

March 4, 1952

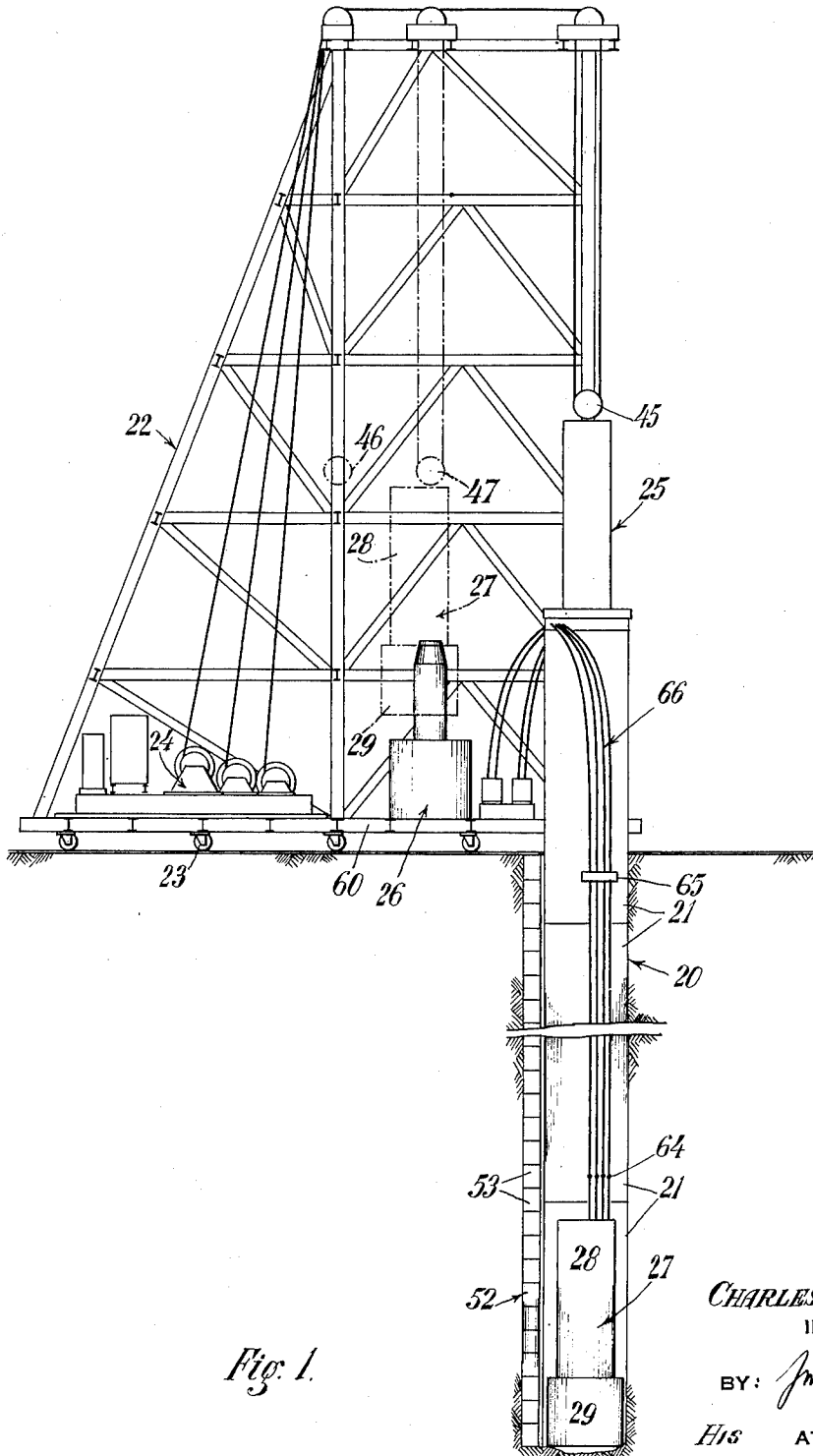
C. GOODMAN

2,587,835

METHOD AND MEANS FOR UNDERWATER CONSTRUCTIONS

Filed Aug. 1, 1946

6 Sheets-Sheet 1



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March 4, 1952

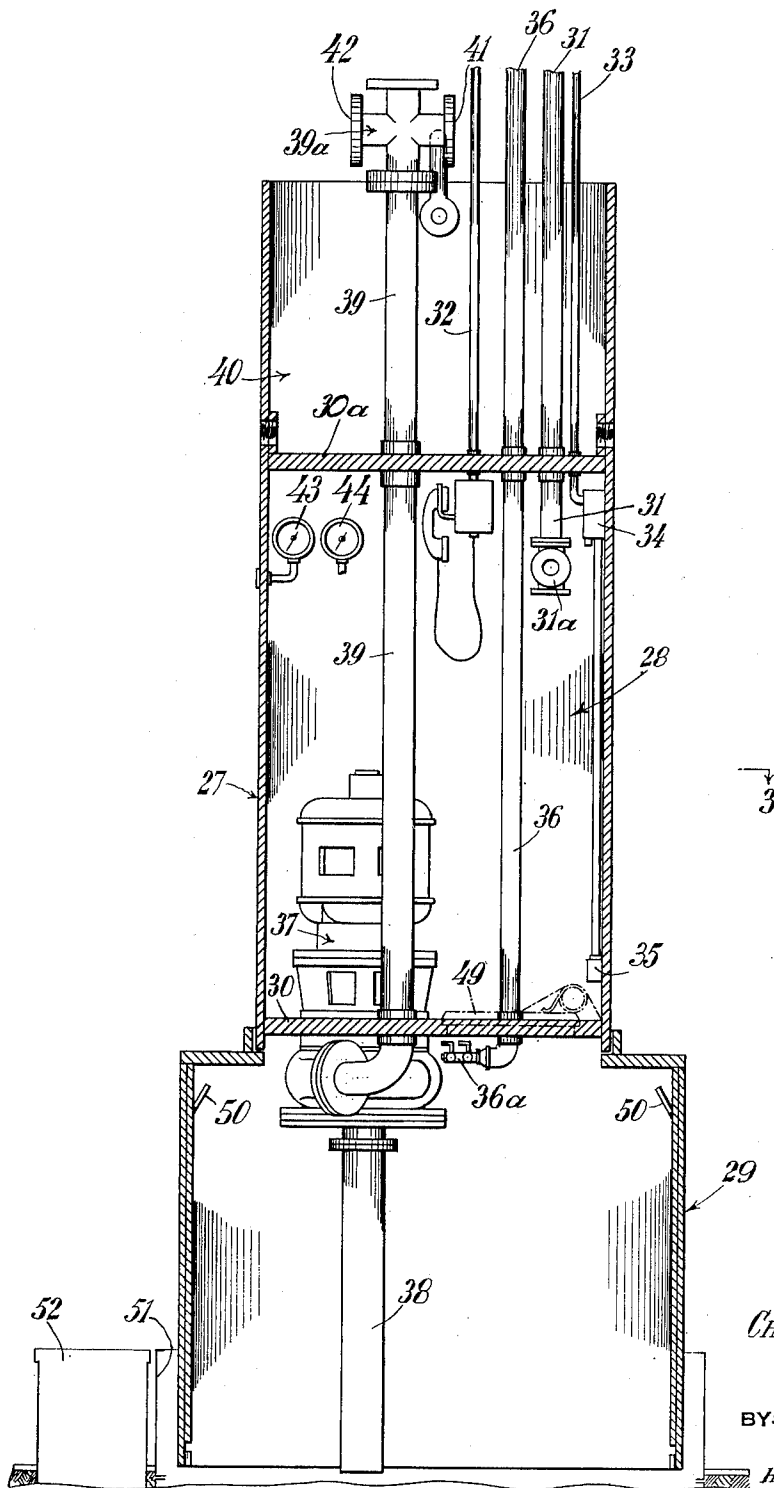
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Fig. 3

