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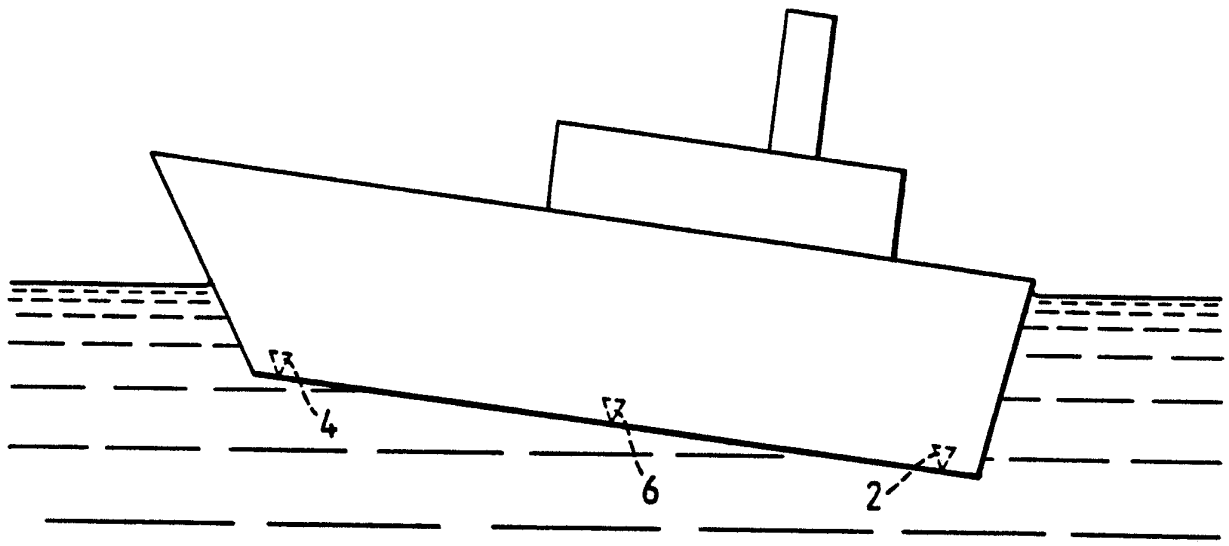

(57) Abstract

A ship (1) is provided with pressure sensors (2, 3, 4, 5, 6, 7) adapted to sense the pressure of water exerted on various points of the hull. As the ship is loaded or unloaded the changes in pressure are noted and a calculating arrangement, such as a computer, calculates the difference in the total weight of water displaced by the ship, that is to say the weight of the cargo that has been loaded or unloaded.

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Method and Apparatus for ascertaining details of the load in a ship

THE PRESENT INVENTION relates to a method and apparatus for ascertaining details of the load in a ship.

There are two conventional ways of determining the weight of the cargo present on a ship, which can be considered to be the external draft survey method and the internal volumetric method.

In utilising the external draft survey method the position of the water line relative to the hull of the ship is initially observed, and then the cargo is loaded on to the ship. The level of the water line relative to the hull is again observed, and by performing a calculation based on the two observed relative levels of the water line it is possible to calculate the depth by which the ship has sunk in the water, thus enabling the mass of water displaced to be determined. Before performing the calculation it may be necessary to ascertain the density of the water using a hydrometer or the like since the density of water varies with temperature, and with salt concentration. Thus the density of water in one port may be very different from the density of water in another port. Of course, the mass of water displaced must equal the weight of the cargo if all other factors remain constant.

It is, of course, very difficult to assess accurately the position of the water line against the hull of the vessel since, even in very calm conditions, small waves exist. Since the observation is performed visually it is not very accurate. Also it is very

difficult to measure the density of water with a high degree of accuracy.

Whilst the external draft survey method can be used with both solid and liquid cargos, the internal volumetric method can really only be utilised with cargos that are fluid. In utilising the internal volumetric method the cargo is caused to flow into tanks or containers of a known volume. Using dipsticks or equivalent techniques it is possible to measure the volume of cargo within each tank or container, and by performing an appropriate calculation the weight of the cargo can be calculated.

It is to be appreciated that neither of the above described conventional techniques for determining the weight of a cargo is totally accurate, and there is a need for a technique for determining the weight of a cargo on a ship which can be accurate to 0.1% or better.

A further problem that exists with a conventional ship is adjusting the trim of the ship. The weight of the ship must be evenly balanced about the mid point of the keel of the ship, both in a port-to-starboard sense and in a for-to-aft sense if the ship is to float evenly in the water. If there is an imbalance in the port-to-starboard sense the ship will list, whereas if there is an imbalance in the for-to-aft sense the stern of the ship will be lower or higher in the water than the bow, and thus in both cases the ship will not be on an even keel.

