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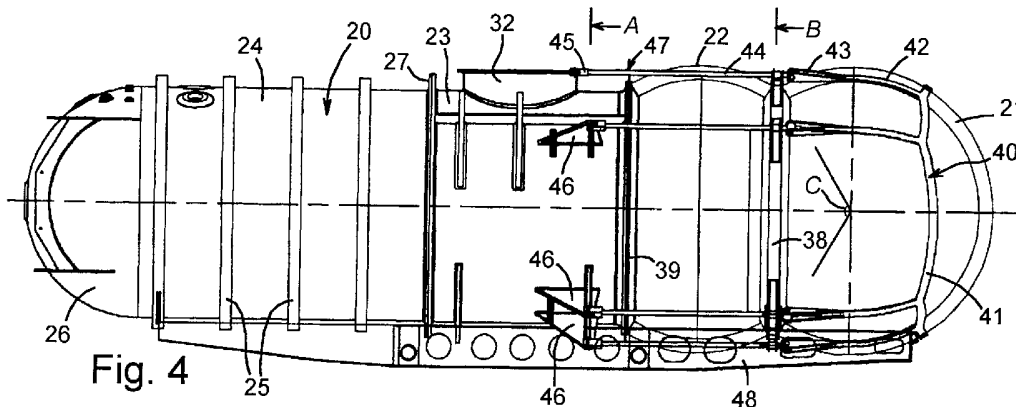
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GB 2223716 A **US 4928614 A**

(58) Field of Search:
UK CL (Edition W) **B7A**
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Other:

(54) Abstract Title: **Submersible vessel with transparent part-spherical sections**

(57) A submarine has a pressure hull 20 which includes a number of adjoining transparent viewing sections 21 and 22 in the shape of truncated spheres. The sections 21 and 22 are clamped to a body section 23, 24 by a cage 40 and tension rods 44 which may pass slidably through a thrust ring 38 interposed between the transparent sections. Access to a passenger compartment within the pressure hull maybe obtained via a hatch 32 in a mid section 23. The pressure hull may be housed in an external hull (10, Fig 1) designed for surface cruising. Ballast tanks are formed between pressure hull and the external hull, and the tension rods may pass through low pressure seals to pivotal anchorage points within the ballast tanks.



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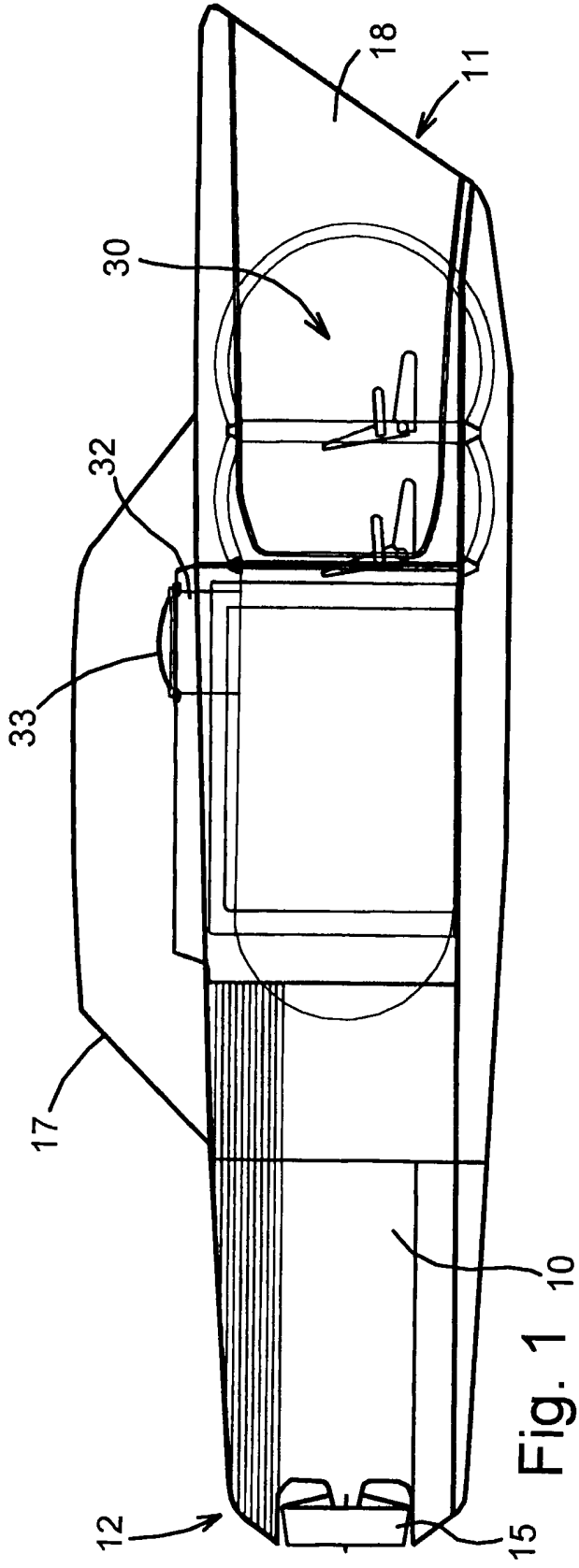


