Sept. 10, 1963 J. Y. COUSTEAU ETAL 3,103,195

SELF-PROPELLED SUBMERSIBLE VESSEL

Filed July 12, 1960 6 Sheets-Sheet 1

FIG.1

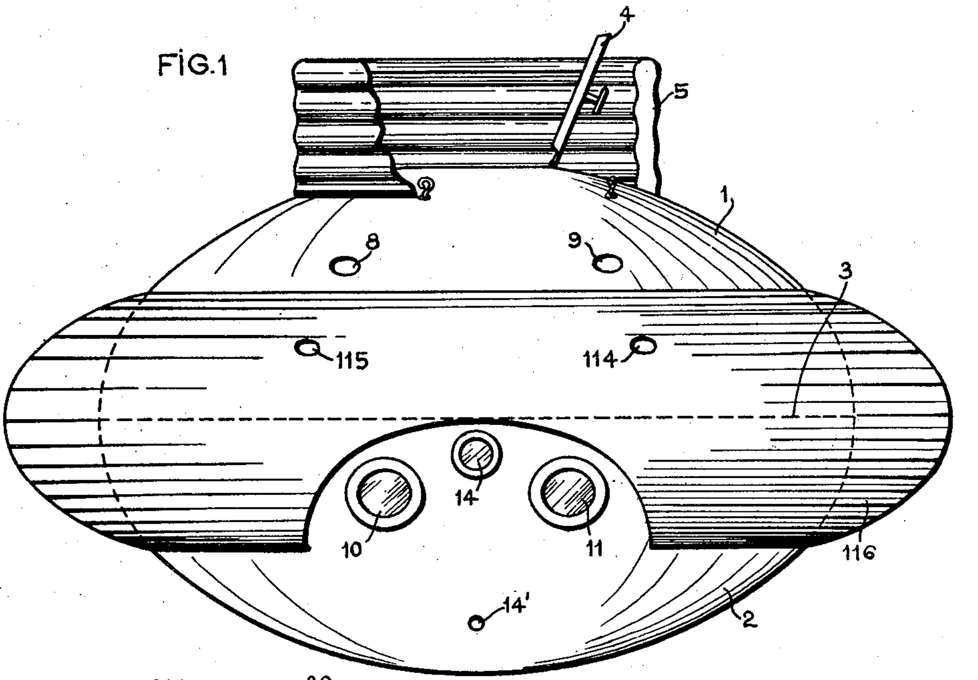
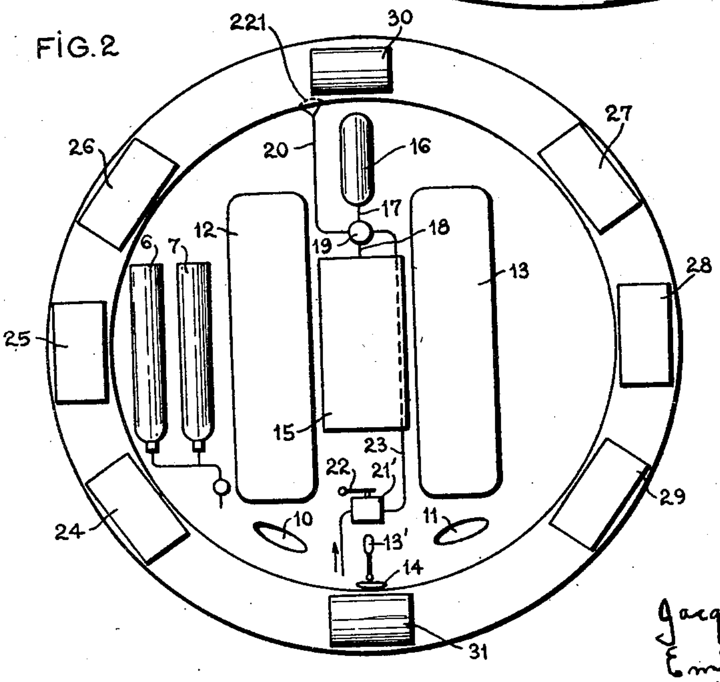


FIG.2



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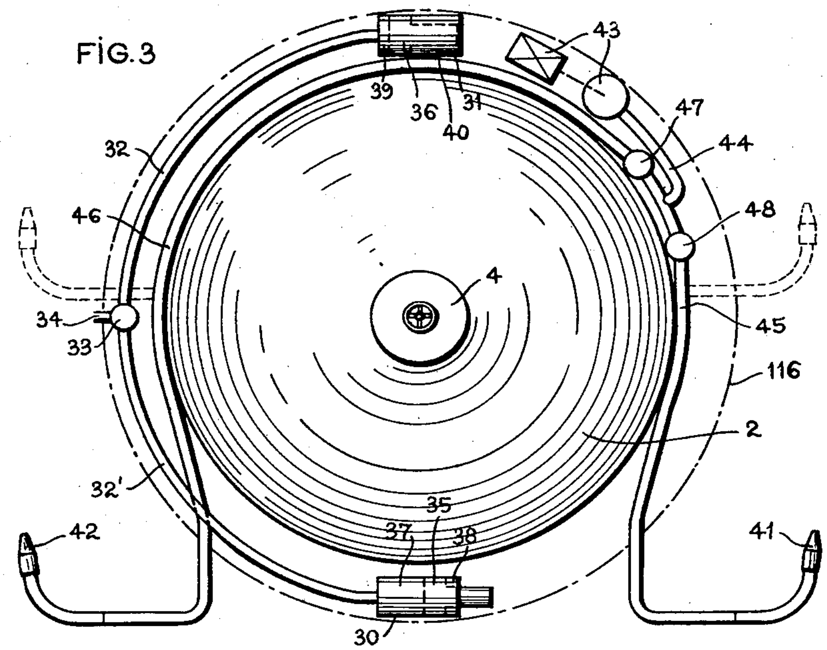
Filed July 12, 1960 6 Sheets-Sheet 2

