Dec. 20, 1966 G. W. LEHMANN 3,292,564

EXPLORATION AND SALVAGE SUBMARINE

Filed March 26, 1964 3 Sheets-Sheet 1

Fig. 1.

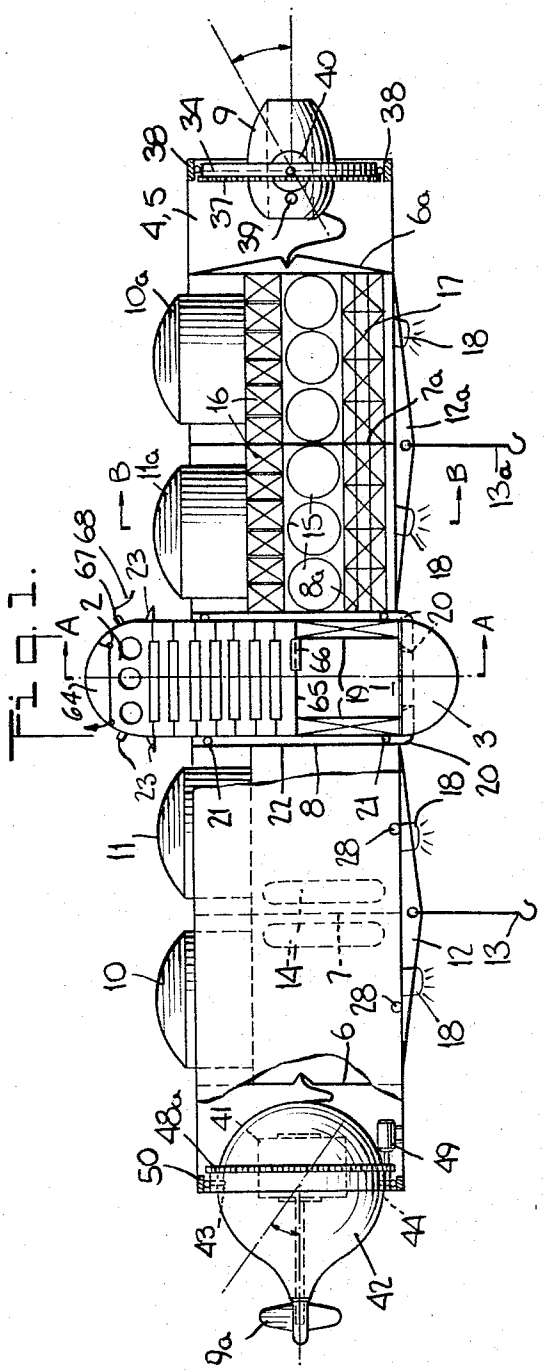
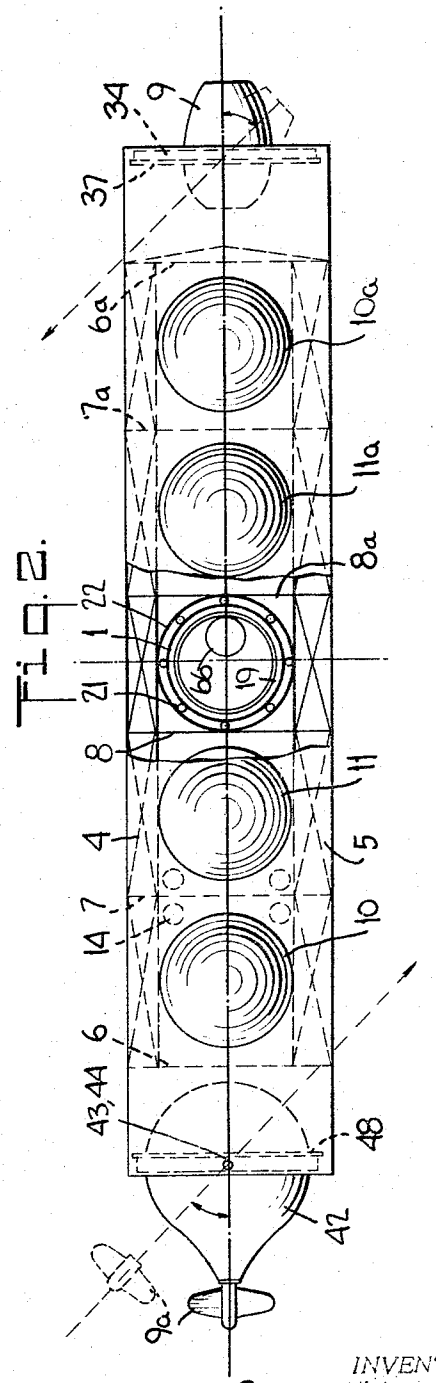


