

[54] METHOD AND APPARATUS FOR
UNDERWATER OPERATIONS

[75] Inventor: **Burton H. Mason**, Covington, La.
[73] Assignee: **Atmospheric Diving Systems, Inc.**
[22] Filed: **June 22, 1972**
[21] Appl. No.: **265,295**

[52] U.S. Cl. **61/69 R, 114/16 R, 214/1 RCM**
[51] Int. Cl. **B63c 11/40**
[58] Field of Search..... 61/69, 46.5, 72.13;
114/16, 50, 51; 166/5, .6; 214/1 CM

[56] **References Cited**
UNITED STATES PATENTS

1,715,918	6/1929	Hartman	61/69 R
3,302,709	2/1967	Postlewaite	166/6
3,323,312	6/1967	Banjavich	61/69 R
3,400,541	9/1968	Lloyd et al.	61/69 R
3,451,224	6/1969	Colechia et al.	61/69 R
3,641,777	2/1972	Banjavich et al.	61/69 R

Primary Examiner—J. Karl Bell
Attorney, Agent, or Firm—Marvin Feldman; J. B.
Felshin

[57]

ABSTRACT

A method and apparatus for performing operations on equipment at an underwater area wherein a chamber is guidingly submerged, said chamber having a pair of guide gripping arms to slidably engage a respective pair of vertically disposed guides during submersion and grippingly engage the guide so as to reside at a desired depth, the chamber having a second pair of arms interconnected to the first pair and means to retractably, extensibly control the pairs of arms to provide horizontal movement to the chamber; and a manipulator arm assembly projecting outwardly from the chamber toward a portion of said equipment and having manipulator means at the outward end thereof adapted for engaging a portion of said equipment. The chamber may be provided with a life-supporting environment and the apparatus and method of this invention being operable from therewithin.

52 Claims, 16 Drawing Figures

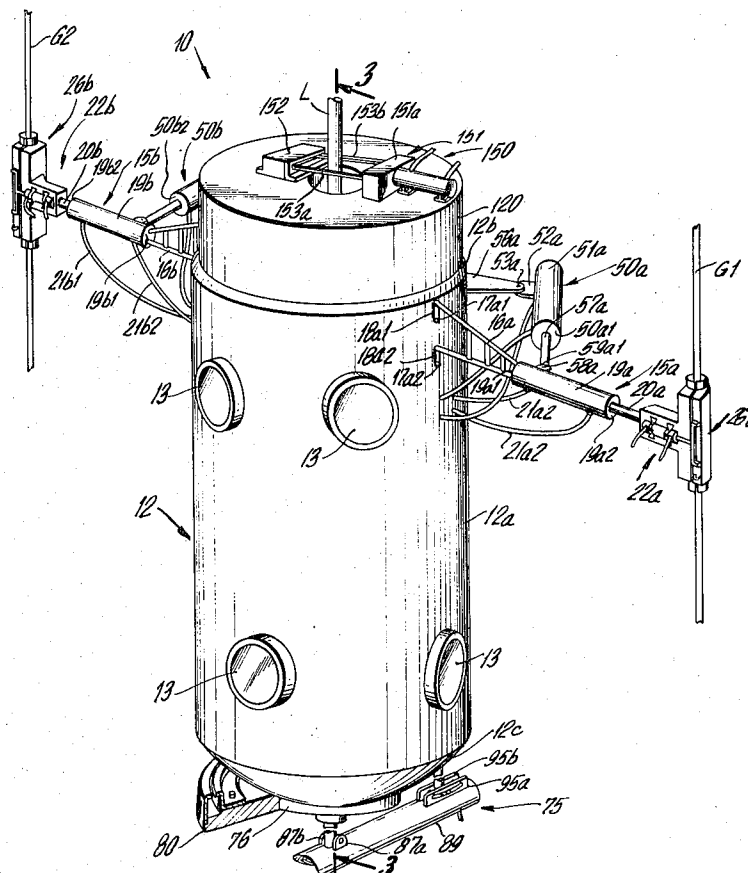
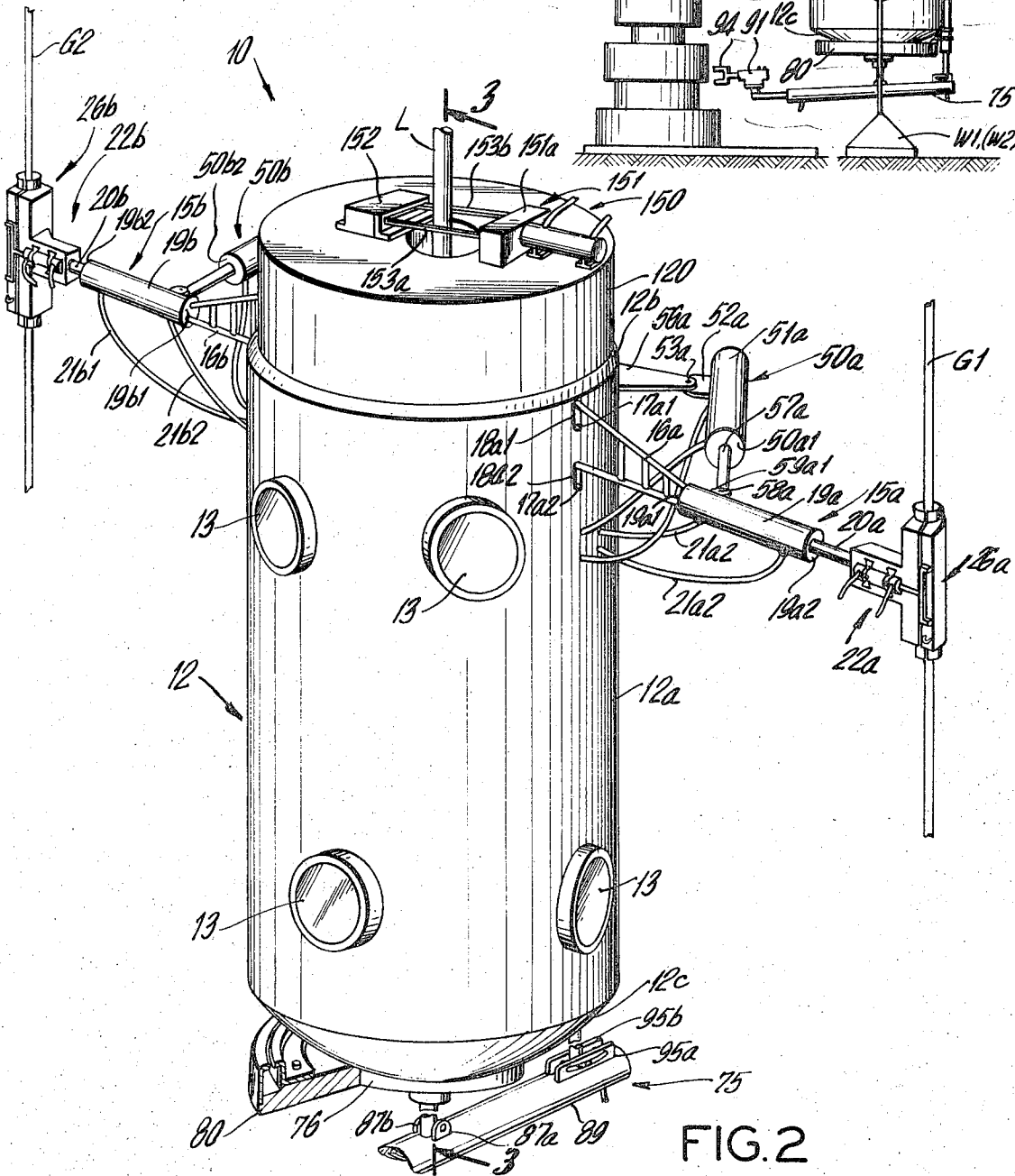
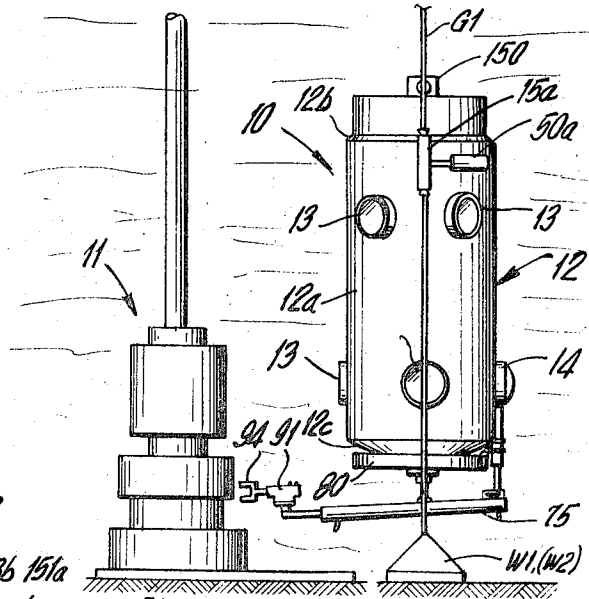