FIG. 3



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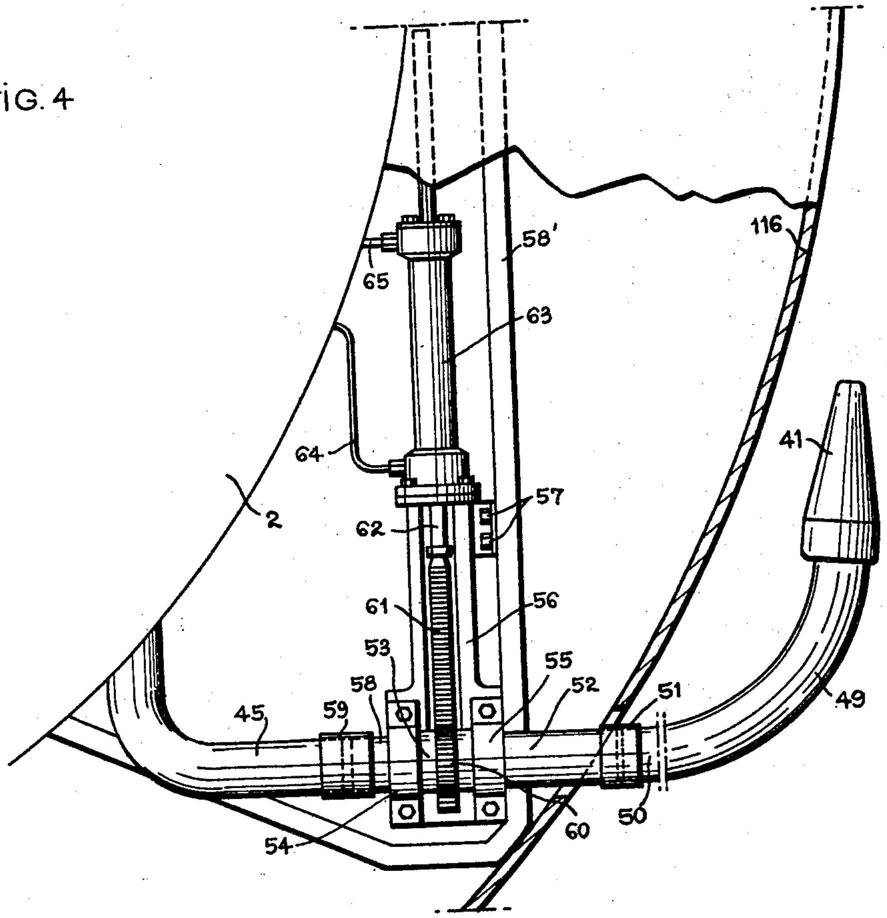
Filed July 12, 1960 6 Sheets-Sheet 3

FIG. 4



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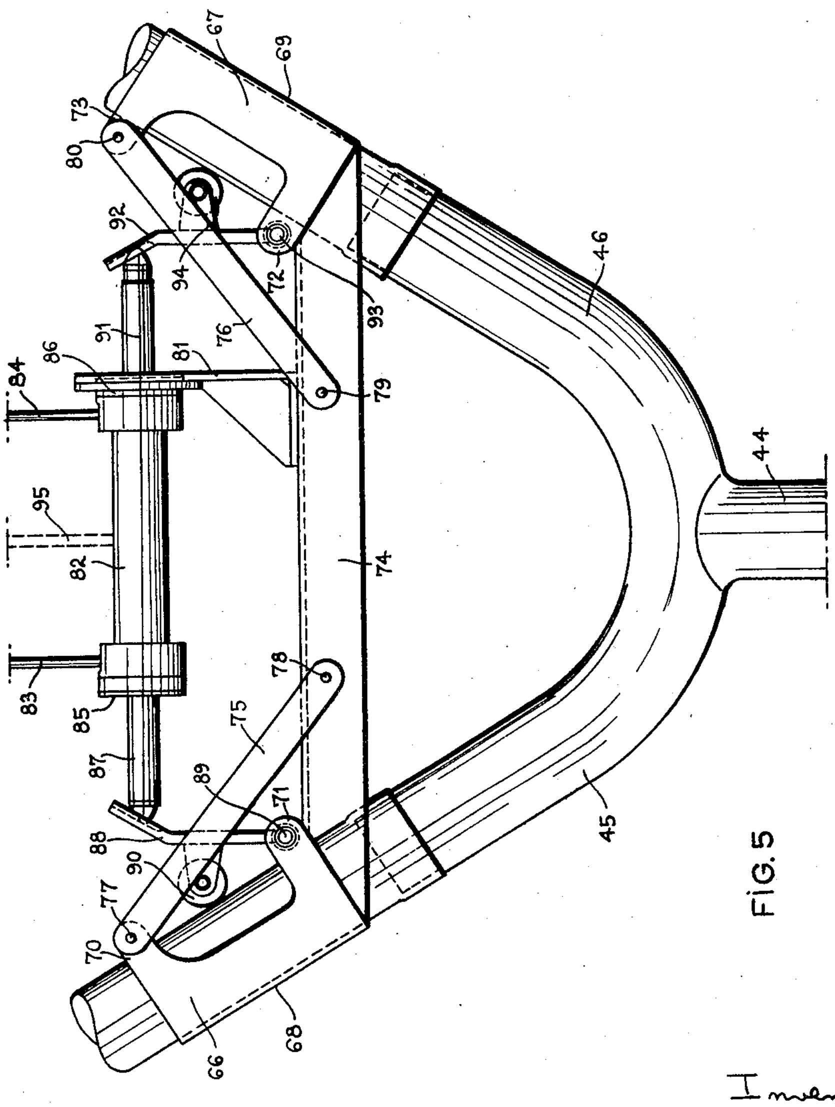

FIG. 5

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Filed July 12, 1960 6 Sheets-Sheet 5

