstand pressures equivalent to those at 500-foot depths. All types of underwater lights must be submerged before being turned on and the current must be turned off before hoisting the light from the water to prevent possible breakage from the resultant change in temperature.

7. The stop watch is furnished primarily for timing the decompression stops.

8. The **spare part box** fig. 9940–75, is used for storing in one place small fittings, springs, and tools that are furnished with the diving outfit. The box is made of 22-gage sheet steel and is 15 inches long, 8 inches wide, and 9 inches deep. The box should be inspected regularly to guard against rusting.

9. **Rubber cement** is furnished for patching the diving dress and for attaching the divers-tenders gloves or cuffs to the dress. As the cement contains a curing agent that will cause it to lose its adhesive properties within a short time if left exposed to air, it should be kept in a tightly sealed container when not in actual use.

10. **Helmet and outfit chests,** fig. 9940–76, are used for stowing the diving helmets and the various other parts of the diving outfit. Both chests are made of sheet metal and are 37 inches long, 17 inches wide, and 23 inches high. The chests should be checked periodically to guard against rusting.

11. **Dies and taps,** fig. 9940–77, are furnished for rethreading damaged bolts, nuts, couplings, and other diving fittings. There are two sets of taps and dies—one for rethreading the helmet breastplate studs and wingnuts—½-inch 12 threads. The other set is for rethreading air-hose fittings, reducers, manifolds, etc., 1 1/16-inch 17 threads. The taps and dies should be given a protective coating of heavy oil when not in use.

12. **Wrenches** are furnished for the air-hose couplings, telephone couplings, and for securing the helmet breastplate nuts and for disassembling the safety air nonreturn valve, fig. 9940–78.

FIGURE 9940–78.

FIGURE 9940–79.

9940.610. LIGHTWEIGHT DIVING OUTFIT

The Lightweight Diving Outfit, fig. 9940–79, consists of the following items: Standard rifle cartridge belt, leather belt, rubberized fabric dress, and mask.

9940.611. RIFLE CARTRIDGE BELT

A standard rifle cartridge belt, fig. 9940–80, with lead weights cut to fit the pockets is satisfactory when using the mask alone. A quick-release type buckle should be used.

9940.612. LEATHER BELT

To compensate for the additional buoyancy gained when using the diving dress and underwear, a leather weighted belt (fig. 9940–81) is substituted for the cartridge belt.

FIGURE 9940–80.

FIGURE 9940–81.

The weight of the belt may be varied up to 45 pounds by removing or adding weight depending upon the amount of clothing worn, water condition, and the diver's preference. The belt buckle also permits the belt to be discarded rapidly in the event the air supply is lost or the mask is accidentally torn from the face. In order to permit the belt to be discarded in an emergency, the shoulder straps should be crossed only in back and under the metal clamp.

9940.613. LIGHTWEIGHT DIVING DRESS

1. The dress, fig. 9940-82, is made from a rubberized fabric of two-ply construction, the outer ply of cotton drill and the inner ply of airplane cloth. The dress is made in one piece, with a hood cemented to the body of the dress, and covers the entire body with the exception of the face opening and hands. Entrance to the dress is made through a cylindrical opening in the back of the dress. In dressing, the diver enters through the back opening, feet first, pulls the lower portion well up around the waist, and then, bending forward, inserts arms and head. If cuffs are used, soap should be applied on the hands before dressing to facilitate putting the hands through the cuffs. If the diver's wrist is small, an elastic tubing should be used over the edge of each cuff to ensure watertightness.

FIGURE 9940–82.

2. After the entrance is made, the back opening is made watertight by gathering the material together and using the metal clamp. The following method of making a watertight seal is recommended: Fold the material into approximately 2½ pleats; then fold across the middle to make a five-ply bundle; finally, the bundle is doubled over and inserted in the metal clamp After the watertight seal is made, the hood should be laced up the back so that it will fit as snugly as comfort will permit and so that the hood volume can be reduced to a minimum.

3. Cemented to the front of the dress hood is a thin rubber gasket which has a face opening extending from the forehead to the chin. The gasket should be placed under a slight tension to eliminate wrinkling, which would cause leaks when the mask is put on. The face opening of the gasket may be enlarged to fit the face. However, if the opening is enlarged, the rim should be folded over approximately one-fourth inch and cemented to prevent the gasket from tearing. The following method of replacing the face gasket is recommended:

a. Remove old strapping, gasket, and old cement from dress with benzine, and trichloroethylene.

b. Sandpaper lightly the edges of suit hood where old gasket was attached, and the strapping for new gasket.

c. Spread a thin film of rubber cement on each sanded surface and allow to dry until tacky. Repeat for two or three coats.

d. As the last application of cement becomes tacky, press new gasket firmly into position on the hood. If marks left by removal of old gasket are followed accurately, the fit will be perfect.

e. Cement old binding tape (or facsimile cut from patching cloth) over the seam. Allow to dry over night before use.

4. As stated before, the principle of operation of the lightweight equipment is based on the elimination of air

FIGURE 9940–83.

from the dress. To dispose of any air in the dress, an exhaust valve is placed in the top of the hood. The dress is improperly adjusted if accumulated air is prevented from entering the hood section from which it can be exhausted through the valve. To release the air trapped in the dress, the diver should enter the water slowly enough to permit the air in the suit to escape through the exhaust valve.

5. Standard 5/16-inch oxygen hose in 50-foot lengths is used to supply air to the diver. The hose is furnished with two female couplings and the necessary double male fitting. When manufactured, the hose is required to withstand a working pressure of 250 psi and a bursting pressure of 700 psi maintained for two minutes. Hose in diving service shall be visually inspected upon receipt and every six months thereafter, and a check made to ensure that the couplings are tight. The hose shall be subjected to an air pressure test of 125 psi held for a period of one minute when it is two years old and every month thereafter. An inspection shall be made to ensure that the couplings are tight. Hose more than five years old shall not be used as diving hose. In an emergency and when the only diving hose available does not have a date stamped on it, the following test should be made: 2 X (D X .445 + 50). It is recommended that the hose be of a continuous length.

9940.614. MASK

1. The essential parts of the mask, fig. 9940–83, are the copper frame, rubber seal, plastic front window, inlet valve, exhaust valve, and head harness. The copper frame and rubber are molded in a shape that provides a seal with the dress hood facepiece and provides a broad field of vision with minimum distortion. The mask complete with fittings does not include the air control valve or nonreturn valve, which are furnished as separate items.

2. Air enters the mask through the inhalation valve on the side of the mask. When the inhalation-valve handle is pointing toward the rear, air enters directly from the air line into the mask. The other valve position was once used with a breathing bag. It may now be used as a surface breather or capped and not used. The section of the inhalation valve on the inside of the mask is a rubber flapper valve which prevents air in the mask from escaping back into the breathing bag.

FIGURE 9940–84.

3. On the opposite side of the mask from the inhalation valve is the exhaust valve, consisting of a rubber disk which opens during exhalation and closes by water pressure at the end of the exhalation period. The rubber disk is held in place by an adjustable stem. The adjustment of the stem is usually set in the proper position. However, if the entire mask seems to bounce or gives a "water hammer" effect, the valve stem should be readjusted. The mask is held in position by means of an adjustable head harness.

4. While the mask is reasonably rugged, care should be taken in the handling and storing of it. The mask should be kept away from sunlight, heat, and oil when not in use and should be thoroughly cleansed with fresh water and dried before storing.

9940.615. CONTROL VALVE

The control valve, fig. 9940–84, used to control the quantity of air entering the mask is a modified standard commercial globe valve. The valve is attached to the inhalation valve on the mask. It is placed so as to maintain a fixed position, and so it will be in the most accessible place for controlling the air supply where the supply is least likely to be closed by accidentally hitting the valve handwheel. The control valve handwheel should be maintained sufficiently tight by means of the packing-gland nut to prevent the handle from turning loosely or too readily.

9940.616. NONRETURN VALVE

1. The nonreturn valve, fig. 9940–85, is located between the air-control valve and the air hose. The purpose of the nonreturn valve is to prevent the diver from being injured by "squeeze" in the event that the air hose bursts or the supply system becomes so seriously damaged as to fail to maintain an air pressure within the mask sufficient to maintain a pressure equilibrium. Under either condition the air pressure to the hose would decrease suddenly and, should there be no nonreturn valve, the compressed air in the mask would escape through the air hose, thereby causing the pressure within the mask to become less than the external pressure, thus causing a "squeeze." The mask being rigid, the effect of the greater external pressure would be to squeeze the diver's face into the mask. This condition might have serious results.

FIGURE 9940–85.

2. The use of the nonreturn valve is so essential that no diving, regardless of depth, should be undertaken unless there is a nonreturn valve operating satisfactorily in the line. A simple method of determining whether the valve is operating satisfactorily is by attempting to blow smoke through it in a direction opposite to the normal flow of air.

9940.617. SPARES

Spares consist of cement, patching cloth, face gasket, head harness, dress and mask flapper valves (fig. 9940-86).

FIGURE 9940–86.

9940.618. LIFE LINE

The life line should be made up on board from 1¼-inch circumference manila rope or sisal rope of equal strength. The life line is secured around the diver's chest, with the line extending to the surface from the front of the diver. The line should not be connected to or looped around the weighted belt and should be arranged so there will be no interference with the releasing of the belt. The line serves three purposes: first to remove any strain from the air hose; second, to allow tending and to assist in descent and ascent; and, third, to maintain communications with the diver. In the event of an emergency ascent involving either the loss of air or face mask, the diver shall continue to exhale during the ascent. If this is not done, air embolism is likely to result. All divers should be familiar with hand signals listed in article 9940.582.

9940.619. OTHER EQUIPMENT

The remaining items, cuffs, gloves, knives, overalls, shoes, and underwear of the lightweight diving outfit are the same as those furnished with the deep-sea diving outfit previously described.

9940.620. MAINTENANCE OF EQUIPMENT

1. Every effort shall be made to keep the diving apparatus in repair and ready for immediate use. With this in mind the following general recommendations on the maintenance of equipment are made.

2. Diving apparatus should not be stowed in compartments below the water line or in places difficult of access in time of emergency. All chests of diving apparatus should, when sufficient space is available, be habitually stowed under cover, away from steam pipes or excessive heat. When it is necessary to keep the equipment in the open and exposed to the weather, suitable canvas cover should be provided and used to protect the outfit.

3. **Spare parts** of diving apparatus not required for immediate use shall be kept in suitable storeroom space and, when drawn for use, shall be replaced by new parts immediately.

4. **Leather articles** used in water soon will become dry and hard and are likely to crack unless properly cared for. Finished leather contains a certain amount of oil and grease and, when this is washed out, the leather loses its flexible quality and soon will show signs of deterioration. Occasionally the leather parts of diving apparatus should be given a coat of neat's-foot oil, well rubbed in, so the articles will not be disagreeable to handle. To treat leather properly with neat's-foot oil, place the article to be treated in as flat a position as possible. Then soak a rag in oil and apply one coat of oil at a time until the oil soaks through on the other side. Do not attempt to apply the oil from both sides at once and do not submerge the article to be treated in the oil.

5. **All metal parts** of diving apparatus should be kept free of rust or verdigris, in efficient working order, and protected from injury. Special precautions are to be taken with valves, valve seats, and like parts. Parts not kept painted, polished, or galvanized should be kept lightly coated with oil.

6. **Rubber.** As oil or grease is specially destructive to rubber, parts of diving apparatus composed of rubber such as dress, hose, cuffs, etc., must be protected from oil or grease in any form. Diving dresses and other parts consisting of rubber with cloth coverings or cloth insertions must not be put away while damp or wet. Rubber materials, when folded, acquire a permanent set at the bends and later, when used, are likely to crack open or break at these points. Such materials should, so far as practical, be stowed without folding. The instructions for making repairs to diving dresses apply also to other rubber or rubberized materials.

7. The longevity of rubber is limited by the characteristics inherent to material of this nature. In using rubber parts of diving apparatus, preference should be given to those of the oldest date of manufacture, so far as it is practical to do so without jeopardy. For example, hose, so far as concerns its use as diving air hose, has a stipulated life limitation. The entire amount of diving air hose furnished with diving outfits is seldom required for an individual routine diving operation. Consequently when new hose is obtained to complete a diving outfit, it should not be put into use until the old hose has reached its age limitation or has become unserviceable for further use.

8. All cotton and woolen goods should be kept clean, dry, and in repair. When not in use, they should be stowed

with a larvicide such as naphthalene and kept tightly wrapped in paper. Dirty woolens should be washed with soap and tepid fresh water, thoroughly rinsed, and carefully dried.

9940.621. INSPECTIONS AND TESTS

1. Upon receipt of diving outfits, in whole or in part, the gear shall be carefully inspected, tested, and made ready for immediate use in every detail. It will thereafter be maintained in the best possible state of efficiency.

2. When it is known that the commanding officer is about to inspect the parts of the ship in which diving apparatus is stowed, the apparatus should be conveniently arranged for his inspection. All chests should be unlocked, the covers opened, and the men should stand by to exhibit the contents as he may require.

3. All diving apparatus, except spare parts, shall be inspected once each week for cleanliness, conditions of stowage, etc. Helmet valves, faceplates, and fittings shall be examined; diving dresses inspected for damage or dampness and repaired and aired, if necessary; dirty woolens washed and dried; oil separators cleaned, if necessary, and their filters washed in hot water and dried; diving knives and their cases, all tools and metal fittings cleaned and lightly oiled; diving shoes, belts, etc., attended to; lengths of air hose that have been coupled together a long time shall be parted, the coupling threads lightly oiled, cleaned of grease or dirt; the interior of all chests must be cleaned of any oil, grease, or dirt.

4. All diving equipment on board ship shall be closely inspected once each month. Each outfit shall be inspected as to its completeness and satisfactory condition. Air-regulating escape valves, air control, safety, and nonreturn valves of the diving helmet, and all valves of the diver's air supply system shall be tested for satisfactory operation. Diving telephone systems shall be checked and tested.

D. Diver's Air Supply

9940.631. GENERAL

1. The most important consideration in surface-supplied diving is that of providing to the diver an adequate supply of air suitable for him to breathe. For dives to shallow depths when an abundant supply of good air is readily available there is very little concern about the actual amount used by the diver. However, in most instances inherent limitations of the diving installation or greater requirements of depth demand consideration of the adequacy of available air. This consideration must be based on various factors determined by the diver's air requirements at his maximum depth and maximum amount of work.

2. **Helmet Ventilation.** Since 3 percent carbon dioxide at atmospheric pressure is about the maximum that can be tolerated without distress, it is essential that this equivalent partial pressure percentage should not be exceeded in the helmet. Accordingly, the volume of air passing through the helmet of a deep-sea diving outfit must be sufficient to keep the concentration of carbon dioxide below the surface equivalent of 2 percent if possible and below a maximum of 3 percent. The relationships between a diver's carbon dioxide production, his breathing, and his helmet ventilation requirement have been discussed extensively in chapter 1.3, para. 4. (11) through (21) of NAVSHIPS 250-538. Pertinent information is reviewed in this section.

3. The diver's rate of production of carbon dioxide depends mainly upon the amount of work he is doing. In terms of volumes measured at the surface, a diver will produce approximately 0.01 cubic foot of carbon dioxide per minute while at complete rest, 0.05 cubic foot while doing a moderate amount of work, and as much as 0.10 cubic foot during periods of heavy exertion – or 10 times the amount at rest. To keep this concentration of carbon dioxide from exceeding 1 percent, the volume of air used to ventilate the diver's helmet must be 100 times the volume of carbon dioxide produced. If the volume of air is 50 times the carbon dioxide production, carbon dioxide concentration in the helmet will be 2 percent, and so on. For example, to keep the concentration below 2 percent effective during a moderate working dive at least $0.05 \times 50 = 2.5$ cubic feet of ventilating air would be required each minute.

4. While the depth of dive does not change the **number** of cubic feet of air required for helmet ventilation, it must be understood that the volume of air needed is measured at the absolute pressure of the depth. Therefore a diver who requires 2 cubic feet of air per minute at the surface will also require 2 cubic feet at 99 feet (4 atmospheres absolute), but the actual volume in terms of free air at the surface will be $2 \times 4 = 8$ cubic feet (Boyle's law).

5. A minimum air supply of 1.5 cubic feet per minute (measured at the absolute pressure of the diver's depth) would keep the surface equivalent of carbon dioxide in the helmet below 3 percent if the diver's carbon dioxide production were less than 0.045 cubic foot per minute. This means that 1.5 cubic feet per minute would only be adequate for light work but that better ventilation is required for all practical purposes. Whenever possible the volume of air supplied to a diver should be at least 4.5 cubic feet per minute at the absolute pressure to which the dive is made. This amount would be ample for all but brief periods of the most strenuous work. It is important to consider that any means of surface supply must provide a sufficient volume of air not only for the diver, but for a possible relief diver.

6. To determine the volume of free air (as measured at the surface) required by a diver the following formula may be used:

$$S = 4.5 \times N \times \frac{(D + 33)}{33}.$$

Where:

S = air supply in cubic feet of free air per minute.

N = number of divers.

D = depth in feet.

For example, 2 divers working at a depth of 80 feet would require:

$$S = 4.5 \times 2 \times \frac{(80 + 33)}{33}.$$

$S = 4.5 \times 2 \times 3.4.$

$S = 30.6$ cubic feet of free air per minute.

9940.632. LIGHTWEIGHT MASK VENTILATION

The flow of air required in the mask of a lightweight diving outfit must be at least equal to the rate of the diver's inspiration. This rate will normally be about 3 times his respiratory minute volume. In turn, his RMV will be about 25 times his carbon dioxide output. Therefore, normal breathing requires that the air supply be equal to about $3 \times 25 = 75$ times the diver's carbon dioxide production. Less than that volume will cause discomfort to the diver. The lower limit of tolerance is about 50 times the carbon dioxide output. This is the same supply volume needed to maintain an effective concentration of 2 percent carbon dioxide in a helmet, showing that the lightweight outfit mask requires at least the same amount of air as the deep sea helmet.

9940.633. OVERBOTTOM PRESSURE REQUIREMENTS

It is considered advisable to maintain in the diver's air hose an air pressure of at least one atmosphere in excess of the absolute bottom pressure. The excess pressure is provided so that there will be immediately available additional pressure over absolute bottom pressure to compensate for any increase in bottom pressure in the event the diver falls; thereby possibly preventing a "squeeze." The amount of overbottom pressure to be maintained in the hose will depend upon the available pressure at the air source, loss in the system before reaching the diver, whether or not the type of work is such that the possibility of falling exists, etc. A pressure in the hose of 100 psi overbottom is considered desirable for dives of more than 120 feet and at least 50 psi for dives of less than 120 feet, whenever capabilities of the air supply system will permit.

9940.634. SOURCES OF COMPRESSED AIR

There are three general sources of compressed air:

1. Gas-driven air compressors.
2. Air flasks.
3. Shipboard air (ASR Divers' Air System).

9940.635. TYPES OF AIR COMPRESSORS

To meet the various diving requirements of the large number of activities having diving equipment and that are called upon to undertake diving operations, two general types of air compressors are available: Heavy duty and lightweight. The type compressor to be used will depend upon the type of diving operations to be undertaken. Operations that require keeping a diver or divers in the water for extended periods, where the compressor will be subjected to rigorous usage, or where the work is located in such a place that the diver cannot make a direct ascent to the surface, or for reasons of decompression, the heavy-duty compressor should be used. The lightweight air compressor is used for minor jobs, inspection, or searching, where ascent can be made direct to the surface without decompression, where the compressor is not subjected to continuous use, etc. While the heavy-duty compressor may be substituted for the lightweight compressor for minor diving jobs, the lightweight compressor should not be used where the working condition requires the use of a heavy-duty compressor.

9940.636. HEAVY-DUTY AIR COMPRESSOR

1. The air compressors furnished with the deep-sea diving outfits are the heavy-duty portable units designed to operate for long periods of time with maximum reliability. The units have a rated capacity of 55 cfm with an operating pressure of 100 psi. These compressors are furnished to activities having an allowance of deep-sea diving equipment and who are called upon to undertake extensive diving operations—repair ships, tenders, salvage vessels, tugs, and other activities as approved by Bureau of Ships.

2. There are at the present time two makes of heavy-duty compressors being issued with the deep-sea outfit. The unit shown on fig. 9940-87 is a four-cylinder engine with two single-stage compressor cylinders in a one-piece "en bloc" cylinder construction, with a crankshaft common to both the engine and the compressor. The crankcase, although in one piece, is divided and sealed between the engine and air compressor to prevent any engine fumes and gases from entering the compressor system and contaminating the breathing air. This unit has an overall length of 83 inches, width 23 inches, height 52 inches, and a total weight of 1,800 pounds.

3. A mechanical flyball type governor is located on the outside of the timing gear cover and is connected to an auxiliary butterfly valve for limiting the maximum engine speed. The slowdown assembly, connected to the throttle body butterfly, controls the acceleration and deceleration of the engine in relation to the loading and unloading of the compressor cylinder. This unit has a water cooling system consisting of a large capacity radiator, centrifugal water pump, thermostat, and fan. The cooling system is designed so that the compressor will operate satisfactorily at ambient temperatures ranging up to 140° F. An air receiver having a volumetric capacity of 5 cubic feet with a working pressure of 125 psi is mounted in a vertical position and is contained within the limits of the frame. The receiver is connected to the discharge ports of the compressor cylinder head by a flexible metallic connection.

4. The second unit, figs. 9940–88 and 9940–89, consists of a 4-cylinder, 4-cycle, V-type engine that develops 23 horsepower at 2,200 rpm (full load). The engine is connected by multiple V-belts to a 2-cylinder single-stage air compressor. The unit has an overall length of 70 inches, width 32 inches, height 37 inches, and weight of 1,750 pounds.

5. The compressor control regulator consists of a mechanical pilot valve, delay valve, engine throttle control, and cylinder unloader. A governor automatically regulates the engine speed by controlling the throttle valve of the carburetor. When the load on the engine decreases, the governor closes the throttle valve and will not let the engine operate beyond its maximum rated speed. Both the engine and compressor are air cooled. An air receiver having a 1.69-cubic-foot capacity at an operating pressure of 125 psi is located at the compressor end of the unit and acts as a storage tank and pulsation chamber.

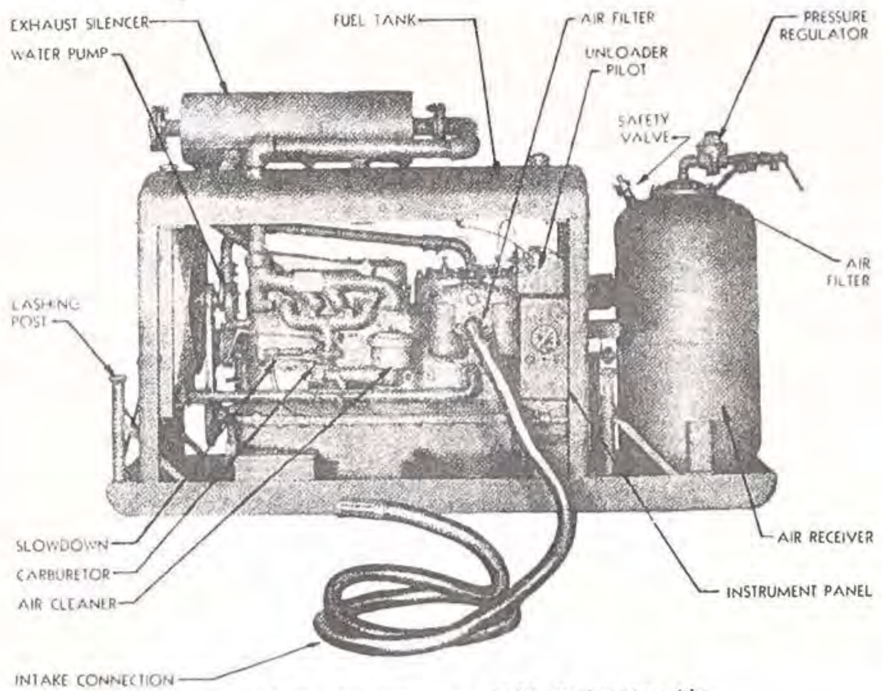
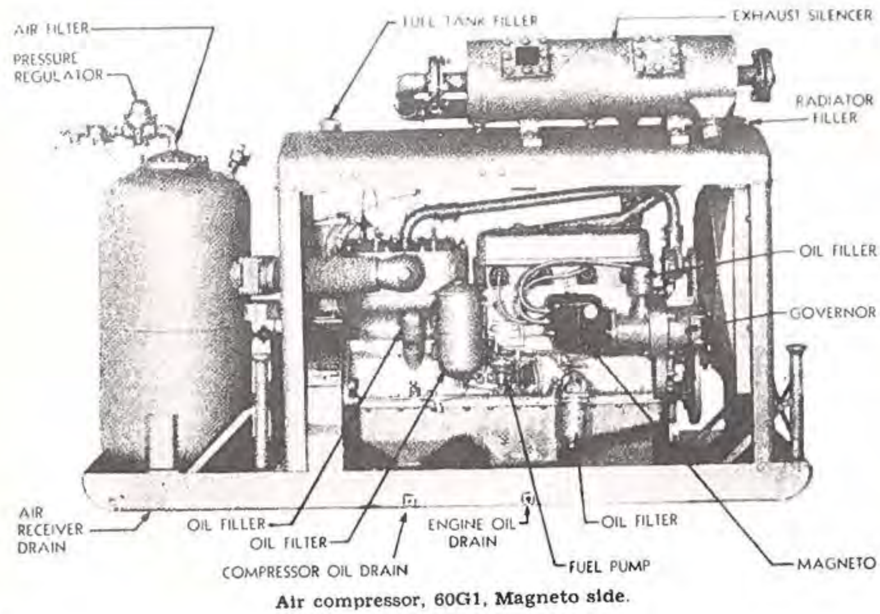


FIGURE 94 88.—Air compressor, 60G1, Carburetor side.

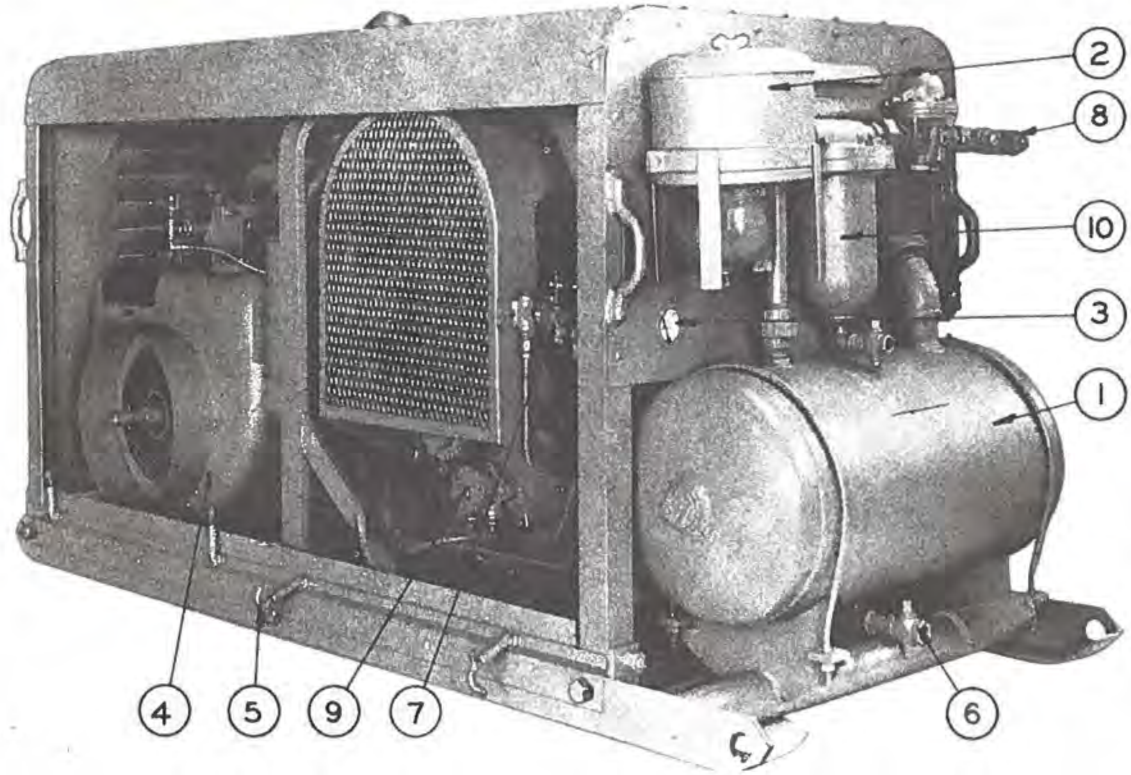


Air compressor, 60G1, Magneto side.

FIGURE 9940–87.

9940.637. AIR PURIFICATION

1. To ensure that air of adequate purity and within reasonable limits of pressure variation is furnished, several special pieces of equipment are supplied with the compressor. To prevent the breathing air from being contaminated with the engine exhaust fumes, both compressor models are furnished with a flexible metallic pipe extension, approximately 15 feet long, for connection to the compressor intake. The compressed breathing air is exhausted into a volume tank where, as a result of expansion, it is cooled and some



Right side of unit (side covers removed).

1. Air receiver.
2. Compressor air filter.
3. Oil pressure gauge.
4. Engine.
5. Hood clips.
6. Air receiver drain.
7. Pilot valve.
8. Hose connections.
9. Oil pump.
10. Air line filter.

FIGURE 9940–88.

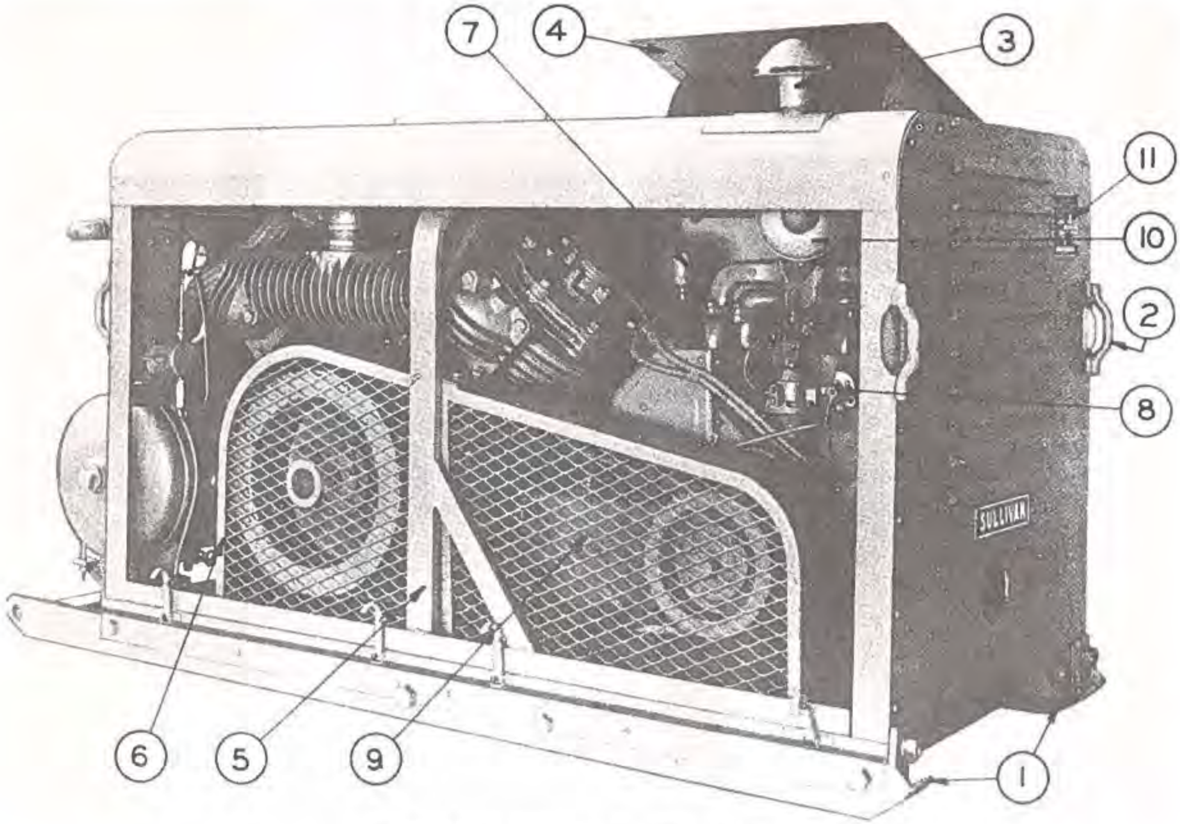
of the oil and moisture are eliminated. There is a tendency in all oil-lubricated compressors for the compressed air to pick up a quantity of lubricating oil and vapor and to carry them over to the diver's line. To prevent this condition, the air is passed from the receiver through an oil filter where the oil vapors are removed from the air.

2. It is essential that the oil filter be kept in first-class condition, otherwise the breathing air will become contaminated with oil and become exceedingly repugnant to the diver. In addition to the contamination of the breathing air, oil in the air will accelerate deterioration of the diver's hose. The air is passed from the oil filter through a pressure regulator that is designed to furnish air to the diver at constant pressure. In this way the pressure fluctuations between the fully loaded and unloaded compressor position will not be transmitted to the diver, with the result that the necessity of the diver changing the valve setting is reduced.

9940.638. MAINTENANCE OF COMPRESSORS

1. The compressor, one of the most vital items of the diving equipment, must be maintained in first-class operating condition at all times, regardless of whether it is being used or stowed. The compressors should be kept clean to maintain maximum efficiency. The unit should be gone over frequently; in addition to removing dirt and grease, many troubles caused by loose connections, nuts, or cap screws will be discovered before they develop.

2. **Cooling.** To maintain the water-cooled compressor in efficient operating condition, the radiators should be filled with clean soft water. The use of rain or distilled water should only be used in emergencies, and the use of hard water also should be avoided because of the tendency for scale to form in the water jackets and passages. Radiator hose connections should be inspected at time of draining and replaced if necessary. When using the compressor in cold climates, adequate antifreeze should be added. In the event that the engine overheats, water should not be poured into the cooling system, as sudden changes in temperatures may cause the cylinder head to crack. The radiators should be filled only after boiling has ceased and engine has cooled; then add the water slowly. The air-cooled units depend for cooling upon air being forced over the large exposed area of the compressor and engine cylinder head and cylinder fins. It can be readily seen that for adequate heat dissipation it is necessary to keep the cylinder head and cylinder cooling fins



Left side of unit (side covers removed).

1. Skid.
2. Lashing ring.
3. Exhaust stack.
4. Ventilator.
5. Lifting bail.
6. Belt guard.
7. Engine air filter.
8. Fuel pump.
9. Fuel tank.
10. Muffler.
11. Nameplate.

FIGURE 9940–89.

free from foreign material and to make sure that there are no obstructions in the engine shrouding or air intake grill to hamper air circulation. This is essential when using the unit under hot-weather conditions.

3. **Lubrication.** An important consideration in the maintenance of the compressor in satisfactory condition is lubrication. In starting the compressor after storage the oil in the unit should be drained and oil of proper viscosity for the prevailing climatic conditions should be placed in the engine and compressor. During the time that the unit is in use the quantity of oil in the crankcase should be kept at the "Full" mark on the dip stick. If necessary, the oil supply in the engine and compressor should be checked daily and replenished as required. However, overfilling should be avoided as it may permit the connecting rods to dip into the oil supply, thus splashing an excessive quantity of oil on the cylinder walls, causing smoking, oil pumping, and excessive carbon deposits. All oil containers and funnels should be kept clean and well-covered when not in use. It is essential that oil pans be drained and refilled with new oil regularly, since oil gradually accumulates small particles of dust, grit, metal, etc., that will cause unnecessary wear. The oil pans should only be drained when oil is hot.

9940.639. OPERATING PRECAUTIONS

1. In addition to the above general maintenance problems, there are a number of precautions that should be taken while using the compressor units. When the compressor is in use, personnel should be assigned whose duties are concerned primarily with the maintenance of the compressor in satisfactory operating condition. The personnel assigned to the compressor should be responsible for removing the unit from storage and preparing the unit for use–removing protective covers, seals, adding proper lubrication, gasoline, cooler, starting unit, ensuring there is no contamination of breathing air, the unit is running smoothly, etc. Any indication that the unit is not running smoothly or gives any evidence of failure should be reported immediately to the diving officer, and the diver

brought to the surface in the prescribed manner. The compressor should be run until it is warmed up and running smoothly before any attempt is made to put a diver over the side.

2. The compressor should never be operated in an unventilated room. However, when it is necessary to operate a unit indoors, a pipe should be run from the engine exhaust to the outside atmosphere. Whether the unit is operated indoors or outside, it should never be covered so that the engine exhaust fumes are thrown onto the compressor intake. The compressors are equipped with lashing rings or posts for securing the compressor in position. While the units will operate satisfactorily when tipped 15° in any direction, it is preferable that the unit be operated on a horizontal plane whenever possible.

9940.640. STOWAGE MAINTENANCE

1. Since diving operations are not conducted continuously but rather at intervals, resulting in the equipment sometimes standing idle for long periods of time, the problem of stowage maintenance must be given careful consideration. In preparing the compressor for stowage it should be stored in a dry, protected place. If the unit is to be stored for a period of 30 days or more, the following general precautions should be taken.

2. The engine and compressor crankcases should be drained and refilled with a light engine oil plus an antirust preventative. Allow the engine to run for a few minutes to permit the oil to reach all passages. As gasoline contains gums which separate and adhere to the various valves and passages which result in serious trouble, the entire fuel system should be drained. Remove spark plugs and pour a few ounces of antirust oil into each cylinder. The engine should then be turned over a few times with the crank to work oil down around the piston rings. Every entrance to the unit—exhaust pipes, cylinder head, breather, oil filler, carburetor, oil filters—should be sealed carefully to prevent entrance of moisture. In the case of the water-cooled compressor, the cooling system should be drained, flushed, and refilled with fresh, clean, soft water and antifreeze if required.

3. When removing the unit from storage, the protective seals covering all entrances should be removed, the fuel tank filled, proper lubrication should be added, etc. The compressor should then be started and run a sufficient length of time to ensure that it is operating normally before any attempt is made to undertake diving operations.

9940.641. INSTRUCTION BOOKS

Each compressor unit is furnished with a complete instruction book containing information on the operation, maintenance, stowage, and parts list of the engine, compressor, and accessories. The instruction book should be retained with the unit at all times, and personnel using the diver's air compressor should be completely familiar with the information in the instruction books.

9940.642. LIGHTWEIGHT AIR COMPRESSOR

1. The lightweight diver's air compressor fig. 9940–90 is intended for use by the many activities whose duties are not primarily concerned with diving but who may be called upon to undertake minor diving operations at infrequent intervals. This type of compressor is furnished generally to auxiliary vessels, landing craft, patrol craft, combatant vessels, and other miscellaneous vessels for undertaking minor diving jobs such as inspection, searching, and clearing lines. In addition, the lightweight compressor is issued as supplementary equipment to repair ships, tenders, salvage vessels, and for use when called upon to do minor diving jobs away from the vessel. It is important that it be clearly understood that the lightweight air compressor cannot be used as a substitute for the heavy-duty diver's air compressors. The lightweight compressor should be used only on diving jobs where the diver can make a direct ascent to the surface in the event the compressor fails. The compressor should not be used for diving to greater depths than 130 feet, and the maximum length of time that the diver spends in the water shall be such that no decompression will be required.

2. As the lightweight compressor is furnished to activities that will undertake very limited diving operations, the equipment will be subject to long periods of storage. It is, therefore, important that the compressor be prepared properly for storage. Prior to storage the water should be removed from the air receiver by running the compressor, with all outlets closed to build up the maximum allowable pressure and then opening the draincock in the bottom of the receiver. Gasoline should be drained from the tank and the engine run until it stops. Remove spark plug, and spray into the cylinder head and block sufficient rust additive to cover the cylinder walls and valve surfaces. The engine should be drained of oil when hot and refilled with a light engine oil plus an antirust additive. When the engine is to be used, the light oil should be drained and oil of proper viscosity, depending on temperature conditions, should be added. All exposed parts should be thoroughly dry before storage. If the compressor and engine have been exposed to salt water or spray, wash down with fresh water. Check all connections for tightness and seal every entrance to the unit to prevent moisture from entering. Cover frame with canvas and stow in a dry place. If the unit is stowed for more than 1 month, the compressor should be run and the above process should be repeated at the end of each 30 days.

3.-Each compressor unit is furnished with a complete instuction book containing information on the operation, maintenance, stowage, and parts list of the engine, compressor, and accessories. The instruction book should be retained with the unit at all times, and personnel using the diver's air compressor should be completely familiar with the information in the instruction books.

9940.643. AUXILIARY AIR SUPPLY IN CASE OF COMPRESSOR FAILURE

1. To provide the greatest possible degree of safety, provision should be made to furnish air to the divers from an auxiliary air supply in the event the compressor fails. The following standby arrangements should be made:

a. Vessels having a shipboard supply of air should arrange suitable outlets with necessary valves and filters so that a line can be run to the manifold on the diver's air compressor during diving operations.

b. Vessels that do not have a shipboard air supply should use a compressed air flash as a standby.

2. Any information contained in the compressor manufacturers' catalogs as to the depth to which the compressor can furnish air that conflicts with the instructions in this manual should be disregarded if a deeper depth is indicated.

9940.644. DURATION OF SUPPLY FROM AIR FLASK

1. The duration air supply from the air flask may be calulated according to the following formula:

$$\frac{CN\ (A-(15+E+1))}{4.5D(E+1)} = \text{Number of minutes on the bottom.}$$

C = Capacity of one air flask in cubic feet of free air.