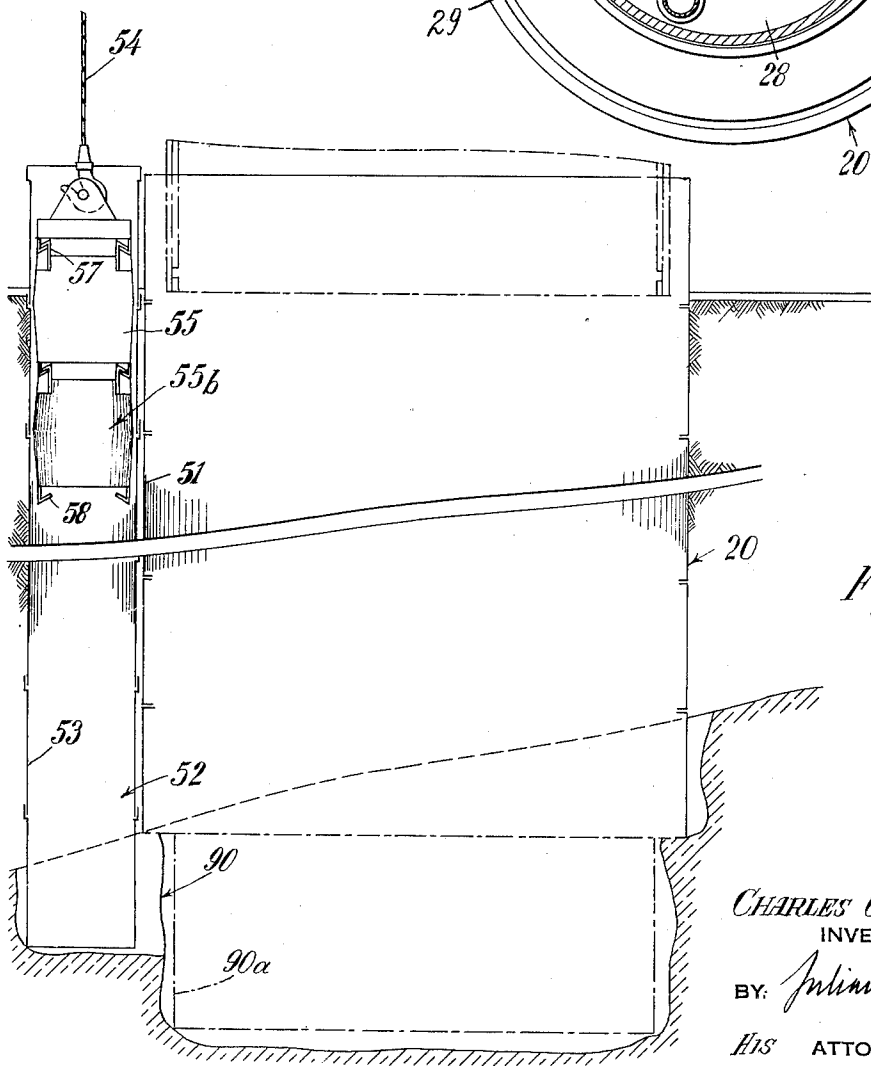
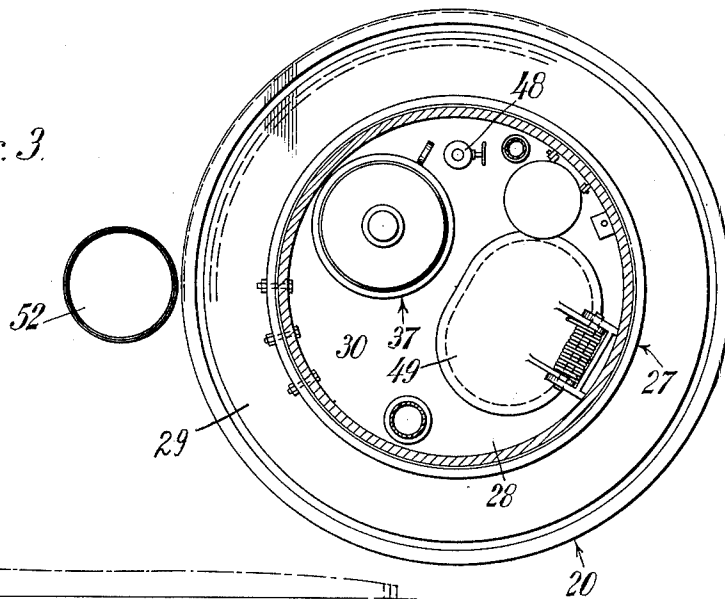


