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SUBMERSIBLE PRESSURE VESSEL

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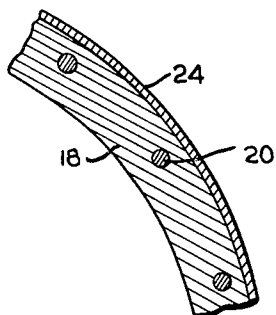
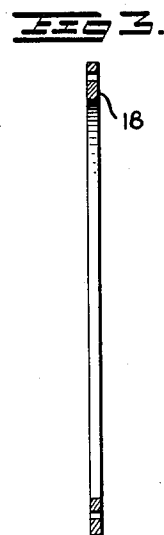
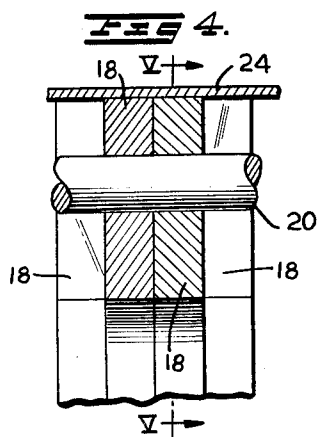
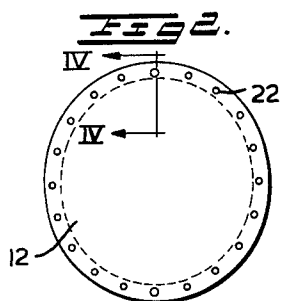
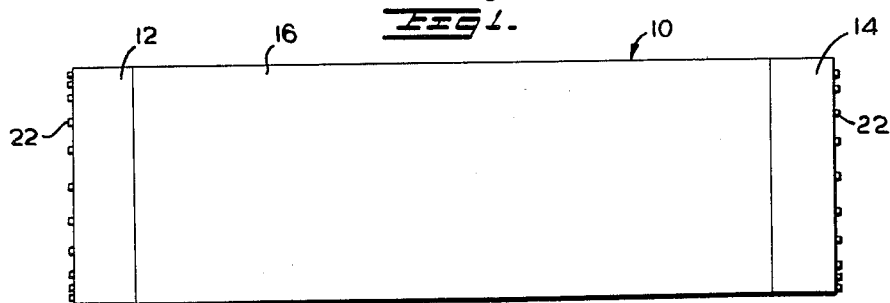


FIG 5.

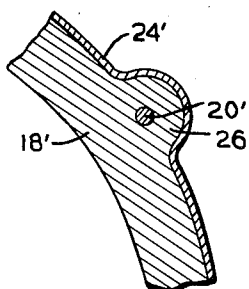


FIG 6.

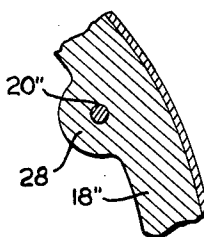


FIG 7.

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1

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SUBMERSIBLE PRESSURE VESSEL

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This invention relates to improvements in construction of submarine hulls and the like which are subjected to great pressures when deeply submerged under the surface of the water.

Conventional submarines submerge to depths at which a steel hull is sufficiently strong for the purpose of withstanding the water pressures at those depths; e.g., a maximum depth of about 500 feet. When designing hulls for greater depths, such as 16,000 feet, the thickness of steel necessary to withstand the water pressure becomes so great as to destroy the necessary buoyancy. For example, a cylindrical hull having an inside diameter of 6 feet would have to have a wall thickness of about 4 inches of steel to withstand pressures at 16,000-foot depths. On the other hand, if aluminum is used, the hull thickness has to be greater (e.g., about 6 inches for a cylindrical hull having an inside diameter of about 6 feet), but the lighter weight of the aluminum more than compensates for the extra thickness which is necessary, and as a result the necessary buoyancy can be preserved.

Conventional steel hull fabrication methods would not be suitable for an aluminum hull designed for submergence at depths in the order of 16,000 feet, for example, and problems of corrosion must also be taken into account.

