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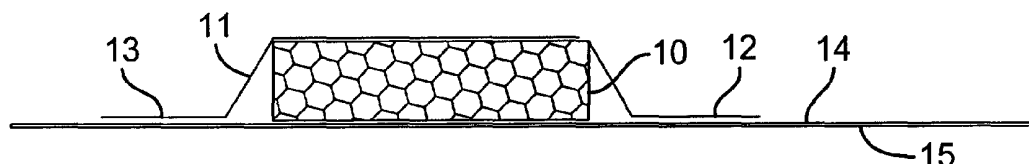
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(54) Title: VESSELS FOR TRANSPORTING FLUENT CARGOES



(57) **Abstract:** The invention relates to flexible vessels, generally of tubular shape and fabricated from synthetic rubberised fabric, for transporting fluent cargoes through liquid, typically sea water, and specifically addresses the problem of removing substantially the entire fluent cargo from such vessels. In this respect, the invention provides such a vessel with buoyant components placed and configured to assist in presenting the cargo to an evacuating pump or similar device. In a preferred embodiment, the buoyant components are secured to one or more regions of the base of the vessel, thereby causing the region or regions to be raised during exhaustion of the cargo. It is further preferred that the buoyant components are secured to the region(s) of the base internally of the vessel, thereby affording protection to the buoyant components and providing for their reliable attachment to the vessel. The buoyant components typically comprise one or more strips of foamed, non-porous material, each encased in a pocket secured to the base of the vessel. The invention also provides a method of exhausting a fluent cargo from such a flexible vessel.



WO 02/00495 A1

- 1 -

VESSELS FOR TRANSPORTING FLUENT CARGOES

The present invention relates to flexible vessels for transporting fluent cargoes through liquid.

5

Vessels of this nature are known and can take the form of closed flexible tubular or envelope structures, generally of a synthetic rubberised fabric. Such vessels are typically used for (though not limited in their application to) transporting fluent cargoes having a specific gravity less than that of the liquid in which they are being transported. Ordinarily, the fluent cargo has a specific gravity less than that of seawater. When laden, it is usual for the vessel to be virtually completely submerged, and buoyancy is supplied by the cargo. To move such laden vessels, they are towed from one end by (for example) a tug boat.

Patent No. EP-B-0 832 032 discloses and claims arrangements for improving the stability of such vessels under towage, since such vessels, especially when laden, have intrinsic stability problems, particularly where the vessel is used in anything other than calm seawater conditions. For example, waves can set up undesirable oscillations in the fluent cargo. The cargo will in this regard have a natural frequency which, if coincidental with an applied wave frequency, can lead to resonance. The resulting magnification of the oscillation of the fluent cargo is clearly to be avoided otherwise damage and rupture of the vessel can occur. In addition, the exterior profile of the vessel can be distorted from its most streamlined and drag-free configuration such that the vessel requires either an increased towing force to maintain speed or a decreased towing speed coupled with a temporary change of direction to recover control of drag forces.

- 2 -

Another problem that affects such vessels is that of satisfactory removal of substantially the entire fluent cargo therefrom. It is usual for the cargo to be extracted from such vessels by pumping it out through pipework connections, 5 but it is found in practice that, due to the inherent flexibility of the vessel, the cargo tends to form pools on the base of the vessel, in areas which are difficult to scavenge by way of the standard pumping and pipework. This problem not only reduces the effective capacity of the 10 vessels, since allowance has to be made for a residue of the fluent cargo to remain after an intended evacuation of the vessel, but also renders it difficult to purge vessels of the remnants of one fluent cargo prior to their use for another such cargo.

15

It is therefore an object of this invention to provide apparatus for, and a method of, reducing the problem described in the immediately preceding paragraph.

20 According to the invention from one aspect there is provided a flexible vessel for transporting fluent cargo through liquid; the vessel having cargo evacuating means associated therewith, and being provided with buoyant means disposed and configured to assist in the presentation of said cargo to said 25 evacuating means.