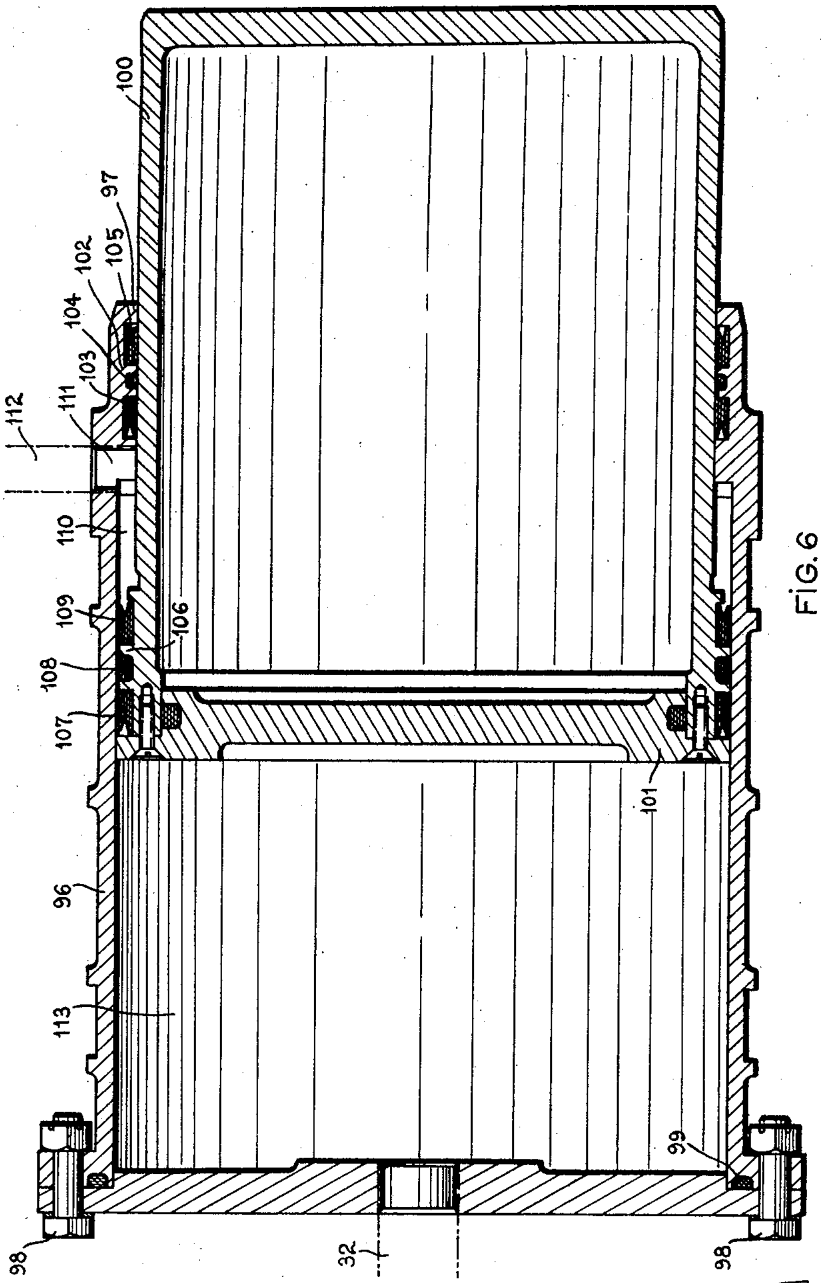

FIG. 6

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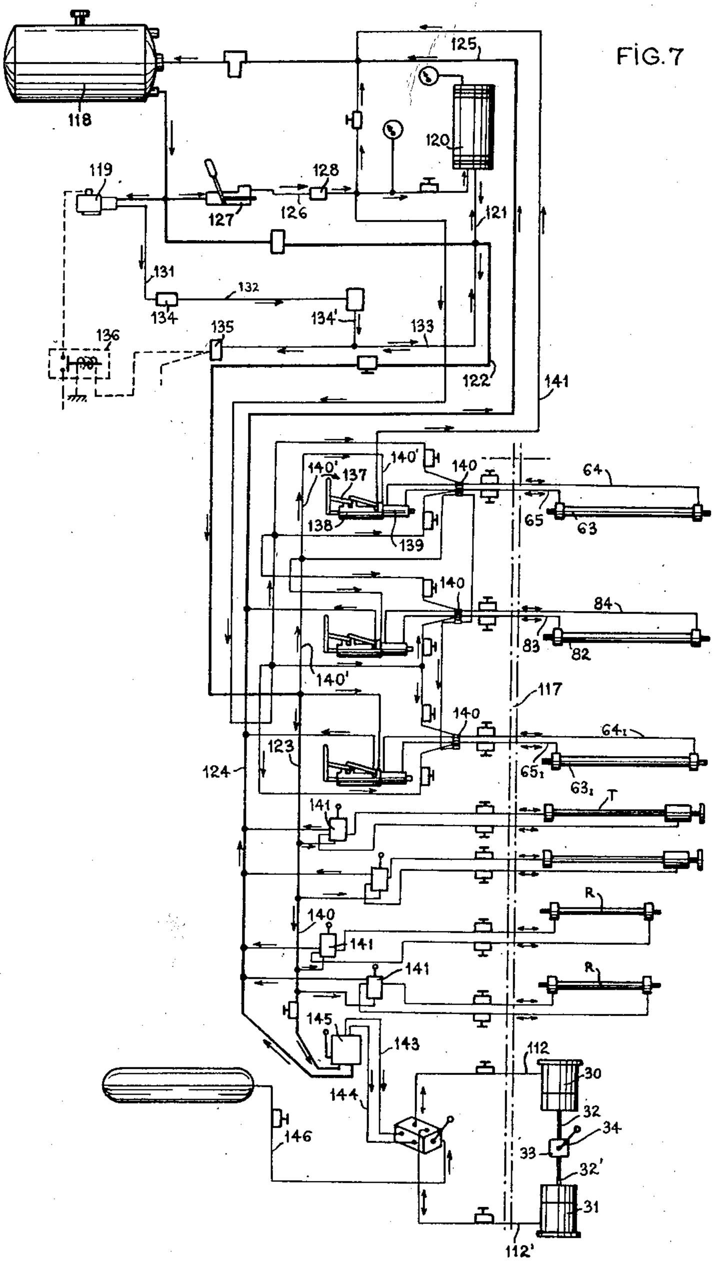
SELF-PROPELLED SUBMERSIBLE VESSEL

Filed July 12, 1960 6 Sheets-Sheet 6

FIG. 7



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United States Patent Office

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3,103,195
SELF-PROPELLED SUBMERSIBLE VESSEL

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9 Claims. (Cl. 114—16)

The present invention relates to a vessel for diving underwater in which the hull is fully sealed and pressure-resistant. The vessel enables observers to have relatively free movement up to average depths up to 300 to 400 metres which are outside the range of skin divers or of divers in pressurized suits. These depths are particularly interesting for the study of the "Continental Shelf" which does not exceed these depths.

Diving vessels are already known, i.e. a "bathyscaphe," which have an observation cabin within a sealed and pressure-resistant spherical hull having attached thereto a system of ballasts containing air, or a liquid of lower specific gravity than water, and enabling, by control of the quantity of water admitted into tanks or expelled therefrom, the buoyant force acting upon the body to be controlled so that the body may descend or ascend at controlled speeds. Such apparatus, when they enable the aforesaid depths to be reached, are very clumsy, hard to handle and very delicate to manoeuvre so that they are not readily suitable for the exploration of a large surface at a given depth, for instance the surface of land submerged under the seas.

It is an object of the present invention to improve upon the known vessels and to provide such a vessel which is relatively light and manoeuverable, and which enables a small number of observers to explore large surfaces of submerged land for the purpose of inspection or measurement.

The diving vessel according to the invention is characterised by the following features taken separately or in combination:

Its hull has the shape of an ellipsoid or analogous surface of revolution which is flattened, the relation between the lengths of the equatorial diameter and the axis of revolution being preferably in the neighbourhood of $\sqrt{2}$.

The devices for manoeuvring the vessel are located exteriorly of the sealed hull in the neighbourhood of the equatorial circle and are preferably protected by a surrounding housing which has the shape of an ellipsoid of revolution which is flatter than that of the hull.

