

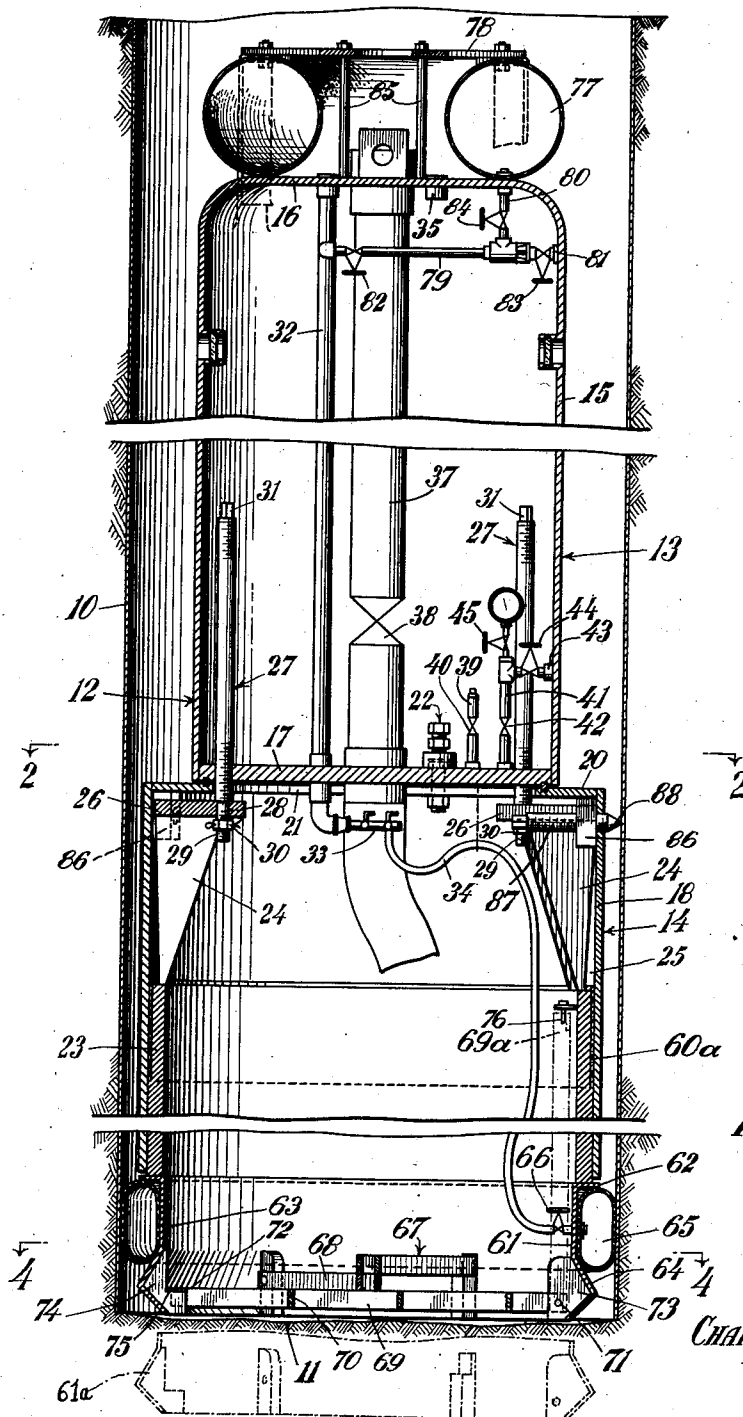
Oct. 3, 1950

C. GOODMAN
MOVABLE UNDERWATER COMPRESSED AIR WORKING
CHAMBER WITH CONTROLLED BUOYANCY

2,524,382

Filed Jan. 13, 1947

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

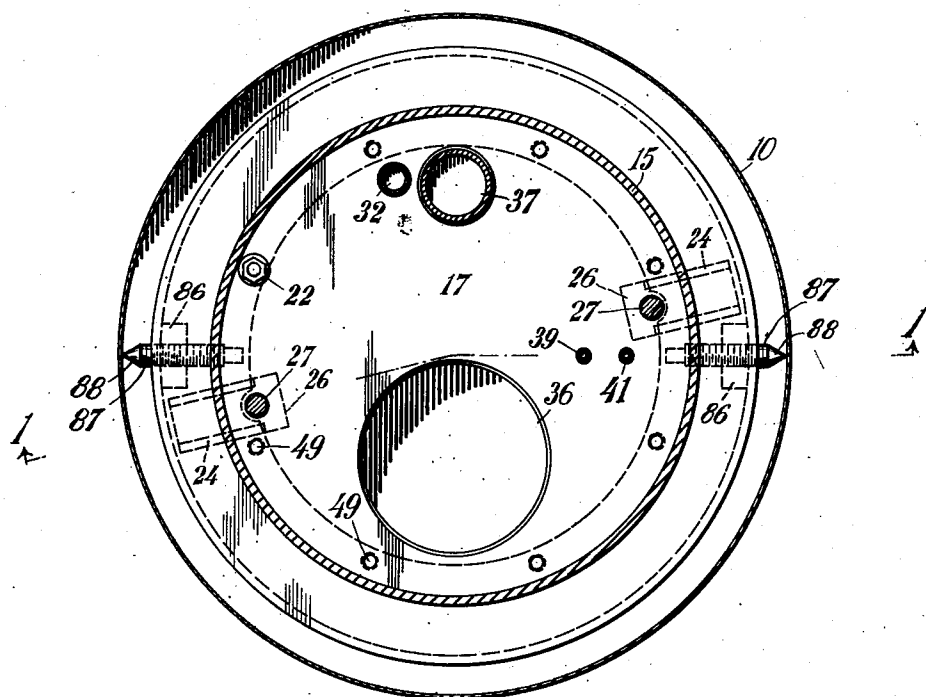


Fig. 2.

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Fig. 3

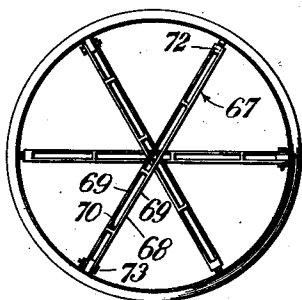
