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SUBMERGIBLE HULL PROPULSION AND CONTROL SYSTEMS

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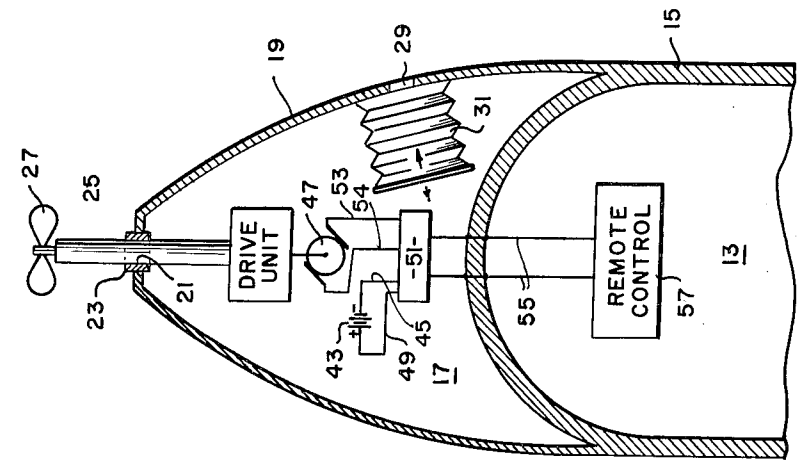


FIG. 2.

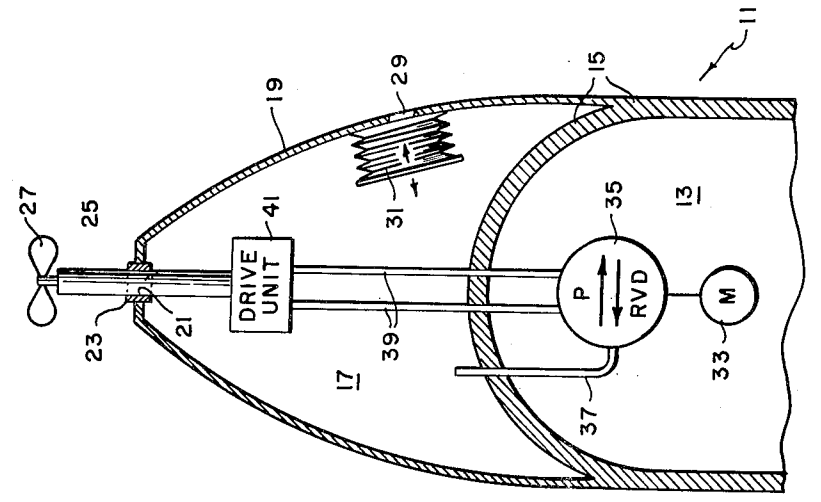


FIG. 1.

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SUBMERGIBLE HULL PROPULSION AND CONTROL SYSTEMS

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to improvements in submergible vessels; and, more particularly, relates to an improved deep submergence hull and propulsion system.

It has been found that prior art hulls and propulsion systems have weaknesses at great depths, one of these weaknesses being the difficulty of sealing the propulsion means where it passes through the hull. Conventional high pressure rotating seals are rather inefficient on vessels capable of deep submergence. At great depths, controlled seal leakage for lubrication purposes cannot be carried out efficiently without excess leakage. In addition not only do high pressure rotary seals have a short operating life and high replacement cost resulting in long operational down time, but they also become increasingly mechanically inefficient as their size becomes larger due to the necessity of large shafts on large high speed submergible vessels. Types of seal arrangements have also been proposed wherein sea water comes into intimate contact with rotating elements for purposes of internal and external pressure equalization. However, these systems are limited to a short operating life due to the corrosive and erosive effects of sea water on the various components. Moreover, all machinery exposed to sea water must be sealed, thus adding to the total number of seals necessary and to the weight of sealing material.

Accordingly, it is among the objects of the present invention to provide an improved hull and propulsion system for submergible vessels; to provide a deep submergence hull and propulsion system safely and efficiently operational not only at any depth, but particularly at great depths, says, several thousand feet; to provide in a simple and effective manner the substantial elimination of pressure differential in a portion of a hull at any depth; and to provide a deeply submergible hull and propulsion system which is safe, which requires a minimum of maintenance and expense, and which may be utilized by itself and easily adapted for incorporation with existing vessels.

These and other objects, features and advantages of the present invention will be better understood by referring to the drawings in which the same reference numerals represent like parts and in which FIGS. 1 and 2 are illustrative diagrams of different embodiments of the present invention.