Fig. 2.



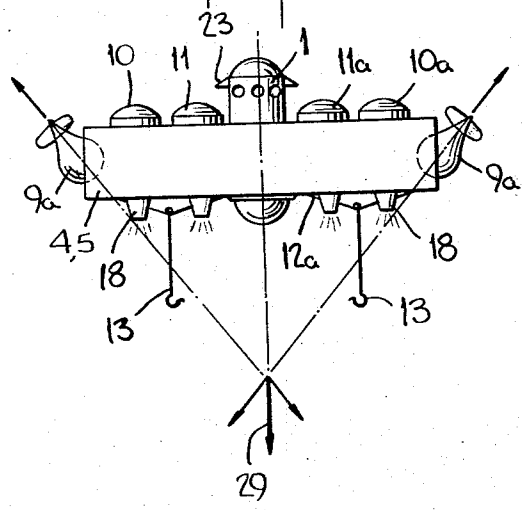
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EXPLORATION AND SALVAGE SUBMARINE

Filed March 26, 1964 3 Sheets-Sheet 2

Fig. 3.



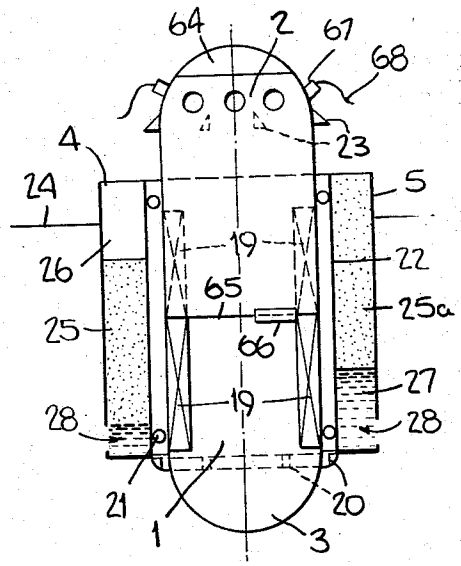


Fig. 4.

Fig. 6.

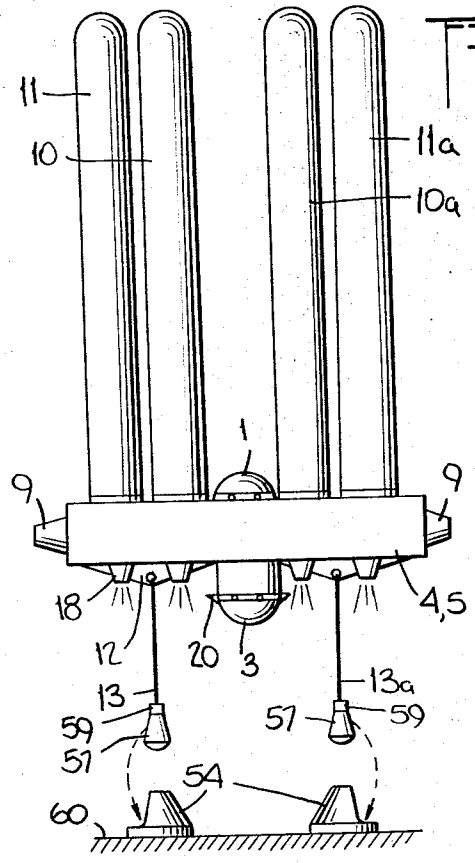
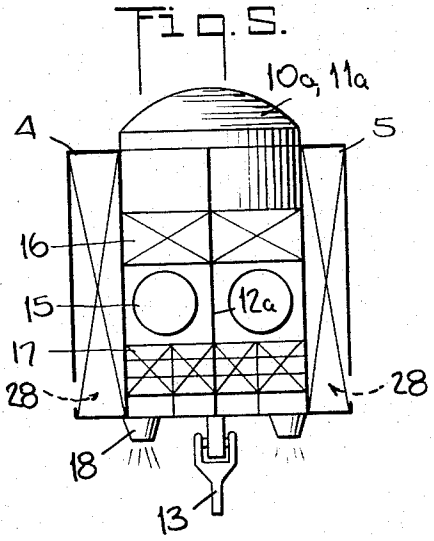


