# United States Patent

[11] 3,611,970


[72] Inventors **Richard H. Hagan**
**Springfield, Pa.;**
**Lewis C. Hazlett, Wilmington, Del.;**
**William Watson, Wallingford, Pa.**



[21] Appl. No. **883,833**
[22] Filed **Dec. 10, 1969**
[45] Patented **Oct. 12, 1971**
[73] Assignee **Sun Shipbuilding & Dry Dock Company**
**Chester, Pa.**


[54] **HIGH-PRESSURE WINDOW ARRANGEMENT**
**4 Claims, 3 Drawing Figs.**


[52] **U.S. Cl.** ..... **114/177**
[51] **Int. Cl.** ..... **B63b 19/00**
[50] **Field of Search** ..... 114/173, 177; 52/80, 200



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,186,450 | 1/1940 | Ducroux | 114/177 |
| 2,602,198 | 7/1952 | Parker | 114/177 |
| 2,659,462 | 11/1953 | Schwartz et al. | 52/80 |
| 3,186,523 | 6/1965 | Brisse | 52/80 |
| 3,371,635 | 3/1968 | Seeley | 114/16 |



*Primary Examiner*—Andrew H. Farrell
*Attorneys*—George L. Church, Donald R. Johnson, Wilmer E. McCorquodale, Jr. and Frank A. Rechif



**ABSTRACT:** A transparent viewing window for high-pressure use, e.g. in a submarine, is made of an organic thermoplastic material and has the form of a hemispherical shell. The window is secured in place covering an opening in the submarine hull or skin by means of a clamping ring which engages the outer surface of the window and is bolted to the hull. An O-ring provides a low-pressure seal between the window and the skin of the submarine.

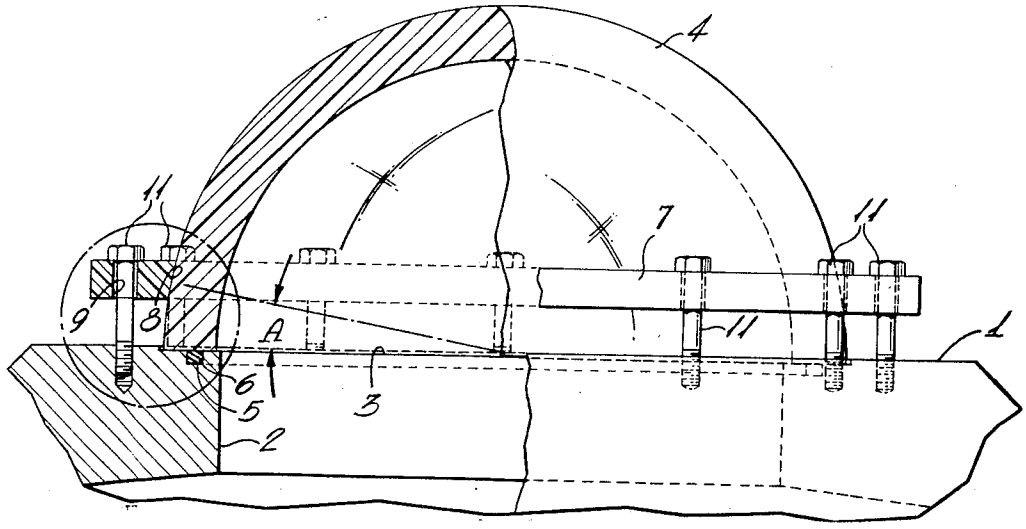



FIG. 2.