Preferably, the buoyant means is secured to at least one area of a base of said vessel, thereby to cause said at least one area to be raised during exhaustion of the cargo.

30

It is further preferred that the buoyant means is secured to said base area internally of said vessel, thereby affording

- 3 -

protection to the buoyant means and providing for its reliable attachment to the vessel.

Preferably, the buoyant means comprises one or more strips of
5 foamed or otherwise non-porous material, each encased in a pocket secured to the base of the vessel. This substantially isolates the buoyant material from the fluent cargo, thereby promoting independent buoyancy thereof relative to the cargo.

10 To the extent that the cargo or some other fluent medium, such as casual water, may, as a result for example of stresses and strains imposed during transit, invade an envelope containing a porous buoyancy strip, valved means are preferably provided for egress of the contaminant from the envelope.

15

According to the invention from another aspect there is provided a method of exhausting a fluent cargo from a flexible vessel used to transport said fluent cargo through liquid; the method utilising buoyancy to assist in the presentation of
20 said cargo for evacuation from said vessel.

In order that the invention may be clearly understood and readily carried into effect, one embodiment thereof will now be described, by way of example only, with reference to the
25 accompanying drawings, of which:

Figure 1 is a plan view, from above, showing how flexible vessels of the kind described herein may advantageously be deployed for transit, as described in WO-A-97/02980;

30

Figure 2 is a cross-sectional view taken through the line A-A of Figure 1;

- 4 -

Figure 3 shows a cross-sectional view taken through a strip of buoyant material and a pocket in which the strip is housed and by means of which it is attached to the vessel;

5 Figure 4 shows, in perspective view, two pockets, each containing a buoyant strip, deployed in a vessel;

Figure 5 shows, in end elevation, how a simple valve may be attached to a pocket of the kind shown in Figure 4; and

10

Figures 6(a), 6(b) and 6(c) show the valve in end elevation, cross-section and plan respectively.

Referring now to the drawings, Figure 1 shows in plan view
15 from above a deployment 1 of flexible vessels, used for transporting fluent cargo, for example, vegetable oil, fruit juice or fresh water, through liquid such as sea water. The apparatus includes a number of units a, b, c etc. connected in sequential linear alignment. Each unit comprises either
20 a single container or pod 2 or two such containers or pods paired together. In the units having paired containers, they are connected so that they are positioned side by side or adjacent with their longitudinal axes parallel.

25 As shown in Figure 2, the paired containers are close coupled. They may be connected at their broadest extents by rolling spring lashings 3. In this way, the top surfaces of the containers can be fixed rigidly or preferably elastically so that they are close-rigged together by tangential springs.
30 Close rigging requires that all adjacent facing edges of the containers are connected.

- 5 -

In general, whilst any suitable shape of container may be used, each is preferably parallel-sided with apexed bow and stern sections 4,5. The containers may take any convenient form and may, for example, be diamond shaped or hexagonal 5 shaped in plan.

Parallel-sided containers may, for example, be rigged in diamond formation or in two or more parallel lines. Diamond-shaped and hexagonal containers are preferably rigged in 10 diamond formation to achieve the advantages of close rigging.

The exterior opposing or facing sides of adjacent respective containers run generally parallel along their length. In this manner, parallel sided channels are set up between adjacent 15 containers through which, during use, the liquid through which the containers are transported, usually sea water, can flow.

Each container is made as a closed flexible envelope from panels of fabric welded together to be form stable under 20 hydrostatic conditions. The fabric has a thickness in the range of 1.5 to 3.5 mm and the circumference of the container is preferably in the range 30 to 63 m though larger dimensions can be used in some circumstances. In use, the container is usually filled to approximately 50% to 70% capacity, although 25 other capacities can be used.

The bow and stern are provided with piped orifices (not shown) for loading and discharge purposes and bridles (not shown) may be provided for towing and mooring the vessel apparatus and 30 can be integral with the structural design of the vessel.