Referring to FIG. 1 the after end of a submergible vessel 11 is shown having substantially fixed pressure a chamber 13 formed by relatively strong (e.g. thick) surrounding walls 15 for withstanding the high pressure differentials occurring at great depths in water. A variable pressure chamber 17 located aft of the thick-walled chamber 13 may be formed by relatively weak (e.g. thin) surrounding walls 19 capable of withstanding relatively low inward or outward differential pressure as compared with the thick walls 15. The thin walls 19 may be integrally joined to the thick walls 15 at a station of the submarine 11 having a large cross section so that the

walls 19 form a smooth aftward extension of the body of the submarine 11 to enhance smooth water flow.

The aftermost end of the thin-walled variable pressure chamber 17 has an opening 21 into which is fitted a conventional bearing and seal 23 supporting a propeller shaft 25 having a propeller 27. The bearing and seal 23 need withstand only relatively small or negligible pressure differentials.

The interior of the thin-walled variable pressure chamber 17 is preferably filled as completely as possible with fluid means such as an essentially lubricative liquid which does not have corrosive and erosive effects on machinery. Any suitable oil may be used. Oils of the type known as MIL–T–2190T.E.P., 2110H and silicon oils have been found to be satisfactory.

As an alternative, the thin-walled chamber 17 may be filled partially with a suitable liquid and the remainder filled with a gas. However, in this instance the ratio of the liquid to gas must be appropriate to permit sufficient changes in pressure in the chamber 17 to substantially match that of the surrounding sea water at depths to which the chamber 17 may be lowered. Since the gas in the chamber 17 may well be at considerably higher than atmospheric pressure, it would in this instance be necessary to seal the chamber 17 against the escape of the gas.

An aperture 29 is located in the thin-walls 19 of the chamber 17 and is watertightly surrounded by volume-changing means, for example, an expandable and contractible hollow body such as a bellows or diaphragm 31 mounted in any suitable watertight manner on the inside portion of the thin walls 19 with the interior of the diaphragm 31 communicating with the aperture 29. The diaphragm 31 need withstand only these pressure differentials withstandable by the thin walls 19. The diaphragm 31 contracts and expands thus changing its volume and, consequently, the pressure in the chamber 17 according to the difference in pressure between the surrounding sea water and the interior of the chamber 17. In the situation where the chamber 17 is filled with a combination of gas and liquid, the limits of expansion and contraction of the diaphragm 31 will necessarily be greater than in the case where only a liquid is used to fill the chamber 17 essentially completely.

As shown in FIG. 1, powerplant means employing a motor 33 which may be of any suitable type is located inside the thick-walled chamber 13 and is connected by suitable linkage to drive a reversible variable delivery pump 35. A conduit 37 watertightly passing through the thick walls 15 is connected to the pump 35 to deliver liquid from the thin-walled chamber 17 acting as a reservoir to the pump 35. A pair of conduits 39 watertightly passing through the walls 15 feeds the output of the pump 35 to a suitable hydraulic torque converter such as a hydraulic drive motor 41 of any suitable construction. The hydraulic motor 41 in turn drives the shaft 25 either directly or through suitable reduction gearing. Obviously by reversing the direction of delivery of the pump the propeller rotation direction is controlled.

In the embodiment of the invention of FIG. 2, propulsion means comprising an electric drive system for providing higher shaft horsepower than that generally obtainable by a hydraulic drive system is shown. Any suitable source of electrical power such as a battery 43 which may be of the type submergible in oil, or a fuel cell or the like, is located in the thin-walled chamber 17. The battery source 43 is connected via a lead 45 and lead a 49 to respective input terminals of a suitable high power switch unit 51 also located in the chamber 17. Leads 53 and 54 connect output terminals of the switch unit 51 to the terminals of an electric motor 47 driving the propeller. A pair of leads 55 connect control terminals of

the high power switch unit 51 to a remote control console 57 located in the thick-walled chamber 13.

The switch unit 51 may include a solenoid actuated relay for reversing the polarity on the field or armature winding terminals of the motor 47 to thereby reverse its direction of rotation and a potentiometer actuated by a servo motor or other suitable means for adjusting the current in the motor windings. The control console 57 is provided with any suitable controls for energizing the switch unit 51.

With the switch unit 51 located in the oil-filled thin-walled chamber 17 as just described, insulation for the relatively high voltages in the switch unit 51 is inherently provided. It is to be understood, however, that the switch unit 51 or the battery source 43, or both, may be located in the thick-walled chamber 13 if desired. The motor 47 may drive the propeller shaft 25 directly or through suitable reduction gearing.

According to the operating principles of the present invention, as the submergible vessel 11 descends, the diaphragm 31 expands in the chamber 17 due to the sea water pressure applied thereto via the aperture 29. The expanding diaphragms 31 reduces the volume of the oil or fluids contained in the chamber 17, thereby increasing the outward pressure on the walls 19 of the chamber 17. The diaphragm 31 will continue expanding until the interior pressure of the chamber 17 is at least approximately equal to the pressure of the surrounding sea water. However, there may yet remain a slight differential in pressure on the walls 19 and on the diaphragm 31 because of the structural resistance and inertia of the diaphragm 31. Accordingly, as a practical matter, it may be necessary to make the thin walls 19 and diaphragm 31 of sufficient material strength (e.g. thickness) to withstand such a resulting pressure differential.

