United States Patent

[11] **3,577,879**

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[33] **France**
[31] **158914 and 182534**

[54] **FLOATING BARRIER MEANS**
6 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **61/1**
[51] **Int. Cl.** **E02b 15/04**
[50] **Field of Search** ..... 61/1, 1 (F); 210/242

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ABSTRACT: This invention relates to barrier elements used, for example, for restraining oil slicks and the like on the surface of the sea. In such a barrier that comprises an inflatable tube and a skirt connected thereto, the invention provides that the skirt consists of two flexible members each of which constitutes an elementary skirt: means are provided to connect together these elementary skirts by their upper portions and the lower portions of the skirts are split vertically, the splits being uniformly spaced apart and the splits in one elementary skirt being offset relatively to those in the other: at least one flexible mechanical reinforcing element is located in the upper portion of the skirt and this flexible reinforcing element may be located in a channel.

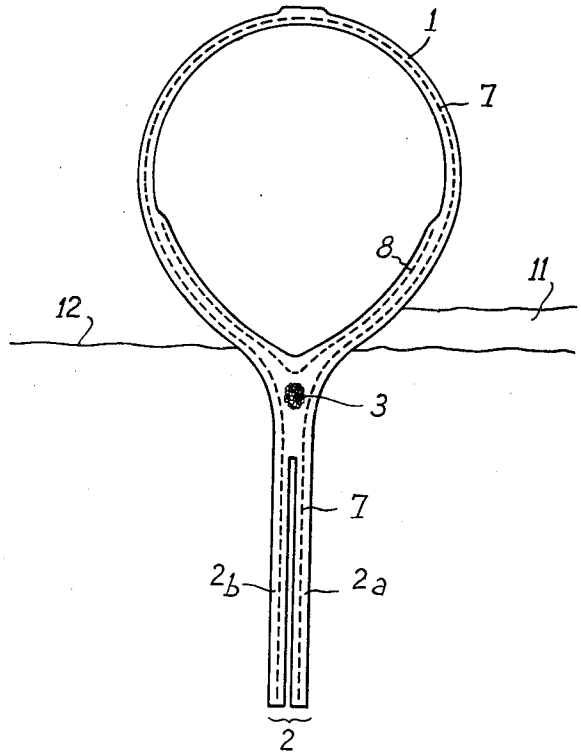


Fig. 1

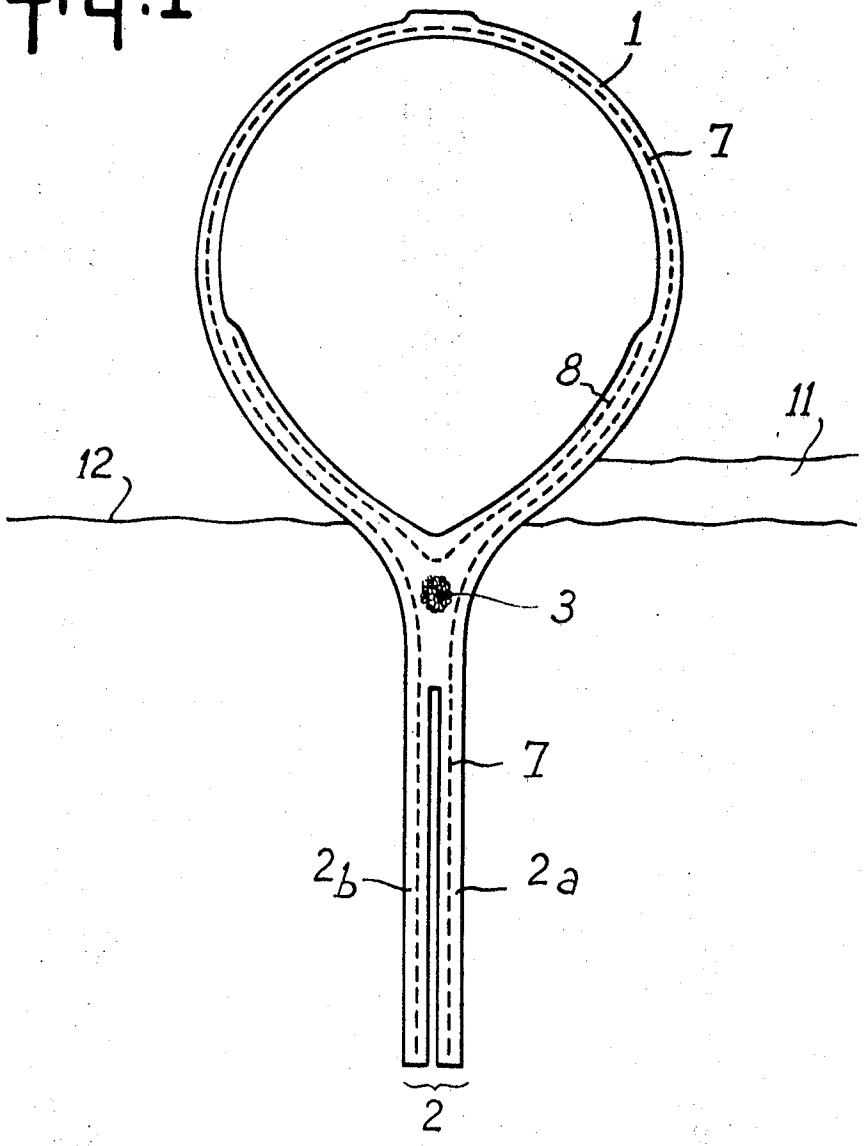
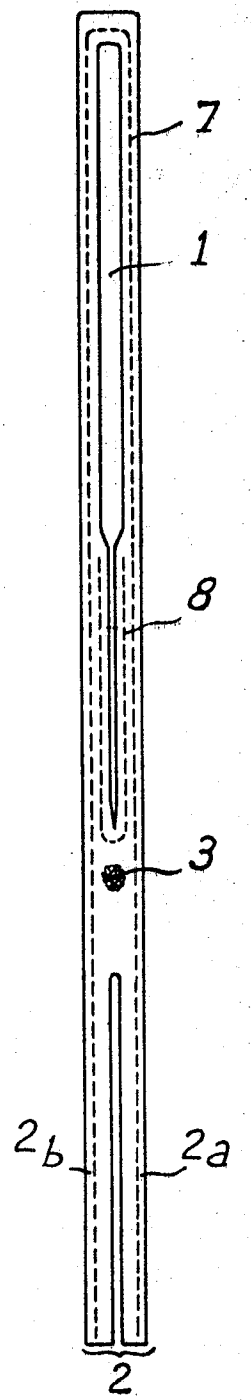