N = Number of flasks.

A = Gage pressure in atmospheres of air in flask (psi) divided by 14.7).

E = Gage pressure in atmospheres to which dive is to be made (depth in feet divided by 33).

D = Number of divers.

2. In this formula, the "1" in the numerator is one air flask atmosphere which is allowed for charging the volume tank, air hose, and helmet. "A" and "E" are each added to 1 to convert them to absolute values.–15" is the 15 atmospheres constituting the 220 psi pressure which has to be preserved in the flask as a minimum reserve. In the denominator, the 4.5 is the cubic feet of air required by each diver per minute measured at absolute pressure, and the "1" is the 1 atmosphere of pressure which has to be added to the pressure at which the dive is made to obtain the absolute pressure. One air flask is held in reserve and should not be considered as available except in an emergency.

Example: Two divers are to descend to a depth of 165 feet. Determine the total time of the dive if air is furnished from four 8-cubic-foot air flasks charged to a pressure of 3,000 psi.

C = 8.

A = 204.

$E = \frac{165}{33}$ or 5.

D = 2.

N = 3 (the fourth flask held in reserve).

Calculation:

$$\frac{8 \times 3\ (205-(15+5 \times 1))}{4.5 \times 2 \times (5+1)} = 81 \text{ minutes on the bottom.}$$

3. When calculating how long the air flask will last, it is important that the time for decompression be considered. In the above illustration, if it were decided to use the 70-minute table, it would require 2,786 cubic feet of free air to decompress two divers.

	Cubic feet
3 minutes to reach bottom (average depth of 83 feet)	63
50-foot stop for 8 minutes	91
40-foot stop for 17 minutes	169
30-foot stop for 19 minutes	163
20-foot stop for 51 minutes	369
10-foot stop for 86 minutes	505
Time between stops 3 minutes at average depth of 83 feet	48
Required air per diver	1,393
Required air for 2 divers	2,786

This would exceed the volume of the reserve flask (assuming that it was entirely consumed) by 2,786 – 8 × 205= 1,146 cubic feet which must be obtained from the other three clyinders. This in turn would reduce the time that the divers can stay on the bottom as follows:

The total quantity of free air in the three cylinders is: CN((A + 1)–(15 + 5 + 2))= 8x183= 4,392.

The length of time the divers can stay on the bottom is equal to:

$$\frac{(4{,}392-1{,}146) \times 81}{4{,}392} = 60 \text{ minutes.}$$

This is the maximum time that two divers can stay at 165 feet and still have an adequate amount of air for decompression.

4. To maintain the CO_2 content within safe limits, it may not be necessary to furnish 4.5 cubic feet per minute during decompression (measured at the absolute pressure of the dive) as the diver's physical activity will be at a minimum. However, in computing the length of time that a flask will last the 4.5 cubic feet figure should be used. This inserts a safety factor in favor of the diver.

9940.645. LOW-PRESSURE ACCUMULATORS

Air for diving can be furnished using high- and low-pressure accumulators. The air pressure in low-pressure accumulators is maintained constant by large capacity low-pressure, steam or electrically driven, automatically controlled air compressors. The capacity of these compressors is such that there is never a question of shortage of air supply. The maximum depth to which a diver or divers may descend will depend upon the pressure of the air supply and the amount of air that is required to pass through the diver's helmet. When using this source of supply, the means of knowing whether adequate ventilation exists is by the diver's own feeling of well-being and by observing the accumulator air pressure.

9940.646. HIGH-PRESSURE ACCUMULATORS

By high-pressure accumulators, reference is made to the air accumulators of the torpedo installation aboard vessels equipped with air-driven torpedoes. When connections are made to accumulators, diving operations should be conducted directly from or in the immediate vicinity of the vessel carrying the accumulators, thus obviating the necessity for use of long lengths of air hose. If the accumulators are of sufficient capacity, diving may be undertaken from those already fully charged, but if they are not of sufficient capacity to meet the requirements of depth and duration of the dive without recharging, then the compressor shall be operated as necessary.

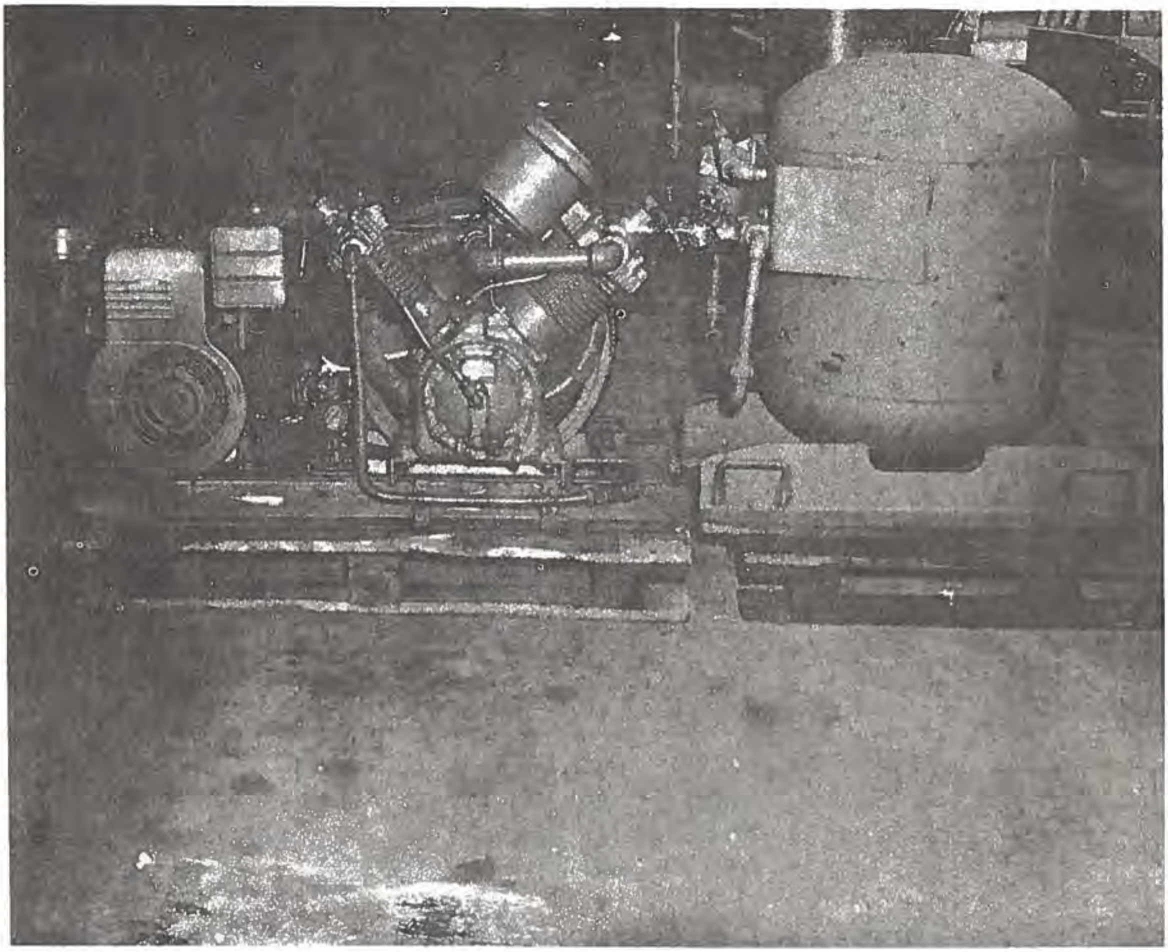


FIGURE 9940–90.

9940.647. CAPACITY OF AIR COMPRESSOR AND ACCUMULATORS

1. The capacity of the air compressor and the accumulators must be known and taken into consideration when calculating the air supply. For example, the capacity of a compressor is 15 cubic feet per hour at 2, 500 psi or 0.25 cubic foot per minute at 2,500 psi. As 2,500 psi would equal $\frac{2500}{14.7}$ or 170 atmospheres, (gage) or 171 atmospheres (absolute) 0.25 cubic foot per minute at 2,500 psi pressure would equal 171 × 0.25 or 42.75 cubic feet per minute at atmospheric pressure. Therefore, since a diver must have an air supply of 4.5 cubic feet per minute at a pressure equal to the absolute pressure at which the dive is made, a dive by one diver to, say, 274 feet, or 8.3 atmospheres, excess pressure (9.3 atmospheres absolute) would require 4.5 × 9.3 or 41.85 cubic feet of air per minute at atmospheric pressure. From this, it is evident that this power-driven compressor working at full capacity would just be able to furnish this supply of air. Under no circumstances, however, should divers be permitted to dive to the capacity limit of their air supply, whatever the source utilized may be.

2. Also, sufficient air must be held in reserve to enable the dispatch of a relief diver. The capacity of the air accumulators aboard may be augmented by connecting them to the torpedo air flasks that have their stop valves open, and taking the air lead from this connection. When charging high-pressure accumulators, it must be remembered that the air is heated by the compressor's cylinders; hence, castor oil should be used to prevent flashing in the cylinders and thus preventing CO and CO_2 production; or, if not available, use Navy symbol 2190T or equal. For this and other reasons, as little oil as possible should be used in the cylinders. Likewise, the air intakes of any compressors used for supplying diver's air must be located in atmosphere that is free from obnoxious or toxic fumes.

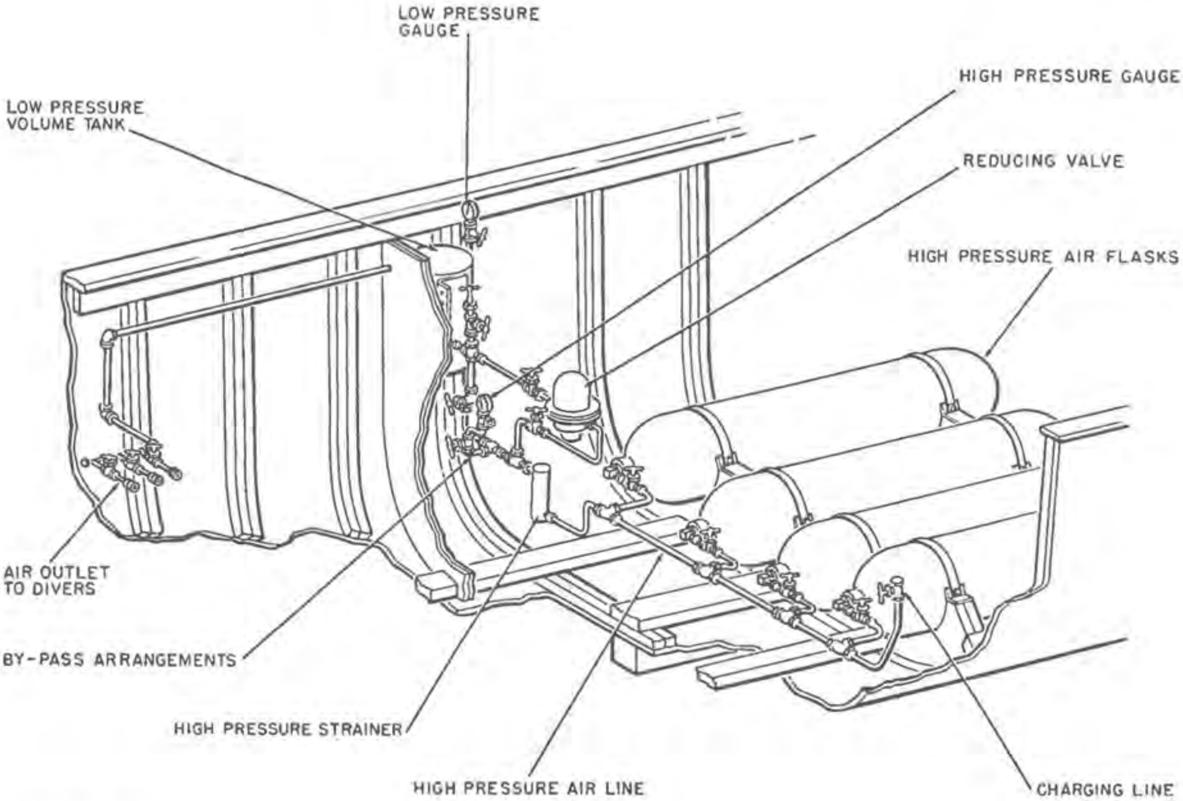


FIGURE 9940–91.

9940.648. OPERATION WITH TORPEDO OR AIR FLASKS

1. When diving operations are to be conducted from a vessel carrying torpedo or air flasks, a very satisfactory and convenient air system can be obtained by connecting three or more air flasks together. A typical air-flask installation is shown on fig. 9940–91. This arrangement consists essentially of four 8-cubic-foot, high-pressure air flasks, connected by copper tubing to a high-pressure strainer, then to a pressure-reducing valve, to a 1-cubic-foot volume tank, and then to the diver's manifold. A high-pressure gage should be located on the high-pressure side of the reducing valve and a low-pressure gage should be connected to the volume tank. A complete detailed description and bill of materials is contained in BuShips Plan 19738–S4904–298223 Alt. 1.

2. When diving with compressed air from torpedo or air flasks, at least one flask shall be open and left open during the time the helmet is being worn by the diver. The diver's air supply shall be taken from the volume tank, and the pressure of the air therein shall be prescribed by the officer in charge.

3. When diving at a depth over 120 feet from a small boat and using torpedo air flasks, a relief diving boat shall be equipped fully and kept ready for emergency use. Also, not more than two divers shall be permitted to dive from the same boat. When the diver's air is supplied from torpedo air flasks, at least three or more flasks must be connected, ready for use, and **one flask shall be held in reserve.** The pressure in the working flasks, as indicated on the high-pressure gage, shall not be permitted to fall below 220 psi in excess of that at which the divers are working while on the bottom. If the gage pressure in the last flasks (excluding the one held in reserve) approaches 220 psi, the divers shall be brought up. After they are clear of the bottom and safely on their way toward the surface, the reserve flask may be used. An exception of this rule will be permitted if there is available an additional independent air supply which can be connected immediately to the diving air manifold.

9940.649. DIVING OPERATIONS FROM A VESSEL

1. When diving operations are to be conducted from a vessel, using the vessel itself as a diving platform, the necessary air connections should be made and precautions taken to ensure a continuous and adequate quantity of air of desired purity. In the case of the submarine rescue vessel, diving operations are conducted directly from the vessel, and a compressed-air system is made an integral part of the vessel. A typical air system consists of:

a. Diver's air supply consists of two compressors capable of supplying approximately 150 cubic feet of air per minute at a pressure of 400 psi.

b. Salvage air supply consisting of a dual set of low-pressure compressors capable of supplying air at 200 psi.

c. High-pressure air compressors capable of supplying air at 3,000 psi.

d. High-pressure air banks containing air at approximately 3,000 psi.

2. The operation of the air system is an important part of the diving, rescue, and salvage routine. An officer should be placed in charge of the plant, whose duties shall be to start the system and route the air as ordered by the officer in charge of diving operations. The officer in charge of the air system should stand a continuous watch, assisted by a chief petty officer, and ensure that desired temperature and pressure are maintained and reported to the officer in charge of diving operations. These should be maintained within specified limits except in emergencies. When diving, rescue, or salvage operations are in progress and air is being used for both diving and blowing purposes, it is necessary to safeguard the diver's air supply; therefore, orders shall be such that they will ensure against opening or closing any air valve without the knowledge of those supervising the diving. The plant officer should always inform the engineer officer when the operation of additional compressors is needed.

3. It is customary when diving is in progress to have one or both 400-pound compressors running on their governors, though air in sufficient quantity can be supplied by one. The reason for two compressors running is that, should one compressor fail, the other is available immediately to take up the load. The governors are set so that the compressor pumps against a certain pressure. If one should stop, the other can be speeded up immediately, thereby maintaining the air in the volume tank at the desired pressure. Further, with both machines on the air-supply line, the load is divided and the safety factor of each compressor is increased. The air ends of the compressor should be cleaned each night after diving has ceased. The valves should be removed, cleaned with soapy water, and wiped off with a castor-oiled rag. The high-pressure air banks should be kept charged to their maximum capacity as emergency diving air supply in event of failure of the air compressors. The banks are connected to the diver's air hose through a reducing valve that reduces the air to the desired pressure.

4. The diving air plants installed on the submarine rescue vessels have 400-pound compressors which permit reaching a low dew point and give a greater volume of air gained through expansion down to 300, 200, or 100 psi, as required. This system also has two after coolers. This complete circuit includes the volume tank, heaters, and coolers.

5. Since the relative humidity at no time is sufficiently low to ensure the delivery of air from the compressors at less than 100 percent humidity, the relative humidity of the atmospheric air is not a determining factor in regulating the dew point of the air supplied to the divers. The relative humidity of the atmospheric air is, however, a gage of the amount of moisture in the air which has to be extracted during the reconditioning process, and serves as a means of regulating the interval of blowing down the coolers. When the relative humidity is from 50 to 70 percent, the coolers should be blown every 15 or 20 minutes; if from 70 to 80 percent, they should be blown every 15 minutes; and if it is 80 to 100 percent, they should be blown every 10 minutes.

9940.650 DEHYDRATION OF AIR SUPPLY

1. To apply this system intelligently, it is necessary to know how to use a table called "Dew point temperature curve" (fig. 9940–92), and have a knowledge of the following definitions:

a. **Dew point** is that temperature at which air is saturated and below which precipitation of moisture occurs. It varies with the humidity of the atmosphere.

b. **Absolute humidity** is the mass of water vapor present in the atmosphere, usually grains per cubic foot.

c. **Relative humidity** is the ratio between the amount of water vapor as determined by the existing dew point and the amount that would be present if the dew point corresponded to the wet and dry bulb readings. When air is saturated, the dew point, wet bulb, and dry bulb readings are all the same.

2. An inspection of the dew point temperature chart (fig. 9940–92) will show, by comparison of the column marked "Temp" with the figures set opposite the various temperatures, that a change in temperature causes a change in humidity; e. g., saturated air at 40° F. contains 2.849 grains of water vapor per cubic foot, whereas at 30° F. it contains 1.935 grains; therefore, cooling will cause precipitation.

3. The amount of percentage of dehydration that it is possible to produce by a reduction of dew point depends entirely on the temperature it is possible to attain by the air-cooling systems of the plant. In this case having produced a reduction of 10°; i. e., 40° F. with 2.849 grains of water vapor to 30° F. with 1.935 grains water vapor, the difference of 0.914 grain per cubic foot of air would be precipitated in the form of water which at a temperature of 30° F. would form slush ice, and could be discharged from the cooler through the blow valve. The air will not be 100 percent saturated for the new temperature; i. e., 30° F., and a further drop in temperature will cause further precipitation.

4. As the cooling agent consists of the circulation of sea water through the cooler, it is obvious that the degree of dehydration possible by cooling depends entirely on the temperature of the sea water. In this case 30° F. would be called the dew point temperature since the air is saturated. However, a further reduction of the dew point may be brought about by expansion as follows: 34° F. (table 138 of fig. 9940–92) contains 2.279 grains of water vapor per cubic foot. Initial pressure of air from the compressors at 150 psi (gage) or 164.7 psi (absolute) and the reducing valve to be set at 100 psi (gage), or 114.7 psi (absolute), the air passes through the cooler. The reduction in pressure from 150 psi to 100 psi has, in ac-

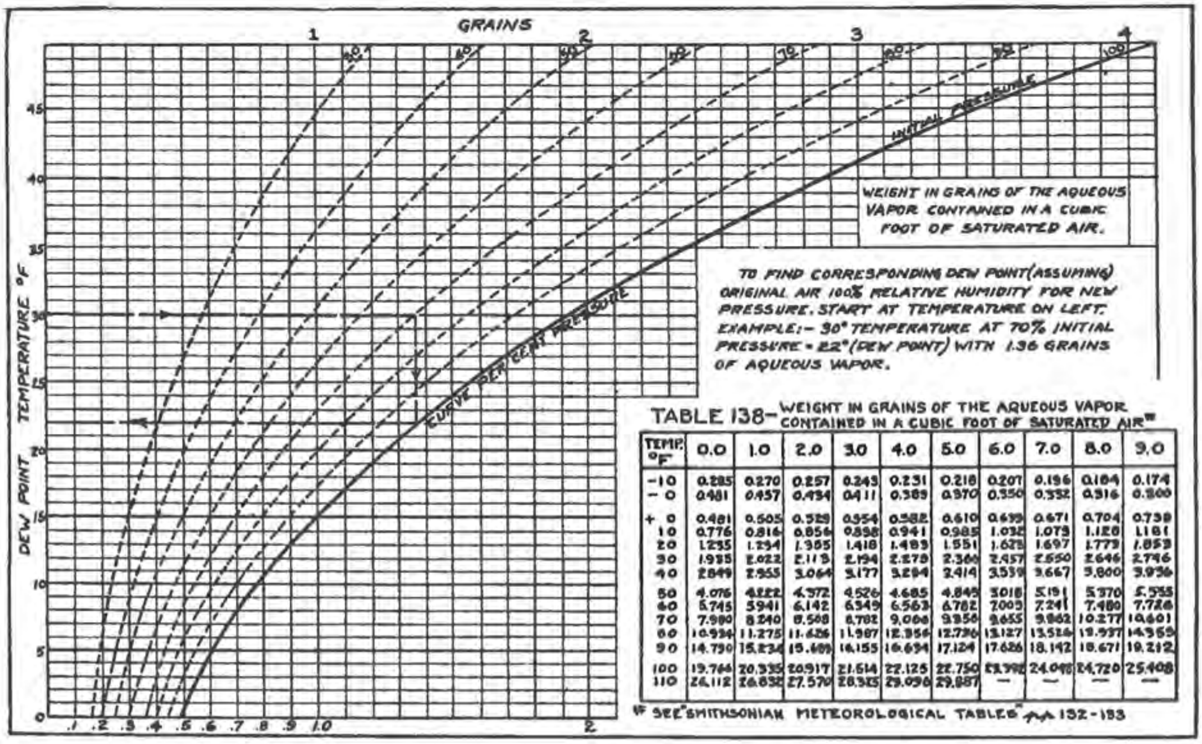


TABLE 138—WEIGHT IN GRAINS OF THE AQUEOUS VAPOR CONTAINED IN A CUBIC FOOT OF SATURATED AIR*

TEMP. °F	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
−10	0.285	0.270	0.257	0.243	0.231	0.218	0.207	0.196	0.184	0.174
−0	0.481	0.457	0.434	0.411	0.389	0.370	0.350	0.332	0.316	0.300
+0	0.481	0.505	0.529	0.554	0.582	0.610	0.639	0.671	0.704	0.739
10	0.776	0.816	0.856	0.898	0.941	0.985	1.032	1.079	1.128	1.181
20	1.235	1.294	1.355	1.418	1.483	1.551	1.623	1.697	1.773	1.853
30	1.935	2.022	2.113	2.194	2.279	2.366	2.457	2.550	2.646	2.746
40	2.849	2.955	3.064	3.177	3.294	3.414	3.539	3.667	3.800	3.936
50	4.076	4.222	4.372	4.526	4.685	4.849	5.018	5.191	5.370	5.555
60	5.745	5.941	6.142	6.349	6.563	6.782	7.009	7.241	7.480	7.726
70	7.980	8.240	8.508	8.782	9.066	9.356	9.655	9.962	10.277	10.601
80	10.934	11.275	11.626	11.987	12.356	12.736	13.127	13.526	13.937	14.359
90	14.790	15.234	15.689	16.155	16.634	17.124	17.626	18.142	18.671	19.212
100	19.766	20.335	20.917	21.514	22.125	22.750	23.392	24.048	24.720	25.408
110	26.112	26.832	27.570	28.325	29.096	29.887	—	—	—	—

* SEE "SMITHSONIAN METEOROLOGICAL TABLES" pp 132-133

FIGURE 9940–92.

cordance with Boyle's law, reduced the density of the air to approximately 70 percent. Therefore, the air, instead of having 2.279 grains, of water vapor, now contains only 70 percent of 2.279 grains, or 1.595 grains of water vapor. Thus, we have reduced the dew point to 25.5° F. by a reduction in pressure. Hence, the diver's air at temperatures about 25.5° F. would not precipitate moisture and no freezing could occur.

5. To use the curves, fig. 9940–92, run a line from the dew point temperature scale to the percent pressure scale. From this intersection drop a perpendicular line to the initial pressure curve, and from this point run a line to the dew point scale. Using the dew point as indicated on this scale, the grains of water vapor will be found by reference to the inserted table. Otherwise, the perpendicular line between the percent pressure and initial pressure curves can be extended to the base and the figure for aqueous vapor determined by interpolation.

6. From service tests of the air-conditioning plants on submarine rescue vessels, it never has been found necessary to reduce the aqueous vapor below 1.355 grains. Since air that is dehydrated completely would probably be injurious to the diver, the dew point should not be lowered beyond that necessary to prevent freezing of the diver's air line.

7. In addition to the expansion caused by the main reducing valve, there is a further expansion at the diver's air-control valve. Hence, without the reducing valve, the air pressure at the diver's air-control valve that allows a drop in pressure of 15 psi would be reduced from approximately 45 psi (gage). With the reducing valve in operation and set for 85 psi, the expansion may be from 85 to 45 psi, thus the orginal factor of 3 to 1 is lowered to a new ratio of 2 to 1.

8. With the air-conditioning plant in operation, it has been found possible to maintain desired air temperatures by the use of bleeders. These are short lengths of hose, one to three in number, connected to outlets on the diving mains on the opposite side from which diving is being conducted, and are weighted a few feet below the surface of the water to eliminate noise. To raise the temperature in the diving air mains, it is necessary only to increase the flow of air by opening bleeders as much as necessary; to decrease the temperature in the diving air mains, decrease the flow of air and cut out the bleeders. The following is a list of the title heads of a record that should be kept of the temperatures of the air during the use of the air-conditioning plant:

Air temperatures.
Water at surface.
Water one-half way down.
Water at bottom.
Water to cooler.
Water from cooler.
Air line – port.
Air lines – starboard.
Diver's air hose from star-

Humidity.
Air to cooler.
Air from cooler.
board side.
Bleeders from port side.

9940.651. PRECAUTIONS IN SUPPLYING AIR

The following is a summary of the safety precautions that should be taken to ensure proper operation of the diver's air system.

1. **Heavy-duty compressor.**

a. Personnel should be assigned to maintain the compressor in first-class operating condition.

b. The proper grade and correct quantity of oil should be added to the engine and compressor.

c. Water and antifreeze, as necessary, should be added to water-cooled engines and, in the case of air-cooled engines, the cooling fins must be kept free from foreign matter.

d. All filters, cleaners, and separators should be kept clean.

e. Make certain that the engine exhaust fumes are not permitted to enter the compressor intake.

f. Service the engine and compressor regularly in accordance with the manufacturers' instruction manuals.

g. Ensure that the engine and compressor are warmed up and running smoothly before a diver is put over the side. Any indication that the unit is not operating in a completely satisfactory manner should be reported immediately to the officer in charge of diving operations.

h. When the unit is stored, it should be removed every 30 days and operated. It should be prepared again for storage in the same manner as if the unit had been used for some time.

2. **Lightweight divers' air compressor.** In the case of the lightweight divers' air compressor, the following precautions should be taken in addition to those listed above for the heavy-duty compressor:

a. The lightweight compressor should be used only where it is possible for the diver to make a direct ascent to the surface.

b. Compressor bearings should be inspected every 30 hours.

3. **Torpedo air flasks.**

a. One flask should be held in reserve.

b. Sufficient air should be maintained for adequate decompression.

c. Valves, gages, fittings, separators, and reducers should be checked and in satisfactory condition before diving is undertaken.

d. If diving is to be done in excess of 120 feet, a fully equipped boat should be available as a standby.

4. **When diving from a vessel.**

a. The necessary air connections should be made to ensure continuous air supply and to prevent air from being accidentally diverted or shut off.

b. An officer should be placed in charge of the air plant, whose duties shall be to control the air to the divers.

c. A standby air supply in the form of a second compressor or air flasks should be available in the event the primary air source fails.

5. Regardless of the type of air supply used, the following conditions are essential:

a. The temperature of the air should be such as not to cause discomfort to the diver.

b. The air must be free from noxious fumes and as near standard purity as possible. (In utilizing air from high-pressure accumulators, the air in the cylinders of the compressors is greatly heated in charging the accumulators, and oil with a high flash point should be used, castor oil if possible.)

c. Whenever possible, it is desirable to maintain 50 psi pressure in the line over the water pressure (at the depth of dive).

d. The reserve air supply should be maintained in case of failure of the air supply.

E. Recompression Chamber

9940.671. NEED FOR RECOMPRESSION CHAMBER

One of the greatest dangers and inconveniences connected with diving is that of decompression. Under ordinary conditions the diver, after having spent a certain length of time on the bottom, will be safely brought to the surface in accordance with the standard decompression tables, with the minimum of inconveniences. However, there are occasions, particularly in deep dives and relatively shallow dives of long exposure, where conditions such as heavy tideway, cold, heavy seas, or other emergencies prevent giving adequate decompression on the way to surface. In addition, there are the special cases where the diver, even though decompressed in the prescribed manner, will be subject to the "bends." To provide for these special cases, recompression chambers are furnished to those activities that will be doing either very deep diving or a large amount of relatively shallow diving or both, such as submarine rescue vessels, submarine tenders, salvage vessels, and others as authorized by the Bureau of Ships.

9940.672. TYPES OF RECOMPRESSION CHAMBER

There are two, common types of recompression chambers. One is a two-lock chamber having a working pressure of 200 psi. The other is a one-lock chamber having a working pressure of 100 psi.

1. The recompression chamber shown in fig. 9940–93 has two locks – the inner lock and outer lock. When it is necessary to recompress for treatment of caisson disease or for surface recompression, the diver is placed in the inner lock and pressure is built up to the desired point. In the event it is necessary for personnel to enter or leave the inner lock, the pressure is built up in the outer lock until the pressures in the two locks are in equilibrium at which time the inner chamber door can be opened. Decompression of the attendants leaving the inner lock will be accomplished in the outer lock, depending on the length of time

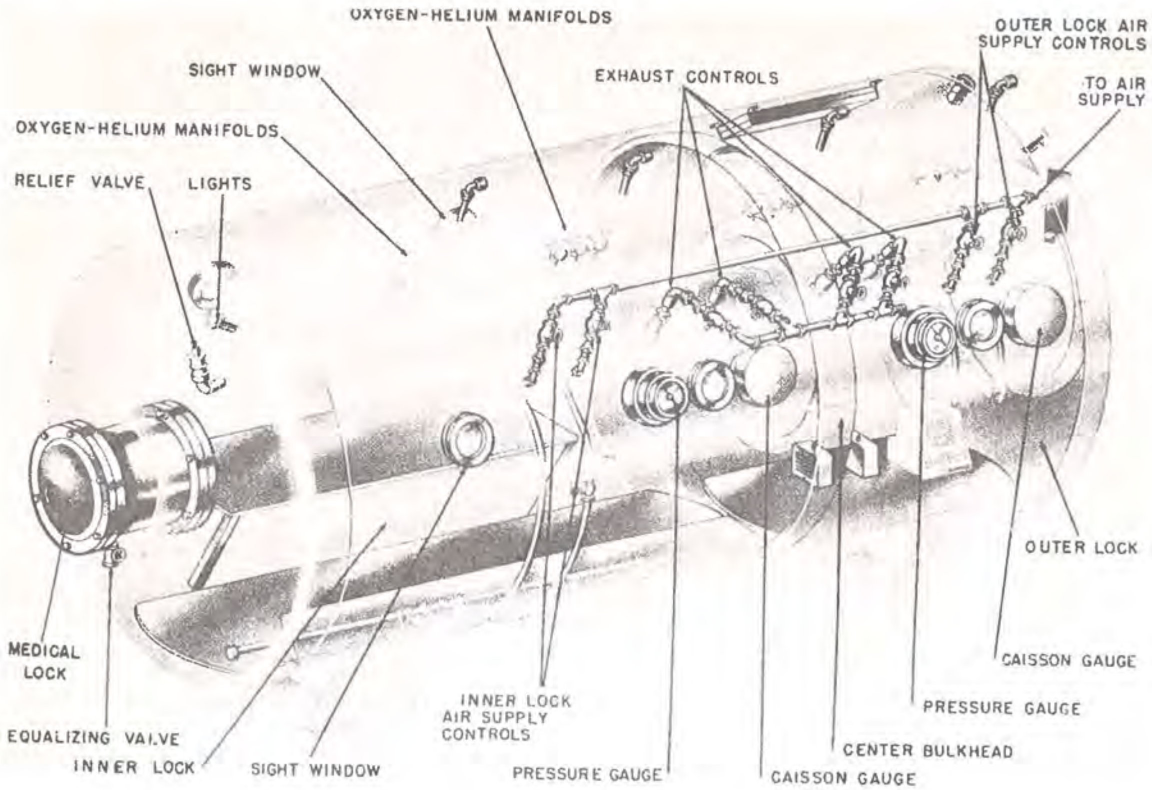


FIGURE 9940–93.

attendant has been under pressure. In addition, there is a small medical lock, with the necessary valves for equalization of pressure, to permit small articles such as food, water, and medicines to be sent into or removed from the inner lock. This large recompression chamber has a total volume of about 500 cubic feet–inner lock 370 cubic feet, outer lock 130 cubic feet. In general, this type of chamber is furnished to activities that are called upon to dive to extreme depths and where resultant cases of compressed air illness are apt to involve complications necessitating not only long recompression but the assistance of medical personnel. In general, the two-lock chambers are furnished to submarine rescue vessels and submarine tenders.

2. The other recompression chamber is similar to the two-lock chamber with the exception that it has a working pressure of only 100 psi and only one lock. In the event it is necessary for attendants to be in the chamber, they should enter the chamber with the diver and remain there until decompression is completed. The small chamber however, is equipped with a medical lock which can be used for passing small articles in or out of the chamber. In general, the one-lock chamber is furnished to activities doing a considerable amount of diving at relatively shallow depths and where cases of compressed air illness are not likely to involve any serious medical complications. The one-lock chamber has a volume of approximately 250 cubic feet.

9940.673. AIR SUPPLY FOR RECOMPRESSION CHAMBER

1. The use of a recompression chamber imposes a heavy drain on the air supply. To charge the two-lock chamber to its maximum working pressure of 200 psi would require 6,800 cubic feet of air at atmospheric pressure:

$$\frac{200}{14.7} = 13.6 \text{ atmos.}$$

$$13.6 \times 500 = 6{,}800 \text{ cubic feet of air.}$$

2. To charge the one-lock chamber to its maximum working pressure of 100 psi, would require 1,700 cubic feet of air at atmospheric pressure.

3. For safety, the chamber should be ventilated continuously during use. This is necessary to keep down the CO_2 and oxygen concentration. It is particularly important during the periods that pure oxygen is being supplied. The oxygen from the mask is exhausted into the chamber, resulting in a higher oxygen percentage. To keep the concentration down, there should be a change of air approximately every 10 minutes. The deepest stop on oxygen is at 60 feet. This is approximately 3 atmospheres absolute which is equivalent to chamber volume of 1,500 cubic feet.

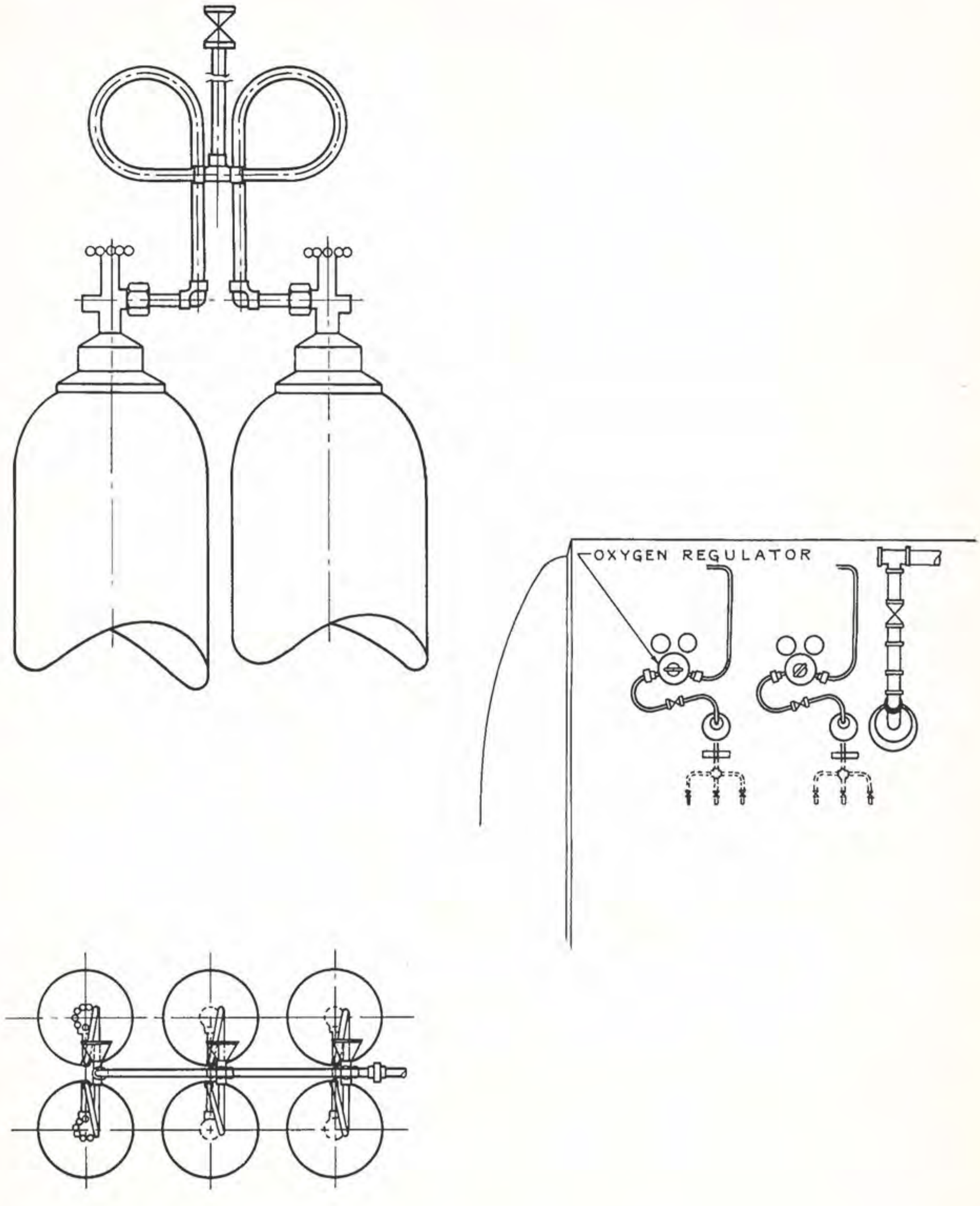


FIGURE 9940–94.

This would be a load of 150 cubic feet per minute for the two-lock chamber. For ventilation at greater depths on air, a 50-60 cfm compressor will provide adequate ventilation. The air supply must be pure, free from engine exhaust or oil fumes, and as cool and dry as possible.

4. The piping is arranged so that the air flow can be controlled from inside or outside the chamber. One supply and one exhaust line is fitted with a single valve located on the outside of the chamber for control by the tenders. The other supply and exhcust lines have double valves, one on the inside and the other on the outside, so that the rate of descent and ascent can be regulated by the patient or his attendant subject to final control by outside tenders.

5. In addition to the piping for the regular air supply, there are two couplings in each lock of the large chamber that lead to a three-outlet manifold on the inside of the chamber for connecting flasks of oxygen or oxygen-helium mixtures. Inhalators through which these breathing mixtures are administered to the diver are attached by rubber tubing to the manifold on the inside of the chamber. In general, it is advisable to have two inhalators connected to each manifold. Figure 9940–94 illustrates a typical arrangement of oxygen and helium-oxygen flasks.

6. To determine the pressure being built up in the chamber, caisson gages reading in pounds per square inch with corresponding foot graduations are placed inside the chamber. In some larger shore installations where extra precise readings are desired, a mercury manometer with absolute depth calibration may also be connected to the main or inner lock.

9940.674. PRECAUTIONS IN USE OF CHAMBER

1. The chamber itself must be kept in an optimum state of repair subjected to periodic test (see fig. 9940–95). Periodic training runs should be made to assure proper operation and readiness of the chamber and all its accessory equipment as well as to keep personnel familiar with its use. Appropriate periodic checks and preventive maintenance routines should be applied to the air supply, oxygen and helium-oxygen systems, and the communication and electrical equipment. The chamber must never be used for stowage of gear, as a locker, or for sleeping quarters.

2. Certain features of operation deserve special comment:

a. Unless doors are sprung or gaskets improperly fitted, only enough force to make an initial seal is required on hatch dogs. As pressure builds up in the chamber, the seal automatically becomes tighter and tighter. Dogs should be released routinely as soon as pressure is adequate to hold. They should be rechecked before pressure is reduced to make sure they have been released.

b. **Explosive fire** is the most serious danger in operation of a recompression chamber. The danger is ever present and is increased at pressure and when pure oxygen enters the chamber in the course of oxygen breathing in treatment. In both cases, the effect concentration (partial pressure) of oxygen is increased. To reduce the possibility of fire, take the following precautions:

(1) Replace all wooden deck grantings, benches, shelving, etc., with metal or other fireproof material.

(2) Use only fire-retarding paint similar to that listed in the Federal Standard Stock Catalog (GF 8010–290–2875) and keep painting to the absolute minimum—one coat preservative and one white coat. If is not known that the chamber has been painted in this manner, remove all old paint and repaint as indicated. Assure that thorough drying of paint and removal of all volatile vapors by ventilation is accomplished before using the chamber.