At the present point in time it is the practice to adjust the trim of the ship, to ensure that the ship is on an even keel, by making visual observations of the water line at different points on the hull of the ship, and by introducing ballast into appropriate

tanks within the ship until such a time that the ship is observed visually to be on an even keel. This procedure is time consuming and can be inaccurate.

According to one aspect of this invention there is provided a method of ascertaining details of the incremental change in the load in a vessel, said method comprising the steps of determining the pressure exerted on the hull of the vessel by the water at predetermined positions on the hull both before and after the loading or unloading of the vessel and calculating, from said pressures, the details relating to the differential change in the weight or mass of water displaced by the vessel.

Preferably the method includes the steps of determining the density of the water in which the vessel is floating to faciliate in the performance of the necessary calculation.

Conveniently the method includes the step of determining the atmospheric pressure, and utilising the measured value in the calculation to correct errors caused by fluctuations in atmospheric pressure.

Advantageously the method includes the steps of determining details of any list or for-to-aft inclination of the vessel. The method may include the additional step of automatically adjusting the ballasting of the vessel in order to place the vessel on a substantially even keel.

Advantageously the method includes the steps of determining the sag or hog of the vessel.

According to another aspect of this invention there is provided a vessel provided with a plurality of

pressure sensors adapted to sense the pressure of water acting at predetermined points on the hull of the vessel, the pressure sensors being associated with a calculation means adapted to calculate the differential change in weight of water displaced by the vessel caused by the loading or unloading of the vessel.

Preferably the pressure sensors comprise force transducers of the oscillating wire or gyroscopic type. Such transducers may have an accuracy or repeatability of better than 0.1%.

Conveniently at least two sensors are spaced apart in a direction transverse to the axis defined by the keel of the vessel and at least two transducers are spaced apart in a direction parallel to the axis defined by the keel of the vessel.

Advantageously at least four transducers are provided, two transducers being mounted in a region of the stern of the vessel at symmetric positions on opposite sides of the keel of a vessel and two transducers being located in the region of the bow of the vessel at symmetric positions on opposite sides of the keel of the vessel.

Preferably at least three sensors are provided, spaced apart in a direction defined by the keel. Such sensors enable the sag or hog of the vessel to be determined.

Preferably the calculation means are associated with means for automatically adjusting the ballasting of the vessel.

Conveniently means are provided for determining the density of the water in which the vessel is

situated and to supply the determined value to the calculating means.

Advantageously means are provided to determine atmospheric pressure. This enables any errors caused by fluctuations in atmospheric pressure to be corrected.

Preferably said density sensing means comprise two sensors spaced apart vertically, and thus adapted to sense the pressure of water at known differential depths below the water line.

Alternatively at least one sensor is adapted to measure the force exerted thereon by the water in which the vessel is immersed, the sensor being associated with a float of known volume, means being provided to retain the float out of contact with the sensor, said retaining means being adapted to be released to permit the float subsequently to exert an upthrust on the sensor, so that the weight of water displaced by the float can be calculated, enabling the density of the water to be calculated.

The pressure sensors may be directly mounted on the hull of the vessel or may be suspended over the side of the vessel, for example on invar wires.

This invention also relates to a pressure sensor for sensing the pressure applied thereto by water, the pressure sensor comprising a transducer, means for applying water pressure to the transducer and a float member which can apply an upthrust to the transducer, means being provided releasably to retain the float in a position spaced from the transducer.

In order that the invention may be more readily understood, and so that further feature thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic plan view of a ship provided with pressure sensors in accordance with the invention,

FIGURE 2 is a rear view of the ship, when unloaded,

FIGURE 3 is a rear view of the ship when loaded,

FIGURE 4 is a rear view of the ship when loaded, whilst listing,

FIGURE 5 is a side view of the ship with the load unevenly spread in the for-to-aft direction,

FIGURE 6 is a rear view of another embodiment of a ship in accordance with the invention,

FIGURE 7 is a diagrammatic cross sectional view of one embodiment of a pressure sensing transducer, and

FIGURE 8 is a side view, corresponding to Figure 5, showing an alternative embodiment of the invention.

It is to be noted, at this stage, that the drawings are of a diagrammatic form.

Figure 1 illustrates the hull 1 of a ship.

The hull is provided with a plurality of pressure sensors mounted on the undersurface thereof. Two pressure sensors 2, 3 are provided adjacent the stern of the vessel. The two pressure sensors are located at symmetric positions about the line defined by the keel of the hull. Thus the sensors are equi-spaced from the keel, one being on the port side of the vessel and the other being on the starboard side of the vessel.

Two further pressure sensors 4, 5 are provided located adjacent the bow of the vessel. Another two pressure sensors 6, 7 are located amid ships of the vessel. In each case the pressure sensors are symmetrically located on either side of the keel, the sensors being equi-spaced from the keel.