Fig. 2a

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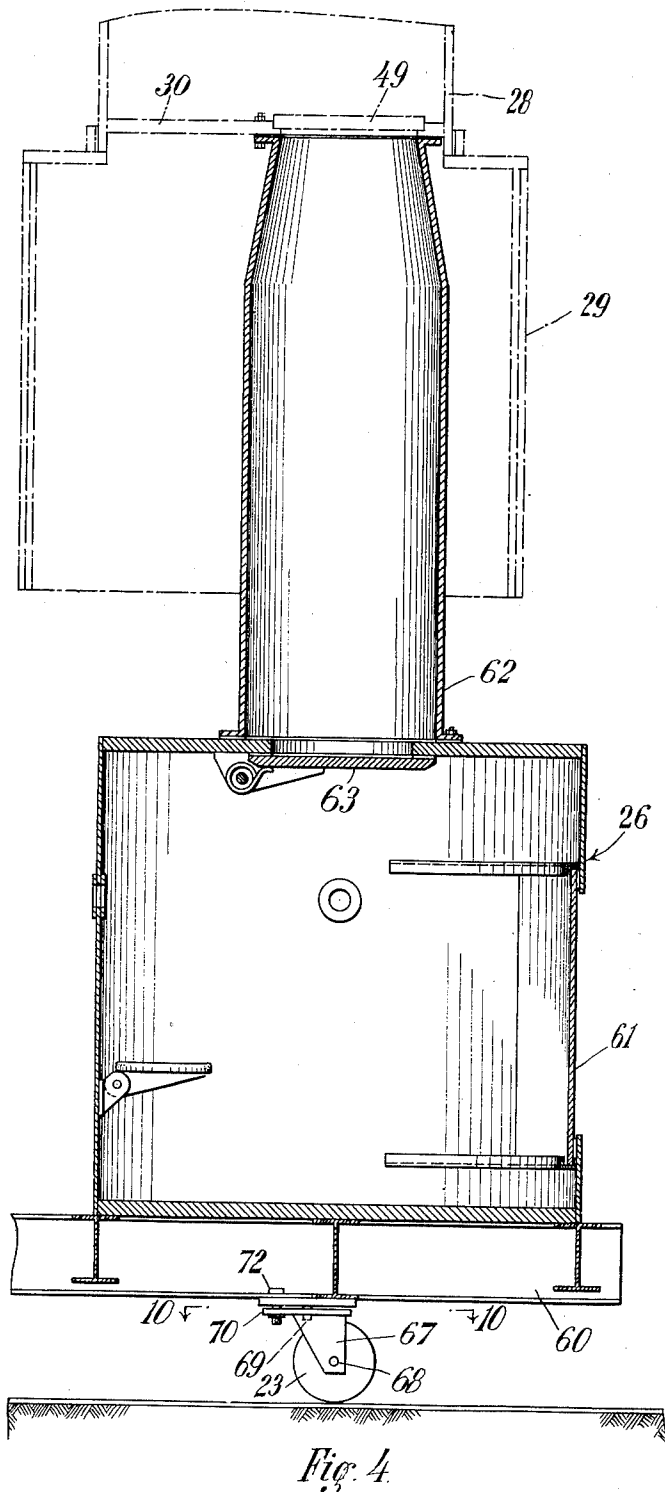


Fig. 4.

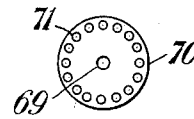


Fig. 10.

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METHOD AND MEANS FOR UNDERWATER CONSTRUCTIONS

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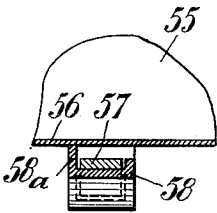
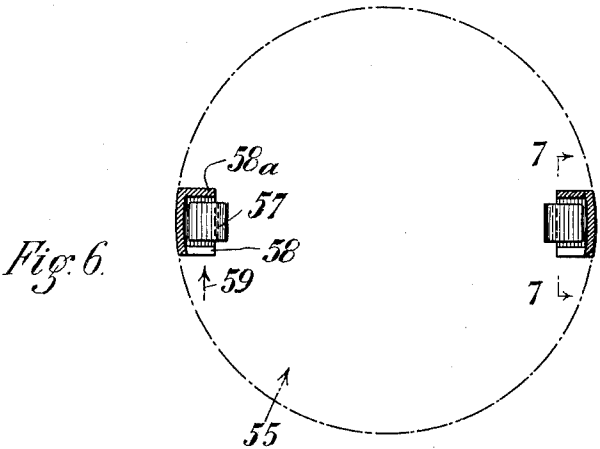


Fig. 7.

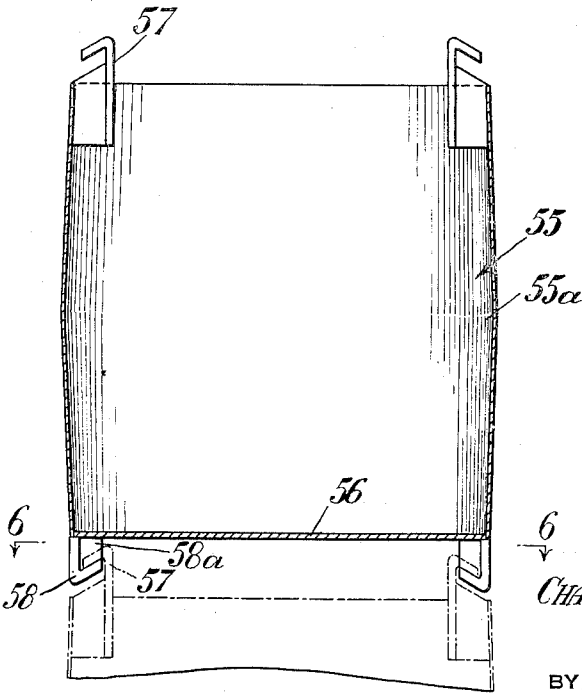


Fig. 5.

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METHOD AND MEANS FOR UNDERWATER CONSTRUCTIONS

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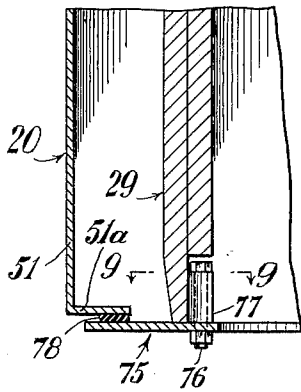


Fig. 8.

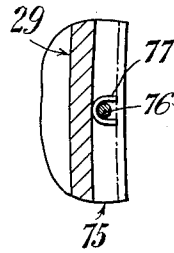


Fig. 9.