Fig. 1

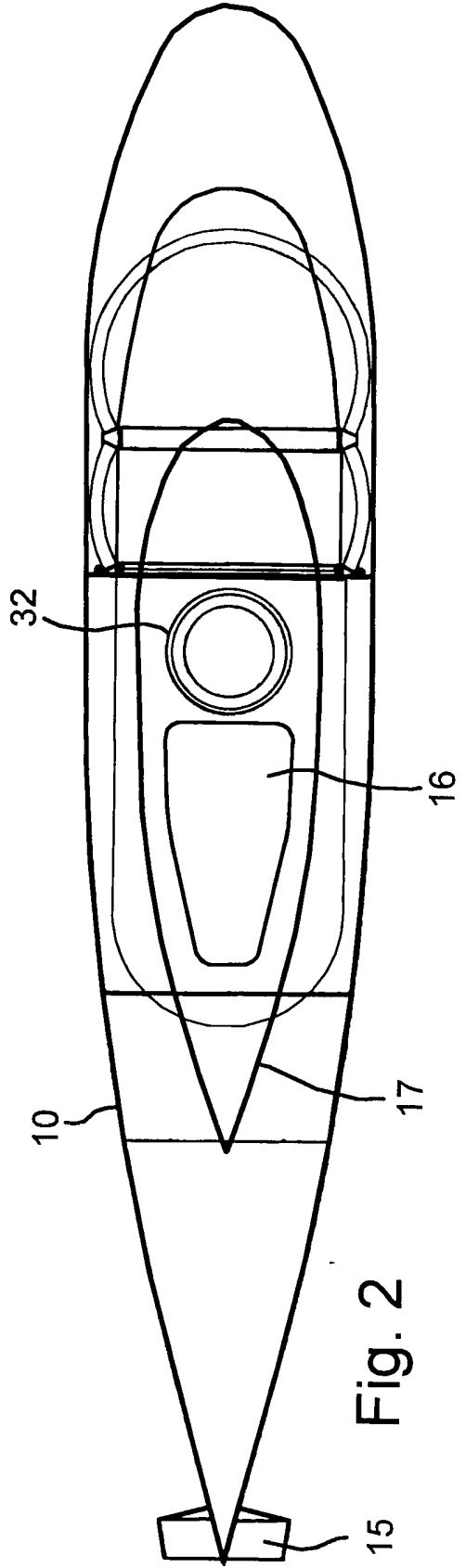


Fig. 2

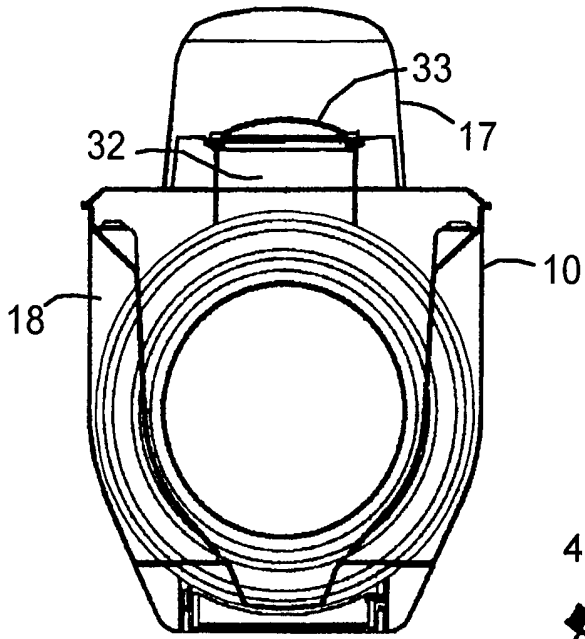


Fig. 3