FIG. 1



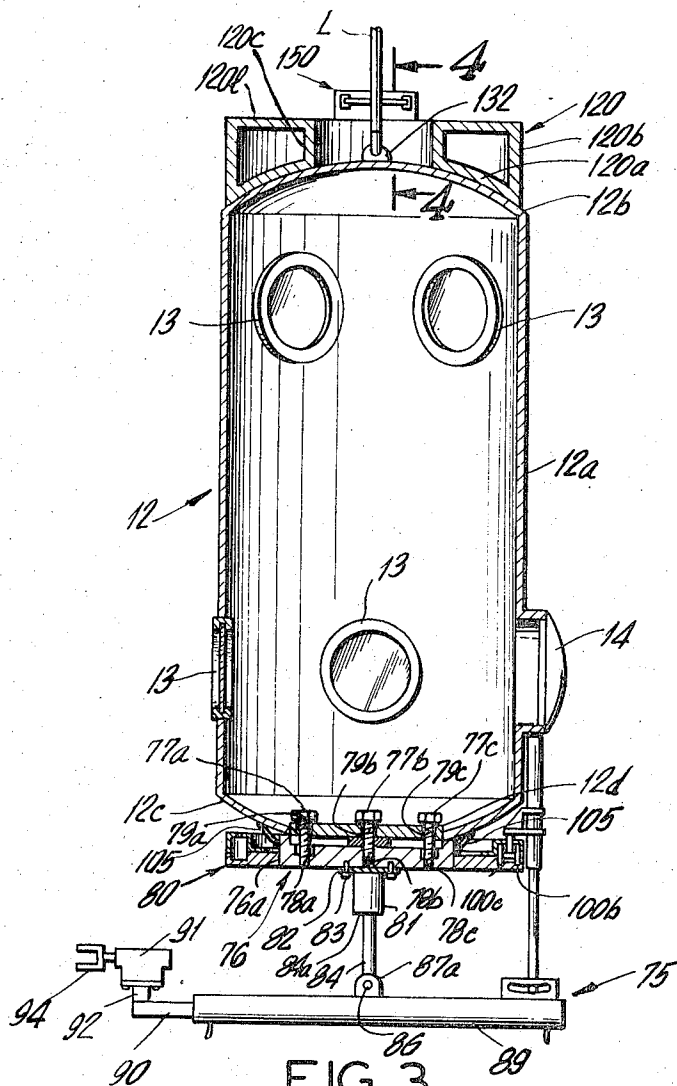


FIG. 3

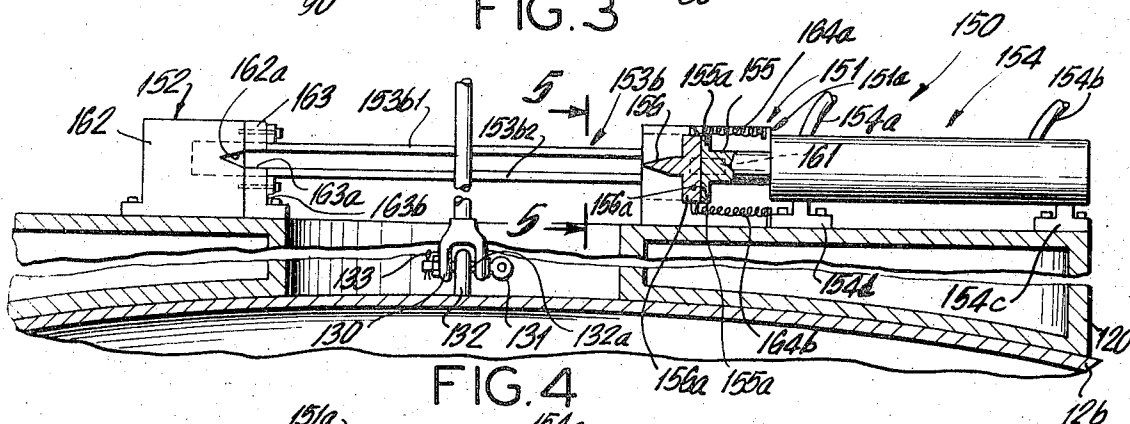


FIG. 4

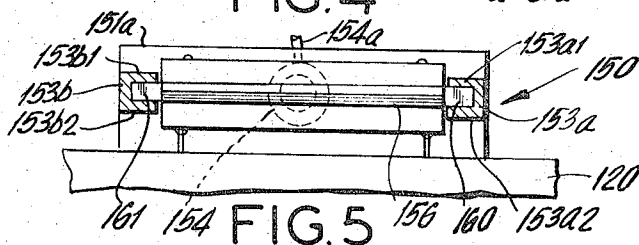
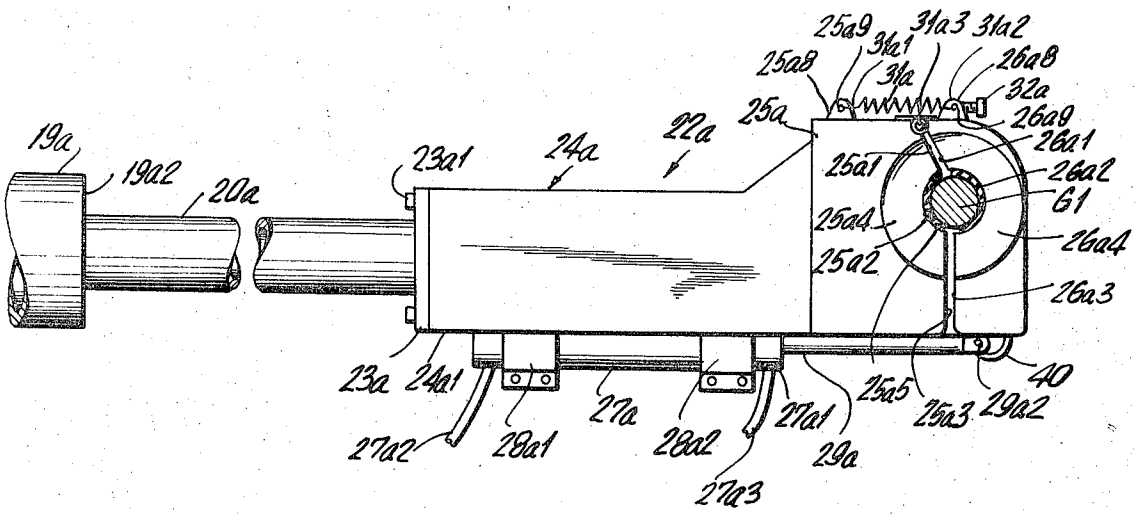
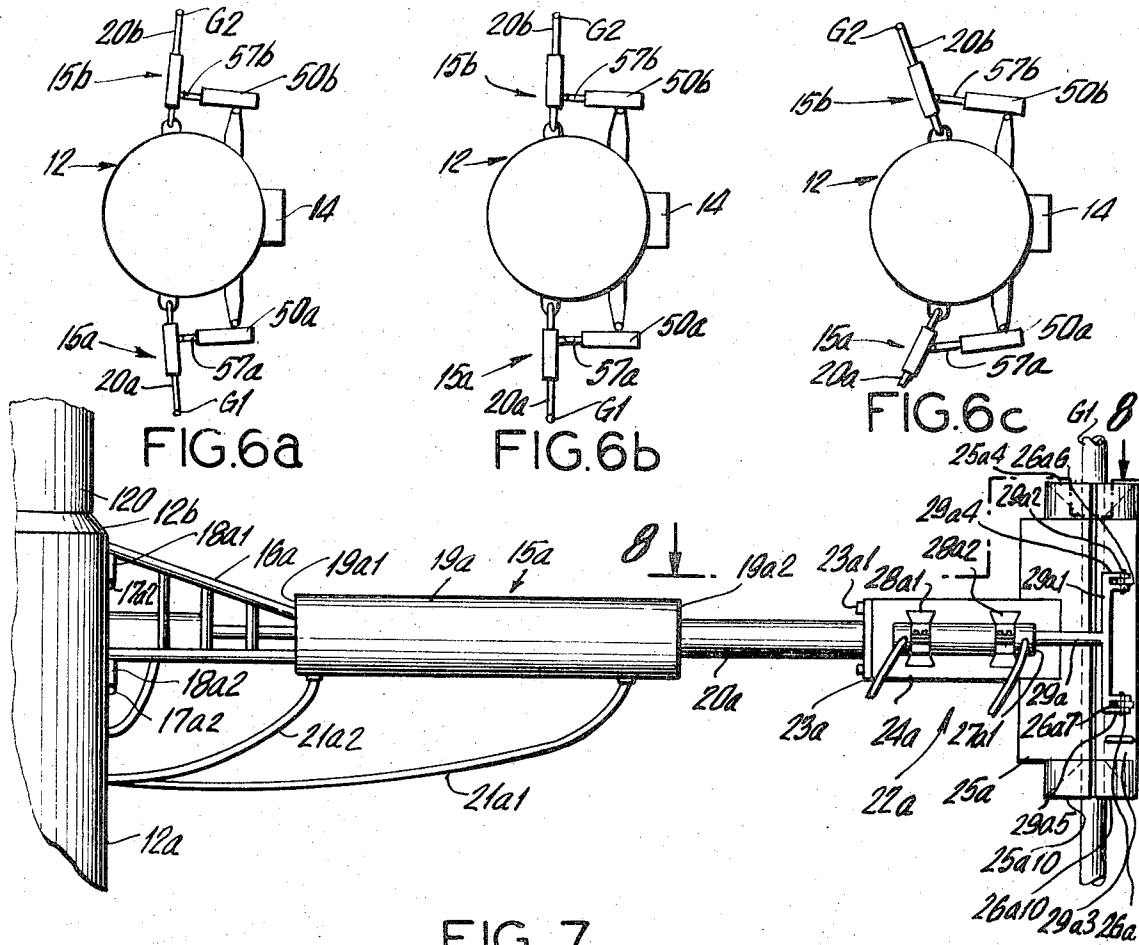