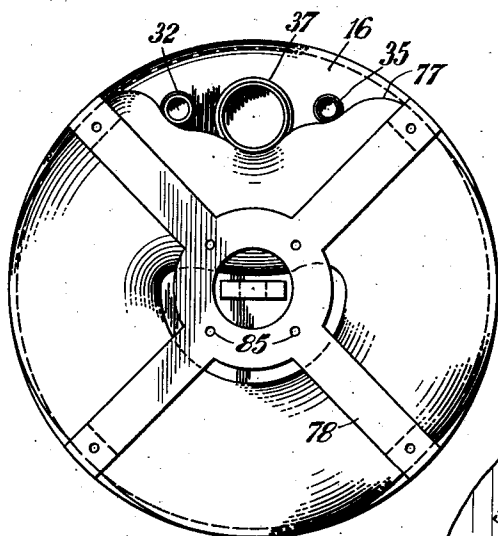


Fig. 4

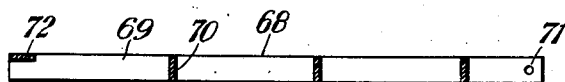


Fig. 5

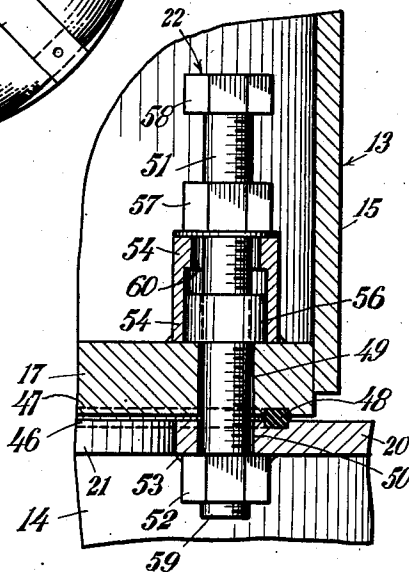


Fig. 6

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UNITED STATES PATENT OFFICE

2,524,382

MOVABLE UNDERWATER COMPRESSED AIR
WORKING CHAMBER WITH CONTROLLED
BUOYANCY

Charles Goodman, New York, N. Y.