The sensors are adapted to sense the hydrostatic pressure exerted on them by the water in which the vessel is floating. When the pressure is sensed while the ship is in a static condition various items of information can be calculated, as will be described.

Whilst one specific array of sensors has been illustrated it is to be appreciated that many different arrays of sensors may be utilised. It is envisaged that the sensors should be arranged so that at least two sensors are spaced apart in a direction transversely to the keel of the vessel, to assist in detecting list of the vessel, and also so that at least two sensors are spaced apart in the for-to-aft direction of the vessel. In one very simple embodiment two sensors may be provided adjacent the stern of the vessel, corresponding to the illustrated sensors 2 and 3, and a single further sensor may be provided adjacent the bow of the vessel. However, it may prove desirable to provide many more sensors, especially in the case of a very large vessel, to provide an "averaging" effect.

The provision of at least three transducers spaced in the direction of the keel is preferred to enable a determination to be made of the degree of "sag" or "hog" in the keel of the ship, so that this can be taken into account to obviate any errors from such a cause. "Sag" or "hog" arises when a ship is not loaded evenly.

Each sensor is a sensor that is able very accurately to measure the pressure applied to the sensor by the water in which the vessel is floating. It is thus possible to utilise, as the sensors, virtually any high precision pressure transducer that will provide an appropriate signal.

It is envisaged that two specific types of transducer may be considered appropriate. The first is a pressure transducer of the resonant wire type in which the pressure applied to the transducer causes the tension in a vibrating wire to be varied. As the tension in the wire varies, so the resonant frequency of the wire varies. The wire is caused to vibrate and the transducer senses the changing resonant frequency, and is adapted to provide an appropriate output signal indicative of the pressure applied to the transducer. Another type of transducer that may be considered appropriate is a gyroscopic transducer in which the pressure applied to the transducer is caused to move a pivot point of a gyroscope causing the gyroscope to precess. The precession of the transducer is monitored and the transducer provides an appropriate output signal. Other pressure transducers may be found to be appropriate.

As can be seen from Figure 2 when the ship 1 is unloaded, the ship floats in the water with the water line W at a distance h above the level of the keel of the

vessel. The pressure transducers 2, 3 thus sense a pressure determined by the height h and the density of the water. In general terms the pressure can be considered to be proportional to the weight of water displaced which will, of course, be equal to the total weight of the vessel.

When the cargo is placed in the vessel the vessel will effectively sink in the water, as illustrated in Figure 3. The water line W will thus be much further from the keel of the vessel, and the pressure sensors 2, 3 will be a depth h1 beneath the water line W. The pressure sensors will thus sense a greater pressure which again can be considered to be proportional to the weight of water displaced by the vessel, which is now equivalent to the weight of the vessel added to the weight of the cargo. It is thus possible to determine the weight of the cargo by recording the pressures experienced under the two conditions described above and performing an appropriate calculation. Thus a calculation based on the differences in pressure recorded by the sensors enables the differential weight to be determined as the vessel is loaded or unloaded, that is to say the incremental change in weight as the vessel is loaded and the decremental change in weight as the vessel is unloaded.

Figure 4 illustrates the position that exists when the cargo has been unevenly loaded about the keel of the vessel. As can be seen the whole vessel is leaning or listing to one side. As a consequence of this the pressure sensor 2 is a distance h3 beneath the water line W whereas the pressure sensor 3 is a distance h4 beneath the water line. Thus each pressure sensor will provide a pressure reading effectively indicative of the depth of that pressure sensor beneath the water line W. By comparing the signals generated by the

pressure sensors 2, 3 it is thus possible to determine the amount of list of the ship or vessel.

Figure 5 illustrates the vessel with the cargo unevenly distributed in a fore-to-aft direction and it can be seen that the pressure sensor 2 provided adjacent the stern of the vessel is much lower in the water than the pressure sensor 4 located adjacent the bow of the vessel. Thus, again by considering the signals provided from the pressure sensors it is possible to determine details of the trim of the vessel.

It is envisaged that it may be practicable to provide signals from the described pressure sensors to a computer which will be appropriately programmed firstly to provide an indication of the weight of the cargo that has been located on the vessel, and secondly to provide an indication of the trim of the vessel, indicating any list from port to starboard or any inclination of the keel of the vessel.

The computer would, of course, be programmed to take into account the effect of the precise configuration of the submerged part of the hull since, in a real situation, ships hulls do not consist of vertical sides and a flat bottom and thus in a real situation, the pressure exerted on the sense is not directly proportional to the weight of water of displaced. However, an appropriate computer program provided with details of the precise configuration of the hull can readily perform the necessary calculations to provide extremely accurate information, especially if any "sag" or "hog" is taken into account. Effectively the memory of the computer will contain a calibration chart for the vessel, and by determining the degree of "sag" or "hog", and the depth of each pressure sensor below the water line when the ship is static when two sets of readings

are taken, the incremental displacement of the ship can be determined very accurately.