FIG. 5



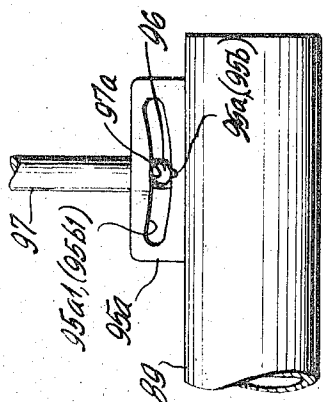
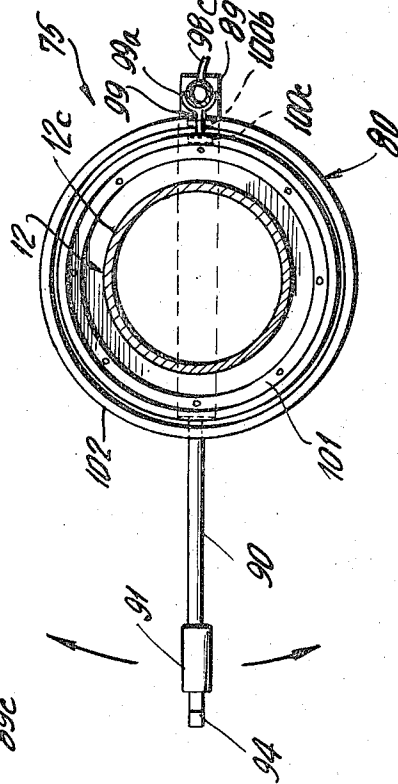
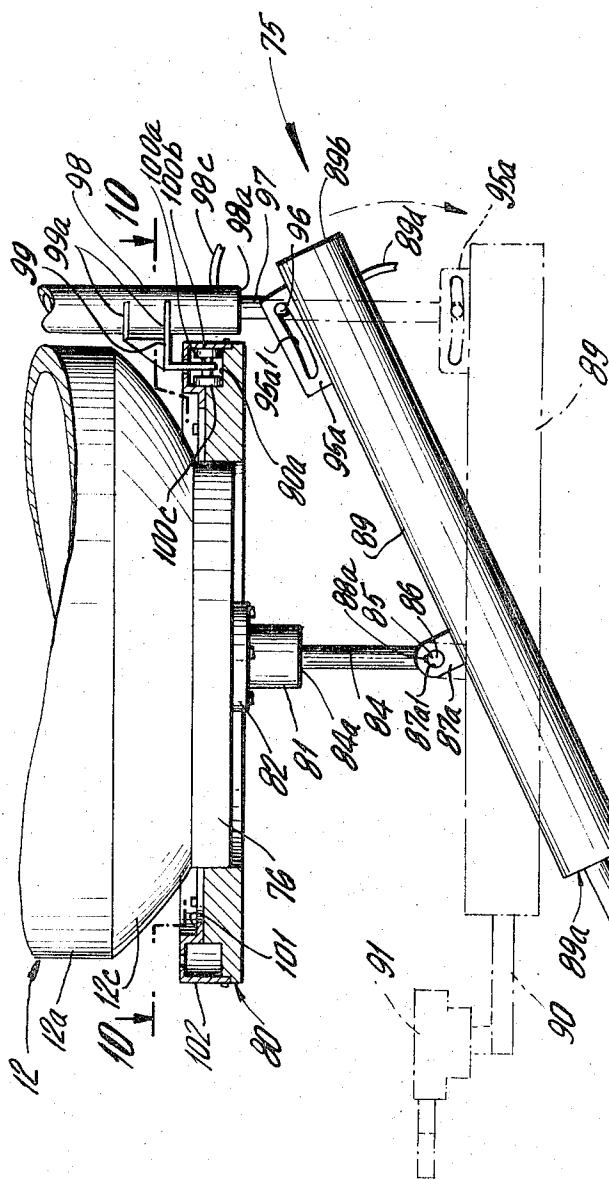


FIG. 11

FIG. 9

FIG. 10

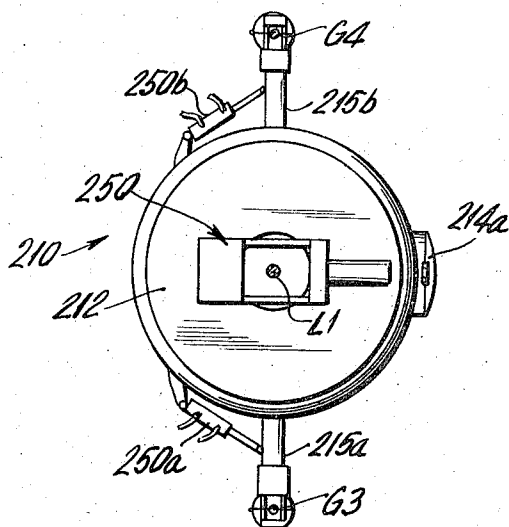


FIG. 12

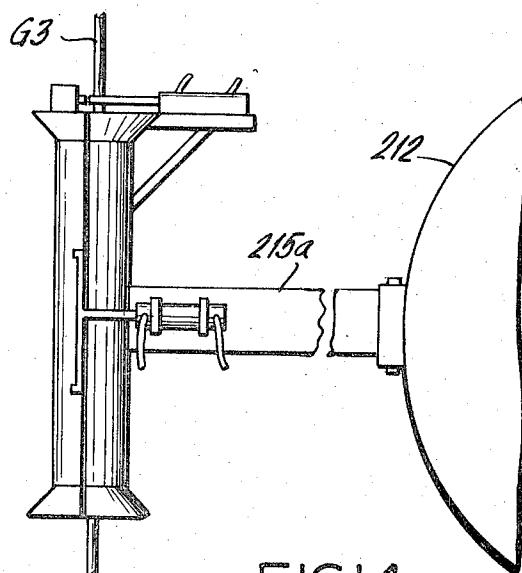


FIG. 14

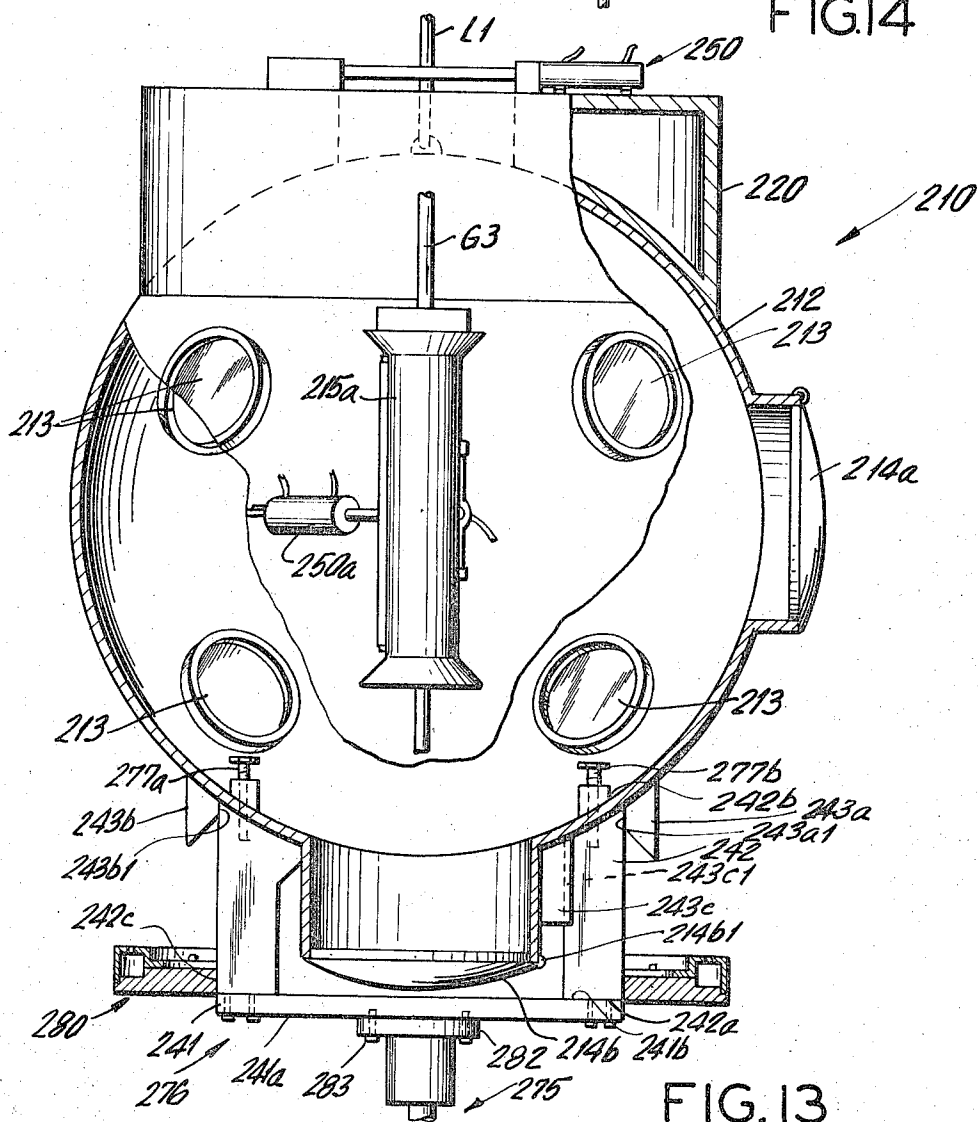


FIG. 13

METHOD AND APPARATUS FOR UNDERWATER OPERATIONS

This invention relates to a method and apparatus for manipulating equipment at an underwater location. Specifically this invention relates to a submergible apparatus guided to and positioned adjacent to an underwater work area and provided with manipulating means to working on equipment in the area. More specifically, this invention relates to a life-supporting environmentally conditioned, submergible apparatus guided to and positioned adjacent to an underwater location for manipulating equipment thereat, whereby positioning and work operations are controllable from within the chambered portion of the apparatus.

Heretofore submersible work chambers for underwater operations, particularly in underwater well operations, were usually mounted above the underwater well and physically connected thereto.

Certain prior art chambers were integrally mounted to and interconnected by seals to the work base of the wellhead.

Still another prior art chamber was positioned onto a track integrally mounted onto the wellhead and work operations controlled from above, at the surface.

Such prior art apparatuses being mounted to the wellhead, suffered from a lack of desirable mobility and further, did not provide for ready escape from the wellhead in case of an emergency.

It is therefore an object of this invention to provide a method and apparatus for positioning a chamber and for performing work at an underwater location without the necessity of fixedly mounting the chamber to an undersea work station, such as a wellhead.