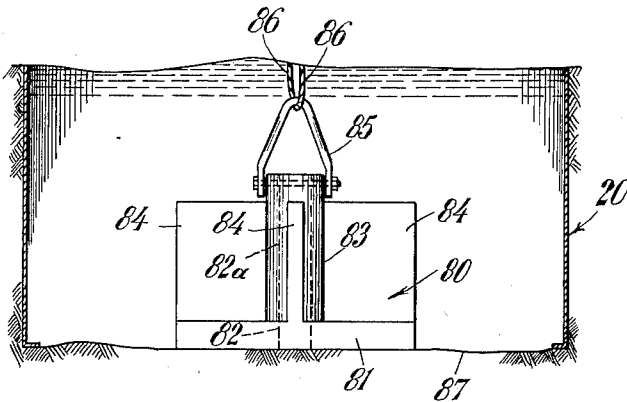


Fig. 11.

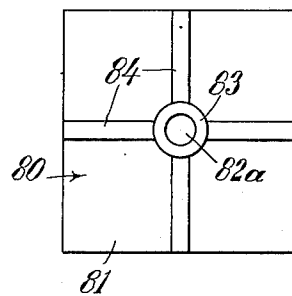


Fig. 12.

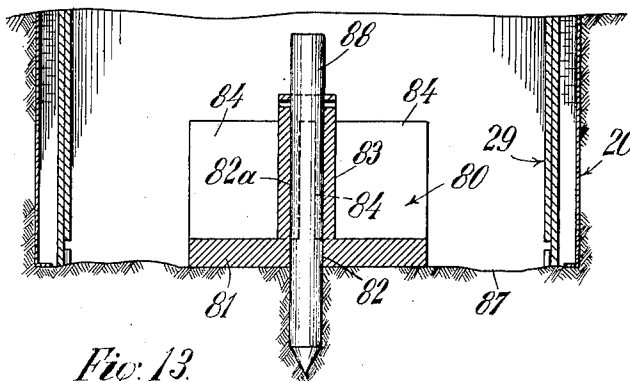


Fig. 13.

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UNITED STATES PATENT OFFICE

2,587,835

METHOD AND MEANS FOR UNDERWATER CONSTRUCTIONS

Charles Goodman, New York, N. Y.

Application August 1, 1946, Serial No. 687,751

3 Claims. (Cl. 61—82)

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This invention relates to construction and sinking of structures, like shafts, pipes, caissons, particularly under water, and has for its main object to provide means and methods whereby such operations may be executed with more efficiency than is the case with the means and methods now used for such purposes.

Particular objects of this invention also are: to provide means and methods of the type characterized hereinbefore, which will accomplish the objects in view with less complicated equipment, with less expense, in a shorter time, with less troubles and handicaps to be met, and with more comfort to the workman employed, than is the case with the methods and means used at present.

It is a well known fact that when driving, sinking, or excavating for the structure, shaft, pipe, or caisson, many difficulties and great troubles are encountered at present, particularly when boulders or rock is met by the lower edge of the device to be sunk, so that caissons, and the like, sometimes have to be left hanging, abandoned, and sometimes they have to be put entirely under compressed air pressure, for continued work, with very costly equipment, and expensive and slow, operations, it also being necessary, among others, to remove men and equipment from the caisson at certain operations, and return them thereafter, with the well known complications, costs, and delays.

My invention, designed to remedy all these difficulties, drawbacks, and handicaps, mainly consists in providing a compressed air lock chamber, adapted to receive a desired number of workmen with the necessary equipments and tools, providing a downwardly open working chamber underneath said lock chamber, then lowering this air lock and working chamber into the shaft or caisson feeding it with compressed air, electricity, telephone, and other services from the surface, the men in the lock chamber then being enabled to drive out the water from the working chamber thereunder, and transfer it into a working chamber under air pressure into which they may descend and perform any necessary excavating or other operations in the dry, with comfort and with all necessary aids and tools. Even explosives may be used in an exceptional case, as will be explained more in detail hereinafter.

In connection with such means and methods, in addition, I employ various novel separate means to raise the excavated material, to reduce the hydraulic head and lower the necessary air pressure in the device, and to perform other necessary or desirable operations in connection with the work of the type indicated.

Still further objects of my invention will be partly apparent and partly pointed out as the specification of the same proceeds.

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

Fig. 1 is a diagrammatic, partly sectional, elevational view of one embodiment of my novel arrangement for underground shaft constructions;

Fig. 2 is a sectional view of a novel combination air lock chamber and working chamber used in my invention, and

Fig. 2a is a sectional view of the lower part of the shaft in which said lock and working chamber are to be used;

Fig. 3 is a sectional view on the line 3—3 of Fig. 2 of the lock chamber and shaft;

Fig. 4 is a sectional view of a decompression chamber to be used with my said air lock and working chamber;

Fig. 5 indicates the detailed construction of an excavation material bucket, which I employ in practicing my invention, and

Fig. 6 is a sectional view thereof, while

Fig. 7 shows one of its details;

Figs. 8 and 9 are sectional details showing means to form the working chamber of my invention into a compressed air chamber at the place of its use;

Fig. 10 indicates a detail of the novel casters to be used for moving the head frame construction of my invention;

Figs. 10, 11 and 12 show how my invention may be employed to mark the center of the working area at the bottom of a cylinder, shaft, caisson, or like structure.

Referring now to the drawings more in detail, by characters of reference, and particularly to the general view or diagram of Fig. 1, the numeral 20 indicates the underground shaft which is being prepared, and in this modification, it is indicated that the method applied is that of using comparatively long cylinders 21, and driving them in succession one over the other into the ground.

As will be understood by those versed in this art, a head frame and tower structure, generally indicated by the numeral 22, is built, preferably movable on casters 23, and preferably having a three drum hoist 24 and a pile driver mechanism 25.

In the embodiment shown, the shaft 20, to be sunk, is at one side of the head frame 22, so that new cylinder sections 21 may be easier placed over the ones sunk, and that the right hand side of the structure, in general, should be left entirely free. The above ground decompression device, indicated at 26 and to be described presently, will then be within the head frame structure and at a place where it will not obstruct the operations on the shaft 20.