On top of the hull there is located a manhole for entry into the hull. This manhole is surrounded by an inflatable or folding skirting.

The accurate control of the buoyancy of the vessel is determined by a water reservoir inside the sealed hull which is subjected to the pressure in the hull and connected to the exterior of the hull by pipes which admit water into the hull or expel the water from the hull.

The means for admitting water to the inside reservoir consist of a bottle filled with air under that pressure which exists inside the hull. The bottle is connected by a three-way valve, externally of the hull, to a water reservoir.

The stability or tipping of the vessel about at least an equatorial diameter perpendicular to the direction of movement selected for the vessel is controlled by at least a pair of mercury filled cylinders located at the opposite ends of the equatorial diameter lying in the line or direction of the movement of the vessel. The mercury filled cylinders are interconnected by conduits. The displacement of the mercury from one cylinder to the other

takes place through a hydraulic control for driving pistons located in the cylinders.

A three-way valve located in the connection between the two cylinders filled with mercury enables the expulsion or discharge of the mercury in order to effect a rapid ascent of the vessel.

The propulsion of the vessel is provided by at least two lateral blowing pipes from which water taken from the sea surrounding the vessel is discharged under pressure. The control of the discharge of the blowing pipes is effected independently one from the other preferably by throttling the conduits for feeding water particularly with the assistance of jacks.

The blowing pipes can be oriented in vertical planes preferably independently one from the other. The orientation of the blowing pipes may for instance be controlled by rack and pinion means hydraulically controlled or regulated.

The blowing pipes are located forward and laterally with respect to the hull and they diverge towards the backside of the hull in such a manner as their axes cross each other preferably towards the front of the vessel.

Lighting of the area surrounding the vessel is provided by lighting means carried by telescopic arms which are located in the vicinity of the observation portholes.

These several features present the following advantages:

The shape of the hull as a flattened ellipsoid of revolution facilitates handling the apparatus which must generally be transported aboard another vessel to the diving area. This shape nevertheless does not reduce to any great degree the relative comfort of the observers because they may lie down in the vessel. It is preferable to limit the flattening of the ellipsoid (determined by the relation between the equatorial diameter and the axis of revolution) so that it has a numerical value of approximately the $\sqrt{2}$. This numerical value is important because if the vessel is further flattened, tensions appear in the equatorial plane of the vessel, which is normally the weakest portion of the vessel, because it is there that observation portholes or apertures for the several instruments controlling the manoeuvres of the vessel are usually located. The hull is preferably constructed by welding two upper and lower shells approximately along the equatorial plane.

By locating the apparatus for manoeuvring the vessel externally of the pressure-resistant hull and approximately along its equatorial plane, the volume of useful space available inside of the shell is increased. In such event the manoeuvring apparatus is then made naturally so that it is water-sealed and connected by interior controls to the inside of the hull by means of tubes or wires traversing the hull, although the hull is nevertheless maintained sealed. The ellipsoidal external housing protects the apparatus against possible impacts without adversely affecting the manoeuvrability of the vessel.

Manoeuvrability of a vessel which has at its top a closable manhole for entry into or exit from the vessel becomes very delicate when the vessel surfaces in a stretch of water which is not perfectly smooth. Thus the buoyancy of the vessel has to be actually very slight or weak in order to avoid the vessel rising with excessive speed and as a result only a very small portion of the vessel around the manhole emerges above the susface of the water. Upon opening the manhole, water from waves or spray may penetrate inside the vessel and sink it. Also the vessel in the swell of the sea is not very stable.

The folding or inflatable skirting above-mentioned enables these disadvantages to be overcome. The skirt, which is adapted to be deflated when the vessel is submerged, is inflated at about the time the vessel emerges from the sea possibly by inflating through any appropriate means (for instance, using an air bottle under pressure). The skirting facilitates from then on the exit of the observers by forming a light central tower which decreases the risk of water entering the vessel and which also stabilises the vessel.

The vessel is made to dive in well known manner by making it heavier through the use of releasable weights. Releasing a first portion of the weights makes the vessel substantially buoyant so that it does not ascend or descend and the releasing of a second portion of the weights makes the vessel more buoyant so that it rises. However, it is not always possible in practice to obtain a buoyancy such that the vessel does not rise or fall or such that the vessel is maintained at the desired depth by only using weights. As already indicated above, the precise control of the buoyancy results from a water reservoir inside the sealed hull which is subjected to the internal pressure of the hull.

Manoeuvring of the vessel takes place preferably as follows. After having released the first portion of the weights in order almost to stop a dive, the observer observes if the vessel continues to descend or begins to ascend. Supposing the vessel continues to descend, water is discharged from the inside water reservoir for instance by using an electrical pump operating at high pressure (supplemented in case of failure thereof by a hand pump) until the descent is stopped. If on the other hand the vessel ascends, it is made a little heavier by placing the bottle containing compressed air at the pressure in the hull in communication with the water outside the hull so that the water under pressure forces back and compresses further the air in the bottle to occupy the larger part of the volume of the container. At this time the communication between the bottle of air and the water surrounding the hull is broken, and the bottle of air is connected to the water reservoir for instance by means of the three-way valve so that the air under increased pressure which is in the bottle then expels water from the bottle into the internal reservoir. It is possible, if necessary, to repeat this operation until the buoyancy desired is obtained. For each such operation the vessel is made heavier by a weight of water which is substantially constant and known.

It is noted that the above described system enables stable control of the buoyancy of the vessel. In comparison the already known system of air ballasts is in itself unstable. Thus when the water is introduced inside the hull in air ballast systems in order to make the vessel descend, the volume of air remaining in the ballast decreases because of the increase of pressure resulting from the increased depth and this decrease in the volume of air in itself tends to accelerate the descent. In the same manner, upon ascending of the vessel, the volume of air in the ballast increases because of the decrease in pressure resulting from the decreased depth which also tends to accelerate the ascent of the vessel. The apparatus in accordance with the invention is such that the air contained in the water reservoir remains under constant pressure i.e., at the pressure existing in the interior of the vessel and thereby removes completely this reason for instability.

During underwater exploration it is often desired to ascend or descend obliquely for instance in order to direct the vessel towards a distant object which it is desired to examine closely or from nearby. This oblique motion of the vessel was practically impossible with appaartus like the "bathyscaphe" and could be obtained in submarines only by the use of diving ailerons or of relatively powerful propelling screws. The previously described arrangement of mercury filled cylinders located at the extremity of the axis which is parallel to the normal path of movement permits tipping of the vessel, about the equatorial perpendicular axis, sufficiently to enable oblique movement either during descent or ascent of the vessel when the propelling means is operative, and this increases considerably the ease of manoeuvrability of the vessel. Also the possibility of discharging the mercury contained in the two cylinders provides greater safety for the crew because it permits a rapid rise of the vessel if it is damaged or if water leaks thereinto.