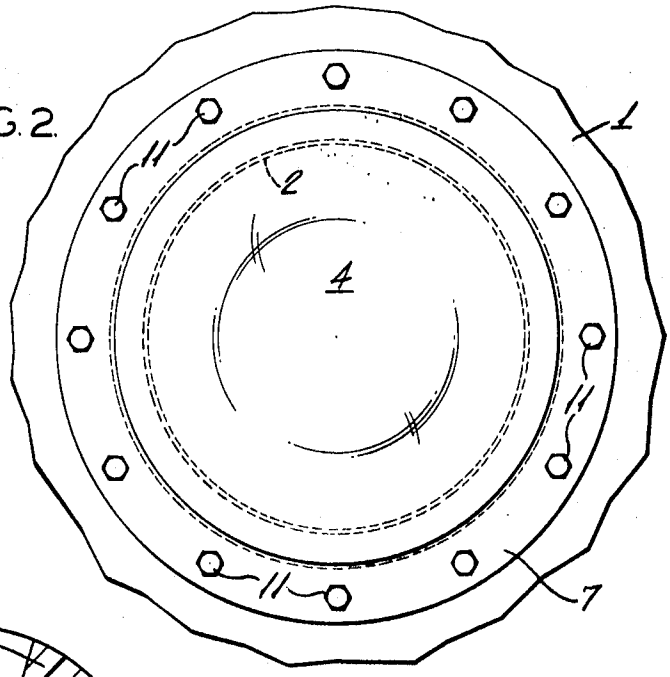



FIG. 3.

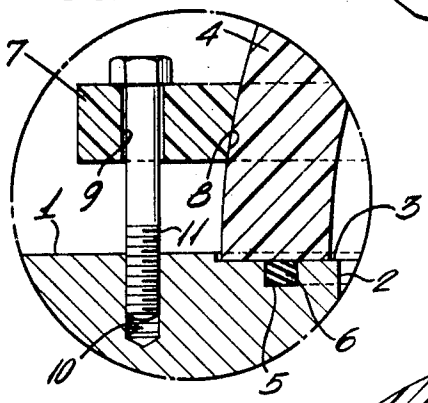
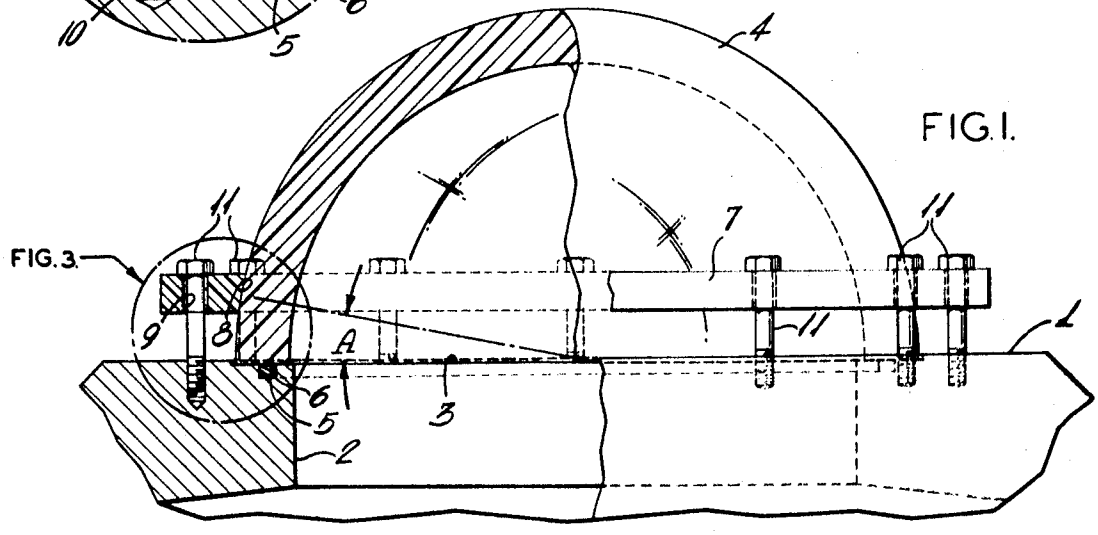



FIG. 1.