(3) Keep the interior of the chamber free of all dirt and refuse and of any oily deposits or volatile materials of any kind. If for any reason flammable liquids such as ether, alcohol, gasoline, or volatile oils, or their vapors, have been present, thorough ventilation must precede use of the chamber. No oils should be in or on high pressure lines or apparatus of the oxygen-breathing installation. Allow no oils or volatile materials to collect or soak into any absorbent material in the chamber or in the well under the deck plates. All air filters and accumulators in lines leading to the chamber must be cleaned regularly to keep oil and vapors from being carried in.

(4) If a mattress is used, be sure it is covered by fire-resistant sheeting on all sides. Keep blankets and other bedding to the minimum required for the patient's comfort. Do not use wool or synthetic fiber blankets because of the possibility of sparks from static electricity. Flame-proof bedding material can be obtained from the Naval Supply Center, Oakland, or the Naval Supply Depot, Bayonne, under Stock No. GF–7210–243–8863 or GF–7210–243–8864. Clothing worn by personnel in the chamber must be free from grease or oil.

(5) No open flames, matches, cigarette lighters, lighted cigarettes, cigars, or pipes are to be taken in or used in the chamber at any time.

(6) When oxygen is being used, the chamber must be ventilated **at least** to the extent specified in table 1–22. Have water and sand buckets on hand in the chamber during use of oxygen. (CO_2 or carbon tetrachloride fire extinguishers must never be used!)

(7) Use no electrical appliance of any kind (other than lights) in the chamber during oxygen-breathing. Ventilate thoroughly following oxygen breathing before any appliance is turned on.

(8) Post a warning like that in fig. 9940–95 prominently inside and outside of the chamber.

(9) If the above precautions are taken, the possibility of fire within the chamber will be reduced to an absolute minimum.

F. Boats and Floats

9940.681. USE OF SMALL CRAFT FOR DIVING PURPOSES

While the diving equipment and diving personnel are generally assigned to tenders, repair ships, salvage vessels, etc., there are a great many diving operations where it is not feasible to dive directly from the deck of the vessel, or the work may be inaccessible to a large vessel. In these cases the practice is to convert a motor launch or other small craft for diving purposes. Small boats are generally used where the diving jobs are of relatively short duration and are performed at different points over a wide area. In cases where a diving job entails perhaps months of diving in a small area, such as in harbor clearance work, it may be convenient to build a diving float.

9940.682. CONVERSION OF SMALL CRAFT FOR DIVING OPERATIONS

1. Many types of small craft are suitable for converting to a diving boat. However, before any attempt is made to rig a boat for diving, it should meet the following basic requirements:

a. Minimum overall length, 40 feet.
b. Minimum beam, 10 feet.
c. Freeboard, 3–5 feet.
d. Engine in good condition and hull seaworthy.

With these basic characteristics, the boat can be rigged for diving operations with ample space for a diving platform, storage of equipment, and for the diving crew.

2. The 50-foot motor launch which is carried by most large ships and tenders will be used to illustrate the method of conversion to a diving boat. Fig. 9940–96 and 9940–97 show a typical layout of a converted 50-footer and several other types of boats. To convert this type of boat for diving, it is necessary, first, to remove all thwarts to make enough space available for diving gear. A portable partial deck should be placed over the midship section to be used as a platform from which all diving operations are conducted. This deck should be flush with the gunwale so that the diver can step from the deck directly on to the ladder. The deck should be of sufficient size so that there will be enough room for two divers (one diver and one standby diver) and the tenders, plus the equipment to put the divers into the water. The deck must have sufficient railings to protect the diver and other diving personnel from being thrown overboard in rough water. Only personnel assisting the diver or his tender should be on the deck during the time that the diver is in the water.

Sufficient personnel should be detailed to man the launch independent of the men required to handle the diving gear. Before permitting the diving launch to leave the shore or immediate vicinity of the ship, the following equipment should be placed aboard:

Complete diving outfit.
Stadimeter.
Boat's diving anchor gear with extra anchor for bow and stern.
Jackknives.
Steel tape measure and 6-foot rule.
Boat's compass.
10-foot probe made of 1/4-inch pipe.
Hand flags for signaling.
Boat box.
Binoculars.
Long heaving line.
Several large shackles.
A coil of small stuff (marlins) for lashings.
A luff tackle.
Drinking water.
Diving logs.
Other special gear as necessary.
Bucket of soapy water if dress without gloves is used.
Blueprint or sketch of job.
Decompression tables.
First-aid equipment.
Standard boat lifesaving gear.

3. Air compressors should be well secured and away from the diving operations. Unless it is absolutely essential, the compressor should be operated in the open. In the event that it is necessary to operate the compressor below deck, as in a confined area, the intake and exhaust must be outboard.

4. If torpedo or high-pressure compressed air flasks are to be used in lieu of a compressor, the necessary fittings, chocks, etc., should be fitted so that at least four flasks can be stowed in a readily accessible location. Figure 9940–91 shows a sample air flask installation. This arrangement consists of four 8-cubic-foot high-pressure air flasks leading to a single 3/8-inch line; a 3/8-inch high-pressure strainer; an automatic reducing valve (3,000/100 psi) which can be bypassed in an emergency; a 1-cubic-foot volume tank; a 1¼-inch line leading to a 3-outlet manifold. There is a gage on the high-pressure side of the reducing valve and a low-pressure gage on the volume tank. There is 3/8-inch copper tubing with the necessary valves for charging the air flasks.

5. In the event that the motor launch is to be used for general duties, a rack can be made to hold the air flasks and auxiliary equipment which may be lowered or hoisted into the boat for emergency diving jobs. Another feature to make the boat complete for diving is to have either 2- or 4-point moorings with an anchor winch in the bow of the boat. The remainder of the diving equipment that is not being used can be stowed under the portable deck or in the chest in which the outfit was originally furnished.

9940.683. DIVING FLOATS

1. Diving floats are useful for training divers and for undertaking diving operations in a closed harbor or basin where the water is reasonably calm. Floats used for such purposes may vary in size, but it is quite convenient to have in service one which is large enough to hold a number of divers with a number of sets of diving gear, and on which a large enough deck house could be built so that all necessary diving equipment can be stored in it.

2. Figure 9940–98 shows a typical diving float used for training purposes. This float has a steel hull with watertight compartments, a wooden deck 60 by 45 feet at the center of which is located a deck house 24 by 18 feet which is used for a storeroom and a place to dress divers in cold weather. This float can accommodate a large number of student divers and is equipped with air winches and booms, phone booths, and electric flood lights for conducting training at night. The float is permanently secured alongside the pier, and receives all the necessary electric-

PRECAUTIONS IN USE OF RECOMPRESSION CHAMBER

PREPAREDNESS

The personnel and facilities of every Navy diving activity must be ready to treat decompression sickness or air embolism at a moment's notice at any time.

1. The chamber and its auxiliary equipment must be in working order and ready for use. Check the following:
   a. The chamber itself—free of extraneous gear, equipped and ready.
   b. The air supply—banks charged, compressor ready to operate.
   c. Communication gear—functioning properly.
   d. Oxygen installation—cylinders full, demand valves operative.
   e. Medical kit—stocked and at hand.

   Follow routine of periodic tests and preventive maintenance.
2. Personnel must be trained in operation of equipment and be able to do any job required in treatment; definite assignment of responsibilities is required.
   a. Hold periodic training runs with rotaton of personnel.
   b. Provide emergency bill listing jobs and duties.

GENERAL PRECAUTIONS IN USE

1. Avoid damage to doors and dogs. Use minimum force required in "dogging-down"; be sure dogs are released before pressure is reduced.
2. Provide ample chamber ventilation especially when oxygen is being used.
3. Assure accurate timekeeping and recording.
4. Keep tender with patient especially when breathing oxygen.
5. Assure proper decompression of all persons entering chamber.

PREVENTION OF FIRE

1. Remove all combustible materials and replace with metal or fireproof construction (deck gratings, benches, etc.).
2. Use only fire-retarding paint, keep painting to minimum.
3. Keep chamber clean and free from all oily deposits and volatile materials of any kind. Keep all air filters clean.
4. Ventilate thoroughly after painting or unavoidable presence of any inflammable substance.
5. Use no oil on any oxygen fitting or equipment.
6. Keep bedding and clothing to minimum. Be sure mattress, if used, is covered with fire-resistant material. Use flameproof bedding material. Be sure that clothing is free of grease and oil.
7. Locate all electrical switches outside chamber. Keep electrical system in perfect condition. Prohibit use of any electrical appliance in chamber during oxygen breathing.
8. Let no flame, matches, cigarette lighter, lighted cigarette, cigar, or pipe be carried into the chamber at any time.
9. Assure ample ventilation of chamber during use of oxygen and before any appliance is used.
10. Provide water and sand buckets.
11. Display the following warning prominently inside and outside the chamber:

WARNING

Danger of fire and explosion is much greater in oxygen or under pressure than in normal atmosphere. Do not admit flames, sparks, volatile or inflammable substances, or unnecessary combustibles of any kind. Provide ample ventilation and use no electrical appliances during oxygen breathing.

FIGURE 9940–95.

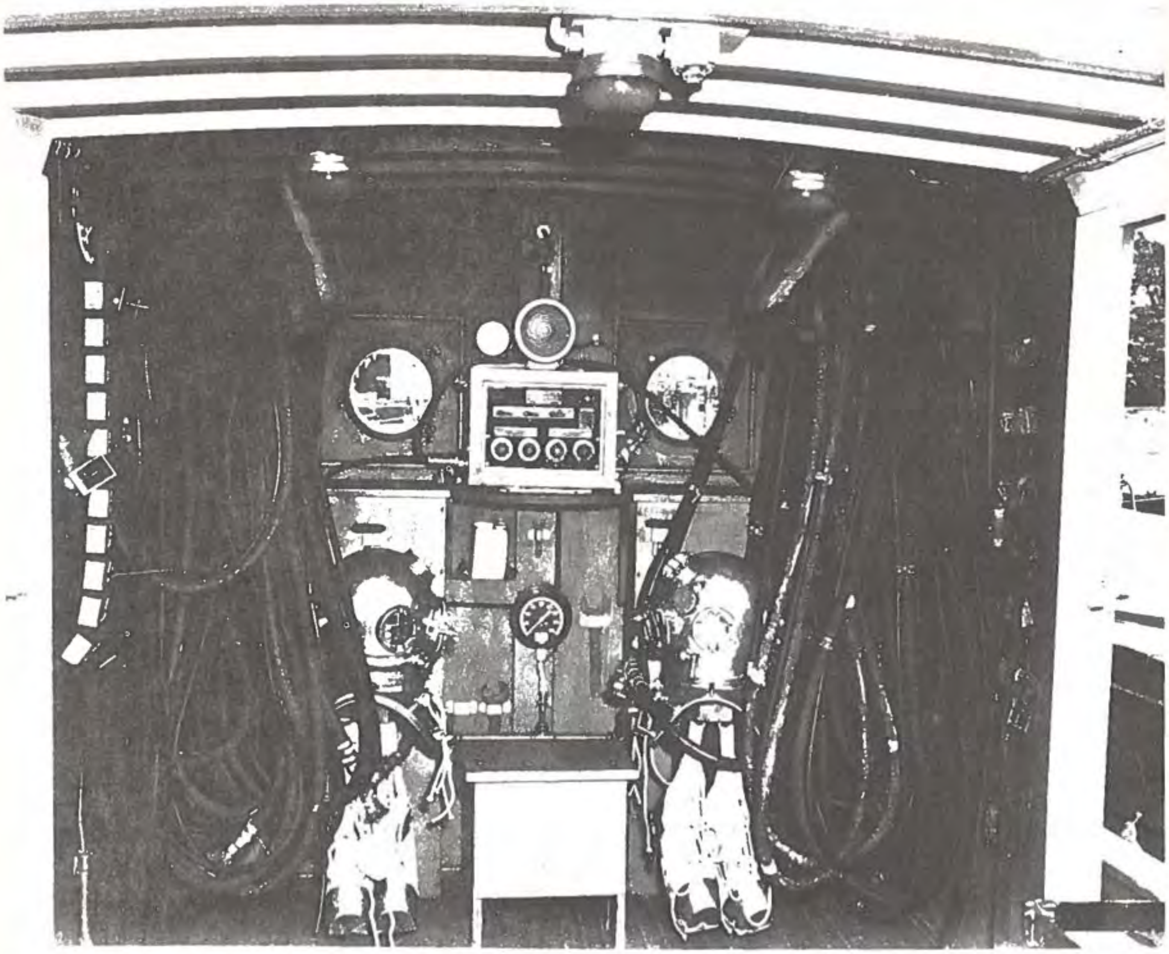


FIGURE 9940–96.

FIGURE 9940–97.

ity, water, and air from the pier where the compressors are located.

3. Such a float, even if not as large, could be modified for use in a salvage operation if the compressor and required equipment for the operation were placed on the float. Although it is very awkward to maneuver such floats into position for a task, they can be pressed into service in closed harbors and basins. It is not recommended for work in rough water or the open sea.

9940.684. GENERAL PRECAUTIONS

In general, when diving operations are undertaken from motor launches, the decks, if portable, should be adequately secured. There should be sufficient railings to protect personnel from being thrown overboard, and the air system should be checked to see that it is of sufficient capacity as to volume and pressure and that it is held securely in place. Only personnel tending the diver or assisting the tender should be on the deck from which diving is being done.

Part 2. Diving Procedures

A. Planning and Arranging of Diving Operations

9940.701. PLAN OF PROCEDURE

1. When diving is to be undertaken, the commanding officer of the vessel shall be informed. When diving on a ship, the officer of the deck shall be notified. He shall futher notify the commanding officer and engineer officer

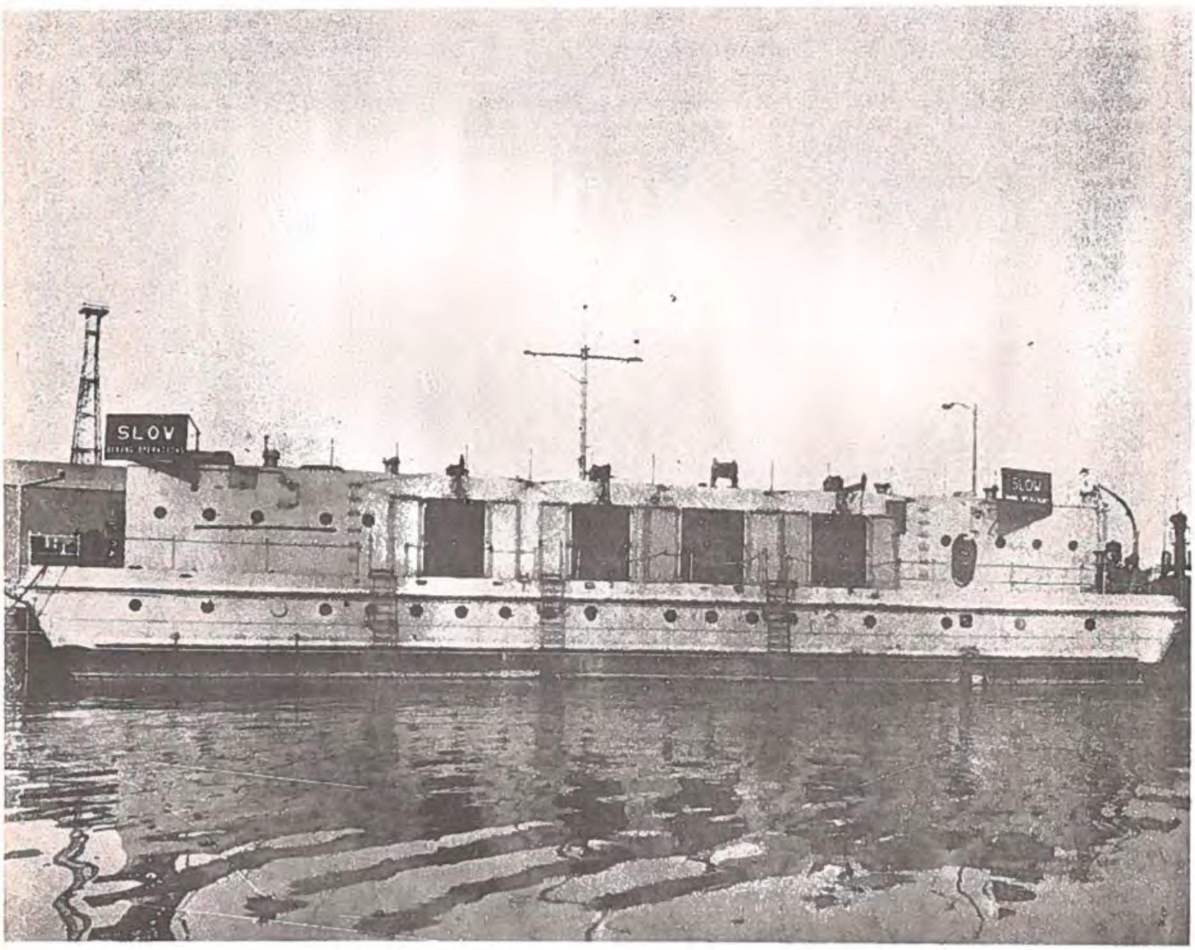


FIGURE 9940–98.

and measures shall be taken to secure and tag any machinery or installations which might endanger the diver or diving personnel. Similar measures must be taken on the ships alongside before a diver is allowed in the water. A general plan of procedure, depending upon the type of work, its location, depth, climatic condition, etc., should be decided upon. The necessary officers, men, quantity and type of equipment, type of vessel or boat to be used, etc., to handle any emergency should be detailed and an effort made to conduct the operations with ease and efficiency. An officer qualified in deep-sea diving is placed in charge of the divers and diving operations. If such an officer or warrant officer is not available, an officer familiar with the principles of diving and the problems encountered by the diver should be placed in charge. Regardless of the magnitude of the diving job, one person shall be placed in charge and assume responsibility for the divers and diving operations.

2. Diving work is no exception to the general rule that a task is more efficiently performed when the work involved has been properly studied and planned, and preliminary work has been done in advance. In diving operations, the procedure which proves most effective is the one which provides that the maximum amount of work be done on the surface by the surface crew, and that a minimum amount be performed by the diver on the bottom. Accordingly, in planning the work, the procedure decided upon should be that which not only reduces the diver's work to a minimum, but limits his operations to tasks which can be performed within a reasonable period of time under the conditions involved.

9940.702. ORGANIZATION AND PLANNING

1. **Command responsibility.** The responsibility of the commanding officer is clearly defined in the U.S. Navy Regulations. He may at his discretion delegate authority to his subordinates for the execution of details. Such delegation of authority shall in no way relieve him of his continued responsibility for the safety, well-being, and efficiency of his entire command.

2. An officer must be assigned the responsibility for any and all diving performed by the command. He is known as the **diving officer.** In the absence of a qualified diving officer (BuPers Manual, articles C–7313, C–7314, C–7315, and C–7316), any officer may be assigned. Such officer must study all diving publications currently in use and make certain that all safety regulations are observed and that all diving is conducted in accordance with good diving practice. Prior to the commencement of combined diving operations the Officer in Charge of the U.S. Navy divers shall, if circumstances permit, request a conference regarding diving safety. An enlisted **diver** whose competency, responsibility, and reliability are commensurate with the particular operation, may be designated as the **diving supervisor.** The term "diving supervisor" as used in the manual denotes that person, officer or enlisted, who has been delegated the authority to take charge of a particular diving operation. One person, the diving supervisor, must be in complete charge at the scene. No diving operation may be commenced without a diving supervisor. To fulfill his responsibility and maintain proper **standards,** a good diving officer confers with the diving supervisor at such times as do not interfere with the proper conduct of the operation. Under no circumstances does he tolerate violations of outlined procedures. This manual is in a looseleaf binding for the benefit of the man with a better method. Instructions in the "Special Note" in the front of this manual give the procedure to follow in recommending an improvement.

3. **Planning and foresight.** Diving, as much as any military operation, emphasizes the necessity for planning and foresight. Bottom time is a premium. The diver must be placed on the job under the absolute optimum conditions of knowledge, equipment, ability, safety, and freedom from distractions. Topside assistance must be well organized and capable. Failure to consider any item of available information during the planning stage may result in failure of the diving operation. Time spent by the supervisor in determining conditions under which he will work will inevitably result in greater efficiency once the job is commenced. Circumstances such as changing weather conditions often prohibit a second attempt to complete diving operations which failed because the supervisor did not initially select the proper equipment, personnel, or procedure. Most important, the lives of many divers have been jeopardized by lack of foresight and failure to consider all eventualities.

4. With the amount of individual emphasis demanded by the size of the job, analyze and plan your job as outlined below. If any phase produces information that you should have considered in a previous step, reconsider the original analysis and re-plan that step.

a. **Objective.**—Decide exactly what it is that you want to accomplish. Review carefully to assure yourself that it is feasible and necessary.

b. **Procedure.**—First and foremost, establish that the objective cannot be realized more simply by surface seamanship and rigging. Then outline a general plan. Consider all phases right up to completion and securing.

c. **Peculiar hazards.**—All diving is essentially hazardous. Protection against normal hazards is the reason for minimum personnel qualification requirements, standardized procedures, and equipment specifications. The fact that the diving supervisor is qualified to conduct the type operation at hand presupposes that he will combat normal hazards with standard practice. At the same time, almost every diving operation will have conditions that are particularly hazardous or might easily generate a hazardous condition. Review the entire outlined procedure and include all special precautions necessary to combat such conditions.

d. **Surface conditions.**—Surface conditions include weather, sea, topside equipment and personnel. Equipment and personnel include that outside of the command as well as that within the command. The surface conditions important to consider are either those available for use if required or those that constitute a potential hazard to the diving operations. Take all present and expected surface conditions into account in the planning phase.

e. **Underwater conditions.** —Underwater conditions include the work site, the depth, the tide, current and visibility underwater, and the type of bottom. Make certain that every one of those elements is used to your advantage.

f. **The dive.**–The "dive" includes more than the simple process of descent, work, and ascent on the part of the diver. The organization and personnel topside are just as critical in the final analysis as the individual ability of the diver himself. Most military diving operations require much preparatory and supporting effort. The most common failing of diving supervisors is to over-plan the dive itself while under-planning all of the preparatory and supporting work. Plan the dive properly. Select your diving and supporting equipment. Outline your intended plan to your entire crew. Include plans for emergencies and any additional special items. Properly organize and train your surface crew to do their assigned jobs in support of the diver. Give your diver step by step instructions on what he is to accomplish. At the same time, organize and detail additional topside personnel in such a manner as to have the lines, the shackles, the tools and countless additional equipment ready to go to the diver the moment they are needed. Do this through subordinate petty officers with a minimum of confusion and you are a good diving supervisor.

5. **Additional notes to the diving supervisor.** Make every effort to detail **all** routine work. Even when your problems as the leader appear small, make it a habit to keep yourself above the minor jobs. You will find that you can always use time to review and improve on your plans for the next phase. Most important, you have to be ready for the contingency that you haven't planned.

6. There is an exception to the above general rule. In many instances a preliminary dive will be of great value in deciding on the correct course of action. Confine yourself to a preliminary dive and a final inspection dive, if they are necessary.

7. Bear in mind that changing or unforeseen conditions may require changes in the original plan. In order to meet this possibility, you must have one or more alternatives available. A successful plan must be flexible.

8. Some of the most regrettable accidents in diving have come about as a result of diving operations becoming routine. When the same type of diving is repeated day after day, there is a strong tendency to relax and lay aside the plans and preparations for emergencies. When you see this happening, visualize a few of the casualties that could happen. Hold a drill emergency, if necessary.

9. **Preparations.** As outlined below, many important preparations must be made prior to commencement of actual diving. The majority will apply only to a particular type of diving apparatus or operation. Specific preparations applicable to surface-supplied diving and self-contained diving are covered in their respective sections of this manual.

a. Ensure that all necessary equipment is at hand.

b. Check all equipment to insure proper operation.

c. Ensure that all who need to know are informed that diving operations are to commence.

d. Ascertain location of nearest medical facilities and recompression chamber and availability of transportation to same.

1. **Depth limits**–Except in emergencies, or in exceptional circumstances, safe diving practices require limitations on the maximum depths and times of dives. These limitations shall not be exceeded except by specific authorization of the officer in charge of the diving operations or by higher authority. The following table summarizes these limitations.

Depth (feet)	Limit for–	Notes
25	Breathing 100% O_2 (or its "equivalent oxygen depth" when breathing gas mixtures) while working or swimming.	(a)
36	Non-designated diver in an emergency situation.	(b)
60	Scuba; normal working limit.	(b)
60	Lightweight diving equipment; normal working limit.	(b)
130	Lightweight diving equipment; maximum working limit.	(b)
130	Scuba; maximum working limit.	(b) (c)
150	All divers except first class and master.	
170	Diving without a medical officer and recompression chamber at the scene.	(d) (e)
190	Surface-supplied deep-sea (air); normal working limit.	(e)
250	Surface-supplied deep-sea (air); maximum working limit.	(f)
300	Surface-supplied deep-sea (air); absolute limit.	(f)
380	Surface-supplied deep-sea(H_e O_2); practical working limit.	(g)

NOTES

(a) For time limit at 25 feet, and for other depth/time relationships, see article 1.5.7 NAVSHIPS 250-538

(b) Do not exceed the "no decompression" limits of table 1–6 of NAVSHIPS 250-538. Dives requiring decompression may be made if considered necessary by the officer in charge of the diving operations. The total time of a scuba dive (including decompression) must never exceed the duration of the apparatus in use—disregarding any reserves.

(c) Certain operational swimmers (as EOD, UDT) are authorized to dive to greater depths when required provided they are First Class Divers or senior.

(d) A medical officer and a recompression chamber are required, on the scene, for all helium-oxygen diving operations using deep-sea equipment.

(e) Do not exceed the limits of table 1–5 of NAVSHIPS 250-538. Table 1–9 of NAVSHIPS 250-538 is computed for **exceptional** exposures and is intended only for exceptional and emergency situations. Such situations defy complete assurance of safety when using the table.

(f) Do not exceed the limits of table 1–9 of NAVSHIPS 250-538.

(g) This is based on a practical consideration of working time vs. decompression time.

9940.703. REPAIRS TO HULLS

In planning for emergency repairs to the hulls of vessels, the following items should be on hand: Collision mats, patent leak stoppers, mattresses, canvas, swabs, cotton waste, caulking, wooden wedges, mild steel plating for small holes, hookbolts, soft grommets made by tow and tallow kneaded together and parceled round with cloth, rubber gaskets, ample supply of planking for large holes, wire cable, bungs, wooden plugs for closing valve openings, and wire brushes and pickers for use in cleaning valve gratings.

9940.704. SECURITY OF MOORINGS

Upon arrival at the scene of diving operations, the local conditions should be observed to determine whether the vessel or motor launch can be moored and the diver put over the side. Sufficient gear should be carried by the vessel from which diving is to be undertaken to moor the vessel securely. The mooring gear should be given a careful inspection before mooring, and when divers are down, a watch should be placed to ensure against any shifting of the moorings or veering of the vessel that would endanger the divers. Usually there is much less tide on the bottom than at the surface. Consequently, although the surface tide may seem strong, it may be advantageous to attempt diving, provided the surface tide is not such as to endanger the moorings. If the velocity of the current is over 1½ knots, the diver should wear additional weights. In sudden squalls, heavy seas, unusual tide, or any other condition which, in the opinion of the commanding officer, jeopardizes the security of the mooring, the divers should be brought up and diving discontinued until more favorable weather conditions prevail.

9940.705. PRELIMINARY PLANNING OF OPERATIONS

1. The success of diving operations will be considerably enhanced by preliminary planning of operations including the laying out of various phases of the work and the assignment of definite tasks to each diver or group of divers. In general, it is better to arrange the diving task so that the number of divers submerged is kept to a minimum. It should be remembered that the greater the number of divers submerged, the greater the possibility of entanglement of the lines involved, and that for continuous diving the number would be multiplied by the lines of the divers decompressing in the water. The number of divers that can safely be submerged simultaneously will depend upon the depth of water, the nature of the bottom, the ship's facilities for handling divers over each side, and the practicability of this procedure under attendant condition, the freedom of the wreck from debris, and the conditions of the weather and sea. Divers can be used singly, in pairs, or in groups of three or more. It is generally preferable to work divers singly or in pairs. It is sometimes advisable to use divers in relays where one diver acts as another diver's tender, the first diver being tended topside.

2. With the foregoing as essential requisites, contributions to the satisfactory operation of underwater work are made by application of the following rules:

a. Make inspection dives to ascertain the extent of the work to be done and to determine the method of attacking the problem.

b. The method of accomplishing the job, the type of equipment, and personnel, should be considered on the basis of the initial inspection dives. Care should be exercised in evaluating the information obtained during an observation dive because the opportunity for observing conditions below the surface is limited. In addition, the plan decided upon should be flexible enough so that it can be modified to take advantage of information obtained on subsequent dives and on the basis of how the work is progressing.

c. Prepare and assign tasks and give the divers instructions well in advance. This will enable the diver to think over the task with the result that he may offer suggestions or ask questions which may assist in completing the job.

d. A diver may unintentionally overestimate his ability to accomplish underwater work. Suggestions should be thoroughly considered and weighed by the judgment of those in charge.

e. Each diver of a group, in addition to his own specific instructions, should be given a general idea of what tasks the other divers of the group are to perform.

f. Final instructions must be given to each diver and to the group by one person only.

g. If the diver forgets part of his instructions, he must immediately ask advice from the diving supervisor. Therefore, the diving supervisor must be immediately available during diving operations.

h. When a diver is on the bottom, it is inadvisable to alter the diver's prearranged task. It is better to instruct and send down a new diver to replace him.

i. Work night and day, while weather permits, provided sufficient divers are available.

j. In planning the work of divers, arrangements should be such as to preclude any necessity for their stay on the bottom in excess of the optimum time of exposure as shown in the decompression table.

9940.706. STOWAGE OF GEAR

When diving operations are completed, all gear should be cleaned and then stowed in a dry, cool compartment, and kept in good repair and in readiness for immediate use. All chests of diving apparatus shall, when sufficient space is available, be kept habitually stowed under cover, away from steam pipes and excessive heat. When it it necessary to keep them in the open and exposed to the weather, suitable canvas covers should be used to protect the outfit.

B. Dressing the Diver

9940.711. RESPONSIBILITY OF OFFICER IN CHARGE

The officer or diver in charge shall see that the diver is properly dressed, the air hose and all air connections properly made, air system is in satisfactory operating condition, and all gear properly arranged on deck or in the diving launch before the diver begins his descent. The officer or diver in charge is responsible for the condition of the diving gear, and should make sure that all equipment is in good working order before the diver is dressed.

FIGURE 9940–99.

FIGURE 9940–100.

9940.712. DRESSING PROCEDURE

1. As shown in the fig. 9940–99, the diver first puts on the woolen shirt, drawers, and socks. The amount of woolens worn will depend on individual preference and climatic conditions. Next, he gets into the dress with the help of the attendants. The legs of the diving dress should be snugly laced. Care should be taken, however, not to draw the lacings so tight that circulation of the blood in the legs is impaired (see figs. 9940-100 and 9940-101).

2. If cuffs are used instead of the gloves, an assistant spreads each cuff by inserting his first and second fingers on each hand, while the diver, taking care to keep his fingers straight, forces his hand through the cuff. Soapsuds rubbed on the inside of the cuffs or dipping the cuffs and diver's hands in fresh soapy water facilitates this operation. If rubber wrist bands are required, they are put on over the edges of the cuff. However, the effect of cold water together with the restriction of the circulation of the blood caused by the rubber wrist bands often results in a loss of the sensation of feeling in the hands so that there is danger of damage or injury to the hands when using tools. Accordingly, for work in cold water, a diver should be dressed in a suit fitted with gloves.

3. Next, the canvas overalls, if used, are put on. Then the diver sits on the dressing stool, and the assistants place the weighted diving shoes on and secures them to the diver's feet by lacings and buckled straps. Lanyards should be well secured around the ankles and the straps pulled tight and buckled. Buckles should be outward.

4. The helmet cushion is put on, followed by the breastplate, fig. 9940–102. Care should be exercised to prevent the rubber collar from being torn when it is pulled up and placed over the projecting studs. The bib is drawn well up, and the rubber collar is placed over the front of the breastplate, working it over the remaining studs in succession toward the back studs, alternately pulling up on the bib. Two attendants, one on each side of the diver, are best for this operation. The diver may, by elevating his arms, assist getting the holes in the collar over the shoulder studs. Four copper washers are now placed on the studs where the breastplate straps join. The four removable breastplate straps are placed over the studs. The wing nuts are then run onto the studs; those on each side of the strap joints are screwed tight first, and those at the joints last. If a dress with gloves is used, the wrist straps are now applied.

5. The weighted belt, fig. 9940-103, is fastened on, making the leather shoulder straps cross in front of the diver's breastplate and over his shoulders. In back, the shoulder straps again cross before being buckled. The diver then stands and the jock-strap is brought between his legs and, with all the slack taken up, buckled firmly in front.

6. During the time the diver is being dressed, the helmet should be examined, the valves and intercom tested, the proper decompression tables determined for the depth and anticipated time on bottom, and the necessary lengths of hose coupled, care being taken that a washer is in place

FIGURE 9940–101.

FIGURE 9940–102.

FIGURE 9940–103.

in each female coupling. One end of the 50-foot length of air hose should be attached to the inlet of the air control valve and a 3-foot length of hose should be connected between the exhaust of the control valve and the nonreturn valve on air-hose gooseneck. The lifeline is secured to the gooseneck on the back of the helmet. The air supply system should be checked thoroughly. If a compressor is to be used, it should be started and warmed up. Air should then be blown through the hose, helmet, etc., to clear the system of any dust or dirt. To reduce the possibility of fouling, the first 50 feet of hose and lifeline are married, and then canvas is sewed on. The remainder of the hose and lifeline should be seized at approximately 10-foot intervals.

7. The helmet is then screwed onto the breastplate, figs. 9940–104 and 9940–105. The ball lever of the safety lock is turned down into its recess and is locked in place by the safety latch and the split cotter pin. The combination amplifier and lifeline cable and air hose are brought up under the right and left arms respectively. The combination amplifier and lifeline cable is secured to the right breastplate eyelet and the hose to the left eyelet. The cable and hose are secured to the eyelet with signal halliard by taking two round turns and a square knot. The air-control valve is then attached to the long stud on the breastplate. The telephone should also be tested by the diver.

8. The tender shall assure himself that the diver is properly dressed, and particular care shall be exercised in making sure that the safety lock is secured. The diver will then adjust his exhaust valve and check his air supply. The tender will then close the faceplate and lock it securely. The diver then steps onto the stage, placing his feet in the center and to the outside, grasping the iron bails with his hands. The knees should be bent slightly while riding the stage. The diver is hoisted clear of the ship's side, and is then ready to begin his descent.

FIGURE 9940–104.

FIGURE 9940–105.

9. If the diver needs to swim on the surface to reach his descending line, the following procedure should be followed. When the diver enters the water, he should adjust his exhaust valve and control valve so that the faceplate will be slightly out of the water when he is floating in a vertical position. When the diver is ready to begin swimming, he faces the direction in which he wishes to travel and pushes himself free of the ladder or stage. The leg motion used is a circular movement that is similar to pedaling a bicycle. At the same time the arms are used in a dog paddle to help propel the body forward. When the diver begins to move, the tender pays out enough slack in the air hose and lifelines so that the diver can make headway easily. If the diver has a tendency to fall over frontward when swimming, arching his back and leaning back in the suit will be found helpful. It should be remembered that the swimmer is in a vertical position and that his direction of travel is in the direction he faces.

10. When the lightweight diving equipment is to be used, the diver is dressed in the same manner as that described for the deep-sea diving equipment. Care should be taken to insure watertightness at the back opening and where the mask comes in contact with the dress face gasket.

C. The Descent

9940.721. STARTING THE DESCENT

1. The diver remains on the stage or ladder until he is satisfied that the dress is tight and that air valves and telephones are in working order and properly adjusted. After reporting such by signal, he steps off and is hauled by the tenders to the descending line that is usually made fast at the point where the stage is put over. The diver locks his legs around the descending line and holds onto it while he adjusts his air supply before he starts the descent. Figure 9940–106 shows the diver making an adjustment of the regulating escape valve.

FIGURE 9940–106.

2. A second method of descending is by means of a decompression stage, fig. 9940–107. The diver stands on the middle of the stage and supports himself by bracing his feet against the side and holding on to the stage bails. The stage is then hoisted over the side and the descending line is passed through the shackle on the side of the stage. The diver is lowered until the helmet is awash. At this point the descent is halted until the diver adjusts the flow of air. After the proper signal is given the diver is lowered at a steady rate, allowing sufficient time for the diver to equalize the pressure. When the stage has reached the bottom, the diver steps off the stage from the same side he entered it. This will prevent the diver's line from becoming fouled with the stage.

FIGURE 9940–107.

9940.722. RATE OF DESCENT

1. The rate of descent should not exceed 75 feet per minute, allowing for the diver's ability to equalize the pressure and "pop his ears," and for checking the descent whenever necessary. The factors limiting the rapidity with which a diver can descend are possibility of a squeeze, inability to equalize the air pressure on both sides of the ear drum, pains in the sinus passages, the tendency toward dizziness, the effect of currents, the necessity of approaching an unknown bottom cautiously, and other variable factors.

9940.723. DESCENDING IN TIDEWAY

When descending or ascending in a tideway, the diver should keep his back to the tide so that he will be forced against the descending line and not away from it. It is not difficult for him to maintain this position if he determines which way the tide tends to swing him and pushes the descending line over to one side or the other so as to check the swing.

9940.724. PAIN IN EARS

Pain in the ears during descent is a warning that must not be neglected as rupture of the ear drums is threatened. The remedy is for the diver to stop his descent and yawn, swallow, or press his nose against the wall of the helmet to block the nostrils, and make a strong effort at expiration. Ascending 3 or 4 feet usually provides relief, and the descent then may be continued. If the dive is to be made in deep water and the diver has trouble with his ears in getting down to 30 feet, it is advisable to bring him to the surface and not let him dive that day. Pain in the sinuses is usually caused by head colds, and the only remedy is to prohibit the diver from diving until his cold clears up.

9940.725. REGULATING AIR DURING DESCENT

As the diver descends, care must be taken that air is supplied to him in the correct volume and at the pressure corresponding to his increase in depth. Insufficient air supply during descent may force the diver to stop because of a squeeze. As the diver descends, air is forced out through the air-regulating exhaust valve by the pressure of the water, so that the dress becomes closely pressed to the legs, arms, and body up to the breastplate. The experienced diver adjusts the air supply so that he breathes easily and comfortably without endangering his stability.

9940.726. PROCEDURE UPON REACHING BOTTOM

Upon reaching the bottom, the diver holds onto the descending line and adjusts his buoyancy to such a degree that the helmet merely lifts the weight of the apparatus off his shoulders. He also checks his ventilation and should spend adequate time at the descending line to permit his body to adjust itself at the new pressure level.

D. Working On The Bottom

9940.741. AIR SUPPLY ADJUSTMENT

1. As the diver descends, it is necessary to adjust the flow of air continually to compensate for the increasing water pressure. As a result, when the diver hits the bottom, the air supply is either too little or too great. Upon reaching the bottom, the diver should remain at the descending line long enough to regulate the flow of air to ensure proper dress inflation and become adjusted to the new pressure level. Ordinarily, the dress will be properly inflated when the helmet and breastplate are just lifted from the shoulders and yet do not overcome the negative buoyancy. Next, it should be determined whether there is proper helmet ventilation. While the diver is standing at rest, his physical condition should be comfortable and normal. Should there be rapid breathing, panting for breath, unnatural perspiring, undue sensation of warmth or dizziness, eyesight not clear, or if the helmet windows become cloudy, there is bound to be an accumulation of CO_2 in the helmet and the remedy is "more air." This can be accomplished by increasing the rate of circulation through the helmet. Proper inflation and ventilation usually can be obtained by opening the helmet air-regulating exhaust valve 2½ or 3 turns and then regulating the air flow with the air-control valve. The best practice is to adjust the exhaust valve at the same time as the control valve; i.e., increase air supply, increase exhaust; reduce air supply, reduce exhaust.

2. There are many occasions where proper control of the air supply can be used advantageously to lessen muscular exertion and assist in completing the job. In addition to the initial settings, it is frequently desirable to obtain a changing inflation or deflation for short periods of time or to accomplish specific tasks without readjusting the regulating escape or control valves. To cause a rapid deflation, the exhaust opening is increased by pushing the escape valve chin button outward. If a rapid inflation is required, the chin button should be grasped by the lips shutting off the exhaust. For a further regulation of air flow the "spitcock" may be used.

9940.742. DETERMINING DIRECTION

1. Before leaving the descending line the diver should note the lead of the hose and life-line cable to ensure that they have not fouled the descending line. To determine the direction, the diver should also note the bearing of the brightest light (diffusion of sun rays) and the direction of the current. By remembering the direction of the work with reference to the direction of the sun while on the surface, it is easy to proceed in the desired direction. If, for instance, before starting the descent, the sun shone on the left helmet window, the greatest amount of light should still shine in the left window of the helmet when on the bottom if the diver's position is the same as when on the surface with relation to the sun. If there is no light, the diver may depend upon the direction of the current for guidance. The slightest general movement of the water can usually be detected by an experienced diver. However, the current does not always flow in the same direction on the bottom as on the surface and, consequently, if the diver should start off in the wrong direction, the tender should warn the diver.