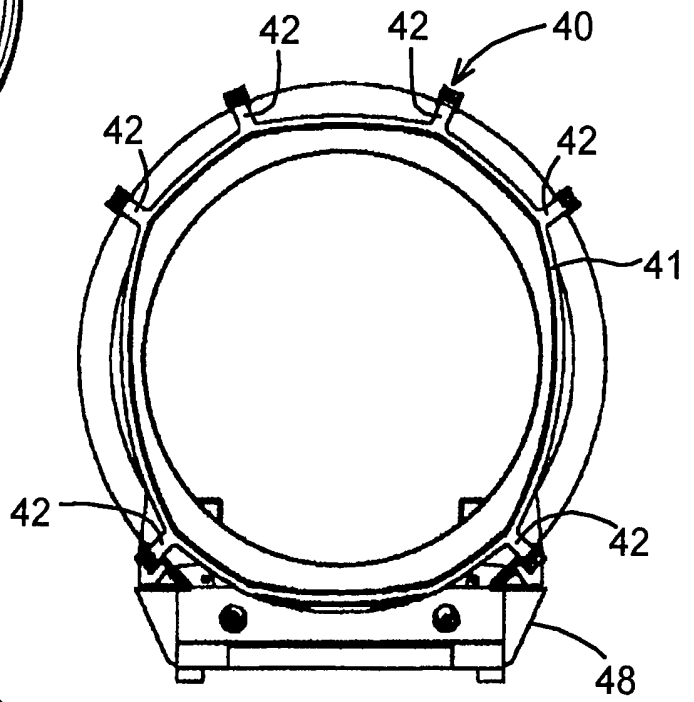


Fig. 6

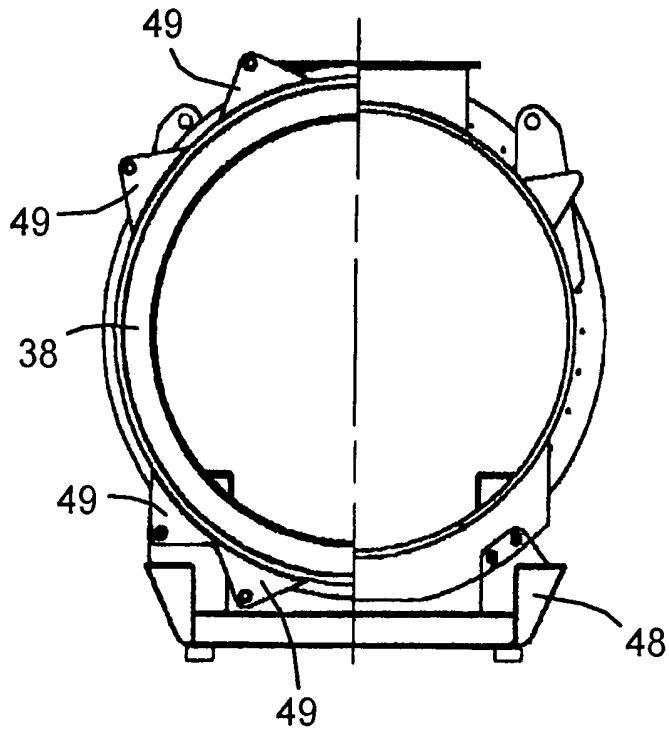
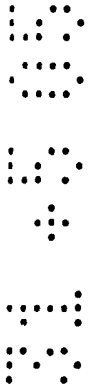