The propulsion of known submersible vessels takes place by means of screws co-operating with rudders or by means of screws the velocity of which may be controlled or which may be oriented. The use of rudders is practically limited to underwater vessels which are elongated and which are capable of moving at a relatively great speed. Screws which may be oriented require a system which is relatively complex and occupies much space. The propelling system according to the invention, by using the blowing of water in the lateral blowing pipes, is based on the principle of reaction. It permits a greater degree of manoeuverability, movement in a plane which is oblique with respect to the horizontal, as well as pivoting of the vessel about its vertical axis by orienting the two lateral blowing pipes one towards the front and the other towards the rear. By way of example there is herein described and shown in the drawings accompanying the application an embodiment of the invention:

FIGURE 1 is an elevation of the vessel,

FIGURE 2 is a schematic plan section view of the vessel along a horizontal plane located slightly below the equatorial plane so as to show a portion of the equipment inside the vessel and a portion of the equipment outside the vessel,

FIGURE 3 is a plan view in section of the vessel showing the arrangement of the mercury filled balancing cylinders and the arrangement of the propelling blowing pipes with the groups of driving pumps used to feed the pipes,

FIGURE 4 is a more detailed plan view of a blowing pipe to a larger scale,

FIGURE 5 is a lateral view of the jacks controlling the feed of water to the blowing pipes,

FIGURE 6 is an enlarged axial view through a mercury filled balancing cylinder, and

FIGURE 7 is a schematic view of the hydraulic circuits.

As already described above the vessel in accordance with the invention consists of a hull having the shape of an ellipsoid and which is made up by the assembly of two half shells 1 and 2 welded at 3 along the equatorial circle. The relation between the major and minor axes of the ellipsoid is preferably equal to the $\sqrt{2}$ or it is approximately equal to this numerical value because it is the value for which the tensions which may appear in the equatorial portion of the hull remain negligible.

The upper shell 1 has, at its top, a manhole which is closed by a sealing cover 4 similar to those used in well-known manner in submersible vessels. A skirting 5, which may be inflated by filling it with compressed air discharged from bottles of compressed air 6, 7 located in the vessel (see FIGURE 2), is fastened in appropriate manner on the upper shell 1 around the area occupied by the manhole. The upper shell 1 includes, besides observation portholes 8, 9, preferably three more portholes spaced and inclined at 120° from each other. Inside each of these latter portholes is positioned a sealed optical apparatus having a wide angle, of the type sold in commerce under the mark "Bloscope," and enabling observation within a field of vision approximately equal to 180°. By this means the observers in the vessel may study a zone of 360° around the vessel.

The lower shell is provided, slightly below the equatorial circle indicated by the welding joint 3, with two observation portholes 10 and 11 of relatively large diameter behind which are positioned in the bottom of the shell, two beds 12, 13 on which the two observers may lie down. Another porthole 14 is located in the metallic wall of the shell between and slightly above these two portholes 10 and 11. This porthole is used wtih a source of light located therebehind within the vessel to light the field of vision of the two observers.

The beds 12 and 13 of these observers are spaced one from the other and they are preferably located symmetrically on one side and the other from the vertical plane of symmetry of the ellipsoid. The longitudinal axis of a parallelepipedic water reservoir 15 is located to coincide with the plane of symmetry of the ellipsoid. The reservoir 15 is in pressure communication with the inside of the vessel by a diaphragm, not shown, which may also include a valve preventing the water contained in the reservoir 15 from leaking into the vessel. The reservoir 15 is connected to a sealed bottle 16, able to withstand a pressure well above normal pressure, through pipes 17, 18 between which is positioned a multi-way valve 19 to which a conduit 20, traversing the wall of the lower shell 2 and opening freely to the outside of the vessel is also connected. The opening of conduit 20 is covered by a filter 221 fastened to the shell. The valve 19 has the following positions:

(1) A first position in which the valve 19 establishes free communication between the conduit 20 and the bottle 16 so that the water may fill the latter to thereby compress air therein.

(2) A second position in which the valve is disconnected from the conduit 20 and places the bottle 16 and the reservoir 15 in fluid communication. Since the reservoir is subjected to the pressure existing in the chamber of the vessel, the air earlier compressed in the bottle acts as a motive gas to expel into the reservoir 15 water stored in the bottle.

(3) A third position in which the valve disconnects the reservoir 15 from the conduit 20 and the bottle 16 and connects the reservoir 15 with a discharge conduit (not shown) through which the water may be discharged from the reservoir.

The three-way valve 19 may be controlled directly by one or the other of the observers in the vessel. In this event the valve will preferably be positioned so as to be easily manipulated. According to another embodiment this valve is controlled by a hydraulic system such as shown in 21 in FIGURE 2 and operated by a handle 22. The reference numeral 23 identifiies only a portion of the hydraulic circuit of this system.

Finally a handle 13' is located between the two beds 12 and 13 for controlling the release of the weights which may be attached by a hook 14' to the outside of the lower shell. The discharge of the water from the reservoir in the third position of the valve 19 takes place normally by means of an electric pump, not shown, located in the vessel; in the event of failure of the pump this discharge may also take place by using a hand operated auxiliary pump. The power for driving the pump which is used to empty the reservoir 15 is provided by accumulators or storage batteries enclosed in sealed containers separated in two groups 24, 25, 26 and 27, 28 and 29 mounted externally of the hull and located on opposite sides of the vertical plane of symmetry passing through the water reservoir 15, the accumulators being distributed radially about a circle within a circumferentially extending shroud 116.

Located between the two groups of accumulators are two mercury filled cylinders 30 and 31 and two pistons 35, 36 shown in FIGURE 3. The two cylinders 30 and 31 are interconnected by a passage 32, 32' in which is mounted a three-way valve 33. The end of a tube 34 which leads directly into the sea communicates with the discharge valve 33. The pistons 35, 36 formed respectively with chambers 37, 38 and 39 and 40, are located in the respective cylinders. The chambers 37 and 39 and the passages 32, 32' connecting them are completely filled with mercury. The other chambers 38 and 40 are connected by circuitry containing oil under pressure, not shown, and they are controlled from the inside of the vessel so that the pistons 35 and 36 are moved in opposite directions with respect to each other. By this means it is possible to make heavier either the forward end or the rear end of the vessel and thereby control its tipping about its equatorial diameter perpendicular to the vertical plane of symmetry of the vessel which is perpendicular to the direction of movement of the vessel.