INVENTORS:
RICHARD H. HAGAN
LEWIS C. HAZLETT
WILLIAM WATSON
BY Donald R. Johnson
ATTY

# HIGH-PRESSURE WINDOW ARRANGEMENT

This invention relates to a transparent window and a mounting arrangement therefor which are particularly adapted for use under high-pressure conditions, i.e. where there is a substantial pressure differential across the window. Typically, the window arrangement of this invention may be used in a manned submersible craft which is adapted to be used for search, survey, and scientific purposes and which is designed for deep submergence, on the order of 1,000 feet, for example. It is pointed out that at a depth of 1,000 feet in sea water, the water pressure is about 444 p.s.i.; since the interior of the craft is operated at atmospheric pressure, there is a substantial pressure differential across the window. (Since the window is to be used for purposes of observation, the outer surface thereof is in direct contact with the water in which the submersible is submerged).

An object of this invention is to provide a novel window for use under high-pressure conditions.

Another object is to provide a novel mounting arrangement for submarine windows.

A further object is to provide a novel sealing means for submarine windows.

The objects of this invention are accomplished, briefly, in the following manner: A transparent window, having the shape of a hemispherical shell and molded from a suitable thermoplastic material, is secured in place covering an opening in the metallic skin of a submarine, by means of a rigid clamping ring which engages the outer curved surface of the window and which is bolted to the submarine's skin, adjacent the window opening. An O-ring which is positioned in an annular groove in the outer surface of the skin at the window opening, engages the annular end face of the hemispherical window to provide a low-pressure seal.

A detailed description of the invention follows, taken in conjunction with the accompanying drawing, wherein:

FIG. 1 is a view, partly in section, through the skin or hull of a submarine incorporating this invention;

FIG. 2 is a front elevation or face view, on a smaller scale, of a submarine window or viewport, looking from the outside of the submarine; and

FIG. 3 is a sectional view of a detail, drawn on an enlarged scale.

Now referring to the drawing, the numeral **1** denotes a portion of the metallic outer skin or hull of a submarine. By way of example, the submarine hull may be substantially spherical in overall shape, and may be made of a high-strength steel known as HY-100, such that it is capable of withstanding substantial external pressure. A circular opening **2** is provided in the forward-facing portion of the spherical skin **1** to provide for a viewport. In a small, two-man submarine of the general type referred to hereinbefore, two of these openings would normally be provided in the forward portion of the skin, but since the structural arrangement at one opening is exactly duplicated at the other, only one such arrangement will be described in detail.

A very shallow (about 60 mils deep, for example) annular planar seating groove **3**, whose I.D. is the same as the diameter of opening **2** and whose O.D. is sufficient to accommodate the O.D. of a hemispherical window **4**, is provided in the outer surface of the skin **1**. Window **4** has the form of a hemispherical shell, with an I.D. of 8 inches, and may have a nominal thickness of three-fourths inch. Window **4** covers the opening **2**, with its substantially planar annular end face engaging the annular surface of groove **3**.

The transparent window **4** is molded from a suitable organic thermoplastic resin, such as the acrylic resin sold under the name "Plexiglas". This organic thermoplastic material is capable of withstanding substantial external pressure, and in a much more reliable manner than an inorganic window material such as glass. The hemispherical shape of the window **4** allows it to be much thinner than a flat plate would be, for the same strength; the reduction in the window thickness provides for improved vision therethrough. In addition, a hemispherical window provides a greater field of vision than would a flat window.



An annular groove **5** is provided in the outer face of skin **1**, approximately midway between the I.D. and the O.D. of groove **3**, and an O-ring **6** is positioned in groove **5**. The O-ring **6** is adapted to engage the annular end surface of the hemispherical shell **4**, to act as an initial or low-pressure sealing means at the joint between the end surface of the window **4** and the skin **1**. Under higher pressure conditions, e.g. as the submarine submerges to increasing depths, the external water pressure, acting against the outer surface of window **4**, forces the annular end surface of the hemisphere against skin **1** at groove **3** to provide the seal. Under these latter or high-pressure conditions, the O-ring **6** is less important.