If any complications arise, or large hydraulic heads are to be met, such operations at present can be conducted only if the whole shaft is put under compressed air pressure, and workmen

are lowered into it to dig, blast, or in other manner excavate and clear the ground underneath the lower edge of the shaft to be sunk. This present method, obviously, entails a very large expense, complicated equipment, slow work, caused by the necessary slow descent and raising of the workmen, and the long time needed for them to be adjusted, either, to the high air pressure when going down, or to the usual atmospheric pressure when coming out of the job.

In my invention, I use a combination air lock chamber and working chamber, which may be easily lowered into the shaft and wherein the workmen can operate almost entirely similarly as working above ground, with all the pneumatic, electrical, and other, tools available, and wherein their descent into, and removing from, the shaft and the exchange of shifts can be made with a very slight delay in time, thereby greatly speeding up the finishing of the job at hand.

In Fig. 1 at 21, I indicate, generally, in diagrammatic manner, my combination air lock and working chamber, and the same is shown, on a larger scale in a more detailed manner, while still semi-diagrammatically, in Fig. 2.

In said figure the numeral 28 indicates the air lock chamber of my device, in general, and 29 is the working chamber attached to the bottom thereof. Both chambers are indicated as circular in cross section, but, of course, in case of need, any other form may be used. The air lock chamber 28 is built of heavy steel plate, and will have a similar heavy, air pressure resisting, bottom 30, and top 30a. A compressed air pipe line 31 rises from the lock chamber 28 to the surface, and provides the low compressed air for said lock, having a discharge head 31a in the chamber through which the occupants may control the air pressure in said chamber, which, of course, may also be controlled from the surface.

A telephone communication line 32 is also provided, as will be obvious, and, finally, an electrical line 33, in which may be united conductors for both, the lighting systems and the electrical power equipment, otherwise said two currents being different and separate. A junction box 34 may be provided in the lock chamber, and a plug-in receptacle 35, so that any desired lighting or electrical power connections can be made, as will be obvious.

A higher compressed air pressure power line 36 is also provided, passing through the air lock chamber and its bottom 30, and ending in an air manifold 36a, for the pneumatic power equipment in the work chamber 29, underneath the lock chamber 28. It will be noted that the lock chamber 28 is comparatively narrow, just sufficient for the equipment therein, and for a desired number of workmen, while the working chamber 29 may be of any desired width, much wider than the lock chamber.

The work chamber simply is a downwardly open bell, secured underneath the lock chamber 28 in a sealing, reliable manner, by any means well known in this art.

An electrically driven dredge pump, generally indicated by the numeral 37, may also be arranged in the lock chamber 28, projecting through its bottom into the working chamber 29, and having a suction pipe 38 therein, through which the muck, released at the bottom of the workings, may be removed and raised through the muck discharge pipe 39 of the pump 37.

I prefer to build a muck storage chamber, generally indicated by the numeral 40, over the lock

chamber, being open at the top. The muck discharge pipe 39 reaches to said open top, and terminates in a discharge head 39a, having openings 41 and 42 at the two sides thereof, through which the raised muck may drop into the muck storage chamber 40. Said chamber may be of such a dimension that the normal amount of muck the workmen can release in one operation may be stored there, after which the whole device may be raised above ground and the muck removed.

An outside water pressure gauge 43 is also arranged in the lock chamber 28, and at the side of it, a lock bell air pressure gauge 44, and, obviously, all the workman in the lock chamber has to do is, to bring the indication on the lock chamber air pressure equal to the indication of the outside water pressure, whereby the working chamber may be cleared of water, as will be described more in detail presently.

After the workmen, with the necessary tools and other equipment, are in the lock chamber, above ground, and brought to the necessary air pressure, they will be lowered into the shaft 20.

For this purpose, the lifting hook 45, over the center of the shaft 20, will be relieved of the pile driver 25, said pile driver being transferred to another lifting hook of the three hoist drums, preferably the innermost one in Fig. 1, as indicated at 46. This transfer of the pile driver may be effected in any manner, well known in this art, whereupon hook 45 may be used for the lock chamber 28. In the diagram of Fig. 1, the lock chamber also is shown in an imaginary manner by dot and dash lines as being attached and resting on the surface of decompression chamber 26, and the third hook 47 may be used for lifting the same, and it may be transferred to the hook 45 over the center line of the shaft 20.

As has been mentioned, the lock chamber 28, with its associate parts, will be lowered into the shaft 20, to the working place at the bottom thereof, whereupon the workmen will permit the compressed air from the chamber 28 to enter into the working chamber 29, for which purpose simply a valve controlled short pipe 48 (Fig. 3), connected to the low air supply pipe 31, may pass through the bottom 30 of the lock chamber.

A spring balanced trap door 49 is also arranged in said bottom, and after the air pressure is equalized in the two chambers, the workmen in the lock chamber may open said door and descend into the working chamber.

Hooks 50 may also be arranged on the walls of the working chamber, on which additional equipment, material, and, particularly, my specific muck buckets, may be suspended.

In case the shaft is built of the cylinder sections 21, as shown in Fig. 1, the workmen may successively clear the soil underneath the lower edge of the leading section, and the pile driver 25 may drive all the sections with a depth of the cleared portion. This obviously will greatly facilitate the driving operation.

In Figs. 2 and 2a another usual form of sinking a subsoil shaft is shown, wherein ring lining sections 51 are used. In this case, the workmen at the bottom will clear a depth of about the height of such a section 51, and the shaft will be lined by ring portions adapted to be bolted together to form a full ring 51, as it is well known in this art. The ring portions, and the adjacent full rings, will be appropriately sealed against the seeping of the water into the shaft.

Preferably, I also employ a separate auxiliary

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shaftway, generally indicated by the numeral 52. This will be built of short sections 53, successively attached to the lower end of the shaft 52, built up in this manner as the digging and excavating at the bottom of the operations proceeds, the workmen at the bottom clearing sufficient space at the side of the main shaft for the next section 53 of the auxiliary shaft 52. Sections 53 may simply be pushed into one another, at their marginal portions, in a telescopic manner.

This auxiliary shaft will be used in cases where broken material is to be lifted from the working place, which material may not be removed by the dredge pump 37. In such cases, a bucket may be filled with the material, then moved sideways at the working place, in line with the auxiliary shaft 52, and raised to the surface therein by the hoist line 54. For such removing of excavated material, I prefer to use a novel bucket of my invention, generally indicated by the numeral 55 (Figs. 5, 6 and 7).

