3

Standard Diving Apparatus and Equipment, with Instructions for Care, Maintenance and Testing

Hand Pumps. Although power-driven compressors and batteries of highly-charged steel cylinders are being increasingly used to supply air to divers, there will always be a demand for the manually-worked air pump, particularly for operations in moderate depths, and where only one diver is employed. In the case of power-driven compressors, however, the air must be pumped into a steel reservoir to ensure a reserve of air sufficient to bring the diver safely to the surface in the event of a breakdown of the motor. To the reservoir is fitted an air control panel (see Fig. 39) to which the diver's air-pipe is connected.

In the succeeding pages some of the types of hand and power pumps and compressors designed and manufactured by Siebe, Gorman & Co. Ltd., are described and illustrated.

The following hand pumps of the rotary type are in general use:

(a) Two-cylinder double-acting, for two divers working simultaneously in moderate depths, or one diver in deeper water (Fig. 23). This is the standard pattern used in the British Navy; it is also largely used on harbour, dock and bridge works.

(b) Four-cylinder single-acting for similar duty to (a). (Fig. 29.)

(c) Three-cylinder single-acting pump for one diver (Fig. 30). This is largely used on harbour, dock and bridge works, and for pearl and sponge diving, etc.

(d) One-cylinder double-acting, for one diver working in moderate depths (Fig. 31).

(e) Two-cylinder single-acting, for one diver working at moderate depths (Fig. 32).

All baseplates, valve chambers and cylinders are of gunmetal. To ensure absolute reliability under all working conditions, iron for any of these parts should be avoided. (A diagrammatic section of cylinder, baseplate and valve chamber for (a) is given in Fig. 27.)

The valves are interchangeable, and are readily accessible without removing the pump from its chest.

The pumps are fitted with compound gauges, which indicate both the pressure of air and the depth of water at which the diver is working (Fig. 28).

Air-distributing arrangement (or Waycock). The two-cylinder double-acting and four-cylinder single-acting pumps are provided with a patent air-distributing cock, which enables each double-acting cylinder, or each pair of single-acting cylinders to act independently of the other (the pump then will supply air to two divers at different pressures if necessary), or both double-acting cylinders, or all four single-acting cylinders, as the case may be, to deliver their air through one nozzle and length of piping, to a single diver. The arrangement is worked by a rod, operated from the upper part of the pump chest by means of the lever shown in Fig. 26.

There are two positions for the cock:

1. When the lever is moved over to "One diver, deep water", the air from both cylinders is delivered at the left-hand nozzle only, none issuing from the right-hand nozzle;
2. When the lever is moved over to "Two divers", each cylinder delivers air through its own nozzle, so that two divers can work independently of each other.

TYPES OF DIVING PUMPS

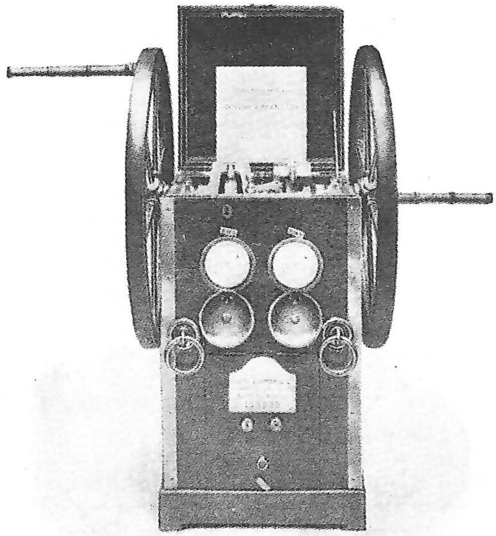


Fig. 23. Two-cylinder double-acting pump

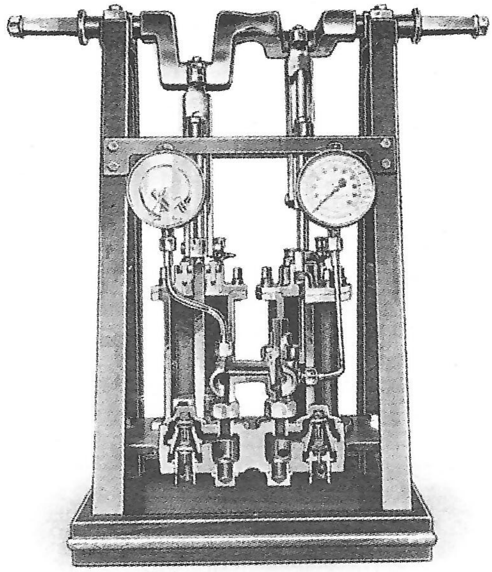


Fig. 24. Sectionized interior of two-cylinder double-acting pump

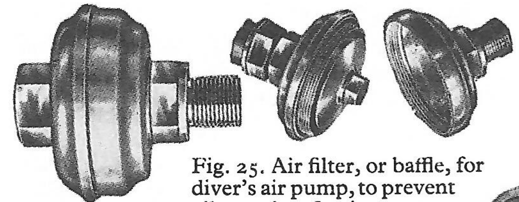


Fig. 25. Air filter, or baffle, for diver's air pump, to prevent oil or other foreign matter from entering the diver's air-pipe

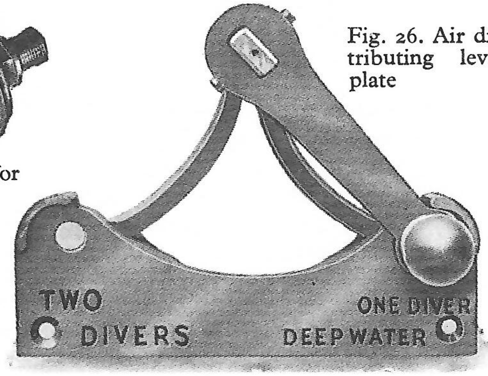


Fig. 26. Air distributing lever plate

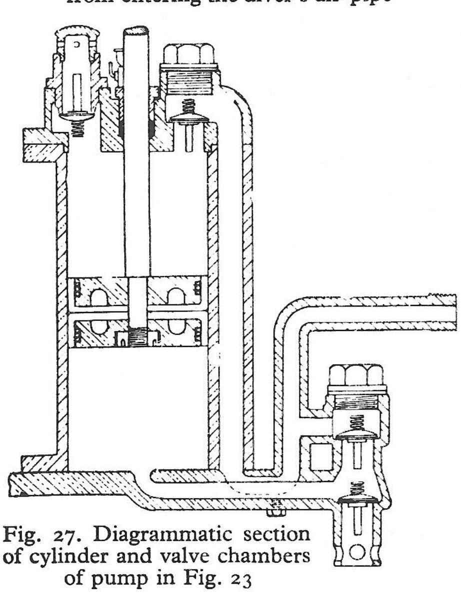


Fig. 27. Diagrammatic section of cylinder and valve chambers of pump in Fig. 23

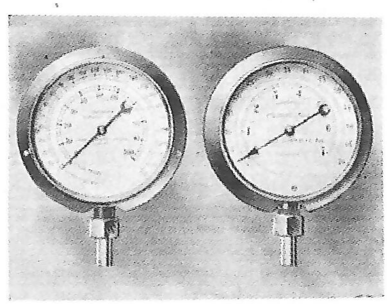


Fig. 28

Gauge calibrated in lbs. per square inch and feet depth of water

Gauge calibrated in atmospheres and metres depth of water

TYPES OF DIVING PUMPS

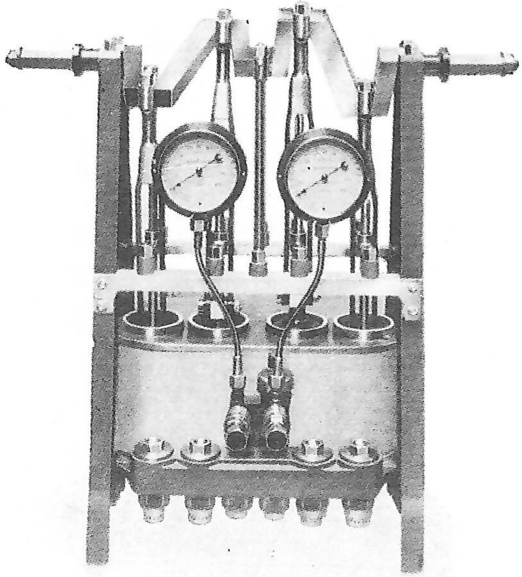


Fig. 29. Four-cylinder single-acting pump

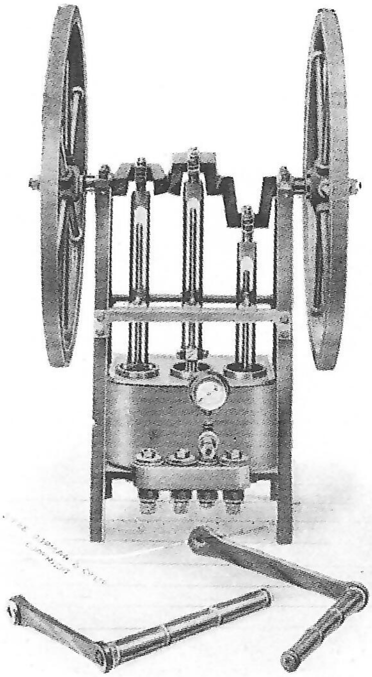


Fig. 30. Three-cylinder single-acting pump

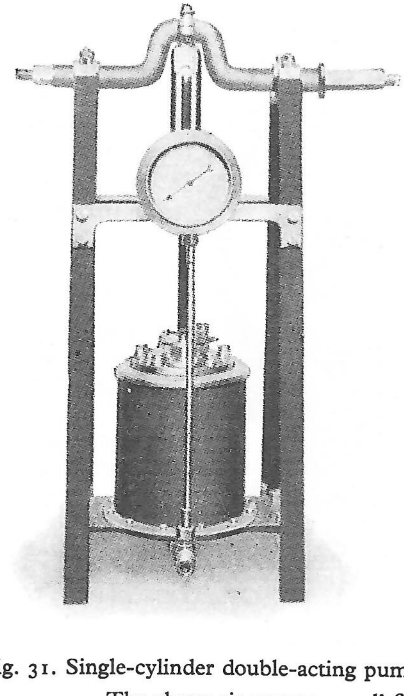


Fig. 31. Single-cylinder double-acting pump

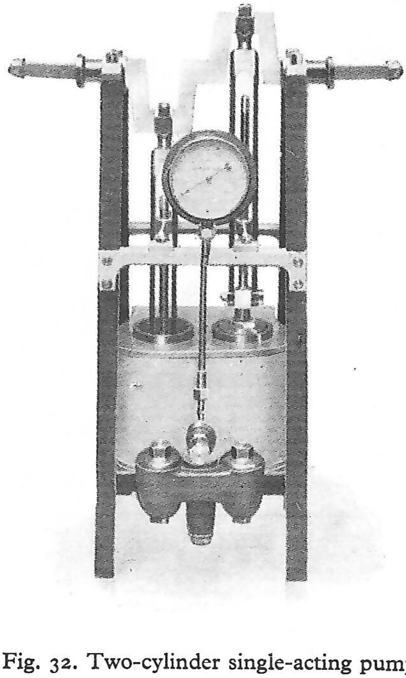
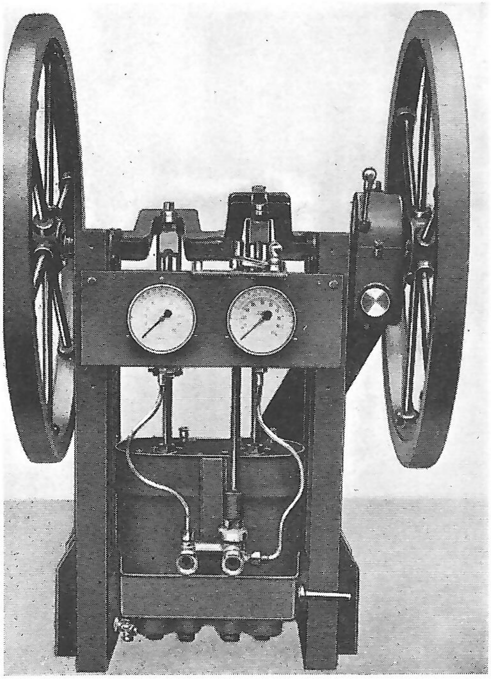


Fig. 32. Two-cylinder single-acting pump

The above air pumps are all fitted in teak chests, similar to fig. 23.

TYPES OF DIVING PUMPS
(Two-cylinder double-acting)



g. 33. Electrically-driven diving pump for alternative working by hand (front view)

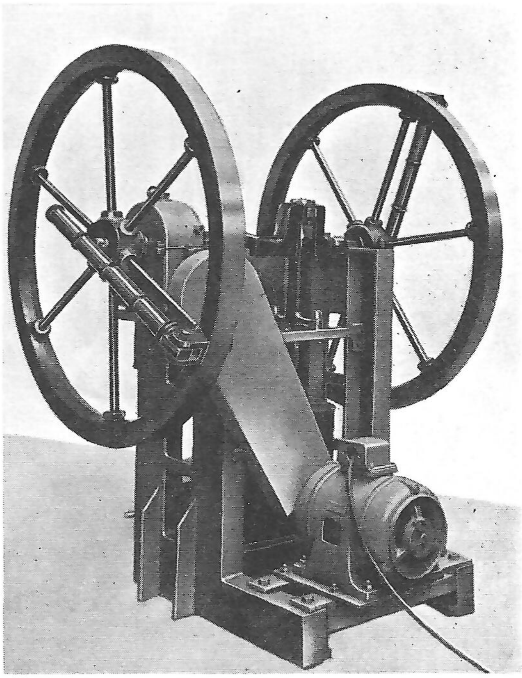


Fig. 34. Electrically-driven diving pump for alterna tive working by hand—handles folded (rear view)

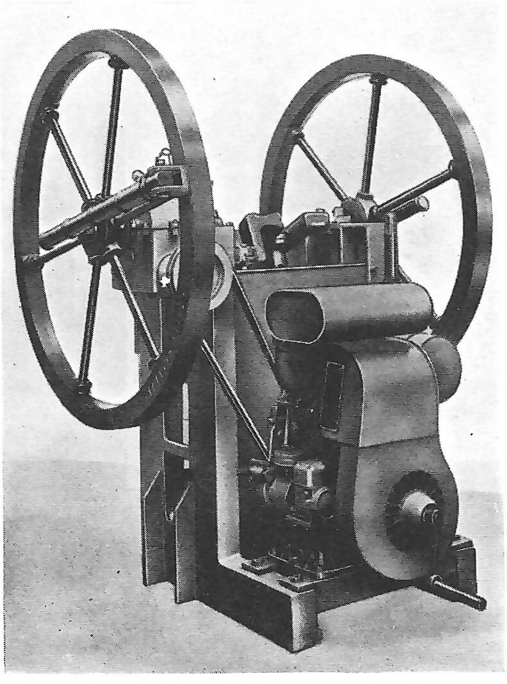


Fig. 35. Petrol-driven diving pump for alternative working by hand (rear view)

When sending a single diver down, his air-pipe must always be joined to the left-hand nozzle, even if it is intended to use one cylinder only. Should the diver ask for more air, the second cylinder can then be switched on; but were the diver joined up to the right-hand nozzle, putting the handle over to "one diver, deep water", would cut off his air supply altogether.

Instructions as to when one double-acting cylinder may be used, and when both are necessary, will be found in the Haldane tables on pages 100-108.

Care of Hand Diving Pumps. It is required of a hand pump that it shall turn without undue friction, and deliver its proper quota of air against high pressure. The efficiency mainly depends on the fit and condition of the leather piston-cups. Before leaving the factory, each pump is run by power for many hours to work the pistons into the best condition, and the output under pressure is measured by passing the delivery through a meter. With ordinary care, there should be no deterioration for a very long time. Water jackets are fitted round the cylinders because heat is generated when air is compressed, and a hot cylinder will deliver less air per stroke to the diver than will a cool one. In cold weather and shallow water diving, it may not be necessary to use the water jackets, but for deep water work they must be filled, and the water changed as soon as it warms up.

After diving, the water jackets should be drained and any condensed moisture wiped away; the lid should be left open for an hour or so in order to let the pump cool off—and the working parts lightly oiled before putting it away. Very little oil should be allowed inside the cylinders, as an excess would find its way into the diver's air-pipe where it is liable to rot the rubber lining. Special oil filters are sometimes fitted to prevent this happening, in the event of the pumping party making free with the oil-can.

If the pump is out of use for long periods, it should be moved round a few turns once a week. When in ordinary use the only internal parts likely to require attention are the valves, and without stripping down the whole pump they may be removed every few months, and dirt or verdigris removed from the discs and seatings, the springs being renewed if necessary. The springs of the bottom inlet valves should be carefully examined. See Fig. 27.

Siebe, Gorman & Co. Ltd. issue instructions for the care, maintenance and testing of hand pumps and air compressors.

Piston Rod Glands. These sometimes leak. If the pump is working at high pressure, open the lid occasionally and listen for the blowing noise caused by air escaping at this point; if in doubt, sprinkle a little water at the point where the rod emerges from the gland, and it will show by spluttering if a leak exists. The pump must be actually working; it is useless to look for a leak with the pump stopped, whatever pressure there may be on the gauge. If leaking, the glands can be tightened up or repacked.