2. The most satisfactory method of determining the direction of travel is by tender-diver communication; either by "intercom" or prearranged hand signals—so many pulls mean to go to the right, so many mean go to the left. A warning or signal to indicate directions means that the diver should first face in the direction from which the lifeline and air hose are tending, and then obey the instructions (see Article 9940.582).

9940.743. MOVEMENT ON THE BOTTOM

1. Upon leaving the descending line, the diver should proceed slowly and cautiously to conserve his strength. It is advisable for the diver to carry one turn of air hose and telephone cable on his arm to prevent sudden pulls from the surface throwing him off balance. The immediate surroundings should be examined and a report made of any wreckage or obstructions encountered. As a general rule, it is advisable to pass over, not under obstructions. In this connection in passing any obstruction, the diver

should keep in mind the side on which he passes so as not to become fouled on the way back.

2. Movement is relatively easy in slack water, but as the tide or current increases, it becomes increasingly difficult to advance. This difficulty may be lessened by advancing in a stooping or crawling position, which reduces the area of the body exposed to the sweep of the current. The latter position is the easiest one for navigation under water. However, it should be remembered that every time the diver assumes a new position, consideration must be given to the regulation of the inflation of the dress.

9940.744. WORKING ON ROCKY BOTTOM

When working on a rocky bottom, the diver should guard against tripping and getting legs or arms caught in crevices. If the rocks are sharp, as coral usually is, it will be advisable to wear gloves. Particular attention should be paid to preventing the air hose and life line from catching on the rocks, and the tender should be cautioned about keeping the slack well in hand. In the event the lines do become fouled, the diver should gather up the lines and retrace his steps by following the lead of the air hose and life line. In practically all cases the diver will be able to clear his own lines without requesting the assistance of the standby diver.

9940.745. WORKING ON MUDDY BOTTOM

1. When working on a muddy bottom, the divers should remember to keep all movement to a minimum in order not to stir up the silt and reduce whatever visibility there may be. In addition the diver should provide more buoyancy by keeping plenty of air in the dress. Sinking deeply into the mud indicates that there is an excess of negative buoyancy. While this condition can be corrected by increasing the inflation of the diving dress, the diver's movements in wiggling out of the mud should be as gradual as possible in order to eliminate the possibility of "blowing up" after breaking loose.

2. There is nothing to fear about mud, quicksand, and the like. Actually, such substances are a cross between land and water; their density is not sufficient to support the diver but is great enough to offer more resistance to sinking than water. Divers have been known to work under many feet of mud and silt for relatively long periods without undue discomfort. The hazard involved in diving in muddy water is the inability to see such objects as pilings, stone walls, debris, cans, bottles, etc., that may cause the diver physical harm. One of the primary reasons for using the deep-sea diving equipment in water where visibility is very limited is the physical protection offered by this type of equipment.

9940.746. SEARCHING FOR LOST OBJECTS

1. When searching for lost articles, the diver should explore thoroughly and as expeditiously as possible the whole of the ground within the sweep of the distance line. To accomplish this, the diver takes up the distance line, holding it taut, and starting from some point sweeps around in a circle. After returning to the starting point which must be judged by some object on the bottom—the direction of the tide, a line stretched along the bottom for the purpose, or signal from topside—the diver moves out along the distance line and makes a fresh circle in the opposite direction, thus avoiding the twisting of his air hose and life line around the descending line. It is generally more advantageous to crawl on the bottom when searching, though in exceptionally clear water, a better field of vision may be obtained by walking.

2. When a diver has explored the whole of the ground in this way without finding the object sought, he may be fairly certain that it is not within the reach of the distance line; hence the next step would be to have the ship or the diving launch moved so that a new area may be searched. Before the ship or the diving launch is moved, the diver is brought up and the position is marked by a buoy so that a systematic search may be accomplished. When a number of buoys have been thus planted over a considerable area, the unimportant ones may be removed by the surface crew. The important ones marking the boundary of the explored area should remain until the search is completed. The diver may be unable to make a complete circle if there is much tide or current. In that case, it is necessary to work back and forth across the tide as far as possible, each time moving out a little farther along the distance line until he reaches the end, and then having the position of the diving boat shifted.

3. Still another method of searching is to plant two large buoys a considerable distance apart. A surface line of adequate size manila is stretched between the two buoys. The diving launch with diver on bottom is then ferried along, the surface line being taken over the bow and stern rollers of the launch, and the boat being given headway by pulling on the line or stopped by holding onto it, according to signal from the diver. The advantage of this method is that the speed of the boat is always under exact control.

4. Upon finding the object sought, the diver should, if possible, fasten the distance line to it, after which he may signal for a rope and have it hauled up or go up and make a report, as circumstances may require. An object once found can always be relocated by means of the distance line tied to it.

9940.747. WORKING ABOUT MOORINGS

When working about moorings, a diver should not dip under chains, etc., without having a distance line to show him the way back. As old moorings are often covered with sharp barnacles, gloves should be worn to protect the hands. A diver should not descend on a chain or wire if it is possible to do otherwise, and neither should a chain, wire, line, or weight be veered, lifted, or moved until the diver is clear of them.

9940.748. WORKING WITH SEVERAL LINES

When a diver is required to work with several lines, it is a good plan to have each of them of a different size or material or marked by using colored rags, turns of small stuff, etc., so that he may know their individual purpose. He should never cut a line until he has made certain the purpose for which it is being used. Since a new line when under water shrinks and usually takes several new turns, it should first be lowered in the water by means of a weight and allowed to remain a considerable length of time before it is sent to the diver. Otherwise, if lowered alongside another line, it is sure to become fouled. For underwater work, cable-laid line is the safest and most useful.

9940.749. RECOVERING AN ANCHOR

1. In recovering an anchor, the line of the watching buoy should be hauled up and down, and the descending line weight dropped close alongside it. The diver can then go down his descending line, keeping the buoy line in hand as he descends, thus preventing his descending line from fouling the buoy line.

2. If a wire hawser has to be shackled onto an anchor, the task may be accomplished in the following manner:

Prepare the wire by fitting a large shackle to the eye and by stopping another shackle with its crown against the wire a short distance above the eye. The pins of both shackles should be fitted with lanyards to prevent their loss under water. Shackle the wire to the descending line or to the anchor buoy rope (if watching) by the upper shackle, which will act as a traveler, leaving the end of the wire free for the diver to handle. When the diver has found the anchor, he should signal for the wire which should be carefully lowered to him, great care being taken to prevent the wire from being dropped on the diver or too much being paid out, since large bights on the bottom render it difficult to find the end and may foul the diver. After shackling on, the diver must come up before any attempt is made to weigh the anchor. If the anchor is any distance from the descending line, or the buoy is not watching, the diver should bend his descending line on or get another rope bent on so that the lifting wire may come down exactly where it is needed. The same applies for raising other heavy weights such as guns or torpedo tubes from a wreck.

9940.750. WORKING ON SHIP'S BOTTOM

1. The amount of work which can be accomplished on ships' bottoms by divers depends largely upon the nature of the work and the extent of stable accessibility that can be maintained by the rigging of lines, ladders, and stages to the wreck. Two or more jacob's ladders lashed together side by side and weighted at the lower ends form a convenient arrangement to enable divers to work over the side of a vessel. If the ladder is hung from the ends of spars secured on deck and projected about 2 feet clear of the ship's side, the ladder is hauled under the bottom by hogging lines; the divers will have room to work, be able to move around freely, and be protected from falling, they of course being on the inboard side of the ladder. For working beneath the bilge keels of large vessels where the bottom is usually flat, a good plan is to lace a net between two jacob's ladders. The two ladders are separated by spars lashed in place so as to stretch the net, and the whole is passed under the keel by the aid of hogging and tricing lines. The diver can then lie back in the net and work on the bottom above him with comparative ease. When a diver is working under a ship, all lines, etc., must be carefully attended.

2. Another method of rigging a stage which is very quickly made and has been found very suitable for the use of divers working on a ship's bottom is as follows:

Two long spars, 20 to 25 feet long, are suspended from each other about 4 feet apart by means of two long ropes, the bights being clove-hitched around the end of each spar, the upper ends forming the tricing lines, and the lower ends the hogging lines. The tricing lines are to take the weight of the stage, and the hogging lines are for holding it down and binding it in to the ship's side. A third spar about 16 feet long is hung to the lower of the two long spars by means of a slung weight, so as to keep it in a horizontal position about 3 feet below the lower long spar, sufficient weight being hung to the stage to overcome its buoyancy. To prevent the stage from being bound too close to the ship's side, crosses of wood can be used, made from any rough pieces about 3½ feet long, and secured in the form of a cross. One of these crosses is secured at each end of the upper spar. A small cleat nailed on the spar prevents the crosses from slipping inward and the clove hitches of the stage ropes prevent them from slipping outward. This stage is suitable for two divers. The stage can be raised or lowered bodily, the diver at each end giving his own signals. When it is desired to fleet the stage, the divers should come to the surface.

9940.751. CLEARING OR REMOVING VALVES

Valves, as a rule, can be easily cleared from the outside by means of a wire brush and a pricker to clear the holes. If barnacles have gathered inside the perforated covering, the grating must be taken off to destroy them. The position of the grating should be marked before removal to facilitate its replacement. In case of the removal of a valve after the securing plate has been taken off, the hole plugged up, and the plug cut off flush with the ship's side, the outside should be covered with wood, lined with greased fearnaught to prevent any leakage inboard. If the valve is only to be kept out a short time, this covering need only be temporarily fastened, as the pressure of the water on the outside keeps it in place.

9940.752. CLEARING PROPELLERS

1. Propellers usually get fouled by rope or wire hawsers, and at times are most difficult to clear. A stage should be rigged near the fouled part (an iron grating will answer the purpose) to enable the diver to work in comfort.

2. First, the fouling should be thoroughly examined to see if it is possible to clear an end; if so, and if the turns are jammed, rope ends or tackles from the surface must be rigged and installed to break them out. Back turns can be taken or the propeller turned by the jacking engine to ensure the lead of the tackle being at its best. Particular care must be taken to see that the diver and stage are out of the way when the propeller is being turned. The engineer officer and engineering officer-of-the-watch must always be informed whenever a diver is working about the propellers.

3. If no end can be exposed, then the hawser must be cut. Rope hawsers can be cut with a knife, hack saw, carpenter's chisel, etc. There are several practical methods of cutting fouled wire cables. The first is by use of the powder-actuated cable cutter provided the diameter of the cable does not exceed 1 inch. The second is by burning with underwater gas or electric torches. The third and most tedious method is by cutting the cable with a sharp chisel or saw.

9940.753. WORKING AROUND CORNERS

When a diver is required to drag a long length of life line and air hose, or when it is necessary to work around several corners, an additional diver or divers are of assistance in tending his lines at intervening locations on the bottom or on deck. Thus, if the intercom should fail, the diver can send signals to one of the divers tending his lines, who, in turn, would transmit them to the surface by intercom or signal over the first diver's lines, using his own lines only for signals affecting himself. However, it should be borne in mind that the greater the number of divers submerged simultaneously, the greater the possibility of fouled lines. Whether the benefits of this procedure justify the acceptance of the greater possibility of fouling depends on the emergency or circumstances involved. This procedure will be at the discretion of the officer or diver in charge.

9940.754. GUARDING AGAINST FALLS

1. Whenever a diver is working clear of the bottom, as on a rocky ledge, ship's bottom, deck of a vessel, etc., caution should be exercised to prevent falls. The significance of a fall is that there results a sudden increase in external pressure without a corresponding increase in internal pressure, which may result in a serious accident or "squeeze." Falls in shallow depths are more serious than falls in deeper depths. In falling from the surface to a depth of 33 feet, the pressure on the body is doubled and the volume is reduced by one-half while in a fall from 165 feet to 198 feet, the pressure is only increased by one-sixth and the volume is reduced one-seventh.

2. The diver should always have something substantial to hold on to. However, it is dangerous to hold on to something overhead and climb around in this manner as the air in the dress may escape out of the cuffs or through leaks in a torn glove, in which case the diver may become so heavy as to precipitate a fall. Similarly a diver should never go under the keel of a ship and come up on the other side, for, in the event of a fall, it would be extremely difficult for the tender to render the diver assistance in checking the fall.

3. Should a fall occur, the descent may be checked by the tender if the lines have been held sufficiently taut or by the diver increasing the flow of air through the control valve and gripping the regulating escape valve chin button between the lips to reduce the exhaust thereby gaining additional buoyancy by inflating the dress. However, when inflating the dress, it is important that the other extreme, over-inflation, does not cause a "blow-up." A "blow-up" can be prevented by reducing the flow of air through the control valve and providing full exhaust by pressing the escape valve chin button.

9940.755. FOULED DIVER

1. Whenever a diver discovers that he has become fouled, the first thing to do is to stop and think over the situation. It should be remembered that there was a way into the situation, and there is, similarly, a way out. Under no condition should the diver become excited, but instead should attempt to extricate himself by slow methodical efforts. Topside should be notified, if possible, by "intercom" or hand signal so that arrangement can be made to send a relief diver if required. The diver should then take the distance line together with the life line and air hose and retrace his steps until the point is reached where the lines have become fouled. The necessary step should then be taken to untangle the lines. After several attempts have been made without success, assistance should be requested and a relief diver will be dispatched.

2. The relief diver should follow down the fouled diver's air hose and life line so that he may discover the tangle. However, if, after discovering the tangle, he is unable to release the fouled diver, arrangements should be made to substitute a new air hose and life line. To accomplish this, the relief diver fastens the new life line around the fouled diver's waist. Next, the fouled diver closes his air-regulating exhaust valve and his air-control valve while the relief diver uncouples the nearest free coupling of the fouled air hose and couples the new one. If an air-control valve is not used, it is important that the hose coupling to be broken shall be at or below the level of the fouled diver's feet.

9940.756. LOSS OF DISTANCE LINE

In the event the distance line is lost, the diver should feel carefully on the bottom within his reach for it. But if, after this simple maneuver, he does not find the distance line, he should inform the surface of the loss and that he is coming up. The attendant should guide the diver over to the descending line, and as the diver is hauled toward the surface, it is highly probable that the diver will discover the descending line. As soon as the descending line is located, the surface attendants are advised by means of the signal "lower." The diver descends and with the distance line again in his possession, returns to work.

9940.757. SENDING DOWN TOOLS

Definite arrangements should be made by topside personnel to ensure the diver's receiving the necessary tools to do a job with the minimum physical strain. Tools that the diver is to carry down should be fitted with lanyard and slipped over the diver's right arm or placed in the diver's tool bag. When tools are not to be carried down by the diver but are to be sent to the diver, a special descending line of 2½- or 3-inch rope should be secured to the point where the material is to be used. The line should be given an angle of lead that will cause anything sliding down to land so that the diver can easily locate it and guide it into place. When a power tool is to be sent down, it should precede the diver, and should be attached by a piece of 6-thread manila to a sliding shackle on the descending line, and lowered to the bottom by means of the tool's air hose. An electric torch and ground wire or a gas torch and igniter may be sent down in the same manner as the power tool, except that the ground wire or torch hose is used as the lowering line. For all other objects, use 15- to 21-thread manila for a lowering line, led from well forward to prevent turns, attached by an eye splice to the sliding shackle on the descending line, the small objects being in turn attached by a short piece of marline to the shackle.

9940.758. SAFETY PRECAUTIONS

To work efficiently and safely under water, a diver should keep in mind the following general rules and facts:

1. The air-regulating exhaust valve adjustment should be set at the desired number of turns open prior to starting the dive.

2. A diver should adjust his air in such a manner that he is enabled to breathe comfortably.

3. The helmet air-regulating exhaust valve stem known as the chin button may be used effectively to release quickly the suit pressure when desiring to stoop or crawl on the bottom without changing the air-control valve and the air-regulating exhaust valve adjustment.

4. The combined discharge of air-regulating exhaust valve and spitcock will not exceed the flow of air that will pass a half-open control valve, hence movement of the control valve wheel must be very small.

5. Never completely close the air-control valve, except during rupture or replacement of the air hose.

6. The helmet spitcock offers a secondary method of relieving excess pressure in the helmet.

7. The safety air nonreturn valve and the air-regulating exhaust valve will seat themselves if the diver's air supply is impaired, but the spitcock, if open, must be closed immediately by hand.

8. A diver is never in danger from a leaking dress provided he remains in an upright position. Divers have descended to a depth of 274 feet with the helmet only.

9. Air trapped in the diving helmet will last from 6 to 9 minutes for breathing purposes after diving air is cut off thus providing ample time for emergency measures to be executed.

10. If a diver should crack his faceplate, he should keep his faceplate downward and increase his air supply to prevent leakage.

11. Never become frightened or excited; slow, methodical efforts are always best in an emergency. Inexperienced divers have been known actually to exhaust themselves worrying over very simple circumstances. Such a state of mind is both needless and useless. A diver should never make the foolish mistake of running away from his air supply and consequently from safety; i. e., to become panic-stricken and make violent exertions to escape from a tangle when the proper course is to go slowly and deliberately. When in trouble, he should slow down his exertions and, if relief is not immediate, rest awhile. No matter how serious the situation appears, a diver should remember that there was a way into his predicament, hence there also is a way out of it, and if he cannot solve the problem himself, the relief diver will.

12. A diver must have confidence, first in himself, and second in those who are tending him.

13. In case a diver is fouled and cannot extricate himself, the relief diver that is sent down must be prepared to replace both air hose and life line, a procedure that may be safely executed on the bottom.

E. The Ascent

9940.771. PREPARATION FOR ASCENT

After the diver has completed the task or has received instructions from the surface to come up, the necessary preparations for ascent should be made immediately. If a special line has been used for sending down tools, the diver should request that a line be sent down so that the tool bag or other tools can be sent to the surface prior to starting the ascent. If no special line has been used, the diver should return to the descending line via the distance line and a line is sent down for attaching the tools. In the event the descending line cannot be located and the tools are too heavy to be thrown over the diver's arm, a line should be secured to the life line which the diver then pulls down. The tool bag is then made fast and the tender is signaled to haul the bag up.

9940.772. BEGINNING THE ASCENT

Everything on the surface being in readiness, the tender advises the diver to stand by to "come up." The diver, after making certain that everything is clear and there is nothing to interfere with the ascent, places one leg around the descending line, as in the manner of descending, and lightens his weight as necessary by inflating the dress. In doing this, the diver should be extremely careful not to overinflate the dress, which may result in a "blow up." While the diver can assist the tender by lightening himself, the diver shall be lifted off the bottom by the tender. In this connection, the decompression table, part 3, is based on the requirement that the diver is brought to the surface at a specified maximum rate which can be more accurately controlled by the tender than the diver.

1. Everything being ready, topside is then notified, "Ready to come up." When ready, the tender will notify the diver, "Coming up. Report when you leave bottom," and then will lift the diver toward the surface. The diver reports when he leaves the bottom. If the diver feels his dress becoming too buoyant and he is ascending too rapidly, he may check his rise by clamping his legs on the descending line and adjust the inflation of his dress by adjusting the air-regulating escape valve. If the dress is not fitted with gloves, reduction in inflation of his dress can be rapidly accomplished by the diver raising his arm which will permit excess air to escape at the cuff.

2. During the time the diver is preparing to come to the surface or just prior to it, the decompression stage is secured to the descending line by means of a shackle fitted to the stage and is lowered to the desired depth. When the diver is warned by surface attendants that he is nearing the stage, he should keep a sharp watch for the stage. As soon

as the diver finds the stage, he should climb upon it and seat himself. When this is done, the topside should be notified, "On the stage," so that the beginning of the proper decompression at this first stop may be started and timed.

3. During the time spent on the first and subsequent stops, the diver should see that his lines are clear of the descending line and stage. In case of fouled lines, he should report the fact immediately to the tenders and they will aid the diver to unfoul the lines as much as possible. Similarly, when the fouling of lines is detected by the tenders, the diver should be apprised of the fact. When the lines are clear, the diver shall notify the tenders, and they shall confirm the fact by repeating back the message, before starting to hoist the stage.

4. When the diver is ascending and is on the stage, he should pay close attention to messages from the surface and in all cases endeavor to answer clearly and distinctly. When word is received from the tenders that the stage is to be hoisted, the diver should assure himself that his hold on the stage is secure before returning the O. K. signal to the surface. Prior to leaving his last stop the diver should stand firmly on the stage before signaling his readiness to be brought to the surface.

9940.773. ASCENT FROM DIVE MADE FROM MOTOR LAUNCH

The foregoing instructions for ascents cover procedure in diving from vessels such as submarine rescue and salvage vessels, which are properly fitted with hoisting and other diving facilities including a recompression chamber. The instructions are equally applicable to ascents from dives made from motor launches except that the stage must be hauled up by hand instead of a powered winch.

9940.774. STAGE DECOMPRESSION

1. The diver is brought to the surface in stages to prevent contraction of compressed air illness or as it is more commonly called, "bends," "screws," "diver's paralysis," "caisson disease." The table for decompression, and the causes and treatment of compressed air illness are contained in part 3. In general, there are two methods of decompression: (1) regular decompression and (2) surface decompression.

2. **Regular decompression** as used herein consists of bringing the diver to the surface, stopping at successive depths, and maintaining him at these stops for the prescribed period before surfacing him. This method of decompressing the diver is standard and shall be followed in all cases except where emergencies or conditions of tide or weather are such as to warrant surface decompression in the opinion of the officer or diver in charge. When the stage arrives at the surface after regular decompression, it is lifted and swung clear of the gunwale, lowered lightly to the deck, and the diver assisted from the stage. As soon as the diver is seated, the faceplate is opened and the air-supply valve closed. If a recompression chamber is available, the diver can be undressed at once. If a recompression chamber is not available, the diver should remain dressed except for the belt and the helmet for at least 20 minutes and closely observed for symptoms of decompression sickness. At the end of this period, if the diver's condition appears normal, the remainder of the equipment should be removed.

3. **In surface decompression,** the stage is lowered to the deck as before. The diver's helmet, belt, and shoes are removed as quickly as possible and he is escorted to the recompression chamber by the attendant, who enters the chamber with him and removes his suit as the pressure is raised to that corresponding to the first decompression stop. Not more than 3.5 minutes should elapse from the time that the stage leaves the water until the diver is inside the recompression chamber and is again being subjected to pressure (See surface decompression table).

4. Regardless of method of decompression, it is well for the diver to remain in the vicinity of the recompression chamber or facilities for underwater decompression for at least an hour following the completion of a deep dive, even though there has been no indication of compressed-air illness during the 20-minute period mentioned. When extremely deep dives have been made, it is advisable to keep the diver aboard ship where he can be observed for 12 hours.

F. Tending the Diver

9940.781. RESPONSIBILITY OF TENDERS

1. From the time diving operations are first planned, the thoroughness with which the tenders understand and carry out their duties will, to a considerable extent, determine the success or failure of the operation and safety of the diver. The most effective assistance can be given by the tender who is familiar with the equipment, safety precautions, conditions, and difficulties that are inherent in diving. It is preferable that the tenders be experienced divers. If this is not possible, personnel should be designated as tenders and instructed in the topside duties by the officer in charge of diving.

2. It is the tender's responsibility and duty to see that the diver receives the proper care while topside and in the water. Before sending the diver down, he must thoroughly check such items as exhaust valve, control valve, intercom, and breastplate nuts. When certain that the diver is properly dressed and ready, a firm grip should be taken on the life line close to the helmet, and with the assistance of another attendant, guide him to the stage or ladder. Care must be taken to prevent the diver from getting off balance, stumbling, or falling. When the diver has adjusted his air and is ready, he should be directed to the descending line. The proper signal will be given when ready to descend. From the time the diver leaves the deck of the ship until he is safe on the bottom, the tender must keep all slack out of the line and be ready to render assistance at a moment's notice.

3. Generally, the topside duties are divided into handling communications, tending lines, and ensuring an adequate flow of air. The primary means of communication between diver and tender is by intercom. However, it is important that the basic hand signals listed in part 1, section (C), plus any supplementary signals originated to fit a particular type of job, should be memorized and practiced so

that they will be recognized instantly in the event of intercom failure or when using lightweight gear not fitted with an intercom.

9940.782. SIGNALS

1. Since signals cannot be received on a slack line, the life line and air hose should be kept well in hand so that the diver can be felt and signals can be made distinctly. The tender, on receiving a signal, shall repeat it only if it is clearly understood. If a signal is not repeated, it indicates to the diver that the signal is not understood and should be repeated. If a wrong reply is received from the diver, the signal should be repeated until it is correctly understood.

2. When the diver is on the bottom and near the descending line, also watch the latter for signals as the diver may want it lowered or the slack taken up. If at any time there is anything seriously wrong, the diver should ask to be hauled up by signaling four pulls on the air hose and life line. Four pulls on the air hose repeated is the emergency signal and should never be used unless something serious has happened and the tender must not delay in obeying it.

3. If the diver does not answer a signal after two or more trials at short intervals, ask him over the intercommunication system if he is all right. If he answers the intercommunication system, it may be that there was too much slack in his lifeline and air hose or that the line was fouled. The reason should be determined and corrected. It should be remembered also that a diver at work may not be in a position to answer pull signals for several seconds and he should be given a reasonable length of time to answer. If the diver does not answer either the hand signals or the intercommunication system, he should be brought to the first decompression stop and the standby diver should be sent down to the stop to determine the trouble and be of assistance. During this time continued efforts should be made to contact the first diver by using all means of communication.

9940.783. INTERCOMMUNICATION SYSTEM

1. When using hand signals, the information and instructions exchanged between diver and tender are necessarily restricted to either standard diving signals or special prearranged signals. The intercommunication system is provided with the deep-sea diving outfit thereby making it possible to relay and receive detailed instructions via voice communications. The attendant hearing difficulties for the diver above the air noise level makes it imperative that conversation with him be only that which is essential. The diver should be instructed to make continuous reports that he is all right while descending and report at regular intervals while on the bottom and ascending. This procedure serves to keep the diving officer continuously informed with only acknowledgements of reports received required by the tender. It is very annoying and time consuming for the diver to have to stop work to listen and reply to extraneous messages. The man assigned to the intercommunications equipment as a talker should have diving experience and clear speaking voice. This will not only result in reducing communications but will afford an additional factor of safety.

2. In case either the diver or attendant fails to get an answer over the intercom, the hand signal should be made to indicate to the other that he is trying to talk over the intercom. After the diver has repeated the hand signal, the tender should wait a few seconds and try the intercom again. Then if no answer is received, it should be assumed that the intercom is out of order and the hand signals should be restored. If, on the other hand, after answering a message over the intercom, the same message is repeated several times and no attention is paid to the answer, the person receiving the message should acknowledge that he understands it by signals. Failure of the diver's intercommunication system may be detected by the tender through a sudden stoppage of air noise and other sounds from the diver's helmet.

3. In deep water when a strong tide is running, the hand signaling method is very difficult and often impossible. Therefore, diving under these conditions should not be attempted unless the intercom is in good working order. Under these circumstances, if the intercom should fail, the diver should be brought to the surface.

9940.784. DIVING LOG

One attendant should be assigned to stand by the intercom to receive and relay instructions all the time the diver is down. In addition, the intercom attendant may make entries on the diving log. The time entries on the log should be very accurate, as it is from these entries that diving officer determines the proper decompression time for the diver.

9940.785. TENDING THE LINES

1. In tending the diver's lines, the tender should make certain that the lines are not held too taut, otherwise the diver will find himself continually being pulled away from the work. In attending the life line and air hose, the diver should be given 2 or 3 feet of slack when he is on the bottom, but not so much that he cannot be felt from time to time.

2. If the combined life line and air hose becomes turned around the descending line, it may become impossible to send or receive signals by this means and the turns must be taken out as soon as they are noticed. If, after a trial, they cannot be cleared, the diver should be hauled up. It may become necessary to haul the diver up along with his descending line and weight. In this event, if the weight is too heavy, the diver must try to cut it adrift and time should be given him for this purpose. Because of the possibility of his lines becoming fouled around another line, a diver ordinarily should not be permitted to descend on a line he cannot cut. However, on occasions it may be imperative or highly desirable to use a steel rope or chain. The selection of the descending line to be used is left to the judgment of the officer or diver in charge.

9940.786. CONDITIONS INDICATING DIVER'S LOCATION AND OPERATION

1. The tender very definitely can use the bubbles rising to the surface to assist in determining how the diver is faring. The bubbles give an indication of the diver's movements on the bottom; and the tender, having a knowledge of the work to be done, can generally tell whether the diver is proceeding satisfactorily. If the diver is searching and the mass of bubbles appearing on the surface seems to be moving in a somewhat definite pattern, or if a job requires the diver to stand in one spot and the bubbles come to the surface in one small area, it is reasonable to assume the diver is proceeding safely.

2. In addition to the above, it is possible to determine where and how the diver is doing by the following methods which are briefly described.

a. The operation of a pneumatic drilling machine can be detected by feeling the supply air hose at almost any point due to the peculiar variation of pressure within the hose when the machine is actually running.

b. The operation of a pneumatic hammer can be detected in the same manner. When divers are working with pneumatic hammers or with hand hammers and chisels of fairly large size, it also is possible to hear every blow that is made by listening in the after hold of the salvage vessel.

c. The operation of an arc torch can be detected by observing the ammeter connected in series with it.

d. The operation of a gas torch may be detected by the flow of gas past the reducing valves that is indicated on adjacent gages. Also, when the torch is lit the noise almost invariably can be heard over the telephone of the diver who is operating it and the large bubbles of gas from the torch break on the surface and emit small bubbles of smoke.

9940.787. PRECAUTIONS TO PREVENT DIVER'S FALLING

Whenever a diver is working clear of the bottom, as on a ship's deck or on a stage under a ship, the attendant should take all necessary precautions to prevent his falling. If under certain conditions it was noted that the bubbles were moving rapidly in a straight line, it would indicate that the diver had fallen. In this event, tightly grip all lines and quickly gather in the slack until the descent is checked, and then determine the diver's condition. In any case where there is danger of a fall, a tight hold should be kept on the diver's lines and a minimum amount of slack left out.

9940.788. EMERGENCY ASCENT

1. In bringing the diver to the surface, the tender shall make certain that the rate of ascent does not normally exceed 60 feet per minute. In case of accident or emergency, it may be necessary to get a diver to the surface as rapidly as possible despite the possibility of decompression sickness. Examples of this might be evidence that the diver is in immediate or imminent danger of blowing up or that the diver is unconscious or in extreme distress. Under these conditions the speed of the ascent will depend on:

a. Nature of the accident or emergency.

b. Depth and length of exposure at which the diver has been working.

c. The proximity of a recompression chamber ready for immediate use.

2. In any case, when the diver fails to answer his signals, the procedures outlined in chapter 1.6, para. 16 of NAVSHIPS 250-534 should be employed. These procedures also are applicable for other emergencies.

3. If a diver loses his distance line and cannot locate his descending line, it becomes necessary for his attendant to pull him up and not waste time searching for the descending line. The attendants should always keep the diver ascending very slowly until he reaches the decompression stage. The tender should cease hauling in the line if it is found that the diver is becoming too light, but continue to take in all slack of the life line. Trouble in this respect may be experienced when the diver is unconscious or helpless. The diver should not be brought up beyond his first stop as indicated by the decompression tables. As the diver reaches this stop, he may be worked over to the decompression stage and if he is conscious, no trouble will be experienced in landing him on it. If it is impossible for the diver to find his descending line or the stage after reaching the first stop, the standby diver should be sent down the descending line while holding the first diver's lifeline and air hose in the loop of his arm until the situation is corrected.

9940.789. MAINTENANCE OF AIR SUPPLY EQUIPMENT

1. One of the most important duties of the tender is to ensure that the machinery used for furnishing compressed air is maintained in satisfactory operating condition. Personnel having a knowledge of air compressors or similar equipment shall be placed in charge of the air system.

2. The portable gas-driven air compressor is the most widely used means of furnishing air for diving operations. While gas-driven compressors have replaced the hand-operated pump due to the limited pump capacity and the large number of men required for its operation, it should be remembered that the compressors are subject to a greater degree of mechanical failure than the hand pump. It shall be the tender's responsibility to see that the compressor is prepared properly for use—check lubrication, ensure that the compressor and engine are properly cooled, that the exhaust fumes are not carried over to the compressor intake, secure the unit to the deck in as near a horizontal plane as possible, make connection between air hose and compressor, etc. After the compressor has been prepared, it should be started and running smoothly before any attempt is made to put a diver over the side. If for any reason the compressor will not operate satisfactorily or should the compressor give any indication of developing trouble, diving operations should cease immediately.

3. In cases where air flasks are used, the tender shall check the valves, gages, reducers, pipe connections, and air-hose connections to determine that everything is in satisfactory condition. Before diving is undertaken, calcu-

lation shall be made to determine whether there is adequate air in the flasks for the diver and to provide for emergencies that may arise.

9940.801. INTRODUCTION TO DIVING REPORTS

The reports and records outlined herein are designed to overcome certain inadequacies in the method of logging diving operations. On the assumption that the diver is the most immediately concerned with his own career, the responsibility for preparation and retention of most of the records is placed on him. The responsibility for a high overall standard of completeness and accuracy rests progressively on the diving supervisor, the diving officer and the personnel and commanding officers.

9940.802. DIVING RECORD SYSTEM

1. There are four objectives to be attained in the establishment of an adequate diving record system. These four objectives are:

a. Establish a satisfactory command and operational record.

b. Authorize disbursements of special pay.

c. Establish a personal record.

d. Provide data for analysis.

2. The command record of the first objective may be described as a standardized record prepared in accordance with established military practice. Such a record is the normal minimum required when life is risked. It tends to ensure proper operational procedures. It promotes safety and safe practices.

3. The authorization of disbursements in the second objective is the normal requirement that the disbursing officer be furnished adequate instructions to permit proper disbursements. There is a tangible and distinct difference between the responsibility of the disbursing officer for the disbursement of funds and that of the commanding officer for the justification of disbursement authorizations. The disbursing officer is responsible for ensuring that the disbursement authorizations presented to him contain certifications required by law. The commanding officer is responsible that the operations in fact are correct as certified.

4. The establishment of a personal record in the third objective is an effort to promote esprit de corps and personal pride. By imposing a certain responsibility on the individual, he becomes more aware of the existence of the record and of the benefit of a good record. The long, arduous, unrewarded dives amass an experience level that is, in itself, rewarding. The diving supervisor and diving officer are provided with an assessment factor to assist in the assignment of difficult diving jobs.

5. The fourth objective, to provide data for analysis, is the least tangible of the four objectives. The expense of diver training and the mission of the Experimental Diving Unit to develop diving equipment and techniques do merit a measure of surveillance effort. The procedure designed to meet this objective requires a minimum effort.

9940.803. COMPONENTS OF THE SYSTEM

1. The components established to meet the objectives outlined in art. 9940.991 are:

a. Diving Log Book, NAVSHIPS 1000 (Rev. 11-57) (fig. 9940–108 is a sample page).

b. Record of Dive form (fig. 9940–109).

c. Diving Duty Summary form (fig. 9940-110).

d. Report of Decompression Sickness and all Diving Accidents: (NAVMED-816 (Rev. 2-56) (figs. 9940–111 and 9940–112)).

2. In general, these components satisfy the parallel objectives. The Record of Dive Form (NavPers-2540) is to be used exclusively for the individual's personal diving record; also, the activity diving logs and accident report form ultimately provide data for analysis.

9940.804. DIVING LOG BOOK

1. The Diving Log Book, NAVSHIPS 1000 (Rev. 11-57) is a bound book of individual dive sheets. In use, it is similar to the Quartermaster's Notebook and the Rough Deck

(Name, last, first, middle) (Service No.)

RANK/RATE	CLASS OF DIVER	GEOGRAPHICAL LOCATION

1. DIVE	DATE	DEPTH FT	BOTTOM TIME MIN		
2 DIVING COND	WATER DEPTH FT	WATER TEMP °F	CURRENT KTS	TYPE BOTTOM	BOTTOM VISIBILITY FT

3 TYPE WORK (None, mild, moderate, heavy)

4 EQUIPMENT ☐ DEEP SEA ☐ HEL-OXYGEN ☐ MASK ☐ SCUBA (Open) ☐ SCUBA (Closed) ☐ OTHER ____

5. BR MED.	AIR	HELIUM %	OXYGEN %	NITROGEN %	6 SOURCE OF BREATH MEDIUM	☐ AIR BANKS ☐ HEO BANKS ☐ COMP

7 REPETITIVE NO-DECOMP DIVES

	1	2	3	4
TIME OUT				
TIME IN				
TIME (Min.)				
DISTANCE (Yards)				
AIR OUT (PSI)				
AIR IN (PSI)				
AIR USED (Cu. feet)				
MAX DEPTH (Feet)				
☐ SUIT USED	BOT VOL (Cu. ft.)	TOT TIME (Min.)	TOT DIST (Yds.)	
10 TOTAL TIME OF DIVE(S)	THIS/THESE MIN	CUMULATIVE HRS MIN		

8 DECOMP TABLE

STD	SURFACE AIR	SURFACE OXYG	HEO	SCHEDULE FT/PP	SCHEDULE MIN
LEFT SURF	REACH D BOT	LEFT BOT	SURF D	ASC TO 1st STOP (Ft./Min.)	
If surface decomp. used, time from last water to first chamber stop				MIN	

9 DECOMPRESSION STOPS (Record additional stops in 12)

DEPTH	WATER MIN	WATER BR MED	CHAMBER MIN	CHAMBER BR MED
50				
40				
30				
20				
10				

11 WORK SCHEDULED AND ACCOMPLISHED

12 REMARKS

DIVING SUPERVISOR (Rank/rate) DIVING OFFICER

U. S. GOVERNMENT PRINTING OFFICE

FIGURE 9940–108.

Log combined. It provides a continuous and permanent official record and its maintenance by Naval commands authorized to conduct diving operations is mandatory.

2. The purpose of the **Diving Log Book** is primarily to establish a satisfactory and permanent command record of diving operations and secondarily to provide data for subsequent analysis.

The first purpose tends to ensure proper and safe operational practices as well as to aid in administration and disbursing of diving in the command.

The second purpose enables the Experimental Diving Unit to maintain a final and overall survey of Naval diving to better carry out its mission of development and improvement of diving procedures.

3. To obtain full benefit from this log and to maintain it properly, the diving supervisor must record entries as they occur at the scene of diving operations. These entries should be printed ligibly and without erasure. If required by the number of diving locations, by clerical requirements, or other valid reason, more than one log may be used. If this is done give each a suitable designation.

4. Most entries are self-explanatory. Amplifying remarks for others are listed below:

Block 1.—"Bottom time" is the elapsed time between leaving the surface in descent and leaving the bottom in ascent. It is used only to select the proper decompression schedule. The time of dive for pay and other purposes includes bottom, ascent time, decompression time, and time required to return to the surface and to the surface crew's care.

Block 5.—If breathing air, so indicate. If breathing other gases indicate percentages.

Block 7.—This block is printed for convenience in scuba diving but it can be used equally well with surface-supplied equipment. Use it when a diver makes one or more "no decompression" dives within a 12 hour period. Buddy pairs may be recorded on the same sheet if they make the same dive or the same series of repetitive dives. "Time out" and "time in" refer to times of entering and leaving the water. Entries for "distance," "air used," "bottle volume," and "total distance" are not mandatory but are included for convenience in certain self contained diving operations.

Block 8.—Do not record more than one dive requiring decompression on the same sheet.

Block 9.—Record any decompression stops deeper than 50 feet in spaces provided and on back of form as necessary.

Block 11.—Specify the purpose of the dive and whether or not the job was completed.

Block 12.—This section may be used to amplify any information listed elsewhere on the page and to record any unusual features of the dive. Computations for repetitive dives requiring decompression may also be made in this section. (Note Art. A-4202, BuPers Manual.)

5. Diving Log Book is distributed by:
Officer in Charge
U. S. Navy Experimental Diving Unit
U.S. Naval Station Annex
Washington 25, D. C.

6. One initial copy is distributed to each **nondiving** activity and two to each **diving** activity. (See latest revision of OPNAV Instruction 9940.1.) One initial copy is also distributed to each shore activity having a diving capability.

7. Retain completed Diving Log Books in the command's files for four years from the date of the last entry involving special pay. At that time forward the log to the Experimental Diving Unit.

9940.805. RECORD OF DIVE FORM

1. The Record of Dive form (NavPers-2540) is to be used exclusively for the individual's personal diving record until such time as current stocks are exhausted.

2. The format for regulations relating to the right of members to special pay for the performance of diving duty is outlined in SECNAV NOTICE 7220 of 18 August 1961 and subsequent notices, and will be included in forthcoming changes to the Bureau of Naval Personnel Manual and Volume 4 of the Navy Comptroller Manual.

3. Upon completion of training at an authorized diver training activity, an entry under Administrative Remarks (page 13) of the individual's service record will be made stipulating depth to which authorized to dive and period of qualification. Additional entries will be made upon each requalification showing period of diver's qualification.

9940.806. THE DIVER'S LOG BINDER

1. A Diver's Log binder is issued to each graduate of the U. S. Naval School, Deep Sea Divers. It is his personal property. The binder serves as a depository for his personal copies of the Record of Dive forms and the Diving Duty Summary forms.

2. Training activities other than the Diving School should present suitable binders to divers of any designation qualified by them. Divers already qualified on promulgation of this article may use a file folder to hold their forms.

3. The binder and its contents are available to the diving supervisor to assist him in the detailing of divers. Each diver is responsible for maintaining his own records and for presenting his binder on each new assignment to diving duty. Each command may establish its own system for assisting the divers in keeping their records current and for providing proper stowage.