Application January 13, 1947, Serial No. 721,833

5 Claims. (Cl. 61-82)

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This invention relates to methods and means for underwater construction, and represents modifications and changes in the subject matter of my co-pending application, "Methods and Means for Underwater Construction," filed August 1, 1946, Ser. No. 687,751.

The main object of my present invention is to provide a compressed air underwater working chamber, the buoyancy of which may be controlled, so that it may be caused to rise upwardly and sink downwardly, or to float at a desired position.

Another object of this invention is to provide a device, as characterized hereinbefore, which may be caused to descend or rise automatically without any other mechanical aid or hoisting device.

Still a further object of this invention is to provide a device of this type, which may be secured in its working position at the bottom of the structure, where it is in operation, or in any position in such structure, particularly a cylinder or shaft in which it is located.

As in the device of my mentioned co-pending application, the present device also consists of a compressed air lock chamber, and a downwardly open working chamber thereunder, the device to be controlled from the lock chamber, but said two chambers being separable, so that the working chamber may be left independently at the place of the operation, while the air lock chamber may rise.

Further objects of this invention will be apparent as the specification of the same proceeds, and partly will be pointed out therein.

In the drawings forming a part of this specification, and accompanying the same:

Fig. 1 is a semi-diagrammatical sectional view of a preferred embodiment of my underwater compressed air working chamber with adjustable buoyancy;

Fig. 2 is a transverse sectional view thereof, being taken on the line 2-2 of Fig. 1;

Fig. 3 is a top plan view thereof;

Fig. 4 is a cross-sectional view adjacent to the bottom of it, as indicated by the line 4-4 in Fig. 1, this view being on a smaller scale than the earlier figures, and

Fig. 5 is a sectional view of a swingable platform member arranged adjacent to said bottom;

Fig. 6 is an enlarged detail showing the releasable watertight securing means between an air lock and a working chamber proper of my device.

Referring now to the drawings more in detail

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by characters of reference, Fig. 1 shows my device as applied in a cylinder 10, but, of course, the same may be employed in any other shaft-like underwater structure, or entirely free of any shaft or cylinder.

Numeral 11 indicates the ground at the bottom of said cylinder or shaft, on which excavations or similar operations are to be performed through the use of my device, and my device is shown as lowered and resting on said bottom.

The numeral 12 indicates my device, in general, and it is composed of two main parts, being an upper closed vessel or chamber 13, which I call the air lock chamber, and a lower bell like downwardly open structure secured to the bottom of the air lock chamber 13, indicated in general at 14, which I preferably call the working chamber.

The air lock chamber 13 is preferably somewhat narrower than the working chamber 14, and preferably of cylindrical shape, having the side wall 15, a top 16, and a heavier bottom 17, forming an entirely closed structure which, however, will be provided with an opening and tightly sealing door for entrance or exit, as will be understood (not shown).

The working chamber 14 is practically in the form of a downwardly open bell, preferably also of cylindrical shape, particularly if it is to be lowered into a cylinder 10, and having the side wall 18 and the top 20. The top preferably has a large central opening 21, and it is secured to the heavy bottom 17 of the upper air lock chamber 13 in a watertight manner by any appropriate means well known in this art.

In the drawing, said securing means are indicated at 22, being of such a nature that, while they can connect the working chamber to the air lock chamber in a safe and watertight manner, at the same time the connection may be comparatively easily and quickly released from the inside of a closed air lock chamber, and thereby the air lock chamber separated from the working chamber 14, when desired. The specific construction of the securing means 22, shown in the present embodiment of my invention, will be described more in detail hereinafter.