Fig. 5.



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EXPLORATION AND SALVAGE SUBMARINE

Filed March 26, 1964 5 Sheets-Sheet 3

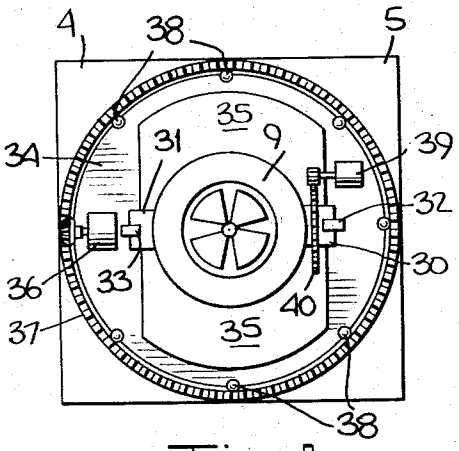
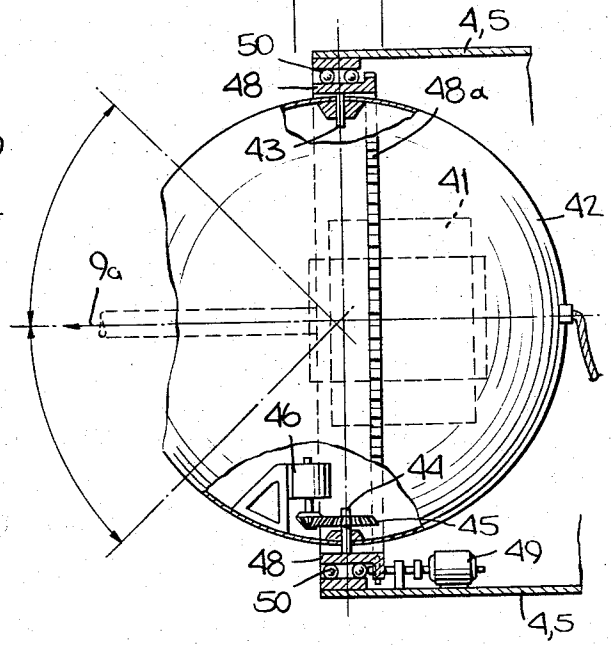


Fig. 8.

Fig. 7.



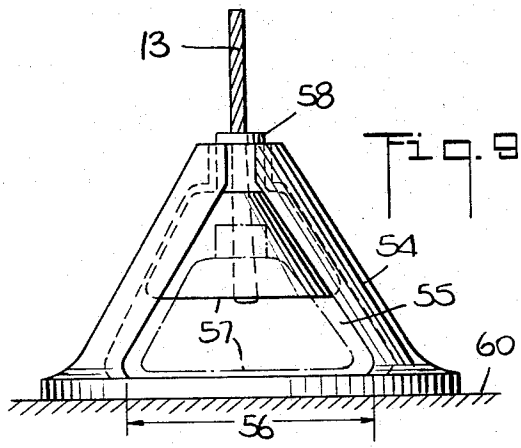
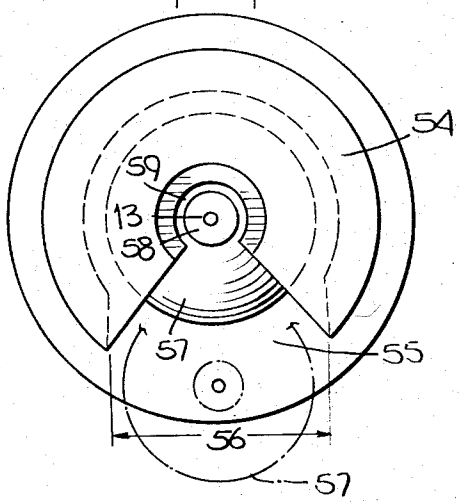


Fig. 9.