4. The Diver's Log is an official record and may be used for such purposes as determining the experience of divers and for comparing the relative experience of several divers. Ultimately the Log will be valuable when considering recommendation of a diver, first class for advancement to master diver.

9940.807. DIVING DUTY SUMMARY FORM

1. Along with the log binder, each graduate of the Diving School is presented with two copies of a Diving Duty Summary Form. The initial entries recording qualification and the issuance of the log binder are completed and signed prior to presentation. The original is placed in the Diver's Log binder and the duplicate copy is placed in his service record.

2. Training activities other than the Diving School should prepare similar forms for presentation to divers of any designation qualified by them. Commands having divers assigned should prepare forms for those divers already qualified on promulgation of this article. Those divers should estimate, to the best of their abilities from available records, prior diving experience and enter that information on the form for each former duty station. These entries may be certified by the diver's signature.

3 It is then the diver's responsibility to ensure that both copies of the form are maintained current with each permanent assignment to diving duty or with each assignment to requalification diving. Just prior to detachment, he must sum up in his copy all of the diving he has performed. It must then be turned in to the ship's office for transcription in the duplicate copy. Both copies must then be signed by the commanding officer or his authorized representative before the diver is transferred. The signature on the diver's copy signifies that the command approves his record and that it has been transcribed to the official copy.

4. This form, when properly filled out, represents a complete record of the diver's diving career. Each line entry represents a permanent assignment to diving duty. It includes all temporary additional duty assignments made within the permanent assignment period. One line may thus represent several years' service on board one command.

5. On failure to retain diving qualification, or on final separation from active duty, the form must be completed and the duplicate forwarded to the Officer in Charge, U.S. Naval School, Deep Sea Divers, U.S. Navy Yard Annex, Washington 25, D.C.

6. Primarily, this record is for the benefit of the Diving School and the Experimental Diving Unit. It provides a source of data to compare against the Reports of Decompression Sickness and all Diving Accidents (NAVMED-816). The knowledge of the amount of diving performed by various units of the fleet, gained by analysis of this record, enables EDU to improve its support of the diving field. It is also a method to keep interested persons in the Navy Department informed of the use and disposition of trained divers. As a final summary, it becomes the record of the individual's diving career.

7. Duplicate Diving Duty Summaries and Divers Log binders may be requested from the Diving School when the original is verified lost or destroyed or when the individual re-enlists after broken service.

8. An individual who is retrained and redesignated at at the Diving School after his previous qualification has lapsed is issued a new Diving Duty Summary. It must be the objective of all concerned to reduce to an absolute minimum the occasions requiring this retraining and redesignation.

9940.808. REPORT OF DECOMPRESSION SICKNESS AND ALL DIVING ACCIDENTS

1. The Report of Decompression Sickness and all Diving Accidents (NAVMED-816) rounds out the system of diving reports. It provides data for analysis concerning the safety of decompression tables and the effectiveness of treatment procedures. It also supplies much valuable information concerning diving hazards of all kinds. Analysis of the reports plays an important role in the continual effort to improve diving practices and increase the safety of diving as a whole.

2. Reporting of the following types of accident is considered mandatory:

a. Cases of decompression sickness requiring treatment; all cases of air embolism.

b. All episodes of convulsion or serious impairment of consciousness during or after a dive, regardless of cause or outcome.

c. Every accident that occurs during the course of a diving operation and results in death, serious injury, or more than brief incapacitation of the victim.

d. Any serious mishap during the course of a dive (i.e., blowup, squeeze, fouling of more than brief duration, failure of scuba requiring free ascent from significant depth) even though the diver escapes actual injury.

e. Any event or aftermath of a dive which requires medical treatment beyond simple first-aid or routine measures.

3. Since the basic purpose of NAVMED-816 is to increase the overall safety of all aspects of diving operations, it is considered highly desirable to report **any** happening or observation that calls attention to a potential hazard or can otherwise contribute to safe practices. In this sense, for example, the report of a narrow escape from a serious accident under unusual circumstances would be of as much value as a report of a fatal accident of the same nature. It also is extremely desirable to report such observations as, for example, an unusual number of cases of a particular type of respiratory infection among a group of divers or some peculiar set of symptoms appearing frequently with a certain type of equipment. It is only through such reporting that a new problem can be recognized early and steps taken to deal with it. (In some instances, as for example when a similar condition has been observed in a number of individuals, it may be more convenient to prepare a letter-report than to utilize NAVMED-816 itself; but the same basic instructions and distribution should be observed.)

4. The cognizant medical officer (normally the medical officer who treats the victim of the accident concerned) is responsible for preparing the report. If no medical officer is attached to the activity or present at the time of the accident or treatment, the medical department representative (hospital corpsman) concerned must prepare and sign it. In this case, the report should also bear the signature of the cognizant medical officer, if any, with indication of his approval and/or comments. Where no medical officer or corpsman is present or directly concerned, preparation of NAVMED-816 becomes the responsibility of the diving officer.

5. The report-form itself is largely self-explanatory. Any information not adequately covered by the spaces provided should be detailed under "remarks." Enough information should be provided to permit anyone reading the report to obtain a clear picture of the accident, circumstances, treatment, and outcome.

Approved by
Comptroller General, U. S.
Dec. 17, 1957

RECORD OF DIVE

NAME (*Last, first, middle*)	SERVICE NO.	RANK/RATE	CLASS OF DIVER
SHIP OR STATION	GEOGRAPHICAL LOCATION		

1. DIVE

DATE	DEPTH	BOTTOM TIME
	FT.	MIN.

2. DIVING CONDITIONS

WATER DEPTH	WATER TEMP.	CURRENT	TYPE OF BOTTOM	BOTTOM VISIBILITY
FT.	°F	KTS		FT.

3. TYPE OF WORK

☐ NONE ☐ MILD ☐ MOD-ERATE ☐ HEAVY

4. TYPE OF EQUIPMENT

DEEP SEA	HEL.-OXYGEN	MASK	SCUBA (*Type circuit*)	OTHER

5. BREATHING MEDIUM

AIR	HELIUM	OXYGEN	NITROGEN
	%	%	%

6. SOURCE OF BREATHING MEDIUM

☐ AIR BANKS ☐ HEO_2 BANKS ☐ COMPRESSOR

7. REPETITIVE NO-DECOMPRESSION DIVES

NO.	TIME OUT	TIME IN	TIME (MIN.)	DISTANCE (YDS.)	AIR OUT (PSI)	AIR IN (PSI)	AIR USED (CU. FT.)	MAXIMUM DEPTH (FT.)
1								
2								
3								
4								

SUIT USED

BOTTLE VOLUME — CU. FT.

TOTAL TIME — MIN.

TOTAL DISTANCE — YDS.

IF SURFACE DECOMPRESSION USED, TIME FROM LAST WATER STOP TO FIRST CHAMBER STOP. — M'

8. DECOMPRESSION TABLE

STANDARD	SURFACE AIR	SURFACE OXYGEN	HEO2	SCHEDULE FT. OR P.P.	SCHEDULE MIN.	LEFT SURFACE	REACHED BOTTOM	LEFT BOTTOM	SURFACED	RATE OF ASCENT TO FIRST STOP
										FT/MIN

9. DECOMPRESSION STOPS

DEPTH OF STOP	WATER MIN. AT STOP	WATER BREATH'G. MED.	CHAMBER MIN. AT STOP	CHAMBER BREATH'G. MED.
50				
40				
30				
20				
10				

11. BRIEF OF WORK PERFORMED

12. REMARKS

10. TOTAL TIME OF DIVES	THIS/THESE DIVE(S)	CUMULATIVE		SIGNATURE OF DIVING OFFICER
	MIN.	HRS.	MIN.	USN

SUBSTANTIATION

TO DISBURSING OFFICER: As provided by law and regulations, the disbursing officer is authorized and directed to adjust the pay record of the above named individual for the reason and the period indicated.

SPECIAL PAY

FOR ☐ DIVING DUTY — DUTY IS ☐ ASSIGNED ☐ TERMINATED — EFFECTIVE DATE — QUALIFIED AS — LAPSING DATE

☐ DIVING TIME ☐ DIVES OF MORE THAN 120 FEET ☐ ACTUAL SALVAGE OR REPAIR OPERATIONS (BUPERS MANUAL ART.) 4202*

If less than 90 ft., indicate the extraordinarly hazardous conditions that existed by inserting (3) or (2) (a), (b), etc.*

INCENTIVE PAY

DUTY INVOLVING TRAINING

☐ OF DIVERS AT NAVSCOL DEEP SEA DIVERS OR AT USN EXPERIMENTAL DIVING UNIT

☐ IN METHODS OF ESCAPE FROM SUBMERGED SUBMARINE (Training Tank)

DUTY INVOLVING

☐ BREATHING HELIUM-OXYGEN MIXTURES DURING DEEP SEA DIVING

DUTY IS ☐ ASSIGNED ☐ TERMINATED ☐ SUSPENDED ☐ RESTORED — EFFECTIVE DATE

☐ DIVE PERFORMANCE REQUIREMENTS IN CONNECTION WITH HELIUM-OXYGEN INCENTIVE PAY COMPLETED FOR PERIOD— TO

COMMANDING OFFICER* (*Signature, rank, title*)	C. O. ORDER NO.	D. O. SYMBOL NO.	DATE

NAVPERS 2540/NAVCOMPT 2039 (New 10-57)
PART 1 — DIVER'S LOG

*When pay is for dives of less than 90 feet and Art. 4202(3) is cited, the personal signature of the commanding officer is required.

FIGURE 9940–109.

DIVING DUTY SUMMARY

QUALIFICATIONS	DATE	CERTIFYING OFFICER	DIVER'S LOG BINDER ISSUED
SCUBA DIVER			ACTIVITY
DIVER SECOND CLASS			DATE
SALVAGE DIVER			DUPLICATE BINDER ISSUED
DEEP SEA DIVER			ACTIVITY
DIVER FIRST CLASS			DATE
MASTER DIVER		AUTHORITY BUPERS LTR. SERIAL OF	REASON

ASSIGNED TO DIVING DUTY		TOTAL DIVES							DETACHED	
		DEEP SEA		LIGHT-WEIGHT	SCUBA					
SHIP OR STATION	DATE	AIR	HEO2		AIR	O2	N_2 O_2	HEO2	DATE	CERT. OFFICER

FORM COMPLETED AND FORWARD TO US NAVAL SCHOOL DEEP SEA DIVERS

C.O. SIGNATURE DATE

☐ ON SEPARATION FROM SERVICE

☐ QUALIFICATION REVOKED (GIVE REASON)

DIVER'S NAME (LAST, FIRST, MIDDLE)	SERVICE NO	RANK OR RATE	BRANCH & CLASS

FIGURE 9940–110.

REPORT OF DECOMPRESSION SICKNESS AND ALL DIVING ACCIDENTS
NAVMED-816 (REV. 2-56)

ORIGINAL - TO BUMED, WASHINGTON, D. C.
COPY - TO EXP. DIVING UNIT, NAVAL GUN FACTORY, WASH., D. C.

REPORTS SYMBOL: MED-6420-1

NAME AND ADDRESS OF REPORTING STATION	DATE

NAME OF PATIENT *(Surname first)*	IDENTIFICATION NUMBER

AGE	WEIGHT	HEIGHT	BUILD *(Check one)*				DIVING QUALIFICATIONS *(Check one)*										
			SLENDER	MED.	HEAVY	OBESE	MAST	1/c	SAL.	D.S.	2/c	UDT	EOD	UWS	STU	(OTHER)	
YRS.	LBS.	INS.															

RECORD OF ALL DIVES MADE DURING THE TWELVE HOURS PRECEDING THE ACCIDENT
(If more than three dives were made, record additional under "REMARKS" on reverse.)

FIRST DIVE					SECOND DIVE					THIRD DIVE				
TYPE OF DIVE		DEPTH OF DIVE	BOTTOM TIME		TYPE OF DIVE		DEPTH OF DIVE	BOTTOM TIME		TYPE OF DIVE		DEPTH OF DIVE	BOTTOM TIME	
WET	DRY	feet	min.		WET	DRY	feet	min.		WET	DRY	feet	min.	
TYPE OF EQUIPMENT					TYPE OF EQUIPMENT					TYPE OF EQUIPMENT				
DEEP SEA	DEEP SEA HELIUM	OPEN CIRCUIT SCUBA	CLOSED CIRCUIT SCUBA	SHALLOW WATER MASK / OTHER	DEEP SEA	DEEP SEA HELIUM	OPEN CIRCUIT SCUBA	CLOSED CIRCUIT SCUBA	SHALLOW WATER MASK / OTHER	DEEP SEA	DEEP SEA HELIUM	OPEN CIRCUIT SCUBA	CLOSED CIRCUIT SCUBA	SHALLOW WATER MASK / OTHER
TYPE OF WORK					TYPE OF WORK					TYPE OF WORK				
NONE	MILD	MODERATE	HEAVY		NONE	MILD	MODERATE	HEAVY		NONE	MILD	MODERATE	HEAVY	
BREATHING MEDIUM					BREATHING MEDIUM					BREATHING MEDIUM				
AIR	HELIUM % OXYGEN %	OXYGEN	OTHER *(Specify)*		AIR	HELIUM % OXYGEN %	OXYGEN	OTHER *(Specify)*		AIR	HELIUM % OXYGEN %	OXYGEN	OTHER *(Specify)*	
SOURCE OF BREATHING MEDIUM					SOURCE OF BREATHING MEDIUM					SOURCE OF BREATHING MEDIUM				
AIR BANKS	HELIUM-OXYGEN BANKS	GASOLINE COMPRESSOR	OTHER		AIR BANKS	HELIUM-OXYGEN BANKS	GASOLINE COMPRESSOR	OTHER		AIR BANKS	HELIUM-OXYGEN BANKS	GASOLINE COMPRESSOR	OTHER	
DECOMPRESSION SCHEDULE					DECOMPRESSION SCHEDULE					DECOMPRESSION SCHEDULE				
STANDARD	SURFACE USING AIR / OXYGEN	HE. DECOMPR. P.P.	TABLE USED MIN.		STANDARD	SURFACE USING AIR / OXYGEN	HE. DECOMPR. P.P.	TABLE USED MIN.		STANDARD	SURFACE USING AIR / OXYGEN	HE. DECOMPR. P.P.	TABLE USED MIN.	
TIME LEFT SURFACE	TIME REACHED BOTTOM	RATE OF ASCENT TO FIRST STOP FT/MIN	TIME REACHED SURFACE		TIME LEFT SURFACE	TIME REACHED BOTTOM	RATE OF ASCENT TO FIRST STOP FT/MIN	TIME REACHED SURFACE		TIME LEFT SURFACE	TIME REACHED BOTTOM	RATE OF ASCENT TO FIRST STOP FT/MIN	TIME REACHED SURFACE	
If surface decompression used, time from last water stop to 1st chamber stop. MIN.					*If surface decompression used, time from last water stop to 1st chamber stop.* MIN.					*If surface decompression used, time from last water stop to 1st chamber stop.* MIN.				

DEPTH OF STOP *(feet)*	WATER		CHAMBER		DEPTH OF STOP *(feet)*	WATER		CHAMBER		DEPTH OF STOP *(feet)*	WATER		CHAMBER	
	MINUTES AT STOP	BREATHING MEDIUM	MINUTES AT STOP	BREATHING MEDIUM		MINUTES AT STOP	BREATHING MEDIUM	MINUTES AT STOP	BREATHING MEDIUM		MINUTES AT STOP	BREATHING MEDIUM	MINUTES AT STOP	BREATHING MEDIUM
210					210					210				
200					200					200				
190					190					190				
180					180					180				
170					170					170				
160					160					160				
150					150					150				
140					140					140				
130					130					130				
120					120					120				
110					110					110				
100					100					100				
90					90					90				
80					80					80				
70					70					70				
60					60					60				
50					50					50				
40					40					40				
30					30					30				
20					20					20				
10					10					10				

FIGURE 9940–111.

SIGNS AND SYMPTOMS BEFORE TREATMENT				
	ONSET		ANATOMICAL LOCATION	INTENSITY (MILD, MOD., SEVERE)
	DATE	TIME		
LOCALIZED PAIN				
RASH				
MUSCULAR WEAKNESS				
NUMBNESS				
DIZZINESS				
VISUAL DISTURBANCES				
PARALYSIS				
UNCONSCIOUSNESS				
DYSPNEA (CHOKES)				
NAUSEA OR VOMITING				
MUSCULAR TWITCHING				
RESTLESSNESS				
CONVULSIONS				
ACOUSTIC AURA				
PARESTHESIA				

REMARKS: *(other signs and symptoms before, during and following treatment)*

TREATMENT SCHEDULE					
LEFT SURFACE		RELIEF		TIME REACHED BOTTOM	
DATE	TIME	TIME	DEPTH		
TIME ON BOTTOM		REACHED SURFACE		TREATMENT TABLE USED	
MIN.		DATE	TIME		

DEPTH OF STOP		CHAMBER *(Stops filled in only when treatment table 3 or 4 is used or when other treatment tables are altered)*	
FEET	LBS	MINUTES AT STOP	BREATHING MEDIUM
165 *	73.4		
140	62.3		
120	53.4		
100	44.5		
80	35.6		
60	26.7		
50	22.3		
40	17.8		
30	13.4		
20	8.9		
10	4.5		
TO SURFACE			

RECURRENCE TREATMENT SCHEDULE					
LEFT SURFACE		RELIEF		TIME REACHED BOTTOM	
DATE	TIME	TIME	DEPTH		
TIME ON BOTTOM		REACHED SURFACE		TREATMENT TABLE USED	
MIN.		DATE	TIME		

DEPTH OF STOP		CHAMBER *(Stops filled in only when treatment table 3 or 4 is used or when other treatment tables are altered)*	
FEET	LBS	MINUTES AT STOP	BREATHING MEDIUM
165	73.4		
140	62.3		
120	53.4		
100	44.5		
80	35.6		
60	26.7		
50	22.3		
40	17.8		
30	13.4		
20	8.9		
10	4.5		
TO SURFACE			

REMARKS: *(Include sequence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors – Use continuation sheet if needed)*

SIGNATURE OF MEDICAL DEPARTMENT REPRESENTATIVE

FIGURE 9940-112.

6. Prepare and submit NAVMED-816 at once unless the victim has residual symptoms and the final outcome remains in doubt. In such a case, prepare the body of the report immediately but delay completion and submission **(not longer than 30 days)** to permit the actual or probable end-result to be specified with reasonable accuracy. Where submission is delayed, be sure that the report is not neglected. If the outcome remains uncertain as long as 30 days following the accident, submit the report with appropriate notations including the patient's condition at that time, medical opinion concerning probable course, and hospital to which patient was transferred (or other disposition). In such cases, supply a follow-up letter-report at a later date whenever possible.

7. Send the original of NAVMED-816 to the Bureau of Medicine and Surgery (Attn: Code 75), Navy Department, Washington 25, D.C. Send a legible copy to the Experimental Diving Unit, U.S. Navy Yard Annex, Washington 25, D.C. (Retention of a copy in the files of the diving activity is recommended.)

9940.809. DIVING SAFETY

1. From the time diving operations are first planned the thoroughness with which the tenders understand and carry out their duties will, to a considerable extent, determine the success or failure of the operation and the safety of the diver. The most effective assistance can be given by the tender who is familiar with the equipment, safety precautions, conditions, and difficulties that are inherent in diving. It is preferable that the tenders be experienced divers. If this is not possible, the diving officer is responsible that personnel designated as tenders are properly instructed in the topside duties. It is the tender's responsibility and duty to ensure that the diver receives proper care while topside and in the water. Before sending the diver down, he must thoroughly check all equipment for proper operation.

2. Generally, the topside duties are divided into handling communications, tending lines, and ensuring an adequate flow of air. The usual means of communication between diver and tender is by intercom. However, it is important that the basic hand signals listed in the preceding paragraphs, plus any supplementary signals originated to fit a particular type of job, be memorized and practiced so that they will be recognized instantly in the event of intercom failure or when using gear not fitted with an intercom.

3. The tender must always keep himself informed as to the depth of the diver. Inasmuch as fathometers, lead lines, descending lines, stage lines, or payed out lifeline and air hose cannot be used to determine depth with accuracy, a simple and accurate device called a pneumofathometer has been developed. Depth is determined by means of an air supply, a depth gage calibrated in feet of sea water, and an oxygen hose. This oxygen hose is made up with the diver's lifeline and air hose, the open end terminating at about the breastplate level. In self contained diving it may be hung off on a weight. To take a reading, blow air through the hose until it escapes at the open end, then secure the air supply. The pressure remaining in the oxygen hose is that necessary to balance a column of water corresponding to the depth of the open end of the hose and is read directly on the gage in feet. While the diver is standing, add 5 feet to determine bottom depth. This device is especially valuable in determining decompression stops during ascent when the diver has been swept from the descending line.

4. The tender should contact the diver frequently by intercom or hand signal while the diver is on the bottom and on the stage to ascertain if all is well. The tender must give the diver a few minutes' notice before the expiration of the diver's times on the bottom so that the diver can make the necessary preparation prior to his ascent and not exceed the limit of his stay on the bottom.

5. The diving officer or supervisor must appoint a qualified diver as timekeeper. The timekeeper must keep an accurate record of time required for the diver to reach the bottom, the depth of dive, the time of exposure on the bottom, the time of ascent to the first stop, and the time spent at each subsequent stop during the ascent. This data must be carefully kept and recorded in the diving log. (see fig. 9940–128). The time-keeper must at all times have the Navy Standard Decompression Tables at hand and be prepared to advise the diving supervisor or tenders at any moment what decompression procedure should be used. In case of any doubt or borderline determinations of decompression procedure, he must decide in the diver's favor (i.e., choose the next deeper table or next longer time of dive). If a predetermined bottom time has been planned for the dive, the timekeeper must be sure to notify the tender and supervisor well in advance so that the diver may be brought up on schedule. No additional duties may be assigned to a timekeeper if they in any way interfere with or distract his attention from his primary duty. He may, however, be assigned such additional duty as observing the diver's air supply pressure. A timekeeper will not normally be required to keep time on more than two divers at once.

6. Before the diver enters the water, the diving supervisor must ensure that all equipment is working properly and that the diver knows exactly what he must do. The depth of the water must be accurately determined by lead line or other reliable means. The standby diver or buddy must be ready. Proper preparation or briefing will save considerable time and effort and may make the difference between a successful job and a complete failure. Where a lifeline to the surface is used, the tender also must be properly briefed. An experienced tender can tell a great deal about the diver's progress and problems by the feel of the lifeline. Due to the diver's limited efficiency and time, the job should be planned so that all possible work is done on the surface.

7. Proper procedures for entering the water depend on the equipment used and are covered in the applicable section of this manual. The rule of "look before you leap" applies to all diving. Landing on another diver's head can be painful to all concerned. Before leaving the surface, a final check is made to see that all gear is working properly. All the equipment must be functioning properly before leaving the surface.

8. The descent should be made as rapidly as possible (but not to exceed 75 feet per minute), provided that the

diver is in complete control of the rate of descent. An uncontrolled descent can result in a squeeze, ruptured eardrums, or injury from hitting material on the bottom. The rate of descent will depend on the divers experience, the type of gear worn, the conditions of visibility, and the diver's ability to equalize the pressure in his ears and sinuses. If the pressure is not equalized, continued descent results in a ruptured eardrum. A diver should never continue to descend if he is unable to equalize the pressure. Pain in the ears may be relieved by yawning, swallowing, or blocking the nostrils and making a strong effort to breathe out. Ascending a few feet will also relieve the pain in most cases. If these remedies do not succeed in equalizing the pressure in the ears and relieving the pain, the diver must return to the surface and should not dive again during the same day.

9. After reaching the bottom, but before starting any work, the diver should make any necessary adjustments of his breathing supply and buoyancy to adapt himself to conditions on the bottom. A few minutes spent in considering the work to be done from all angles and planning the method to be used is also necessary. No matter how thorough the topside briefing, the final plan of attack must always be the decision of the diver. An experienced diver can make his work much easier by proper use of his equipment. Forinstance, a deep-sea diver can lift heavy weights on the bottom by hooking his arms under the object to be lifted and holding his chin button. The increase in buoyancy of his suit does most of the work. Specific techniques depend on the equipment used and may be found in the applicable parts of the manual.

10. When working on the bottom, the diver must never become so engrossed in his work that he forgets about his own condition. It is possible to work to the point of exhaustion on the bottom without realizing it. Failing to pay attention to the condition of the air supply may easily result in unconsciousness.

11. After completing his task, the diver prepares to ascend. This may involve sending tools to the surface, final inspection of the job, and clearing any fouled lifeline or air hose. The diver must never ignore the tender's signal to come up. At times it is a strong temptation to remain on the bottom a few more minutes to complete a task, but the tender is aware of conditions which the diver is unable to see for himself and must be obeyed. If the diver is unable to come to the surface due to fouling of lines or any other cause, he should make the situation known to the tender by any possible means. The tender, on the other hand, must never ignore the diver's signal to haul him up. The rate of ascent must be under control at all times. Excess speed of ascent can result in blowing up due to overexpansion of air in the deep-sea outfit. Blowup is a a serious accident.

12. Regardless of the type of equipment, in all dives using the air decompression tables, ascend at the rate of 60 feet per minute. In the event you exceed the 60 feet per minute rate:

a. If no decompression stops are required, but the bottom time places you within 10 minutes of a schedule that does require decompression; stop at 10 feet for the time that you should have taken in ascent at 60 feet per minute.

b. If decompression is required; stop at 10 feet below the first listed decompression depth for the time that you should have taken in ascent to the first stop at 60 feet per minute.

13. In the event you are unable to maintain the 60 feet per minute rate of ascent:

a. If the delay was at or near the bottom; increase the bottom time, by the difference between the time used in ascent and the time that should have been used at the rate of 60 feet/minute. Decompress according to the requirements of the total bottom time. This is the safer procedure.

b. If the delay was near the surface, increase the first stop by the difference between the time used in ascent and the time that should have been used at the rate of 60 feet per minute.

NOTE.–When employing the table for **surface decompression using oxygen,** a rate of ascent of **25 feet per minute** must be used.

14. The necessity for decompression depends upon the time and depth of dive. Particularly cold dives and those involving exceptionally hard work require additional decompression. Careful planning of bottom time and decompression time is necessary, particularly where the air supply is limited, as in the case of the scuba diver. A scuba diver must know the required decompression time before he makes his dive and must have a means of keeping track of time and depth. Use a descending line plainly marked at 10 foot intervals for decompression of the scuba diver. For surface-supplied diving, mark the lifeline so that the tender can know the diver's depth. When long decompression stops are necessary, a decompression stage should be used so that the diver may rest while decompressing. When the stage is used, mark the line to the stage to determine the diver's depth.

15. In case of emergency it may be necessary to bring the diver to the surface before he has completed his decompression. In any emergency, it is the responsibility of the diving supervisor to weigh the dangers of decompression sickness against the hazard of remaining in the water. The problem is particularly serious when no recompression chamber is available.

16. The chief danger in surfacing is in coming up under the diving boat or float, with resulting damage to the head. The possibility of injury of this nature exists in all diving but is most serious in self contained. Fortunately, the self contained diver is, in most cases, better able to see what is above him and with reasonable care can avoid injury.

17. After completing a dive, the diver should remain in the vicinity of the recompression chamber or facility for underwater recompression for at least one hour. This time should be extended to twelve hours for any dive requiring decompression.

18. A dive performed within twelve hours of surfacing from a previous dive is a repetitive dive. Limit the equivalent single dive schedule of repetitive dives to

fig. 9940–114. No repetitive dives falling in the limits of fig. 9940–118 are permitted. Nor are repetitive helium-oxygen dives with surface-supplied equipment permitted.

9440.810. GENERAL DIVING TABLES

The tables and procedures outlined herein have been developed to provide safety from the hazards of decompression sickness and oxygen toxicity. At the same time, the tables have been made as efficient as possible so that they will be the least possible hindrance to diving operations.

AIR DECOMPRESSION TABLES

1. The air decompression tables comprise:

a. Decompression Procedures (fig. 9440-113).

b. U.S. Navy Standard Air Decompression Table (fig. 9940-114).

c. "No Decompression Limits and Repetitive Groups" (fig. 9440-115).

d. Surface Interval Credit Table (fig. 9940-116).

e. Repetitive Dive Timetable (fig. 9440-117).

f. Standard Air Decompression Table for Exceptional Exposures (fig. 9940-118).

2. Regardless of the type of diving apparatus, for all dives where air is the breathing medium, use these tables as prescribed.

4. A single dive is the first dive of the day. It is denoted by an exposure to a specific depth in feet for a specific time in minutes. An example would be 134 feet for 14 minutes. The depth is the maximum depth attained. The time is the actual bottom time. Bottom time is the elapsed time between leaving the surface in descent and leaving the deepest depth in ascent. A combination of depth and time listed in the decompression tables is called a dive schedule. All dives are included and covered in the next deeper and next longer schedule. Do not interpolate.

5. Any dive performed within 12 hours of a previous dive is a **repetitive dive.** The period between dives is the **surface interval.** Decompression following a repetitive dive requires special consideration because dissolved inert gas from the previous dive remains in the body at the **beginning** of the repetitive dive.

6. A detailed consideration of all the factors involved would be prohibitively complicated. A simplified and workable solution is based on the degree of saturation of the "120 minute half-time tissue" (Experimental Diving Unit Research Report 6–57 documents the calculations and tests). The basic idea of this approach involves considering the previous dive, the surface interval, and the repetitive dive together as a whole to yield an **equivalent single dive.** For the **depth** of the equivalent single dive, the **actual** depth of the repetitive dive is used. But the **bottom time** is the sum of the actual time plus an additional amount of time to take into account the residual nitrogen from the previous dive and surface interval.

7. Upon surfacing from a dive, the diver is catalogued by fig. 9940-117 or 9940-115 into one of 16 lettered **repetitive groups** in accordance with the amount of inert gas left in his body. During the surface interval the diver loses inert gas and is given "credit" for the loss by means of fig. 9940-116 which shows the change from one group to another for various time intervals on the surface. For every depth of dive, there is a certain time of exposure that would bring the diver to the same degree of saturation as that represented by each repetitive group. This time, based on the residual inert gas from previous dive and surface interval, is called the **residual nitrogen time.** In fig. 9940-117, residual nitrogen time is expressed as a number of minutes for various depths (in 10-foot increments) and for each repetitive group designation. The bottom time of the **equivalent single dive** is then obtained by adding this residual nitrogen time to the actual bottom time of the repetitive dive being considered. The proper decompression for the ascent from the repetitive dive may be found in the Standard Air Decompression Table (fig. 9940-114) by using the actual depth of the repetitive dive and the equivalent single dive bottom time. Successive repetitive dives may be handled similarly.

8. The Standard Air Decompression Table (fig. 9940-114) covers the normal range of diving. The depth limit is 190 feet and the bottom time limit for each depth is approximately 12,000 divided by the depth. This is an arbitrary time, but it is a good maximum for normal practice. Stay within the limits of this table for all routine air dives.

9. Details on the use of the Standard Air Decompression Tables are:

a. Time of decompression stops in the table is in minutes.

b. Enter the tables at the listed depth that is exactly equal to or is the next greater than the maximum attained during the dive.

c. Select the bottom time listed for the selected depth that is exactly equal or is next greater than the bottom time of the dive.

d. Use the decompression stops listed on the line for the selected bottom time.

e. For any repetitive diving, use the repetitive group designation listed on the same line (or if no decompression is required, obtain the repetitive group from fig. 9940-115).

f. Maintain the diver's **chest** as close as possible to each decompression depth for the number of minutes listed.

g. The rate of ascent **between** stops is not critical. Commence timing each stop on arrival at the decompression depth and resume ascent when the specified time has elapsed.

10. Specific examples of the use of the table are:

a. You made a single dive to 82 feet for 36 minutes. You wish to determine the proper decompression procedure: The next greater depth listed in the table is 90 feet. The next greater bottom time listed opposite 90 feet is 40 minutes. The proper decompression procedure is therefore a 7 minute stop at 10 feet in accordance with the 90/40 schedule.

b. You made a single dive to 110 feet for 30 minutes. You know that the depth did not exceed 110 feet. You wish to determine the proper decompression procedure: The exact depth of 110 feet is listed. The exact time of 30 minutes is listed opposite 110 feet. Decompress according to the 110/30 schedule unless the dive was particularly cold or arduous or conditions will prohibit accurate de-

GENERAL INSTRUCTIONS FOR AIR DIVING

Need for Decompression

A quantity of nitrogen is taken up by the body during every dive. The amount absorbed depends upon the depth of the dive and the exposure (bottom) time. If the quantity of nitrogen dissolved in the body tissues exceeds a certain critical amount, the ascent must be delayed to allow the body tissue to remove the excess nitrogen. Decompression sickness results from failure to delay the ascent and to allow this process of gradual desaturation. A specified time at a specific depth for purposes of desaturation is called a decompression stop.

"No Decompression" Schedules

Dives that are not long or deep enough to require decompression stops are "no decompression" dives. Dives to 33 feet or less do not require decompression stops. As the depth increases, the allowable bottom time for "no decompression" dives decreases. Five minutes at 190 feet is the shortest and deepest "no decompression" schedule. These dives are all listed in the No Decompression Limits and Repetitive Group Designation Table for "No Decompression" Dives, ("No Decompression Table" (table 1-6)) and only require compliance with the 60 feet per minute rate of ascent.

Schedules That Require Decompression Stops

All dives beyond the limits of the "No Decompression Table" require decompression stops. These dives are listed in the Navy Standard Air Decompression Table (table 1-5). Comply exactly with instructions except as modified by surface decompression procedures.

Variations in Rate of Ascent

Ascend from all dives at the rate of 60 feet per minute.

In the event you exceed the 60 feet per minute rate:

(1) If no decompression stops are required, but the bottom time places you within 10 minutes of a schedule that does require decompression; stop at 10 feet for the time that you should have taken in ascent at 60 feet per minute.

(2) If decompression is required; stop 10 feet below the first listed decompression depth for the time that you should have taken in ascent at 60 feet per minute.

In the event you are unable to maintain the 60 feet per minute rate of ascent:

(1) If the delay was at or near the bottom; add to the bottom time, the additional time used in ascent. Decompress according to the requirements of the total bottom time. This is the safer procedure.

(2) If the delay was near the surface; increase the first stop by the difference between the time consumed in ascent and the time that should have been consumed at 60 feet per minute.

Repetitive Dive Procedure

A dive performed within 12 hours of surfacing from a previous dive is a repetitive dive. The period between dives is the surface interval. Excess nitrogen requires 12 hours to effectively be lost from the body. These tables are designed to protect the diver from the effects of this residual nitrogen. Allow a minimum surface interval of 10 minutes between all dives. Specific instructions are given for the use of each table in the following order:

(1) The "No Decompression Table" or the Navy Standard Air Decompression Table gives the repetitive group designation for all schedules which may preceed a repetitive dive.

(2) The Surface Interval Credit Table gives credit for the desaturation occurring during the surface interval.

(3) The Repetitive Dive Timetable gives the number of minutes or residual nitrogen time to add to the actual bottom time of the repetitive dive in order to obtain decompression for the residual nitrogen.

(4) The "No Decompression Table" or the Navy Standard Air Decompression Table gives the decompression required for the repetitive dive.

U.S. NAVY STANDARD AIR DECOMPRESSION TABLE

INSTRUCTIONS FOR USE

Time of decompression stops in the table is in minutes.

Enter the table at the exact or the next greater depth than the maximum depth attained during the dive. Select the listed bottom time that is exactly equal to or is next greater than the bottom time of the dive. Maintain the diver's chest as close as possible to each decompression depth for the number of minutes listed. The rate of ascent between stops is not critical. Commence timing each stop on arrival at the decompression depth and resume ascent when the specified time has lapsed.

For example – a dive to 82 feet for 36 minutes. To determine the proper decompression procedure: The next greater depth listed in this table is 90 feet. The next greater bottom time listed opposite 90 feet is 40. Stop 7 minutes at 10 feet in accordance with the 90/40 schedule.

For example – a dive to 110 feet for 30 minutes. It is known that the depth did not exceed 110 feet. To determine the proper decompression schedule: The exact depth of 110 feet is listed. The exact bottom time of 30 minutes is listed opposite 110 feet. Decompress according to the 110/30 schedule unless the dive was particularly cold or arduous. In that case, go to the 110/40, the 120/30, or the 120/40 at your own discretion. (Rev. 1958)

FIGURE 9940–113. (Tables referenced here are in the diving manual and are figs. 9940–118 and 9440–117 of this chapter.)

compression. In any of these cases go to the 110/40, the 120/30 or the 120/40 schedule at your own discretion.

11. The "No Decompression Table" is officially and more accurately titled **"No Decompression" Limits and Repetitive Group Designation Table for "No Decompression" Schedules.** It is a new table required by repetitive diving. It is no longer sufficient merely to know where decompression requirements begin. In repetitive diving you must know the amount of nitrogen remaining in the tissues from any dive, no matter how short or shallow. The repetitive group designations provide that information.

12. Repetitive group designations are given for depths of 10 feet to 40 feet in 5-foot increments and for depths of 40 feet to 190 feet in 10-foot increments. Opposite each depth and each repetitive group is listed the maximum bottom time which will allow the diver to remain within the group. On the assumption that it is the operational limit, the times for 10 to 25 feet end at about 5 hours. From 40 feet on, the times end at the "no decompression" limit.

13. The "no decompression" limits listed in this table for depths of 40 feet and greater are useful in planning operations. The diver may surface directly ("no decompression dive") as long as the bottom time is less than the maximum listed for the depth. For depths not greater than 33 feet, direct surfacing is permissible regardless of the bottom time.

14. Other than the above uses to obtain "no decompression" limits, the only purpose of this table is to provide the repetitive group designation for "no decompression" dives. This knowledge is necessary to make repetitive dives after "no decompression" dives.

15. Details and an example of its use to obtain the repetitive group designations are given directly on the table.

16. The Surface Interval Credit Table is another requirement of the repetitive diving system. It is the real reason for the success and efficiency of the repetitive dive system.

17. The diver continues to lose nitrogen while he is on the surface until he is completely desaturated. This requires 12 hours or more. To provide efficient decompression instructions, it is necessary to know the amount of nitrogen remaining in the tissues at the time a repetitive dive commences. This table provides that information.

18. The repetitive groups are the measuring units. In this table, the loss of inert gas with increasing length of surface interval is reflected in the change from one group to another.

19. Details and an example of its use are given directly on the table.

20. The Repetitive Dive Timetable lists the number of minutes at each depth that will build up the nitrogen partial pressure represented by each repetitive group.

21. Knowing the diver's repetitive group designation, the system gives an arbitrary bottom time (the residual nitrogen time) that he must assume he has already completed when he starts his repetitive dive. This arbitrary bottom time and the actual bottom time of the repetitive dive are added to yield the bottom time of the equivalent single dive mentioned previously.

22. Details and an example of its use are given directly on the tables.

23. There is one exception to the table. It occasionally occurs when the repetitive dive is to the same or greater depth than the initial dives and the surface interval is short. Because of the necessity to account for the greatest exposure within group, the arbitrary bottom time assigned may be greater than the sum of the actual bottom times of the previous dives. In such case, if the repetitive dive is to the same or greater depth than the previous dive or dives, add the actual bottom time of the previous dives to the actual bottom time of the repetitive dive.

24. The U.S. Navy Standard Air Decompression Table for Exceptional Exposures (fig 9940-118) includes only schedules of decompression for exceptional or emergency cases. Schedules are provided for "complete saturation" exposures up to 140 feet, and for extreme exposures up to 300 feet. Great demands are imposed upon the diver's endurance by emergencies which might necessitate use of the table. Therefore complete assurance of success of the schedules is impossible. They have, however, been tested to every practicable limit and found reasonably safe.

25. Repetitive group designations are not given on the Table for Exceptional Exposures. Never follow a dive covered by that table with a repetitive dive. Make every effort to limit the equivalent single dive schedule of repetitive dives to the Standard Air Decompression Tables. The diving officer must be the one to weigh the need for any dive in the Table for Exceptional Exposures against the increased danger and demands on the diver's physical endurance.

26. Figure 9940-119 is a suggested worksheet for the selection of decompression schedules in repetitive diving. A systematic approach of this kind must **always** be used in applying the repetitive diving tables. (Fig. 9940-120 can be removed from the manual and reproduced locally.)