In order to provide this manoeuvre, the three-way valve 33 affords, in a first position, communication between the two chambers 37 and 39 of cylinders 30 and 31. The second position of this valve is an emergency position providing communication between the two passages 32 and 32' and the end of tube 34 thereby to permit simultaneous and rapid expulsion of the full contents of mercury in the two cylinders 30 and 31 to lighten the vessel if it becomes urgent to surface. In this second position of the valve, oil under pressure is simultaneously admitted to the chambers 38 and 40.

The propulsion of the vessel is effected by means of the two blowing pipes 41 and 42 located as described in a low position towards the front and at the opposite sides of the vessel. These two blowing pipes have their axes, when horizontal and pointing rearwardly, converging towards the front of the vessel and they are supplied with sea water by means of a driving pump 43 taking its source of power from the accumulators above described. The pump discharges the sea water inside a primary conduit 44 leading to a secondary conduit 45 which communicates with the blowing pipe 41 and to a secondary conduit 46 which communicates with the blowing pipe 42. All these conduits are in the greater part made from polyvinyl chloride. Inside the secondary conduits 45 and 46 are located control valves 47 and 48 which permit regulation of the discharge of the two secondary conduits 45 and 46 and hence the discharge from the blowing pipes 41 and 42. These valves therefore act as rudders and permit turning the vessel about its vertical axis. Preferably a jack system may be substituted for these valves. The jack system serves to more or less throttle one or the other of the secondary conduits 45 or 46 in the manner described below.

In order to enable more rapid turning of the vessel about its vertical axis, the blowing pipes are so located that each one of them may be displaced in a vertical plane. For this purpose each blowing pipe is mounted as in FIGURE 4 in which there is shown in detail the mounting of the blowing pipe 41, the mounting of blowing pipe 42 being identical.

The blowing pipe 41 is mounted at the end of a bent tube 49 which has its end 50 in frictional engagement in a rubber sleeve 51 which also overlies the end 52 of a tube section 53 of manufactured synthetic material such as for instance "Teflon." This tube section may rotate inside two bearings 54 and 55 carried by a frame 56 fastened at 57 to a bracket 58' welded to the vessel. The other end 58 of the tubular section 53 is engaged relatively freely inside a rubber sleeve 59 which is provided at the end of a tube 45. The tubular section between the bearings 54 and 55 carries a toothed wheel 60 which is also made from a block of "Teflon." The toothed gear 60 meshes with a rack 61 carried by the shaft 62 of a hydraulic jack having a cylinder 63. The reference numerals 64 and 65 refer to two oil conduits under pressure which may be positioned above or below the piston of the jack, not shown, which is integral with the shaft 62. If the conduit 65 is connected with the oil conduit in which the oil is under pressure and the conduit 64 is also connected to a discharge conduit, the rack 61 will be pushed downwardly in the plane of the drawings to cause rotation of the toothed gear 60 and of the tubular section 53, which is connected with the bent tube 49 through sleeve 51. This in turn rotates the blowing pipe 41 rearwardly as viewed in FIGURE 4. The angle of rotation will depend upon the displacement of the rack. Preferably each blowing pipe is so located that it can rotate through an overall angle of 270° starting from the position shown in FIGURE 3.

The two hydraulic jacks may be controlled separately or simultaneously. In the latter case the two blowing pipes may rotate in the same direction or in opposite directions. It is also possible to position one of the blowing pipes so that it is directed towards the rear while the other is directed towards the front. This position is that in which the blowing pipes are used when it is desired to turn the vessel rapidly about its vertical axis. The phenomenon which produces this rotation is analogous to that of a rowing boat in which the oarsman pulls one of the oars while he pushes the other oar.

The jacks for controlling the rotation of the blowing pipes are each controlled by a hydraulic servo motor fed through a main conduit under oil pressure. This servo motor controls a relay pump of which the two chambers are connected to those of the control jack of a blowing tube, the control levers of the control jacks being inside the vessel near the observers.

FIGURE 5 is a lateral view of the mechanism which is made up from two adjustable valves 47, 48, see FIGURE 3.

There is shown in FIGURE 5 the discharge conduit 44 of the pump 43 for distributing the sea water discharged to the two tubes 45 and 46 which terminate respectivley at the blowing tubes 41 and 42. The two tubes 45 and 46 pass respectively inside the iron brackets 66 and 67 which are U-shaped sections, the bases of the U-shaped sections being identified by 68 and 69. The lateral arms of the brackets are provided with cut-aways between projecting arms 70, 71, 72 and 73. The brackets 66 and 67 are joined by a cross-member 74 and the assembly is made rigid by struts 75 and 76 connected to the extensions 70 and 73 and to the cross-member 74 at 77, 78, 79 and 80. A standard 81 carrying a hydraulic jack having a cylinder 82 is welded on the cross-member 74 by means of which the mechanism shown in FIGURE 5 is attached in the vessel. Two ducts 83, 84 for oil under pressure are connected at the two ends of cylinder 82. The ducts 83, 84 act on a piston, not shown, moving within this cylinder and carrying on each of its faces an axial rod projecting through the ends 85 and 86 of the cylinder. The rod 87 co-operates with a lever 88 articulated at 89 on the arm 71 and carrying a roller 90 which presses against the portion of the conduit 45 which is located adjacent the cut-aways in the arms of the U-shaped member 68.

The other rod 91, which projects through the end 86 of cylinder 82, co-operates with a lever 92 pivoted at 93 on the arm 72 of the bearing bracket 67 and carries a roller 94 which presses against the portion of the conduit 46 which is located adjacent the cut-aways provided in the sides of the member 67.

The operation of the device is as follows.

Assuming oil under pressure is fed through the duct 83, the piston inside cylinder 82 is displaced towards the right and pushes back the rod 91. This rod pivots lever 92 clockwise and the roller 94 throttles the conduit 46 made of a flexible material, reducing its section and thereby the passage of water to the blowing tube 41. If the discharge of the blowing tube 42 is to be reduced oil under pressure is fed in the duct 84.

According to another embodiment, it is possible to provide the cylinder with a supplementary central duct 95, shown in dotted lines, which is adapted to control the simultaneous displacement of two separate pistons of which one would have a rod 87 and the other a rod 91. This embodiment enables controlling simultaneously and in the same direction the discharge of water which is sent to the blowing tubes 41 and 42. It is possible to provide a second set of blowing tubes which are controlled in an analogous manner to that already described and which serve to make the vessel rotate about its axis parallel to the normal direction of movement. This rotation is useful for instance in order to prevent the vessel being carried away laterally or drifting during turning. These additional blowing tubes are orientable in the vertical plane and they may be located on the outside of the housing 116 on either side of the axis parallel to the normal direction of movement of the vessel and at a sufficient distance from this axis.