Fig. 10.



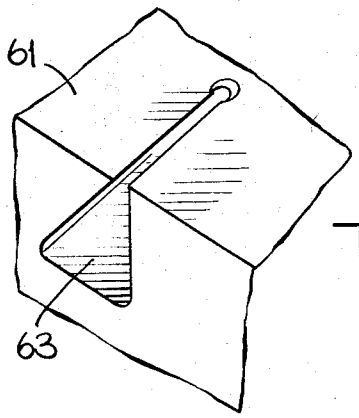


Fig. 11.

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3,292,564

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EXPLORATION AND SALVAGE SUBMARINE

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16 Claims. (Cl. 114—16)

Salvage work has been done in the past up to moderate depths only, mainly on account of restrictions set upon divers with regard to physical endurance of water pressure. Future exploration and salvage work, however, has to be done at considerable greater water depths, particularly with reference to ocean mining operations. It is one objective of the present invention to design a submarine for exploration purposes at great water depths. Another objective of the present invention concerns the attachment of salvage means to the submarine, enabling the submarine, for instance, to salvage stricken ocean mining equipment from the ocean bottom. In other words, a multi-purpose submarine which answers future requirements of deep-sea operations, may it be scientific work or commercial operations, like ocean mining.

It is proposed to provide for the operating personnel a pressure vessel of preferably cylindrical shape with half-spherical ends. The pressure vessel with its main axis in vertical position is embraced by a rigid buoyancy structure which serves as a beam for the attachment of preferably inflatable salvage bags as described in my U.S. Patent No. 3,080,844, and further for the attachment of propulsion organs.

The rigid buoyancy structure, composed of preferably two boxgirders, is designed for neutral buoyancy obtained by partly filling the space of the boxgirders with a fluid lighter than water, and partly filling it with seawater. In this way, the boxgirders are pressure equalized and need not be built of special shapes like cylinders or spheres. Flat boxgirders are also better suited to sustain forces and moments from the salvage gear. However, it is understood that a row of cylinders, stacked one above the other, may replace the recommended boxgirder without departing from the present invention.

Surplus buoyancy is in part produced by the pressure vessel which accommodates the operating personnel. The pressure vessel is not fixedly attached to the boxgirders but has allowance to move up and down. In order to prevent the pressure vessel from slipping in either direction there are noses at the upper and lower rim of the cylindrical part of the pressure vessel. When the vessel is floating at the surface, the lower noses contact the rigid structure of the submarine, exerting a lifting force. When the vessel is submerged with slight negative buoyancy of the pressure vessel, the upper noses contact the rigid structure of the submarine. It is recommended to provide a special cylinder between the boxgirders in which the pressure vessel is housed with the purpose in mind to allow a number of noses coming in contact with the upper and lower rim of the special cylinder.

Ballast tanks within the pressure vessel, when filled, produce a slight negative buoyancy of the pressure vessel, causing the latter to sink until the upper noses contact the rim of the special cylinder. This again produces a vertical load on the submarine structure which contributes to negative buoyancy of the structure, and the submarine will sink. Sinking of the submarine may be assisted by the propulsion means as described later. Draining of the tanks inside the pressure vessel has the opposite effect.

An exploration and salvage submarine designed to work at great water depths requires high maneuverability. It is suggested to install propulsion means capable to produce forces and moments with six degrees of freedom.