27. An example using fig. 9940-119 follows. A diver makes a dive to 105 feet with a bottom time of 24 minutes and decompresses properly according to the Standard Air Decompression Table. After being on the surface for 2 hours he is required to make a second dive, this time to 145 feet. It is anticipated that 15 minutes bottom time will be required to complete his work. The problem is to determine the proper decompression for this second or **repetitive dive.** Use the time and depth of his first or **previous dive** in worksheet part I. fig. 9940-117 indicates that he is in repetitive group "H" (according to the 110/25 schedule). During the surface interval of 2 hours he loses sufficient nitrogen to change from group "H" to group "E" according to the Surface Interval Credit Table (fig. 9940-116). His residual nitrogen time may now be determined using the depth of his second or repetitive dive and the **new** group from the end of the surface interval by referring to the Repetitive Dive Timetable (fig. 9940-117). This indicates that the diver's residual nitrogen time is 12 minutes. The 15 minute actual bottom time of the repetitive dive is added to the residual nitrogen time to obtain the **equivalent single time** which is 27 minutes. This is used, as indicated in worksheet part V, to select the decompression schedule

DEPTH (ft)	BOTTOM TIME (mins)	TIME TO FIRST STOP	DECOMPRESSION STOPS 50	40	30	20	10	TOTAL ASCENT TIME	REPET. GROUP
40	200						0	0.7	*
	210	0.5					2	2.5	N
	230	0.5					7	7.5	N
	250	0.5					11	11.5	O
	270	0.5					15	15.5	O
	300	0.5					19	19.5	Z
50	100						0	0.8	*
	110	0.7					3	3.7	L
	120	0.7					5	5.7	M
	140	0.7					10	10.7	M
	160	0.7					21	21.7	N
	180	0.7					29	29.7	O
	200	0.7					35	35.7	O
	220	0.7					40	40.7	Z
	240	0.7					47	47.7	Z
60	60						0	1.0	*
	70	0.8					2	2.8	K
	80	0.8					7	7.8	L
	100	0.8					14	14.8	M
	120	0.8					26	26.8	N
	140	0.8					39	39.8	O
	160	0.8					48	48.8	Z
	180	0.8					56	56.8	Z
	200	0.6				1	69	70.6	Z
70	50						0	1.2	*
	60	1.0					8	9.0	K
	70	1.0					14	15.0	L
	80	1.0					18	19.0	M
	90	1.0					23	24.0	N
	100	1.0					33	34.0	N
	110	0.8				2	41	43.8	O
	120	0.8				4	47	51.8	O
	130	0.8				6	52	58.8	O
	140	0.8				8	56	64.8	Z
	150	0.8				9	61	70.8	Z
	160	0.8				13	72	85.8	Z
	170	0.8				19	79	98.8	Z
80	40						0	1.3	*
	50	1.2					10	11.2	K
	60	1.2					17	18.2	L
	70	1.2					23	24.2	M
	80	1.0				2	31	34.0	N
	90	1.0				7	39	47.0	N
	100	1.0				11	46	58.0	O
	110	1.0				13	53	67.0	O
	120	1.0				17	56	74.0	Z
	130	1.0				19	63	83.0	Z
	140	1.0				26	69	96.0	Z
	150	1.0				32	77	110.0	Z
90	30						0	1.5	*
	40	1.3					7	8.3	J
	50	1.3					18	19.3	L
	60	1.3					25	26.3	M
	70	1.2				7	30	38.2	N
	80	1.2				13	40	54.2	N
	90	1.2				18	48	67.2	O
	100	1.2				21	54	76.2	Z
	110	1.2				24	61	86.2	Z
	120	1.2				32	68	101.2	Z
	130	1.0			5	36	74	116.0	Z
100	25						0	1.7	*
	30	1.5					3	4.5	I
	40	1.5					15	16.5	K
	50	1.3				2	24	27.3	L
	60	1.3				9	28	38.3	N
	70	1.3				17	39	57.3	O
	80	1.3				23	48	72.3	O
	90	1.2			3	23	57	84.2	Z
	100	1.2			7	23	66	97.2	Z
	110	1.2			10	34	72	117.2	Z
	120	1.2			12	41	78	132.2	Z
110	20						0	1.8	*
	25	1.7					3	4.7	H
	30	1.7					7	8.7	J
	40	1.5				2	21	24.5	L
	50	1.5				8	26	35.5	M
	60	1.5				18	36	55.5	N
	70	1.3			1	23	48	73.3	O
	80	1.3			7	23	57	88.3	Z
	90	1.3			12	30	64	107.3	Z
	100	1.3			15	37	72	125.3	Z
120	15						0	2.0	*
	20	1.8					2	3.8	H
	25	1.8					6	7.8	I
	30	1.8					14	15.8	J
	40	1.7				5	25	31.7	L
	50	1.7				15	31	47.7	N
	60	1.5			2	22	45	70.5	O
	70	1.5			9	23	55	88.5	O
	80	1.5			15	27	63	106.5	Z
	90	1.5			19	37	74	131.5	Z
	100	1.5			23	45	80	149.5	Z
130	10						0	2.2	*
	15	2.0					1	3.0	F
	20	2.0					4	6.0	H
	25	2.0					10	12.0	J
	30	1.8				3	18	22.8	M
	40	1.8				10	25	36.8	N
	50	1.7			3	21	37	62.7	O
	60	1.7			9	23	52	85.7	Z
	70	1.7			16	24	61	102.7	Z
	80	1.5		3	19	35	72	130.5	Z
	90	1.5		8	19	45	80	153.5	Z
140	10						0	2.3	*
	15	2.2					2	4.2	G
	20	2.2					6	8.2	I
	25	2.0				2	14	18.0	J
	30	2.0				5	21	28.0	K
	40	1.8			2	16	26	45.8	N
	50	1.8			6	24	44	75.8	O
	60	1.8			16	23	56	96.8	Z
	70	1.7		4	19	32	68	124.7	Z
	80	1.7		10	23	41	79	154.7	Z
150	5						0	2.5	C
	10	2.3					1	3.3	E
	15	2.3					3	5.3	G
	20	2.2				2	7	11.2	H
	25	2.2				4	17	23.2	K
	30	2.2				8	24	34.2	L
	40	2.0			5	19	33	59.0	N
	50	2.0			12	23	51	88.0	O
	60	1.8		3	19	26	62	111.8	Z
	70	1.8		11	19	39	75	145.8	Z
	80	1.7	1	17	19	50	84	172.7	Z
160	5						0	2.7	D
	10	2.5					1	3.5	F
	15	2.3				1	4	7.3	H
	20	2.3				2	11	16.3	J
	25	2.3				7	20	29.3	K
	30	2.2			2	11	25	40.2	M
	40	2.2			7	23	39	71.2	N
	50	2.0		2	16	23	55	98.0	Z
	60	2.0		9	19	33	69	132.0	Z
	70	1.8	1	17	22	44	80	165.8	Z
170	5						0	2.8	D
	10	2.7					2	4.7	F
	15	2.5				2	5	9.5	H
	20	2.5				4	15	21.5	J
	25	2.3			2	7	23	34.3	L
	30	2.3			4	13	26	45.3	M
	40	2.2		1	10	23	45	81.2	O
	50	2.2		5	18	23	61	109.2	Z
	60	2.0	2	15	22	37	74	152.0	Z
	70	2.0	8	17	19	51	86	183.0	Z
180	5						0	3.0	D
	10	2.8					3	5.8	F
	15	2.7				3	6	11.7	I
	20	2.5			1	5	17	25.5	K
	25	2.5			3	10	24	39.5	L
	30	2.5			6	17	27	52.5	N
	40	2.3		3	14	23	50	92.3	O
	50	2.2	2	9	19	30	65	127.2	Z
	60	2.2	5	16	19	44	81	167.2	Z
190	5						0	3.2	D
	10	2.8				1	3	6.8	G
	15	2.8				4	7	13.8	I
	20	2.7			2	6	20	30.7	K
	25	2.7			5	11	25	43.7	M
	30	2.5		1	8	19	32	62.5	N
	40	2.5		8	14	23	55	102.5	O
	50	2.3	4	13	22	33	72	146.3	Z
	60	2.3	10	17	19	50	84	182.3	Z

*See table 1-6 for repetitive groups in "no decompression" dives.

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FIGURE 9940–114. (See fig. 9940–115 for repetitive groups in "no decompression" dives.)

DEPTH (ft.)	NO DECOM-PRESSION LIMITS (Min.)	REPETITIVE GROUPS														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10	–	60	120	210	300											
15	–	35	70	110	160	225	350									
20	–	25	50	75	100	135	180	240	325							
25	–	20	35	55	75	100	125	160	195	245	315					
30	–	15	30	45	60	75	95	120	145	170	205	250	310			
35	310	5	15	25	40	50	60	80	100	120	140	160	190	220	270	310
40	200	5	15	25	30	40	50	70	80	100	110	130	150	170	200	
50	100	–	10	15	25	30	40	50	60	70	80	90	100			
60	60	–	10	15	20	25	30	40	50	55	60					
70	50	–	5	10	15	20	30	35	40	45	50					
80	40	–	5	10	15	20	25	30	35	40						
90	30	–	5	10	12	15	20	25	30							
100	25	–	5	7	10	15	20	22	25							
110	20	–	–	5	10	13	15	20								
120	15	–	–	5	10	12	15									
130	10	–	–	5	8	10										
140	10	–	–	5	7	10										
150	5	–	–	5												
160	5	–	–	–	5											
170	5	–	–	–	5											
180	5	–	–	–	5											
190	5	–	–	–	5											

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INSTRUCTIONS FOR USE

I. "No decompression" limits

This column shows at various depths greater than 30 feet the allowable diving times (in minutes) which permit surfacing directly at 60 ft. a minute with no decompression stops. Longer exposure times require the use of the Standard Air Decompression Table (Table 1-5).

II. Repetitive group designation table

The tabulated exposure times (or bottom times) are in minutes. The times at the various depths in each vertical column are the maximum exposures during which a diver will remain within the group listed at the head of the column.

To find the repetitive group designation at surfacing for dives involving exposures up to and including the "no decompression limits": Enter the table on the exact or next greater depth than that to which exposed and select the listed exposure time exact or next greater than the actual exposure time. The repetitive group designation is indicated by the letter at the head of the vertical column where the selected exposure time is listed.

For example: A dive was to 32 feet for 45 minutes. Enter the table along the 35 ft. depth line since it is next greater than 32 ft. The table shows that since group "D" is left after 40 minutes exposure and group "E" after 50 minutes, group "E" (at the head of the column where the 50 min. exposure is listed) is the proper selection.

Exposure times for depths less than 40 ft. are listed only up to approximately five hours since this is considered to be beyond field requirements for this table.

FIGURE 9940–115. (Table 1–5 referenced herein is in the Diving Manual and is fig. 9940–114 of this chapter.)

REPETITIVE GROUP AT THE END OF THE SURFACE INTERVAL

REPETITIVE GROUP AT THE BEGINNING OF SURFACE INTERVAL (FROM PREVIOUS DIVE)

	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
Z	0:10-0:22	0:34	0:48	1:02	1:18	1:36	1:55	2:17	2:42	3:10	3:45	4:29	5:27	6:56	10:05	12:00*
O		0:10-0:23	0:36	0:51	1:07	1:24	1:43	2:04	2:29	2:59	3:33	4:17	5:16	6:44	9:54	12:00*
N			0:10-0:24	0:39	0:54	1:11	1:30	1:53	2:18	2:47	3:22	4:04	5:03	6:32	9:43	12:00*
M				0:10-0:25	0:42	0:59	1:18	1:39	2:05	2:34	3:08	3:52	4:49	6:18	9:28	12:00*
L					0:10-0:26	0:45	1:04	1:25	1:49	2:19	2:53	3:36	4:35	6:02	9:12	12:00*
K						0:10-0:28	0:49	1:11	1:35	2:03	2:38	3:21	4:19	5:48	8:58	12:00*
J							0:10-0:31	0:54	1:19	1:47	2:20	3:04	4:02	5:40	8:40	12:00*
I								0:10-0:33	0:59	1:29	2:02	2:44	3:43	5:12	8:21	12:00*
H									0:10-0:36	1:06	1:41	2:23	3:20	4:49	7:59	12:00*
G										0:10-0:40	1:15	1:59	2:58	4:25	7:35	12:00*
F											0:10-0:45	1:29	2:28	3:57	7:05	12:00*
E												0:10-0:54	1:57	3:22	6:32	12:00*
D													0:10-1:09	2:38	5:48	12:00*
C														0:10-1:39	2:49	12:00*
B															0:10-2:10	12:00*
A																0:10-12:00*

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INSTRUCTIONS FOR USE

Surface interval time in the table is in hours and minutes ("7:59" means 7 hours and 59 minutes). The surface interval must be at least 10 minutes.

Find the repetitive group designation letter (from the previous dive schedule) on the diagonal slope. Enter the table horizontally to select the listed surface interval time that is exactly or next greater than the actual surface interval time. The repetitive group designation for the end of the surface interval is at the head of the vertical column where the selected surface interval time is listed. For example – a previous dive was to 110 ft. for 30 minutes. The diver remains on the surface 1 hour and 30 minutes and wishes to find the new repetitive group designation: The repetitive group from the last column of the 110/30 schedule in the Standard Air Decompression Tables is "J". Enter the surface interval credit table along the horizontal line labeled "J". The 1 hour and 47 min. listed surface interval time is next greater than the actual 1 hour and 30 minutes surface interval time. Therefore, the diver has lost sufficient inert gas to place him in group "G" (at the head of the vertical column selected).

*NOTE: Dives following surface intervals of more than 12 hours are not considered repetitive dives. Actual bottom times in the Standard Air Decompression Tables may be used in computing decompression for such dives.

FIGURE 9940-116.

REPET. GROUPS	REPETITIVE DIVE DEPTH (Ft.)															
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
A	7	6	5	4	4	3	3	3	3	3	2	2	2	2	2	2
B	17	13	11	9	8	7	7	6	6	6	5	5	4	4	4	4
C	25	21	17	15	13	11	10	10	9	8	7	7	6	6	6	6
D	37	29	24	20	18	16	14	13	12	11	10	9	9	8	8	8
E	49	38	30	26	23	20	18	16	15	13	12	12	11	10	10	10
F	61	47	36	31	28	24	22	20	18	16	15	14	13	13	12	11
G	73	56	44	37	32	29	26	24	21	19	18	17	16	15	14	13
H	87	66	52	43	38	33	30	27	25	22	20	19	18	17	16	15
I	101	76	61	50	43	38	34	31	28	25	23	22	20	19	18	17
J	116	87	70	57	48	43	38	34	32	28	26	24	23	22	20	19
K	138	99	79	64	54	47	43	38	35	31	29	27	26	24	22	21
L	161	111	88	72	61	53	48	42	39	35	32	30	28	26	25	24
M	187	124	97	80	68	58	52	47	43	38	35	32	31	29	27	26
N	213	142	107	87	73	64	57	51	46	40	38	35	33	31	29	28
O	241	160	117	96	80	70	62	55	50	44	40	38	36	34	31	30
Z	257	169	122	100	84	73	64	57	52	46	42	40	37	35	32	31

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INSTRUCTIONS FOR USE

The bottom times listed in this table are called "residual nitrogen times" and are the times a diver is to consider he has already spent on bottom when he starts a repetitive dive to a specific depth. They are in minutes.

Enter the table horizontally with the repetitive group designation from the Surface Interval Credit Table. The time in each vertical column is the number of minutes that would be required (at the depth listed at the head of the column) to saturate to the particular group.

For example – the final group designation from the Surface Interval Credit Table, on the basis of a previous dive and surface interval, is "H". To plan a dive to 110 feet, determine the "residual nitrogen time" for this depth required by the repetitive group designation: Enter this table along the horizontal line labeled "H". The table shows that one must start a dive to 110 feet as though he had already been on the bottom for 27 minutes. This information can then be applied to the Standard Air Decompression table or "No Decompression" Table in a number of ways:

(1) Assuming a diver is going to finish a job and take whatever decompression is required, he must add 27 minutes to his actual bottom time and be prepared to take decompression according to the 110 foot schedules for the sum or equivalent single dive time.

(2) Assuming one wishes to make a quick inspection dive for the minimum decompression, he will decompress according to the 110/30 schedule for a dive of 3 minutes or less (27 + 3 = 30). For a dive of over 3 minutes but less than 13, he will decompress according to the 110/40 schedule (27 + 13 = 40).

(3) Assuming that one does not want to exceed the 110/50 schedule and the amount of decompression it requires, he will have to start ascent before 23 minutes of actual bottom time (50 - 27 = 23).

(4) Assuming that a diver has air for approximately 45 minutes bottom time and decompression stops, the possible dives can be computed: A dive of 13 minutes will require 23 minutes of decompression (110/40 schedule), for a total submerged time of 36 minutes. A dive of 13 to 23 minutes will require 34 minutes of decompression (110/50 schedule), for a total submerged time of 47 to 57 minutes. Therefore, to be safe, the diver will have to start ascent before 13 minutes or a standby air source will have to be provided.

DEPTH (ft.)	BOTTOM TIME (Min.)	TIME TO FIRST STOP	DECOMPRESSION STOPS													TOTAL ASCENT TIME
			130	120	110	100	90	80	70	60	50	40	30	20	10	
40	360	0.5													23	24
	480	0.5													41	42
	720	0.5													69	70
60	240	0.7												2	79	82
	360	0.7												20	119	140
	480	0.7												44	148	193
	720	0.7												78	187	266
80	180	1.0												35	85	121
	240	0.8											6	52	120	179
	360	0.8											29	90	160	280
	480	0.8											59	107	187	354
	720	0.7										17	108	142	187	455
100	180	1.0										1	29	53	118	202
	240	1.0										14	42	84	142	283
	360	0.8									2	42	73	111	187	416
	480	0.8									21	61	91	142	187	502
	720	0.8									55	106	122	142	187	613
120	120	1.3										10	19	47	98	176
	180	1.2									5	27	37	76	137	283
	240	1.2									23	35	60	97	179	395
	360	1.0								18	45	64	93	142	187	550
	480	0.8							3	41	64	93	122	142	187	653
	720	0.8							32	74	100	114	122	142	187	772
140	90	1.5									2	14	18	42	88	166
	120	1.5									12	14	36	56	120	240
	180	1.3								10	26	32	54	94	168	386
	240	1.2							8	28	34	50	78	124	187	511
	360	1.0						9	32	42	64	84	122	142	187	683
	480	1.0						31	44	59	100	114	122	142	187	800
	720	0.8					16	56	88	97	100	114	122	142	187	923
170	90	1.8								12	12	14	34	52	120	232
	120	1.6						2	10	12	18	32	42	82	156	356
	180	1.3					4	10	22	28	34	50	78	120	187	535
	240	1.3					18	24	30	42	50	70	116	142	187	681
	360	1.2				22	34	40	52	60	98	114	122	142	187	873
	480	1.0		14		40	42	56	91	97	100	114	122	142	187	1006
200	5	3.2													1	5
	10	3.0												1	4	8
	15	2.8											1	4	10	18
	20	2.8											3	7	27	40
	25	2.8											7	14	25	49
	30	2.7										2	9	22	37	73
	40	2.5									2	8	17	23	59	112
	50	2.5									6	16	22	39	75	161
	60	2.3								2	13	17	24	51	89	199
	90	1.8					1	10	10	12	12	30	38	74	134	323
	120	1.7				6	10	10	10	24	28	40	64	98	180	472
	180	1.3		1	10	10	18	24	24	42	48	70	106	142	187	684
	240	1.3		6	20	24	24	36	42	54	68	114	122	142	187	841
	360	1.2	12	22	36	40	44	56	82	98	100	114	122	142	187	1057
210	5	3.3													1	5
	10	3.2												2	4	10
	15	3.0											1	5	13	22
	20	3.0											4	10	23	40
	25	2.8										2	7	17	27	56
	30	2.8										4	9	24	41	81
	40	2.7									4	9	19	26	63	124
	50	2.5								1	9	17	19	45	80	174
220	5	3.5													2	6
	10	3.3												2	5	11
	15	3.2											2	5	16	27
	20	3.0										1	3	11	24	43
	25	[illegible]										3	8	19	33	66
	30	2.8									1	7	10	23	47	91
	40	2.8									6	12	22	29	68	140
	50	2.7								3	12	17	18	[illegible]	56	190
230	5	3.7													2	6
	10	3.3											1	2	6	18
	15	3.3											3	6	18	31
	20	3.2										2	5	12	26	49
	25	3.2										4	8	22	37	75
	30	3.0									2	8	12	23	51	99
	40	2.8								1	7	15	22	34	74	156
	50	2.8								5	14	16	24	51	89	202
240	5	3.8													2	6
	10	3.5											1	3	6	14
	15	3.5											4	6	21	35
	20	3.3										3	6	15	26	53
	25	3.2									1	4	9	24	40	82
	30	3.2									4	8	15	22	56	109
	40	3.0								3	7	17	22	39	75	166
	50	2.8							1	8	15	16	29	51	94	217
250	5	3.8												1	2	7
	10	3.7											1	4	7	16
	15	3.5										1	4	7	22	38
	20	3.5										4	7	17	27	59
	25	3.3									2	7	10	24	45	92
	30	3.3									6	7	17	23	59	116
	40	3.2								5	9	17	19	45	79	178
	60	2.7					4	10	10	10	12	22	36	64	126	297
	90	2.2		8	10	10	10	10	10	28	28	44	68	98	186	513
	120	(SEE EXTREME EXPOSURES BELOW)														
	180															
	240															
260	5	4.0												1	2	7
	10	3.8											2	4	9	19
	15	3.7										2	4	10	22	42
	20	3.5									1	4	7	20	31	67
	25	3.5									3	8	11	23	50	99
	30	3.3								2	6	8	19	26	61	125
	40	3.2							1	6	11	16	19	49	84	19
270	5	4.2												1	3	9
	10	4.0											2	5	11	22
	15	3.8										3	4	11	24	46
	20	3.7									2	3	9	21	35	74
	25	3.5								2	3	8	13	23	53	106
	30	3.5								3	6	12	22	27	64	138
	40	3.3							5	6	11	17	22	51	88	204
280	5	4.3												2	2	9
	10	4.0										1	2	5	13	25
	15	3.8									1	3	4	11	26	49
	20	3.8									3	4	8	23	39	81
	25	3.7								2	5	7	16	23	56	113
	30	3.5							1	3	7	13	22	30	70	150
	40	3.3						1	6	6	13	17	27	51	93	216
290	5	4.5												2	3	10
	10	4.2										1	3	5	16	30
	15	4.0									1	3	6	12	26	52
	20	4.0									3	7	9	23	43	89
	25	3.8								3	5	8	17	23	60	120
	30	3.7							1	5	6	16	22	36	72	162
	40	3.5						3	5	7	15	16	32	51	95	264
300	5	4.7												3	3	11
	10	4.3										1	3	6	17	32
	15	4.2									2	3	6	15	26	56
	20	4.0								2	3	7	10	23	47	104
	25	3.8							1	3	6	8	19	26	61	128
	30	3.8							2	5	7	17	22	39	75	171
	40	3.7						4	6	9	15	17	34	51	90	234
	60	3.0		4	10	10	10	10	10	14	28	32	50	90	187	458
	90	(SEE EXTREME EXPOSURES BELOW)														
	120															
	180															

(Rev. 1958)

EXTREME EXPOSURES – 250 AND 300 FT.

DEPTH (ft.)	BOTTOM TIME (Min.)	TIME TO FIRST STOP	DECOMPRESSION STOPS																				TOTAL ASCENT TIME
			200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
250	120	1.8							5	10	10	10	10	16	24	24	36	48	64	94	142	187	682
	180	1.5					4	8	8	10	22	24	24	32	42	44	60	84	114	122	142	187	929
	240	1.5					9	14	21	22	22	40	40	42	56	76	98	100	114	122	142	187	1107
300	90	2.3					3	6	8	10	10	10	10	16	24	24	34	48	64	90	142	187	691
	120	2.0			4	8	8	8	8	10	14	24	24	24	34	42	58	66	102	122	142	187	887
	180	1.7	6	8	8	8	14	20	21	21	28	40	40	48	56	82	98	100	114	122	142	187	1165

FIGURE 9940–118.

REPETITIVE DIVE WORKSHEET

I. PREVIOUS DIVE:

___ minutes } see table 1-5 or 1-6 for repetitive group designation } Group___.

____ feet

II. SURFACE INTERVAL:

__hours___minutes on surface } see table 1-7 for new group } Group___

Group___ (from I.)

III. RESIDUAL NITROGEN TIME:

____ feet (depth of repetitive dive) } see table 1-8 } ___minutes

Group___ (from II.)

IV. EQUIVALENT SINGLE DIVE TIME:

___ minutes (residual nitrogen time from III.)

(add) ___ minutes (actual bottom time of repetitive dive)

(sum) ___ minutes

V. DECOMPRESSION FOR REPETITIVE DIVE:

___ minutes (equivalent single dive time from IV.) } see table 1-5 or 1-6 1-17 or 1-18 }

____ feet (depth of repetitive dive)

☐ No decompression required

or

Decompression stops: ____ feet ____ minutes

____ feet ____ minutes

____ feet ____ minutes

____ feet ____ minutes

____ feet ____ minutes

Table Used ______

Repet. Group ______

FIGURE 9940–119. Repetitive dive worksheet (filled in). (Tables referenced herein are in the Diving Manual.)

REPETITIVE DIVE WORKSHEET

I. PREVIOUS DIVE:

24 minutes } see table 1-5 or 1-6 for
105 feet } repetitive group designation } Group H

II. SURFACE INTERVAL:

2 hours 0 minutes on surface } see table 1-7
Group H (from I.) } for new group } Group E

III. RESIDUAL NITROGEN TIME:

145 feet (depth of repetitive dive) } see table
Group E (from II.) } 1-8 } 12 minutes

IV. EQUIVALENT SINGLE DIVE TIME:

12 minutes (residual nitrogen time from III.)

(add) 15 minutes (actual bottom time of repetitive dive)

(sum) 27 minutes

V. DECOMPRESSION FOR REPETITIVE DIVE:

27 minutes (equivalent single dive time from IV.) } see table
145 feet (depth of repetitive dive) } 1-5 or 1-6
1-17 or 1-18

☐ No decompression required

or

Decompression stops: 20 feet 8 minutes
10 feet 24 minutes
____ feet ____ minutes
____ feet ____ minutes
____ feet ____ minutes

Table Used ______
Repet. Group ______

Figure 9940–120.–Repetitive dive worksheet (sample for reproduction; see figure 9940–119).

for the repetitive dive; in this case from fig. 9940-114, the 150/30 schedule.

28. When one repetitive dive is to be followed by another, the procedure for selecting the proper decompression schedule for the first repetitive dive is **repeated**. The time and depth of the equivalent single dive of the **first** repetitive dive calculation becomes the time and depth of the "previous dive" of the **second** repetitive dive calculation. That is, the time and depth used in the worksheet part V (fig. 9940-119) become the time and depth in part I of the following worksheet.

9940.811. SURFACE DECOMPRESSION

1. In surface decompression procedures, stage decompression in the water is reduced to a minimum or eliminated and the major part of decompression is accomplished in a recompression chamber on the surface. Oxygen is the standard breathing medium during the decompression period on the surface. Air or gas mixtures are alternate breathing mediums. There are separate decompression tables and procedures which apply specifically to the breathing medium used.

2. At present in the U.S. Navy, surface decompression procedures expose the diver to atmospheric pressure for a **brief surface interval** between leaving the water and attaining the scheduled decompression stop depth in the recompression chamber. The interval **must** be as short as possible.

3. The principal advantages of surface decompression are the comfort and security of the diver in situations of extremely cold or rough sea, physical exhaustion, and the like. In certain dives, surface decompression with pure oxygen has the additional advantage of saving an appreciable amount of the total decompression time required for straight air decompression.

4. Surface decompression schedules may be applied to emergencies where a surface interval **must** come between the dive and the major part of the decompression. Such cases may be emergencies forcing unscheduled surfacing, or in scuba diving, when the diver **must** surface to obtain a new air supply. Although it is possible when air is the breathing medium for the decompression period following the surface interval to be in the water, **recompression in a chamber if available is always to be preferred.**

5. If a recompression chamber is available and is equipped with proper oxygen-breathing equipment, the procedure outlined in Surface Decompression Table Using Oxygen (Fig. 9940-121) may be used in a routine manner. Follow the instructions accurately and take all precautions to ensure that only pure oxygen is breathed. Maintain breathing equipment in perfect working condition to ensure successful results from this table.

6. In the event of oxygen toxicity symptoms, or failure of the oxygen supply, give decompression in accordance with Fig. 9940-122, distregarding time spent on oxygen.

7. Figure 9940-121 has not been recomputed in accordance with the concepts established in the calculation of the Standard Air Decompression Tables. There are some discrepancies in limits of allowable exposures. However, this table is considered to be safe in its present form. Note that ascent at the rate of 25 feet per minute is required for the initial ascent when using this table.

8. The Surface Decompression Table Using Air (Fig. 9940-122) may be used in any situation requiring surface decompression when breathing oxygen in a chamber is impossible. Since there is no saving of time over ordinary decompression methods, the comfort and security of the diver are the only advantages for the use of this surface decompression method.

9. In self contained diving it may be impossible for the diver to carry sufficient air supply for the duration of the entire dive and standard decompression. When this is the case, the diver may (according to either Fig. 9940-121 or 9940-112) surface, and receive the major part of his decompression in a recompression chamber. If no chamber is available, he may (according to Fig. 9940-122) take the "water stops" in the water, surface, obtain new air supply, and return in the water to the scheduled stop depths. However, providing surface-supplied air or extra air cylinders for use at the decompression stop depth, with decompression according to standard tables, is a safer and more reasonable procedure.

10. Figure 9940-122 requires repetition of one stop and increases the total decompression time required by the same scheduled in the Standard Air Decompression Table by that amount. At the moment, there is no procedure outlined for surface decompression following a dive on the Standard Air Decompression Table for Exceptional Exposures.

11. Ascend from the last water stop to the surface at the rate of 60 feet per minute. Maintain the time on the surface to the absolute minimum. Do not exceed the 3½ minute limit. Descend to the first chamber stop at the normal rate.

9940.812. OMITTED DECOMPRESSION IN EMERGENCIES

1. Certain emergencies may interrupt or prevent specified decompression. Blowup, complete loss of communication without a standby diver, exhausted air supply, bodily injury, and the like are among such emergencies. If there are symptoms of decompression sickness or air embolism, immediate treatment by recompression (see Fig. 9940-124) is essential. Even without evidence of any ill effects, omitted decompression must be made up in some manner to avert later difficulty.

2. It may **appear** that surface decompression schedules offer an immediate solution to this problem since they provide for a surface interval. Such schedules should **only** be used, however, **if the emergency surface interval occurs at such a time that "water stops" are not required or have already been completed** according to whichever surface decompression table is considered most appropriate.

3. When the conditions in paragraph 2 are **not** fulfilled, the diver's decompression has been compromised. Special care should be taken to detect signs of decompression sickness regardless of what action is initiated. The diver must be returned to pressure as soon as possible. Use of a recompression chamber, if available, is always preferable to water decompression.

1** Depth in feet	2** Time	3** Time (min.) at water stops breathing air at 60'	50'	40'	30'	4**	5** Time (min.) at 40' chamber stop oxygen	6**	7** Approximate total decompression time (min.)
70	52	0	0	0	0	SURFACE INTERVAL NOT TO EXCEED 5 MINUTES	0	2 MINUTE ASCENT FROM 40 FEET IN CHAMBER TO SURFACE WHILE BREATHING OXYGEN	3
	90	0	0	0	0		15		24
	*120	0	0	0	0		23		32
	150	0	0	0	0		31		40
	180	0	0	0	0		39		48
80	40	0	0	0	0		0		3
	70	0	0	0	0		14		23
	85	0	0	0	0		20		29
	100	0	0	0	0		26		35
	*115	0	0	0	0		31		40
	130	0	0	0	0		37		46
	150	0	0	0	0		44		53
90	32	0	0	0	0		0		4
	60	0	0	0	0		14		24
	70	0	0	0	0		20		30
	80	0	0	0	0		25		35
	*90	0	0	0	0		30		40
	100	0	0	0	0		34		44
	110	0	0	0	0		39		49
	120	0	0	0	0		43		53
	130	0	0	0	0		48		58
100	26	0	0	0	0		0		4
	50	0	0	0	0		14		24
	60	0	0	0	0		20		30
	70	0	0	0	0		26		36
	*80	0	0	0	0		32		42
	90	0	0	0	0		38		48
	100	0	0	0	0		44		54
	110	0	0	0	0		49		59
	120	0	0	0	3		53		66
110	22	0	0	0	0		0		5
	40	0	0	0	0		12		23
	50	0	0	0	0		19		30
	60	0	0	0	0		26		37
	*70	0	0	0	0		33		44
	80	0	0	0	1		40		52
	90	0	0	0	2		46		59
	100	0	0	0	5		51		67
	110	0	0	0	12		54		77
120	18	0	0	0	0		0		5
	30	0	0	0	0		9		20
	40	0	0	0	0		16		27
	50	0	0	0	0		24		35
	*60	0	0	0	2		32		45
120	70	0	0	0	4	SURFACE INTERVAL NOT TO EXCEED 5 MINUTES	39	2 MINUTE ASCENT FROM 40 FEET IN CHAMBER TO SURFACE WHILE BREATHING OXYGEN	54
	80	0	0	0	5		46		62
	90	0	0	3	7		51		72
	100	0	0	6	15		54		86
130	15	0	0	0	0		0		5
	30	0	0	0	0		12		23
	40	0	0	0	0		21		32
	50	0	0	0	3		29		43
	*60	0	0	0	5		37		53
	70	0	0	0	7		45		63
	80	0	0	6	7		51		76
	90	0	0	10	12		56		90
140	13	0	0	0	0		0		6
	25	0	0	0	0		11		23
	30	0	0	0	0		15		27
	35	0	0	0	0		20		32
	40	0	0	0	2		24		38
	45	0	0	0	4		29		45
	50	0	0	0	6		33		51
	*55	0	0	0	7		38		57
	60	0	0	0	8		43		63
	65	0	0	3	7		48		70
	70	0	2	7	7		51		80
150	11	0	0	0	0		0		6
	25	0	0	0	0		13		25
	30	0	0	0	0		18		30
	35	0	0	0	4		23		39
	40	0	0	3	6		27		49
	45	0	0	5	7		33		58
	*50	0	2	5	8		38		66
	55	2	5	9	4		44		78
160	9	0	0	0	0		0		7
	20	0	0	0	0		11		24
	25	0	0	0	0		16		29
	30	0	0	0	2		21		35
	35	0	0	4	6		26		49
	40	0	3	5	8		32		62
	*45	3	4	8	6		38		73
170	7	0	0	0	0		0		7
	20	0	0	0	0		13		26
	25	0	0	0	0		19		32
	30	0	0	3	5		23		44
	35	0	4	4	7		29		58
	*40	4	4	8	6		36		73

*These are the optimum exposure times for each depth which represent the best balance between length of work period, safety and amount of useful work for the average diver. Exposure beyond these times is permitted only under special conditions.

**Notes on columns.

Column 1. Depth–In feet, gage.

Column 2. Time–Interval from leaving the surface to leaving the bottom.

Column 3. Water stops–Time spent at tabulated stops using air. If no water stops are required use a 25 foot per minute rate of ascent to the surface. When water stops are required use a 25 foot per minute rate of ascent to first stop. Take an additional minute between stops. Use one minute for the ascent from 30 feet to the surface.

Column 4. Surface interval–The surface interval shall not exceed 5 minutes and is composed of the following elements:

(a) Time of ascent from the 30-foot water stop, ~~or from~~ 30 feet if no water stops are necessary, to the surface (1 minute).

(b) Time on surface for landing the diver on deck and undressing (not to exceed 3½ minutes).

(c) Time of descent in the recompression chamber from the surface to 40 feet (about ½ minute).

Column 5. During the period while breathing oxygen the chamber shall be ventilated.

Column 6. Surfacing–Oxygen breathing during this 2-minute period shall follow the period of oxygen breathing tabulated in Column 5 without interruption.

Column 7. Total decompression time–This includes

(a) Time of ascent from bottom to first stop, or to 30 feet if no water stop is required, at 25 feet per minute.

(b) Sum of tabulated water stops, column 2.

(c) One minute between water stops.

(d) Surface interval.

(e) Time at 40 feet in recompression chamber, column 4.

(f) Time of ascent, an additional 2 minutes, from 40 feet in the recompression chamber to the surface, column 5.

The Approximate Total Decompression Time may be shortened only by decreasing the time required to undress the diver on deck.

FIGURE 9940–121.–Surface decompression table using oxygen.

Table 1-18. Surface Decompression Table Using Air.

DEPTH (ft.)	BOTTOM TIME (Min.)	TIME TO FIRST STOP	TIME AT WATER STOPS 30	20	10	CHAMBER STOPS (AIR) 30	20	10	TOTAL ASCENT TIME
40	230	0.5			3			7	10.5
	250	0.5			3			11	14.5
	270	0.5			3			15	18.5
	300	0.5			3			19	22.5
50	120	0.7			3			5	8.7
	140	0.7			3			10	13.7
	160	0.7			3			21	24.7
	180	0.7			3			29	32.7
	200	0.7			3			35	38.7
	220	0.7			3			40	43.7
	240	0.7			3			47	50.7
60	80	0.8			3			7	10.8
	100	0.8			3			14	17.8
	120	0.8			3			26	29.8
	140	0.8			3			39	42.8
	160	0.8			3			48	51.8
	180	0.8			3			56	59.8
	200	0.7		3			3	69	75.7
70	60	1.0			3			8	12.0
	70	1.0			3			14	18.0
	80	1.0			3			18	22.0
	90	1.0			3			23	27.0
	100	1.0			3			33	37.0
	110	0.8		3			3	41	47.8
	120	0.8		3			4	47	54.8
	130	0.8		3			6	52	61.8
	140	0.8		3			8	56	67.8
	150	0.8		3			9	61	73.8
	160	0.8		3			13	72	88.8
	170	0.8		3			19	79	101.8
80	50	1.2			3			10	14.2
	60	1.2			3			17	21.2
	70	1.2			3			23	27.2
	80	1.0		3			3	31	38.0
	90	1.0		3			7	39	50.0
	100	1.0		3			11	46	61.0
	110	1.0		3			13	53	70.0
	120	1.0		3			17	56	77.0
	130	1.0		3			19	63	86.0
	140	1.0		26			26	69	122.0
	150	1.0		32			32	77	142.0
90	40	1.3			3			7	11.3
	50	1.3			3			18	22.3
	60	1.3			3			25	29.3
	70	1.2		3			7	30	41.2
	80	1.2		13			13	40	67.2
	90	1.2		18			18	48	85.2
	100	1.2		21			21	54	97.2
	110	1.2		24			24	61	110.2
	120	1.2		32			32	68	133.2
	130	1.0	5	36			36	74	152.0
100	40	1.5			3			15	19.5
	50	1.3		3			3	24	31.3
	60	1.3		3			9	28	41.3
	70	1.3		3			17	39	60.3
	80	1.3		23			23	48	95.3
	90	1.2	3	23			23	57	107.2
	100	1.2	7	23			23	66	120.2
	110	1.2	10	34			34	72	151.2
	120	1.2	12	41			41	78	173.2
110	30	1.7			3			7	11.7
	40	1.5		3			3	21	28.5
	50	1.5		3			8	26	38.5
	60	1.5		18			18	36	73.5
	70	1.5	1	23			23	48	96.5
	80	1.3	7	23			23	57	111.3
	90	1.3	12	30			30	64	137.3
	100	1.3	15	37			37	72	162.3

TIME ON SURFACE NOT TO EXCEED 3.5 MINUTES

DEPTH (ft.)	BOTTOM TIME (Min.)	TIME TO FIRST STOP	TIME AT WATER STOPS 50	40	30	20	10	CHAMBER STOPS (AIR) 30	20	10	TOTAL ASCENT TIME
120	25	1.8					3			6	10.8
	30	1.8					3			14	18.8
	40	1.7				3			5	25	34.7
	50	1.7				15			15	31	62.7
	60	1.5			2	22			22	45	92.5
	70	1.5			9	23			23	55	111.5
	80	1.5			15	27			27	63	133.5
	90	1.5			19	37			37	74	168.5
	100	1.5			23	45			45	80	194.5
130	25	2.0					3			10	15.0
	30	1.8				3			3	18	25.8
	40	1.8				10			10	25	46.8
	50	1.7			3	21			21	37	83.7
	60	1.7			9	23			23	52	108.7
	70	1.7			16	24			24	61	126.7
	80	1.5		3	19	35			35	72	165.5
	90	1.5		8	19	45			45	80	198.5
140	20	2.2					3			6	11.2
	25	2.0				3			3	14	22.0
	30	2.0				5			5	21	33.0
	40	1.8			2	16			16	26	61.8
	50	1.8			6	24			24	44	99.8
	60	1.8			16	23			23	56	119.8
	70	1.7		4	19	32			32	68	156.7
	80	1.7		10	23	41			41	79	195.7
150	20	2.2				3			3	7	15.2
	25	2.2				4			4	17	27.2
	30	2.2				8			8	24	42.2
	40	2.0			5	19			19	33	78.0
	50	2.0			12	23			23	51	111.0
	60	1.8		3	19	26			26	62	137.8
	70	1.8		11	19	39			39	75	184.8
	80	1.7	1	17	19	50			50	84	222.7
160	20	2.3				3			3	11	19.3
	25	2.3				7			7	20	36.3
	30	2.2			2	11			11	25	51.2
	40	2.2			7	23			23	39	94.2
	50	2.0		2	16	23			23	55	121.0
	60	2.0		9	19	33			33	69	165.0
	70	1.8	1	17	22	44			44	80	209.8
170	15	2.5				3			3	5	13.5
	20	2.5				4			4	15	25.5
	25	2.3			2	7			7	23	41.3
	30	2.3			4	13			13	26	58.3
	40	2.2		1	10	23			23	45	104.2
	50	2.2		5	18	23			23	61	132.2
	60	2.0	2	15	22	37			37	74	187.0
	70	2.0	8	17	19	51			51	86	234.0
180	15	2.7				3			3	6	14.7
	20	2.5			1	5			5	17	30.5
	25	2.5			3	10			10	24	49.5
	30	2.5			6	17			17	27	69.5
	40	2.3		3	14	23			23	50	115.3
	50	2.2	2	9	19	30			30	65	155.2
	60	2.2	5	16	19	44			44	81	211.2
190	15	2.8				4			4	7	17.8
	20	2.7			2	6			6	20	36.7
	25	2.7			5	11			11	25	54.7
	30	2.5		1	8	19			19	32	81.5
	40	2.5		8	14	23			23	55	125.5
	50	2.3	4	13	22	33			33	72	179.3
	60	2.3	10	17	19	50			50	84	232.3

TIME ON SURFACE NOT TO EXCEED 3.5 MINUTES

FIGURE 9940–122.—Surface decompression table using air.