The FIGURE 6 is an axial section through one of the

mercury filled stabilizing cylinder means designated by references 30 and 31 in FIGURE 2.

Such a stabilizing means includes a cylinder 96 of which the rear end 97 is largely open and of which the front end is closed by a cover secured by bolts 98, with a sealing member 99 compressed between the cover and a flange or rib provided at the front end of the cylinder. The cover is provided with a central aperture communicating with conduit 32 (see FIGURE 3). A hollow piston 100 is located inside the cylinder 96, this piston, which is elongated and has the shape of a hollow container, having a diameter equal to the internal diameter of the rear cylinder opening 97. The front end of the piston is closed and sealed by means of a cover 101.

The cylinder 96 includes in the portion of its internal surface adjacent the rear end 97, an annular thickened wall part 102 having three ribs inside of which are located sealing members 103, 104, 105. An annular thickened wall part 106 is also provided on the piston 100 near the cover 101 and this wall part 106 also has ribs therearound between which are located sealing members 107, 108 and 109. As a result of these two thickened wall parts there is formed between the cylinder and the piston 100, a chamber 110 communicating with an opening 111 in the wall of the cylinder 96 and communicating with an oil conduit.

The two stabilizing means are identical and they are controlled in such manner by oil under pressure, that the mercury discharged from the chamber 113 may flow into the chamber of the other stabilizing means. This control is effected preferably by means of a distributor having five paths and two positions controlled by the valve 33, see FIGURE 3, which is located in the conduits connecting the two stabilizers.

In addition to the equipment already described, the vessel is provided with means for supporting, above the portholes 10 and 11, two telescopic arms at the ends of which there may be fastened a source of light which may be more or less moved in the water surrounding the vessel. These telescopic arms are fastened on the exterior wall of the upper shell 1 and they pass through openings 114 and 115 provided in the housing 116.

Each telescopic arm is formed with a hydraulic jack similar to that controlling the rotation of the blowing tubes and has, at its extremity, means for fastening the source of light.

The housing or shroud 116 around the hull 2 has the shape of an ellipsoid of revolution more flattend than that of the sealed hull of the vessel. The housing 116 which is open to the surrounding water consists of concave panels preferably laminated or in layers which are fastened to a body welded to the vessel. The housing surrounds the portion of the vessel near or adjacent the equatorial circle and is formed with a recess opposite the portholes 10 and 11. The housing protects the manoeuvring apparatus which is, in accordance with the invention, located outside the sealed hull while all the means for controlling the apparatus are located inside the hull. Thus, the containers for the accumulators, the two stabilizing mercury filled cylinders, the motor pump group feeding the blowing tubes, the blowing tubes and their control elements, the telescopic arms and the jack for throttling the water conduits feeding to the blowing tubes, are all located outside the hull in the equatorial region of the hull but this is not to be considered to be limiting. Also, the greater part of the mechanisms which control the manoeuvring devices are located inside the sealed hull.

The operation of the vessel is as follows:

For diving, after closing the manhole cover 4 and partially filling the reservoir 15 with water, two or more weights are fastened to the hook 14′. The vessel begins to descend and this may be accelerated by filling the reservoir 15, using the bottle 16. If it is desired to maintain the vessel at a certain depth, one of the weights is released. If the lightening thus produced is not sufficient it is also possible to discharge a certain quantity of water contained in the reservoir by means of the motor pump group carried by the vessel. It is possible to change the depth of the vessel and to maintain the level of this new depth by maintaining small quantities of water in the reservoir **15** or by expelling small quantities of water from the reservoir **15**.

If it is desired to modify the field of observation through the portholes, it is possible to incline or tip the vessel about its equatorial diameter perpendicular to the vertical plane containing the vertical axis of the vessel. This operation may be effected by displacing mercury from one to the other of the reservoirs **30, 31**. Thus in order to tip the vessel towards the front, it is possible to send mercury from reservoir **30** to reservoir **31**. In order to right the vessel and possibly tip it upwardly, the mercury from the reservoir **31** may be fed back to the reservoir **30**.

The vessel is propelled when water is discharged from the blowing tubes by operating the motor pump **43**. In order to change the direction of movement of the vessel it is possible to vary the quantities of water discharged from each blowing tube by means of the jack mechanism shown in FIGURE 5. When it is desired to turn towards the right it is possible to throttle with the aid of this jack the conduit **46**. In order to turn towards the left it is possible to throttle the conduit **45**. If it is desired to accelerate the turning of the vessel it is possible simultaneously with this throttling operation to rotate or shift one of the blowing pipes **41** or **42** in such manner that it discharges water in a direction opposite to the other.

In order to bring the vessel to the surface, it is possible to release the remaining weight and to empty the water reservoir. The speed of ascent of the vessel may be regulated by the successive quantities of water discharged from the reservoir.

In case of emergency the ascent may be accelerated by also emptying the two mercury reservoirs **30** and **31**, as already specified.

The positions of the blowing tubes towards the front gives to the vessel a stability of direction of movement which is sufficient despite the relatively small length of the vessel.

FIGURE 7 shows schematically the hydraulic circuits for the hydraulic jacks controlling the rotation of the blowing tubes, that is, for the jacks similar to those shown in FIGURE 4 and designated by the references **62** and **63**, for the jack **82** (FIGURE 5) which controls the distribution of the water towards the blast pipes, for the two telescopic arms which each carry a source of light for the two auxiliary jacks and for the stabilizing cylinders **30** and **31** which are filled with mercury. The wall of the vessel **117** is indicated in dot-dash lines, FIG. 7, in order to show that all these jacks and these stabilizing cylinders are located outside the hull.

The hydraulic circuit includes a principal circuit and secondary circuits connected to each jack and to the assembly of the stabilizing means.

The principal circuit includes an oil reservoir or container **118** containing approximately 8 litres, the contents being discharged by an electric pump **119** to a pressure accumulator **120**. The oil in the accumulator **120** passes through the conduits **121, 122, 123, 124** and **125** and goes back to the reservoir in order to be thereafter compressed again. The circuit which is shown in thicker lines constitutes, with the associated apparatus, a closed circuit. A conduit **126** connects the pump **119** and the accumulator **120** and a hand pump **127** is also provided together with a control valve **128** which enables the oil to be pressurised if the electric motor pump **119** fails.

Another conduit connects the electric pump **119** to the accumulator **120** and constitutes a control and safety circuit which interrupts the feeding of electric current to the pump as a function of the oil pressure in the accumulator **120**. This circuit comprises the conduits **131, 132, 133**, including the control valve **134**. Conduit **134'** establishes communication between **132** and **133** which leads to a contact **135** controlling the supply of the pumps **119** by the intermediate of an electric relay **136**.