To accomplish this, there are at each end of the submarine propulsion means in form of jets or customary propellers which are rotatable around the transverse axis and around the longitudinal axis of the submarine. In this way, thrust forces can be adjusted at any spatial angle. When both propulsion means are acting in the longitudinal axis, the submarine proceeds straight ahead or astern. When the forward thrust is directed under an angle against the longitudinal axis and the aft thrust directed at the same angle in mirror arrangement, both thrusts produce a resultant thrust which transverses the submarine without motion in longitudinal direction. When the propulsion means at the aforesaid adjustment are rotated around the longitudinal axis, the submarine transverses in any longitudinal plane. Limit cases are vertical up and down motions, corresponding to rising and sinking.

When the two propulsion means are rotated around the transverse axis and adjusted under the same angle fore and aft against the longitudinal axis, positive at the one end and negative at the other end, there is a moment produced which rotates the submarine on the spot when both thrusts are the same. Again, when both propulsion means are rotated in this position around the longitudinal axis, the submarine turns on the spot in the respective plane. A limit case is the rotation of the submarine from its level position into a vertical position with ends up-side-down.

When currents are present, and it is desired to keep the submarine motionless against such currents, the forward and aft propulsion means can be adjusted in such manner that the resultant thrust produces the required counterforce and countermoment. This applies not only for currents in the level plane but for currents in any other plane, for instance, downward currents or currents which may attack the submarine from any direction. The propulsion means can be rotated around the longitudinal axis under 360 degrees. For practical reasons the rotation for the propulsion means around the transverse axis is limited to ± 45 degrees which is sufficient to product the desired effect.

Salvage means are arranged in the space between the two boxgirders. To provide stiffness of the structure, particularly with reference to salvage forces, the two boxgirders are crossconnected by bulkheads. Longitudinal centerbeams transfer salvage hook forces to the structure on which the salvage bags are suspended, i.e., the two boxgirders and appropriate foundations for the salvage bags.

Since a diver cannot work at great water depths, fastening jobs of salvage hooks have to be done remote-controlled by special means. It is suggested to use a conical shaped body attached to the lower end of the salvage rope or chain. The cone is introduced by proper submarine maneuvers into a matching conical sleeve which is fastened to ships, barges and the like structure beforehand as a precautional measure.

In order to introduce the cone into the sleeve, the sleeve has at the side a slot. This will be done by proper maneuvers of the submarine. After the cone is engaged in the hollow of the sleeve, the submarine is slightly raised which causes the cone to be firmly hooked at the salvage object. This procedure is repeated at several locations. With all salvage bags placed in hooking position, the salvage bags are simultaneously inflated by remote controlled means, and the salvage object is raised.

Since only the salvage bags and the boxgirders are needed for the salvage operation, the pressure vessel, accommodating the operating personnel, has no function anymore. It is therefore a special feature of the present invention that the pressure vessel detaches herself from

the structure of the submarine after completion of the attachment work. It is also suggested to detach the pressure vessel from the structure of the submarine from each unit after completion of the attachment work of each unit, and to insert the pressure vessel into each following unit. In this way, one pressure vessel can serve a number of salvage beams, in order to use this expression for the rigid structure of the submarine less the pressure vessel.

Detachment of the pressure vessel from the rigid structure of the submarine is accomplished by removing the lower ring of the pressure vessel which carries the lower noses. The ring, and consquently the noses are removed preferably by remote controlled means from inside the pressure vessel, preferably by explosion rivets. Prior to removal of the nose-ring, the ballast tanks inside the pressure vessel are blown resulting in positive buoyancy of the pressure vessel which enables the pressure vessel to rise immediately upon removal of the nose-ring. The pressure vessel and the operating personnel ascend to the surface. The possibility of an easy attachment of the pressure vessel from the rigid structure of the submarine provides at the same time a safety measure when for any reason the operating personnel has to abandon the submarine using the pressure vessel as a rescue vehicle.

The space between the boxgirders is occupied by gas producing apparatus, air flasks, batteries, fuel-cells and other equipment as needed for the operation of the submarine.

Power cables leading from the pressure vessel to the propulsion means and other equipment are preferably arranged at the upper portion of the pressure vessel with enough length to yield vertical movements of the pressure vessel. At those points where the power cables are going through the shell of the pressure vessel, there are remote controlled detachable means for releasing of the power cables when the pressure vessel detaches herself from the rigid submarine structure as previously mentioned.