Of course, when the submarine 11 is caused to ascend, the diaphragm 31 contracts in the thin-walled chamber 17 proportionately to the decreasing pressure of the surrounding sea water, again resulting in a very small or negligible differential in pressure acting on the walls 19.

It will thus be appreciated that with a small or negligible pressure differential acting on the thin-walled chamber 17, any rotary or other types of seals located in the thin-walls 19 need be made to withstand only very small or negligible pressure differentials. Consequently, the leakage of such seals will be quite low. Moreover, it will be appreciated that the depths to which a submergible vessel having the hull and propulsion system according to the present invention may descend are practically unlimited. It is necessary only that the limit of expansion of the diaphragm 31 be sufficient to maintain the low differential in pressure withstandable by the thin walls 19 and seal leakage limitations. In some cases it may be necessary to use more than one diaphragm in the thin-walled chamber 17, and it is obvious that other types of expandable and contractable devices may be used in lieu of the diaphragm, such as bags, sliding joint couplings, piston and cylinder arrangements, bellows, etc.

It will be realized that not only does the system according to the present invention provide extended life over any other known system which operates with sea water in contact with, surrounding, or internal to the rotating and fixed elements, but it also provides a minimum of leakage problems and permits bidirectional propeller rotation. Moreover, the liquid in the chamber 17 serves to cool any machinery or mechanisms which may be provided therein such as, in addition to those illustrated and discussed above, reversing thrust bearings, propeller drive shaft support bearings, auxiliary machinery, and the like.

In an emergency, fresh water may replace the oil in the variable pressure chamber 17 when there are no uninsulated electrically conducting elements in the chamber 17, and in an extreme emergency, even sea water may be used for short periods, thus giving the system of the present invention a considerable degree of back-up safety.

It is to be understood that according to the invention the thin-walled chamber 17 may be used by itself without attachment to anything else in certain situations where it is unnecessary that personnel accompany the chamber 17 to depths to which it may be lowered. Where the chamber 17 and appropriate equipment contained therein is used by itself, the thin walls 19 thereof would be completely surrounding the liquid 28 instead of there being a wall in common with the vessel to which the chamber 17 may be attached.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A submergible vessel comprising:
(*a*) a substantially fixed pressure chamber having walls of sufficient strength to withstand all differential pressures to which the chamber may be subjected;
(*b*) a variable pressure chamber having walls capable of withstanding a differential in pressure lower than those to which the vessel is to be subjected;
(*c*) said fixed and variable pressure chambers being connected to form a unitary body;
(*d*) powerplant means located in said fixed pressure chamber;
(*e*) propeller shaft means located in said variable pressure chamber and responsive to said powerplant means for driving said vessel through water;
(*f*) a pool of liquid substantially entirely filling said variable pressure chamber;
(*g*) said variable pressure chamber having aperture means in the walls thereof; and
(*h*) volume changing means watertightly surrounding said aperture and disposed in the interior of said variable pressure chamber for varying the pressure in said variable pressure chamber in response to the sea water pressure acting through said aperture means on said volume changing means.

2. The vessel as defined in claim 1 but further characterized by at least a portion of said powerplant means being located in said fixed pressure chamber.

3. The vessel as defined in claim 1 but further characterized by control means located in said fixed pressure chamber for controlling said powerplant means and said propeller shaft means.

4. A self-propelled submergible vessel comprising:
a substantially fixed pressure chamber having walls of sufficient strength to withstand all differential pressures to which the chamber may be subjected;
a variable pressure chamber located tandemly of said fixed pressure chamber and sharing a common wall therewith;
said variable pressure chamber having walls capable of withstanding a pressure differential lower than those to which the vessel may be subjected;
a pool of liquid substantially entirely filling said variable pressure chamber;
said variable pressure chamber having aperture means in its walls;
changeable volume hollow body means watertightly surrounding said aperture means and disposed in the interior of said variable pressure chamber for varying the pressure in said variable pressure chamber in response to sea water pressure acting through said aperture means on said changable volume hollow body means;
a powerplant located in said fixed pressure chamber;
reversible pump means located in said fixed pressure chamber and coupled to said powerplant for being driven thereby;
a propeller shaft extending through the wall of said

variable pressure chamber and supported at its wall by bearing means;

a drive unit located in said variable pressure chamber and coupled to said propeller shaft for driving the shaft; and

fixed conduit means passing fluidtightly through said common wall for coupling said reversible pump to said drive unit.

5. A self-propelled vessel according to claim 4 but further characterized by said reversible pump means having a fixed reservoir conduit extending through the wall of said fixed pressure chamber and having its intake end located in said variable pressure chamber.

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