Fig. 7



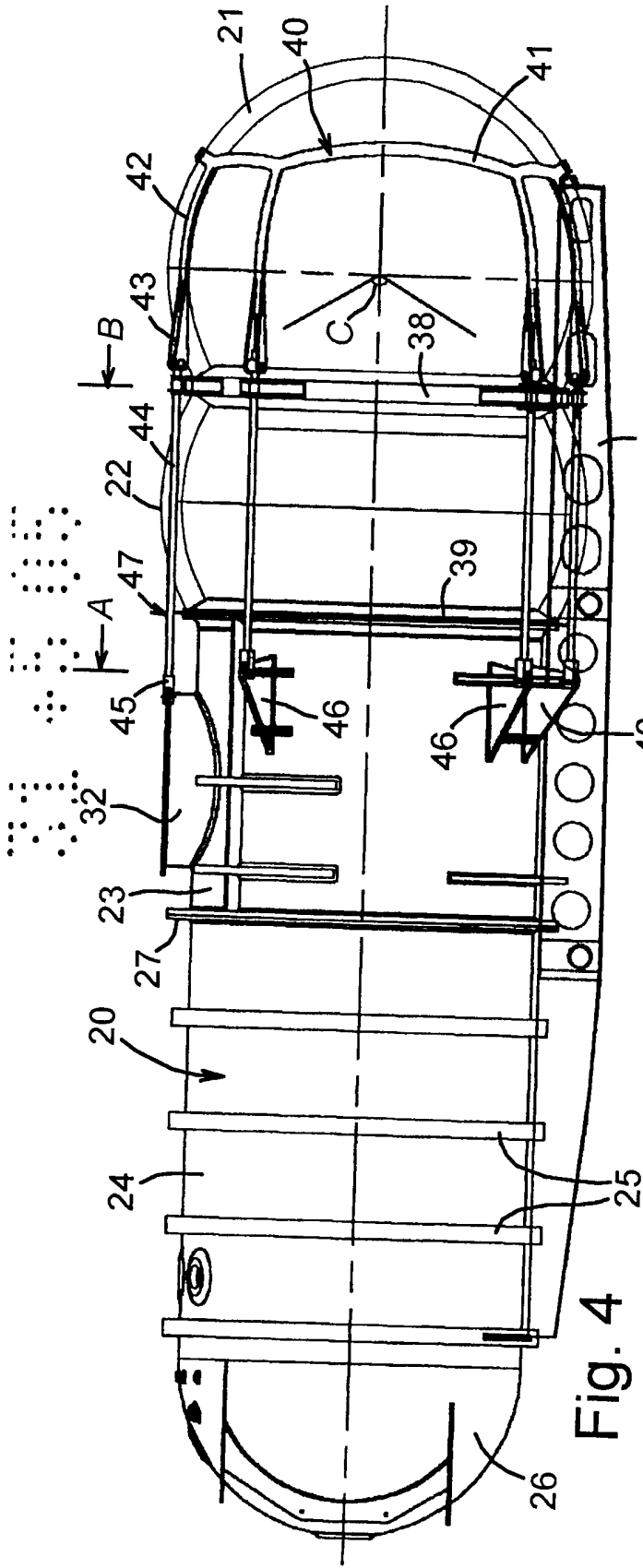


Fig. 4

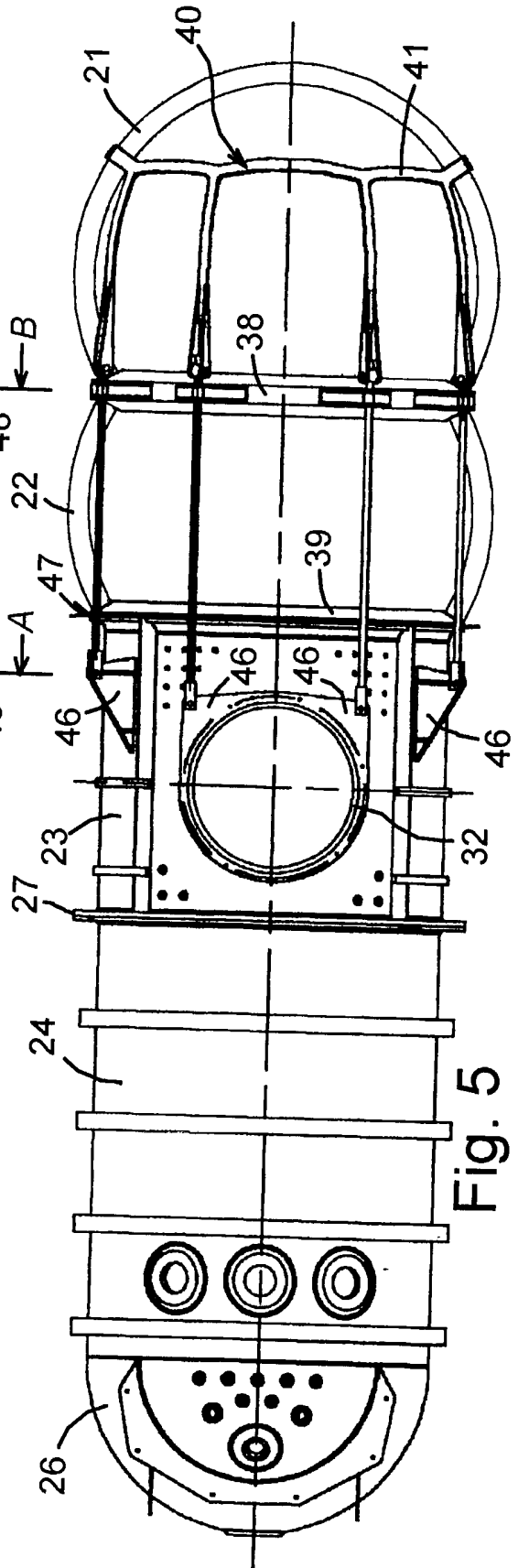