It is envisaged that the computer may be adapted to operate an automatic ballasting system, the computer thus controlling the pumping of ballast into and out of ballast tanks present in the vessel, to provide the vessel with perfect trim.

Where the shape or configuration of the hull varies considerably at different positions relative to the normal water line it must be possible to calculate the actual depth to which the ship is immersed in the water, rather than just the pressure at the base of the hull, in order for the computer to be able to calculate the information with sufficient accuracy, since an essential item of information is the volume of the hull that is submerged, thus displacing water, and this volume can vary considerably.

The sensors used measure pressure very accurately. The pressure under the surface of water does vary with variations in atmospheric pressure over the water. Thus a further transducer 8 may be provided to measure atmospheric pressure so that it can be taken into account, as shown in Figure 6.

It should be explained that many ships that travel around the world are often in harbours where the salt content of the water can be within a wide range of possible concentrations. Thus the density of the water can be very different in one harbour from another harbour. When the vessel is in a harbour where the water is not very dense the vessel will sit deeper in the water than when in a harbour where the water is very dense. If the vessel had a perfectly uniformly configured hull, i.e. straight vertical sides and a flat

bottom, this would not have any deleterious effects since although the vessel would sit deeper in the water in the harbour where the water was less dense, the pressure exerted on the pressure sensors would in each case be exactly the same since a greater height of less dense water acting on the pressure sensors would provide exactly the same pressure as a lesser height of more dense water.

However, in view of the fact that the hull of a typical vessel does not have this flat bottom and vertical side configuration it is necessary, as a starting point, to be able to calculate the actual distance between one sensor and the surface of the water. To enable this calculation to be performed the density of the water must be known. Whilst this information could be obtained by utilising a conventional manual hydrometer and providing that information to the computer in an appropriate way, it may well be preferred to provide an additional pressure sensor 9 at a position higher up the hull of the vessel 1 than the pressure sensors 2, 3 as shown in Figure 6. Since the distance H between the pressure sensors 2 and 9 is known accurately, when the vessel is on an even keel, by comparing the pressures sensed by the pressure sensors 2 and 9 it is possible to calculate the density of the water in which the vessel is floating. Alternatively a pressure sensor of the type shown in Figure 7 may be utilised.

Referring now to Figure 7 the pressure sensor 10 is mounted in an aperture formed in the hull 11 of the vessel. The pressure sensor consists of a housing 12 defining flanges 13, 14 that are secured to the vessel and defining an inlet 15 to permit water to enter the housing 12 from the exterior of the vessel. A flexible membrane 16 is provided which extends across the housing 12 and a connecting rod 17 connected to the

centre of the membrane extends upwardly into contact with a force transducer 18 of the type described above. Water entering the housing through the inlet 15 will apply an upthrust P (as indicated by the arrows 19) to the membrane 16, resulting in a force Fo exerted in an upward direction on the force transducer. The force transducer can thus generate a signal which is representative of the pressure applied to the membrane by the water.

A buoyant float member 20 is provided which is located beneath the membrane. The float has a volume Vb. Depending from the float is a metallic arm 21 which is located within the coils of an electromagnet 22. When current is supplied to the electromagnet 22 through the appropriate leads 23 the float is drawn downwardly and thus does not contact the membrane 16. However, when no current is supplied to the electromagnet 22 the float will float upwardly, the upthrust generated by the float being equivalent to the weight of water displaced. This upthrust results in an additional upward force F1 being applied to the membrane and thus to the transducer. The pressure thus measured by the transducer is greater than the pressure previously measured by the transducer, the differences between the two pressures being indicative of the upthrust provided by the float member 20. Since the float member 20 is of a known volume V_b it is thus possible to calculate the density of the water in which the vessel is floating.

Once the density of the water has been obtained it is possible to calculate precisely the position of the water line relative to the hull of the vessel, and it is then possible to calculate the precise volume, and thus weight, of water displaced.

Figure 8 is a view corresponding to Figure 5 illustrating an alternative embodiment of the invention. Whereas, in the previously described embodiments, the transducers are firmly fixed to the hull of a vessel 1, in the embodiment shown in Figure 8 the vessel 1 is provided with a plurality of pressure sensors 32, 34, 36 which are suspended from the side of the vessel by means of wires 37 which may be made of INVAR, or some other material which does not expand and contract due to changes of temperature. As can be seen, at least one of the wires may be provided with two pressure sensors, such as the pressure sensors 32, 39, to enable the density of the water to be determined, as described above.

Whilst the invention has been described with reference to certain preferred embodiments of the invention it is to be appreciated that many modifications or improvements may be effected without departing from the scope of the invention.