Stripping down the Pump. It is a great mistake to strip down the pump unless there is real necessity, but if it has to be stripped, a clean tarpaulin should be spread, and every care taken to prevent grit getting on to the leathers or into the cylinders. The following is the procedure to follow in the case of the two-cylinder double-acting type:

1. Place the pump in shelter, spread a clean tarpaulin, and have clean cotton rag at hand.
2. Remove the coupling bolts (using the small end of the air-pipe spanner), and, by unshipping the upper brass, disconnect the slings from the cranks.
3. Remove the nuts securing the end bearings of the crank shaft (using the small end of air-pipe spanner), and unship the caps of the bearings.
4. Lift out the crank shaft.
5. Unscrew the bolts securing the guide plates (still using the same spanner), and lift off the guide plates.

6. Unscrew the bolts of the cylinder cover (using the box spanner kept inside the pump on the left), and lift out the slings, piston-rod, piston and cylinder cover, with upper valves, complete.
7. Remove dome of lower valve box (with the long-handled box spanner, specially supplied), and lift out the bottom outlet valve. Insert the same box spanner again, and remove the cap of the bottom inlet valve, after which the bottom inlet valve and spring can be lifted out.
8. Underneath the water-tank round the valves are the oil catchers; these should be unscrewed (using the large end of the air-pipe spanner), emptied and cleaned.

To examine the Waycock. One corner of the square head of the waycock is cut away and a corresponding corner of the socket on the valve working rod is filled in so as to ensure the latter being correctly shipped.

1. Remove the screws from the direction plate, and unship the plate, lever and valve-working rod.
2. Insert the long box spanner and unscrew the cap of the waycock, then lift out the collar and waycock complete. A slight tap on the square head of the waycock may be required to loosen it in its seating.

Re-assembling the Pump. A maker's number is stamped on the large parts of the pump, such as the crank shaft and frames. The smaller parts are marked one and two; all gear marked one being left gear, and all marked two right gear.

In assembling, everything goes back in reverse order, numbers to the front, and coinciding. Before replacing the pistons make sure that there is no grit on them or in the cylinders. See that all the caps of bearings are the same distance apart at their ends, with the securing bolts moderately tight.

To replace worn cup leather on Piston. Spare cup leathers with springs are supplied by the makers—sealed in oil in tin boxes; thus they are ready to be put in place without any preliminary treatment and all that has to be done is to remove the piston, file off the burr at the end of the rod, unscrew the nut securing the pistons and remove the old leathers; open two of the tin boxes supplied each containing a cup leather with spring in oil; wipe off superfluous oil, fit them in position and secure the nut as before, being careful to burr over the piston rod sufficiently to make it impossible for the nut to slack back. If the nut did slack back, it would, of course, happen while the pump was working, with probably a diver below; as the clearance at the bottom of the cylinder is very small, the pump would quickly be brought up and the consequences might be serious. New piston leathers will not give their best effect till they have been "run in". If it is not convenient to wait till this is done in the ordinary course of work, an air-pipe may be connected to the pump, its end weighted and lowered overboard, so as to produce a back pressure of 20-30 lbs., and the pump hove steadily round for an hour or so.

Possible Leakage of Pumps. As already mentioned (page 37), the deeper a diver goes the greater volume of free air does he require and, at the same time, the higher becomes the pressure against which the pump has to deliver. It is obvious that an old, badly worn pump may give satisfactory service to a diver on a dockside, where the depth never, perhaps, exceeds five to eight fathoms, and yet may be inadequate to give the same man a full supply at 12 to 15 fathoms.

Divers often test pumps by blocking up the end of the air-pipe with their thumbs, heaving round a few turns till some pressure builds up on the gauge, stopping the pump and watching whether the needle remains steady. If the needle falls, leakage in the pipe or the inlet valves of the cylinder is indicated. If it remains steady, these parts are shown to be in good order. But this test tells nothing more; it is a partial one which could be passed by a really bad pump in which part of the air which ought to be forced down to the diver at each stroke blows idly past the piston. Such leakage can only be detected by a test which measures how much air the pump actually delivers against

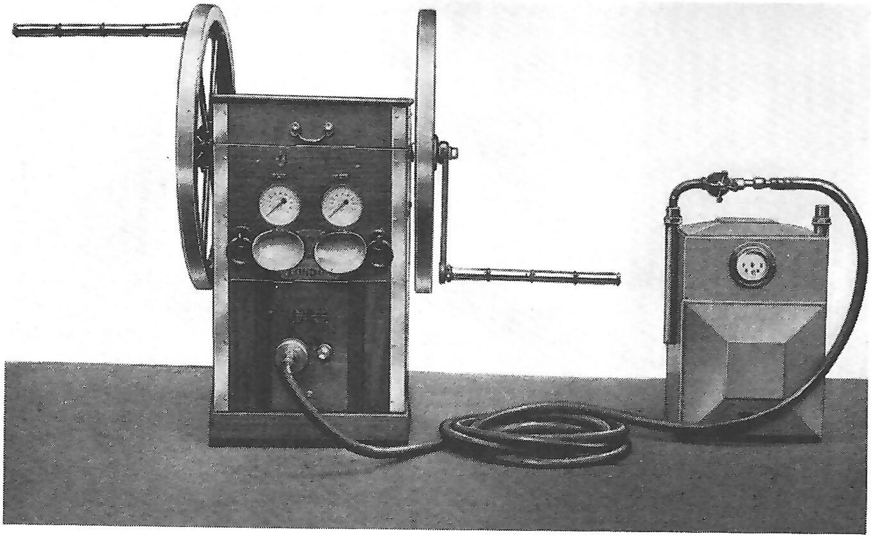


Fig. 36. Testing volumetric efficiency of air pump by gas meter

pressure. In the Royal Navy, where deep water diving may be called for at any moment, all the pumps are tested in the following way every three months.

Testing Diving Pumps. One method is to use an ordinary dry gas meter of "30-light capacity" (it can be hired from any gas company) and to make a screw-down throttle valve, adapted to fit the intake thread of the meter on one side and the diving pipe thread on the other. Join up the pump so that air passes through the throttle valve into the meter, which will measure the amount passing. See Fig. 36.

The pump should first be hove round at a steady rate of about 25 r.p.m. with the throttle wide open and giving no resistance; the number of revolutions required by the cylinder under test to pass 5 cubic feet of air through the meter under these conditions is then noted. With the pump still heaving round at the same steady rate, the throttle is gradually closed till the pressure on the gauge rises to the equivalent of 25 fathoms; this pressure is kept steady by small adjustments of the throttle to suit the slightly varying speed of the pump, and the number of revolutions required to pass 5 cubic feet is again noted. Comparison of this with the previous result will indicate how much the pump leaks at 25 fathoms depth. Thus, if a pump working against no pressure delivered 5 cubic feet in 100 revolutions, and when working against 25 fathoms pressure delivered 5 cubic feet in 150 revolutions, the leakage at the latter pressure would evidently be $33\frac{1}{3}$ per cent.

Theoretical Capacity of two-cylinder double-acting Air Pump. The standard Siebe, Gorman two-cylinder, double-acting, Admiralty-type pump, working against no pressure, delivers 0·1 cubic feet of air from each cylinder at each revolution; therefore the number of revolutions found in the first part of the above test should always be very near 50, if the meter is correct.

When pumping against pressure a greater number of revolutions than this will always be required to deliver 5 cubic feet of air, because, however fine the clearances are made, a certain amount of highly compressed air must be left in the cylinder and valve chambers at the end of each stroke, this apparent leakage being made larger by inevitable heating effects arising from compression of air in the cylinder. In addition to the capacity of the Standard Admiralty pump already referred to, the following table gives also the capacities of other types of pump.

Type		Theoretical capacities per 50 revolutions			Actual deliveries per 50 revolutions*
A	.. ..	Each cylinder	.. 5·0 cubic feet	..	4·0 cubic feet
		Both cylinders	.. 10·0 cubic feet	..	8·0 cubic feet
B	.. ..	Each pair of cylinders	4·15 cubic feet	..	3·35 cubic feet
		All four cylinders ..	8·35 cubic feet	..	6·70 cubic feet
C	.. ..	All three cylinders ..	6·25 cubic feet	..	5·5 cubic feet
D	.. ..	Single cylinder	.. 4·20 cubic feet	..	3·9 cubic feet
E	.. ..	Both cylinders	.. 4·9 cubic feet	..	3·35 cubic feet

Standard of Efficiency. The Admiralty standard is that the pump is considered efficient if the total leakage (real and apparent) at a pressure equivalent to 25 fathoms depth does not exceed 25 per cent, and in the tables (pages 100-108) showing the number of cylinders required to supply divers at various depths, allowance is made for such normal leakage.

The private user requiring, perhaps, to dive at a certain depth with pumps he suspects are badly worn, can test them on the meter against the pressure he is going to work at, and see whether they are capable of giving the required volume of air per minute (taken from table on page 38). If not, he can adjust them, fit new leathers and so on, or possibly obtain an additional pump to make up the supply, joining it up as described on page 94.

In calculating the capacity of air pump required for a particular depth of water, the nature of the diver's work must also be taken into consideration. From what we have said in a preceding chapter, it will be understood that a diver when working hard produces more CO_2 than when he goes down merely to make observation or examination; consequently for the former a greater supply of air will be required for adequate ventilation of his helmet than for the latter. The requirements previously given are based on the assumption that hard work is being performed. For work of a lighter nature, about 20 per cent may be added to the depths so calculated.

Another Way of Testing Pumps. When a gas meter is not available, the output test may still be carried out by making use of some strong vessel, such as a compressed air reservoir which has an ample margin of safety over and above the pressure which is going to be applied to it. The capacity of this vessel must be accurately known or measured; the best way of doing this is to weigh the vessel empty, then completely fill it with water and weigh again. The difference in the weights is the weight of the volume of water it contains, and that volume may be calculated by allowing 62·5 lbs. as the weight of a cubic foot of fresh water, or 64 lbs. if salt water be used. The pump is now connected so as to deliver air to the vessel through a short length of air-pipe.

The principle of the test is that if the volume of the vessel is, say, 5 cubic feet, then the effect of pumping another 5 cubic feet of air into it will be to raise the pressure to 14·7 lbs. This pressure will be shown by the gauge on the pump. Thus (still supposing the capacity of the vessel to be 5 cubic feet), if we heave round the pump, the gauge needle will rise. When it reaches 14·7 lbs. we have delivered 5 cubic feet of air; 29·4 lbs., another 5; 44·1 lbs., another 5; 58·8 lbs., another 5; 73·5 lbs., another 5, or 25 cubic feet altogether. If the capacity of the vessel was 3·23 cubic feet, the rising of the gauge to 14·7 lbs. would mean that we had delivered 3·23 cubic feet of air, and so on. The number of revolutions required to raise the pressure from 58·8 to 73·5 lbs. can be compared with the number required to raise the pressure from 0 to 14·7 lbs., and the leakage at the former pressures (which cover the depth of 25 fathoms) ascertained or the actual delivery of the pump at any depth. The pressures are here given measured in decimals, but in practice one would exactly compare the number of strokes required to raise the pressure from 0 to 15 lbs., with the number required to raise it from 60 to 75 lbs., and so on.

* Against pressure equivalent to 25 fathoms depth.

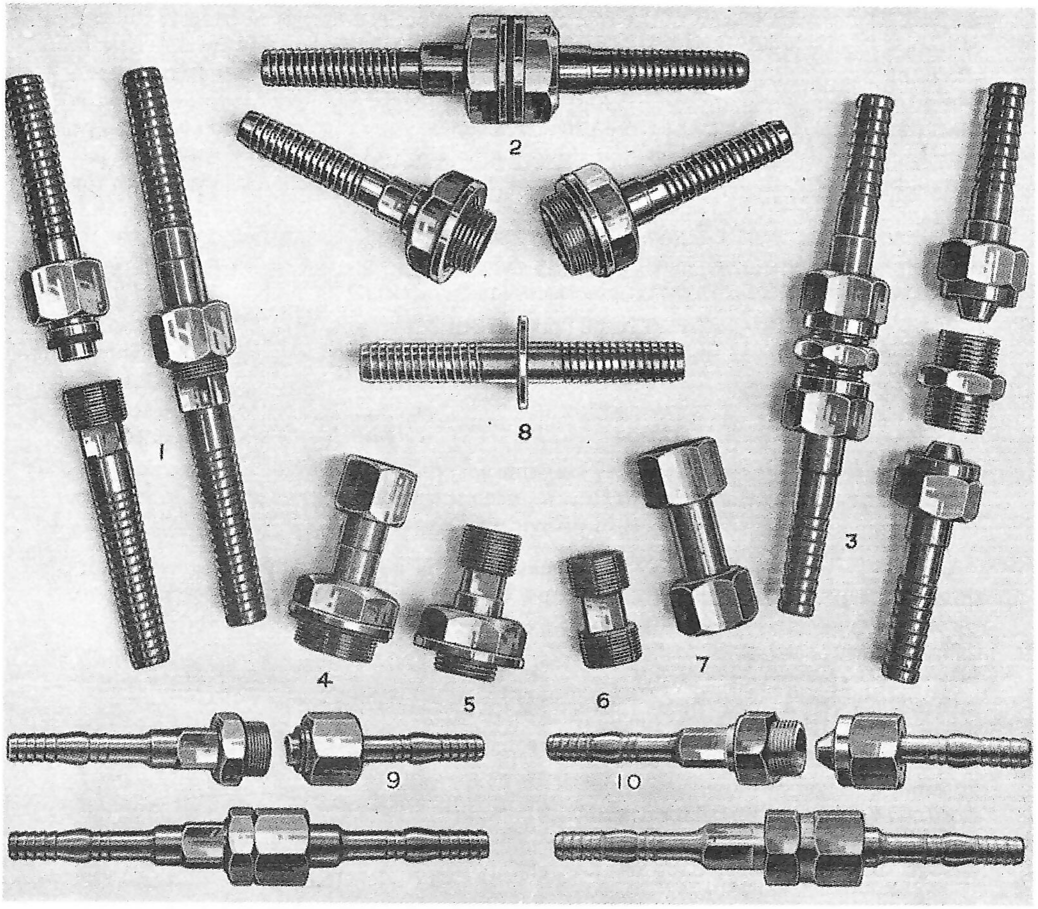


Fig. 37. Siebe, Gorman & Co.'s diver's hose couplings

(1) Standard type. (2) Double-capped type. (3) Continental type. (4) Interconnector; double-capped female and male. (5) Interconnector; double-capped male and female. (6) Interconnector; double male. (7) Interconnector; double female. (8) Plain interconnector. (9) Male-female with lock nut. (10) Male-female with lock nut; coned metal to metal joint

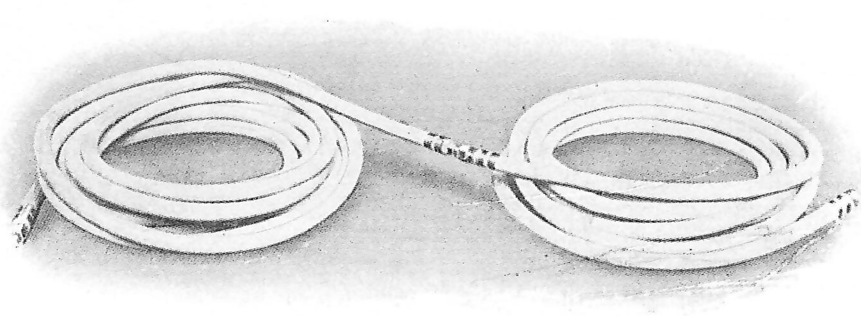


Fig. 38. Two lengths of diver's air-hose coupled together

Testing the Gauges. For bringing a diver up safely from deep water and for testing the pumps, it is important that any error of the gauges should be known. Sixty feet or more of air-pipe should be joined up to the pump, carefully measured off, and marked at every ten feet from the free end of the pipe. A sinker is secured to the end of the pipe, and at slack water it is lowered overboard till the ten-foot mark is awash, when the pump is hove round till air bubbles appear at the surface, and then stopped while the gauge is lightly tapped and its reading taken and recorded. The pipe is lowered another ten feet, when the process is repeated, and so on up to 60 feet. The pipe must, of course, hang up and down (vertically) in the water, so that the test should be done at slack water, or if a boat be used it may be allowed to drift with the tide.

The results are to be tabulated as in the following example and pasted up in the lid of the pump, where they can be readily referred to, and the necessary correction applied when bringing up a diver. For example:

Test of Left Gauge (carried out May 17th, 1934)

True Depth			Gauge shows	True Depth			Gauge shows
10 feet	..	..	7 feet	40 feet	..	..	38 feet
20 feet	..	..	17 feet	50 feet	..	..	49 feet
30 feet	..	..	28 feet	60 feet	..	..	60 feet

The test should be repeated every six months, or whenever error is suspected.

The gauges can be changed over so as to bring the more accurate one to the left side, as it is the left gauge that is used in bringing a diver up.

Use of Power-driven Air Compressors. It is sometimes better to use power-driven compressors instead of hand pumps. The use of compressors is governed more by the general conditions of the job than by any hard and fast rule. Wherever continuous diving is called for over a long period, or where more than one diver is employed, compressors should always be used, however shallow the diving depth. The cost of installation and running costs will, under these conditions, be very soon offset by a saving in the labour costs which would have been necessary had hand pumps been used.

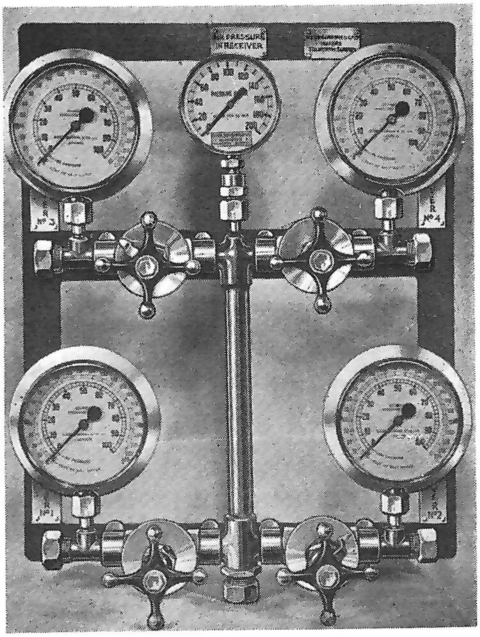


Fig. 39. Air control panel for four divers

When the diving depth exceeds 20 fathoms, so many men are required to maintain an adequate air supply that a great economy can be effected by the use of a power-driven air compressor, and this is strongly recommended.