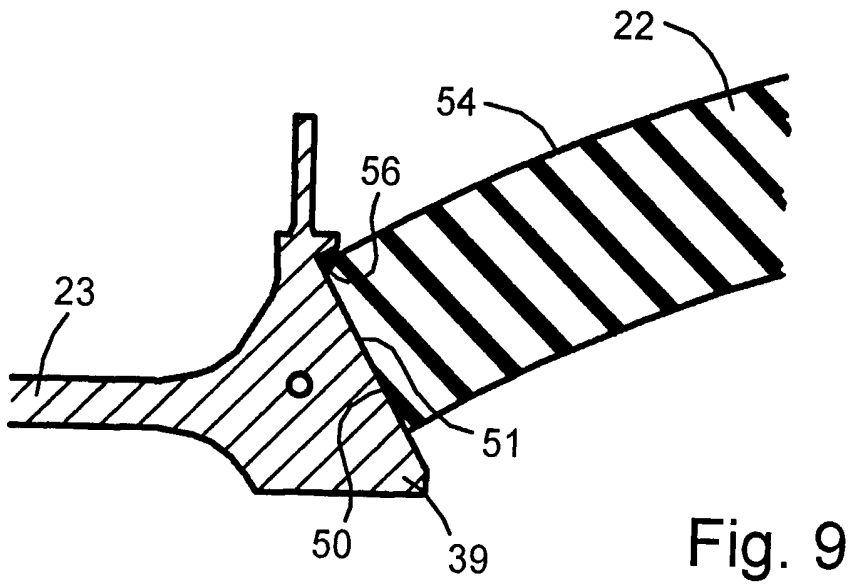
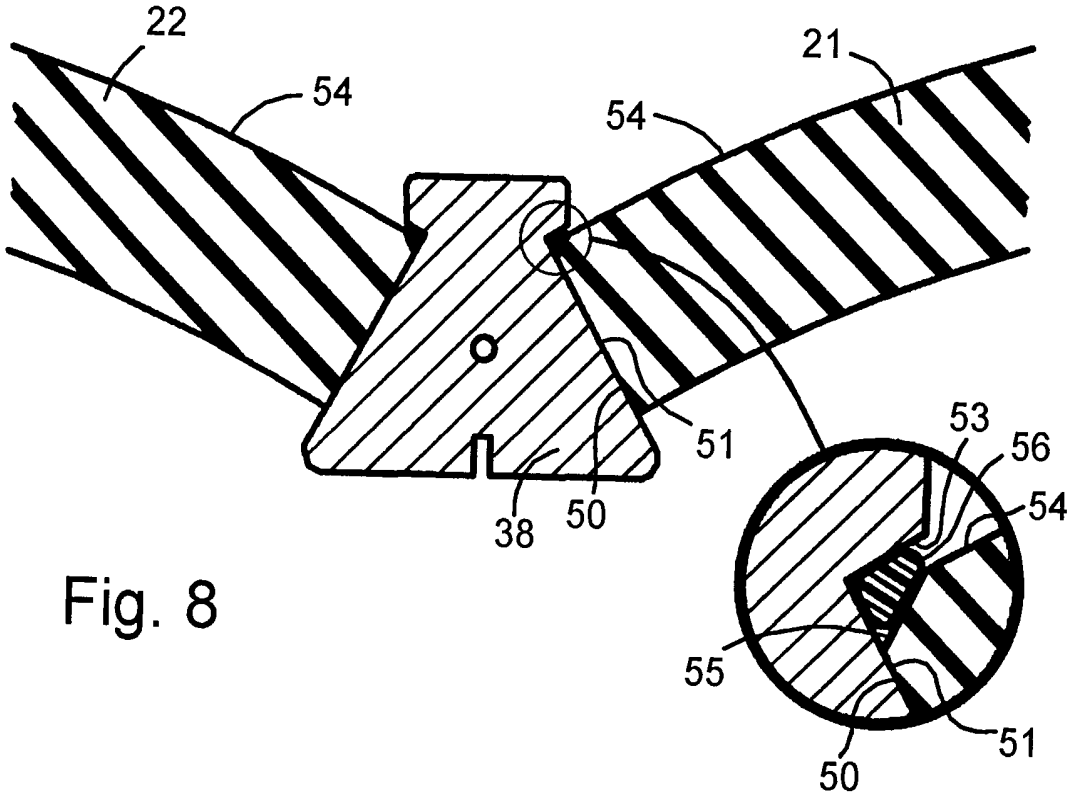