Flexible tubes of fabric (air sponsons) can be provided which are inflatable to increase the torsional stability of the

- 6 -

vessel apparatus should this be required. The vessel may be provided with further flexible tubes of fabric (water sponsons) which when filled with fluent cargo or sea water create stiffened structures which assist to reinforce the apparatus against hydro-dynamic pressures. The flexible containers have stiffened flexible anchorage points at the bow and stern and at intermediate positions for the purposes of inter-connection.

10 For towing purposes, the containers are rigged directly to a tender-barge or an integral buoyancy device which is towed by a tug according to normal practices. This arrangement is possible because of the self-stabilising nature of the apparatus.

15

The containers may be provided with buoyancy means to provide support when the container is empty or partially empty.

It will be understood that the arrangement illustrated in
20 Figures 1 and 2 shows one particular deployment configuration for the purposes of illustration only. In practice the invention may be applied to vessels intended for many different deployment configurations; the detailed embodiments being straightforward for those skilled in the art to
25 implement.

Typically the vessel or vessels are intended to lie submerged, or partially submerged in the fluid, e.g. sea water, through which they are to be moved, and they are usually towed in that
30 condition. Such vessels may, however, be operated on the surface.

- 7 -

During the course of sea trials and water transportation operations of vessels of this kind, complete unloading of the cargo therefrom has been to an extent frustrated because residual fluid cargo inside the vessels tends to "pond", or
5 form pools, on areas of the vessel base inaccessible to the internal discharge pipework when the vessel is substantially collapsed as a consequence of the unloading operation.

In order to address this problem, the inventors have devised
10 an arrangement whereby additional buoyancy is provided to lift selected regions of the base of the vessel during evacuation of the cargo, thereby to present to the evacuation apparatus those areas of the base which would otherwise have contained, in pools, the residual cargo.

15

The additional buoyancy is, in this example, located inside the vessel and attached to its base, thereby presenting the residual cargo for evacuation by lifting the pools of fluent cargo and allowing the internal pipework of the evacuation
20 system to become submerged therein, consequently allowing the pump to evacuate the vessel to an acceptable extent.

Also in this embodiment, the additional buoyancy is constituted by strips of closed-cell foam contained in pockets
25 of material welded to appropriate areas of the base of the vessel to provide the required selective up-lift during cargo evacuation. The amounts of foam used and its positioning are influenced, of course, by factors such as the buoyancy of the foam in relation to the specific gravity of the fluent cargo;
30 the configuration that tends to be adopted by the base of the vessel under evacuation, in relation to the associated pipework used for evacuation and the pumping capacities available. Account has also to be taken of the tensile

- 8 -

properties of the pockets for the buoyancy-providing foam, as welded to the vessel's base.

Figure 3 shows, in cross-section, a buoyancy device and a means for its incorporation in a vessel in accordance with one example of the invention.

In Figure 3, there is shown a buoyancy strip 10, formed of polyethylene foam, enclosed within a pocket 11 provided with flange-like side strips 12, 13, which are welded to the inner surface 14 of the base 15 of the vessel (shown in part only in Figure 3). The strips such as 10 are usually aligned with the longitudinal axis of the vessel, though this need not necessarily be the case and other orientations may be used if preferred, or if necessary to apply lift to certain areas in which pooling of the cargo occurs, or may occur. In any event, the open ends of the pockets such as 11 are closed, as will be described in more detail hereinafter, by welding of excess material to the inner surface 14, with the intention that the pockets such as 11 should resist the ingress of fluids, such as the cargo or casual water, thereby preserving the buoyant characteristics of the foam in the strips such as 10.

With regard to the characteristics required of the foam itself, and bearing in mind that vessels of the kind under consideration here are frequently used to transport drinking water, it is preferred to use drinking water-compatible PE closed-cell foam weighing approximately 35 Kg per cubic metre. In this form, the material provides approximately 965 Kg of uplift per metric tonne at surface water level. However, the material may be specified in various weights, depending upon the precise application, and it is envisaged that weights

- 9 -

ranging from (and including) 20 Kg to 50 Kg per cubic metre may be utilised.

In some configurations, the foam may be thermo-laminated to provide concentrated additional buoyancy within a confined area.