4. Even if the diver shows no ill effects from his omitted decompression, he needs immediate recompression. Take him to 100 feet in the chamber and keep him at that depth for 30 minutes. If he is still all right after that time, bring him out according to **TREATMENT TABLE 1 or 1A** (see Fig. 9940-124). Consider decompression sickness developing during or after this as a recurrence (see Fig. 9940-127).

5. Recompress the diver in the water, following the procedure in paragraph 4 as nearly as possible. Keep the diver at rest, provide a standby diver, and maintain good communication and depth control.

6. When the course of action outlined in paragraph 5 is impossible, use the following procedure which is based on the Standard Air Decompression Table using one minute between stops:

a. Repeat any stops deeper than 40 feet.

b. At 40 feet, remain for 1/4 of the 10-foot stop time.

c. At 30 feet, remain for 1/3 of the 10-foot stop time.

d. At 20 feet, remain for 1/2 of the 10-foot stop time.

e. At 10 feet, remain for 1 1/2 times the scheduled 10-foot stop time.

9940.813. DIVING HAZARDS

1. Diving confronts man with forces and physiological effects which are not encountered in his normal environment. These impose definite limits and can cause serious accidents. The diver's safety depends upon his knowledge of these factors and his ability to recognize and handle them.

2. The discussions on physics and physiology have made you aware of most of the potential hazards of diving. The purpose of the article is to give you knowledge which will help you to avoid hazards when you can, to cope with hazards which cannot be avoided, and to recognize and treat accidents when they occur. It permits you to evaluate factors of environment, of specific equipment, and of your own condition in relation to each job. **Ignorance is the diver's worst enemy.** Many potential dangers can be avoided almost completely if they are recognized. To cite just one example, many dead amateurs divers would be alive today if they had known that holding their breath on ascent would cause air embolism. Even after such an accident had occurred, many of these lives could have been saved if anyone nearby had recognized the condition and had been able to provide proper treatment.

3. You will meet many unavoidable hazards, but awareness and understanding will permit you to face them with a minimum of risk. Under combat conditions, some of these hazards are likely to be increased and diving must be performed under conditions which otherwise would be unacceptable.

4. When a dangerous condition is developing in yourself, your buddy, or the man you are tending or supervising, active **awareness** promotes early recognition of danger and prompts you to take immediate corrective action. As a diver, you must know the **causes, symptoms,** and **signs** of diving accidents so that proper actions or treatment can be commenced without delay.

5. In the following discussions of accidents, the words **symptom** and **sign** will be used frequently. This explanation is given to clarify their meanings as used in this manual: **Symptom** refers to those sensations experienced by the diver. **Sign** refers to those changes which can be observed by another person. A symptom can also be a sign. For example, a diver may complain of inability to move his leg. This is a symptom. The observer would see limping or the inability to lift that leg. These are signs. Pain is purely a symptom since the observer cannot feel or see it. He may see evidence of it, such as wincing or grimacing, but the observer cannot determine the existence of a symptom like pain other than by what the patient reports. This differentiation of signs and symptoms adds to the awareness of the diver. This becomes particularly important in the use of scuba where the individual and his buddy must protect not only themselves but each other. The diver must be able to recognize **symptoms** in himself and also be able to recognize **signs** of early stages of accidents in his buddy so that early corrective action may be taken.

6. When a hazard is encountered or an accident occurs, you must take all possible action to prevent further development of the condition. You must know the proper treatment of a condition which has already developed. To accomplish treatment, you must be familiar with the proper operation of specialized equipment like recompression chambers and resusciators. In addition, knowledge of manual artifical respiration methods and of the principles of first aid must be a part of your ability to cope with diving accidents. You must know how to transport casualties properly, taking into consideration problems of pressure and good first aid technique.

9940.814. DECOMPRESSION SICKNESS

1. Decompression sickness is the result of formation of gas bubbles in the blood or tissues. Depending on their number, size, and location, these bubbles may cause a wide variety of symptoms including pain, paralysis, unconsciousness, and possibly death. Decompression sickness can occur only when decompression (a reduction in the pressure surrounding the body) has taken place—as when a diver comes up from depth or when an aviator goes up to high altitude. It will not occur unless there is an excessive amount of inert gas dissolved in the blood or tissues at the time. Note.—Other terms applied to decompression sickness include the bends, compressed-air illness, and caisson disease. Aviators' bends are sometimes called aero-embolism; do not confuse this with **air embolism**—a different condition.

2. When a diver speaks of **decompression,** he means not only the reduction of pressure that takes place on ascent but also the systematic procedure used to eliminate the excess of dissolved gas safely (making decompression stops on ascent according to the decompression table).

3. Decompression sickness is caused by **inadequate decompression** following a dive, but this does not necessarily mean that the decompression table has not been followed properly. An excessive amount of gas in the tissues can result from any condition (in the man or in the

surroundings) that causes and unexpectedly large amount of inert gas to be taken up at depth or that results in abnormally slow elimination of gas during the decompression procedure. In such situations, following the table to the letter would not always assure adequate decompression. However, the decompression tables are designed to cover all but exceptional cases of this sort, so the actual risk of decompression sickness is small if the right table is properly employed.

4. The prevention of decompression sickness is best accomplished by the observing of these rules:

a. **Careful selection of personnel.**—For example, old injuries or diseases which result in poor circulation would be cause for rejection.

b. **Observation and evaluation of each man before he makes any dive.**—Alcohol intoxication or "hangover," excessive fatigue, or a general rundown condition should be sufficient cause to restrict a man from diving. It is the duty of the diving officer and the diving supervisor to keep any man from diving on a day when his physical condition is not satisfactory. If any doubt exists as to the diver's physical fitness, the medical officer's recommendation normally will be the deciding factor. Divers have a responsibility for keeping themselves fit to the best of their ability.

c. **Careful attention to the details of the dive.**—Accurate determination of the depth and time of the dive and of the decompression time must be made. All data concerning these details must be accurately and completely recorded and kept readily available. They are important in the diagnosis and treatment of decompression sickness.

d. **Strick observance of the decompression tables, with due consideration of modifying factors.**—Follow the tables at all times unless there is reason to question the accuracy of depth or time. In this event, decompress the diver for a dive of greater depth or longer duration. When in doubt, always act in the diver's favor by adding to decompression. Never shorten a decompression table merely for convenience.

e. **Report all symptoms or signs immediately to the medical or diving officer.**—Serious cases of decompression sickness often begin with a slight itch or pain. When men fail to report early symptoms, their chance of suffering permanent damage is greatly increased and their treatment is likely to be much more prolonged.

5. Diagnosis of decompression sickness depends upon the evaluation of the history of the dive, the symptoms and signs of the patient, and your ability to do a simple physical examination.

6. A man cannot have decompression sickness unless he has been diving; and if the dive was as much as 24 hours before symptoms appeared, it is not at all likely that decompression sickness accounts for the symptoms. The fact that a dive was of short duration, at a relatively shallow depth, or that the decompression table was followed does not necessarily rule out the possibility of decompression sickness. As a general rule, however, as the depth, time, and severity of work increase, the frequency of decompression sickness increases also. The likelihood increases very much when a diver does not receive proper decompression.

7. Decompression sickness usually causes symptoms within a short period of time following a dive. If a diver comes to the surface quickly without stops when they are required, or if he makes stops of greatly insufficient duration, he may be suffering from decompression sickness when he reaches the surface. Most cases develop after a short period of time on the surface and almost always before 12 hours. A review of data concerning onset of symptoms following decompression revealed that:

50 percent occurred within 30 minutes
85 percent occurred within 1 hour
95 percent occurred within 3 hours
1 percent delayed over 6 hours.

8. Various symptoms of decompression sickness have been found to occur with the following frequency:

	Percent
Local pain	89
Leg	70
Arm	30
Dizziness (the "staggers")	5.3
Paralysis	2.3
Shortness of breath (the "chokes")	1.6
Extreme fatigue and pain	1.3
Collaspe with unconsciousness	0.5

9. Occasionally, the skin may show a blotchy and mottled rash. There may be small red spots which vary in size from a pinhead to the size of a dime. Sometimes mottling is so pronounced that the skin takes on an appearance like pink marble, and the term "marbling" is applied.

10. A typical case of decompression sickness may begin with itching or burning of a localized area of the body. This may spread and then finally become localized again. There may be a feeling of tingling or numbness of the skin. In rare cases, the man may have a sensation of ants crawling all over him.

11. Pain, which is the most frequent and predominating symptom, is of a deep and boring character. Divers describe it as being felt in the bone or in the joint. Usually the pain is slight when first noticed and then becomes progressively worse until it is unbearable. The pain usually is not affected by motion of the area, but it may be temporarily relieved by vigorous rubbing or hot applications. The most frequently confused situation is when a diver suffers a muscle strain or a joint sprain during a dive. However, this can usually be distinguished by the fact that strains and sprains are painful to touch and motion while pain in a joint from decompression sickness generally is not. Swelling and discoloration usually occur with a sprain but are rare in uncomplicated cases of decompression sickness. A diver who has pain that might be a symptom of decompression deserves treatment by recompression even though it may turn out to have been a strain or sprain. WHEN IN DOUBT, TREAT BY RECOMPRESSION. Failure to treat doubtful cases is the most frequent cause of lasting injury.

12. When dizziness occurs, the diver feels that the world is revolving around him and that he is falling to one side. Frequently, he will have ringing in the ears at the same time that dizziness occurs. History and physical

examination become important when these symptoms occur because they also can follow middle ear damage, as from squeeze.

13. Serious symptoms are those caused by bubbles in the brain, spinal cord, or lungs. These require longer treatment (see fig. 9940–123 and 9940–124) than the "pain only" type; and it is very important not to overlook them when they are present. Many of the serious symptoms are so clean-cut that the diver is certain to notice and report the symptoms, or the signs are so obvious that his tenders could not miss them. However, it is quite possible to miss some of the less obvious signs and symptoms or to fail to recognize the milder disorders like simple weakness, partial paralysis, or a defect in vision. Do not let a serious case be treated inadequately just because no one bothered to check! For example, every now and then a diver who complains only of pain in an arm or leg will also be found to have weakness or partial paralysis when he is examined thoroughly. It is also important to know **all** that is wrong with the patient so that you can be sure when he is really relieved of all his symptoms during treatment.

14. If a medical officer is present, it is his responsibility to examine the man (see fig. 9940–125). If there is no medical officer, this becomes the responsibility of the corpsman, diving officer, or diving supervisor.

a. If the diver reports only pain and is not suffering severely, examine him thoroughly at the surface.

b. If it is clear that serious symptoms are present, do not take time for complete examination at the surface. You know the man needs treatment on table 3 or table 4 (see figs. 9940–123 and 9940–124), and the best procedure is to take him to 165 feet in the chamber without delay. Once that depth is reached, go ahead with the best examination you know how to perform (see fig. 9940–125).

TREATMENT OF AN UNCONSCIOUS DIVER

(Loss of consciousness during or within 24 hours after a dive. See art. 1.6.4)

1. IF NOT BREATHING, *start manual artificial respiration at once.* (See tables 1–23, 1–24, and 1–25.)

2. RECOMPRESS PROMPTLY. (See note (d).)

3. Examine for injuries and other abnormalities; apply first aid and other measures as required. (Secure the help of a medical officer as soon as possible.)

NOTES

Artificial respiration

(*a*) Shift to a mechanical resuscitator if one is available and working properly, but never wait for it. Always start a manual method first.

(*b*) Continue artificial respiration by some method without interruption until normal breathing resumes or victim is pronounced dead. Continue on way to chamber and during recompression. (Do not use oxygen deeper than 60 feet in chamber.)

Recompression

(*c*) Remember that an unnconscious diver may have air embolism or serious decompression sickness even though some other accident *seems* to explain his condition.

(*d*) Recompress unless—

(1) Victim regains consciousness and is free of nervous system symptoms before recompression can be started.

(2) Possibility of air embolism or decompression sickness can be ruled out without question.

(3) Another lifesaving measure is absolutely required and makes recompression impossible.

(*e*) Try to reach a recompression chamber no matter how far it is.

(*f*) Treat according to treatment TABLE 3 or 4 (see table 1–21), depending on response. Remember that early recovery under pressure never rules out the need for adequate treatment.

FIGURE 9940–123. (Articles and tables referenced herein are in the diving manual.

<table>
<tr><th colspan="2">Stops</th><th colspan="4">Bends—Pain only</th><th colspan="2">Serious Symptoms</th></tr>
<tr><td colspan="2" rowspan="2">Rate of descent—25 ft. per min.
Rate of ascent—1 minute between stops.</td><td colspan="2" rowspan="2">Pain relieved at depths less than 66 ft.
Use table 1—A if O_2 is not available.</td><td colspan="2" rowspan="2">Pain relieved at depths greater than 66 ft.
Use table 2—A if O_2 is not available.
If pain does not improve within 30 min. at 165 ft. the case is probably not bends. Decompress on table 2 or 2—A.</td><td colspan="2">Serious symptoms include any one of the following:
1. Unconsciousness.
2. Convulsions.
3. Weakness or inability to use arms or legs.
4. Air embolism.
5. Any visual disturbances.
6. Dizziness.
7. Loss of speech or hearing.
8. Severe shortness of breath or chokes.
9. Bends occurring while still under pressure.</td></tr>
<tr><td>Symptoms relieved within 30 minutes at 165 ft.
Use table 3</td><td>Symptoms not relieved within 30 minutes at 165 ft.
Use table 4</td></tr>
<tr><th>Pounds</th><th>Feet</th><th>Table 1</th><th>Table 1-A</th><th>Table 2</th><th>Table 2-A</th><th>Table 3</th><th>Table 4</th></tr>
<tr><td>73.4</td><td>165</td><td>----------</td><td>----------</td><td>30 (air)</td><td>30 (air)</td><td>30 (air)</td><td>30 to 120 (air)</td></tr>
<tr><td>62.3</td><td>140</td><td>----------</td><td>----------</td><td>12 (air)</td><td>12 (air)</td><td>12 (air)</td><td>30 (air)</td></tr>
<tr><td>53.4</td><td>120</td><td>----------</td><td>----------</td><td>12 (air)</td><td>12 (air)</td><td>12 (air)</td><td>30 (air)</td></tr>
<tr><td>44.5</td><td>100</td><td>30 (air)</td><td>30 (air)</td><td>12 (air)</td><td>12 (air)</td><td>12 (air)</td><td>30 (air)</td></tr>
<tr><td>35.6</td><td>80</td><td>12 (air)</td><td>12 (air)</td><td>12 (air)</td><td>12 (air)</td><td>12 (air)</td><td>30 (air)</td></tr>
<tr><td>26.7</td><td>60</td><td>30 (O_2)</td><td>30 (air)</td><td>30 (O_2)</td><td>30 (air)</td><td>30 (O_2) or (air)</td><td>6 hrs. (air)</td></tr>
<tr><td>22.3</td><td>50</td><td>30 (O_2)</td><td>30 (air)</td><td>30 (O_2)</td><td>30 (air)</td><td>30 (O_2) or (air)</td><td>6 hrs. (air)</td></tr>
<tr><td>17.8</td><td>40</td><td>30 (O_2)</td><td>30 (air)</td><td>30 (O_2)</td><td>30 (air)</td><td>30 (O_2) or (air)</td><td>6 hrs. (air)</td></tr>
<tr><td>13.4</td><td>30</td><td rowspan="4">5 (O_2)</td><td>60 (air)</td><td>60 (O_2)</td><td>2 hrs. (air)</td><td>12 hrs. (air)</td><td>First 11 hrs. (air) Then 1 hr. (O_2) or (air)</td></tr>
<tr><td>8.9</td><td>20</td><td>60 (air)</td><td rowspan="3">5 (O_2)</td><td>2 hrs. (air)</td><td>2 hrs. (air)</td><td>First 1 hr. (air) Then 1 hr. (O_2) or (air)</td></tr>
<tr><td>4.5</td><td>10</td><td>2 hrs. (air)</td><td>4 hrs. (air)</td><td>2 hrs. (air)</td><td>First 1 hr. (air) Then 1 hr. (O_2) or (air)</td></tr>
<tr><td colspan="2">Surface</td><td>1 min. (air)</td><td>1 min. (air)</td><td>1 min. (air)</td><td>1 min. (O_2)</td></tr>
</table>

Time at all stops in minutes unless otherwise indicated.

FIGURE 9940–124.

Figure 9940–125.–Medical officer examining diver in recompression chamber. It is extremely important to detect any abnormal sign or symptom a diver may have as a result of decompression sickness. Abnormalities that indicate bubbles in nervous system call for treatment shown in table 3 or table 4.

Figure 9940–126.–Diver breathing oxygen during treatment of decompression sickness. Use of oxygen hastens elimination of nitrogen and greatly shortens treatment. Since there is a slight chance that patient may develop oxygen poisoning, he must be tended carefully while breathing oxygen.

15. These are the most important things to check when examining a man prior to treatment or when trying to determine whether all symptoms have been relieved:

a. How does he feel–(Ask him).

(1) Pain–where and how severe? Changed by motion? Sore to touch or pressure? Bruise marks in the area?

(2) Mentally clear?

(3) Weakness, numbness, or peculiar sensations anywhere?

(4) Can he see and hear clearly?

(5) Can he walk, talk, and use his hands normally?

(6) Any dizziness?

b. Does he look and act normal? (Don't just take his word for it if he says that he is all right.)

(1) Can he walk normally? Any limping or staggering?

(2) Is his speech clear and sensible?

(3) Is he clumsy or seem to be having difficulty with any act of movement?

(4) Can he keep his balance when standing with his eyes closed?

c. Does he have normal strength? (Check his strength against your own and compare his right side with his left.)

(1) Normal handgrip?

(2) Able to push and pull strongly with both arms and legs?

(3) Able to do deep knee bends and other exercises?

d. Are his sensations normal?

(1) Can he hear clearly?

(2) Can he see clearly both close (reading) and distant objects? Normal vision in all directions?

(3) Can he feel pin pricks and light touches with a wisp of cotton all over his body? (Note that some areas are normally less sensitive than others–compare with yourself if in doubt.)

e. Look at his eyes.

(1) Are the pupils normal size and equal?

(2) Do they close down when you shine a light in his eyes?

(3) Can he follow an object around normally with his eyes?

f. Check his reflexes if you know how.

16. Note that it should not take a great deal of time to examine a man reasonably well. Especially when you are under pressure in the chamber, there is seldom time to waste; but do not shortchange the patient. If there is real need for haste, having him walk and do a few exercises will usually show (or call to his attention) the more serious defects.

17. In all cases where there is any doubt, treat the diver as though he is suffering from decompression sickness. If you are not sure that he is completely free from **serious** symptoms, use the longer table. Remember that time and air are much cheaper than joints and brain tissue.

9940.815. AIR EMBOLISM AND RELATED ACCIDENTS

1. **Air embolism** refers to the plugging of a blood vessel by a bubble of air (or whatever the diver has been breathing) that entered the circulatory system directly from the lungs. It is similar to a vapor lock in a gasoline line. When this condition occurs in a diver, arteries in the brain are usually affected. Since the brain cannot function without a constant flow of blood, the consequences are rapid in onset and extremely serious in effect.

2. **Emphysema** refers to a swelling or inflation due to adnormal presence of air in the tissues. **Subcutaneous emphysema** is the presence of air in the tissues just under the skin. When seen in diving, it usually involves the skin of the neck and nearby areas. **Mediastinal emphysema** is the presence of air in the tissues in the vicinity of the heart and large blood vessels in the middle of the chest. Unless extreme, neither of these conditions is likely to cause serious difficulty. If emphysema is extreme, air embolism will usually be present also.

3. **Pneumothorax** indicates presence of air between the lungs and the chest wall. When air enters this space, the lung on the affected side collapses. This results in varying degrees of difficulty in breathing depending on the volume of air and the extent of resulting collapse. If pressure builds up in the space, severe difficulty in breathing and interference with the circulation can follow.

4. In diving, the same basic process produces air embolism and the related conditions: excessive pressure in the lungs sufficient to produce leakage of air. In diving, this comes about because of the expansion of air retained in the lungs during ascent. For example, if a man holds his breath on ascent, the lung air will expand as the surrounding pressure decreases (Boyle's Law). If it expands enough to fill the lungs completely, and the man still continues to hold his breath, the pressure in the lungs will become higher than that in the rest of the body. The lungs will be overexpanded, and at some point they will start to leak air—either into the blood vessels that go through the lungs or into the surrounding tissues or both. Actual tears in the lung tissue usually occur in the process of overexpansion. If air enters the mediastinum in sufficient amounts and under enough pressure, it will make its way up toward the neck and appear under the skin as subcutaneous emphysema.

5. Trapping of air in the lungs may result from several causes. The most common, in diving, is the voluntary holding of breath. Among amateur divers this is usually the result of a lack of understanding of the physics and physiology of diving. Breath holding may also come about as the result of panic. When panic occurs it is instinctive to hold your breath. Diseases of the lungs may produce pockets of air, which do not empty on ascent, or cause restriction of flow of air from areas of the lungs. The disease may be of recent orgin, such as pneumonia, or it may be one which occurred earlier in life and caused permanent changes such as scarring.

6. Pressure changes in extremely shallow depths may be sufficient to cause air embolism. Cases have occurred in depths as shallow as 12 feet. Air embolism and its related conditions most frequently occur in what is usually termed shallow water diving. It has also become a problem of primary importance in the use of self-contained breathing apparatus.

7. To develop air embolism or any of the related conditions there must have been an ascent from a depth greater than a few feet after using any source of air under pressure. This need not be compressed air in the way we usually think of it. A case occurred in a small boy who had taken an ordinary bucket down in the water to a depth of 11 feet. He breathed in the bucket until the air became foul. After this, he surfaced holding his breath. He was pronounced dead several hours later as the result of air embolism.

8. The arteries of the brain are almost always involved immediately; and since the brain is extremely sensitive to reduced circulation of blood, there is rarely a delay of more than a minute or so before the development of signs and symptoms. Certainly, any symptoms other than unconsciousness developing more than 5 minutes following the ascent should **not** be considered air embolism. Other possible causes should be investigated.

9. Symptoms developing from **air embolism** are dramatic and sudden in onset. In the usual case they will occur within seconds of the time of surfacing. In a case in which the leakage of air from lung tissue took place at a relatively deep depth, the symptoms may have started long before reaching the surface. Many cases will occur without the development of any symptoms prior to unconsciousness.

10. Symptoms, if they do develop prior to unconsciousness, are primarily those of involvement of the brain. For example, the diver will experience weakness, dizziness, paralysis or weakness of extremities, visual disturbances such as blurring, all of which indicate involvement of the brain. Any symptoms that develop will then rapidly become more severe and be joined by others until unconsciousness occurs, usually within a matter of seconds.

11. The diver may or may not have experienced discomfort or pain in the chest prior to or during the rupture of the lungs. Sometimes a victim will report that he felt a blow to the chest.

12. When actual tearing of lung tissue has taken place, the victim of an embolism will often have bloody froth at the mouth. When this is seen in a diver who loses consciousness on or before surfacing, it is a strong indication of air embolism. However, it is by no means always seen when this accident has occurred. Never assume that an unconscious diver **does not** have air embolism simply because there is no bloody froth. (On the other hand, bloody froth can also appear after a lung squeeze; and blood from an ear or sinus squeeze or a bitten tongue can sometimes be mistaken for bloody froth.)

13. The symptoms of **mediastinal emphysema** are pain under the breast bone and in extreme cases, shortness of breath or faintness due to interference with circulation as the result of direct pressure on the heart and large blood vessels.

14. Unless it is extreme, there are no symptoms with **subcutaneous emphysema** except perhaps a feeling of fullness in the neck and a change in the sound of the voice.

NOTES ON RECOMPRESSION

Explanation: All references to TABLES *indicate parts of table 1-21 "Treatment of Decompression Sickness and Air Embolism."*

1. *General Considerations*
   a. Follow TREATMENT TABLES (table 1-21) accurately.
   b. Permit no shortening or other alteration of tables except on advice of trained *diving medical officer* or in extreme emergency.

2. *Rate of Descent in Chamber*
   a. Normal rate is 25 feet per minute.
   b. Serious symptoms: rapid descent is desirable.
   c. If pain increases on descent: stop, resume at a rate tolerated by patient.

3. *Treatment Depth*
   a. Go to full depth indicated by table required.
   b. Do not go beyond 165 feet except on decision of medical officer.

4. *Examination of Patient* (see article 1.6.2(14))
   a. If no serious symptoms are evident and pain is not severe, examine thoroughly before treatment.
   b. If any serious symptom is noted, do not delay descent for examination or for determining depth of relief.
   c. In "pain only" cases where relief is reported before reaching 66 feet, make sure it is complete before deciding on TABLE 1.
   d. On reaching maximum depth of treatment, examine as completely as possible to detect
      1) Incomplete relief
      2) Any symptoms overlooked
      NOTE.—At the very least, have patient stand and walk length of chamber.
   e. Recheck before leaving bottom.
   f. Ask patient how he feels before and after coming to each stop and periodically during long stops.
   g. Do not let patient sleep through changes of depth or for more than an hour at a time at any stop. (Symptoms can develop or recur during sleep.)
   h. Recheck patient before leaving last stop.

5. *Patient Getting Worse*
   a. Never continue bringing a patient up if his condition is worsening.
   b. Treat as a *recurrence during treatment* (see 6).
   c. Consider use of helium-oxygen as breathing medium for patient (see 8).

6. *Recurrence of Symptoms*
   a. *During* treatment:
      1) Take patient to depth of relief (but never to less than 30 feet; and not deeper than 165 feet except on decision of medical officer).
      (If recurrence involves serious symptom not previously present, take patient to 165 feet.)

6. *Recurrence of Symptoms*—Continued
   a. *During* treatment—Continued
      2) Complete the treatment according to TABLE 4.
   b. *Following* treatment:
      1) Recompress to depth giving relief.
      2) If depth of relief is less than 30 feet,
         a) Take to 30 feet.
         b) Decompress from 30-foot stop according to TABLE 3.
      3) If relief occurs deeper than 30 feet,
         a) Keep patient at depth of relief for 30 minutes.
         b) Complete remaining stops of TABLE 3.
         NOTE.—If original treatment was on TABLE 3, use TABLE 4.
      4) Examine carefully to be sure no serious symptom is present. If the original treatment was on TABLE 1 or TABLE 2, appearance of a serious symptom requires full treatment on TABLE 3 or TABLE 4.

ALWAYS KEEP DIVER CLOSE TO CHAMBER FOR AT LEAST 6 HOURS AFTER TREATMENT. (Keep him for 24 hours unless very prompt return can be assured.)

MOST FREQUENT ERRORS RELATED TO TREATMENT

1. Diver's failure to report symptoms early.
2. Failure to treat doubtful cases.
3. Failure to treat promptly.
4. Failure to recognize serious symptoms.
5. Failure to treat adequately.
6. Failure to keep patient near chamber after treatment.

7. *Use of Oxygen*
   a. Use oxygen wherever permitted by tables unless
      1) Patient has not had oxygen tolerance test, or
      2) Is known to tolerate oxygen poorly.
   b. Be sure mask fits snugly.
   c. Take all precautions against fire (see table 1-29).
   d. Tend carefully, being alert for symptoms of oxygen poisoning such as
      1) Twitching 3) Nausea
      2) Dizziness 4) Blurring of vision
   e. Know what to do in event of convulsion. Have mouth-bit available.
   f. If symptoms appear, remove mask at once.
   g. If oxygen breathing must be interrupted—
      1) On TABLE 1, proceed on TABLE 1-A.
      2) On TABLE 2, proceed on TABLE 2-A.
      3) On TABLE 3, continue on TABLE 3 using air.
   h. At medical officer's discretion, oxygen breathing may be resumed at 40-foot stop. If this is done, complete treatment as follows:
      1) Resuming from TABLE 1-A: breathe oxygen: at 40 feet for 30 minutes at 30 feet for 1 hour
      2) Resuming from TABLE 2-A: breathe oxygen: at 40 feet for 30 minutes at 30 feet for 2 hours
      3) In both cases, then surface in 5 minutes still breathing oxygen.
      4) Resuming from TABLE 3: breathe oxygen: at 40 feet for 30 minutes at 30 feet for first hour (then finish treatment with air)

FIGURE 9940-127. (Articles and tables referenced herein are in the Diving Manual.)

NOTES ON RECOMPRESSION

Explanation: All references to TABLES *indicate parts of table 1–21 "Treatment of Decompression Sickness and Air Embolism."*—Continued

8. *Use of Helium-Oxygen*
   a. Helium-oxygen mixtures (ratio about 80:20) can be used *instead of air* (not in place of oxygen) in all types of treatment and at any depth.
   b. Use of helium-oxygen is especially desirable in any patient who
      1) Has serious symptoms that fail to clear within a short time at 165 feet.
      2) Has recurrence or otherwise becomes worse at any stage of treatment.
      3) Has any difficulty in breathing.

9. *Tenders*
   a. A qualified tender must be in chamber
      1) If patient has had any serious symptom.
      2) Whenever patient is breathing oxygen.
      3) When patient needs unusual observation or care for any reason.
   b. Tender must be alert for any change in patient, especially during oxygen breathing. (See 7, d–f.)
   c. *Tender must breathe oxygen* if he has been with patient throughout TABLE 1 or TABLE 2
      TABLE 1: Breathe oxygen—
      at 40 feet for 30 minutes
      TABLE 2: Breathe oxygen—
      at 30 feet for 1 hour
   d. Tender in chamber only through oxygen breathing part of TABLE 1 or 2 gains safety-factor by breathing oxygen for 30 minutes of last stop, but this is not essential. Tender may breathe oxygen during use of TABLE 3 or 4 at 40 feet or less.
   e. Anyone entering chamber and leaving before completion of treatment must be decompressed according to standard diving tables.
   f. Personnel outside must specify and control decompression of anyone leaving chamber and must review all decisions concerning treatment or decompression made by personnel (including medical officer) inside chamber.

10. *Ventilation of Chamber*
    (See art. 1.6.21, par. 18)
    Rule 1. Volume of air required (volume as measured at chamber pressure—applies at any depth):
    a. Basic requirement:
       1) Allow 2 cubic feet per minute per man.
       2) *Add* 2 cubic feet per minute for each man *not at rest* (as tender actively taking care of patient).
    b. When using oxygen:
       Allow 4 cubic feet of air *per man breathing oxygen* if this yields larger figure than basic requirement. (Do not add to basic requirement.)

    Rule 2. Maximum interval between ventilations:
    a. Not using oxygen:

    $$\text{Interval (min.)} = \frac{\text{Chamber (or lock) volume (cu. ft.)}}{\text{Basic vent. req. (cu. ft./min.) (from rule 1)}}$$

    b. Using oxygen:

    $$\text{Interval (min.)} = \frac{\text{Chamber (or lock) vol. (cu. ft.)}}{\text{No. of men br. } O_2 \times 10}$$

    a. Timing of ventilation:
       1) Use any convenient interval shorter than maximum from rule 2.
       2) (Continuous steady-rate ventilation is also satisfactory.)
    b. Volume used at each ventilation:
       1) Multiply volume requirement (cu. ft./min.) from rule 1 by number of minutes since start of last ventilation.
    c. Use predetermined exhaust valve settings to obtain required volume of ventilation. (See article 1.6.21 (18), (b).)

11. *First Aid*
    a. First aid measures may be required in addition to recompression. Do not neglect them.
    b. See table 1–26 and *Standard First Aid Training Course*, NAVPERS 1–0081.

12. *Recompression in the Water*
    a. Recompression without a chamber is difficult and hazardous. Except in grave emergency, seek nearest chamber even if at considerable distance.
    b. If water recompression must be used and diver is conscious and able to care for himself:
       1) Use deep sea diving rig if available.
       2) Follow treatment tables as closely as possible.
       3) Maintain constant communication.
       4) Have standby diver ready.
    c. If diver is unconscious or incapacitated, send another diver with him to control his valves and otherwise assist him.
    d. If lightweight diving outfit or scuba must be used, keep at least one diver with patient at all times. Plan carefully for shifting rigs or cylinders. Have ample number of tenders topside and at intermediate depths.
    e. If depth is inadequate for full treatment according to tables:
       1) Take patient to maximum available depth.
       2) Keep him there 30 minutes.
       3) Bring him up according to TABLE 3 if he can tolerate exposure. (If patient has been taken beyond 100 feet, do not use stops shorter than those of TABLE 2–A.)

FIGURE 9940–127. (Continued) (Articles and tables referenced herein are in the Diving Manual.

15. The symptoms of **pneumothorax** are:

a. Sharp pain in the chest usually made worse by deep breathing.

b. Shortness of breath.

16. The signs which may be observed in a diver suffering from **air embolism** are, from less serious to more serious:

a. Bloody frothy sputum.

b. Staggering.

c. Evidence of confusion or difficulty in seeing (for example, moving in the wrong direction or bumping into objects.)

d. Paralysis or weakness of extremities.

e. Collapse.

f. Unconsciousness.

g. Convulsions.

h. Cessation of breathing.

(Note that onset may be so sudden that none but the more serious signs can be seen.)

17. With **mediastinal emphysema** the following signs may be seen:

a. Blueness or cyanosis of the skin, lips, or fingernails.

b. Difficulty in breathing.

c. Shock.

18. With **subcutaneous emphysema**, the following signs may be seen:

a. Swelling or inflation of the neck even to the extent of resembling a bull frog.

b. A crackling sensation (crepitation) when the skin is moved slightly.

c. Change in sound of the voice.

d. Difficulty in breathing or swallowing.

19. With **pneumothorax**, the person may show any or all of the following:

a. Blueness (cyanosis) of the skin, lips, or fingernails.

b. Evidence of pain such as grimacing or clutching the side of the chest involved.

c. Tendency to bend chest towards the side involved.

d. Rapid shallow breathing.

20. The treatment of air embolism consist of **recompression** in a recompression chamber. This reduces the size of the bubble and may permit the resumption of normal circulation of blood in the brain. Recompress the patient without delay to a depth of 165 feet. Descend at the maximum rate possible within the capability of the tender or tenders to equalize. (The normal descent rate of 25 feet per minute does not apply to the treatment of air embolism.) If the tenders have difficulty equalizing, descent must continue regardless. After reaching 165 feet, follow either Table 3 or Table 4, whichever is indicated by the response of the patient: If he **completely** recovers within 30 minutes, use Table 3. If he does not completely recover within 30 minutes, use Table 4, (Both of these tables are given in fig. 9940–124. Be extremely watchful for any evidence of recurrence of symptoms during ascent.

Note.–Having a case of air embolism when no recompression chamber is nearby presents very serious problems. The delay involved in getting the victim to a chamber may result in death or permanent injury. However, attempting to treat such a patient in the water presents so many difficulties and risks (especially if only scuba equipment is available) that this seldom can be recommended except where the nearest chamber is at great distance.

21. Use oxygen where permitted by the treatment table, but discontinue it if there is evidence that oxygen-breathing is producing lung irritation (pain or coughing) or difficulty in breathing. Note that a helium-oxygen mixture can be used at any time during treatment with Table 3 or 4 (see figs. 9940–124 and 9940–127).

22. In a simple, uncomplicated case of mediastinal or subcutaneous emphysema where air embolism is not present, recompression is seldom desirable unless there is marked difficulty in breathing or evidence of impairment of circulation of blood due to pressure about the heart. If recompression is used, then Table 3 or Table 4 must be used for decompression.

23. In a case of pneumothorax uncomplicated by air embolism, do not use recompression. If it is severe and causes marked difficulty in breathing, the treatment required is direct removal of the air trapped between the lung and chest wall. This should be done by a medical officer. It is accomplished by careful insertion of a long hypodermic needle into the air-filled space and withdrawing the air by means of a syringe. The needle must be inserted no farther than necessary to reach the air. Care must be taken not to admit additional air during this procedure. This can best be avoided by using a two-way petcock between the needle and the syringe so that a direct free airway never exists into the chest cavity. Another emergency means of accomplishing this consists of constructing a simple one-way flutter valve using a condom slit at one end and tying the normally open end securely about the end of the needle. This then permits the air to escape; but no air can enter the chest cavity, and the lung will then expand.

24. In any case of air embolism or its related accidents, breathing may cease. In this case, artificial respiration must be started in addition to immediate recompression. Stimulants are indicated to help restore respiration. Shock must also be treated when it exists.

9940.816. LOSS OF CONSCIOUSNESS

1. Loss of consciousness during or after a dive is an acute emergency, and it may result from many different accidents. Air embolism and serious forms of decompression sickness have been discussed and should always be considered when a diver loses consciousness. Simple fainting occurs occasionally. Any mishap that stops breathing or seriously interferes with any part of the respiratory process will also lead to unconsciousness. Especially when a diver "passes out" underwater, more than one accident may have happened by the time he can be rescued. For example, loss of consciousness due to oxygen poisoning or some other initial accident might then lead to drowning, air embolism, or even a head injury – or conceivably all three. It often is very difficult to determine exactly what has happened to the victim, and it is far more important to start treating him at once than to try

to figure out the cause. Actually, the supposed nature of the accident seldom will change the steps that should be followed in treatment.

(Figure 9940-123 presents the most important steps in treatment.)

2. **Artificial respiration** must obviously be started without delay whenever a man is not breathing. **Recompression** should be given in almost every case of unconsciousness simply because it is seldom possible to be **certain** that it is not essential. Air embolism can result from only a few feet of ascent with breathholding or respiratory obstruction. Decompression sickness has been known to follow dives that were well within the "no decompression" limits, and its symptoms may appear many hours after surfacing.

3. Although the steps given in fig. 9940-123 provide a sound basis for treating almost any case of unconsciousness, several problems can arise. Common sense and good judgment must always be used.

a. If transporting the victim to a chamber and recompressing him will make some other lifesaving procedure difficult or impossible, then it may be best to concentrate on the other measure instead, especially if it seems extremely remote that the victim has a condition requiring recompression. In general, it is safer to assume that recompression is essential and make every effort to provide it, plus all other necessary measures as well. For example, it almost always should be possible to continue artificial respiration by some means while transporting the patient and recompressing him. Also, there are very few tests, treatments or even surgical procedures that could not be performed in a chamber of usual size in a real emergency. Recompression can seldom do harm. Failure to recompress can lose a life needlessly.

b. If the chamber is at a considerable distance, the likelihood that recompression will be beneficial is naturally reduced. But even in air embolism, recompression is worthwhile as long as the victim remains alive. Distance is never a sufficient excuse for not trying to reach a chamber as rapidly as possible. Attempting to recompress an unconscious man in the water (see fig. 9940--127) involves great difficulty and risk even when the conditions and available gear are ideal. It seldom can be recommended if any other course of action is possible.

c. Where unconsciousness results from a less serious condition like fainting, mild anoxia, or carbon dioxide excess, consciousness frequently will return before the man can be recompressed. In such a case, recompression is unnecessary unless some abnormality like paralysis or some other neurological sign remains and fails to show definite spontaneous improvement. In the milder conditions, recovery may occur very shortly after recompression is started. In some of these, the fact that recovery occurred under pressure may seem only a coincidence. However, it **never** is safe to assume that this was true. Any patient who regains consciousness during recompression deserves full proper treatment (no less than TABLE 3).

d. While following the steps of fig. 9940-123, bear in mind that unconsciousness may have been caused by some medical emergency not directly related to diving. The more time since surfacing from a dive, the more likely this is to be the case. Do not fail to examine the patient for signs of injury or other abnormalities and see that he is examined completely by a medical officer at the earliest opportunity. Recompression should not be delayed for this, and even positive findings of another condition will seldom veto recompression; but it is important to be fully aware of all that is wrong with the patient so appropriate action can be taken.

9940.817. RESPIRATORY ACCIDENTS

1. Some of the most important hazards of diving, especially in the use of scuba, are those that can **stop or seriously interfere with breathing** or with some other phase of the respiratory process. These can all result in unconsciousness even though in some cases breathing itself may continue for some time. In all of them, the proper initial treatment is the same as specified for unconsciousness (see fig. 9940-123). Any special considerations are indicated in the discussions of the individual accidents.

Drowning

2. **Circumstances**

a. Drowning is extremely unlikely with **deep-sea rig** but could occur in event of:

(1) Loss of helmet.

(2) Being in **head-down position** with spit cock open or when leaning on chin button, or with torn or ruptured suit.

b. Normally, as long as he remains upright and has air supply, a deep-sea diver can keep water out of his helmet even though his suit is badly torn.

c. With lightweight gear, drowning can follow loss or ditching of mask. (interruption of air supply may necessitate ditching.)

d. Numerous possibilities of drowning with self contained breathing equipment include:

(1) Loss or flooding of mask or mouthpiece.

(2) Failure of gear or gas supply.

(3) Surface exposure in rough water.

(4) Overexertion, exhaustion.

(5) Almost any mishap followed by failure of emergency procedures or panic.

(6) Any accident causing unconsciousness.

3. **Treatment**

See fig. 9940-123.

4. **Prevention**

a. Adequate training and drill in emergency procedures.

b. Proper equipment in good condition.

c. Use of lifejacket with scuba; lifeline with lightweight outfit.

d. Good diving practices; adequate preparations.

e. Appropriate boats, floats, etc.; readiness for going to aid of diver in distress.

Anoxia (oxygen deficiency)

5. Usual causes of anoxia in diving are:

a. **Loss or inadequacy of air supply.** (This also causes carbon dioxide excess, thus represents asphxia. **Diver generally knows he is in trouble.)**

b. Using up available oxygen in rebreathing-type apparatus (closed or semiclosed circuit). **This seldom gives warning.**

In **closed circuit** apparatus:

1. Poor initial purge.
2. Use of gas other than pure oxygen.

In **Semiclosed "mixed gas"** apparatus:

1. Use of too-low oxygen concentration in mixture.
2. Too-low flow setting.
3. Accidental reduction or cessation of flow.