In accordance with the present invention, an improved hull design suitable for submergence at great depths is provided. The strength members of the hull can be made of high-strength aluminum, which is not weakened by welded joints. In order to protect the high-strength members from corrosion, the invention further provides, in its present preferred embodiment, a skin of high-purity aluminum which extends around the high-strength members and serves the double function of sealing the joints between them against leakage into the hull, and of covering the high-strength members so that they are not subjected to corrosion. While a skin of high-strength aluminum is preferred for this purpose, other materials can be used, such as plastics.

For a better understanding of the invention, reference is now made to the accompanying drawings, in which there are shown, for purposes of illustration only, present preferred embodiments of the invention. In the drawings:

FIG. 1 is a semidiagrammatic side elevation of a pressure hull constructed in accordance with the invention;

FIG. 2 is an end elevation of the hull shown in FIG. 1;

FIG. 3 is an enlarged transverse sectional view of one of the ring elements forming the hull shown in FIG. 1;

FIG. 4 is an enlarged view of a section taken on the line IV-IV in FIG. 2, partially broken away;

FIG. 5 is a view of a section taken on the line V-V in FIG. 4;

FIG. 6 is a sectional view corresponding to FIG. 5, but showing a modified species of the invention; and

FIG. 7 is a sectional view corresponding to FIG. 5, but showing another species of the invention.

Referring now more particularly to the drawings, and initially to FIG. 1, there is illustrated a pressure hull 10 comprising a pair of opposite end members 12 and 14, and an intermediate section 16. The end members 12 and 14 are shown as round heavy plates which are flat on both sides, but these members can be forged into other shapes suitable for particular purposes, and having suit-

2

able fittings for observations ports, hatches and propulsion means, as will be understood by those skilled in the art.

The intermediate section 16 is made up of a series of hollow rings 18 which are adapted to fit tightly against each other on both sides or, in the case of the endmost rings 18, against one of the end members 12 or 14. The rings 18 are held tightly against each other by a series of tie rods 20 extending parallel to the aligned central axes of the rings 18, and preferably made of high-strength alloy steel. In the illustrated example, the tie rods 20 also extend through the end members 12 and 14, and are secured thereto by nuts 22 which are tightened to compress the rings 18 between the end members 12 and 14. Other methods of arranging the tie rods and securing their ends can be used. For example, it is possible to use a series of relatively short tie rods which bolt against intermediate rings and are arranged in endwise staggered relation so that the hull as a whole is held together in unitary endwise compression.

The rings 18 are preferably made of high-strength aluminum alloys, and in the present state of the art such alloys are known to be relatively susceptible to corrosion in salt water. Moreover, although tight compression of the tie rods 20 operates to seal the joints between the rings 18, particularly if the joints are sealed by a suitable underwater sealant, it is nevertheless desirable to make absolutely sure that there will be no leakage when the hull is submerged at very great depths. Accordingly, a continuous water-tight sheath 24 of high-purity aluminum (e.g., 99.7% aluminum) is wrapped entirely around the rings 18. The sheath 24 is held tightly against the rings 18 by water pressure when the hull is submerged, but it is preferable to secure the sheath 24 to the rings 18 in order to resist tearing as a result of striking against some object, particularly when the hull is at or near the surface of the water. A suitable cement can be used for that purpose, or tack-welding can be employed. The sheath 24 is also secured in water-tight relation around the end members 12 and 14, to prevent seepage of water between the outermost rings 18 and the sheath 24. The thickness of the sheath 24 need not be great, but it should be ample to resist tearing against outside objects. At the present time, a thickness of about 1/4 inch, for example, is considered adequate in the case of a hull having rings 18 of an inside diameter of about 6 feet.

The rings 18 can be of any desired thickness, but the invention contemplates efficient and economic construction of the hull by rolling high-strength aluminum alloy to a suitable plate thickness (e.g., about 1 1/2 inches) and then cutting out the rings, preferably in a stamping operation. The holes for the tie rods 20 can be made to fit closely around the tie rods, and thereby enhance the strength of the final assembled structure.