As has been mentioned, the present invention is a modification of an improvement on an application to specific objects of the underlying idea in my co-pending application for Method and Means for Underwater Construction, filed August 1, 1946, Serial No. 687,751, and it will be seen that in said co-pending application, I also describe an air lock chamber and a downwardly

open bell type working chamber secured to the bottom thereof.

The improvements and changes in the present application over said co-pending application are mainly that a person within the device of the present application may control the buoyancy thereof in a novel, efficient and simple manner, and may separate the working chamber from the air lock chamber, so that the air lock chamber may be caused to rise to the surface and leave the working chamber at the bottom of the operations. I also employ in this device novel means for causing the air lock chamber to rise to the surface without any hoisting mechanism.

For controlling the buoyancy of the device, I employ in the modification illustrated an upwardly and downwardly slidable inner or lining cylinder 23 around the wall of the working chamber, said inner lining cylinder 23 having means to secure it in said working chamber in an upwardly and downwardly slidable manner, and it will be obvious that, when my device is in the water, an upward movement of said cylinder 23 into the working chamber 18 will cause my device to displace a smaller volume of water, thereby reducing its buoyancy, and a downward or outward movement of said cylinder will cause the same to displace added amounts of water, when the working chamber is completely filled with air, thereby increasing the upward lift or buoyancy in my device.

In the embodiment shown, the cylinder 23 is closely fitting and sliding on the inner surface of the working chamber wall 18, and two triangularly upwardly widening lugs 24 are secured to its upper end, preferably in diametrically opposite places, and spaced apart from the wall 18, as indicated at 25.

The upward lugs 24 terminate in horizontal heavier top plates 26, and a lifting or lowering screw, generally indicated by the numeral 27, is rotatably secured in each plate 26. As clearly seen in the drawing, said operating screw 27 will have a narrower lower termination 28, the upper portion thereof being smooth and rotatable in an aperture in the plate 26, while the lower part thereof is screw threaded as at 29, and a nut 30 is threaded on it, closed on the plate 26, and locked in such a position, whereby the screw 27 is rotatably and safely secured to the plate 26.

Screw 27 is of considerable length and screw threaded from top to bottom, having means adapted to be applied to its upper end 31, whereby to rotate it in one or the other direction. The screw threaded heavy long portion of the member 27 will pass an appropriate screw threaded hole in the heavy bottom 17 of the air lock chamber 13, and it will be seen that, when the screws 27 are rotated in one direction, they will move upwardly through the threaded holes in the bottom 17 and pull the cylinder 23 upwardly into the working chamber 14, and, vice versa, when the screws 27 are rotated in the opposite direction, they will move downwardly through the heavy bottom 17 and push the cylinder 23 outwardly from the working chamber 14.

The cylinder 23 may have the thickness and length predetermined for a desired weight, and this weight is added to the total of the weight of the working chamber 14 and air lock chamber 13 with the associated devices therein, and the buoyancy caused by the water displaced through the device is counteracting this weight.

Now, as the weight 23 is pulled inwardly, the amount of water displaced will be reduced, but

the weight of the whole device will remain, and in such a condition the device will have an added tendency to sink, while if the weight 23 is pushed outwardly from the working chamber 14, and the working chamber is completely filled with air, the amount of water displaced will be increased, increasing the upward force or lift caused thereby, while the weight of the device will remain the same, so the device will have a reduced tendency to sink, and in an appropriate case, when the dimensions and weights are appropriately designed, it may even have an upward tendency greater than its weight, in which case it will automatically rise to the surface of the water.

In this manner, the buoyancy of my combined air lock chamber 13 and working chamber 14 may be controlled, and in appropriate cases, the device may be caused to sink or to rise automatically, and it may even be entirely balanced so that it will float at any desired depth in the water, and remain so floating. Of course, instead of a movable cylinder 23, individual weights may be secured on the lugs 24, and more than two of them may be employed around the circumference of the working chamber 14.

It also will be obvious that the upwardly and downwardly slidable weight, whether the cylinder 23 or individual weights, may be made detachable from the lugs 24, so that in a desired case, the weights may be entirely dropped, and greatly increasing the upward buoyancy of the device, and causing the same to rise to the surface, as desired.