It should be remembered that an air supply which is only just sufficient to maintain the diver in safety is not necessarily adequate for maximum working efficiency. When a diver is required to make even moderate exertion on the bottom, he must have full and sufficient ventilation through his helmet to enable him to think normally and make the fullest use of the available time under water. The difference between a minimum

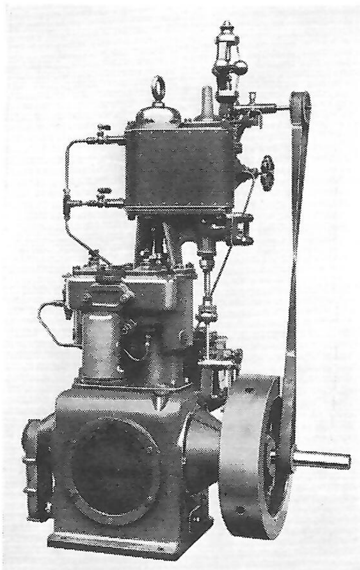


Fig. 40
Steam-driven air compressor (single-cylinder type)

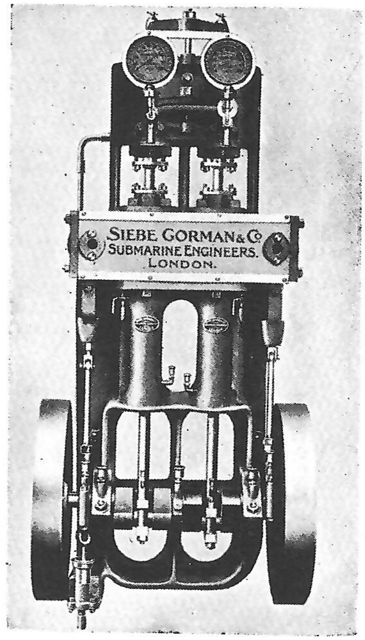


Fig. 41
Double tandem steam-driven air compressor to bolt against bulkhead

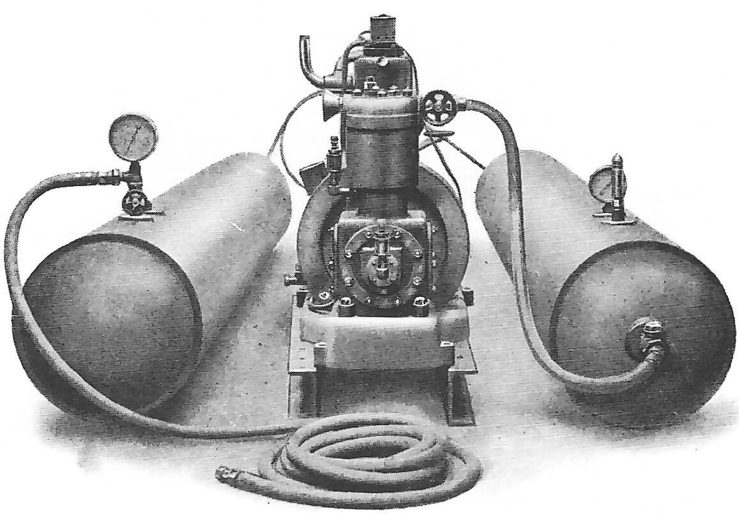


Fig. 42
Oil-driven air compressor with air receivers as supplied for pearling luggers, etc.

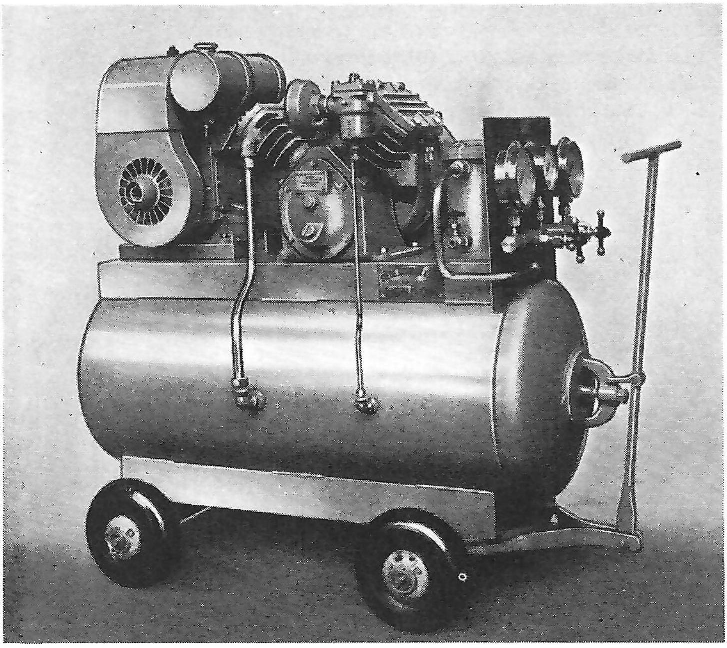


Fig. 43. Petrol-driven air compressor for two divers. Horizontal air receiver (side view)

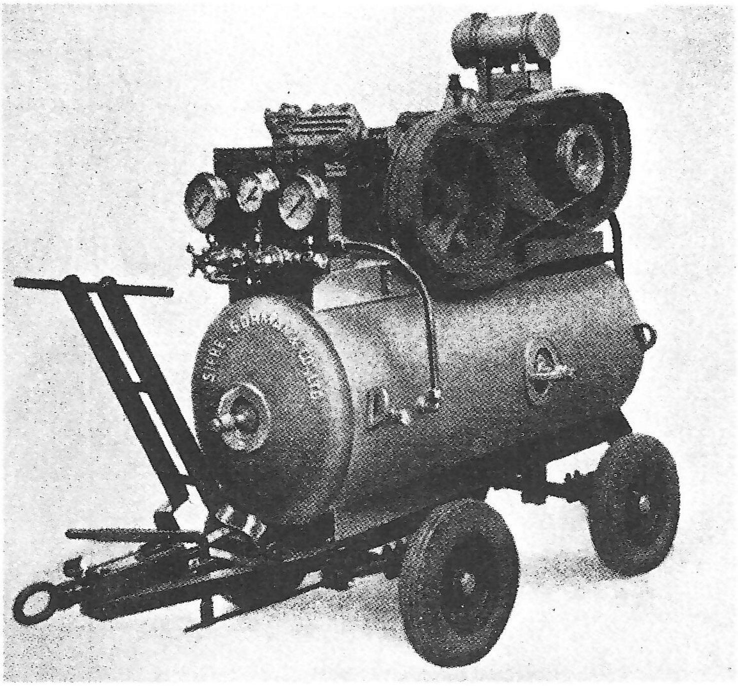


Fig. 44. A similar type of compressor to Fig. 43

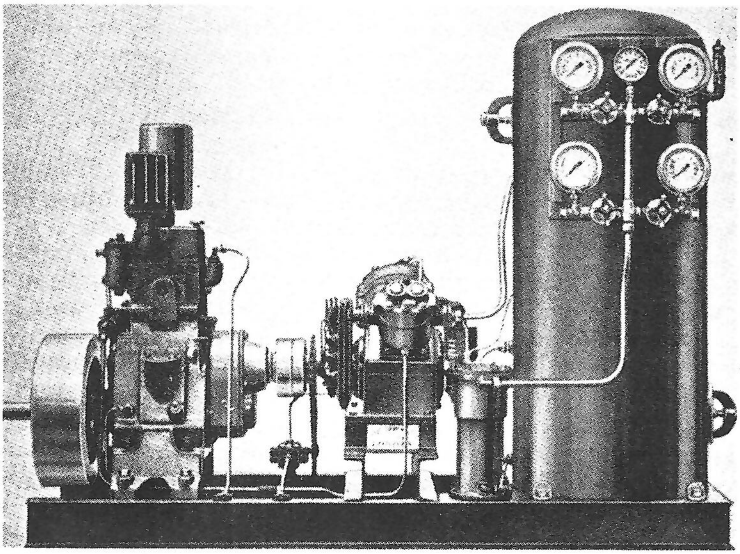


Fig. 45
Petrol-driven air compressor with vertical air receiver and control panel for four divers

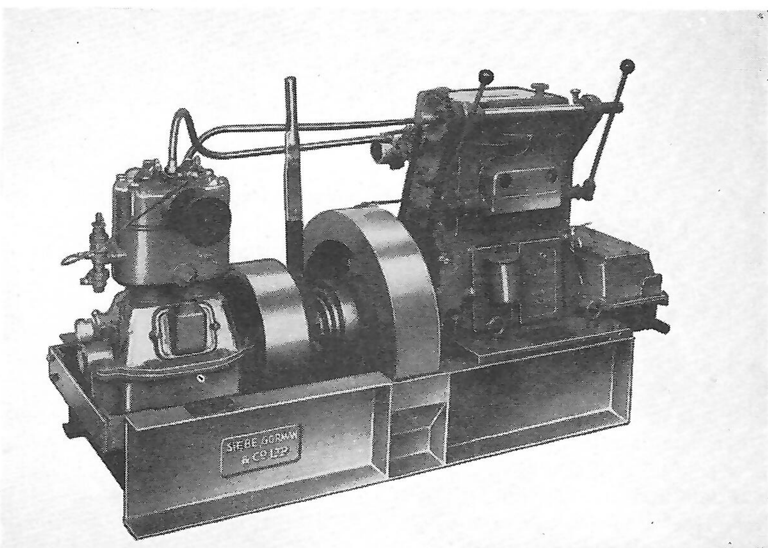


Fig. 46
Marine Diesel-driven propelling and air compressing set. Air supply for two divers

air supply and an efficient working supply may represent a considerable effort with hand pumps, but only a few additional revolutions and a slight increase in fuel consumption with a power-driven compressor. Any increase in cost will be amply repaid by improved performance of the divers.

Several types of compressors are available to meet all requirements. The prime mover may be petrol or diesel engine, or electric motor where mains supply is available. Steam-driven compressors can also be supplied if required, and may be particularly suitable on board ship where steam power is available.

In considering the appropriate type of compressor installation, the following points should be borne in mind:

1. The capacity of the compressor should be such that it can supply at least two divers' in the maximum depth envisaged. Even if only one diver is normally employed, he may get into difficulties and require assistance from another diver.
2. The compressor must always supply its air through a reservoir whose capacity should be such that the diver can be brought to the surface in safety, allowing for stoppages, in the event of a mechanical breakdown of the compressor.
3. The air must be filtered to remove any possible impurities from the compressor itself, and be delivered to the diver through an efficient control valve.

Compressors which have not been designed for diving—e.g. road-drill compressors, should not be used for supplying air to divers, as their use may be injurious to the divers' health, owing to impurities in the air delivered.

Some of Siebe, Gorman & Co.'s compressors are illustrated in Figs. 40 to 48.

Diver's Air Supply from Cylinders of Compressed Air. In certain cases it may be advantageous to dispense with pumps or compressors on the spot, and to supply the diver with his air from high pressure (1,800 lbs. or more) cylinders or torpedo air reservoirs which have been charged beforehand (see page 55). This system would be particularly suitable in any case where one wanted to dive deep from a small boat, as the cylinders can be stowed down in the bottom of the boat, out of the way, and the space and weight of pumps and pumping parties are saved; moreover the pressure available would enable the diver to go as deep as he needed, whereas hand pumps are near their limit at 25 fathoms depth.

For charging the cylinders either a suitable compressor may be installed at the depot or on the salvage ship, or special arrangements may be made; practically all warships carry suitable torpedo air compressors. In charging cylinders for divers, great care must be taken that nothing but pure clean fresh air is compressed into them; for example, over-heating of the compressors which might produce poisonous oil fumes must be guarded against.

The high-pressure reservoirs should be arranged to deliver through a reducing valve into a low-pressure reservoir and from this the diver is supplied through a throttle valve. The table on page 38 gives the requirements in free air of a diver at various depths, and an outside estimate of the time a given supply of highly compressed air would last at a given depth can be obtained by dividing the amount of free air available by the amount required per minute by the diver at the working depth. It must be remembered that part of the free air in the high-pressure cylinders is not available, as some has to be used in filling the low-pressure reservoir, and another part is lost when the pressure in the cylinder becomes too low to drive the air down to the diver; there may also be great waste through giving the diver more air than he really needs.

The apparatus illustrated in Fig. 47, still in use in some cases, is built up of three cylinders. Nos. 1 and 2 each contain 100 cubic feet of free air compressed to 120 atmospheres per square inch, while No. 3 acts as a low-pressure reservoir at a pressure of, say, 200 lbs. per square inch; from this the diver is supplied. Between Nos. 1 and 2 is a valve which can be closed to enable No. 1 cylinder to be disconnected when the pressure falls to a certain level and replaced with another fully charged cylinder.

AIR SUPPLY FROM COMPRESSED AIR CYLINDERS FOR DEEP WATER DIVERS

(See page 54)

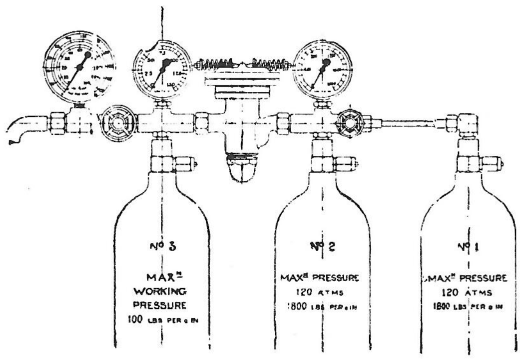


Fig. 47

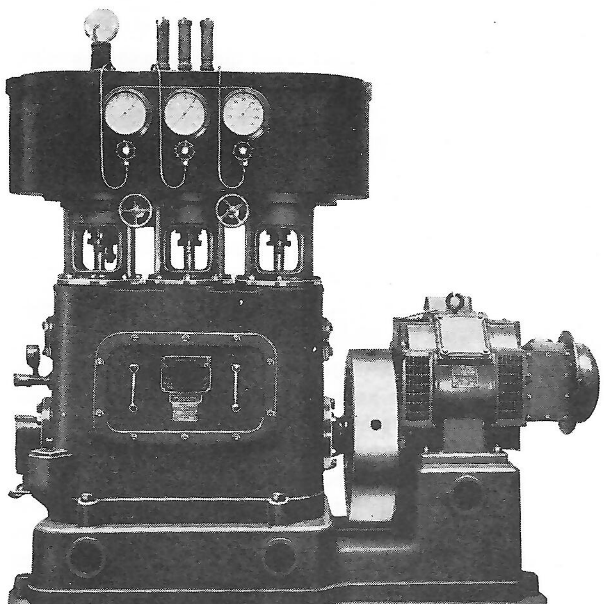


Fig. 48
Electrically-driven three-stage air compressor for pressures up to 120 atmospheres

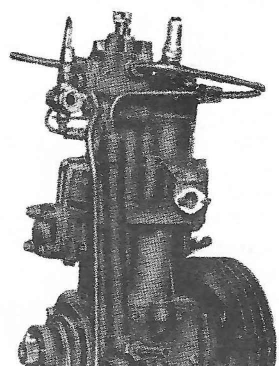


Fig. 47A
Three-stage high pressure air compressor for charging air cylinders

No. 2 cylinder is fitted with a reducing valve which reduces the pressure to 200 lbs. per square inch and maintains it constantly at that level in No. 3 cylinder. No. 3 is fitted with a throttle valve to which the diver's air-pipe is screwed. Pressure gauges are provided to show the pressure in each cylinder and the low-pressure reservoir; also the depth at which the diver is working.

Fig. 48 illustrates one type of H.P. compressor suitable for charging and recharging cylinders for this apparatus. It is of the Siebe, Gorman & Co. three-stage type, capable of delivering 35 cubic feet of free air per minute against a pressure of 2,000 lbs. per square inch. It has intercooling coils and water separator.

Siebe, Gorman & Co. supply other and larger types, also four-stage compressors for still higher pressures.

Standard Types of Diving Dresses are made of solid sheet rubber between two layers of tanned twill. They have an outer collar of thick vulcanized rubber, which is clamped to the corselet to make a watertight joint, and an inner collar, or bib, of the same material as the dress which pulls up, inside the corselet, round the diver's neck, so as to form a trap or pocket to catch any water which may leak in at the corselet joint and prevent it from running down inside and wetting the diver. The cuffs are of vulcanized rubber, fitting close to the wrists where, with the aid of vulcanized rubber rings, they form a watertight joint.

Dresses are made in three grades of twill—heavy, medium and light. The first stands up best to hard work and rubbing against rocks and barnacles, while the last is the most comfortable and supple in wear.

Three standard sizes of dress—large, medium and small—are made to suit men of different stature, but (except as mentioned in Chapter 7) there is only one size of corselet, and the outer collars of any dress of a given type, will fit any corselet of the same type.

Several types of dress, differing in the way in which the outer collar clamps to the corselet, which are in common use are illustrated in this volume. There is nothing better than the Standard Admiralty pattern six-bolt type (Fig. 60), but all are efficient.

Experimental suits have also been made using Neoprene, a synthetic rubber consisting principally of polymerized chloroprene, for which is claimed greater resistance to heat than natural rubber, resistance to oils and most chemicals, and greater durability.