6. **Symptoms:**

a. Diver frequently notices nothing; loses consciousness without warning.

b. May note mental changes similar to those of alcohol intoxication.

7. **Signs:**

a. Slowing up of responses, confusion, clumsiness, foolish behavior, and the like.

b. Unconsciousness.

c. Cyanosis (blueness).

d. Cessation of breathing in severe anoxia; death if not treated promptly.

8. **Treatment:**

a. If underwater with rebreathing apparatus, add oxygen to breathing bag immediately if possible. Otherwise, get to surface and give fresh air.

b. If still breathing and not suffering from another accident, fresh air will cause rapid recovery. Use oxygen if available.

c. If unconscious, treat according to fig. 9940-123.

9. **Prevention:**

a. Training, good equipment, etc.

b. Special attention to proper purge in using closed-circuit apparatus.

c. With mixed gas apparatus, extreme care in maintenance and preparation; attention to any sign of flow reduction or other malfunction during dive.

Carbon dioxide excess (including **shallow water blackout**)

10. **Usual causes:**

a. Loss or inadequacy of air supply. Using too little air in deep-sea rig.

b. Failure of carbon dioxide absorption in rebreathing scuba.

(1) Canister too small or poorly designed.
(2) Exhausted absorbent or poor filling.
(3) Exceeding duration of canister.
(4) Water leakage into canister.

c. Overexertion.

d. Excessive "controlled breathing."

11. **Symptoms:**

a. **Sometimes none,** as in anoxia. (See par. 5.)

b. Usually notice labored breathing, airhunger.

c. May have headache, dizziness, weakness, unusual sweating, nausea

d. May note mental changes: inability to think clearly, confusion.

12. **Signs:**

a. Slowing up of responses, confusion, clumsiness, foolish actions, and the like.

b. Unconsciousness; may have muscular twitching in extreme case.

c. (Breathing usually continues.)

13. **Action:**

a. Diver should stop, rest, ventilate. Surface if practical.

b. Bring diver up and provide fresh air. (Effects usually subside rapidly.)

c. If unconscious, treat according to fig. 9940-123.

14. **Prevention:**

a. Avoid causes.

b. Rest when breathing becomes labored.

c. Discontinue dive if breathing continues to be excessive or if mental changes are noted.

Asphyxia

15. Asphyxia involves **both** anoxia and carbon dioxide excess.

Usual causes:

a. Loss or inadequacy of air supply.

b. Obstructed breathing (strangulation).

16. **Signs and Symptoms:**

a. Usually have labored breathing.

b. May have headache, weakness, dizziness.

c. Mental changes as in anoxia and carbon dioxide excess.

d. Cyanosis (blueness).

e. Unconsciousness if severe.

f. May have violent increase in breathing followed by cessation of breathing.

17. Action:

a. Diver should stop, rest, ventilate. Surface if practical.

b. Bring diver up and give fresh air.

c. If unconscious, follow steps of fig. 9940-123.

18. **Prevention:**

Same as for anoxia and carbon dioxide excess.

Strangulation

19. Strangulation refers to **obstruction** of breathing. It will produce asphyxia if severe. Inhalation of foreign material such as chewing gum, a false tooth, or vomitus is the **most likely cause** of strangulation in diving. The diver may have spasm of the larynx due to inhalation of water. Strangulation may be a complication of drowning and other conditions requiring artificial respiration.

20. **Signs and symptoms:**

a. Extremely difficult (usually noisy) breathing; choking.

b. Unconsciousness if severe or prolonged.

c. Struggle to breathe eventually ceases.

21. **Treatment:**

a. Relieve cause if possible. If he is conscious, encourage victim to cough, pound him on back, hold inverted.

b. Attempt removal with finger or forceps if obstructing object is within reach, but take care not to push it farther down the throat.

c. Consider emergency tracheotomy if other measures fail.

22. **Prevention:**

a. Remove dentures; do not chew gum during a dive.

b. Guard against strangulation in unconscious victims of any accident.

Carbon monoxide poisoning

23. Carbon monoxide combines with hemoglobin in blood and keeps it from carrying oxygen. Basic difficulty, as a result, is that insufficient oxygen reaches the tissues (tissue anoxia).

24. **Usual cause** of carbon monoxide poisoning in diving is contamination of diver's air from:

a. Compressor intake too close to exhaust.

b. Flashing of lubricating oil in compressor.

25. **Symptoms:**

a. Frequently no symptoms noted; unconsciousness without warning.

b. Occasionally have tightness across forehead, headache, dizziness, nausea, weakness.

c. Confusion and other mental changes similar to those of anoxia.

26. **Signs:**

a. Failure to respond, clumsiness, bad judgment, and the like may be noted by tender or buddy.

b. Unconsciousness.

c. Breathing ceases in severe cases.

d. Abnormal redness of lips, nailbeds, or skin may help make diagnosis.

27. **Treatment:**

a. Get victim into fresh air. Give oxygen if available.

b. If unconscious, treat according to fig. 9940-123.

c. Continue use of oxygen in chamber (but not deeper than 60 feet or longer than 30 minutes at that depth).

28. **Prevention:**

a. Place exhaust downwind and as far from compressor intake as possible.

b. Assure adequate maintenance and proper operation of compressors.

c. Where any doubt exists, test air periodically for carbon monoxide.

Other respiratory accidents

29. **Electrocution** can cause abrupt cessation of breathing.

a. **Causes.** –Rare in diving but can occur through–

(1) Accidents with underwater cutting and welding procedures.

(2) Careless handling of lights, power tools, and other electrical equipment.

(3) Allowing use of electrical gear in bad condition.

b. **Prevention.**

(1) Comply with instructions in the Underwater Cutting and Welding Manual, NAVSHIPS 250-692-9.

(2) Exercise special care and attention at all times when electrical appliances are in use around the diving station.

(3) Repair or replace defective equipment promptly.

c. **Action.** Free victim from source of current promptly, but exercise extreme caution to avoid electrocution of rescuer. Cut power first if at all possible.

d. **Treatment.**

(1) Give artificial respiration.

(2) Get medical assistance at once.

Note.–Electrocution frequently stops heart action as well as breathing.

(3) Continue artificial respiration until victim revives or is pronounced dead.

(4) When a victim of electrocution revives, keep him strictly at rest for 24 hours even though consciousness and heart action (pulse) have returned to normal.

9940.818. SUMMARY OF SAFETY PRECAUTIONS

DIVER MUST BE QUALIFIED

1. Never put a man down who is not a qualified diver, except for training dives.
2. Never put a diver down whose qualification has lapsed, except in case of an emergency or to requalify under adequate supervision.
3. Never exceed depth to which diver is qualified.
4. Never send a diver down who has been physically disqualified.
5. Never dive a man until he has passed the physical examination outlined in the Manual of the Medical Department.
6. Never dive a man unless he is schooled properly in operating the type of diving outfit he is to wear.
7. Never dive a man if he does not know the diving hand signals.
8. Never dive a man if he has consumed excessive alcohol in the preceding 24 hours.
9. Never dive a man if he is suffering from severe cold, sinus, or ear trouble or an acute illness.
10. Never dive a man who is subject to fatigue from loss of sleep or previous severe physical or emotional strain.
11. Never exceed the depth limitations of article 9940.702.10 except as authorized in the article.

9940.819. DIVING EQUIPMENT

1. All equipment must be in first-class operating condition.
2. The control, nonreturn, and regulating escape valves shall be inspected daily before diving commences and must operate satisfactorily at all times.
3. The leather items should be checked and oiled to prevent deterioration.
4. The helmet fittings–safety lock, windows, goosenecks, air passages, gaskets–should be securely in place and free from all obstructions or verdigris.
5. The diver's air compressor must be properly lubricated, cooled, and cleaned, both during use and stowage. If the compressor is not used, it should be broken out every 30 days and operated, and again prepared for stowage.

6. The decompression chamber must be ready for us at all times.

7. All flammable material possible should be removed from the chamber.

8. Only fire-retarding paint should be used in the chamber.

9. No open flames, matches, cigarette lighters, lighted cigarettes, or pipes shall be taken in or used in the chamber during its use.

10. Decompression tables and treatment tables should be located on the inside and outside of the chamber.

11. The diver's lifeline and air hose shall be led over a roller or suitable curved place on the gunwale to avoid sharp bends which could break the conductor wires or core or damage the rubber cover.

If the foregoing procedure does not restore operation, the most likely source of trouble is failure of one or more of the vacuum tubes or failure of the power supply vibrator. To check or replace these tubes, the amplifier must be removed from its case by removing the panel screws. This will enable the main amplifier panel, the cover, and the rear panel to be withdrawn from the case as a unit. Before removing the tubes, it is necessary to loosen the locking clamps around the tube bases. Defective tubes and vibrators should be replaced with new ones. Only tubes of the type furnished with the amplifier should be used. The tubes are not interchangeable and replacement tubes should be installed in the sockets marked for the particular type of tube used.

If the foregoing check does not disclose the cause of failure, the trouble may be due to an open or short circuit in the amplifier connections or failure of component parts. The circuit may be checked by reference to the respective wiring diagrams and list of parts as shown in the instruction book accompanying the equipment.

9940.820. PLANNING DIVING OPERATIONS

1. Never start any diving operations without an officer qualified in diving being present. If such an officer is not available, a qualified diver should be placed in charge.

2. Never send a diver down without having immediately available the means of sending down a relief diver and being able to maintain both divers on the bottom for a reasonable length of time. For shallow water diving the diver may be backed up by a standby equipped with a lightweight outfit or SCUBA. For deeper dives the standby diver must be dressed in a deep-sea outfit except for his helmet, with communications tested and air supplied up to his control valves. For H_eO_2 dives of over 300 feet, while the diver is below his first decompression stop, the standby must be completely dressed in an H_eO_2 outfit. It is recognized that special circumstances on the scene may require the diving officer to modify the above in some cases.

3. Never rely on charts or hearsay as to depth of water when diving, but have a qualified man take soundings with a lead line or preferably, determine depth with a pneumofathometer. If an area is being searched, soundings should be repeated from time to time.

4. Never undertake diving operations without having a decompression table readily at hand. If decompression is contemplated, a stage should be rigged and stage line marked at 10-foot intervals.

5. In all cases where diving operations are to be undertaken, the depth of water and fatigue of the diver should determine the diver's time on bottom instead of the amount of work to be done.

6. A diver should never be allowed to descend without first determining his decompression time for his expected time on bottom.

7. Foresight used in the sound planning of a diving or salvage operation is half the job. Emphasis is often laid on the emergency of the job resulting in men and equipment arriving at the scene of operation unprepared.

8. Planning is paramount if systematic locating operations are to be undertaken from the surface, but in most cases it is easier, quicker, and more accurate than the diver with his circling line.

9. No diving locker is considered complete without equipment for performance of the following in a manner commensurate with the capacity of the men available:

a. Location and search equipment adequate to search a given area properly, including buoys and anchors for marking such areas.

b. Adequate and safe diving equipment for two divers.

10. Do not send a diver down unless he thoroughly understands what he has to do when on the bottom. This is important. Use sketches, blueprints, or inspection of a sister ship of the sunken vessel if available. If the diver does not fully understand his task, it is useless to send him down.

11. Never make a dive unless the available air supply is sufficient for all dives planned plus an adequate reserve for a relief diver in event of an emergency.

12. Never put a diver down unless the boat or ship is in at least a two-point moor.

13. Never send a diver down unless the proper naval or international diving signal is flying. (These signals are noted in communications publications.)

14. Never attempt to shift moor while a diver is down.

15. Never turn the propeller or get underway while a diver is down.

16. Never send a diver down on the propeller of a ship without first taking proper precautions.

17. Never send a diver down around the hull of a submarine until the duty officer has been notified not to operate bow planes, stern planes, sound heads, rudder, or propellers.

18. Never set off an explosive charge with a diver down.

19. Never let a diver work around corners or inside a wreck without the help of another diver to tend his lines from the point of entry.

20. A diver should never cut a line until he has made certain of the purpose for which it is being used.

21. Prior to all diving, the diver should remove from his mouth anything which might tend to choke him (dentures, gum, etc.).

9940.821. DRESSING THE DIVER

1. Don't dive without a safety nonreturn valve on helmet or mask; always check this valve for proper working order.

2. Don't dive with a helmet without first checking the safety nonblow-up type exhaust valve.

3. Don't dive with a hand pump without knowing its efficiency or without overhauling it if the efficiency has dropped too low.

4. Do not attempt any diving operations if the compressor is not operating satisfactorily or gives any indication that it will not continue to operate satisfactorily.

5. Never connect a diver's air hose directly to the delivery nozzle of a diving compressor or diving pump; an oil separator and volume tank are required.

6. Don't dive without first checking jock strap for possible breakage.

9940.822. THE DESCENT

1. Don't allow a diver to descend without first making these final checks:

a. The helmet is tightened securely and the helmet lock is locked in place.

b. The air hose and life line are securely tied to the breatstplate.

c. The exhaust valve is set.

d. The control valve is opened and air is passing through the suit.

e. The diver makes a sound test of the nonreturn valve seating.

f. Telephone communications are in good order.

g. The jock strap is tightened properly.

h. The faceplate is securely closed.

i. The diver has a ready, pure, and adequate supply of air at the proper over-bottom pressure and that this pressure is maintained.

j. The descending line is properly placed.

k. Finally, that the diver gives his signal to descend.

2. In going down, never get ahead of your air supply. To do so may result in serious injury.

9940.823. WORKING ON THE BOTTOM

1. To work efficiently and safely underwater, a diver must keep in mind the following:

a. Never completely close the air-control valve, except in case of rupture or replacement of air hose.

b. The helmet air-regulating exhaust valve stem, known as the chin valve, may be used effectively to release quickly the suit pressure when desiring to stoop or crawl on the bottom without changing the air-control valve and the air regulating exhaust valve adjustment.

c. The helmet spitcock offers another method of relieving excess pressure in the helmet.

d. The safety nonreturn valve in the helmet gooseneck and the helmet air-regulating exhaust valve will seat themselves if the diver's air supply is impaired, but the spitcock, if open, must be closed immediately by hand.

e. A diver is never in danger from a leaking dress provided he remains in an upright position.

f. Air trapped in the diving helmet will last from 6 to 9 minutes for breathing purposes after the diving air is cut off, thus providing ample time for emergency measures to be executed provided the diver does not get excited or exert himself.

2. Never leave a diver on the bottom in sudden squalls, heavy seas, strong tides, or any other conditions which, in the opinion of the commanding officer, jeopardize the security of the moorings.

3. Never weld or burn underwater with alternating current where direct current is available. See Underwater Cutting and Welding Manual (NAVSHIPS 250–692–9) for full information.

4. Never perform electric welding or burning underwater, except in extreme emergency, unless the diver is wearing a complete suit to fully insulate his body from the work, the torch or electrode holder, and the water itself. The use of rubber or rubberized canvas gloves, bonded to the suit, is mandatory. The diving outfit in use must be fitted with voice communications.

5. When working about moorings, or wreckage, a diver should be especially careful not to get fouled. He should not dip under chains or lines. He should, if possible, always go over obstacles instead of under them. This is especially important in case of a blow-up. A diver should not descend on a chain or wire if it is possible to do otherwise, and neither should a chain, wire, line, or weight be veered, lifted, or moved until the diver has been brought up.

6. Whenever a diver discovers that he is fouled, he should not get excited but should attempt to extricate himself by slow methodical steps. The distance line should never be released, as it is a safe guide and should show the way out of a tangle. He should inform the surface crew to take up slowly the slack in his air hose and life line. After resting and again attempting unsuccessfully to free himself, he should ask for help.

7. In case a diver is fouled and cannot extricate himself, a relief diver who is sent down must be prepared to replace both air hose and life line—a procedure that may be safely executed on the bottom.

8. When a diver is working on the bottom of a ship, he should never run the risk of falling off, but should always have something substantial to hold on to, and have the tenders keep the life line and air hose well in hand. It is dangerous for a diver to hold on to something overhead and climb around in that manner; all the air in the dress may escape out of the cuffs or through leaks in a torn glove, in which case he may become so heavy that it will precipitate a fall. He should never go under the keel of a ship and up the other side. If it is necessary to work on the other side, he should ask to have the diving boat shifted.

9940.824. TENDING THE DIVER

1. Never allow a dressed diver to walk on topside, unattended.

2. Never let a man who does not know his signals tend a diver.

3. When a diver is going down a ladder, the tender must keep both hands on life line and air hose, and be backed up by another man.

4. Do not allow air hose and life line to run free when diver is descending.

5. Do not give diver too much slack while he is on the bottom. To do so increases the chances of fouling.

6. Do not try to send hand signals to diver without first taking up all the slack.

7. Do not give signals with long heavy jerks, diver may be hurt in doing so. Signals are to be short and distinct pulls. Never belay a diver's life line and air hose to a cleat or a stanchion.

8. Never give a diver too much slack where there is any danger of a fall; keep a tight hold on the diver's lines and do not give out any more slack than necessary.

9. "Fish" diver occasionally taking in all slack easily and paying out as before. This is a good way of telling if the diver has shifted his position. An expert tender can do this without the diver's knowledge.

10. In case a diver is blowing up, the tender should take in his slack as fast as he ascends and haul him in upon reaching the surface. A check of diver and equipment must be made before descending again.

11. A good tender can help a diver considerably. A poor one is a menace.

12. Don't use a man as a tender who does not understand the dangers of a squeeze or blow up and what to do under the circumstances.

13. The tender should be continuously on the alert. Don't stand where there is a chance of the tender being pulled into the water. When the diver is going down or coming up, make sure the tender is backed up by someone.

9940.825. LIGHTWEIGHT DIVING

1. Don't duck the mask while on the bottom except in an emergency, and then remember to exhale continuously while ascending.

2. In shallow water diving, don't send a man down who is not a qualified diver and a first-class swimmer.

3. Don't put shoes or any extra weight on a diver while using a mask or helmet alone for diving.

4. Don't dive without a lifeline attached around the diver's waist. This line must be securely fastened above the belt.

5. In helmet and mask diving, i. e., "skin" diving, the diver must be able to rid himself instantly of all equipment except his lifeline in case it becomes necessary to swim to the surface. Only a belt with a quick release shall be used.

6. It is well to remember that mask, helmet, and "soft" suit diving can, because of its simplicity, become the most dangerous type of diving if not properly supervised.

7. Never, except in extreme emergency, dive inside a ship or in any other situation which would not allow a direct ascent to the surface.

Part 3. Decompression

A. Decompression Tables

9940.831. DEFINITION OF DECOMPRESSION

The degree of body saturation by various gases is dependent upon three influencing factors–time of exposure, depth of dive, and circulatory efficiency. To bring a diver safely to the surface, time for this gas to escape without bubble formation in the body tissues must be allowed. The escape of this gas is called decompression, and the time required for the process is known as decompression time. It is apparent that the deeper the dive or the more time spent on the bottom, the greater is the amount of gas absorbed by the body. It is clear that if more gas is taken up by the diver's body tissues, there will be more to get rid of and this takes time.

9940.832. STAGE DECOMPRESSION

1. Some time ago, Dr. Haldane of England stated that if the human body contained dissolved gas at a pressure more than twice the outside pressure, bubbles would form. On the basis of Dr. Haldane's investigation, the first practical decompression tables were calculated. Extensive work has been undertaken in an attempt to reduce this ratio of 2 to 1, and consequently the decompression time.

2. The most practical method of bringing the diver to the surface to prevent the formation of bubbles is "stage decompression," that is, bringing the diver up to a given depth and holding him there for a stated length of time, then bringing him up to the next stop and repeating the process until he reaches the surface. These stops can be made at any intervals but, for convenience, they are made at 10-foot intervals. Stage decompression can be accomplished by one of two methods: (a) Regular decompression or (b) surface decompression.

9940.833. INSTRUCTIONS TO TENDERS

1. The tender shall always keep himself informed as to the depth of the diver. Inasmuch as fathometers, lead lines, descending lines, stage lines, or payed-out lifeline and air hose cannot be used to determine depth with accuracy, a simple and accurate method has been devised. Depth is determined by means of an air supply, a depth gage calibrated in feet of sea water, and an oxygen hose. The oxygen hose is made up with the diver's lifeline and air hose, the open end terminating at about the breastplate level. To take a reading, blow air through the hose until it escapes at the open end, then secure the air supply. The pressure remaining in the oxygen hose is that necessary to balance a column of water corresponding to the depth of the open end of the hose and is read directly on the gage in feet. While the diver is standing, add 5 feet to determine bottom depth. This device is especially valuable in determining decompression stops during the ascent when the diver has been swept from the descending line. A similar device, independent of the diver's lifeline and air hose, may be assembled to be used for soundings prior to the commencement of diving operations. (See article 9940.606.)

2. The tender shall frequently contact the diver by intercom or signal while on the bottom and on the stage to ascertain if all is well. The tender shall give the diver a few minutes' notice before the expiration of the diver's time on the bottom so that the diver can make the necessary preparation prior to his ascent and not exceed the limit of his stay on bottom.

NAVY STANDARD DECOMPRESSION TABLE

(Using compressed air]

1 Depth of dive (feet)	2 Time on bottom (minutes)	3 Stops (feet and minutes) Feet 90	Feet 80	Feet 70	Feet 60	Feet 50	Feet 40	Feet 30	Feet 20	Feet 10	4 Sum of times at various stops (minutes)	5 Approximate total decompression time (minutes)
40	120									0	0	2
40	180									2	2	4
40	Opt.* *240*									4	4	6
40	300									6	6	8
50	78									0	0	2
50	120									2	2	5
50	150									5	5	8
50	Opt.* *190*									9	9	12
50	300									12	12	15
60	55									0	0	3
60	75									2	2	5
60	110									13	13	16
60	Opt.* *150*								5	15	20	24
60	180								7	16	23	27
60	210								8	18	26	30
70	43									0	0	3
70	60									4	4	8
70	75									13	13	17
70	90								4	16	20	24
70	Opt.* *120*								13	16	29	33
70	150								18	21	39	43
70	180								21	32	53	57
80	35									0	0	3
80	50									6	6	10
80	70								6	16	22	27
80	100								20	16	36	41
80	Opt.* *115*								22	26	48	53
80	150								28	29	57	62
90	30									0	0	4
90	45									6	6	10
90	60								9	16	25	30
90	75								18	14	32	37
90	Opt.* *95*							2	27	21	50	56
90	130							9	27	29	65	71
100	25									0	0	4
100	40									12	12	17
100	60								18	16	34	39
100	75								27	21	48	53
100	Opt.* *85*							6	28	21	55	61
100	90							8	27	24	59	65
100	120							17	28	48	93	99
110	20									0	0	5
110	35									12	12	17
110	65								22	21	43	49
110	Opt.* *75*							14	27	37	78	84
110	105						2	22	20	50	103	110
120	18									0	0	5
120	30									11	11	17
120	45								18	21	39	45
120	Opt.* *65*							13	28	32	73	80
120	100						5	22	27	69	123	130
130	15									0	0	5
130	35								11	15	26	32
130	52							6	28	28	62	69
130	Opt.* *60*							13	28	28	69	76
130	90						9	22	28	69	128	136
140	15									4	4	10
140	30								8	21	29	36
140	45							5	27	27	59	67
140	Opt.* *55*							15	28	32	75	82
140	85						14	22	32	69	137	145
150	15									7	7	14
150	30								13	21	34	41
150	38								28	30	58	65
150	Opt.* *50*							16	28	32	76	84
150	80						18	23	32	69	141	150
160	15									9	9	16
160	34								27	28	55	63
160	Opt.* *45*							17	28	43	88	96
160	75					3	19	23	34	68	147	156
170	15									11	11	18
170	30								24	27	51	59
170	Opt.* *40*							19	28	46	93	102
170	75					9	19	23	38	68	157	167
185	15									25	25	33
185	26								24	37	61	70
185	Opt.* *35*							19	28	46	93	102
185	65				18	18	23	37	65	51	212	223
200	15									32	32	41
200	23								23	37	60	69
200	Opt.* *35*							22	28	46	96	106
200	60			5	18	18	23	37	65	51	217	229
210	15									35	35	44
210	Opt.* *30*						5	16	28	40	89	100
210	55			6	18	18	23	37	65	51	218	231
225	15								6	35	41	51
225	Opt.* *27*						22	26	35	48	131	143
225	60			13	18	18	23	47	65	83	267	280
250	15								17	37	54	66
250	Opt.* *25*					2	23	26	35	51	137	150
250	50		12	14	17	19	29	49	65	83	288	303
300	12								20	37	57	70
300	Opt.* *20*					9	23	26	35	51	144	159
300	45	6	14	15	17	18	31	49	65	83	298	315

*These are the optimum exposure times for each depth which represent the best balance between length of work period and amount of useful work for the average diver. Exposure beyond these times is permitted only under special conditions.

FIGURE 9940-128

9940.834. COMPLETION OF ASCENT

In regular decompression, the ascent is completed by hoisting and stopping the stage to and at the successive stops prescribed in Navy Standard Decompression Table. Prior to hoisting of the stage between the first and successive stops, the timekeeper shall notify the diving officer sufficiently in advance of the termination of the prescribed time at the respective stop to permit necessary preparation for the hoisting. For example, if the diver has been decompressed at the first stop and the time spent on the stage at the first stop is within 1 minute of the total time prescribed for that stop, the timekeeper shall indicate it by distinct announcement of "1 minute to go." The diver is then notified by the tender to stand by for hoisting to the next stop. The timekeeper shall announce the termination of the proper time at the various stops, and before starting the stage upward, the diver shall be informed by the tender of the intended hoisting by the message "coming up." On confirmation reply from the diver, the diving officer or diver-in-charge will order the diver brought to the next stop.

B. Compressed Air Illness and Treatment Tables

9940.851. CAUSE OF COMPRESSED AIR ILLNESS

1. Compressed air illness, commonly called the bends, decompression sickness, or caisson disease, is a condition resulting from inadequate decompression following exposure to pressure. Bubbles of nitrogen are formed in the tissues and blood stream and by their mechanical obstruction cause pain, paralysis, asphyxia, and, if large or numerous enough, death. As a diver descends, his body is subject to the increasing pressure of the water. In the case of a diver working in a full suit, this pressure is exerted directly on the suit and helmet and indirectly on the body through the air in his suit and helmet. In a satisfactory dive the pressure is transferred through the air in the helmet to the air in the lungs and thence to the blood. Air is forced into solution in the blood and this dissolved air is carried to each cell of all parts of the body and to the spaces between the cells.

2. As the diver ascends, the pressure of the water becomes progressively less. Along with this drop in pressure, there is a fall in the pressure of the air in the helmet and the air in the lungs. In accordance with physical laws, the air dissolved in the blood and tissues comes out of solution in the form of gas and is expelled through the lungs, thereby decreasing its partial pressure inside the body until a new equilibrium is established with the outside pressure. If the diver ascends too rapidly or, expressed another way, if he receives inadequate decompression, the gas dissolved in the blood and tissues will come out of solution so rapidly as to produce bubbles of undissolved gas in these tissues. Bubbles will cause symptoms directly in the cells by their pressure on nerve cells or indirectly by interfering with circulation. In the latter case, the bubbles either join together to form one or more large bubbles which block the blood vessels or there are so many present that they replace the blood in a portion of the body.

9940.852. SYMPTOMS OF COMPRESSED AIR ILLNESS

1. Compressed air illness usually causes symptoms within a short period of time following a dive. If a diver comes to the surface quickly without any stops, he may be suffering from the bends when he reaches the surface. If he makes a stop or two of greatly insufficient duration, he may have symptoms before he reaches the surface. In general, however, most cases develop after a short period of time and almost always before 12 hours. A review of several sets of statistics gives the following figures:

50% occurred within 30 minutes.
85% occurred within 1 hour.
95% occurred within 3 hours.
1% delayed over 6 hours.

2. The symptoms of compressed air illness have been found to occur with the following frequency:

Local pain	89%
Leg	70%
Arm	30%
Dizziness ("The Staggers")	5.3%
Paralysis	2.3%
Shortness of breath ("The Chokes")	1.6%
Extreme fatigue and pain	1.3%
Collapse with unconsciousness	.5%

The typical case may begin with itching or burning of a localized area. This may become generalized and then finally localize again. Rarely, the man may have a sensation as of ants crawling all over him. There may be a feeling of tingling of the skin or numbness. There may be a rash, the skin appearing blotchy and mottled. Occasionally, there will be small red spots which vary from the size of a pin head to the size of a dime.

3. Pain, which is the predominating symptom, is of a deep, boring character. Divers describe it as being felt in the bone or in the joint. Frequently the pain is slight, but becomes progressively worse until it is unbearable. The pain usually is not affected by motion of the area, but frequently may be temporarily relieved by vigorous massage or hot applications.

4. When dizziness occurs, the diver feels that the world is revolving around him and that he is falling to one side. Usually he experiences ringing in the ears at the same time.

5. Paralysis, shortness of breath, with pain on deep breathing ("chokes"), extreme fatigue, asphyxia, and collapse, though very unusual, are so dramatic in onset that they are immediately recognized.

6. In all cases where there is any doubt, the diver should be treated as though he is suffering from compressed air illness. Any delay is dangerous.

9940.853. PREVENTION OF COMPRESSED AIR ILLNESS

The prevention of compressed air illness is accomplished through the observance of a few simple rules:

1. Careful selection of personnel. This is the problem of the medical officer.

2. Careful observation and evaluation of each man before he makes any dive. Recent over-indulgence in alcohol excessive fatigue, or a general "run-down" condition should be sufficient cause to restrict a man from diving. It is the duty of the diving officer and the senior divers present to prohibit any man from diving when his physical condition on that day is not satisfactory. If any doubt ex-

ists as to the diver's physical fitness, the medical officer's opinion must be the deciding factor.

3. Constant meticulous attention to the details of the dive. Diving officers and divers should see to it that at all times a record is kept of the exact time of the dive, the depth of the dive, the duration of the dive, and all details of the decompression given the diver. This record should be easily available at all times as the knowledge of these facts is of the utmost importance in diagnosis and treatment.

4. Strict observance of the decompression tables with due consideration for modifying factors. The tables should be followed at all times unless there is definite evidence from past experience that the decompression time given for a dive is inadequate. In that case the diver should be decompressed as if he had made a dive 10 feet deeper than he actually did.

5. The incorporation of a safety factor in all dives. For example, if a dive is to 85 feet for 70 minutes, the diver should be decompressed in accordance with the table for a dive to 90 feet for 75 minutes. (See Decompression Table.)

6. Immediate reporting of all symptoms to the medical or diving officer. Serious cases of bends often begin as a slight itch or pain. All too often men fail to report their symptoms early and as a result their treatment is much more prolonged and their chances of suffering permanent damage greatly increased.

9940.854. TREATMENT OF COMPRESSED AIR ILLNESS

1. As soon as a diver experiences any unusual sensation in his skin or any pain or other symptoms mentioned above, he should report at once to a medical officer and/or to the diving officer. The treatment of compressed air illness is by compression in accordance with the Treatment Tables. These tables shall be strictly adhered to, and may be modified only by medical officers experienced in deep-sea diving when, in their opinion, deviations therefrom are indicated. The tables shall not, except in emergencies, be shortened for reasons of convenience or to save time.

2. If only pain is present, treat in accordance with tables 1, 1-A, 2, or 2-A, as shown in fig. 9940–129.

3. If serious symptoms occur, treat in accordance with tables 3 and 4 as shown in fig. 9940–130. The symptoms requiring this treatment are:

a. Unconsciousness.
b. Convulsions.
c. Weakness or inability to use arms or legs.
d. Visual disturbances.
e. Dizziness.
f. Loss of speech or hearing.
g. Shortness of breath.

4. If dizziness, nausea, muscular twitchings, or blurring of vision occurs while breathing oxygen, remove the mask and proceed as follows:

a. If using table 1, complete remaining stops on table 1-A.
b. If using table 2, complete remaining stops on table 2-A.
c. If using table 3, complete remaining stops on table 3, breathing air.

At the discretion of the medical officer, oxygen breathing may be resumed at the 40- and 30-foot stops for a total of 90 minutes if using tables 1 or 3, or for 150 minutes if using table 2 in fig. 9940–129.

5. In the treatment of compressed air illness, certain techniques must be followed:

TREATMENT TABLES FOR COMPRESSED AIR ILLNESS

Stops		Bends—Pain only			
Rate of descent, 25 feet per minute	Rate of ascent, 1 minute between stops	Pain relieved at depths less than 66 feet. Use table 1-A if O_2 is not available.		Pain relieved at depths greater than 66 feet. Use table 2-A if O_2 is not available. If pain does not improve within 30 minutes at 165 feet, the case is probably not bends. Decompress on table 2 or 2-A.	
Lbs.	Feet	Table 1	Table 1-A	Table 2	Table 2-A
73.4	165	----------	----------	30 (Air)	30 (Air).
62.3	140	----------	----------	12 (Air)	12 (Air).
53.4	120	----------	----------	12 (Air)	12 (Air).
44.5	100	30 (Air)	30 (Air)	12 (Air)	12 (Air)
35.6	80	12 (Air)	12 (Air)	12 (Air)	12 (Air).
26.7	60	30 (O_2)	30 (Air)	30 (O_2)	30 (Air).
22.3	50	30 (O_2)	30 (Air)	30 (O_2)	30 (Air).
17.8	40	30 (O_2)	30 (Air)	30 (O_2)	30 (Air).
13.4	30		60 (Air)	60 (O_2)	2 hours (Air).
8.9	20	5 (O_2)	60 (Air)		2 hours (Air).
4.5	10		2 hours (Air)	5 (O_2)	4 hours (Air).
Surface			1 minute (Air)		1 minute (Air).

Time at all stops in minutes unless otherwise indicated.

FIGURE 9940–129.

TREATMENT TABLES FOR COMPRESSED AIR ILLNESS

Stops		Serious symptoms	
Rate of descent, 25 feet per minute	Rate of ascent, 1 minute between stops	Symptoms relieved within 30 minutes at 165 feet. Use table 3.	Symptoms not relieved within 30 minutes at 165 feet. Use table 4.
Pounds	Feet	Table 3	Table 4
73.4	165	30 (Air)	30 to 120 (Air).
62.3	140	12 (Air)	30 (Air).
53.4	120	12 (Air)	30 (Air).
44.5	100	12 (Air)	30 (Air).
35.6	80	12 (Air)	30 (Air).
26.7	60	30 (O_2) or (Air)	6 hours (Air).
22.3	50	30 (O_2) or (Air)	6 hours (Air).
17.8	40	30 (O_2) or (Air)	6 hours (Air).
13.4	30	12 hours (Air)	First 11 hours (Air). Then 1 hour (O_2) or (Air).
8.9	20	2 hours (Air)	First 1 hour (Air). Then 1 hour (O_2) or (Air).
4.5	10	2 hours (Air)	First 1 hour (Air). Then 1 hour (O_2) or (Air).
Surface		1 minute (Air)	1 minute (O_2).

Time at all stops in minutes unless otherwise indicated.

FIGURE 9940–130.

a. Symptoms occasionally become temporarily worse if pressure is applied too rapidly. The descent should be made at a rate of 25 feet a minute. If the symptoms become worse, stop momentarily and then slowly raise the pressure at a rate tolerated by the diver.

b. In all cases, particularly serious cases with paralysis, the ability of the diver to stand up and walk the length of the chamber should be tested. This test should be made routinely before leaving the bottom and upon completion of the 30-foot stop.

c. Treatment includes first-aid measures. These are discussed below.

d. Always keep the patient near the chamber for at least 24 hours to be able to treat any recurrences immediately.

9940.855. RECURRENCES

Occasionally, because of the severity of the conditions or the inadequacy of the treatment, recurrences of symptoms will occur.

1. If symptoms recur during treatment with any of the above tables, recompress to the depth at which relief is obtained, but never less than 30 feet, and then complete decompression from this depth according to table 4.

2. Should symptoms recur following treatment with any of the above tables, recompress the diver to a depth giving relief.

a. If relief occurs at a depth less than 30 feet, take diver to 30 feet and decompress from the 30-foot stop according to table 3.

b. If relief occurs deeper than 30 feet, remain at the depth of relief for 30 minutes and then complete remaining stops of table 3 using air throughout.

9940.856. USE OF OXYGEN

When using oxygen, certain precautions are to be followed:

1. Observe all fire precautions as listed in part 1 (E). The electric fan and heater outside disconnect-switch should be open. The chamber should be ventilated frequently to keep the oxygen concentration in the chamber at a low level.

2. A very high concentration of oxygen, preferably above 95 percent, should be delivered to the patient. The mask used should be as tight-fitting and as leak-proof as possible to make the treatment tables effective.

3. If possible, the oxygen should be humidified to avoid dryness of the nose and throat.

4. The tender should be acquainted with the symptoms and treatment of oxygen poisoning.

9940.857. APPLYING FIRST AID

In the treatment of compressed air illness, certain first aid and supportive methods should be used. The patient should be kept warm by the use of fire-resistant blankets, hot-water bottles, and the feeding of hot coffee or soup. Never give fluids by mouth to an unconscious man. When the patient is in shock, he should be placed flat, with his feet slightly elevated. In the hands of a medical officer or an experienced pharmacist's mate, intravenous and subcutaneous injections of blood, plasma, or saline solution may be administered if the patient's condition so warrants. Adrenalin and other heart and respiratory stimulants should be on hand and used if heart failure is present or imminent.

9940.858. USE OF HELIUM-OXYGEN

Helium-oxygen mixtures, in about an 80:20 ratio, may be used instead of air in all types of treatment at any depth.

9940.859. TREATMENT WITHOUT CHAMBER

1. Frequently, diving operations are carried out without a recompression chamber being available. Should a diver develop compressed air illness, the attending personnel may be hard put to administer adequate recompression. If the man is conscious and able to care for himself, he should be put in a suit and recompressed in the water. If he is partially paralyzed, another diver should be put down with him to operate his valve and help him. This is a particularly difficult and dangerous procedure which should not be undertaken unless absolutely necessary.

2. In certain instances, especially in emergency harbor clearance work, a man may develop compressed air illness and there will be no chamber available and an insufficient depth of water in which to recompress him in accordance with the tables given above. In such cases, the diver should be taken to 30 feet and there treated in accordance with table 3, fig. 9940–130.

9940.860. TENDER ALWAYS PRESENT IN CHAMBER

1. A tender must always be present in the chamber with a diver breathing oxygen. If possible, this tender should be a pharmacist's mate trained in diving. If one is not available, the tender should be one who has had experience in the use of oxygen.

2. While using table 1, 30 minutes of oxygen breathing is adequate for the tender; while using table 2, 60 minutes of oxygen breathing is required. If the diver is treated as outlined in tables 3 and 4 (fig. 9940–130), the tender will necessarily be subjected to the same treatment. The tender should not make an attempt to calculate and follow his own decompression. Several cases of compressed air illness have occurred as a result of such action. Decompression for additional tenders who may subsequently enter the recompression chamber for short periods will be carried out in accordance with standard diving tables.

9940.861. PREPAREDNESS

At all diving activities, the personnel should be prepared at all times to deal with cases of compressed air illness.

1. The chamber should be tested regularly and kept in a state of repair and readiness. It should not be used as a stowage space, as a private locker, or as sleeping quarters.

2. The oxygen masks shall be operable and clean and the oxygen banks filled at all times.

3. The air lock should be tested at frequent intervals and personnel instructed in its use.

4. A fire-resistant mattress and blankets should be kept in the chamber at all times, along with a bucket for body wastes.

5. A medical kit containing first-aid equipment should be in the chamber. It should be well stocked with fresh supplies and contain, in addition to the usual items, adrenalin and other stimulants, sterile syringes, and needles.

6. All personnel should be assigned definite tasks to perform in the treatment of a case of compressed air illness, and training runs should be directed by a medical or diving officer.

9940.862. SUMMARY

Compressed air illness is a disease peculiar to those who have been exposed to increased air pressures. It results from inadequate decompression which causes the formation of bubbles of gas in the blood stream and tissues. It manifests itself as a rash, pain, paralysis, asphyxia, or death. Most cases of compressed air illness can be prevented. If it does occur, it should be reported to the medical or diving officer at once. Treatment is by recompression given in accordance with the tables appearing above. Diving activities must always be in a state of readiness to handle any cases that arise.

Part 4. Summary of Safety Precautions

9940.941. DIVER MUST BE QUALIFIED

1. Don't put a man down who is not a qualified diver.
2. Don't put a diver down whose qualification has lapsed except in case of an emergency or to requalify under adequate supervision.
3. Don't exceed depth to which diver is qualified.
4. Do not send a diver down who has been physically disqualified.
5. Don't dive a man until he has been given the physical examination outlined in the manual of the Medical Department.
6. Don't dive a man unless he is schooled properly in operating the type of diving outfit he is to wear.
7. Don't dive a man if he does not know the diving hand signals.
8. Don't dive a man if he has consumed excessive alcohol in the preceding 24 hours.
9. Don't dive a man if he is suffering from a severe cold, sinus, ear trouble, or an acute illness.
10. Don't dive a man who is subject to fatigue from loss of sleep or previous severe physical or emotional strain.

9940.942. MEDICAL ASPECTS OF DIVING

1. The rate of ascent for air diving shall not exceed 25 feet per minute. Decompression shall be strictly in accordance with the decompression tables.
2. The compressed air illness treatment tables shall be strictly adhered to. There shall be no deviation from the tables for reasons of convenience or to save time where time is not of a vital nature.

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