Like in the device of the mentioned co-pending application, a high pressure air line 32 may be introduced into my air lock chamber 13, from the surface, and, as shown, it may pass through the bottom 17 into the working chamber 14, where it may have a manifold 33 with appropriate branches, with valves or other closure devices, as indicated at 34.

Another lower pressure air line may also be introduced from the surface into the air lock chamber for keeping the air pressure in said chamber as desired, and the other usual connections, like telephone, electric light, and power, etc., may also be made from the air lock chamber to the surface, as will be obvious, and has been shown in my said co-pending application, and I prefer to introduce all these connections through one tube in the top 16 of the air lock chamber, as partly indicated at 35, the rest of such lines and connections having been omitted from the drawings for the sake of clearness.

An opening 36 may be arranged in the bottom 17 of the air lock chamber for communication with the working chamber 14, and an appropriate air and water tight inwardly opening door may be provided for the same, as will be understood. (Not shown.)

In the embodiment shown, the central portion of the top 20 of the working chamber is open, as indicated at 21, and said communicating opening and door 36 may register with a portion of the opening 21, as well as the various air, telephone, and electric lines may pass in a sealing manner through the bottom 17 of the air lock chamber and then through said opening 21 into the working chamber, where there may be facilities arranged thereon for any efficient use of the same by the workman descending into said chamber.

A muck discharge pipe 37 may also pass through the air lock chamber 13, sealingly through its top

and through its bottom, having appropriate adjustable and yielding connections to the surface at the one end, and similar connections into the working chamber at the other end, whereby in case of such operations, the muck may be raised therethrough, as by an air lift device, and as it is well known to those versed in this art.

A valve 38 may also be arranged in the muck discharge pipe 37 in the air lock chamber 13 to close the same when not in use, and when it may cause the air to escape therethrough from the air chamber, if not closed.

When my combined air lock chamber and working chamber are lowered to the bottom, the working chamber 14 may be filled with water, thereby aiding the descent, and when desired, the water may be forced out of the same, and for this purpose an air connection 39 is arranged through the bottom 17 of the air lock chamber, having a normally closed valve 40 therein, and when said valve is open, the air, under considerable pressure in the chamber 13, will pass into the working chamber and will gradually drive the water therefrom.

On the other hand, when it is desired to again decrease the buoyancy of the device, valve 40 will be closed and the pipe 41 used for discharging the air from the working chamber. Said pipe is provided with a valve 42, and communicates with the working chamber, being sealingly set into the bottom 17 of the air working chamber.

Branch 43 thereof will go to the outside through the wall 15 of the air lock chamber, also having a valve 44 inserted therein. Pipe 41 may also communicate with the air in the air lock chamber 13, so that when the valve 44 is closed and valve 42 is open, pipe 41 will have the same role as pipe 39, and will also let air into the working chamber, thereby speeding up the evacuation of the water therefrom.

If, however, valve 40 is closed and valves 42 and 43 are open, the air from the working chamber 14 will have a free exit to the outside through the pipe 43, and will permit the entry of the water into the working chamber.

A valve 45 may also be employed, if the pipe 41 is open to the working chamber 13, to close said opening when the inundation of the working chamber is desired, and the air therefrom is to be evacuated through the pipe 43.

In Fig. 6 I show the construction of the releasable securing means 22 between the bottom 17 of the air lock chamber and the top 20 of the working chamber.

First of all, I may provide registering grooves 46 and 47 in the top of the working chamber and the bottom of the air lock chamber, respectively, and insert a sealing ring 48 thereinto which will be compressed when the bottom 17 of the upper chamber and the top 20 of the lower chamber are drawn to one another, as will be described presently.

For every securing means 22, registering apertures 49 and 50 are provided in the bottom 17 and top 20, respectively, and a long threaded screw or bolt 51 passes therethrough. A nut 52 is permanently secured on the top 20 of the working chamber, as by welding 53, registering with the hole 50, and a sealing cap 54 is similarly permanently welded over the bottom 17 for the opening 49 therein, said cap having an aperture 55 in its top and said screw or bolt 51 passing through said cap and through its opening 55. A round lower locking nut 56 is rotatable within the cap 54, and a second upper locking nut 57 is over

the cap 54. The screw or bolt 51, finally, is provided with a head 58.