CLAIMS:

1. A method of ascertaining details of the incremental change in the load in a vessel, said method comprising the steps of determining the pressure exerted on the hull of the vessel by the water at predetermined positions on the hull both before and after the loading or unloading of the vessel and calculating, from said pressures, the details relating to the differential change in the weight or mass of water displaced by the vessel.

2. A method according to claim 1 including the step of determining the sag or hog of the vessel.

3. A method according to any one of the preceding claims including the steps of determining the density of the water in which the vessel is floating to facilitate in the performance of the necessary calculation.

4. A method according to any one of the preceding claims including the step of determining the atmospheric pressure, and utilising the measured value in the calculation to correct errors caused by fluctuations in atmospheric pressure.

5. A method according to any one of the preceding claims wherein the method includes the subsequent steps of determining details of any list or for-to-aft inclination of the vessel.

6. A method according to claim 5 including the additional step of automatically adjusting the balasting of the vessel in order to place the vessel on a substantially even keel.

7. A vessel provided with a plurality of pressure sensors adapted to sense the pressure of water acting at

predetermined points on the hull of the vessel, the pressure sensors being associated with a calculation means adapted to calculate the differential change in the weight of water displaced by the vessel caused by the loading or unloading of the vessel.

8. A vessel according to claim 7 wherein the pressure sensors comprise force transducers of the oscillating wire or gyroscopic type.

9. A vessel according to claim 7 or 8 wherein at least two sensors are spaced apart in a direction transverse to the axis defined by the keel of the vessel and at least two transducers are spaced apart in the direction parallel to the axis defined by the keel of the vessel.

10. A vessel according to claim 9 wherein at least four transducers are provided, two transducers being mounted in a region of the stern of the vessel at symmetric positions on opposite sides of the keel of a vessel and two transducers being located in the region of the bow of the vessel at symmetric positions on opposite sides of the keel of the vessel.

11. A vessel according to claim 10 wherein at least three sensors are provided which are all spaced apart in a direction defined by the keel.

12. A vessel according to any one of claims 7 to 11 wherein the calculation means are associated with means for automatically adjusting the ballasting of the vessel.

13. A vessel according to any one of claims 7 to 13 wherein means are provided to determine atmospheric pressure and to supply the determined value to the calculating means.

14. A vessel according to any one of claims 7 to 13 wherein means are provided for determining the density of the water in which the vessel is situated, and to supply the determined value to the calculating means.

15. A vessel according to claim 14 wherein said density sensing means comprise two sensors spaced apart vertically, and thus adapted to sense the pressure of water at known differential depths below the water line.

16. A vessel according to claim 14 wherein density sensing means comprises at least one sensor adapted to measure the force exerted thereon by the water in which the vessel is immersed, the sensor being associated with a float of known volume, means being provided to retain the float out of contact with the sensor, said retaining means being adapted to be released to permit the float subsequently to exert an upthrust on the sensor, so that the weight of water displaced by the float can be calculated, enabling the density of the water to be calculated.

17. A vessel according to any one o claims 7 to 16 wherein the sensors are directly mounted on the hull of the vessel.

18. A vessel according to any one of claims 7 to 16 wherein the sensors are suspended from the side of the vessel.

19. A pressure sensor for sensing the pressure applied thereto by water, the pressure sensor comprising a transducer, means for applying water pressure to the transducer and a float member which can apply an upthrust to the transducer, means being provided releasably to retain the float in a position spaced from the transducer.

Fig.1.

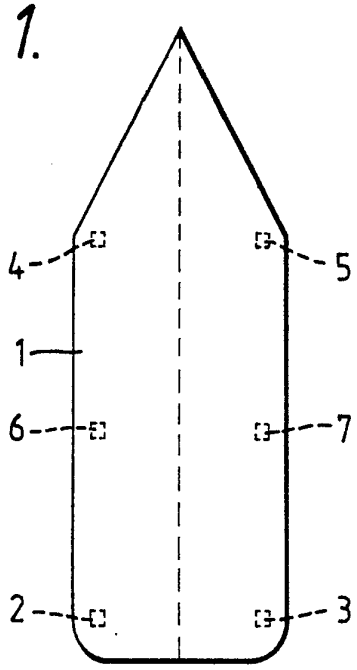

Fig.2.