It is a further object of this invention to provide an apparatus as aforesaid which is submersible to a desired depth and removably fixedly held at such depth, without fixed attachment to an undersea work station.

It is still a further object of this invention to provide an apparatus as aforesaid which is horizontally movable while remaining vertically fixedly held at a desired depth.

It is still a further object of this invention to provide an apparatus as aforesaid which can provide a life-supporting environment within a chambered part of the apparatus, so that positioning and work operations can be controlled from therewithin.

It is a further object of this invention to provide a method and apparatus whereby work and positioning operations may be controlled from within a submerged chamber under an atmospheric or alternatively a pressurized environment.

It is still a further object of this invention to provide an apparatus for performing work at a desired depth adjacent an underwater area and which may be readily removed from the area and returned to the surface.

It is still a further object of this invention to provide a submergible, bouyancy-controlled apparatus connected from subsea to the surface by means of wires and means for severing such wires so as to facilitate bouyant return to the surface.

It is still a further object of this invention to provide an apparatus as aforesaid wherein the work performing elements are readily and safely disconnectable from the chambered portion of the apparatus so as to facilitate a safe ascent of said chambered portion.

Another object of this invention is to provide a method and apparatus which is safe and practical for employing at subsea locations and yet such apparatus is readily fabricated and of relatively inexpensive construction and practical in design and operation.

Further objects and advantages of the present invention will become apparent from the following description and the accompanying drawings which illustrate certain presently preferred embodiments of the invention and wherein:

FIG. 1 is a side elevational view of the apparatus of the invention positioned adjacent a wellhead;

FIG. 2 is an enlarged perspective partial view of the apparatus of the invention;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is an enlarged transverse sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 4;

FIGS. 6a, 6b, and 6c schematically illustrate the horizontal positioning of the apparatus;

FIG. 7 is an enlarged front view of a guide gripping arm assembly;

FIG. 8 is a partial top view of the guide gripping arm assembly taken along line 8—8 of FIG. 7;

FIG. 9 is an enlarged partial side view of the work arm assembly with schematic illustration of work arm assembly movement;

FIG. 10 is a bottom sectional view taken along line 10—10 of FIG. 9;

FIG. 11 is an enlarged view of the cam pivot of the work arm with schematic illustration of the cam pivot movement;

FIG. 12 is a top plan view of another embodiment of the apparatus wherein the chamber is spherical;

FIG. 13 is an enlarged front elevational view of the apparatus of FIG. 12 with a partial cut away section; and

FIG. 14 is a partial side elevational view illustrating the guide gripping arm assembly of FIG. 13.

Referring now to FIGS. 1 and 2, there is shown the apparatus 10 of the invention positioned adjacent an underwater wellhead work area 11. The apparatus 10 comprises a vertically disposed cylindrical chamber 12 comprising a cylindrical body portion 12a, a top portion dome 12b and a bottom dome portion 12c, and having seven portholes 13 (typical) spaced on the cylindrical body portion 12a, and a hatchway 14 on the cylindrical body portion 12a. Extending outwardly from the cylindrical body portion and pivotally hinged therewith, is a pair of guide gripping arms 15a and 15b, shown grippingly engaging guide wires G1 and G2, respectively.

Guide wires G1 and G2 are held in a vertical disposition by means of weights W1 and W2 (not shown) affixed to the lower end of each guide wire and wire reel means holding the upper end of each guide wire at the surface (not shown). Weights W1 and W2 reside on the floor of the body of water as shown in FIG. 1 and are generally positioned thereon and therefrom by means of the guide wire reel means.

Referring now specifically to the assembly components of guide gripping arm 15a, it is to be understood that corresponding components and the operation thereof are part of guide gripping arm 15b, and are denoted by corresponding numerals 15—31 with the suffix

b. Guide gripping arm 15a comprises a triangular support member 16a, being formed with two vertically disposed pins 17a1 and 17a2 pivotally hinged to respective hinge mounts being integrally formed with the cylindrical body portion 12a of chamber 12.

At the apex of triangular support member 16a, a hydraulic cylinder 19a is fixedly mounted thereto. One end 19a1 of the cylinder is fixedly attached to triangular support member 16a. The other end 19a2 of hydraulic cylinder 19a is formed with an opening to slidably receive extensible ram 20a. Hydraulic fluid transmission conduits 21a1 and 21a2 are interconnected from and through chamber 12 to the hydraulic cylinder 19a, and pressure sealed at the points of connection. Mounted at the other end of the ram 20a, is a guide gripping means 22a.

Referring now specifically to FIGS. 7 and 8, there is shown the guide gripping arm assembly 15a, as aforesaid. Guide gripping means 22a is mounted to ram 20a by means of flange 23a and four bolts 23a1 (typical). Guide gripping means 22a comprises a body member 24a, one end thereof mounted to ram 20a as aforesaid and the other end thereof being formed with elongated vertically disposed, opposing clamp members 25a and 26a. Said clamp members being pivotally hinged to each other by means of vertically disposed elongated pin hinge 31a3. Each clamp member has opposed surfaces comprising first vertical straight portions 25a1 and 26a1, respectively starting from pin hinge 31a3 toward the center vertical axis of the clamp; semi-cylindrical portions 25a2 and 26a2, contiguous to said first vertical straight portions and, second vertical straight portions 25a3 and 26a3, respectively, contiguous with said semi-cylindrical portions, and terminating at the vertical partible split of the clamp. The transverse upper 25a4, 26a4 and lower surfaces 25a10, 26a10 of semi-circular opposed surfaces 25a2 and 26a2 are frusto-conically shaped, for receiving vertically disposed guide wires G1 and G2, respectively. Guide wire G1 is disposed between semi-cylindrical surfaces 25a2 and 26a2, each of said surfaces 25a2 and 26a2 being covered with neoprene sheets 25a5 and 26a5, respectively, for frictionally compressively engaging guide wire G1 when clamp members 25a and 26a are closed, as shown in FIGS. 7 and 8; and for slidably engaging wires G1 and G2 when said clamp members are open.

A hydraulic cylinder 27a is fixedly mounted to the side 24a1 of body member 24a by means of straps 28a1 and 28a2. Hydraulic ram 29a is slidably, received in one end 27a1 of hydraulic cylinder 27a and is retractably, extensible therefrom.

Ram 29a is transversely disposed to clamp member 25a and 26a, and perpendicular transverse to partible opposed surfaces 25a3 and 26a3, thereof. At the outward end of ram 29a there is formed a vertical perpendicularly disposed member 29a1 having vertically disposed pins 29a2 and 29a3 transversely disposed in respective upper and lower end C-shaped brackets 29a4 and 29a3, integrally formed with member 29a1. Each pin, 29a2 and 29a3, is slidably received in brackets 26a6 and 26a7, respectively, of said clamp member 26a. By this manner of construction, ram 29a is connected to clamp member 26a and the retractable extension of ram 29a in turn causes clamp member 26a to pivot about the pin of hinge 31a3, while clamp member 25a remains fixed. The hinged opening of clamp 26a,

of course releases the gripping action on guide wire G1, so that said guide wire G1 is then slidably engageable between the opposed neoprene sheets.

For safety purposes, a tensioned spring 31a is transversely disposed and connectably held across surfaces 25a1 and 26a1 of clamp members 25a and 26a. One end 31a1 of spring 31a is affixedly connected to bracket 25a8 of clamp member 25a, within hole 25a9 thereof, while the other end 31a2 of spring 31a is affixedly connected to bracket 26a8 of movable clamp member 26a within hole 26a9 thereof. A spring tensioner 32a is mounted to the end 31a2 of spring 31a, to adjust the tension of said spring. In the event of failure of hydraulic means to actuate ram 29a, said spring exerts a sufficient force, across the clamp members 25a and 26a, so as to force said clamp members apart, thereby freeing the grip on guide wire G1, in turn permitting ascent of chamber 12.

A horizontally disposed ring 40 is integrally formed with the movable clamp section 26a and it serves as an auxiliary attachment for safety lines to divers in the performance of underwater operations outside chamber 12, as will be further discussed hereinafter. Correspondingly, a second ring (not shown) is integrally formed with the movable clamp section of the other arm assembly.

Hydraulic transmission conduit lines 27a2 and 27a3 (partially shown) are pressure sealably connected to hydraulic cylinder 27a at one end each thereof and the other end each thereof is pressure sealably connected through chamber 12 to means to actuate said cylinder 27a and ram 29a.

Referring now to FIGS. 1, 2, 6a, 6b and 6c, there is shown a second pair of arm assemblies 50a and 50b, each arm of said second arm assemblies being pivotally interconnected to and cooperative with one of each of said first arm assemblies 15a and 15b, respectively. Referring now specifically to the assembly components of arm assembly 50a, it is to be understood that corresponding components and operation thereof are part of arm assembly 50b, and are denoted by corresponding numerals 50-60, bearing the suffix b.

Arm assembly 50a comprises a hydraulic cylinder 51a, being formed with bracket 52a, said bracket 52a outwardly extending from the side of said cylinder opposed to chamber body side 12a. Bracket 52a is formed with a hole (not shown) for slidably rotatably receiving a vertically disposed pin 53a, vertically held within said hole and fixedly attached to one end of bracket 56a. Bracket 56a is integrally formed with chamber wall 12a and extends horizontally outwardly therefrom.

At the end 50a1 of cylinder 50a, facing arm 15a, is an opening for slidably receiving one end of retractably extensible hydraulic ram 57a. The other end of hydraulic ram 57a is formed with a vertically disposed hole, into which is slidably received a vertical pin 58a. Said pin 58a is fixedly held between a pair of brackets 59a1 and 59a2 (partially shown), which brackets are integrally formed on and with the side of cylinder 19a opposing said arm assembly 50a. By this manner of construction ram 57a of arm assembly 50a is pivotally connected to cylinder 19a of arm assembly 15a. Retraction or extension of ram 57a, results in a corresponding pulling or pushing on arm assembly 15a and a concomitant reaction force causing horizontal positioning by arm assembly 50a by means of the double pin hinges 58a and 53a.