Fig. 5



SUBMERSIBLE VESSELS

TECHNICAL FIELD OF THE INVENTION

This invention relates to submersible vessels such as (without prejudice to the generality) submarines.

BACKGROUND

It has long been known that hollow submersible bodies of spherical shape are capable of withstanding approximately twice the external pressure of a substantially cylindrical body of comparable diameter and wall thickness. Submersible vessels having pressure hulls formed from a number of interconnected sections in the form of truncated spheres are already known, as disclosed for example in **GB 279 483**, **GB 2 223 716 A** and **US 5 477 798**.

In submersible vessels, windows or viewports may also be formed with a part-spherical shape for strength. A common material used in the manufacture of such viewports is acrylic plastics, since this has a refractive index close to that of seawater and therefore minimises visual distortion. However, the viewport mounting must be capable of maintaining an effective seal over a wide range of external pressures and operating temperatures.

In a known form of mounting for part-spherical viewports, a radial face of the viewport surrounding a circular opening is seated against a part-conical surface with provision of suitable seals. The viewport is held in position by a clamping ring which holds a peripheral edge of the viewport against the part-conical seat. Such arrangements may be used to effectively secure viewports of substantial size.

In general, increasing the angle of the opening reduces the range of hydrostatic pressures which the mounting can handle. On the other hand, reducing the angle of the opening restricts the internal space. In pressure hulls which include a viewing area formed from a number of adjoining part-spherical transparent sections this would place a restriction on the size of the internal compartment.

The present invention seeks to provide a new and inventive form of submersible vessel having a number of adjacent part-spherical transparent sections in which the size of the internal compartment is maximised whilst maintaining an effective seal throughout a wide range of external pressures.

SUMMARY OF THE INVENTION

The present invention provides a submersible vessel having a pressure hull which includes:

- a body section,
- a substantially transparent part-spherical end section having a single opening, and
- at least one substantially transparent part-spherical intermediate section

having a pair of openings and being disposed between the end section and the body section such that the said sections provide a common internal compartment;

characterised by

a cage partially surrounding the end section;

and

a plurality of tension elements connecting the cage to the body section, disposed externally of the intermediate section or sections.

The cage preferably comprises a tension ring and a plurality of anchoring members projecting from the tension ring and each connected with a respective tension element.

In a preferred arrangement a thrust member is interposed between adjacent transparent sections, and the tension elements pass slidably through the thrust member. The thrust member may thus locate the tension elements whilst balancing the sealing pressures on opposite sides of the thrust member.

BRIEF DESCRIPTION OF THE DRAWINGS

The following description and the accompanying drawings referred to therein are included by way of non-limiting example in order to illustrate how the invention may be put into practice. In the drawings:

Figure 1 is an external side view of a submarine in accordance with the invention;

Figure 2 is a plan view of the submarine;

Figure 3 is an end view of the submarine as seen from the bow end;

Figure 4 is a side view of an internal pressure hull of the submarine;

Figure 5 is a plan view of the pressure hull which comprises a body section and two transparent sections;

Figure 6 is an end view of the pressure hull as seen from the bow end;

Figure 7 is a transverse section through the pressure hull, the right hand side of the drawing showing the section *A-A* of Fig. 4 and the left hand side showing the section *B-B*;

Figure 8 is a section through the area of the thrust ring which separates the two transparent sections, including an inset detail; and

Figure 9 is a section through the area where the transparent sections join the body section.