Lacing up the Legs of Dresses. The legs of dresses have to be made wide so that the diver can get his feet into them, and the risk of "blowing up" is lessened by reducing the volume of the legs either by lacing or strapping them up after the diver has dressed. This is here illustrated and also on page 77. The method of strapping or lacing is plainly seen in the photographs, and needs no description. Dresses supplied to the Royal Navy are so fitted. It is true that a man with tightly laced legs cannot climb so well, and finds it more difficult to kneel than if his legs were free, so divers generally prefer to work with unlaced legs, but there is no disadvantage in having

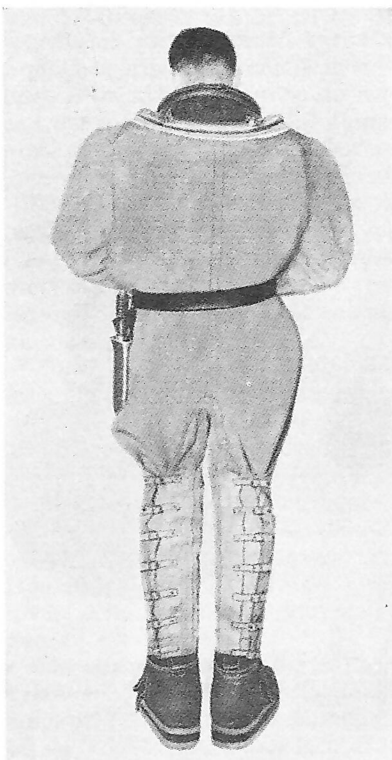


Fig. 49. Diving dress with strapped legs

the legs of the dress fitted for lacing as the eyelet flaps are no encumbrance, and if a man is going to work in an awkward place head downwards, or to dive to a very great depth where a blow-up is likely to be fatal, it will make for safety to insert the lacing and tighten it up.

Rings for Wrists. Occasionally, a diver has a smooth, rounded wrist, so well adapted to the standard cuff, that it makes a watertight joint without assistance, but as a rule, rubber rings are needed. Three sorts are made—broad, narrow, and broad fluted. The narrow rings are worn on the outside of the cuff, and serve to tighten its grip; the broad fluted are worn half on the cuff and half on the wrist, the beaded edge of the cuff fitting into the fluting; the broad plain rings are generally worn in the same way, but men with specially slender wrists sometimes wear them under the cuff to make up the diameter of the wrist. Too tight a joint embarrasses the circulation, and makes a cold, easily-tired hand, while too slack a joint means a wet arm. A diver soon gets to know the combination of rings which suits him best; plain, broad rings are the most generally useful.

Protection for the Hands. When working on docksides or moorings covered with sharp barnacles, or when handling corpses or putrid cargo, divers should wear gloves for their own safety. Ordinary wash-leather gauntlets, secured by means of a rubber wrist-ring are quite suitable for this purpose, but, as they do not keep the water away, afford little protection against the cold.

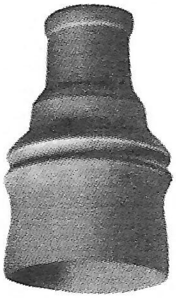


Fig. 50

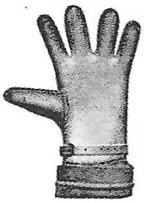


Fig. 51

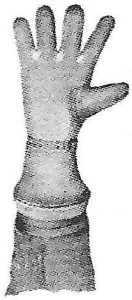


Fig. 52

Davis patent diving dress cuff and glove

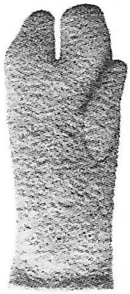


Fig. 52A

Diver's mitten with roughened palm to ensure good grip

So much diving work has to be done in pitch darkness by the sense of touch alone that gloves may be a handicap, but, in the White Sea and similar waters, where the hands become numb and senseless after a submersion of a minute or two, they are a necessity. To keep the hand warm under water, it must be kept dry, and if possible, in communication with the warm atmosphere pervading the body of the dress rather than isolated in a little pocket of its own. These conditions are best secured in the cold water dress (Fig. 58), which has arms ending in permanent mitts or fingerless gloves. Provided the thumb can be used, separate fingers on a glove offer little advantage for such work as divers have to do, and the hand keeps much warmer without them.

Divers in less frigid seas demand some arrangement by which, with one and the same dress, their hands can be left bare or protected at will. The usual method is for the diver, after dressing, to draw on first a pair of woollen gloves, and then a pair of rubber gloves with gauntlet wrists which reach over the cuffs of the diving dress, where they are secured with the usual rubber wrist-ring, making a watertight joint. It is difficult to keep this joint tight without constricting the wrist, thereby tending to stop circulation in the hand; it is also uncomfortable.

Another system is illustrated in Figs. 50, 51 and 52. The upper part of the cuff of the dress grips the wrist in the ordinary way when diving with bare hands, but the lower part of the cuff incorporates a light metal grooved ring which only comes into play when it is desired to wear gloves. The special gloves have sleeves made with a circumferential concave portion which engages in the grooved metal ring in the cuffs, the two being clamped watertightly by a metal ring, of convex section, by means of a thumbscrew provided, so that a joint is made between the gloves and the cuffs without any pressure on the diver's arm. As the rubber of which such gloves are made is not a good material for keeping out cold, inner gloves or linings, sometimes made in two thicknesses, should be worn. This type of cuff can be put on to any dress by the procedure described below for replacing a torn cuff.

Care of Diving Dresses. When in regular daily use, dresses can be hung up at night over a jackstay to drain, and require little more attention. They should not be spread out in the sun, which is a great destroyer of india-rubber. It is when a diving dress is only used at long intervals and is stowed away out of mind in the meantime, that special care is required. In the first place, the dress should not be put away till it is thoroughly dry. But, before it can be properly dried, it must have the salt washed

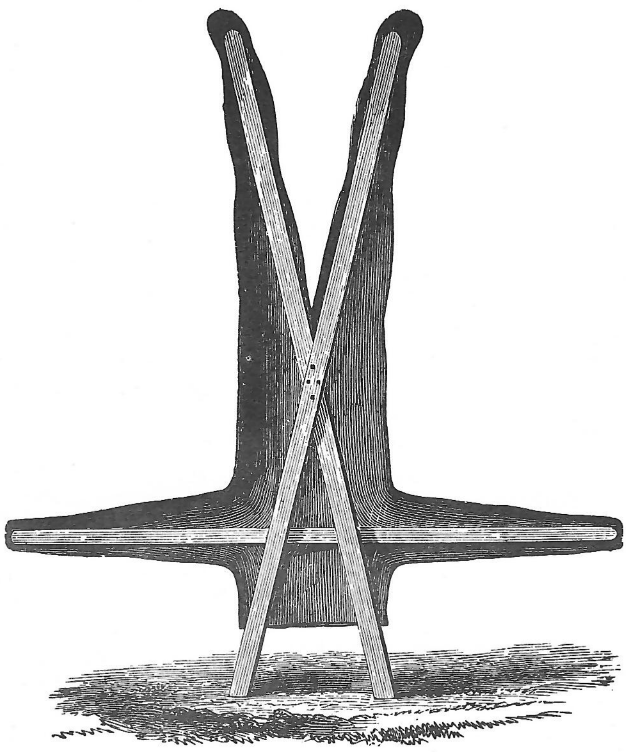


Fig. 53. Drying diving dress

or scrubbed out with fresh water. If the dress has got wet inside, it must be turned inside-out, and the salt washed out of the damp patches and the inside dried first. A handy folding frame for drying dresses is illustrated in Fig. 53. It is made of two battens about 8 feet long, with a shorter loose batten to pass through the arms and keep them extended; a fourth and much shorter piece of wood can be placed crosswise in the neck to keep it wide open.

Dresses should be stowed in a cool place, in the dark, and should not be folded up tightly, or crushed.

Repairing Diving Dresses. Prepared twill and rubber solution are supplied for this purpose. If, through long storage, the solution has become too thick, it may be diluted with pure naphtha. If the leak is due to a tear, first wash the place in fresh water and thoroughly dry it. Apply naphtha around the tear sufficiently, and see that naphtha is applied so that it does not travel farther than the place to be stripped up. Strip up twill, leaving rubber on the dress, and cut away ½ in. round tear with scissors. Allow naphtha to evaporate. Place edges of tear together and solution thoroughly 2½ in. round tear. Cut patch to the size of solutioned parts, and apply one coat of solution to india-rubber side of prepared patch. Put on patch when both surfaces (i.e. surface of patch and surface of part being repaired) are hardened sufficiently to form firm adhesive contact. The patch may be smoothed down with a warm (not hot) flat iron, or shaped piece of wood. Turn dress, but this time do not strip up twill on inside of dress, but solution thoroughly round tear and repeat operation described above. If a tear is due to an imperfect seam, the following operations will effect a satisfactory repair:

Turn dress and pass leaky section inside out. Apply naphtha on tape, strip up and cut away twill with scissors at affected section, leaving rubber on dress. Allow naphtha to evaporate. Solution thoroughly 1 in. around stripped section. Cut out patch and solution, performing the same operation for repairing a tear. A quick repair can often be effected by rubbing solution into the channel of the seam.

Always wash all salt away from the neighbourhood of the leak before attempting a repair.

The hands should be clean before applying a coat of solution, as each coat of solution applied is rubbed dry by friction. A coat is dry and fit for the second coat after five minutes sharp rubbing with the tips of the fingers. The last coat should be rubbed until the fingers will not adhere to it. The coat on the patch is to be treated in like manner. When the two apparently dry surfaces are placed together and pressed, it will be found impossible to pull them apart with the fingers. If this method is properly carried out when recuffing or patching a dress, it requires no further drying and is fit to go straight into deep water. French chalk should never be used. After the patch or cuff is placed, any surplus solution can be rubbed with the fingers until it leaves the dress in the form of a rubber ball.

Inserting New Collar in Diving Dress. Remove inner collar by careful application of naphtha. Having removed the old rubber collar and inner collar—which should be done after the careful application of naphtha, to avoid damaging the dress—solution out neck of dress inside, about 2½ in. in width all round, allow two hours for drying, solution out again, and allow to dry two or three hours, according to temperature of atmosphere. Remove sulphur from rubber collar with naphtha at the section to be solutioned. Solution out rubber collar inside and put on the twill strip (if same is not already on collar), then solution the outside of collar 1¾ in. wide from outer edge; allow, say, two hours for drying—according to temperature of atmosphere. Solution the inner collar about 2½ in. wide on the inside, allow usual drying, then insert solid rubber collar in dress and roll down. Insert inner collar now, and roll down. Press collar of dress with warm flat iron to make contact.

Inserting New Cuffs in Diving Dresses. Cuffs often get torn through carelessness in stretching them over the diver's hands when dressing him, and sometimes by sharp objects under water; they cannot be repaired, and have to be replaced. As a dress is useless with a torn cuff, it is usual to keep spare cuffs in readiness. These are fitted with two flaps of twill between which the bare edge of the twill sleeve of the dress, from which the damaged cuff has been cut, is inserted—sandwich fashion—and stuck with solution. A dummy arm, or mandrel, must be used. It should be about 2 feet long and of circular section, 5½ inches diameter at the big end, and tapering down to fit the cuff.

The first step is to cut off the damaged cuff about 1 inch above the leather protecting band, turn the sleeve inside out, and push in the mandrel. Take the new cuff, turn it likewise inside out, separate the two twill flaps and turn them back over the rubber part of the cuff, one inside and one outside, slide the cuff up the mandrel and secure it in place with a wrist-ring. (See Fig. 54.) Solution is now applied to sleeve and to flap, as directed, for sticking on patches (three coats on sleeve) rubbed dry, and then the flap is turned back over the sleeve and the joint made and smoothed down (Fig. 55). The mandrel is removed, the sleeve turned right way out, and the operation repeated (Fig. 56).

Worn Collar Holes. The rubber collars sometimes get worn at the holes where the corselet studs pass through; spare collars can be supplied, and are to be fixed as directed on the previous page.

CORSELETS

The corselet is the metal breastplate which is connected watertightly to the rubber dress below, and the metal helmet above. The joint with the dress is always made by some clamping arrangement, and there are a number of different systems which are more particularly described and illustrated later. In most, the lower rim of the corselet carries studs which pass through corresponding holes in the rubber collar of the dress fitting over the rim. Metal straps curved to the shape of the corselet rim, and pierced so that the studs can pass through them, are laid on top of the rubber collar, and, when forced down by butterfly nuts working on the studs, clamp the rubber collar against the corselet rim and make a watertight joint. Such corselets carry an interrupted thread on their upper rim to which the helmet screws, the joint being made watertight by a large leather washer sunk in a recess in the neck of the corselet.

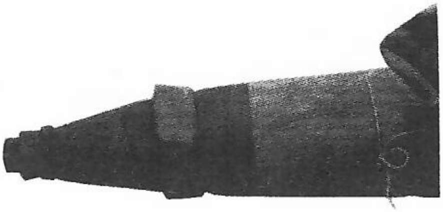


Fig. 54

Fig. 55

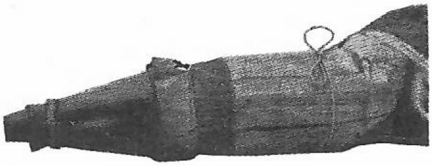


Fig. 56

Fitting new cuffs to diving dresses

Corselets are made of tinned copper with the upper and lower rims formed of machined brass castings. The back and front weights are supported by the corselet, which carries studs to which they can be clipped. If a jock-strap is worn, it is attached to the same or additional studs. At the back of the neck is a recess in which the stop-pin of the helmet engages.

THE DIFFERENT TYPES OF CORSELET

Twelve-bolt and eight-bolt Types (Figs. 57 and 59). These only differ in the number of studs or bolts set round the lower rim of the corselet. The appropriate dresses have a corresponding number of holes in the rubber collar. This lies on the corselet rim with the studs passing up through it. Four metal clamping-straps lie on top of the collar, and are hove down by wing nuts working on the studs.

Six-bolt Type (Fig. 60). This is the British Admiralty type, designed by R. H. Davis, and is an improvement on the above. There are onlv two clamping-straps, and ribs are formed on the upper surface of the rubber collar which fit into recesses in the underside of the clamping straps. This arrangement keeps the drag of the collar off the stud holes, and the dress is less likely to get torn at these points.

Three-bolt Type (Figs. 70 and 72). In this, the dress is clamped, not to the lower rim but between the helmet and upper rim of the corselet. The dress passes up under the corselet, and its neck has a flanged rubber rim which lies on top of the flat brass upper rim of the corselet. The helmet is hove down to make a watertight joint by nuts working on three studs carried by the corselet, and passing through the collar of the dress. This system necessitates a narrow neck to the dress which, is, therefore, harder to put on than the wide-necked types described above.

Two-bolt Type (Fig. 63). The helmet and corselet are in one piece. The collar of the dress is beaded and fits under the rim of the corselet. The single clamping-strap, of the same curvature as the rim of the corselet, goes under the collar of the dress; it carries two studs which pass up through holes in the collar, and other holes in the corselet. Two nuts working on these studs heave all together and make a watertight joint.

Lock Helmet Type (Fig. 64). This, like the three-bolt type, has a narrow-necked dress which is clamped between the helmet and corselet. The lower rim of the corselet rests freely on the outside of the dress. The helmet is hinged to the corselet, its lower rim being machined to interlock with the upper rim of the corselet on which the flanged collar of the dress rests. There are no bolts, but the helmet, after being turned down into position over the diver's head, is hove down and locked by a special device.

Flange Helmet Type (Fig. 65). Another narrow-necked type with the collar of the dress clamped between the helmet and the corselet. The corselet is worn inside the dress, and the joint made by screwing the helmet down on to the soft rubber collar, as shown.

Twelve-bolt Square Type (Fig. 66) with 12-bolt square corselet (solid gunmetal) and three round windows. The exhaust valve is sometimes fitted on the corselet instead of on the helmet.

HELMETS

It is unnecessary to describe all the types in detail, as the principal features are practically the same in all; the following description has special reference to the six-bolt (Admiralty) type (Fig. 60) which is the one most generally used. The body of the helmet is made of tinned copper carrying at the neck a brass ring in which is formed the female interrupted thread to engage with the male thread on the neck of the corselet, so that the helmet may be screwed on with one-eighth of a turn. At the back of the helmet is a small hinged stop-pin intended to engage in a recess at the back of the corselet, so as to prevent the helmet becoming accidentally unscrewed. In front, level with the wearer's eyes, is the "front glass" $4\frac{1}{4}$ inches diameter and $\frac{1}{2}$ inch thick. It is arranged to unscrew (or else to turn back on a hinge), so that the diver can give orders or answer questions without the delay of removing the helmet. At the sides are fixed oval glasses protected with brass guards. An additional top window is sometimes fitted above the front glass to give an upward view. (Seen in Figs. 64, 70 and 72.)