Now, when it is desired to secure the top 20 of the working chamber 14 to the bottom 17 of the air lock chamber, the screw 51 will be threaded downwardly until it passes through the lower stationary nut 52, as indicated at 59, whereupon the upper locking nut 57 will be strongly driven against the top of the sealing cap 54, and through this arrangement, the top 20 will be strongly drawn against the bottom 17 and the two secured in that position, as indicated in Fig. 6.

When it is desired to release the top 20 from the bottom 17, the screw 51 will be rotated in the opposite direction, thereby withdrawing the same from the stationary lower nut 52 and thereafter through the top 20. In such a rotation, however, the screw 51 will carry the intermediate nut 56 rotating with it until the same arrives against the shoulder 60 in the top of the sealing cap 54, when said nut will be strongly pressed against it and then the upper locking nut 57 tightened over it.

It will be seen that, in this manner, the bottom 17 has been separated from the top 20, and the opening 49 in said bottom is tightly sealed by the action of the opposite locking screws 56 and 57 against the two sides of the top of the sealing cap 54.

When, again, it is desired to secure the working chamber 14 to the bottom of the air lock chamber 13, the same movements will be gone through in an opposite manner, and the situation will be as illustrated in Fig. 6.

A plurality of such securing screws 22 may be employed, and in the embodiment shown, eight of them are indicated.

Referring now again to the adjustable weight 23 in the working chamber 14, which, as has been mentioned, in this embodiment is in the form of a cylinder closely but slidably fitting on the wall of the working chamber, the upper portion of said cylinder may be recessed, leaving a small space 60a between the wall 18 of the working chamber and the upper portion of the cylindrical slidable weight 23, and in said space an appropriate slidable sealing or stuffing material may be employed to prevent an escape of the air between the two sliding metal elements.

In the embodiment of my invention, as shown in the drawing, particularly Fig. 1, I may employ a downward addition or skirt 61 secured on the sliding cylinder weight 23, also being in the form of a cylindrical sheet steel body, however, possibly thinner than the weight 23 and having the peculiar shape and contour shown in Fig. 1.

As seen in said figure, the upper portion of said skirt 61 may have a flange 62 continued in a straight cylindrical portion 63, which again is downwardly continued in a concave angular bottom portion 64. An inflatable tubular body 65, preferably of rubber, is secured on the straight cylindrical portion 63, between the upper branch of the angular termination 64 and the flange 62.

The space within said inflatable tube may be connected to the manifold 33 of the high pressure air, as by the mentioned flexible tube 34, having a valve 66 inserted therein. When said valve is open, the high pressure air will inflate the tube 65, and the same will be strongly pressed both against the skirt 61 and against the cylinder 10, forming the shaft for the underwater construction.

In this manner, an air tight seal is provided between the cylinder 10 and the working cham-

ber 14, so that the air pressure therein may entirely drive the water out from said chamber through the bottom 11, as will be obvious, and then further excavations may be effected on said bottom, deepening the shaft, whereupon the whole device may be lowered with the depth of the new excavations as indicated by the imaginary dot and dash line position 61a of said skirt.

I also may form a platform grid structure, generally indicated by the numeral 67 (Figs. 1, 4 and 5), secured on the angular lower termination 64 of the skirt 61, and for this purpose, in the embodiment shown, I may employ three bars 68, each being made of two vertically set individual bars 69, connected by reinforcing cross pieces 70 and having a pivot hole 71 at one end, and an upper horizontal cross member 72 at the other end.

Three diametrically opposite pairs of vertical plates 73 and 74 are arranged around the circumference of the lower portion of the skirt 61, the one marked with 73 being adapted to receive a pivot pin for the pivot hole 71 in the respective bar 68, while the vertical plates 74 will have the shoulders 75 formed therein, on which the transverse horizontal plate 72 in the respective bar may rest.