DETAILED DESCRIPTION OF THE DRAWINGS

Fig.s 1 to 3 show a vessel which is commonly referred to as a submarine. The vessel is capable of both surface and sub-surface use. The vessel has an external hull 10 which is shaped for surface cruising, having a

leading bow end 11 and an aft end 12 which may have horizontal tail fins 13 and 14 and a propeller 15. During surface use the propeller 15 may be driven by an internal diesel engine to provide economical use over a considerable distance, but during dives the propeller may be by an internal electric motor powered by a rechargeable battery. The external hull is surmounted by a deck area 16, which is surrounded by an upstanding safety wall 17. The bow end 11 is provided with a transparent window 18 which extends on both sides of the vessel.

The external hull 10 contains an internal pressure hull 20, shown in **Fig.s 4 to 7**, which is designed to withstand the high external pressures encountered during sub-surface dives. Starting at the bow end, the pressure hull includes a bow section 21, an intermediate section 22, a mid section 23, and an aft section 24. The bow and intermediate sections 21 and 22 are both formed of transparent acrylic plastics (other suitable transparent materials could be used, of course) whereas the mid and aft sections 23 and 24 form a metal body section, both being generally of cylindrical shape with circumferential, axially-spaced reinforcing rings 25. The aft section 24 is closed by a part-spherical end 26 and is joined to the mid section 23 by conventional flange seals 27. Referring back to **Fig. 1**, the transparent sections 21 and 22 form part of an internal passenger compartment 30 within the pressure hull, which extends into the mid and aft sections defined by an internal passenger compartment wall 31, seen in ghost view in the drawing. The passenger compartment is accessed through a cylindrical access hatch 32 which passes through the top of the mid section 23 into the deck area 16 and is closed during dives by a pressure cover 33. The remainder of the body section outside the passenger compartment contains service equipment such as the drive motors, batteries, air supply equipment etc.

A space is formed between the body section 23, 24 of the pressure hull and the external hull 10 containing one or more enclosed ballast tanks which are part-flooded to control the diving depth. The transparent sections 21 and 22 of the pressure hull are disposed behind the bow window 18 so that the external environment is clearly visible to people in the passenger compartment. The intervening space between the sections 21, 22 and the window 18 may be flooded to reduce pressure forces on the window 18 during dives.

Returning to **Fig.s 4 to 7**, the bow section 21 is formed as a truncated sphere with a single opening subtending an angle C at the centre of the sphere of about 120° . The intermediate section 22 is similarly formed as a truncated sphere of the same radius, but this section has two opposing openings each subtending the same angle (about 120 degrees) from the centre of the sphere. A metal thrust ring 38 is interposed between the transparent sections 21 and 22 whereas the mid section 23 is provided with a ring-shaped seat 39 against which the intermediate section 22 is held. A cage 40 is shaped to partially surround the bow section 21, in contact with its external surface. The cage includes a tension ring 41 and a number of anchoring members 42 which project aft from the tension ring, each terminating, adjacent to the thrust ring 38, in a pair of spaced pivot plates 43. A respective tension rod 44 is pivotally connected with each of the anchoring members by means of a pivot pin inserted through the plates 43. The tension rods 44 extend externally of the intermediate section 22 substantially parallel to the fore-aft axis of the pressure hull, each terminating in a clevis 45. Each of the tension rods 44 is pivotally secured to the mid section 23 by means of a respective external anchorage plate 46. The two uppermost tension rods are secured to circumferential anchorage plates on the access hatch 32 whereas the remaining plates 46 project radially from the mid section. The anchorage

plates 46 are all located within the ballast tanks, but the tie rods pass slidably through low pressure seals at the point of entry 47 into the ballast tanks.

The cage 40 and tension rods 44 clamp the transparent sections 21 and 22 to the mid section 23. It will be noted in **Fig. 6** that eight tension rods are provided in the present embodiment. However four of the rods are disposed at the upper region of the transparent sections 21 and 22 and four are disposed at the lower region. The rods 44 do not therefore impede the side view from the passenger compartment but the balanced arrangement enables the cage 40 to apply even clamping pressure to the transparent sections. It will also be noted that a base platform 48 projects forwardly from the mid section 23 below the transparent sections 21 and 22, which supports the transparent sections during assembly and maintenance of the pressure hull.