Referring now to FIGS. 6a, 6b and 6c, there is shown the horizontal positioning of the chamber 12 by means of the cooperative interaction of arm assemblies 15a, 15b with respective arm assemblies 50a and 50b.

Referring now specifically to FIG. 6b there is shown chamber 12 with arm assemblies 15a and 15b extending radially outwardly from said chamber 12 and grippingly engaging respective guide wires G1 and G2. Rams 57a and 57b are perpendicularly disposed to and interconnected with arm assemblies 15a and 15b.

To move the chamber 12 horizontally toward well head 11, that is to proceed from the position of FIG. 6b to the position of FIG. 6a, rams 20a and 20b of arm assemblies 15a and 15b are outwardly extended and in cooperation therewith, rams 57a and 57b of arm assemblies 50a and 50b are retracted. Rams 50a and 50b are thusly pivoted about respective pins 53a and 53b, as the guide arm assemblies are pulled closer to the respective second arm assemblies. Insofar as the gripping means 22a and 22b grippingly engage guide wires G1 and G2, the outward extension of arm assemblies 15a and 15b in cooperation with the pulling by the second arm assemblies 50a and 50b causes the chamber to move away from the guide wires and towards the well head.

To move the chamber 12 horizontally away from well head 11, that is to proceed from the position of FIG. 6b, to the position of FIG. 6c, rams 20a and 20b of arm assemblies 15a and 15b are retracted and in cooperation therewith, rams 57a and 57b of arm assemblies 50a and 50b are extended. Rams 50a and 50b are thusly pivoted about respective pins 53a and 53b, as the guide arm assemblies are pushed further away from the respective second arm assemblies. Insofar as the gripping means 22a and 22b grippingly engage guide wires G1 and G2, the lengthening of arm assemblies 15a and 15b in cooperation with the extension pushing of second arm assemblies 50a and 50b cause the chamber to move away from the guide wires and away from the well head.

It is to be understood that other arrangements of positioning arms, that is of the second arm assemblies, is permissible and is within the contemplation of the invention. As by way of example, a second pair of positioning arms may be provided, one positioning arm of each respective pair to be connected on opposite sides of each guide arm. In this alternative manner of construction, the sets of positioning arms may each be retracted and extended to provide a broad range of horizontal positions.

It is to be further understood that by varying the respective retraction and extension of each guide arm, horizontal positioning toward or away from each of the guide wires is permissible as well as the horizontal positioning transverse to the guide wires as aforescribed.

Referring now to FIGS. 2, 3, 9-11, there is shown work arm assembly 75. Work arm assembly 75 comprises, a circular support base plate 76 disconnectably mounted to bottom plate 12d of chamber 12 by means of three bolts 77a, 77b and 77c. Support base 76 is formed with three threaded holes 78a, 78b and 78c corresponding to three clearance holes 79a, 79b and 79c in the bottom plate 12d integrally formed with bottom dome section 12c of the chamber. Support base 76 is aligned below bottom plate 12d so that holes 78a, 78b and 78c coincide with holes 79a, 79b and 79c, respectively. The shank portions of bolts 77a, 77b and 77c are

then passed through holes 79a, 79b and 79c respectively and rotatably engage threaded holes 78a, 78b and 78c to connect the base. Each bolt is provided with means at the upper end thereof to rotate the bolt and connect or disconnect the base as the case may be.

Integrally formed with outer circumferential edge 76a of support base plate 76, is an annular track 80, to be further discussed in greater detail hereinafter.

A rotational drive motor 81, one end thereof, is centrally axially mounted to support base 76 by means of circular plate 82 and bolts 83 (typical). At the other end of drive motor 81 is means to receive a journaled end 84a of rotatable, cylindrical support arm 84, said support arm 84 depending downwardly from said chamber and being in axial disposition thereto. The downward end of support arm 84 is formed with a transverse hole 85; the axis of said hole 85 perpendicularly intersecting the axis of cylindrical support arm 84. A cylindrical pin 86 is slidably received in hole 85 and said pin 86 is of sufficient length to extend outwardly beyond the diameter of the support arm 84.

Power transmission conduit lines (not shown) are interconnected from motor 81 through chamber 12 to means to actuate said motor from within said chamber.

On each of two parallel brackets 87a and 87b there is a hole 87a1 and 87b1, the holes being concentric, for slidably receiving pin 86. Stop pins 88a and 88b are provided at each end of pin 86 to hold said brackets in place, so that upon rotation of support arm 84, the brackets 87a and 87b rotate therewith.

Brackets 87a and 87b are integrally formed to the body of hydraulic boom cylinder 89 at an intermediate point along the body of boom cylinder 89; said boom cylinder thereby being transversely disposed to, pivotally interconnected with and rotatable with said support arm.

At one end 89a of boom cylinder 89 is means to receive one end 90a of boom ram 90, the boom ram 90 being retractably extendible from the boom cylinder 89. At the other end 90b of boom ram 90 a rotational drive motor 91 is attachably mounted thereto by platform 92 and bolts 93 (typical).

A manipulator member 94 comprises, by way of example, a U-shaped pronged shaft; the shaft end 94a thereof being journaled to the drive end of motor 91, so that said manipulator member 94 is axially rotatably. the manipulator member is adaptably formed, as by way of example, with prongs to engage a portion of wellhead equipment, e.g. a valve wheel, and upon axial rotation of the manipulator member the valve wheel is turned as desired.

Motor 91 is generally of the electrical power type and power transmission lines (not shown) are interconnected from motor 91 through chamber 12 to means to actuate motor 91 from within the chamber.

Power transmission conduit lines, 89c and 89d, are interconnected from hydraulic cylinder 89 through chamber 12 to means to actuate the cylinder from within the chamber.

At the other end 89b of cylinder 89 is a pair of brackets 95a and 95b, integrally formed with the body of cylinder 89 and in spaced parallel disposition to brackets 87a and 87b. Each bracket 95a, 95b is formed with a cam slot 95a1, 95b1, respectively; said cam slots being in parallel disposition and in geometric agreement to each other. Slidably engageable with each cam slot is

one end each of pin 96. Pin 96 is transversely, perpendicularly disposed to and slidably mounted within hole 97a of pivot shaft 97 at the downward end. Stop pins 96a and 96b are fixedly held to pin 96 at each end thereof to hold pin 96 in place.

The upward end of pivot shaft 97 is slidably received in one end 98a of vertically disposed hydraulic cylinder 98, and pivot shaft 97 is retractably extensible from cylinder 98. Pivot shaft 97 is in parallel disposition to support arm 84 and in the retraction or extension of pivot shaft 97, boom 89 is pivoted at pin 86 relative to support arm 84.

To permit arcuate travel of end 89b of boom 89, cam slots 95a1 and 95b1 are provided, so that pin 96 contactingly engages the edges of the cam slots, during retraction and extension of pivot shaft 97.

Integrally attached to the body of hydraulic cylinder 98 is one end 99a of an inverter L-shaped bracket 99, the other end thereof rotationally slidably receiving shaft 100a of rollers 100b and 100c. End 99a is semi-circular shaped to engage the body of hydraulic cylinder 98. The rollers 100b and 100c are affixedly connected by shaft 100a, the rollers slidably engagingly roll on and within annular track surface 80a of track 80. Two annular retaining brackets, one of Z-shaped cross-sectional configuration 101 and the other of inverted L-shaped cross-sectional configuration 102, are bolt-mounted to the top end 80b and circumferential edge 80c, respectively of track 80 so as to retain the rollers 100b and 100c between track surface 80a, and retaining brackets 101 and 102.

Hydraulic power transmission conduit lines 98c and 98d (not shown) are each interconnected from the cylinder 98 through chamber 12 to means to actuate the retractable extension of pivot shaft 97 from within the chamber.

To reiterate track 80 is integrally connected to support base 76 which in turn is disconnectably connected to and through the bottom 12d of the chamber. Upon disconnection of support base 76 from chamber 12, the entire work arm assembly is disconnected therewith.

Referring now specifically to FIG. 3 there is shown two of three load calculated breakable filaments 105 (typical) interconnected from support base 76 to chamber 12. Upon disconnection of support base 76, by means of the disengagement of bolts 77a, 77b and 77c from base 76, filaments 105 permit such disengagement while preventing the cocking and jamming of bolts 77a, 77b and 77c in support base 76. After disengaging of the aforesaid bolts, filaments 105 (typical) will break and freely disconnect the support base from the chamber, when the tension stress on the filaments is greater than the precalculated load values. This aspect of support base disconnection will be further discussed hereinafter.

Referring now specifically to FIGS. 9, 10 and 11 is shown the several modes of positioning achievable by the work arm assembly. In FIG. 10 there is shown the 360° track 80 and the arrows indicating the clockwise or counter-clockwise rotation of boom cylinder and ram, 89 and 90, by the actuation of motor 81 to rotate support arm 84. In FIGS. 9 and 11 there is shown the additional positioning of pivoting of boom cylinder 89 about support arm 84 by means of actuation of hydraulic cylinder 98 to retract or extend shaft 97 in turn causing the pivoting as aforesaid. Pin 96 travels in vertical path during extension or retraction of shaft 97 and

in such travel pin 96 rides in cam slots 95a1 and 95b1 to permit vertical arcuate translation of boom 89 during pivoting. The dashed line configurations in FIG. 9 depict the pin travel in the cam slots, in the half range of pivoting.

In FIG. 9 still further modes of positioning the work arm assembly, are shown, specifically the retractable extension of boom ram 90 from cylinder 89; the dashed line configuration depicting the retracted position, and the axial rotation of manipulator member 94 by motor 91; the dashed line configuration thereof depicting a 90° rotated position from the solid line configuration.