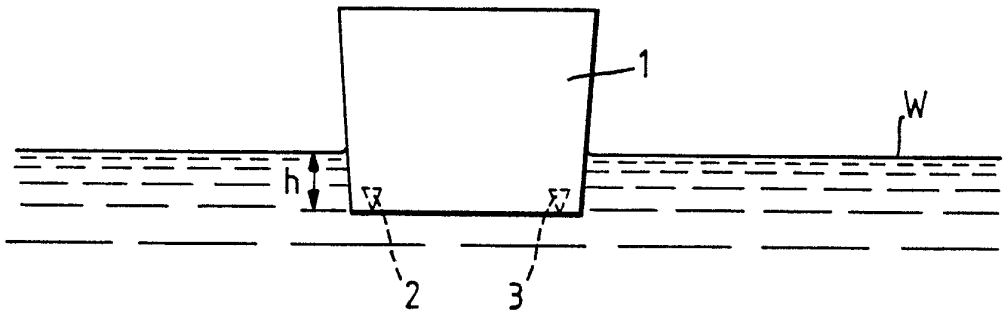

Fig.3.

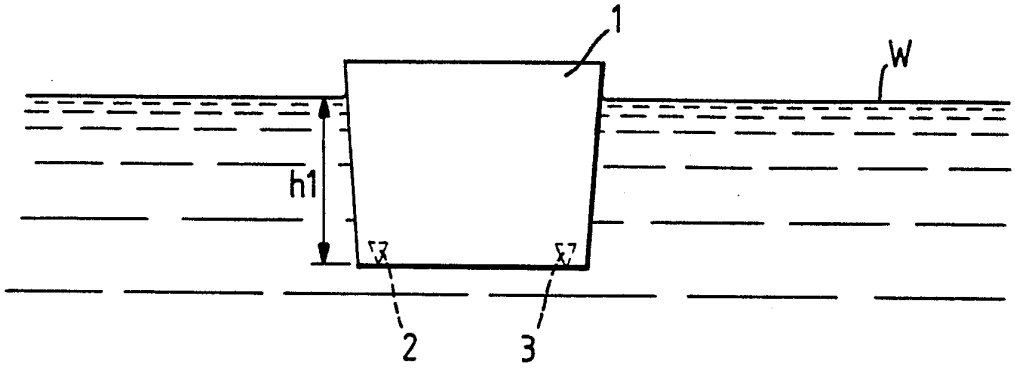

Fig. 4.

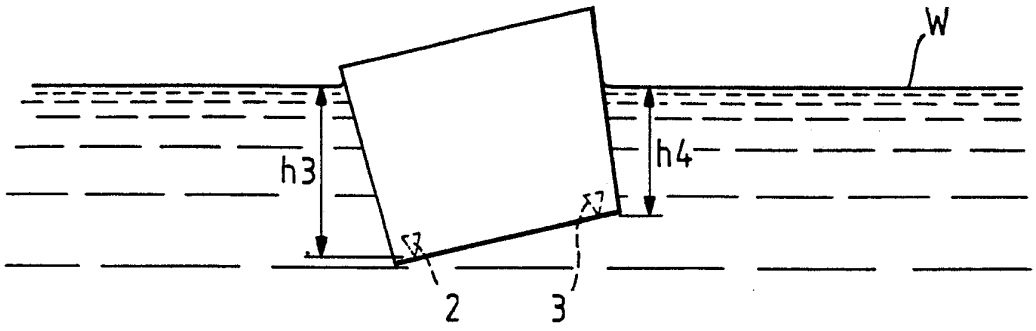

Fig. 5.

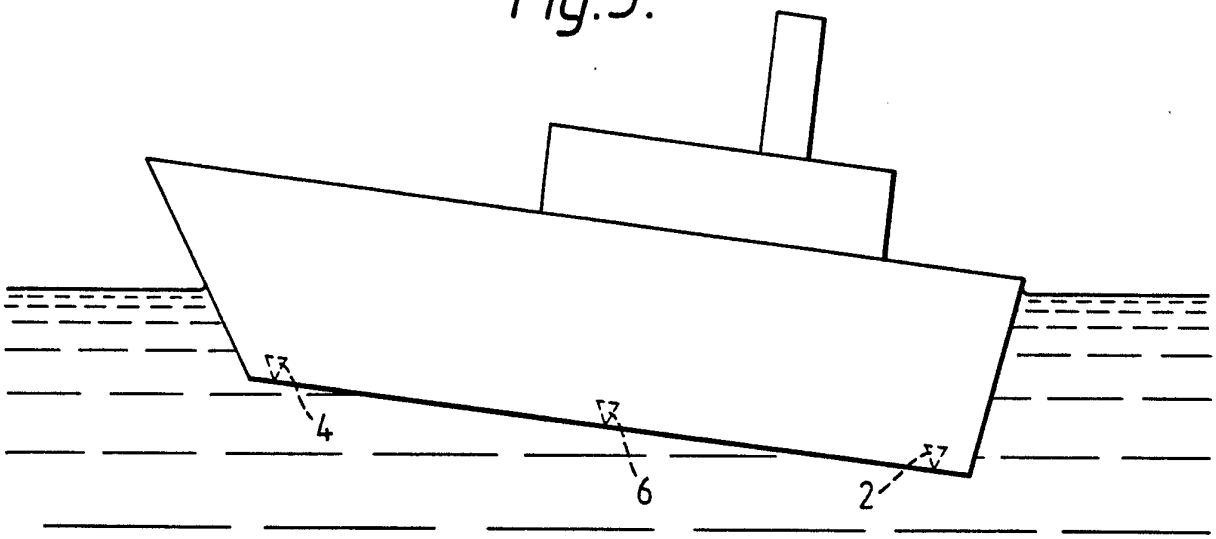

Fig. 6.