Inlet Valve (Figs. 73, 74 and 75). At the back of the helmet is fixed the non-return inlet valve through which air from the pump enters the helmet. It carries a male thread to which the diver's air-pipe screws. The valve itself consists of a metal disc and spindle pressed on to a coned metal seating by a light spring. Air coming from the pump easily lifts the valve and enters the helmet, but none can pass back from the helmet to the air-pipe. The object of this arrangement is to prevent injury to the diver in the event of his air-pipe being cut or seriously damaged, or some accident happening to the pump or compressor. In either case, there would be a tendency for the highly compressed air in the helmet to escape up the air-pipe, with the result (if there were no inlet valve) that the pressure inside the rigid helmet would fall to less than the pressure

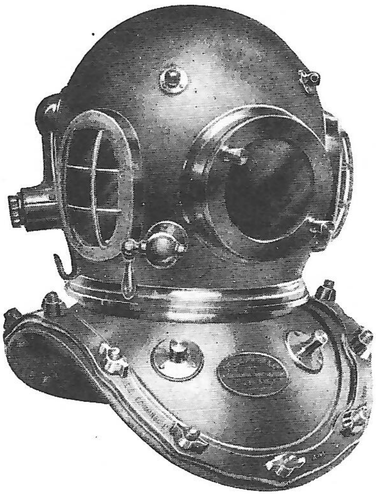


Fig. 57. Twelve-bolt helmet with dress to correspond

Fig. 58
Dress with mitts

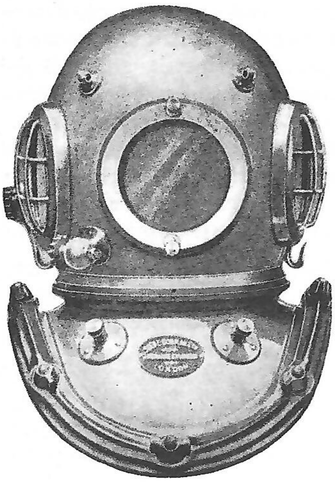
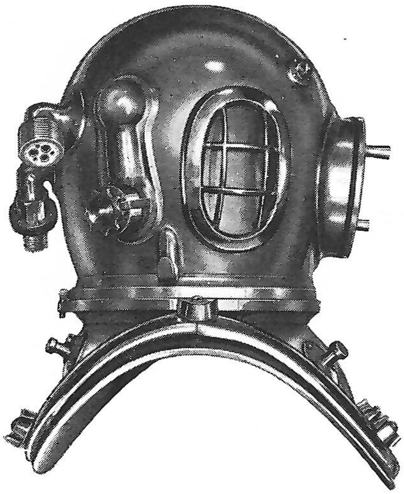


Fig. 59. Eight-bolt helmet and dress

TYPES OF DIVING HELMETS AND DRESSES



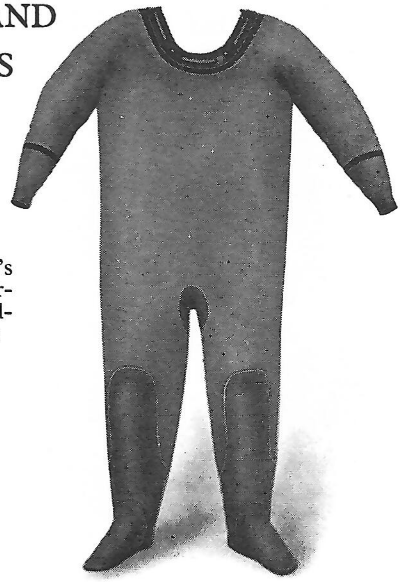


Fig. 60
R. H. Davis's six-bolt Admiralty pattern helmet and dress

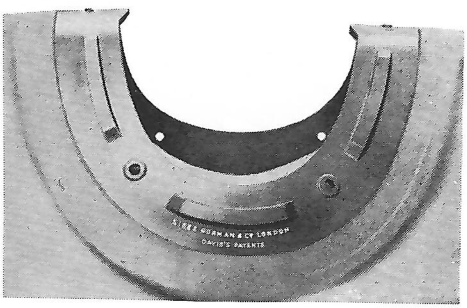


Fig. 61. Close-up of Davis six-bolt I.R. collar, showing ridges clearly

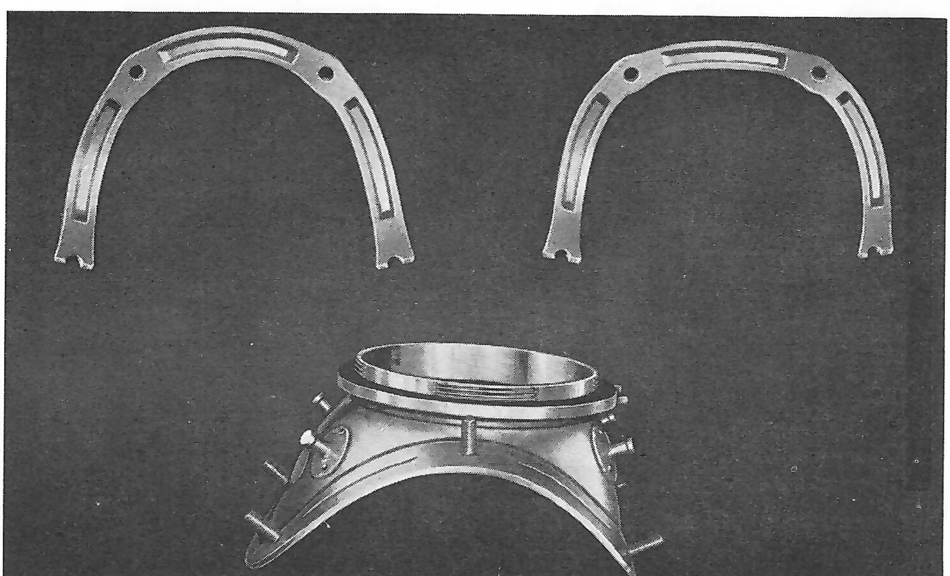


Fig. 62. Six-bolt corselet and metal straps

TYPES OF DIVING HELMETS AND DRESSES

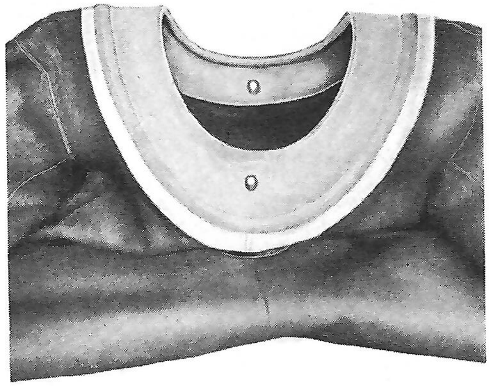


Fig. 63. Two-bolt helmet and dress

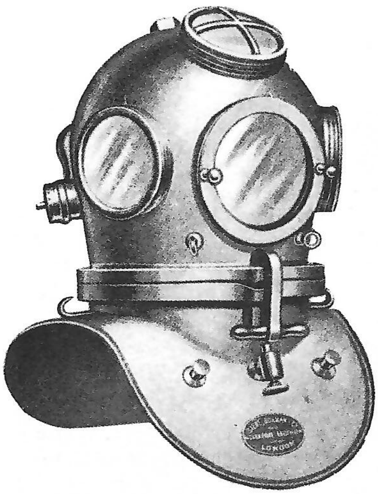
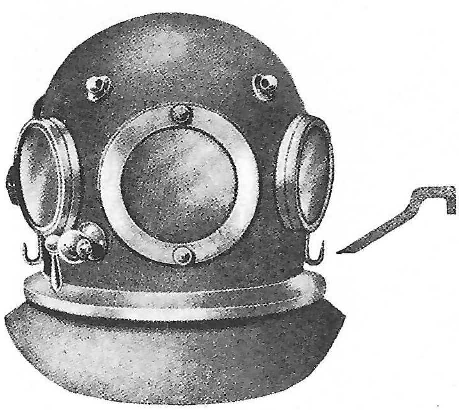


Fig. 64
Lock (No-bolt) helmet and dress



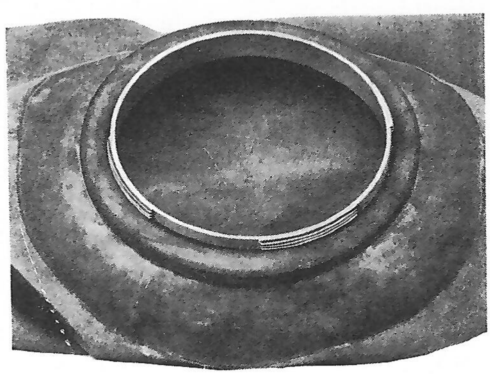


Fig. 65. Flange helmet and dress

that the surrounding water was exerting on the diver's body through the flexible dress. The effect would be similar to that of a fall under water (see page 34), so that the body of the diver would be squeezed up into the helmet in the same way that a cork is forced into an empty bottle if it be lowered to some depth in the sea. Even a slight pressure applied in this way is known to be very dangerous. The efficiency of the inlet valve is, therefore, a matter of vital importance; if working properly, its action, together with that of the outlet valve (which could be closed by the diver), would retain enough air and pressure inside the helmet to enable the diver to reach the surface in spite of damage to pump or pipe.

After passing through the valve, the air is divided between three conduits inside the helmet and conducted to the neighbourhood of the front and side glasses where it is discharged near the diver's mouth.

Additional Inlet Valve. Very rarely, helmets are fitted with two inlet valves, one being spare, and for use in case the diver became foul under water, or his air-pipe were held by something falling on it. A second diver could then descend with a fresh air-pipe and screw it to the second inlet valve, after which the original air-pipe which was preventing the diver from coming up could be unscrewed or cut adrift.

Outlet Valve (Fig. 76). The foul air escapes through the outlet valve which is fixed in such a position as to be behind the diver's right ear when the helmet is screwed on; the bubbles issuing from it do not obstruct the view, as would be the case were the valve in front. This also is a non-return valve, which works in the opposite way to the inlet valve and, while allowing the air to escape from the helmet, prevents water from flowing in. The pressure of the surrounding water tends to keep the valve pressed hard down upon its seating. Before air can lift the valve and escape, it must be raised to a slightly higher pressure than the water. In addition to the water pressure, a small metal spring is fitted, which bears the valve down on its seating; the force exerted by this spring can be varied by a screw regulator, which is adjusted by the diver himself when under water. By screwing it up he increases the pressure of the spring upon the valve, and consequently the pressure of the air inside the dress, making it equal to the pressure of a lower level of water. The air then reaches farther down beneath the corselet, and breathing is rendered easier.

Stops are fitted to prevent the screw from being turned so far in either direction as to become metal-bound. The outlet valve is connected to the interior of the helmet through a metal channel. The purpose of this arrangement is to catch any water that might creep in through the valve when it is chattering; such water is blown out of the chamber again with the next discharge of air, instead of dripping down inside the helmet.

In the Siebe, Gorman Admiralty type outlet valve (Figs. 77 and 78) there is a screw-cap for adjustment, but, in addition, the spindle of the valve disc is carried right through the centre of the screw-cap, so that pressure of the finger on this spindle will close the valve immediately, without any screwing motion or disturbance of the adjustment of the screw-cap, which comes into action again as soon as the finger is taken off the spindle. This quick action is used to stop the noise of the escaping air when the diver wants to listen carefully to the telephone or to make himself light for coming up the shot rope; it enables him also to release the air without delay if he feels himself becoming too buoyant. This is undoubtedly the best type of outlet valve for all-round use.

Figs. 76 and 79 illustrate two other types of valve cap without free spindles, and Fig. 80 shows a valve which, in addition to the adjusting cap and free spindle described for the Admiralty type, has the spindle extended inwards, and terminating in a metal disc, so that the valve can be opened by pressure of the side of the diver's head upon the disc. This is recommended for such work as underwater cutting and welding, in which the diver needs to have both hands free.

TYPES OF DIVING HELMETS AND DRESSES

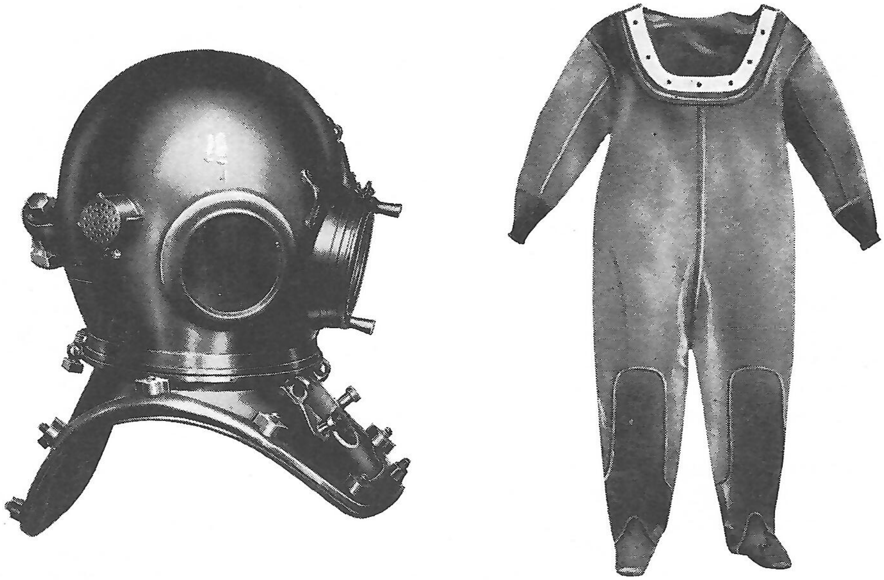


Fig. 66. Twelve-bolt square corselet, helmet and dress

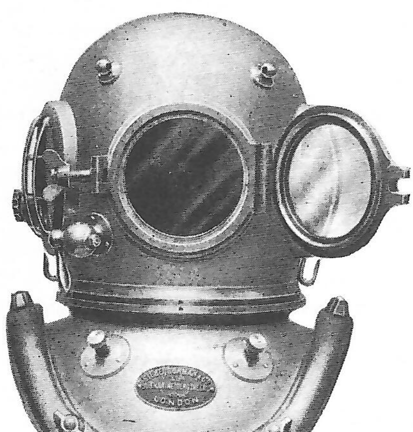


Fig. 67. Helmet with hinged window

Fig. 69. Dress with removable urinating plate

Fig. 68. Portable urinal

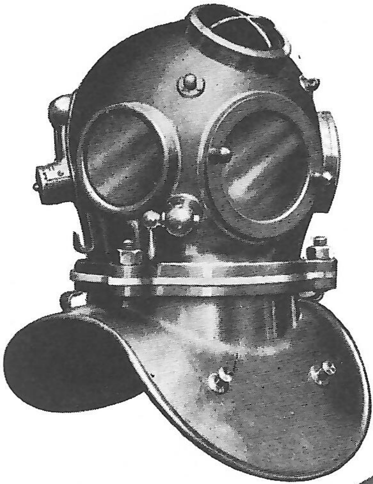


Fig. 70
Three-bolt helmet and dress

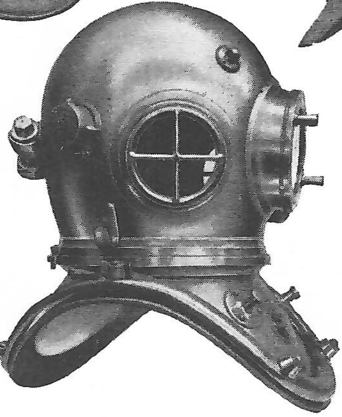


Fig. 71. R. H. Davis's patent six-bolt helmet, with round side-windows with cross-bars and inlet and outlet valves as in Figs. 75 and 79

Fig. 71A. M.R.S. helmet for use with suit and breathing apparatus illustrated on page 321. The front window is hinged

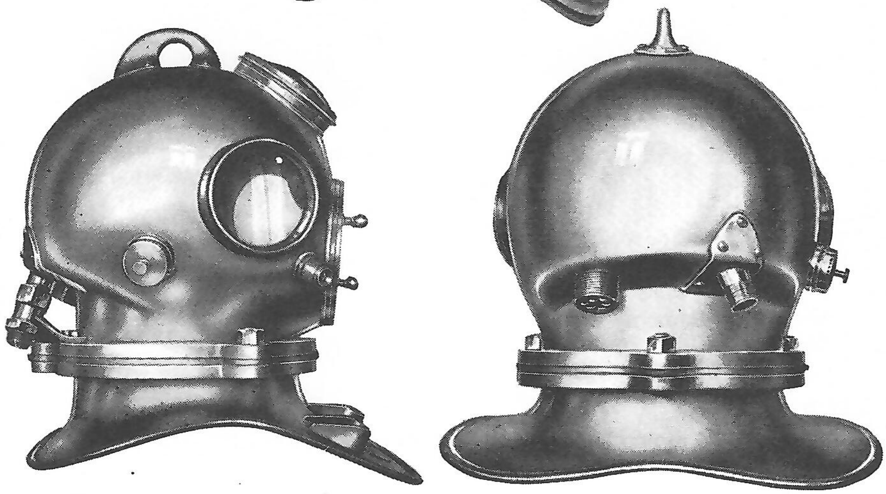


Fig. 72. Three-bolt helmet with protuberance making a snug housing for the telephone and air-pipe connections (side and back views)