It should be appreciated that the advantages of the present invention with regard to high maneuverability and to use the submarine as a salvage means are mainly obtained by a basically symmetrical layout of the submarine with reference to the midship transverse plane.

Other features and innovations of the invention will become more apparent when the description proceeds in conjunction with the drawing of a preferred embodiment of the invention, wherein:

FIG. 1 is a side elevation of the submarine showing alternately a jet propulsion means and a customary propeller;

FIG. 2 is a plan view of FIG. 1;

FIG. 3 is a side elevation showing propellers for translatory motion of the submarine, here downward motion;

FIG. 4 is a cross-section along line A—A of FIG. 1;

FIG. 5 is a cross-section along line B—B of FIG. 1;

FIG. 6 is a side elevation of the submarine with salvage bags in operating condition and salvage rope attachment cones;

FIG. 7 shows the drive arrangement for rotating a customary propeller around the longitudinal axis and the transverse axis;

FIG. 8 shows the drive arrangement for rotating a jet propulsion means around the longitudinal axis and the transverse axis;

FIG. 9 is an elevation of the salvage sleeve;

FIG. 10 is a plan view of the salvage sleeve;

FIG. 11 is a view on a built-in salvage sleeve at the side of a barge.

Referring now to the drawing, and particularly to FIG. 1, there is a pressure vessel **1** with an upper half-sphere **2** and a lower half-sphere **3**. The pressure vessel **1** is arranged between two boxgirders, **4**, **5**, which are cross-connected by bulkheads **6**, **7**, **8**, and **6***a*, **7***a*, **8***a*. Propulsion means **9** and **9***a* are arranged at the ends of the boxgirders **4**, **5**. Number **9** indicates a jet type propulsion means, and number **9***a* a customary propeller. Salvage bags **10**, **11** and **10***a*, **11***a* are arranged between boxgirders **4**, **5**, shown in folded condition in FIG. 1 and in operating condition in FIG. 6. Beams **12**, **12***a* connect the base of the salvage bags and adjacent structure and carry salvage ropes **13**, **13***a*. The space between the boxgirders **4**, **5** is occupied by equipment like air flasks **14** and spheres **15**, gas producing means **16**, fuel-cells **17**. Lights **18** are arranged at the lower portion of the submarine.

The pressure vessel **1** has inside tanks **19**. When the submarine is at the surface, tanks **19** are empty, and noses **20** at the lower portion of the pressure vessel **1** contact the lower rim of a special cylinder **22** which is connected to the boxgirders **4**, **5**, exerting an upright force on the submarine. When the tanks **19** are ballasted, the pressure vessel **1** has negative buoyancy and sinks. During sinking the pressure vessel **1** is guided by rollers **21** between the pressure vessel **1** and the special cylinder **22**. The pressure vessel **1** sinks down until noses **23** contact the upper rim of the special cylinder **22**. In this position of the pressure vessel **1** the lower half-sphere, preferably built of glass, allows an unobstructed view to the outside, preferably to salvage gear.

When the submarine floats at the surface **24**, FIG. 4, the boxgirders **4**, **5** are filled with fluid lighter than water at the lower portion of the tank **25**, the upper portion **26** occupied by air. In order to destroy buoyancy, air **26** is released, whereupon fluid occupies the upper portion **25***a* of the boxgirder space, and the lower portion **27** is occupied by seawater which passes through openings **28**.

It is recommended to design the submarine in this condition with neutral buoyancy, except the small buoyancy of the pressure vessel **1**. Negative buoyancy of the entire system is produced by filling tanks **19** as previously described. After filling of tanks **19**, the submarine sinks, ready to assume underwater work. Sinking of the submarine may be assisted by placing the propulsion means in appropriate position as shown in FIG. 3 producing a resultant thrust **29** which pulls the submarine down.