To secure window **4** in place covering the opening **2**, a rigid clamping ring **7** is utilized. Ring **7** may be one-half inch thick and is preferably made of the same material as is window **4**. The inner face of ring **7** has a planar beveled surface **8** which engages the outer curved surface of window **4** at a location (more specifically set forth hereinafter) which is somewhat above (referring to FIGS. **1** and **3**) the annular end surface of the hemisphere. Ring **7** has therein a plurality (say 12 in number) of holes **9** which are located at equal intervals on a base circle centered at the center of the ring, and a matching set of tapped holes **10** are provided in the outer face of skin **1**. A cap screw **11**, made of stainless steel for example, extends through each respective ring hole **9** and threads into the respective aligned tapped skin hole **10**, the head of each screw **11** engaging the outer face (upper face in FIGS. **1** and **3**) of ring **7**. In assembly, the series of bolts **11** are tightened sufficiently to place the O-ring **6** under some compression, by forcing the annular end surface of window **4** against this O-ring.

The location of the clamping ring **7**, relative to the window **4** and to the skin **1**, is rather important. This ring should be far enough from the metal surface (i.e., from the outer face of skin **1**) to permit sufficient force to be exerted through it (as a result of the forces provided by screw **11**) on window **4**, to provide a seal by means of O-ring **6**. On the other hand, ring **7** should be close enough to this metal surface to not appreciably (adversely) affect the visibility through window **4**. Taking into consideration both of the criteria just mentioned, it has been determined that the optimum distance between the outer face of skin **1** and the outer (i.e., upper in FIG. **3**) face of ring **7** should be one inch. For the 8 inch I.D. window **4**, this would mean that the angle A between the plane of the planar outer surface of skin **1** (adjacent the window **4**) and a plane passing through the center of curvature of hemisphere **4** and the midpoint of the beveled surface **8**, should have a value of 9°5′.

As mentioned hereinbefore, a two-man submarine of the type referred to previously by way of example would have two forward-looking viewports, and each of these would have a hemispherical window such as previously described, secured in position by a mounting arrangement such as just described. Each of these two windows would be stationary or relatively fixed in position.

The submarine mentioned may also have a top window covering an opening in a hatch plate which is pivotally secured to the upper region of the spherical hull or skin. This top window also has the form of a hemispherical shell, and is secured in place on the pivoted hatch plate by a mounting arrangement exactly similar to that previously described. The top window similar to window **4**, and its clamping ring similar to ring **7**, are preferably made of the same material as window **4** and ring **7**. The top window, however, would have an I.D. of 16 inches and a nominal thickness of 1¼ inches. The clamping ring for the top window would necessarily be of a diameter to suit the top window. For the top window, the angle (corresponding to angle A, FIG. **1**) between the plane of the planar outer surface of the hatch plate (adjacent the top window) and a plane passing through the center of curvature of the top window and the midpoint of the beveled surface of the clamping ring for the top window, should have a value of 2°.

This would provide the same optimum distance of one inch between the outer face of the metal hatch plate and the upper face of the top window (thermoplastic) clamping ring.

The item 1 has been referred to hereinabove as a portion of the metallic skin or hull of a submarine. Likewise, in connection with the larger top window, the hatch plate was described as pivotally secured to the upper region of the spherical hull or skin of the submarine. For convenience in assembly, however, both of these items (to wit, item 1 and the upper region of the skin, to which the hatch plate is secured) may actually be fabricated as metallic inserts, which are made of the same high-strength steel as the body of the hull and which are, in final assembly, welded (by means of weldments formed on the inserts) into openings in the hull body. Since these inserts are made of the same material as the skin of the submarine and are rigidly secured thereto by welding, they are in essence portions of the submarine's skin or hull.

We claim:

1. In a submersible craft having an outer metallic skin capable of withstanding substantial external pressure: a transparent window positioned over and around an opening in said skin, said window having the form of a hemispherical shell and being capable of withstanding substantial external pressure; a rigid clamping ring engaging the outer curved surface of said window, means fastening said ring to said skin, and means for sealing the joint between the annular end surface of the hemispherical window and said skin.

2. Structure of claim 1, wherein said sealing means comprises an O-ring mounted in an annular groove in said skin and adapted to engage said annular end surface.

3. Structure of claim 1, wherein said ring is made of the same material as said window.

4. Structure of claim 3, wherein said material is an acrylic resin.