In general, however, the base of the vessel is raised evenly. Thus, multiple strips are sited in parallel longitudinally of the vessel and preferably centred on respective panels of the vessel. The distance between strips is influenced by factors such as the hydrodynamics of the vessel's shape and the specific gravity of the cargo fluid but, in the case of fresh water cargo, the strips are approximately 1.5 metres apart. The panels of the vessel are asymmetrical and this locates the strip optimally in respect of the cargo load.

In this example, the pockets such as 11 are made from polyurethane-coated woven base material, such as nylon or polyester, and it is convenient if the pockets are made from the same material as the shell or skin of the vessel itself. Each pocket such as 11 is configured and dimensioned to encase the entire length and breadth of a respective strip such as 10, and to this end typical dimensions in cross-section are:

Strip 10: 100 mm wide and 25 mm thick;

Pocket 11: 240 mm wide including 40 mm flange at either side of the strip.

The lengths of the strip and pocket depend, of course, on application but are typically in the range from 1 metre to

- 10 -

18.5 metres; and strips may be split into separate lengths for convenience during vessel fabrication.

Using the above dimensions, the cross-sectional width of a pocket, between outer edges of the flanges, is about 210 mm when assembled to envelop a strip and with its flanges welded to the base of the vessel.

Figure 4 shows, in perspective view, pockets 11 and 21, containing closed cell foam, with respective end closures 111, 211 and 121, 221 folded over to enclose the ends of the respective strips and welded to the inner surface 14 of the base 15 of the vessel.

As mentioned previously, as a result of the continual flexing of the vessel in service, the pockets such as 11 may not entirely preclude the ingress into the foam strips such as 10 of casual water or cargo fluid. In order to address this problem, a relief valve may be provided and attached as necessary to enable any pocket to be evacuated of such fluids.

Typically, relief valves (if used) are mounted on the aft-facing closure ends, 211, 221, of pockets such as 11 and 21, so that the linear forces generated by forward motion of the vessel evacuates contaminant fluids from the pockets.

Figure 5 shows, in perspective view, a valve 22 attached to the aft end closure 221 of pocket 21, and Figures 6(a), 6(b) and 6(c) show various views of the valve 22, illustrating its construction and its manner of attachment to the aft end 221 of the pocket 21, as will now be described.

- 11 -

The valve 22 is constructed of a pair of similarly shaped and juxtaposed PU film 23, 24 joined at their longitudinal edges, as indicated at 25, 26 in Figure 6(c) and attached by welding to the rear surface of a disc 27, formed of polyurethane-coated nylon or polyester fabric, so as to form a "lay-flat" tubular valve.

In order to attach the valve 22 to the aft-facing end 221 of the pocket 21, a transverse slit 28 (Figure 5) is made in the end 221 with a knife or other suitable object; the valve 22 is positioned centrally over the slit and the rear of the disc 27 is then hot-air welded to the surface of the pocket. Leak-proofing of the valve-to-pocket joint is achieved by sealing around the edge of the joint with polyurethane tape.

15

Typically, the slit 28 is around 20 mm long; the outside and inside diameters of the disc 27 are 50 mm and 20 mm respectively; and the two layers of film 23 and 24 are identical and of total length 60 mm (including the tapered portion as shown in Figure 6(c)), which tapered portion is 18 mm in length. At their ends opposite from the taper, the first 10 mm or so of the films 23, 24 are welded to the rear surface of the disc 27. With regard to lateral dimensions of the films 23 and 24, their overall width is 36 mm, with 3 mm welding area to either side, leaving a flat opening of width around 30mm at and adjacent the tapered ends of the films.

Overall, therefore, as will be understood from the foregoing, the invention envisages, inter alia, internal buoyancy of flexible containment vessels for fluent cargoes being provided by strip-like inserts of closed-cell polyurethane foam, thereby improving the evacuation of the fluent cargo from such vessels. Moreover, the internal buoyancy assists in

- 12 -

maintaining desired operational draft of such vessels, thereby providing adequate clearance beneath the bases of such vessels when mooring and berthing under fully laden conditions. Simple valving may, moreover, be provided as necessary to
5 permit the removal of fluids which have invaded the environment occupied by the inserts.