Referring now to FIG. 8, a jet propulsion means **9** is hinged at **30**, **31** with bearings **32**, **33** which are attached to a rotatable sheave **34** having ample openings **35** for transverse rotation of the propulsion means **9**. The sheave **34** is rotated by a motor **36** which engages a bevel gear ring **37** attached to the boxgirders **4**, **5** and adjacent structure as best shown in FIG. 1. The sheave **34** is kept in position by thrust bearings **38**. The propulsion means **9** is rotated around a transverse axis by a motor **39** via a tooth gear rim **40**. The motor **39** is attached to the sheave **34**.

A customary propeller **9***a*, as shown in FIGS. 1 and 7, is driven by an electromotor **41** housed in a spherical body **42**. The spherical body **42** is rotatable around the transverse axis by the aid of pins **43**, **44**. The pin **44** carries a bevel gear **45**. A motor **46** attached to the spherical body **42** and engaging the bevel gear **45** rotates the propeller **9***a* around the transverse axis. Pins **43**, **44** are fastened to a ring **48** carrying a bevel gear ring **48***a* in the transverse plane which is rotated by a motor **49** attached to the boxgirder structure. The ring **48** is kept in place by thrust bearings **50**. Sphere **42** is filled with fluid.

Referring to the salvage hooking device as shown in FIGS. 9, 10 and 11, there is a sleeve **54** which has a slot **55** with an opening **56** that a cone **57** can be introduced in the hollow of the sleeve **54**. The cone **57** is attached to a salvage rope **13**. After the cone is introduced into the sleeve **54** and lifted, the upper part **58** of the cone **57** engages a hole **59** of the sleeve **54** which prevents the cone **57** from slipping. In this position the cone **57** contacts the inner surface of the sleeve **54** and is able to transmit salvage forces. It should be appreciated that the opening of the hole **59** is slightly larger than the diameter of the salvage rope **13**, and the bore of the hole **59** slightly larger than the diameter of the upper part of the cone **57**.

The upper part **58** of the cone **57** is perferably of cylindrical shape. Sleeves **54** are attached to salvage objects **60** as shown in FIG. 6. A number of sleeves may be attached to hard points of ships, barges and the like structures. Another arrangement of the sleeves **54** is shown in FIG. 11. A barge **61** has at a number of places at the side matching channels **63** in which the cone **57** is introduced by proper manuevering of the submarine in the same fashion as shown in FIG. 9 for establishing salvage rope connections. It should be appreciated that the high maneuver capabilities of the submarine on account of the special arrangement of the propulsion units as described previously will greatly contribute to the establishment of salvage rope connections to the salvage object at great water depths where customary diver work to perform such jobs is prohibitive.

The upper half-sphere **2** of the pressure vessel **1** carries an access hatch **64**. Tanks **19** may be arranged at the lower portion or at the upper portion of the pressure vessel **1** as indicated by dotted lines in FIG. 4. A platform **65** divides the space of the pressure vessel **1** in an upper and in a lower observation space. The platform **65** has a hatch opening **66**. Detachment means **67** hold cables **68**, FIG. 4.

While the invention has been described in connection with a single embodiment, it will be obvious that many changes and modifications in structural details may occur to the skilled in the art, particularly after benefiting from the present teaching, without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An exploration and salvage submarine, comprising a cylindrical pressure vessel with half-spherical ends in vertical positioning between two longitudinal boxgirders, inflatable salvage bags fore and aft of said pressure vessel and attached to said two longitudinal boxgirders, propulsion means at both ends of the submarine attached to and between said two longitudinal boxgirders, transverse bulkheads connecting said two longitudinal boxgirders, structural transverse and longitudinal members at the lower portion of said bulkheads fore and aft of the pressure vessel and salvage ropes and hooks attached thereto.

2. The exploration and salvage submarine of claim **1**, wherein the cylindrical pressure vessel is floating at positive buoyancy while the system is at the surface, and equipped inside with ballast tanks for producing a negative buoyancy of the cylindrical pressure vessel while the system is submerged.