The rings 18 referred to in FIGS. 1-5 have the rod holes formed through the main body of each ring, which is continuously circular along its inside and outside circumferences. Alternatively, the rings can be formed with a series of ears for receiving the tie rods, as shown in FIGS. 6 and 7. The ring 18' shown in FIG. 6 has a series of outwardly extending ears 26 for receiving tie rods 20' through openings in or next to the ears 26, and the outer sheath 24' is curved to fit around the ears. The ring 18'' shown in FIG. 7 has a series of inwardly extending ears 28 for receiving tie rods 20'' through openings in the ears 28. Of these two modifications, the outwardly extending ears of FIG. 6 are preferable, because they concentrate the compressive force near the outside of the rings, where it is of greatest service in resisting the pressure against the outside of the hull.

The dimensions stated in the examples given above can

readily be extrapolated for hulls and like pressure vessels of other sizes, because there is no weakening of the joints due to welding to complicate the calculations.

While present preferred embodiments of the invention and methods of practicing the same have been illustrated and described, it will be understood that the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. A submersible marine pressure vessel sealed around its entire boundary surface to prevent entry of water into its hollow interior, said vessel comprising a series of metal rings arranged coaxially in side-by-side relation to form a substantially cylindrical wall, said rings having opposed faces in metal-to-metal abutting relation, said rings having openings formed therein between their inner and outer peripheries, said openings being aligned to form continuous openings along the length of said cylindrical wall, tie rods extending through said openings parallel to the axis of said rings, means connected to the ends of said tie rods and axially compressing said rings to press their opposed faces tightly together, means closing and sealing the opposite ends of the cylindrical wall formed by said rings, and a sheath of metal surrounding the outside of the cylindrical wall formed by said rings for protecting the rings against salt water corrosion and sealing the joints between their opposed faces.

2. A submersible marine pressure vessel sealed around its entire boundary surface to prevent entry of water into its hollow interior, said vessel comprising a series of metal rings arranged coaxially in side-by-side relation to form a substantially cylindrical wall, said rings having opposed faces in metal-to-metal abutting relation, said rings having openings formed therein between their inner and outer peripheries, said openings being aligned to form continuous openings along the length of said cylindrical wall, end plates extending across the opposite ends of said cylindrical wall, said end plates having openings formed therein aligned with the openings in said rings, tie rods extending through said openings in said rings and said end plates, means connected to the ends of said tie rods and axially compressing said rings to force their opposed faces tightly together, a generally cylindrical sheet of metal surrounding the outer surface of said rings for protecting the rings against salt water corrosion and sealing the joints between their opposed face.

3. A submersible marine pressure vessel sealed around its entire boundary surface to prevent entry of water into its hollow interior, said vessel comprising a series of aluminum alloy rings arranged coaxially in side-by-side relation

to form a substantially cylindrical wall, said rings having opposed faces in metal-to-metal abutting relation, said faces extending substantially normal to the axis of the rings, said rings having openings formed therein between their inner and outer peripheries, tie rods extending through said openings parallel to the axis of the rings, means connected to the ends of said tie rods and axially compressing said rings to force their opposed faces tightly together, means closing and sealing the opposite ends of the cylindrical wall formed by said rings, and a sheath of aluminum alloy containing at least 99.7 percent aluminum extending around and adhering to the outside of the cylindrical wall formed by the said rings, thereby protecting the rings against salt water corrosion and sealing the joints between their opposed faces.

4. A submersible marine pressure vessel sealed around its entire boundary surface to prevent entry of water into its hollow interior, said vessel comprising a series of aluminum alloy rings having an inner diameter of at least about six feet, said rings being arranged coaxially in side-by-side relation to form a substantially cylindrical wall, said rings having opposed faces in metal-to-metal abutting relation, said faces extending substantially normal to the axis of the rings, said cylindrical wall formed by said rings having a thickness of at least about six inches, said rings having openings formed therein between their inner and outer peripheries; tie rods extending through said openings parallel to the axis of said rings, said rings having a series of projections along their peripheries adjacent to which the tie rods extend; means connected to the ends of said tie rods and axially compressing said rings to force their opposed faces tightly together; means closing and sealing the opposite ends of the cylindrical wall formed by said rings; and a sheath of aluminum alloy containing at least 99.7 percent aluminum extending around and adhering to the outside of the cylindrical wall formed by the said rings, said sheath protecting the rings against salt water corrosion and sealing the joints between their opposed faces.

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