This bucket is generally cylindrical but barrel shaped, that is, its wall is somewhat bulging out at the center, as indicated at 55a. It will have a bottom 56, but open at the top, and the excavated material may be filled into it.

The bucket will easily fit into the auxiliary shaftway 52, and its barrel-shape and bulging center 55a will prevent its catching therein when moved up or down. Specific hook devices 57 will be secured to its top, and hook devices 59 will be secured to the underside thereof, whereby a lower next bucket 55b may be suspended on an upper bucket 55.

The workmen will fill a bucket, and hook it to the hoisting line 54, and give signal to raise the same to the desired extent, whereupon the next filled bucket will be hung to the bottom of the first bucket, and so on, until a desired number of filled buckets are connected in a chain, whereupon they will be raised, emptied, and returned.

The bottom hook 58 of the buckets is made in such a manner that it will prevent an accidental self-escape from it of the top hook 57 of the next bucket, for which purpose the hooks are formed, as illustrated, and a side wall 58a is provided for the bottom hook 58, so that the top hook 57 has to be pushed into engagement with it sideways, as indicated by the arrow 59. Since the free space in the bottom hook 58 is only slightly larger than the corresponding thickness of material in the upper hook 57, the same may be hooked into it by a workman, but it will be practically impossible for it to be freed, by itself.

As has been mentioned hereinbefore, a decompression chamber 26 is also arranged on the base or supporting platform 60 of my structure, and in Fig. 4 I show, in a semi-diagrammatical manner, and on a larger scale, the construction of said decompression chamber, or air lock, indicating the way the lock and working chambers may be attached to it when they are lifted from the shaft.

After the workmen finish their shift, they have to be raised to the surface, they have to leave the work chamber, and they have to be replaced by new workmen, and for this purpose, the laborers of the earlier shift must have facilities to get used to the normal atmospheric pressure, while the incoming new shift must be adjusted to the higher pressure. My decompression chamber 26 is constructed for these two purposes. It is built of strong steel plates, and has an en-

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trance door 61. The new shift of workmen will enter into said chamber, and the air pressure will be gradually raised, as usual, until it will be about the same as that to be met at the working station. A communicating tube or passage 62 is built on said air lock, communicating therewith through a spring balanced trap door 63 in the top of it, which normally will be kept tightly closed by the air pressure therein.

When the air lock chamber 28 with the working chamber 29 is raised to the surface, the same will be moved over the air lock 26 and secured thereto in the manner indicated in Fig. 4, trap door 49 of the lock chamber now being in line with the passage 62, and bottom 30 of said chamber being sealingly secured on the top thereof, like by bolts.

Compressed air will be admitted into the passage 62, until its pressure is about equalized with that in the decompression chamber 26 and lock chamber 28, whereupon the respective trap doors will be opened, and the new shift may go, through the passage 62, into the lock chamber, and the old shift will go down from the lock chamber into the decompression chamber. The air now will be drawn out of the passage 62, the trap doors will close, the lock chamber will be released from the passage 62, raised from it, and then lowered into the shaft with the new workmen.

The air pressure in the decompression chamber 26 will then be gradually lowered, as usual, until it is safe for the men therein to exit into the atmosphere.

It will be seen that by this means and method, the exchange of the shift can be done in a very quick manner, without the usual long delay, and aside from this, both, the incoming and outgoing shifts, may be prepared for their respective tasks in an easy, comfortable manner.

The air, electricity, and telephone lines will be enclosed in pipes or tubes to a desired distance above the muck chamber 40, as indicated in Fig. 2, the upper limit of said protecting tube being indicated at 64 in Fig. 1. This is to protect the various connections from injury through the muck, or any other material. Above the limit 64, said lines will be made flexible, like enclosed in rubber hoses, but at a predetermined distance above the lock chamber, all said tubes will be secured to a cross beam 65, which may be suspended from a hook and raised independently of the air lock and working chamber 27, when the same is raised. The purpose of this arrangement is to prevent an entangling or confusing of the various flexible lines.

As my device 27 is raised, the beam 65 will be raised simultaneously, so that the portion of the flexible lines between said beam and the device 27 will always remain straight, taut, and stretched. The rest of the flexible conduits, generally indicated by the numeral 66 (Fig. 1) then will have a chance to drop on the side of the shaft 20 above the surface and coil without being entangled.

In Figs. 4 and 10, I also indicate a novel caster construction for my platform 60. As will be seen from the diagrams in said figures, the casters are carried by a member 67, rotatable therein, as at 68, said member itself being again rotatable on a shaft 69 in the platform structure 60. All this is usual well known construction in this art. I, however, secure a disk 70, having a plurality of holes or perforations 71 around its margins, on the caster carrier member 67, and a pin 72 is

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adapted to be passed through an appropriate aperture in the platform structure 60, and through a respective hole 71 of the disk 70, whereby the caster may be locked in a desired position with reference to the platform 60.

Now, when it is desired to move the platform, with the head frame, tower, and other equipment thereon, to a new location, casters 23 will be turned into the direction desired, and each will be locked, by their respective pins 72, so that the moving of the whole heavy complicated upper structure to the desired direction may be easily done.

The mentioned auxiliary shaft or tube 52 may also be used for another purpose, than that of raising the excavated material. In some cases, it is necessary to pump the water from the adjacent region at the bottom of the shaft, and thereby reduce the hydraulic head or pressure at that place. To use shaft 52 for such a purpose, buckets 55 and the lifting line 54 will be removed from it, and a pump device, well known in this art, will be inserted, whereby the shaft 52 will be formed into a suction line for the pump. If sufficient quantity of water is removed from the bottom of the auxiliary shaft 52, with sufficient speed, the hydraulic pressure at the working place will be reduced, and much lower air pressure will be needed in the air lock chamber and in the working chamber or bell. Through this device, I will be enabled to go much deeper with such working chambers, than has been the case heretofore, since normally there is a limit of 115 feet depth, and a corresponding hydraulic pressure, which may be counterbalanced by air pressure sufferable by the workmen.

With my described method, this head and pressure may be reduced several times, so that, upon applying an auxiliary shaft 52, and pumping the water through the same, I may send my air lock and working chamber much deeper than the former limit of 115 feet.