Whilst the present invention has been described with reference to transporting cargoes through sea water, it will be apparent
10 that the invention can be adapted to transport cargoes through fresh water. The flexible container of the present invention preferably has a generally compressed circular cross-sectional shape which is determined by the hydrostatic pressures.

- 13 -

CLAIMS:

1. A flexible vessel for transporting fluent cargo through liquid; the vessel having cargo evacuating means associated
5 therewith, and being provided with buoyant means disposed and configured to assist in the presentation of said cargo to said evacuating means.
2. A vessel according to claim 1 wherein the buoyant means
10 comprises means secured to at least one area of a base of said vessel, thereby to cause said at least one area to be raised during evacuation of the cargo.
3. A vessel according to claim 1 or claim 2 wherein the
15 buoyant means is secured to said base area internally of said vessel.
4. A vessel according to any of claims 1 to 3, wherein the buoyant means comprises one or more strips of foamed or
20 otherwise non-porous material, each encased in a pocket secured to the base of the vessel.
5. A vessel according to claim 4 wherein said pocket is dimensioned and configured to substantially isolate the
25 buoyant material from the fluent cargo.
6. A vessel according to claim 4 or claim 5 wherein the pocket comprises a polyurethane-coated woven base material welded to an internal surface of the vessel.
30
7. A vessel according to claim 6 wherein said woven base material comprises one of the group comprising nylon or polyester.

- 14 -

8. A vessel according to any preceding claim wherein the buoyancy means comprises closed cell foamed material.

9. A vessel according to any preceding claim wherein said
5 foamed material comprises polyethylene.

10. A vessel according to any preceding claim wherein valved means are provided for egress of fluid contaminants from the envelope.

10

11. A vessel according to any preceding claim further including valve means permitting the escape of fluid from said buoyant means.

15 12. A vessel according to claim 11 wherein said valve means incorporates, as the valving element, first and second layers of a plastics film assembled to form a lay-flat tube.

13. A vessel according to claim 12 wherein said first and
20 second layers of plastics film are attached to a discoidal member intended to be affixed to a surface of a pocket containing said buoyant means.

14. A vessel according to any of claims 11 to 13 wherein the
25 buoyant means is disposed longitudinally of the vessel and contained within a pocket, and wherein said valve means is attached to an aft-facing surface of said pocket.

15. A method of exhausting a fluent cargo from a flexible
30 vessel used to transport said fluent cargo through liquid; the method utilising buoyancy to assist in the presentation of said cargo for evacuation from said vessel.