Referring now to FIGS. 1, 2, 3 and 4 there is shown the construction assembly at the top section 12b of cylindrical chamber 12. Integrally attached to top section 12b is an annular shaped ballast tank 120 having an annular bottom wall 120a seated to and conforming with the dome-shaped section 12b, two annular parallel vertically disposed side walls 120b and 120c, and a horizontal top wall 120d perpendicularly disposed to and contiguous with side walls 120b and 120c. within chamber 12 is provided the means to actuate the regulation of the ballast in the ballast tank and by such ballast operation, underwater descent and ascent of the chamber is facilitated.

Normally the lower end of a lift wire L connected to the top 12b of chamber 12 by means of shackle 130 and eye bolt 131 assembly with chamber bracket 132; said chamber bracket 132 being formed with a hole 132a for receiving bolt 131. Eye bolt 131 passes through the shackle 130 and hole 132a, and is held in place by cotter pin 133 (see FIG. 4). The upper end of lift wire L is secured to a vessel at the surface (not shown) so as to vertically move the chamber through the body of water. The ballast tank operation may of course be used in conjunction with the lift wire operation, so as to facilitate the desired underwater ascent or descent of the chamber.

Referring now to FIGS. 2, 3, 4 and 5, there is shown a wire cutter assembly 150 integrally mounted on and to top wall 120d of the ballast tank. Wire cutter assembly 150 comprises a wire cutting blade driving section 151, a blade receiving section 152 opposed to the blade, and a pair of parallel, horizontally disposed, blade guide tracks 153a and 153b. Blade guide tracks 153a and 153b each comprises an elongated U-shaped bracket formed with a pair of parallel, vertically disposed guide bars 153a1, 153a2, 153b1, and 153b2, respectively, each of said tracks attachably interconnected by bolts, from the blade driving section 151 to the blade receiving section 152.

Lift wire L is centrally disposed between the guide track 153a and guide track 153b, as well as being intermediately disposed between blade driving section 151 and blade receiving section 152. Blade driving section 151 comprises a housing 151a, a hydraulic cylinder 154, horizontally disposed to and bolt-mounted to plates 154c and 154d attached to top wall 120d of the ballast tank. Hydraulic cylinder 154 is interfitted with hydraulic transmission conduit lines 154a and 154b. At the end of hydraulic cylinder 154 that faces lift wire L, is a retractably extensible ram 155, one end thereof slidably received in the cylinder and the other end thereof formed with a transverse, horizontally disposed flange 155a. A vee-shaped wire cutting blade 156 facing said lift wire and horizontally, transversely disposed

to lift wire L and being formed with a flange 156a. The outward face 156a1 of flange 156a of the blade 156 is attachably mounted to the inward face 155a1 of flange 155a by bolts or other suitable means (not shown). Blade 156 and ram 155 are disposed between blade guide tracks 153 and 154. One each of a pair of rectangular blade guides 160 and 161 are attachably mounted (not shown) to the blade and ram assembly at one each horizontal outward end of said assembly. Said guides 160 and 161 are both suitably dimensioned so that each guide is slidably engageable between said with one respective pair of the guide bars, so that the blade is positioned between the guide tracks 153 and 154, upon being advanced from driving section 151 to lift wire L, and cutting therethrough, to blade receiving section 152.

Blade receiving section 152 comprises a housing 162 being formed with a V-shaped groove 162a opposing said cutting blade and conformably dimensioned for said blade 156 to seat therewithin. A face plate 163 having a transverse slot 163a for slidably receiving blade 156, is bolt mounted to housing 162. Upon the seating of blade 156 in vee-shaped groove 162a, guides 160 and 161 blockingly engage the face 163b of plate 163.

Blade 156 is provided with a pair of springs 164a and 164b, each of said springs being interconnected from blade 156 to housing 151a of the blade driving section. The springs 164a and 164b act in tandem to retractably hold blade 156 within the blade driving section so as to avoid inadvertent advancement of blade 156 toward and into lift wire L.

Referring now to FIGS. 12, 13 and 14 there is shown another embodiment of the invention, specifically apparatus 210, comprising a spherical chamber 212 having guide gripping arm assemblies 215a and 215b, positioning arm assemblies 250a and 250b, ballast section 220, and work arm assembly 275 (partially shown). Eight portholes 213 (typical) are formed with chamber 212 for viewing outwardly therefrom.

The construction and operation of the guide gripping arms 215a and 215b, position arm assemblies 250a and 250b, work arm assembly 275, ballast tank 220, lift wire cutting assembly 250 are similar to the corresponding assemblies of the embodiment hereinbefore discussed, and certain modifications thereto are as hereinafter set forth.

Spherical chamber 212 is formed with a side hatchway 214a disposed 90° on the horizontal from each of the guide gripping arm assemblies and a bottom hatchway 214b disposed 90° in the vertical from each of the guide gripping arm assemblies.

Support base 276 for work arm assembly 275 comprises a horizontally disposed circular plate 241 having centrally mounted on the lower face 241a thereof, circular mounting plate 282 which is provided with radial bolt-holes for receiving bolts 283 (typical), so as to supportably downwardly mount work arm assembly 275 to support base 276. A vertically disposed, annular, cylindrical mounting frame 242 is centrally disposed about hatchway 214b. The lower annular edge 242a of frame 242 contactingly engages an annular segment of the upper face 241b of plate 241. Bolts 243 (typical) are radially spaced and secure plate 241 to frame 242. The upper annular edge 242b of frame 242 is provided with three bore holes for rotatably receiving disconnect bolts 277a, 277b and 277c (partially

shown). The construction and operation of bolts 277a, 277b and 277c are similar to that of bolts 77a, 77b and 77c as previously discussed.

Support arm track 280 is integrally mounted to the other cylindrical surface 242c of frame 242 at the lower end thereof, Track 280 is similar in construction and operation to that track 80 as previously discussed.

To insure a positive disconnect of support base 276 and work arm 275 from chamber 212, guide brackets 243a, 243b, and 243c are provided and are integrally attached to chamber 212. Guide brackets 243a and 243b are circumferentially disposed about frame 242 with inward faces 243a1 and 243b1 of each thereof slidably engaging outer surface 242c of frame 242. Guide bracket 243c is integrally attached to chamber 212 and to the cylindrical surface of hatchway 214b above hatchway hinge 214b1. A slotted groove 243c1 is formed on the outward face of bracket 243c to slidably engage frame 242 during connection or disconnection of the support base 276 from chamber 212. Further guide bracket 243c additionally functions to protect hatchway hinge 214b1 from abutment during connection or disconnection of the support base. Additional guides may be provided for as desired.

A further modification of the spherically chambered embodiment, although likewise applicable to the aforesaid cylindrically chambered embodiment, is a pair of guide wire cutting assemblies 245a and 245b. Each guide wire cutting assembly is mounted to a respective guide gripping arm assembly by means of a bracket 246a and 246b (not shown), respectively. The blade guide tracks 253a and 253b for each cutting assembly are split at an intermediate parts, 300a and 300b (not shown), so as to permit the blade receiving section 262 to pivotally move with the movable clamp section 226a on which it is affixedly mounted. The operation of guide wire cutting assemblies 254a and 245b is similar to that of the lift wire cutting assemblies, namely assemblies 50 and 250.

The clamp sections for each guide gripping arm, of the spherical embodiment are elongated so that the vertical height of the opposed semi-cylindrical gripping surfaces is from about 0.5 foot to about 3 feet. This elongated gripping surface insures against rolling of the chamber about an axis of the chamber coincident with the horizontal longitudinal axis of the guide gripping arms.

Horizontal positioning arms 250a and 250b are provided on the spherical chamber to act in cooperation with pivotally hinged retractably extensible guide gripping arm (the retractable extensible means not shown), in a similar manner to that of the cylindrically chambered embodiment as aforescribed.

Chamber 212 is descended and ascended through the water by means of lift wire L1 and reel means therefor controllable at the surface. As previously stated, the tank ballast assembly may be utilized in conjunction with the operation of the lift wire so as to facilitate ascent and descent of the chamber in underwater positioning.

As previously stated the present invention contemplates a submergible chamber provided with a work-controlling and life-supporting environment so that an operator may be housed within the chamber, descended underwater therewith, perform desired operations at a wellhead and be returned to the surface. To permit and aid the operator in underwater operations,

generally, in addition to the lift wire, the following lines are interconnected from the chamber to a surface station, as by of example: a telephonic communication line, an electric power line, a pneumatic gage line to measure prevailing air pressure within the chamber, emergency breathable air supply line and a blow-down hose for the ballast tank. The chamber is generally provided with an oxygen containing gas supply capable of supporting two men for about 12 hour period. Flow meters, analyzers, recorders, alarm devices and the like for measuring, controlling and recording the environmental quality of the air within the chamber are provided to ensure safe and adequate oxygen supply for an operator. Additionally an environmental air recirculation system is provided so as to reprocess the air within the chamber. Recirculation generally requires the employment of scrubbers for CO₂ removal and water vapor condensers for dehumidification. It is further within the contemplation of this invention that the controls for the aforesaid life-support system be operable by the operator from within the chamber. For added safety a second set of life-support controls may be provided at a remote surface station.

Additional aid devices that may be provided for the apparatus of this invention to assist an operator within the chamber are, by way of example; television transmitters and monitors to view surroundings, directional control lamps to selectively light areas under observation and resistance coil heating system for maintenance of chamber temperature.

In operation, the apparatus is held at a surface station and the lift wire is connected to the top bracket mount of the chamber. The guide wires are then normally threaded through the opened clamps of the guide gripping arms and weights are affixed to the free ends of the guide wires. The upper ends of the lift wire and the guide wires are each attached to a winch so as to permit controlled pay out of the respective wires.

An operator enters the chamber through the side hatchway and the hatchway is secured. The weights are then sent to the floor of the body of water and the winch provides a suitable degree of tautness to the vertically disposed guide wires.