The pairs of the respective elements in the opposite pivot and securing plates for them are set in three planes, one above the other, and when the bars are pivotally turned downwardly over and resting on the opposite shoulder 75, as shown in Fig. 4, they form a kind of a platform which in many operations is useful or necessary for the man working in the chamber 14.

When, on the other hand, it is desired to keep the lower end of the working chamber entirely free, said bars may be swung upwardly on their pivots 73, as indicated at 69a in dot and dash line imaginary position of one of them, and a releasable securing pin 76 may be provided for them on the sliding weight 23.

As has been mentioned, by manipulating the water content of the working chamber 14 and by manipulating upwardly or downwardly the weights 23 therein, the buoyancy of the whole device may be adjusted, and when it is desired to move my combined air lock chamber and working chamber to the surface, possibly without the aid of any mechanical hoisting mechanism, I may employ an inflatable comparatively large ring shaped tube 77 at the top of the air lock chamber 13.

As will be seen in Figs. 1 and 3, a steel cage construction 78 may be secured on the top, as indicated and the inflatable tube 77, arranged therebetween, preferably secured to the top 16 of the air lock chamber. A pipe 79 may be branched off the high air pressure line 32 adjacent to said top of the air lock chamber, and one continuation 80 thereof will lead into the inflatable lifting tube 77, while another continuation 81 thereof will lead to the outside.

Now, when it is desired to inflate the tube 77, valve 82 in the pipe 79 will be opened, permitting the high pressure air to pass through the same. Valve 83 in the outward line 81 will be closed, and valve 84 in the line leading into the lifting tube 77 will be opened, and the same will be inflated. In such an inflated condition, it exerts a predetermined amount of lifting force on the device, which may be sufficient to raise the same or, in case it is desired to keep it floating, will counterbalance the downward gravity thereof. Strong additional securing bolts 85 may connect

the top of the air lock chamber with the cage 78, so that the lifting force of the tube 77 may be releasably and safely transmitted to the air lock chamber.

Since considerable upward tendency may reside in my device, when the same is in the bottom of the shaft, and the working chamber is entirely filled with air, I provide means whereby the same may be releasably secured in such a working position. For this purpose, two oppositely placed lugs 86 are arranged in the working chamber, preferably adjacent to the top thereof, having registering screw thread holes in the wall of the working chamber, and a heavily screw threaded screw or jack 87 will be arranged through said holes, having a pointed outer end 88.

It will be seen that, when these jacks are moved outwardly in the screw threads of the lugs 86, their outer pointed ends 88 will engage the material of the cylinder 10 and lock my device against upward or downward movement, while, if it is desired to move the same in either direction, said screw jacks may be released, as will be obvious.

As has been mentioned, I may easily separate my compressed air lock chamber 13 from the working chamber 14, and the air lock chamber may independently rise or be lifted to the surface, leaving the working chamber at the place of the operation. In such a position, by obvious means well known to those versed in this art, the working chamber may be provided with a closed top and door, independent air, telephone, electric power, and similar lines, so that working men even may be left in the working chamber and continue to operate, while the air lock chamber is lifted for some reason. When desired, the working chamber may be withdrawn independently to the surface or the air lock chamber may be lowered and again secured on the working chamber.

It also will be obvious that the excavation and sinking operations may be continued even while the working chamber is left at the bottom of the shaft or cylinder, and that in either case, whether the air lock chamber is on the working chamber or separated therefrom, the sinking of the shaft or cylinder may continue, while the men are acting in said chamber. Indeed, in case cylinder 10 would be employed as shown in the drawing, said cylinder may be hammered at the top, as usual, and as has been more fully described in my said co-pending application, and the cylinder lowered or kept sinking by such hammering, while the men are working, which is an entirely novel feature, possible only through my device in combination with a cylinder for a shaft.

It also will be seen that all the devices and operations to influence the buoyancy of my device are such that the center of gravity of the same will be kept low, insuring the stability for it in any position.