It will be obvious that a second auxiliary shaft 52 may be built, adjacent to the main shaft 20, preferably at an opposite position to the first one, and then one shaft may be used for raising the material, while the other may be used for pumping. Obviously, however, two or more auxiliary shafts may be used for pumping, to provide a quicker and greater reduction in the hydraulic head.

It also will be understood that the auxiliary shaft 52 may be made of sections welded to the cylinder or caisson, and sunk with the same. The auxiliary shaft, or well pump, may also be arranged inside of the cylinder or caisson by any appropriate means, as will be understood.

Through the use of such well pumps, the head of water in the working chamber will be reduced, as mentioned, and the men not only will work in lower air pressure more comfortably, but they may stay for long hours at work, indeed, in some cases, the water head may be reduced to zero, thus permitting a structure to be built in the open without any air pressure used.

In Figs. 8 and 9 I indicate a method and means by which the working chamber also may be formed into a compressed air lock chamber, so that the work may be done entirely in the dry. For this purpose, I may employ plate sections, generally indicated by the numeral 75, which will be secured to the lower edge of the working chamber, pointing outwardly therefrom, and going around its circumference to provide a transverse horizontal wall, projecting from the bottom

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edge of the working chamber all around thereof. These plate sections may be secured, in the embodiment shown in Figs. 8 and 9, by bolts 76, placed into channels 77, secured to the wall of the working chamber.

Adjacent and along the outer ends of the plates 75 are placed rubber hose sections 78, secured on the plates, and if the shaft, cylinder, or caisson 20, is built of lining rings 51, after placing the plate section 75 around the bottom of the work chamber 29, said work chamber will be raised to the desired degree, whereby the rubber tube sections 78 will be squeezed between the said plate sections, and the flanges 51a of the lining, and this way a substantially air and water tight seal will be provided between the bottoms of the shaft 20 and the work chamber 29. In this manner, a sealed compressed air chamber will be formed at the bottom, to permit adding of extra air pressure to dry up the ground underneath the working chamber, whenever it is desired. In this work chamber, under the extra air pressure, the excavation can be deepened, dug flaring outwardly to make wider foundations, the sides of the excavation will be stable, and any desired structures can be built therein.

In case of a caisson or cylinder being sunk by weight or hammering, a similar air seal may be used at the bottom between it and the working chamber, the rubber sealing means to be compressed being right under the edge of the cylinder or casing. Obviously, other sealing means may be employed than the one described, as, for instance, a comparatively large rubber tube may be placed in the space between the lower edges of the working chamber and the structure in which it is arranged, and said rubber tube expanded by air pressure until it adheres, tightly sealing, to both, the working chamber and the bottom margin of the structure.

In Figs. 11 to 13 I show a method by which my air lock and work chamber may be adapted for an improved, novel centering of a sub-surface or a sub-aqueous structure.

This method generally consists in the following steps: First my working chamber and air lock will be withdrawn from the cylinder or other upwardly open structure, which is being built, and a weight will be lowered at the exact center thereof, said center being established on the surface by means well known to those versed in this art. The plumbing weight will have an aperture therein, and when it is carefully permitted to rest at the bottom of the excavation, the lowering line for said plumbing weight will be withdrawn, leaving the weight to rest with its aperture at the exact center of the cylinder or the like being sunk.

It is to be understood that first the bottom will be levelled, through the use of my compressed air lock and working chamber, and after said weight is placed on the levelled bottom, my device is lowered again and the workmen will drive a stake through the aperture in the weight and then remove the weight. In this manner, the stake at the bottom will mark the exact center of the device, and the workmen in the further operations may take measurements from this center point, and thereby insure that the structure, as it is being sunk, will be in exact vertical direction, as against the usual deviations now met in sinking such structures, and the well known serious drawbacks accompanying the same.

In Fig. 11 the numeral 80 indicates the plumb-

ing weight, in general, the same, in this embodiment, being formed of a bottom plate 81, having a central aperture 82. An integral tube 83 rises over the aperture 82, having an identical inner passage 82a. Four wings 84 may also be provided for better centering the weight, when it is being lowered. A pivoted bail 85 is secured at the top of the tube, and a looped double lowering line 86 engages the bail 85. When the weight is set in the exact center line of the structure on the bottom 87, double line 86 will be withdrawn, as will be understood, leaving the weight at the bottom. The working chamber with the air lock is now lowered over said weight, the workman will enter the same, and will drive a stake or rod 58 through the central passages 82 and 82a into the ground to a safe depth, whereupon the plumbing weight 80 will be withdrawn by pulling the same upwardly on the stake 88. In this manner, the stake 88 will mark the exact center of the structure, and may be used as a starting point for any desired measuring done at the bottom of the underwater excavation.

In this manner, accurate plumbing of the structure may be resorted to at desired intervals, to insure against any error.

Heretofore, caissons, round or square, and steel pipes and cylinders have been sunk by weight, by jacks, or by blows from a power hammer. It has been found that these structures go out of line by meeting obstructions at the cutting edges, so that it is rare to find a caisson which is sunk plumb. A vertical slope of $1\frac{1}{2}\%$, or 3 inches off center at the top, is considered good work. The departure from the vertical makes the caisson eccentric with respect to the load, and where heavy loads are supported, this eccentricity is a serious detriment.

My described method to insure a plumb construction of any type of water foundations is a great improvement which is highly desirable to meet the requirements of correct design.

Another novel and highly practical feature of my invention is that my air lock and working chamber with the workmen therein may even be left in a cylinder, caisson, or other structure, while the same is being sunk, either by weight, or by hammering through a pile driver arranged over the top of the structure in an appropriate manner, as indicated in Fig. 1.

I believe this employment of my invention not only is novel, but the only one proposed in this art where work may be done at the bottom of a structure under compressed air and still a hammer may be employed at the top to drive the structure downwardly, and the reason for it is that my method and means are the only one in which an air lock and working chamber may be employed independently of the cylinder, caisson or other structure.

This independent feature also enables me to admit compressed air into the working chamber during the descent of my device, so that the same will arrive to the bottom practically dry, water having been driven out of the same, thereby greatly expediting the operations and adding to the comfort of the workmen.

As has been mentioned, through my method and means, I am enabled to dig underneath the cutting edge of the cylinder, caisson, or the like, and thereby greatly facilitate its sinking, which normally requires a great force or weight. With my invention, it may be driven into a free space instead of against resistance at the bottom.