3. The exploration and salvage submarine of claim **1**, wherein said two longitudinal boxgirders define buoyancy spaces on port and star-board which are partly filled with a fluid lighter than water in their lower portion and with air in their upper portion for positive buoyancy of the system, openings at the lower portion of said boxgirders allowing entrance of water when the said air is allowed to escape for producing neutral or slightly negative buoyancy when the system is submerged with said boxgirders pressure equalized when their space is filled entirely with water and fluid.

4. The exploration and salvage submarine of claim **1**, wherein the propulsion means at both ends of the submarine are rotatably attached to the longitudinal boxgirders around the longitudinal axis and the transverse axis.

5. The exploration and salvage submarine of claim **4**, wherein the propulsion means consist of a reversible submersible electromotor, a propeller shaft, a propeller, and the propulsion means housed in a pressure equalized sphere having a pear-shaped extension accommodating the shaft and the propeller, and said sphere filled with fluid.

6. The exploration and salvage submarine of claim **5**, wherein the said sphere rotates around the transverse axis by the aid of two rods, said rods engaging bearings fixedly attached to the sphere, said rods fixedly attached to a ring which rotates around the longitudinal axis, said ring held in position by thrust bearings fixedly attached to the longitudinal boxgirders and other adjacent structure of the vehicle.

7. The exploration and salvage submarine of claim **1**, having a first motor and gear for rotating said propulsion means around the longitudinal axis, and a second motor and gear for rotating said propulsion means around the transverse axis.

8. The exploration and salvage submarine of claim **1**, having a power supply cable to the propulsion means extending from the end-bulkhead and of sufficient length beyond the end-bulkhead to allow for rotation of the propulsion means around the longitudinal axis and the transverse axis.

9. The exploration and salvage submarine of claim **1**, equipped with at least one salvage rope, said salvage rope carrying at its lower end a cone with an upper cylindrical extension, said cone matching the hollow of a conical sleeve with a corresponding slot for introducing said cone, said sleeve attached to surface structures beforehand as a precautional measure, said sleeve having a bore at the upper end with a diameter slightly greater than the diameter of the cylindrical upper extension of the cone, said bore having a slot with an opening slightly greater than the diameter of the salvage rope.

10. The exploration and salvage submarine of claim **1**, having power supply cables from inside of the pressure vessel to outside, said cables being of sufficient length to yield vertical movements of the pressure vessel.

11. The exploration and salvage submarine of claim **1**, having structural members basically in symmetrical arrangement relative to the midship transverse plane.

12. An exploration and salvage submarine, comprising a cylindrical pressure vessel with half-spherical ends mounted movably in vertical direction between two longitudinal boxgirders, inflatable salvage bags fore and aft of said pressure vessel and attached to said two longitudinal boxgirders, propulsion means at both ends of the submarine attached to and between said two longitudinal boxgirders, transverse bulkheads connecting said two longitudinal boxgirders, structural transverse and longitudinal members at the lower portion of said bulkheads fore and aft of the pressure vessel, and salvage ropes and hooks attached thereto.

13. An exploration and salvage submarine, comprising a cylindrical pressure vessel with half-spherical ends mounted movably in vertical direction between two longitudinal boxgirders within a special cylinder attached to said boxgirders, inflatable salvage bags fore and aft of said pressure vessel and attached to said two longitudinal boxgirders, propulsion means at both ends of the submarine attached to and between said two longitudinal boxgirders, transverse bulkheads connecting said two longitudinal boxgirders, structural transverse and longitudinal members at the lower portion of said bulkheads fore and aft of the pressure vessel, and salvage ropes and hooks attached thereto.

14. The exploration and salvage submarine of claim **12**, wherein the cylindrical pressure vessel is floating at positive buoyancy while the system is at the surface and equipped inside with ballast tanks for producing a negative buoyancy of the cylindrical pressure vessel while the system is submerged.

15. The exploration and salvage submarine of claim **1** having power supply cables from inside of the pressure vessel to outside arranged at the upper half-spherical structure, said cables being of sufficient length to yield vertical movements of the pressure vessel.

16. The exploration and salvage submarine of claim **1**, wherein the propulsion means are housed in a pressure-equalized sphere.

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