The thrust ring 38 is provided with outwardly-projecting flanges 49 through which the tension rods 44 are slidably inserted to ensure accurate circumferential and radial location of the rods **Fig. 8** shows how the thrust ring 38 is interposed between the two transparent sections 21 and 22 whilst **Fig. 9** shows how the intermediate section 22 is held against the seat 39 of the mid section 23. The adjacent opening of each section is surrounded by a radially-extending face 50 which is supported against a respective part-conical seat 51. The outer circumferential limit of each seat is formed by an abutment face 53 which projects substantially perpendicularly from the seat 51. (See inset detail) The adjacent corner of the transparent section, between the radially-extending face 50 and the external face 54, is formed with a short inclined face 55 An O-ring seal 56 is enclosed between the seat 51, the abutment face 53 and the inclined face 55 so that, when the rods 44 are correctly tensioned, the O-

rings are sealingly compressed between these three faces.

During a dive the hydrostatic pressures on the external faces of the transparent sections are resisted by the cage 40 and tension rods 44 so that the radial faces 50 are held against the part-conical seats 51. Since the thrust ring 38 is slidably located on the tension rods 44 the compression forces are equally divided between the three seats 51. As the external pressure increases the faces 50 may eventually slide radially inwards on the seats 51 but as long as the O-rings remain compressed an effective pressure seal is maintained

In larger vessels which are intended to accommodate a larger number of passengers the pressure hull may include two or more intermediate sections 22 with a similar thrust ring 38 interposed between each adjacent pair of sections.

With the arrangement described the size of the passenger compartment is maximised whilst maintaining effective seals over a wider range of external hydrostatic pressures. The high pressures to which the seals may be subjected during a dive remain substantially balanced throughout the intended operating range.

It will be appreciated that the features disclosed herein may be present in any feasible combination. Whilst the above description lays emphasis on those areas which, in combination, are believed to be new, protection is claimed for any inventive combination of the features disclosed herein

CLAIMS

1. A submersible vessel having a pressure hull which includes:
 - a body section,
 - a substantially transparent part-spherical end section having a single opening, and
 - at least one substantially transparent part-spherical intermediate section having a pair of openings and being disposed between the end section and the body section, the transparent sections forming part of a common passenger compartment,characterised by
 - a cage partially surrounding the end section,
 - and
 - a plurality of tension elements connecting the cage to the body section, disposed externally of the intermediate section or sections.

2. A submersible vessel according to Claim 1, in which the cage comprises a tension ring and a plurality of anchoring elements projecting from the tension ring for connection with a respective tension element.

3. A submersible vessel according to Claim 2, in which the tension elements are pivotally connected with the anchoring elements.

4. A submersible vessel according to Claim 1, 2 or 3 in which a thrust member is interposed between the end section and the adjacent intermediate section.

5. A submersible vessel according to Claim 4, in which the

tension elements pass slidably through the thrust member.

6. A submersible vessel according to any preceding claim, in which the tension elements are anchored to the body section.

7. A submersible vessel according to any preceding claim, in which the tension elements are anchored to the body section by pivotal connections.

8. A submersible vessel according to any preceding claim, in which the body section of the pressure hull is provided with external ballast tanks.

9. A submersible vessel according to Claim 8, in which the tension elements extend sealably into the ballast tanks.

10. A submersible vessel according to any preceding claim, in which the tension elements are arranged in two groups disposed at top and bottom regions of the transparent sections.

11. A submersible vessel according to Claim 10, in which both group have the same number of tension elements.

12. A submersible vessel substantially as described with reference to the drawings.



Application No: GB0411984.8

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Examiner: Richard Collins

Claims searched: 1 to 12

Date of search: 27 July 2004

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular reference
A	-	US4928614 A (FORMAN) see figure 1 and related description.
A	-	GB2223716 A (SMITH) see whole document.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W :

B7A

Worldwide search of patent documents classified in the following areas of the IPC⁰⁷

B63B; B63G

The following online and other databases have been used in the preparation of this search report

EPODOC, JAPIO, WPI