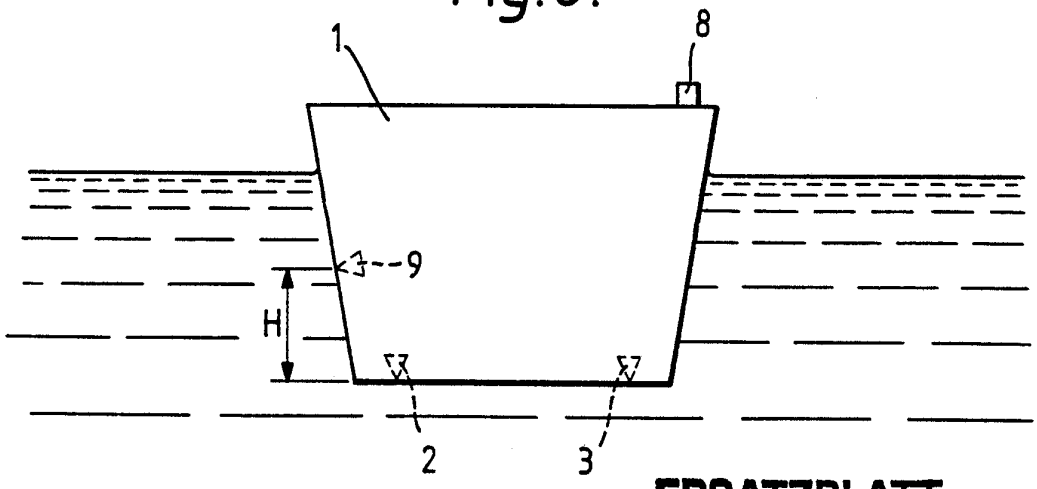

Fig. 7.