TYPES OF AIR INLET AND OUTLET VALVES FOR DIVER'S HELMETS

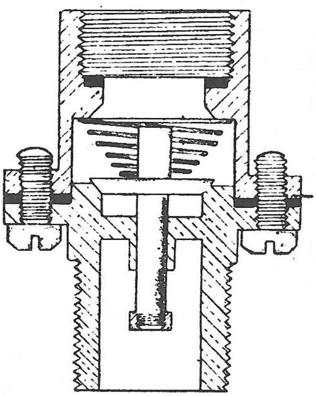


Fig. 73. Section of Fig. 74

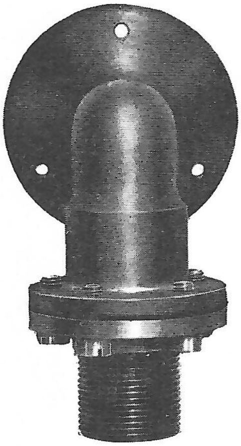


Fig. 74

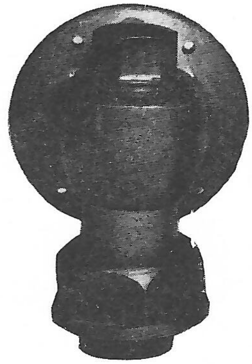


Fig. 75

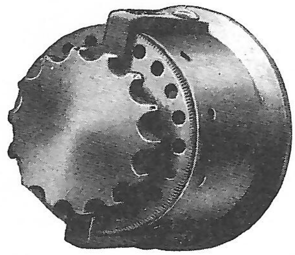


Fig. 76

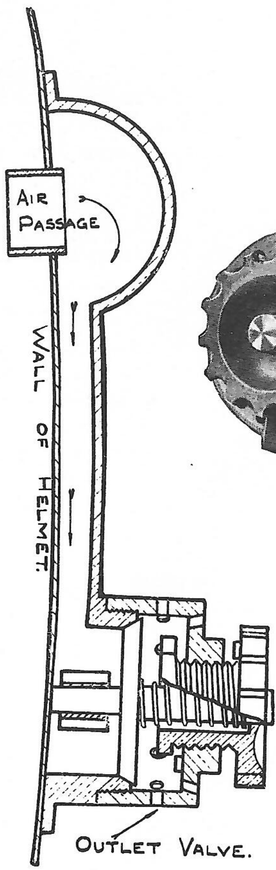


Fig. 77. Section of Fig. 78

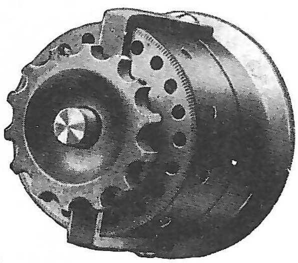


Fig. 78

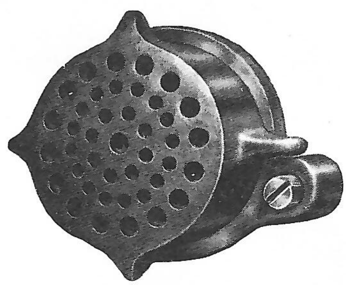


Fig. 79

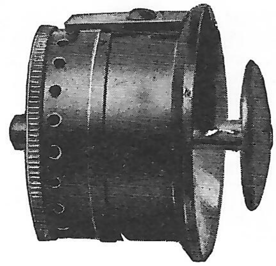


Fig. 80

Front Tap. A small gunmetal cock (sometimes called the "spitcock") is fitted in line with the diver's mouth. When the handle is vertical, the tap is closed; when the handle is turned outwards, the tap is open. Its principal use is to enable the diver to suck in a mouthful of water from the outside with which he can wash down the inner side of his face glass when it has become clouded by condensation of moisture. It can also be used as an auxiliary to the outlet valve in controlling the escape of excess air, especially when the diver is lying on his back or right side, but its bore is too small to allow of it producing much effect in this way. In investigating certain matters, it is often necessary to obtain samples of air from the helmet of a diver under water; they are collected in glass receivers connected by a rubber tube with the front tap, which is prepared by having a spigot, over which a narrow rubber tube can be pushed, soldered to it. Occasionally a wheel valve is substituted for the simple cock.

Brass Hooks are fitted on each side of the neck; the lanyards of the back weights pass over them.

Small Brass Eyes are fitted on each side above the face glass; these are intended for the attachment of light stops by which the air-pipe and breast-rope may be seized to the front of the helmet and kept out of the way of the front glass; few divers use them.

Breast-Rope and Telephone Connection. Most modern helmets are fitted for the telephone (see pages 71-75) and carry, at the back, near the inlet valve, a screw connection with internal terminals to which the breast-rope (through which run the telephone wires) is attached.

Care of Helmet and Corselet. Damage to screw threads and bearing surfaces, grit or verdigris in the valves, and moisture in the telephone, are the main things to guard against. After use, the helmet should be wiped out, firstly with a cloth damped in fresh water, and then with a dry cloth, so as to get rid of salt and dampness; it should then be screwed on to its own corselet to protect the threads, and the brasses put into place and the wing nuts run on to the studs for the same purpose. Before finally stowing away, the helmet should be left upside-down for some hours in a really warm place (for instance, near the boilers or in full sunlight) to evaporate the last traces of moisture from the telephone diaphragm and terminals.

If the diver has been working in dirty water or sandy places, the outlet valve should be take apart and cleansed from any grit or dirt which may have lodged round the spindle or seating. Similarly, when a new helmet is taken into use the outlet valve should be examined to make sure that no shavings or packing material have dropped into it.

The inlet valve should be tried before screwing on the air-pipe at the start of each day's work. It is sufficient to insert the tip of the little finger through the pipe connection and to push up the spindle so as to feel that the valve is working freely and that the spring is strong enough to snap it down on its seating as soon as the finger pressure is removed.

If there is any doubt about the efficiency of the inlet valve, it must be properly tested by unscrewing the whole fitting from the elbow pipe at the back of the helmet, and screwing this end on to the male end of an air-pipe which is connected to a diving pump. The end of the valve to which the diver's air-pipe is meant to be screwed is left open so that the diving pump will be trying to force air through the valve in the wrong direction. The valve is submerged in a bucket of water and a good pressure put on by means of the pump. Any leak will be betrayed by escaping bubbles and, unless very slight, should be remedied by grinding in the valve or doing whatever else is required.

Helmet Washers These large leather washers, sunk in a recess in the neck of the corselet, make the joint watertight, and should be just the right thickness, so that, when the helmet is screwed on tightly the front glass comes square in front of the diver's face, and the hinged stop at the back can be locked into its recess. The nature of leather is such that some washers, when exposed to oil and water, swell more than others, so that the helmet will not screw on far enough. In this case, the best cure is to squeeze or wear the washer flatter by lightly coating it with olive oil and working the helmet on and off till it will travel far enough round for the hinged stop to engage in its recess. After much wear, the washer may become too thin, so that the helmet screws round too far; a new washer is then required, but if spare ones are not on hand, a satisfactory temporary adjustment can be made by cutting out paper washers, and inserting one or more in the recess beneath the leather one.

Damage to Helmet and Glasses. Small dents are of no consequence, and larger ones can be taken out by a coppersmith. Spare glasses should be carried, and any cracked ones replaced. The side glasses are removed by taking off the brass guards which are secured by nuts inside the helmet, and the front glass by unscrewing the keep ring; after cleaning off the seating, the new glass is bedded down in red lead, which must be given time to harden.

Diver's Air-Pipe has to withstand the pressure of the air passing through it (upwards of 133 lbs. per square inch when diving at 300 feet), but must also be quite flexible and at the same time free from any tendency to flatten when bent over a sharp edge or nipped under something heavy. All air-pipe is specially tested before issue, to a much higher pressure than that required for normal work. Its strength is obtained from several layers of canvas in the walls, and the resistance to flattening from a spiral layer of tinned steel wire embedded in rubber between the layers of canvas. The canvas layers are protected from the water by inner and outer layers of rubber. The construction of the piping is as follows, starting from the outside:

1. Outer cover of rubber
2. Layer of three plies of fabric
3. Layer of rubber
4. Wire reinforcing coil between rubber plies 3 and 5
5. Layer of rubber
6. Layer of two plies of fabric
7. Inner tube of rubber

Hardened bronze wire is sometimes used instead of tinned steel wire. Air-pipe is made in two weights, called "sinking pipe" and "floating pipe", according to its behaviour in salt water when full of air. It is usual when using both sorts to connect the floating pipe next the diver and the sinking pipe next the pump, but the matter is of minor importance.

Piping is made in lengths of 30, 45, 50 and 60 feet, and each length has a screw connection at either end. In making up the air-pipe for a deep dive, several lengths have to be joined by their screw connections, and auxiliary double male and double female screwed gunmetal connectors are provided for cases where it is desired to join two female or two male ends of air-pipe together. (See page 49.)

To ensure an adequate length of air-pipe when selecting diving apparatus, allowance must be made not only for the vertical depth to the sea bottom, but also for the diver's radius of action when he reaches bottom.

Pipe Washers. Whenever air-pipe is connected together, or screwed to the helmet or diving pump, leather washers must be used in the female connection to make an airtight joint. Plenty of these washers should always be on hand

Care of Air-Pipe. Before putting a new length of pipe into use, it is advisable to connect it up to the pump and give it a good "blow through" to expel any loose French chalk. After use, air-pipe should be drained of any condensed moisture that may have accumulated in it, and then coiled away in a cool place. Rubber deteriorates rapidly if allowed to come in contact with hot bulkheads, decks or steampipes, or with grease, tar or oil. Exposure to sunshine shortens its life, and when pipe is in daily use the coil should be protected by a canvas cover or kept under an awning

Telephone Breast-Rope is of plaited hemp, in the core of which run the wires of the telephone circuit, heavily insulated, and ending in male terminals at the screwed end fittings of the rope. The ends of the telephone breast-rope are interchangeable, and will connect either to the telephone box or to the helmet, where they make a watertight joint. Breast-ropes can be made of any length. Admiralty specifications demand strength to withstand a pull of 850 lbs. without loss of electrical continuity, and 1,500 lbs. without breakage. A rope lizard runs on the breast-rope and secures it to the diver's waist.

Life-Line. This is a rope, usually of 2-inch manilla, secured round the diver's waist with a running eye, and stopped to his helmet or corselet; it leads to the surface and is used for making signals or hauling up the diver if necessary. The breast-rope described above takes its place when telephone gear is in use.

Marking Breast-Rope or Life-Line (see page 97). Marks are to be placed on the breast-rope or life-line by which the diver can be checked for his stoppages when coming up from a deep dive. The 10-foot mark should be placed 13 feet 6 inches from the end of the rope next the diver; the extra 3 feet 6 inches is allowance for the part that passes under his arm. The 20-foot mark should be 10 feet above the 10-foot mark, and so on, up to 80 feet. Marks should be placed at each end of the breast-rope, since they are interchangeable.

Care of Breast-Rope. After use, disconnect the ends and thoroughly dry and clean the terminals. The vulnerable part of a breast-rope is in the last few feet, where it gets bent backwards and forwards, and twisted this way and that, when connecting up to the diver or telephone box. Avoid roughness when doing this, and do not bend the ropes into sharp nips or turns; repeated bending fatigues and breaks the copper conductors, in spite of their flexibility, or cracks the insulation. The insulation at the diver's end needs to be very perfect, as the head of water due to his depth will force moisture in through the smallest breach, but the conditions at the telephone box end are less severe, so that service may be restored by drying out the moisture and changing the breast-rope end for end. This bad end can afterwards be cut out, and the terminals and connection jointed on higher up. This is a job for a good electrician.

COMMUNICATION BETWEEN DIVER AND SURFACE

The time-honoured method of exchanging signals between the diver and his attendant by means of pulls on the life-line (see pages 89-91), of course, still survives, but about 55 years ago Siebe, Gorman & Co. introduced the first system of vocal communication.

The earliest method of *vive voca* communication between diver and attendant was a rubber speaking-tube but, since this added to the diver's impedimenta, it proved to be short-lived and gave way to the more effective telephone. The helmet instruments included a cap which carried two earpiece receivers, a transmitter being fitted between the front window and one of the side windows.

In the next advance, the headphones were replaced by a loud-sounding receiver fitted in the crown of the helmet, and in this position it continued for some years.

The Alfred Graham–Robert H. Davis intercommunication system followed with improved receiver and transmitter and an arrangement whereby two divers or more could communicate with each other and with their attendants; each helmet being fitted with a chin contact for ringing a bell or buzzer at the surface. This apparatus was in use throughout the Royal Navy for many years. Later, the Admiralty, for special reasons, reverted in some case to headphones for the diver in place of the receiver in the crown.

Another form of telephone adopted in some cases in commercial circles was the "Laryngaphone", the small transmitter of which was held by a band against the diver's larynx, the receiver being carried on a head-band. (Fig. 84.)

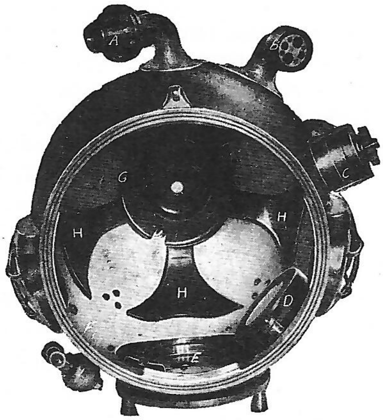


Fig. 81. Receiver and transmitter fitted in helmet

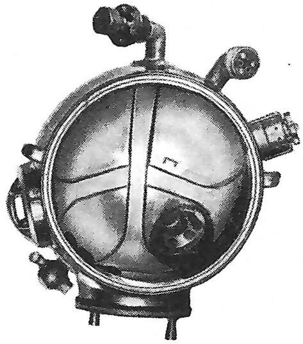


Fig. 82. Transmitter/receiver for thermionic telephone

Fig. 83. Receivers on separate head-band. Transmitter in helmet. British Admiralty pattern

Fig. 84. "Laryngaphone" with head receivers

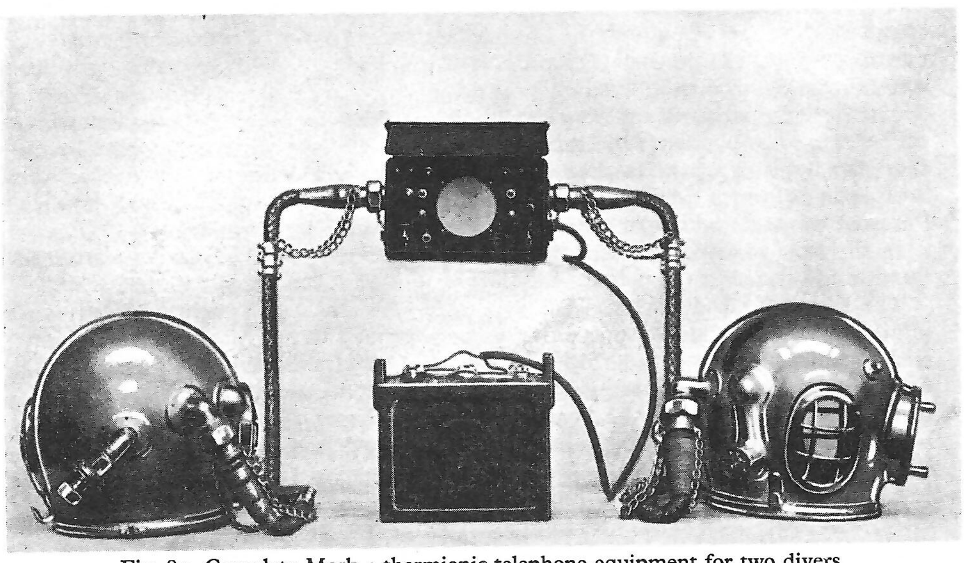


Fig. 85. Complete Mark 4 thermionic telephone equipment for two divers

The latest form of diver's telephone introduced by Siebe, Gorman & Co. Ltd., is one on the loudspeaking thermionic system which is described below.

In the first telephone designed for a diver by Siebe, Gorman & Co., over 50 years ago, the insulated conductors were secured at intervals along the length of his life-line or air-pipe. Another method was to run the wires through the bore of the air-pipe, but this involved rather complicated connections to the diver's helmet. Finally, it was found more advantageous to embed the wires in the life-line and this method is now universally employed.

The greater the depth of water, and the more highly organized the diving, the greater is the need for telephonic communication. Neither the *Laurentic* nor the *Egypt* treasure recoveries could have been accomplished without this link between the diver in the wreck and the winch-men above, who were working the grabs and hoisting great pieces of the wreck to the surface under his directions.

As compared with a fixed installation on land, divers' telephones have to work under most unfavourable conditions. The helmet is always damp, and divers occasionally take salt water into it in order to wash down the face glass. The transmitter and receiver inside the helmet have to work in compressed air, which affects their vibrations; drops of moisture may form on the junctions, and at the back of the helmet is a vital plug connection (breast-rope to helmet) which is made afresh on each occasion of diving, and yet has to be perfectly watertight against pressure heads of 50 lbs. per square inch and upwards. The circuit in the breast-rope has to be as efficient as that in a submarine cable which, once laid, remains undisturbed, but the telephone circuit must also stand the twisting and bending back and forwards on each occasion of joining up, undressing the diver, and coiling down, and, in addition, be strong enough to stand heavy strains.

At the surface, the telephone box and batteries are generally exposed to spray and rain while conversations have to be carried on amid the rushing and bubbling of compressed air in and out of the diver's helmet, and the chattering of winches on deck.

No telephonic material, however, good, can work if short-circuited by salt water, or with connections loosely made. Care, attention, and gentle handling are essential if reliable communication is to be maintained.

Single Diver Telephone. A wooden box contains a battery of eight cells and the combined receiver and transmitter for the use of the telephone attendant. The circuit is embedded in the breast-rope which has a similar plug connection at each end, fitted with three spills. One end of the breast-rope is screwed to the battery box, and the other to the helmet; the spills, or plugs, being of different sizes, will only enter their own proper sockets, and no mistake can, therefore, be made. The diver's receiver is fixed above his head in the top of the helmet, and the transmitter on the side opposite his right cheek. In speaking, the diver should remember this, and turn his mouth to the right; it is a great help to those of dull hearing to shut off the air temporarily, and so abolish the noise it makes in entering and escaping from the helmet. Shouting is to be avoided.

Two-Diver Telephone (British Admiralty Patterns). This is similar to the above, but the battery box contains the necessary dry cells to maintain communication with two divers. Outside the box are two connections marked "No. 1 Diver" and "No. 2 Diver" respectively; inside is a combined receiver and transmitter. There is a second receiver on an independent length of wire, the use of which is explained below. In connection with "No. 1 Diver" is a bell, while "No. 2 Diver" has a buzzer. The attendant, on receiving a call, therefore knows at once which diver wants him, and puts over the switch accordingly.