The apparatus is then moved outward from the surface station, over the water, and lowered into the water. The chamber operator opens the vent valve and the water intake valve of the ballast tank assembly. The ballast tank is water filled for descent of the chamber. The chamber operator in descent, upon reaching the desired depth closes the vent valve and introduces air or other suitable gas into the ballast tank to provide positive buoyancy to the chamber. The winch operation of the lift wire is stopped. The chamber operator actuates the means to close the clamp means so as to grippingly engage the guide wires. An operator at the surface station then slacks the lift wire from about 3 feet to about 6 feet. If desired the chamber operator may then provide greater positive buoyancy to the chamber so as to tautly hold the chamber on the weighted guide wires. The chamber is thereby secured at the desired depth.

The chamber operator may then actuate the retraction or extension of the horizontal positioning arms in conjunction with the retraction or extension of the guide gripping arms to horizontally position the chamber in a suitably desired position.

Thereafter, the chamber operator may actuate the work arm to position the work arm for engaging a portion of the subsea equipment to be worked on, in the manner as aforesaid. The reactive force of the manipulator means against the equipment is transmitted to the chamber which is held in place by the guide gripping arms, and minimal reaction motion of the chamber in performing work operations is contemplated.

Often it is desired, but generally unnecessary, to employ a suited diver operation outside of the chamber in conjunction with operations performed from within the chamber. A suited diver may secure a safety line to an eye ring on the clamp section of the guide gripping arm if desired.

In the event the manipulator member of the manipulator means becomes inextricably engaged with a portion of the subsea equipment, a potentially dangerous situation is presented to the chamber operator. The apparatus of this invention is designed however to obviate such potential danger. The chamber operator may rotate the bolts in the bottom plate so as to disengage the bolts from the work arm support plate thereby disconnecting the work arm. The clamp means of the guide gripping arm assemblies may then be actuated to relieve the gripping of the guide wires. A signal is then sent to the surface and the winch operator lifts the chamber upward. When the upward lift force of the chamber causes sufficient tensile force on the chamber-to-support base safety filaments, the filaments break and the chamber is freed of the work arm assembly. This also results in an increased buoyancy to the chamber, further facilitating ascent to the surface.

In the event, the lift wire is disengaged from the surface station to the chamber, another potentially dangerous situation is presented to the chamber operator. The apparatus of this invention is designed however to obviate such potential danger. The disengaged lift wire of several hundreds of feet in length adds significant weight to the chamber and inhibits buoyant return of the chamber to the surface. The chamber operator may first actuate the cutting blade to drive the blade through the lift wire, thereby severing the lift wire from the chamber. Then the chamber operator may disconnect the work arm assembly as aforesaid. Both of these disconnect procedures greatly increases the buoyancy of the chamber. Thereafter the clamp means of the guide gripping arm may be pivoted open to permit sliding engagement with the guide wires. Finally, the introduction of a gas to the ballast tank with the concomitant removal of the water ballast further increases the buoyancy of the chamber which permits buoyant return of the chamber to the surface.

The disconnection of the support base from the chamber may be effected by several methods and the support base and chamber so modified to provide for such alternative methods. As by way of example, the support base and chamber may be contactingly mated and securing lines interconnected from the support base to the chamber adjustably, compressively mate the support base to the chamber. Inconjunction therewith means for severing the securing lines is provided, said means for severing the securing lines being actuable from within the chamber.

It is also within the contemplation of this invention that the ballast tank operation be one of a commercially available kind and further that for added safety

measures, ballast tank operation control means be located both within the chamber and at the surface station.

It is also within the contemplation of this invention that the chamber be designed to be pressurized for pressurized operations. Of course with pressurized submergence, the chamber operator will undergo a programmed decompression in ascent to the surface.

The gas contained in supply tank (not shown) which is utilized for breathing by the chamber operator will normally be helium-oxygen mixture, and this gas may also be employed for pressurized diving operations as well.

It is also to be stressed that the manipulator means as previously discussed may be of several diverse designs such as, by way of example; gripping device, cutting device, turning device and so forth. And further it is contemplated that such member be formed to be interchangeable one device with the other.

Hydraulic power supply for the several hydraulic cylinder of the several assemblies, as previously discussed, is provided by a hydraulic pump housed within the chamber. Electrical power supply is mounally supplied from the surface station to the chamber by means of electrical power transmission lines.

The several means to actuate the hydraulic cylinders and the hydraulic cylinders, as previously discussed, which may employed in the invention are those which are generally known and used in the industry. And one additional feature of the apparatus of this invention is that such readily available hydraulic systems may be readily adapted in the invention.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the method and apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An apparatus for carrying out an operation at an underwater area, said apparatus comprising a submergible chamber, arm means interconnected thereto and extending outwardly therefrom, gripping means attachably mounted to said arm means at the outward end thereof, said gripping means being adaptably formed to grip vertically disposed guides, means to actuate said gripping means, whereby said chamber is submergible to a depth whereat said gripping means is actuated to grip said guides so as to hold said chamber at said depth adjacent said area.

2. The apparatus of claim 1, wherein said gripping means further comprises means adapted to slidably receive vertically disposed guides, whereby said means to actuate said gripping means actuates said gripping means to a first position to slidably receive said guides, and to a second position so as to grip said guides to hold said chamber at a depth.

3. The apparatus of claim 2, said arms means comprising a pair of outwardly, retractably extensible arms and means to retractably extend said arms.

4. The apparatus of claim 1, said arms means comprising a pair of outwardly, retractably extensible arms and means to retractably extend said arms.

5. The apparatus of claim 4, further comprising means to pivotally interconnect each of said arms to said chamber.

6. The apparatus of claim 5, wherein said means to pivotally interconnect each of said arms to said chamber comprises a vertically disposed hinge.

7. The apparatus of claim 5, wherein said means to pivotally interconnect each of said arms to said chamber comprises a pair of spaced, vertically disposed hinges.

8. The apparatus of claim 1, wherein said gripping means comprises a pivotally hinged clamp.

9. The apparatus of claim 8, wherein said clamp comprises a pair of opposed clamp members.

10. The apparatus of claim 9, wherein one of said clamp members is pivotally movable and the other of said clamp members is non-pivotally movable.

11. The apparatus of claim 10, wherein said means to actuate said gripping member comprises hydraulic power means, retractably extensible ram means connected from said hydraulic power means to said pivotally movable clamp member, and hydraulic power transmission conduit means interconnected from said power means to said retractably extensible ram means.

12. The apparatus of claim 10, wherein said clamp members have opposed clamp surfaces extending vertically for a length of from about 1/2 foot to about 3 feet.

13. The apparatus of claim 10, further comprising spring means disposed transversely to said clamp pivot hinge and one end thereof affixed to said pivotally movable clamp and the other end thereof affixed to said non-pivotally movable clamp so as to be expandably, affixedly held therebetween.

14. The apparatus of claim 2, wherein said gripping means comprises a pivotally hinged clamp, said clamp being slidably engageable with said guides in said first position and grippingly non-slidably engageable with said guides in said second position, and means to pivotally actuate said clamp.

15. The apparatus of claim 5, further comprising a second pair of arms, one end thereof pivotally interconnected to and outwardly extensible from said chamber, each of said second pair of arms peripherally spaced from a respective arm of said first pair of arms, the outward end of each of said second arms being formed with means to pivotally interconnect with said respective first arm, and means to retractably extend said second arms.

16. The apparatus of claim 15, each of said second arms comprising a hydraulic cylinder one end thereof, slidably receiving one end of a ram, said ram being retractably extensible with said cylinder, the other end of said ram being pivotally interconnected to a respective first arm, the other end of said cylinder being pivotally interconnected to said chamber, and means to actuate said cylinder so as to retractably extend said arm.

17. The apparatus of claim 16, further comprising means to proportionally, controllably retractably extend said first and second arms so that when said first pair of arms grippingly engages said guides, said means

to actuate said first arms and means to actuate said second arms are actuated, said chamber is thereby horizontally positionable.

18. The apparatus of claim 4, wherein said arms are diametrically disposed one from the other, relative to said chamber.

19. In combination with a submergible chamber, a work arm assembly for performing work on equipment at an underwater work area, comprising in combination, a support base connectably mounted to said chamber, a support arm extending outwardly from said base, said base provided with means to receive one end of the support arm, a boom transversely disposed to, rotatably interconnected with, and pivotally mounted to the other end of said support arm at an intermediate point of said boom between the ends thereof, means to rotate said support arm and boom, manipulator means for engaging said equipment, said manipulator means being integrally connected at one end of said boom, means to actuate said manipulator means and means to pivot said boom about said support arm, said means to pivot said boom being connected to the other end of said boom, so that said manipulator means is positionable and engageable with said equipment so as to perform work thereon.

20. The combination of claim 19, said manipulator means comprising a rotatable shaft, means to axially rotate said shaft attached to one end of said boom, said means to axially rotate said shaft having means to receive one end of said shaft, a manipulator member connected to the other end of said shaft so that said manipulator member is rotatable with said shaft.

21. The combination of claim 20, further comprising means to disconnectably connect said manipulator member to said shaft.

22. The combination of claim 20, wherein said manipulator member is a U-shaped pronged member engageable with a portion of said equipment and being formed with a shaft depending from said U-shaped position for axial rotation.

23. The combination of claim 19, said boom being retractably extensible so as to retractably extend said manipulator means, and means to retractably extend said boom.

24. The combination of claim 20, wherein said manipulator member comprises gripping means, means to actuate said gripping means from within said chamber, so as to actuate the gripping of said equipment.