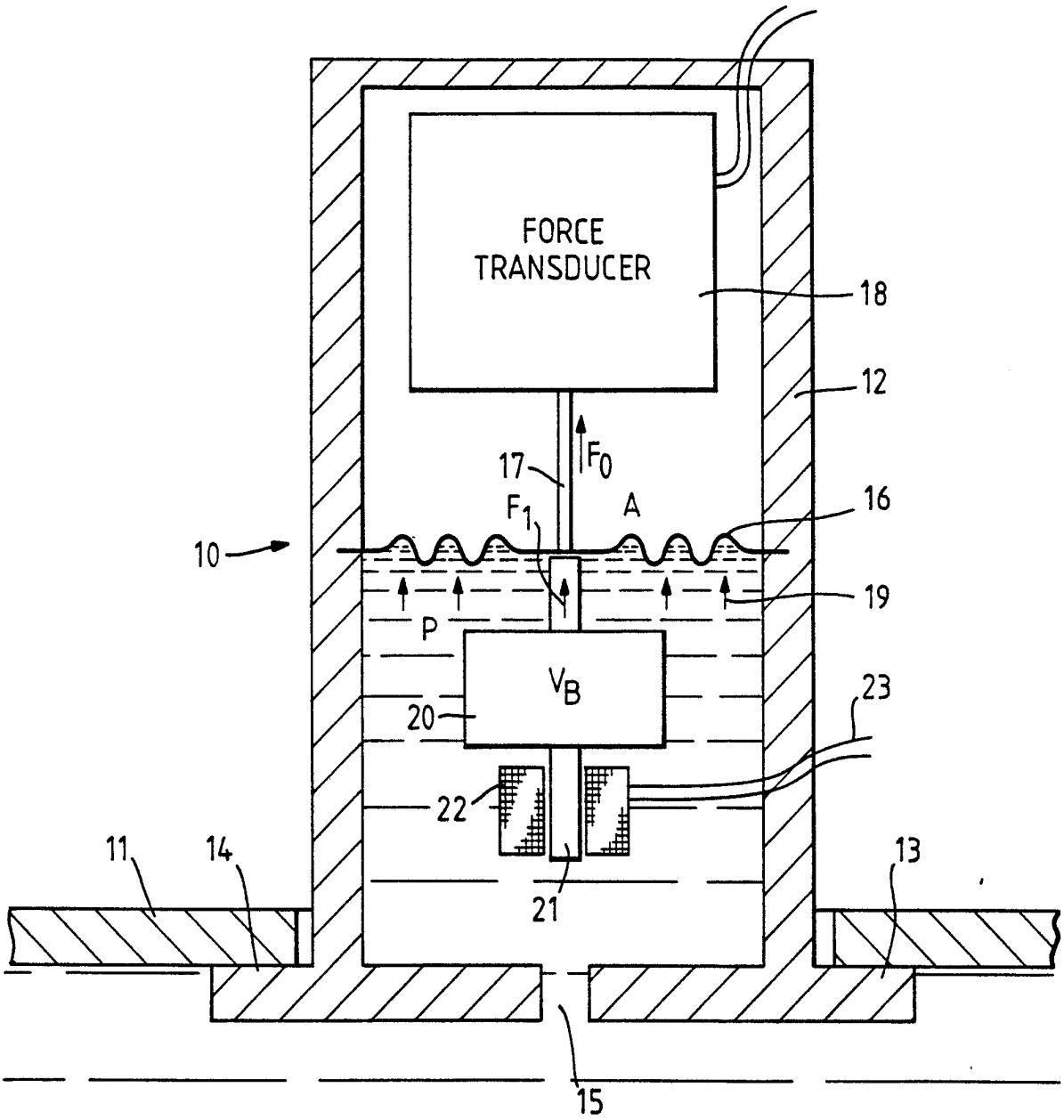
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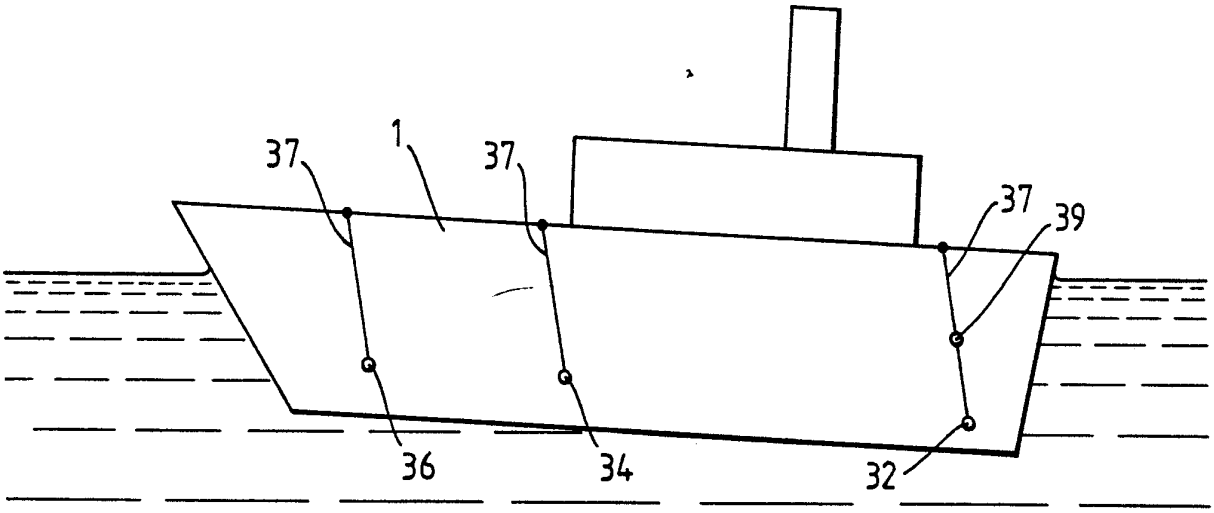
Fig.8.



INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 87/00319

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: B 63 B 39/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	B 63 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 3110181 (G. CALAMARES) 12 November 1963, see column 2, lines 1-47; column 5, lines 29-43; claim 1	1
Y	GB, A, 554435 (R.M. KRISTAL) 5 July 1943, see page 1, lines 15-20; claims 1,2	1,2,3
Y	FR, A, 2250668 (CERMAT) 6 June 1975, see page 2, line 35 - page 3, line 2; claim 1	1,2,3
A	FR, A, 2569157 (E.V. NAIDENOV) 21 February 1986, see page 5, line 18 - page 6, line 13; page 7, lines 22-35	5,9,10,11, 12
A	GB, A, 1105274 (M.T.I.) 6 March 1968, claim 1; figures 1,2	7,9,10
A	GB, A, 939326 (TAKASHI ISOBE) 9 October 1963, see claims 1,2; figure 1	18

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* Special categories of cited documents: [10]

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
28th September 1987	28 OCT 1987
International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/EP 87/00319 (SA 17616)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 21/10/87

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 3110181		None	
GB-A- 554435		None	
FR-A- 2250668	06/06/75	None	
FR-A- 2569157	21/02/86	None	
GB-A- 1105274		NL-A- 6500713 BE-A- 670671	21/07/66 31/01/66
GB-A- 939326		None	