The switch is marked "Off", "No. 1 Diver", "No. 2 Diver", "Both Divers", and "No. 1 to No. 2 Diver". These markings are self-explanatory. When the switch is at "No. 1 to No. 2 Diver", the two divers can talk and hear one another, but though nothing can be heard at the usual receivers in the box, their conversation is audible at the second receiver previously mentioned.

The switch is always to be kept at "off", even when divers are down, unless talking is actually going on. The divers can ring up the attendant when the switch is at "off", by pressing on the bell (or buzzer) push which is placed in the front of the helmet within reach of the chin.

In our original Graham-Davis Telephonic Apparatus described above, it will be seen that the receiver is fitted in the crown of the helmet (see Fig. 81). While this arrangement is very compact and efficient, some divers who are rather hard of hearing prefer the type of receiver which is carried on a headband and fits directly over each ear (see Fig. 83) because it excludes all external noises such as the bubbling caused by the escape of air through the outlet valve into the water, pulsations of the air pump, etc. We therefore designed another apparatus embodying the latter type of receiver, and also an alternative form of intercommunication between diver and diver, and between divers and their attendant at the surface. The attendant's instruments comprise headband carrying two receivers, and a transmitter slung near his mouth. Batteries of the nickel-iron-alkaline type and switches are contained in a teak case, to which are also fitted the connections to the divers' breast-ropes.

Loudspeaking Thermionic Telephones. The loudspeaking thermionic telephone is the latest equipment for communication between the surface attendant and one or two divers and, additionally, in the case of the Mark 4, for communication between two divers (Fig. 85). The use of headphones and carbon microphones is no longer necessary. A specially designed, all-metal transmitter/receiver located in the upper part of the diver's helmet (see Fig. 82) enables him to transmit and receive speech clearly at a volume more than adequate to overcome air and helmet noises. The volume is variable and a tone control is fitted to correct the attenuation of speech which is experienced when divers work at great depths.

Reception at the surface is such that it is audible to the attendant when he is some distance from the instrument. Headphones for the surface attendant can be provided should the diving operations be such that divers' messages are confidential. The instrument is robust, compact, light and, with the accumulator provided, creates a loudspeaking sound channel of the highest reliability. It is used with the standard telephone breast-rope.

Mark 4—for Two Divers (see Fig. 85). This gives a complete three-way communication system by means of very simple switching. It enables the following functions to be carried out immediately:

1. Surface attendant to speak to diver submerged at any working depth.
2. Diver to speak to surface attendant.
3. Surface attendant to speak to two divers simultaneously.
4. Intercommunication between two divers with surface attendant listening. Speech between divers is controlled by means of "chin-pushes" in the divers' helmets which actuate relays at the surface, thereby effecting the appropriate circuit change. The surface attendant can interject to either or both divers if necessary.

Mark 5 Model—for One Diver. This is similar in principle to the Mark 4 Model but, being for one diver only, is controlled at the surface by a single "Listen/Speak" switch.

Summarized, the main advantages of this equipment are as follows:

1. The diver is not encumbered with earphones and does not have to concentrate on talking or listening. Conversation between diver and surface is as natural as talking to people in the same room.
2. The diver's reports can be heard first-hand by everybody interested on deck, instead of being filtered through an attendant. This is of great value in any major operation and in salvage work.

3. All the noises in the helmet can be heard on the surface as a background to speech and this is particularly helpful when training new divers, enabling advice to be passed to them before they get into any serious distress. It also serves to detect any defect of the apparatus, such as an injector failure, by those in charge; sometimes before the diver is aware of it himself.

Amplified telephones are essential for deep-diving and any major diving operations.

The Diver's Boots (Fig. 86) are of stout leather, with wooden soles, to which are riveted lead soles, bringing the weight of each boot up to about 18 lbs. Brass toe-caps are sometimes fitted to protect the leather and prolong the life of the boot. Another type of diver's boot (Fig. 87) has the whole sole and lower part formed of a brass casting shaped to enclose the foot; the upper part is of leather and renewable, so that there is no limit to the time they will last. These brass-soled boots are excellent on sand or mud and for crawling over rough ground, but on the smooth iron plates of wrecks the non-slipping qualities of lead-soled boots make the latter preferable.

The Diver's Weights (Figs. 88 and 89). The back and front lead weights weigh about 40 lbs. each, and their function is to maintain the diver's equilibrium when under water; their weight is always partly or wholly taken by hooks (already mentioned on page 69) formed on the sides of the helmet. Most patterns of weights are fitted with clips which engage over studs on the front of the corselet, the clips of the back weight being spliced at the ends of lanyards long enough to reach to the front of the corselet, passing over the helmet hooks on the way. The weights are hollowed and shaped to fit neatly over the corselet into which they are drawn by a lanyard spliced into the front weight, passing through a ring in the back weight and right round the waist. Many divers, including those of the Royal Navy, do not use the clips, but prefer to support their weights by simple lanyards spliced into the back weight from which they pass over the helmet hooks, to rings on the front weight where they are secured with bow-hitch. This arrangement might be of use in a grave emergency, such as the sinking of the diving boat with the air pump in it. The diver could cut himself adrift from his air-pipe and breast-rope, let go the lanyard round his waist and, by merely pulling on the bow hitches, release the weights, so becoming sufficiently buoyant to rise to the surface without assistance or any exertion on his own part. When fitting such lanyards to weights, they should be made on $1\frac{1}{4}$ inch tarred hemp, 3 feet long; the waist-lanyard of the same size rope should be spliced into the back weight on the bight leaving one end 4 feet long and the other 3 feet, so that the ends are hitched together on the diver's side.

Sometimes a suitably shaped and weighted electric light is substituted for the front weight, and in special types of apparatus like the "self-contained" and the "deep diving" equipments, oxygen cylinders or air purifiers are substituted for one or both weights.

Weighted Belt (Figs. 90 and 91). This is a wide canvas or leather belt fitted with pockets into which slabs of lead are inserted and used instead of the back and front weights. The weight of the belt (which is generally a good deal less than the ordinary weights) is taken by braces passing over the helmet hooks. A diver wearing a belt can get through narrower openings than if he was wearing back and front weights on his corselet, but owing to the relatively low position of the belt he has not such good command of his head and shoulders. For working under a ship's bottom on a stage, the lightness of a belt affords some advantages, especially as divers seldom have to stoop when so engaged, and in some salvage jobs, like clearing pump suctions in a flooded compartment, where the diver is constantly getting in and out of water or working with his helmet only partly submerged, a belt is better than ordinary weights.

The Shoulder Pad or Helmet Cushion is an oval ring-shaped horsehair cushion which goes over the diver's head, and rests on his shoulders under the dress. Its use is to distribute the load of the helmet, corselet and weights over the shoulders and to prevent the bony points from getting chafed.

Fig. 86. Diver's lead-soled boots with metal toecaps

Fig. 87. Diver's boots with all-metal goloshes and renewable leather uppers

Fig. 88. Diver's breast and back lead weights

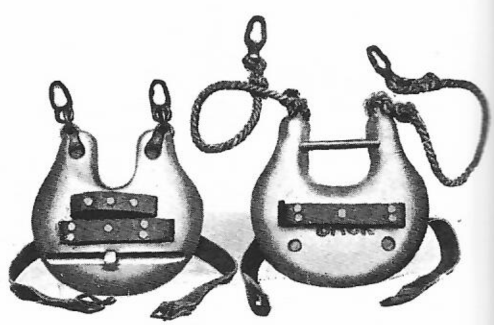


Fig. 89

Fig. 90. Diver's weighted belt with removable lead weights

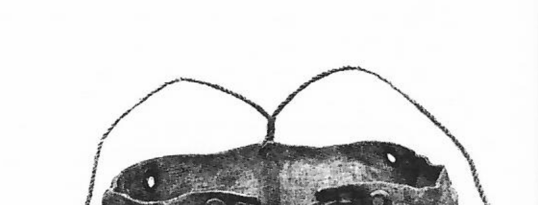


Fig. 91. Diver's weighted belt with non-removable weights

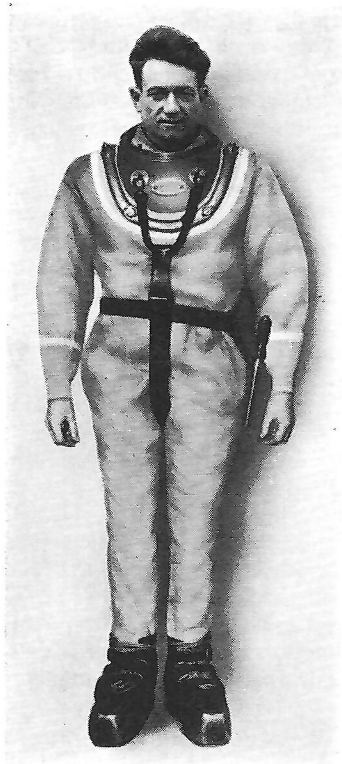


Fig. 92

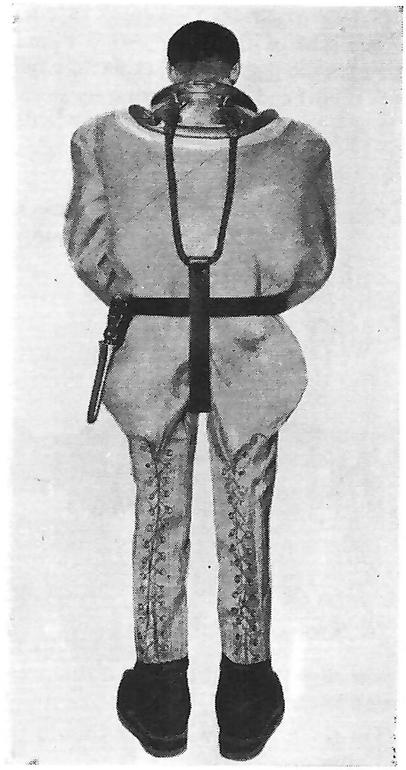


Fig. 93

The Diver's Woollen Underclothing consists of the warm knitted frocks or jerseys, drawers, long and short stockings, which all divers wear under the dress and outside their own clothes. This layer of soft clothing and the air entangled in its interstices, not only keep the diver warm, but protect his body from bruises and chafes when knocking about in disturbed water. A red knitted cap is traditionally associated with the diver's garments. Some form of cap is desirable, especially when the diver has to do long stops on the shot rope with his head resting against the cold damp copper of the helmet, but the beret type (which may carry telephone earphones) tied under the chin is really the best. Many a diver has found his red cap worked off his head and blocking his outlook through the front glass at a critical moment, or with its tassel stuck in the air outlet threatening to blow him up. If one of these caps **must** be worn, let it be turned inside-out, so as to suppress the tassel.

Overalls are stout canvas outer garments worn to protect the diving dress in work where it is likely to get chafed; often they are made with a wide pocket for tools, which is a great convenience. When sliding up and down long wire shot ropes, the crutch of the diving dress suffers unless guarded by short overall trousers, which in turn need padding where the rub comes.

Knife (Chapter 12). A diver should never go down without his knife, which is held in a metal sheath on a leather belt. To keep the belt from slipping down, it is either rove through the bight of the air-pipe or the air-pipe is rove through a ring or loop formed on the belt for the purpose.

Jock-Strap (Figs. 92 and 93) is a leather strap, adjustable for length, with clips on either end to take studs projecting from the corselet. It passes from the back of the corset, down under the crutch and up to the front of the corselet. Its length is adjusted to the size of the diver, so that it holds the helmet down on his shoulders. This obviates the discomfort, especially felt by short divers, of having the helmet lifted high over their head when coming up the shot rope with lots of air in the dress. Though not a necessity, the Jock-strap seems to fill a want and to be appreciated by divers who have tried it.

Four-Way Junction, sometimes called "Manifold" (Fig. 94). The junction is used for connecting up two or more pumps to one diver when going into very deep water (see pages 37 and 94). It has four connections; three of them, fitted with shut-off taps, are for joining up pumps; the fourth, which has no tap, is for connecting the air-pipe to the diver.

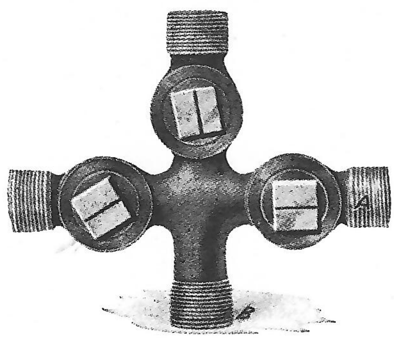


Fig. 94. Four-way junction

If, when using this junction (the diver being under water) it is desired to take off one of the pumps, the tap on the connection to which that pump is joined must first be shut. When putting on an additional pump, it must first be hove round, delivering its air against the shut tap till its gauge shows the same pressure as that of the other pumps heaving for the diver; after this the tap may be opened. The greatest caution must be exercised in opening taps on the junction when the diver is down, as the diver might be killed if the pressure were allowed to escape and if his inlet valve failed to act.

On no account whatever should the pipes of two divers be joined up to the same junction.

Urinal. Some, otherwise good, divers cannot hold their water for any length of time and when a long job is in hand want to be undressed at frequent intervals. To obviate the waste of time a rubber urinal can be provided to be worn inside the suit (Fig. 68) or dresses can be fitted with an aperture closed by removable screw plug (Fig. 69).

Ladder. A good stout ladder for getting in and out of the boat is a necessity; a good pattern is made of iron and has hooks which clip over the gunwale or transom of the diving boat, and the sides (or one of them) are carried up 3 or 4 feet above the top rung, so that when the diver has his feet on the top rung he will have something to steady himself by (Chapter 12). The ladder is canted off at an angle from the vertical by a short length of spar or a wooden bolster placed between it and the boat's gunwale, and in addition a lashing should be passed from the top of the ladder to the thwarts of the boat.

If much diving is to be done from a ship, it pays to get a good iron ladder made to ship in her gangway with off-setting struts. If obliged to extemporize, do not forget that a diver weighs more than two ordinary men and may get badly hurt if a rung breaks.

Shot Rope. This is best made up on board ship to suit the job. The usual thing is a $2\frac{1}{2}$ or 3 inch hemp rope of sufficient length, spliced into a 50 lbs. weight. Three feet above the weight a "distance line" is spliced into the main rope; it consists of a few fathoms of $1\frac{1}{2}$ inch hemp line the end of which is held by the diver or made fast near his work, so that it may guide him back to the shot rope (which may be invisible), when he wants to come up (see also page 121).

Fig. 95. Tungsten type 3,000 candle-power lamp with reflector

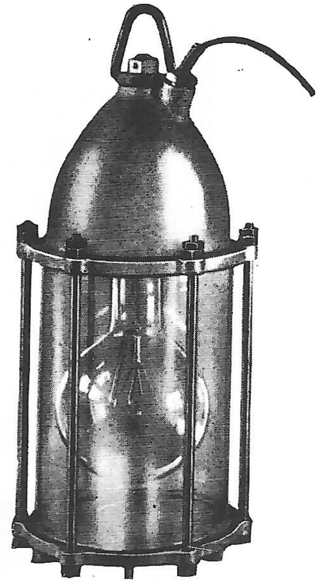


Fig. 96. Same lamp as Fig. 95 without reflector

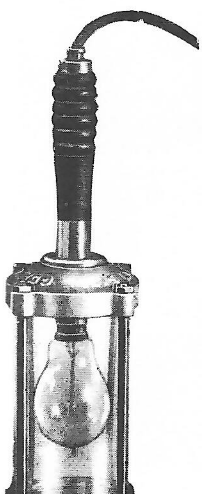


Fig. 97. Tungsten type hand lamp

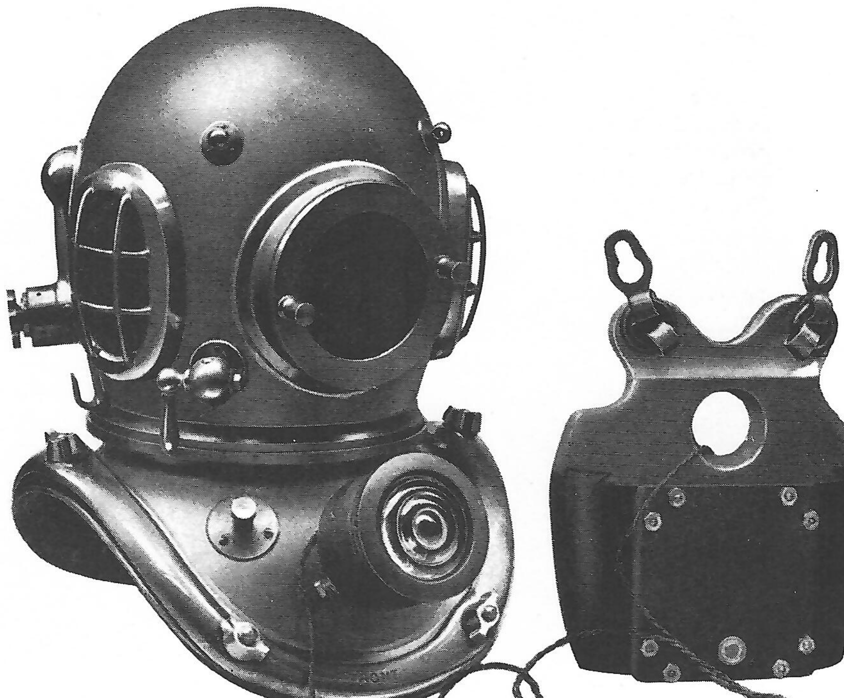


Fig. 98. Early type of lamp carried on corselet, with battery in diver's weight

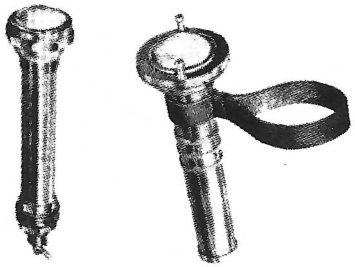


Fig. 99. Diver's electric torches (left: with switch)