Each jack **63** which controls a blowing tube is connected by its two oil feeds **64** and **65** to a mechanism **137** consisting of a servo control **138** controlling a jack or relay pump **139** in communication with the two conduits which form a closed circuit with the jack **139** and the control jack **63**. In order to compensate for losses of oil which may exist in the closed circuit, for instance owing to non sealing or a leak, a compensating system **140** is provided in the conduits **64** and **65**. The compensating system is connected to the oil accumulator **120**. The arrangement of servo control **138** is on the other hand connected by the conduit **140** to the conduit **123** of the principal circuit and by the conduit **124** to the reservoir **118**.

An analogous arrangement is provided for the jack **82**.

The circuits of the jacks T and R are not controlled by a servo mechanism but they are controlled by distributors **141** branched in parallel on the conduits **123** and **124** of the main circuit. The hydraulic circuit of the stabilizing cylinders of mercury **30** and **31** comprise the conduits **112** and **112'** leading to a distributor **142**, having five paths and two positions, which is connected by the conduits **143** and **144** to a rotating distributor **145**. The valve **33** is connected to the distributor **142** through which it also communicates, via conduit **146**, with a bottle of compressed air for rapidly emptying the mercury from cylinders **30** and **31** in case of emergency. This circuit is such that in normal operation the distributor **142** enables the passage of the oil in opposite directions from the conduits **112** and **112'** as a function of the operation of the distributor **145** although in case of emergency it only enables the passage of compressed air in the same direction in the two conduits **112** and **112'** in order to empty the cylinders of their mercury after the said distributor has been placed in its second position.

The vessel described may be modified within the scope of the present invention. For instance it may be provided with a second pair of mercury filled cylinders located on an equatorial diameter which is perpendicular to that passing through the first pair of cylinders. The second pair of cylinders enables tipping the vessel laterally during turning of the vessel to thereby prevent the vessel from drifting.

We claim:

1. A self-propelled submersible vessel for exploring submarine surfaces comprising a water-tight hull of ellipsoidal form, shroud means mounted on and extending circumferentially of said hull and open to the water surrounding said vessel, a pair of reaction nozzles capable of being supplied with water from the water surrounding the vessel, each nozzle of said pair being pivotally mounted on either side of the hull approximately in the plane of the maximum hull diameter and on a transverse axis in the forward portion thereof, a single power driven pump, means providing a source of power therefor, said pump and said power source being mounted on the outside of said hull and within said shroud means, said pump means having a suction side in communication with the water surrounding the vessel and a pressure side in communication with both said reaction nozzles, and motor means mounted on the outside said hull and within said shroud means, controlled from within said hull for angularly adjusting said reaction nozzles independently of each other within vertical planes containing their axis.

2. A self-propelled submersible vessel according to claim 1, having an entrance thereto comprising, a closable manhole located at the central uppermost point of said hull, and an inflatable protective skirt positioned around said manhole, the said skirt being supplied with compressed air from within said hull when the vessel sur-

faces and adapted to be deflated when the vessel descends below the water surface.

3. A self-propelled submersible vessel according to claim 1, further comprising a set of two cylinders mounted on the outside of said hull and substantially in alignment with the fore-and-aft axis of the vessel, a piston movable in each of said cylinders and defining therein a chamber containing mercury, a pipe disposed externally of said hull and connecting both said chambers, a three-way valve in said pipe for selectively establishing direct communciation between said chambers or from said chambers with the water surrounding the vessel, hydraulic means for controlling the axial position of each of said pistons in its cylinder, said pistons and three-way valve being adapted to be controlled from within said hull.

4. A self-propelled submersible vessel for exploring submarine surfaces, comprising a water-tight hull of ellipsoidal form, an ellipsoidal shroud mounted on and extending circumferentially of said hull about its area of maximum hull diameter and open to the water surrounding said vessel, said hull extending vertically beyond said shroud, a pair of reaction nozzles capable of being supplied with water surrounding the vessel, said nozzles being pivotally mounted on either side of the hull substantially in the plane of maximum hull diameter, a single pump mounted on the outside of said hull and positioned within said shroud, said pump having a suction side thereof in communication with the water surrounding vessel and a pressure side in communication with both reaction nozzles, hydraulically actuated means mounted on the outside of the hull and within said shroud for angularly adjusting the position of each of said reaction nozzles independently of each other in a vertical plane containing their respective axis, and means inside said shroud for simultaneously controlling the water supplied to the reaction nozzles.

5. A self-propelled submersible vessel according to claim 4, in which each said reaction nozzle is carried at one end of a bent tube, the other end of said bent tube being rotatably mounted in a bearing supported by the hull, said other end of said tube having a pinion thereon meshing with a rack controlled by said means for angularly adjusting the reaction nozzles.

6. A self-propelled submersible vessel according to claim 4, in which said means for simultaneously controlling the water supplied to the reaction nozzles comprises a first conduit connected to the pressure side of said pump, communicating conduits connected to said first conduit and leading to said reaction nozzles, and throttling means positioned in each of said communicating conduits simultaneously controlling the amount of water supplied to each of said reaction nozzles.

7. A self-propelled submersible vessel according to claim 4, in which the means for simultaneously controlling the water supplied to said nozzles comprises a tube

section having the form of a Y and connected by one of its arms to the pressure side of said pump, conduits having deformable sections connecting respectively the other arms of said tube section to said reaction nozzles, throttling means operatively connected to the said deformable sections and a hydraulic jack positioned between said throttling means for simultaneously controlling the amount of water supplied to each of said reaction nozzles.

8. A self-propelled submersible vessel according to claim 4 wherein the ratio of the equatorial diameter to the axis of revolution of said ellipsoidal hull is approximately the value of $\sqrt{2}$, said shroud being an ellipsoid of revolution which is appreciably flatter than that of said hull.

9. A self-propelled submersible vessel for exploring submarine surfaces, comprising a water-tight sealed hull of ellipsoidal form, a pair of reaction nozzles supplied with water from the water surrounding the vessel, said nozzles being pivotally mounted on either side of the hull substantially in the plane of maximum hull diameter for pivoting about a transverse axis in the forward portion thereof, said nozzles when pointed generally rearwardly of the hull diverging from each other such that their axes cross each other forwardly of the vessel, a single pump having its suction side in communication with the water surrounding the vessel and its pressure side in communication with both said reaction nozzles, control means mounted on the outside of said hull for angularly adjusting said nozzles independently of each other in vertical planes substantially parallel to each other and to a vertical plane passing through the fore-and-aft axis of the vessel, and means for simultaneously controlling the amount of water supplied to each of said reaction nozzles.

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