In a similar manner, ledge rock may be removed from the bottom underneath a cylinder or other shaped caisson, and boulders may be removed, thus permitting the lowering of the structure to its final foundation.

Excavation at the bottom of the operations may be done by loosening up the hard ground with the aid of compressed air drills and tools. Boulders may even be blasted. The loosened material and small size rock will be loaded in the buckets described hereinbefore and raised through the auxiliary shaft.

A large boulder may even be moved into the working chamber, a chain passed therearound, and hung on hooks in my device, after which the same may be brought to the surface with the boulder suspended on it.

Earth may be dredged and pumped to the said storage chamber on the top of the air lock and may be removed when the same is brought to the surface. It is obvious, the dredge pump power may be electric, air, or any other power.

In a word, the operations may be done at the bottom and under water exactly the same way and with similar tools as used for surface work, which again is a great advantage in using my invention.

Instead of discharging into a muck chamber, a dredge pump or an air lift or a hydraulic lift may discharge directly to the surface. Indeed, often this can be done without any men being present in my air lock, or working chamber, as the operation of such lifts may be controlled from the surface.

A removal of the muck from the working chamber will keep the same clear, whereby the workmen may move with more freedom and work with more efficiency. It is also to be noted that my air lock and working chamber will replace the water and will not disturb the ground, which is kept safe and stable by the water pressure.

In normal compressed air operations in caissons or the like, great weights must be used to overcome the upward thrust of the compressed air, which also is eliminated through the use of my device as it will work under water pressure, which counterbalances the upward force of the air therein.

At present very often it happens that a cylinder, caisson, or the like, being sunk, may come to rest on rock with a slope, and thereby will be unsafely supported and also inclined from the vertical, with the mentioned serious drawbacks. With my device, in such a case, the rock may be made level to provide a substantially even, uniform support all around the lower edge of the structure, as indicated in the lower part of Fig. 2a.

If further excavations are necessary in the rock, it may be done underwater through the use of my working chamber, as indicated, in general, at 90 in Fig. 2a. The excavation in rock usually is of smaller area than the sheeted area through the earth, generally indicated by 20. The rock will be drilled and blasted by men working in the work chamber, and removed to make a level bottom. Liner plates are then placed down to the level bottom, or, if it is a steel cylinder or shell, it can be driven down by hammer to reach the same. It is not practical to drive steel casings in the rock, and it cannot be done with hard rock. The clear line of the shaft to be cut into the rock is indicated in an imaginary manner by dot and dash lines in Fig. 2a at 90a.

I may also mention that my working chamber may be made in several sections, having doors between the sections, and platforms, to support men or weights, can be built where needed in the working chamber.

When the working chamber travels through water, its entrapped air may be removed, if desired, to discharge outside the lock as through a valve operated in the lock, thus permitting the work chamber to fill with water. This reduces the amount of displaced water, makes the excess weight of the steel structure greater, to make it more stable for travel through water, like in streams where the tide may be considerable.

On the other hand, through a pipe line leading from the lock to the working chamber, a valve may be operated to flow compressed air into the work chamber to force out its contained water.

My portable work chamber does not disturb conditions and is suitable for use in sinking foundations alongside of buildings which require a minimum of disturbance.

It also is usable in all waters, whether ocean, river or lake, for excavating the bottom in earth or rock material to form trenches or excavated areas as desired.

A very important, novel use of my device also may consist in the following: My lock chamber may be entirely sealed under atmospheric pressure with the workmen therein, and then lowered to the location of the operation under water, the working chamber having been put under compressed air pressure of the required degree, to drive the water therefrom and keep it dry. The workmen in the sealed lock chamber may direct the operation in the working chamber and observe it, as by through transparent windows between the two, and any desired machinery or tools adapted for the purpose may be placed and lowered with the working chamber, as, for instance, the mentioned dredge pump. In this manner, my air lock and working chamber may be lowered to practically any depth, to which it was never before possible to sink working machinery, and the workmen all the time will be under normal atmospheric pressure and may enter the device, or leave it, without any waiting and adjusting period.

Of course, the sealed lock chamber will be provided with fresh air from, and with means to remove the exhausted air to, the surface.

Indeed, the working chamber in this case may be made globe-shaped to resist a very high pressure when lowered to a great depth.

As has been mentioned before, one important feature of my invention is the provision of compressed air locks and working chambers, which are entirely independent of the structure to be built, so that in case of a caisson or cylinder, the same may be moved, like by a hammer or weights, on the top, while excavating operations may be effected at the bottom.

It also sometimes may happen that the work chamber, which is larger in diameter than the compressed air lock chamber, may get stuck in the cylinder or caisson, and if no other method may be available, then the air lock chamber may simply be disconnected from it, and raised to the surface, for which purpose releasable securing means may be employed between the two, such means being obvious and well known in this art,

and, as has been mentioned and indicated in the drawings, that they may be in the form of bolts between the top of the working chamber and the bottom of the air lock chamber.

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

1. In sinking a substantially water-tight structure like a cylinder or a caisson open at both ends and resting on a ground bottom, the method of providing a dry compressed air working chamber for its bottom, while the structure may remain under water, consisting in lowering onto said bottom a downwardly open working chamber, placing same under air pressure and causing workmen to descend into it, and placing a removable transverse wall between the bottom edges of said working chamber and of said structure, respectively, said walls sealingly engaging both edges.

2. In a device for underwater excavations, the combination of an upwardly and downwardly movable operating chamber adapted to receive workmen and predetermined instruments, tools and machinery, a downwardly open working chamber secured to its bottom, air communicating means between the two, a door between the two, means to lower or to raise said two chambers, a flexible and extendible compressed air conduit from the surface into said lock chamber, a muck chamber at the top of said operating chamber, and means in said operating chamber and working chamber adapted to raise material from said working chamber and deposit it in the muck chamber whereby upon raising said operating chamber to the surface, said deposited material will be raised with it.

3. In a device for underwater excavations, the combination of an upwardly and downwardly movable operating chamber adapted to receive workmen and predetermined instruments, tools and machinery, a downwardly open working chamber secured to its bottom, air communicating means between the two, a door between the two, means to lower or to raise said chambers, a flexible and extendible compressed air conduit from the surface into said operating chamber, a muck chamber at the top of said operating chamber, and a pump in said operating chamber adapted to raise material from said work chamber and to deposit it in the muck chamber whereby upon raising said operating chamber to the surface, said deposited material will be raised with it.

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