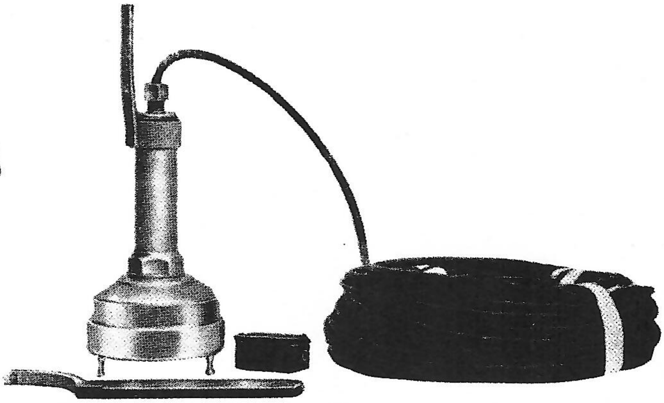


Fig. 100. Diver's hand torch with electric cable to surface

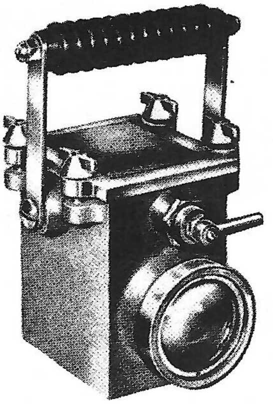


Fig. 100A. Diver's self-contained hand lamp (battery or accumulator)

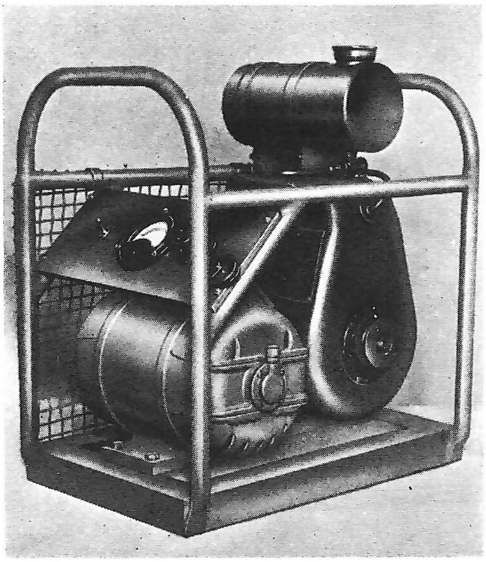


Fig. 101. Petrol generator set for 3 × 45-watt sodium lamp

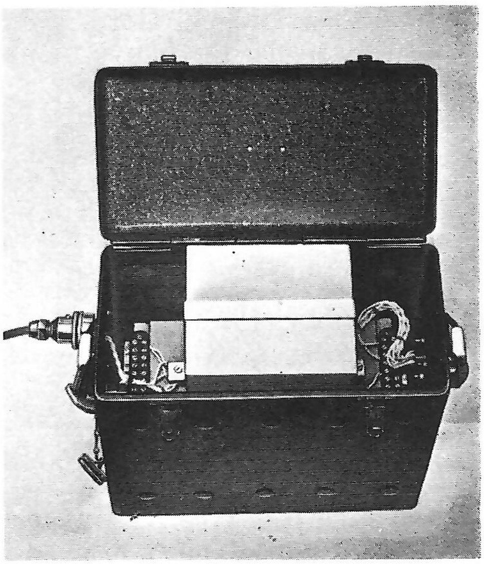


Fig. 102. Power pack for 3 × 45-watt sodium lamp—A.C. mains

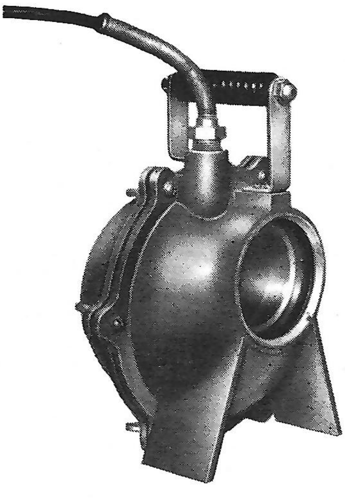


Fig. 103. 250-watt mercury vapour hand lamp

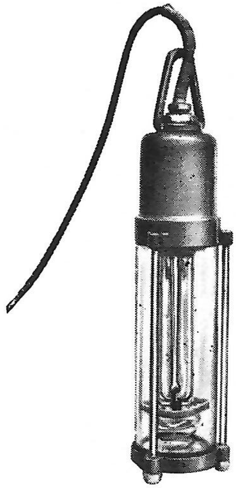


Fig. 104. 45-watt sodium hand lamp

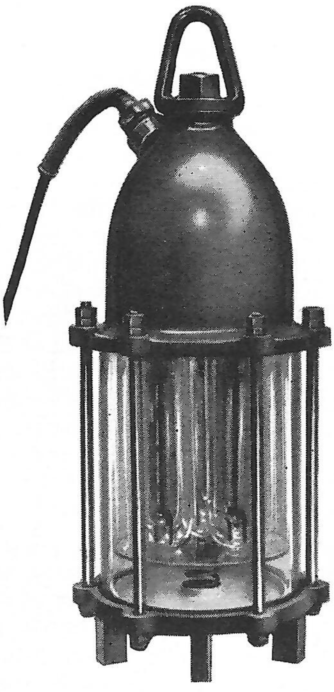


Fig. 105. 3 × 45-watt sodium flood lamp—well glass type

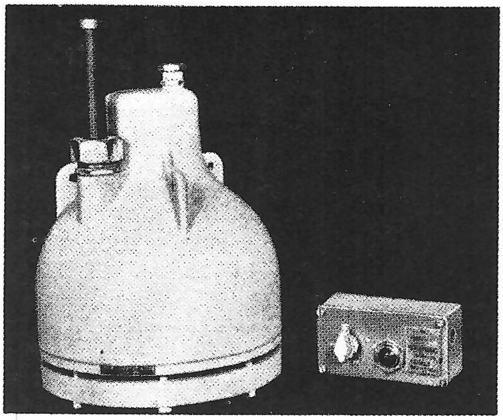


Fig. 105A

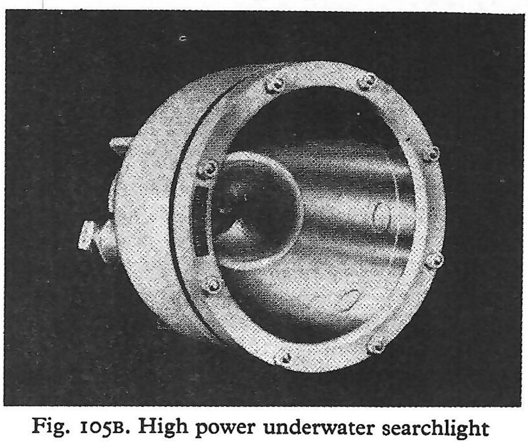


Fig. 105B. High power underwater searchlight

Fixed electric flood lamps supplied with current from the surface, or portable lamps embodying dry batteries or with surface current supply, are used according to circumstances. The fixed lights are intended to be slung over the job out of the diver's way. Portable lamps are very handy when working inside a wreck or in other cases not suitable for a fixed light; but, of course, a diver working with tools cannot spare one hand to hold a light. An early type of lamp introduced by Siebe, Gorman & Co. many years ago and designed to overcome this difficulty is shown in Fig. 98. This had a parabolic lens and was fitted on a ball-and-socket joint on the front of the corselet so that it could be turned in any direction. The lamp could also be fitted to the helmet above the front window. The battery was carried in a covered recess in the diver's lead weight.

Portable lamps and underwater torches also give a very useful light for close examination work, as in repairing worn underwater masonry, etc.

All types of lamps must be submerged before being switched on in order to prevent the glass, when heated, from being cracked by the plunge into cold water. They must also be switched off before being taken out of the water.

Tungsten Type Lamps. Examples of flood lamps of this type are illustrated in Figs. 95 and 96. and, as shown, can be made with or without the reflector. Their range of bulb is from 200 to 3,000 candle-power.

Self-contained hand lamps and torches are illustrated in Figs. 99, 100 and 100A. It will be noticed that one type of torch is switchless, the light burning continuously under water, and the other is fitted with a watertight switch enabling the diver to turn on the light as required.

250-Watt Mercury Vapour Hand Lamp (Fig. 103). Since Siebe, Gorman & Co. first used the mercury vapour principle for underwater illumination in 1919, great improvements have been made.

Today, the 250-watt high pressure compact light source box lamp is used, consisting of a quartz bulb containing two tungsten electrodes between which an arc of high brightness burns steadily. The arc length is approximately 3·75 mm. and its width 1·5 mm., and attains a maximum brightness of 18,000 candles per square centimetre. This lamp consists of a watertight case in which is housed the 250-watt high-power compact light source mercury vapour box lamp, its three-pin 5-amp holder, and a condenser lens system of 4 inches diameter. These are mounted wholly on the front of the lamp housing, thus facilitating lamp renewal and service by the simple expedient of removing a few wing nuts. The lens system is movable and is pre-set on the surface to produce converging, diverging and almost parallel beams. After switching on, this lamp takes between eight and 14 minutes to attain full brilliancy. This is in no way a disadvantage, as it is normally submerged and switched on prior to the descent of the diver. It is admirable for close-up working and also for searching at greater range and it is unexcelled in clear water. This lamp is suitable for use up to 450 feet. Its weight, excluding cable, is 30 lbs.; size 10 inches sphere without handle and cable outlet. It will operate satisfactorily from either D.C. mains (120-250 volts) using resistive ballast, or from A.C. (190-260 volts, 50 cycles) using inductive ballast. In locations where a mains supply is not available the lamp can be run from a petrol generator.

45-Watt Sodium Hand Lamp (Fig. 104). In turbid water, however, it is found that ultra-bright light sources are not so effective. The main reason for this is that the dirt particles suspended in the water, which are irregular in shape, reflect some of the forward light backwards and have the effect of partly blinding the user. The motor-car headlamp in fog is a similar example. In order, therefore, to obtain sharp visual contrast and acuity, sodium discharge lighting is used. Its rich, golden yellow light has high luminous efficiency, and, according to rating, it has a range from three to nearly five times that of tungsten lamps of comparable output. The colour of the light is mainly yellow (98·2 per cent), wave-length 5890/6A°, in the region of the eyes' greatest sensitivity.

The lamp is housed in a well glass of "perspex", lampholder and vacuum jacket being spring-mounted to resist shock. The supply leads enter the lamp through a watertight gland at the top of the lamp, and the top and bottom castings are held together by means of three tie bolts. This construction allows easy lamp renewal. It is suitable for use up to a depth of 200 feet. The weight of the lamp is 6¼ lbs. and its dimensions are 15¾ inches in length by 4½ inches diameter.

This lamp normally operates on A.C. 190-250 volts, 50 cycles, and can be supplied from mains of this nature via a leak transformer.

D.C. operation can be achieved by a rotary converter, and a power pack employing this principle is made. This power pack contains a rotary converter, leak transformer and capacitor for power factor correction; weight 52 lbs. The input operating voltage is 24 volts D.C. The equipment is self-contained and portable.

Three × 45-Watt Sodium Flood Lamp—Well Glass Type (Fig. 105). This is an enlarged design of the hand lamp shown in Fig. 104.

It is very useful where two or more divers are working in close proximity in turbid water. The three lamps are spring-mounted and are placed at 120° within a well glass (perspex) of 6 inches diameter, thus giving a very compact light source. The rubber-covered seven-core supply leads enter the lamp at the top through a watertight gland. The top and bottom castings are held by tie bolts, allowing easy access to the interior of the lamp. It is suitable for use up to a depth of 250 feet. The weight of the lamp, excluding cable, is 38 lbs., and its dimensions are 22 inches in length by 8½ inches diameter.

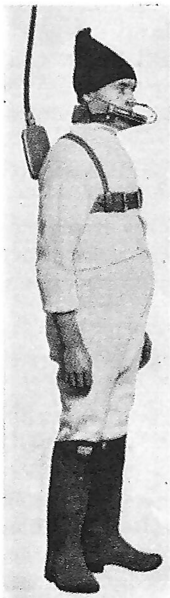
For supplying the Well Glass Sodium Flood Lamp, a mains unit is made; this unit houses three leak transformers and capacitor for power factor correction (Fig. 102). Should, however, A.C. mains not be available the petrol-driven alternator set (Fig. 101) can be used; its weight is 101 lbs., and it is compact and is easily transportable.

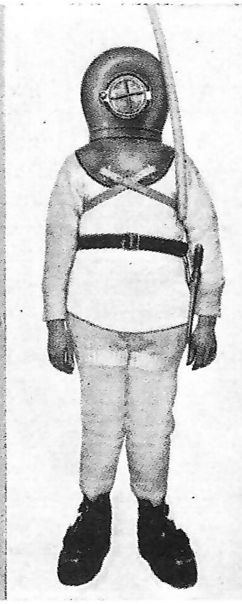
In conclusion, it may be stated that the foregoing series of underwater lamps cover completely every phase of underwater lighting required—from clear to turbid water conditions.

SHALLOW WATER DIVING EQUIPMENT

This simple apparatus (Fig. 106) was designed primarily to enable naked sponge and pearl divers and other underwater workers in very warm climates, who had been in the habit of diving without artificial aid, by holding their breath for a minute or two at a time, to prolong their stay beneath the surface. Parts of this apparatus were already embodied in the Fleuss-Davis self-contained breathing apparatus for mines*, and in their original self-contained diving dress which carries its own supply of compressed oxygen in steel cylinders, the difference being that, in the present case, instead of carrying his own supply of compressed oxygen and CO_2 absorbent chamber, atmospheric air is pumped down to the diver, as with the ordinary closed diving dress and helmet. As will be seen from the illustrations, the apparatus consists of a metal three-way tubular fitting to the central part of which is attached a vulcanized india-rubber mouthpiece, while to the end are connected a flexible corrugated tube and an outlet valve. To the tube is connected an air inlet valve. At the back is a vulcanized india-rubber bag into which the air is delivered through a tube from the pump, the bag acting as an equalizing chamber and ensuring a steady flow of air to the diver, any excess over the pressure of the surrounding water being released automatically through the rubber "flutter" valve. The diver breathes by the mouth only, the nose being closed with a clip. Goggles are also provided. In some cases a complete mask (Fig. 107) is provided in place of goggles. The equipment includes an air pump and 50 feet of air-tube with couplings.

* Self-contained breathing apparatus is dealt with fully in the author's "Breathing in Irrespirable Atmospheres": The Saint Catherine Press, London.





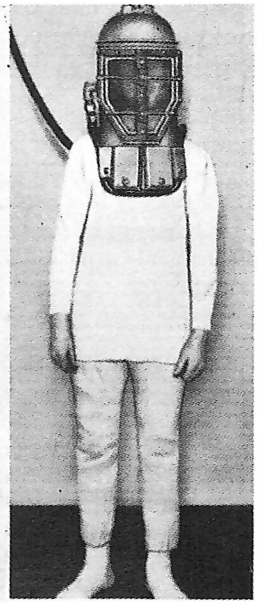


Fig. 106 Fig. 107 Fig. 108 Fig. 109

Fig. 108 shows a copper helmet strapped to the shoulders, and Fig. 109 an American type helmet with weights, both types being supplied with air from the surface, the excess air escaping at the lower edge of the helmet.

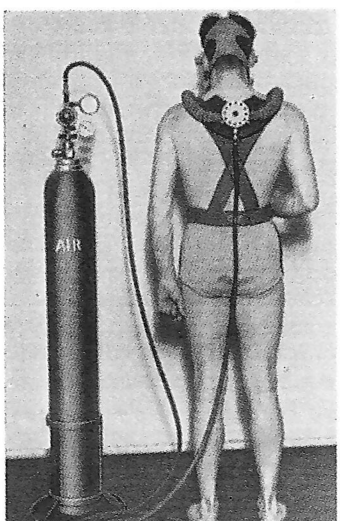


Fig. 110

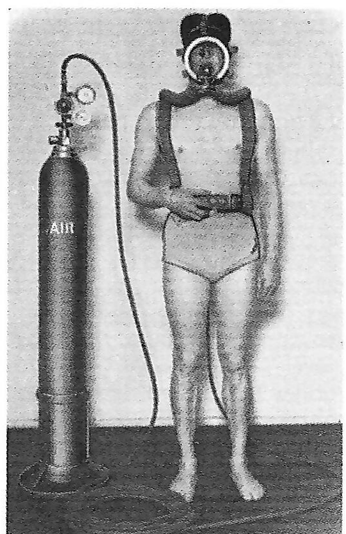


Fig. 111

Dive mask, with mouthpiece and noseclip, supplied from compressed air cylinder at the surface. Demand valve type

Fig. 112

Shallow water diving apparatus supplied with air from surface by lever pump. The diver is wearing a two-piece suit. A small neck breathing bag and a full face-mask with special mouth-piece form part of the apparatus

Converted Gas Mask for Shallow Water Diving. Shallow water diving has been carried out in warm waters, using a converted gas mask connected by air-pipe to an ordinary hand diving pump. This improvization of diving equipment is hazardous, however, if undertaken by other than experienced persons.