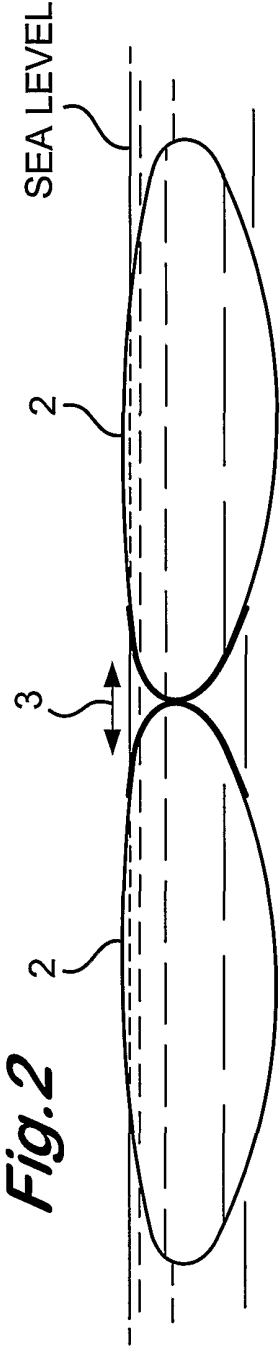
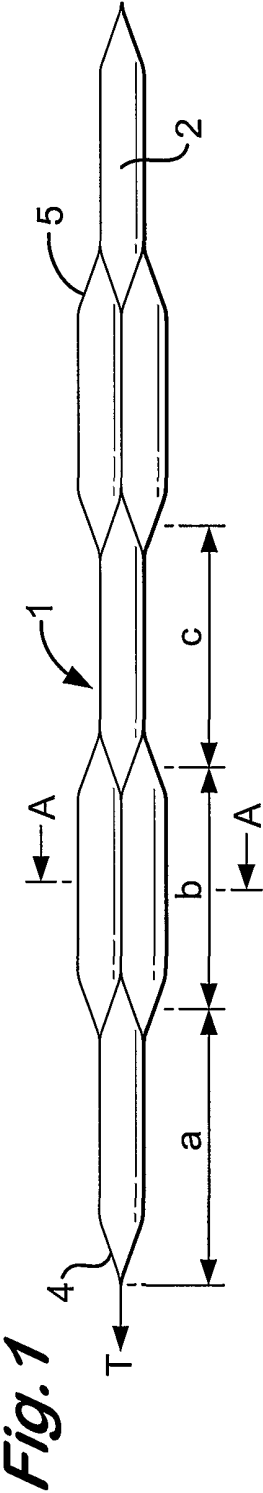
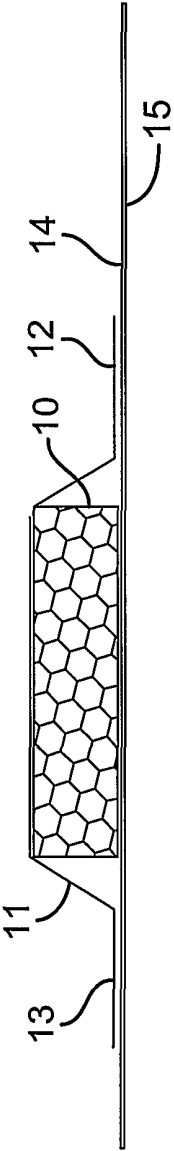
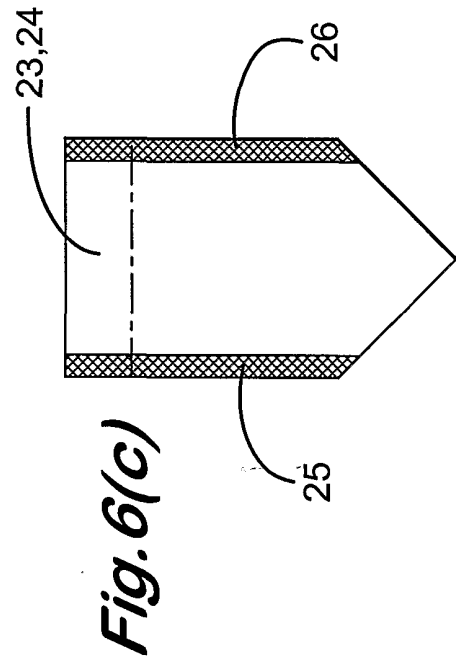
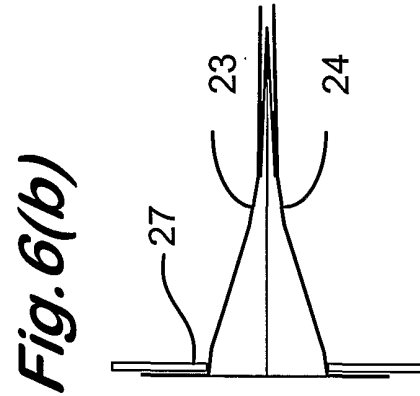
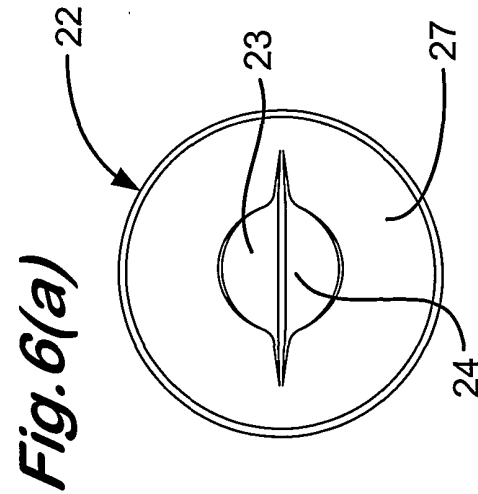
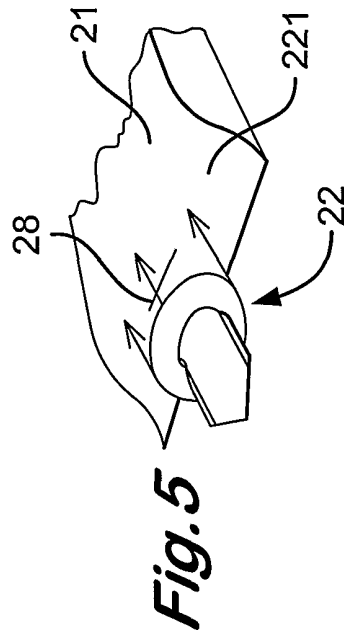
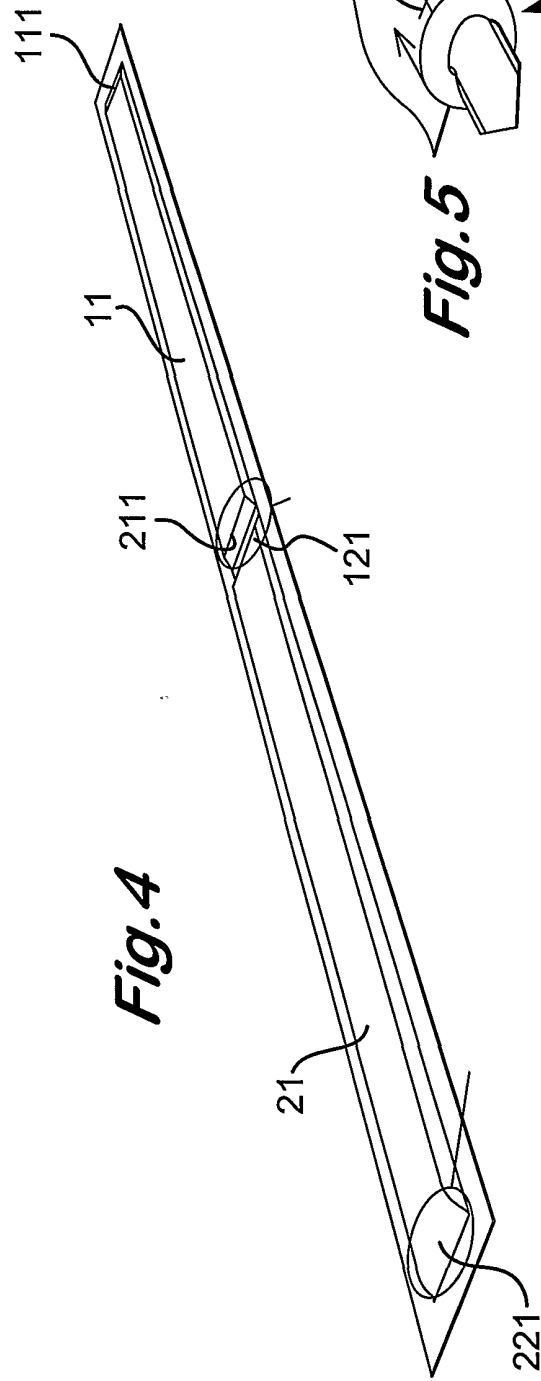


Fig. 3





INTERNATIONAL SEARCH REPORT

International Application No

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B63B35/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B63B B63G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	column 6, line 5 - line 53; figures	3,6,7,9, 11
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Y	GB 2 196 717 A (MARITIME RESCUE INTERNATIONAL) 5 May 1988 (1988-05-05) abstract; figures 2,4	9
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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