Outwardly or inwardly movable screw jack securing means 87 may engage such a cylinder, as has been described, but they also may engage any other structure into which my working chamber is lowered, or the rock therearound, if the operations are of such a nature.

While I have shown a preferred embodiment of my invention, it is to be understood that changes and variations may be resorted to in the elements, combinations and operation of my invention, and I reserve my rights to such changes and variations as are within the spirit of this specification, and the scope of the claims hereunto appended.

I also want it to be understood that when, in this specification and the claims hereunto appended, the expression "underwater" is used, it obviously means any other liquid medium, like under oil.

It is also obvious that, when desired, my invention may be constructed in such a manner that the buoyancy controlling weights 23, or any other weights, may simply be dropped from the device when it is desired to quickly increase its buoyancy.

What I claim as new, and want to protect by Letters Patent of the United States, is:

1. In a shaft to be sub-aqueously sunk, an upwardly and downwardly movable operational device comprising an air lock chamber, a downwardly open work chamber secured underneath the same, means to place said air lock chamber under compressed air pressure, communication between said air lock chamber and working chamber whereby workmen may descend from the air lock chamber into said working chamber, means to place said working chamber under compressed air pressure from said air lock chamber when desired, and means to vary the buoyancy of said device whereby the same may descend, rise or float at a predetermined level in said shaft as desired, said device being adapted to so move through said control of its buoyancy entirely independent of any outside means to raise or lower the same, said means to influence the buoyancy of the device including members inwardly and outwardly slidable on the wall of said working chamber through its open bottom.

2. In a device, as set forth in claim 1, means in said air lock chamber to control said inwardly and outwardly movable slidable members.

3. In a shaft to be sub-aqueously sunk, an upwardly and downwardly movable operational device comprising an air lock chamber, a downwardly open work chamber secured underneath the same, means to place said air lock chamber under compressed air pressure, communication between said air lock chamber and working chamber whereby workmen may descend, rise or float at a predetermined level in said shaft as desired, said device being adapted to so move through said control of its buoyancy entirely independent of any outside means to raise or lower the same, said means to place the air lock chamber under compressed air pressure including yielding pipe lines to the surface, a center tube leading from the working chamber to the surface for removing material from said working chamber, and means to influence the buoyancy of the device including a deflatable or inflatable ring shaped hollow element secured on the top of said air lock chamber, said pipes and tube to the surface being encircled by said inflatable ring shaped element.

4. In a shaft to be sub-aqueously sunk, an upwardly and downwardly movable operational

device comprising an air lock chamber, a downwardly open work chamber secured underneath the same, means to place said air lock chamber under compressed air pressure, communication between said air lock chamber and working chamber whereby workmen may descend from the air lock chamber into said working chamber, means to place said working chamber under compressed air pressure from said air lock chamber when desired, and means to vary the buoyancy of said device whereby the same may descend, rise or float at a predetermined level in said shaft as desired, said device being adapted to so move through said control of its buoyancy entirely independent of any outside means to raise or lower the same, an inflatable hollow ring member secured around the outside of the bottom of the wall of the working chamber adapted when inflated to provide a sealing between the bottoms of the working chamber and of the shaft, respectively, whereby an entirely dry working chamber may be produced by compressed air over the bottom ground operated on.

5. In a shaft to be sub-aqueously sunk, an upwardly and downwardly movable operational device comprising an air lock chamber, a downwardly open work chamber secured underneath the same, means to place said air lock chamber under compressed air pressure, communication between said air lock chamber and working chamber whereby workmen may descend from the air lock chamber into said working chamber, means to place said working chamber under compressed air pressure from said air lock chamber when desired, and means to vary the buoyancy of said device whereby the same may descend, rise or float at a predetermined level in said shaft as desired, said device being adapted to so move through said control of its buoyancy entirely independent of any outside means to raise or lower the same, a removable grid for the bottom of the working chamber comprising rods placed thereacross, said rods being pivoted at one of their ends on the wall of the working chamber whereby said rods may be folded along the wall of the working chamber when it is desired to remove the grid.

CHARLES GOODMAN.

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