25. In combination with a submergible chamber, a work arm assembly for performing work on equipment at an underwater work area, comprising in combination, a support base connectably mounted to said chamber, a support arm extending outwardly from said base, said base provided with means to receive one end of the support arm, a boom transversely disposed to, rotatably interconnected with, and pivotally mounted to the other end of said support arm, means to rotate said support arm and boom, manipulator means for engaging said equipment, said manipulator means being integrally connected at one end of said boom, means to actuate said manipulator means and means to pivot said boom about said support arm, said means to pivot said boom being connected to the other end of said boom, said means to pivot said boom comprising a pivot shaft in parallel disposition to said support arm, one end thereof pivotally interconnected to said other end of said boom, means to retractably extend said

pivot shaft, and means formed on said boom to adaptably couple said boom to said one end of said pivot shaft, so as to permit arcuate travel of said boom in pivoting said boom about said support arm, so that said manipulator means is positionable and engageable with said equipment so as to perform work thereon.

26. The combination of claim 25, said chamber further comprising track means horizontally, circumferentially disposed in relation to the central axis of said support arm, means to guidably engage within said track means, interconnecting means affixedly held to said guidably engageable means and to said means to retractably extend said pivot shaft, and means to affixedly mount said track means to said support base.

27. The combination of claim 19, further comprising actuation transmission conduit means extending from said means to actuate said manipulator means, in said chamber to said manipulator means.

28. The combination of claim 20, means to mount said means to rotate said support shaft on said support base.

29. The combination of claim 24, said gripping means comprising a pivotally hinged clamp adaptably engageable with a portion of said equipment.

30. The combination of claim 19, said support base further comprises means to disconnectably connect said support base to said chamber.

31. In combination with a submergible chamber, a work arm assembly for performing work on equipment at an underwater work area, comprising in combination, a support base connectably mounted to said chamber, a support arm extending outwardly from said base, said base provided with means to receive one end of the support arm, said support base further comprises means to disconnectably connect said support base to said chamber, said means to disconnectably connect said base comprising at least one bolt rotatably engageable mounted through said chamber and a portion of the shank thereof protruding outwardly therefrom, a screw-threaded bore in said base to rotatably receive said protruding bolt shank, means to rotate said bolt from the inside of said chamber, so that said bolt may be rotatably disengaged from said bore thereby disconnecting said base, and further comprising a plurality of pre-calculated load-breakable, elongated elements, one end each thereof fixedly attached to said chamber and the other end each thereof fixedly attached to said disconnectable support base, a boom transversely disposed to, rotatably interconnected with, and pivotally mounted to the other end of said support arm, means to rotate said support arm and boom, manipulator means for engaging said equipment, said manipulator means being integrally connected at one end of said boom, means to actuate said manipulator means and means to pivot said boom about said support arm, said means to pivot said boom being connected to the other end of said boom, so that said manipulator means is positionable and engageable with said equipment so as to perform work thereon.

32. The combination of claim 31, further comprising at least three bolts rotatably, engageably mounted through said chamber, said bolts being spaced from and in parallel disposition to each other.

33. The combination of claim 32, the head of each of said bolts being formed with a means for rotation thereof.

34. In combination with a submergible chamber, a lift wire attachably connected to said chamber at the top thereof, blade means to sever said lift wire, said blade means being mounted to said chamber and being transversely disposed to said lift wire, means being mounted to said chamber to actuate said blade means to sever said lift wire so as to cut said wire and free said chamber therefrom, and means to provide a positive bouyancy to the freed chamber to permit bouyant return.

35. The combination of claim 34, means to guide said blade means said means to actuate said blade means being controllable from within said chamber and actuation transmission conduit means interconnected from said means to actuate said blade means to said blade means, so that said actuated blade means is guidingly driven so as to sever said lift wire.

36. An apparatus for carrying out an operation on equipment at an underwater area, said apparatus comprising a submergible chamber, arm means interconnected thereto and extending outwardly therefrom, gripping means attachably mounted to said arm means at the outward end thereof, said gripping means being adaptably formed to grip vertically disposed guides, means to actuate said gripping means, a work arm assembly connected to said chamber and extending outwardly therefrom, manipulator means attachably connected to the outward end of said work arm assembly and adaptably formed to engage a portion of said equipment, means to actuate said manipulator means to engage said portion of said equipment, whereby said chamber is submergible to a depth whereat said gripping means is actuated to grip said guides so as to hold said chamber at said depth adjacent said area and said manipulator means is engaged with said portion of said equipment to perform work thereon.

37. The apparatus of claim 36, wherein said gripping means comprises means to slidably receive a vertically disposed guide, whereby said means to actuate said gripping means actuates said gripping means to a first position to slidably receive said guide and to a second position so as to grip said guide.

38. The apparatus of claim 36, said arm means being outwardly extensible and means to retractably extend said arm means.

39. The apparatus of claim 36, further comprising means to pivotally interconnect said arm means to said chamber.

40. The apparatus of claim 36, said arm means comprising a pair of first arms pivotally interconnected to and outwardly extensible from said chamber, a pair of second arms pivotally interconnected to and outwardly extensible from said chamber, each of said second pair of arms peripherally spaced from a respective arm of said first pair or arms, the outward end of each of said second arms being formed with means to pivotally interconnect said respective first arm, means to retractably extend said first arms and means to retractably extend said second arms.

41. The apparatus of claim 40, said means to retractably extend said first arms and said means to retractably extend said second arms, one each of said means comprising a hydraulic cylinder, a retractably extensible ram one end thereof slidably received in one end of said cylinder, hydraulic actuation means within said chamber, and hydraulic actuation transmission conduit means interconnected from said hydraulic actuation means to said hydraulic cylinder.

42. The apparatus of claim 41, further comprising means to proportionally control said means to retractably extend said first arms and said means to retractably extend said second arms so that said chamber is controllably horizontally positionable.

43. The combination of claim 36, wherein said manipulator means comprises a rotatable extensible shaft, means to rotate said shaft, said means to rotate said shaft being integrally mounted to said end of said boom and said means to rotate extend said shaft having means to couple one end of said shaft thereto, a manipulator member connected to the other end of said shaft thereto, a manipulator member connected to the other end of said shaft, said manipulator member being adaptably formed to be engageable with a portion of said equipment.

44. The apparatus of claim 36, said work arm assembly comprising in combination, a support base connectably mounted to said chamber, a support arm extending outwardly from said base, said base provided with means to receive one end of the support arm, a boom transversely disposed to, rotatably interconnected with, and pivotally mounted to the other end of said support arm, means to rotate said support arm and said boom, manipulator means adaptably formed for engaging said equipment, said manipulator means being attachably connected at one end of said boom, and means to pivot said boom about said support arm, said means to pivot being connected to the other end of said boom.

45. The combination of claim 36, said means to pivot said boom comprising a pivot shaft in parallel disposition to said support shaft one end thereof pivotally interconnected to said end of said boom, means to retractably extend said shaft adaptably coupled to the other end of said shaft.

46. An apparatus for carrying out an operation at an underwater work area, said apparatus comprising, a submergible chamber, means extending from said chamber to removably fixedly, vertically position said chamber to guides in spaced relation to and adjacent said work area, means extending outwardly from said chamber to adjustably, horizontally position said vertically fixed chamber in spaced relation to and adjacent said work area, means for actuating said vertical positioning means, and means for actuating said horizontal positioning means, with said guides being in about fixed spaced relation to said work area.

47. The apparatus of claim 46, further comprising actuation transmission conduit means extending from each of said actuating means to each of the respective positioning means.

48. A method for carrying out an operation on equipment at an underwater work area, said method comprising descending a submergible chamber having a pair of outwardly extending guide gripping arms and having an outwardly extending work arm assembly, through the water, guiding said chamber in descent by said arms slidably engaging one each of two spaced parallel guides, actuating said arms to grip said guides so as to hold said chamber at a depth whereat said chamber is adjacent said equipment, and actuating said work arm assembly to engage a portion of said equipment to perform work thereon.

49. A method for positioning a chamber to carry out an operation on equipment at an underwater work area, said method comprising descending a submergible chamber through the water said chamber having

two retractably extensible outwardly disposed guide gripping arms, and having two retractable extensible, outwardly disposed horizontal positioning arms, each of the outward ends thereof interconnected to one of said guide gripping arms, guiding said chamber in descent by each of said arms slidably engaging one of two spaced parallel guides, actuating said arms to grip said guides so as to hold said chamber at a depth whereat said chamber is adjacent said equipment, proportionally controlling the retraction and extension of each of said interconnected position arms and guide gripping arms so as to horizontally position said chamber at said depth.

50. In combination with a submergible chamber, a work arm assembly for performing work on equipment at an underwater work area, comprising in combination, a support base connectably mounted to said chamber, a support arm extending outwardly from said base, said base provided with means to receive one end of the support arm, said support base further comprises means to disconnectably connect said support base to said chamber, and further comprising a plurality of pre-calculated load-breakable, elongated elements, one end each thereof fixedly attached to said chamber and the other end each thereof fixedly attached to said disconnectable support base, a boom transversely disposed to, rotatably interconnected with, and pivotally mounted to the other end of said support arm, means to rotate said support arm and boom, manipulator means for engaging said equipment, said manipulator

means being integrally connected at one end of said boom, means to actuate said manipulator means and means to pivot said boom about said support arm, said means to pivot said boom being connected to the other end of said boom, so that said manipulator means is positionable and engageable with said equipment so as to perform work thereon.

51. An apparatus for carrying out an operation at an underwater area, said apparatus comprising a submergible chamber, arms means interconnected thereto and extending outwardly therefrom, gripping means attachably mounted to said arm means at the outward end thereof, said gripping means being adaptably formed to grip vertically disposed guides, means to actuate said gripping means, whereby said chamber is submergible to a depth whereat said gripping means is actuated to grip said guides so as to hold said chamber at said depth adjacent said area, means to sever said guides, said severing means being mounted to said arm means, whereby said guides are severable so as to free said chamber therefrom, and means to provide a positive bouyancy to the freed chamber to permit bouyant return.

52. The apparatus of claim 51, said means to actuate said severing means being controllable from within said chamber and actuation transmission conduit means interconnected from said means to actuate said severing means to said severing means.

* * * * *

35

40

45

50

55

60

65