Fig. 2



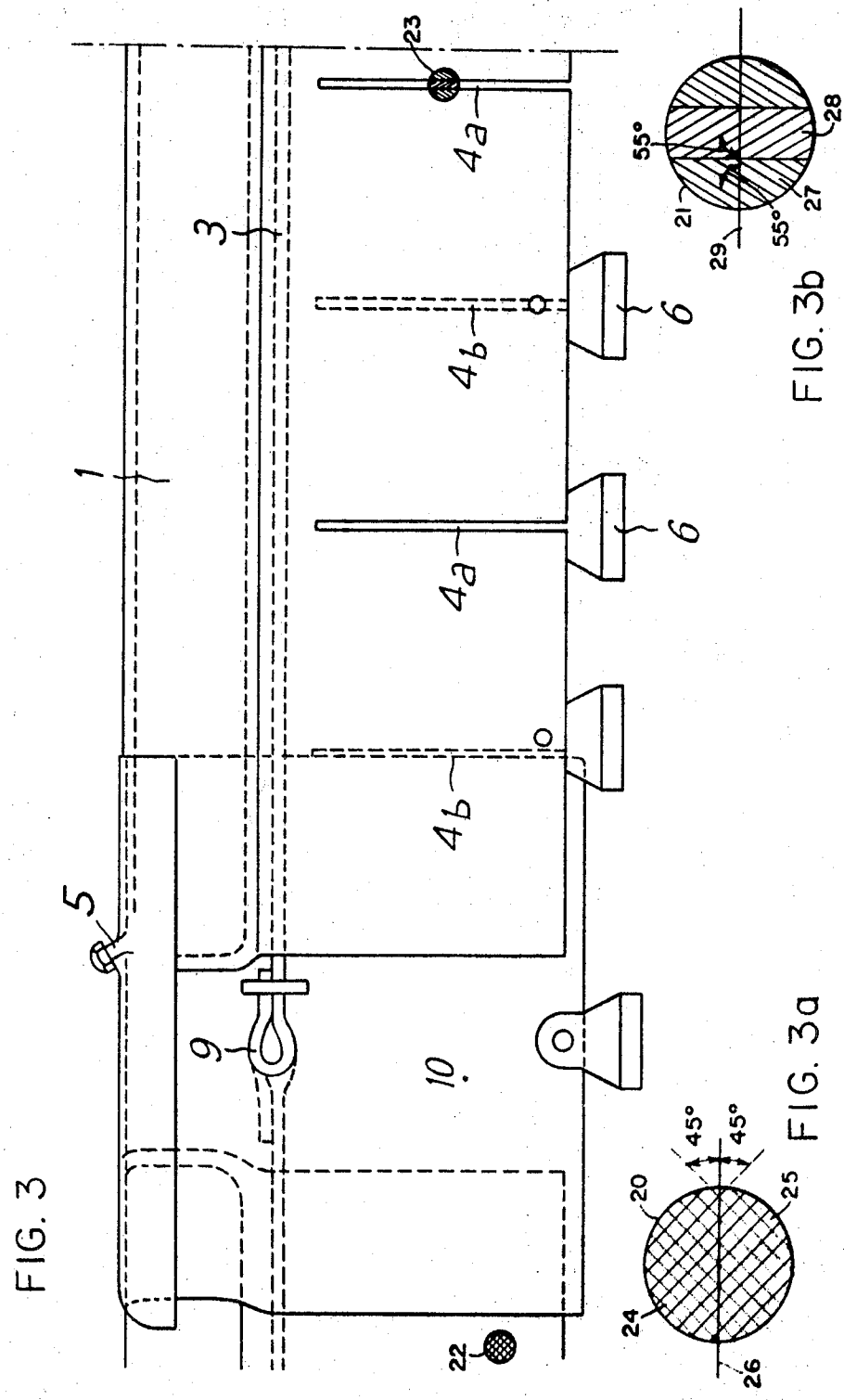


FIG. 3

FIG. 3b

FIG. 3a

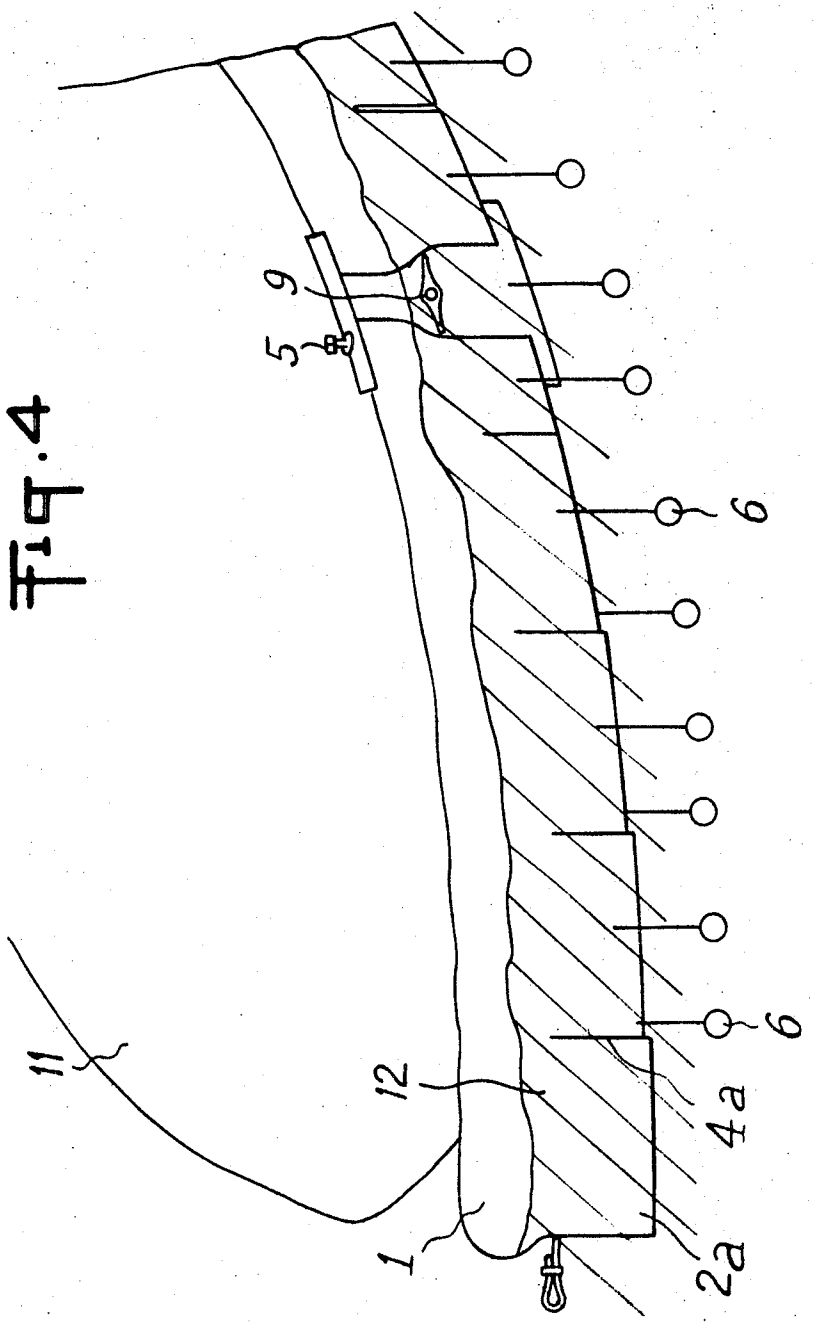


FIG. 4

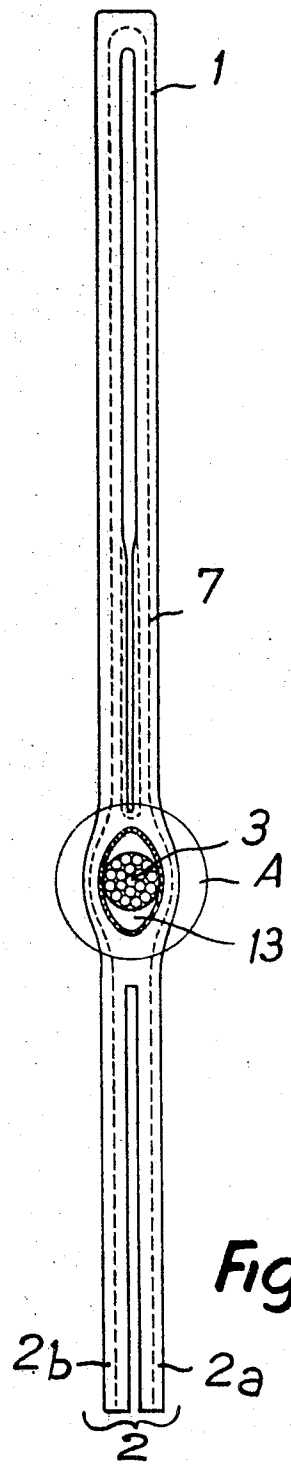


Fig. 5

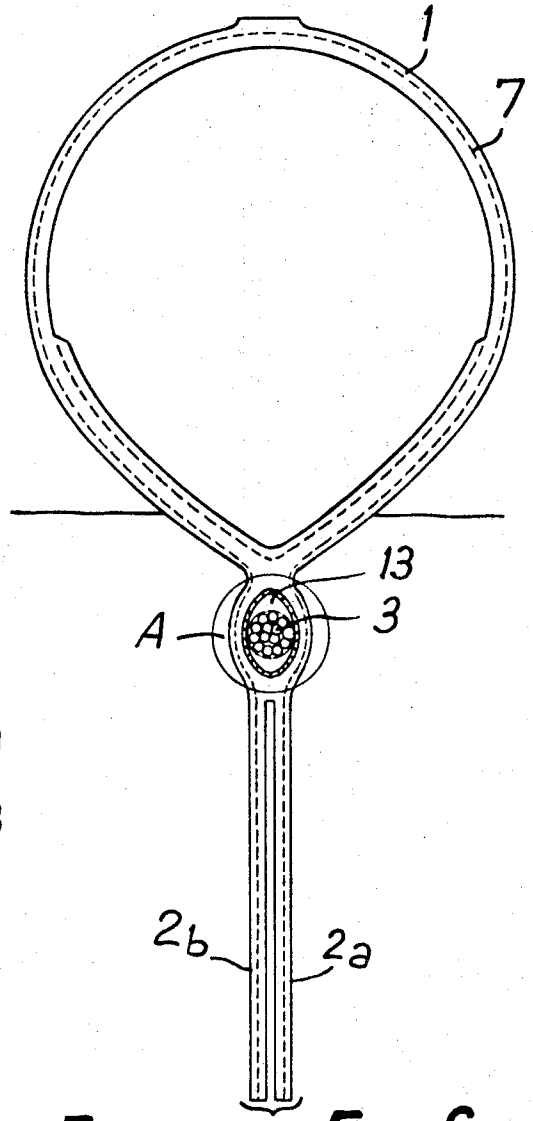


Fig. 6

Fig. 7

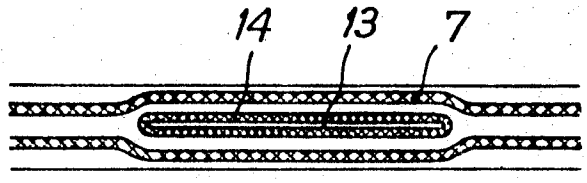


Fig. 8

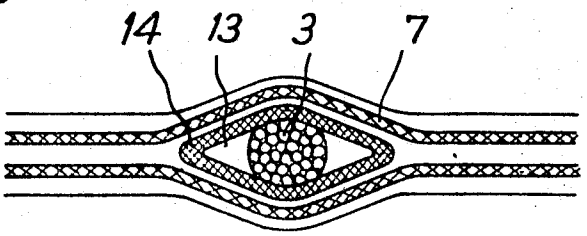
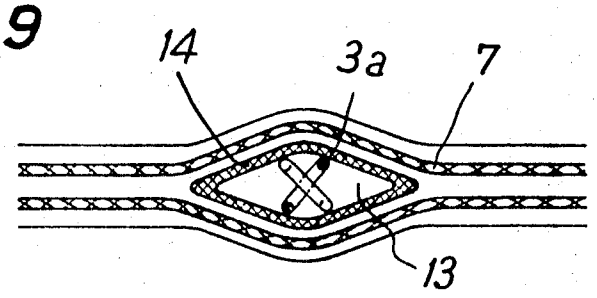


Fig. 9



FLOATING BARRIER MEANS

The present invention relates to floating barriers formed by an inflatable enclosure extended by a flexible element generally referred to as a skirt, which extends below the inflatable enclosure. Barriers of this kind may, for example, be used at the sea in order to restrict the spread of areas of pollution which are the result of accidental discharges of hydrocarbons such as oil and thus to allow the said hydrocarbons to be recovered.

Such barriers, i.e., the floating barriers which enclose layers of hydrocarbons, should not be continuous solution in spite of the deformations and mechanical stresses to which they are subjected, due to the movement of the sea and of any beaching operations. It should be possible for their ends to be drawn together so as to reduce the surface of the layer and to limit its thickness. Moreover, they should be easy to store and transport and to locate in position.

Hitherto, numerous floating barriers constituted by an inflatable enclosure and a skirt have been proposed and certain of them have been actually produced but they have only been suitable for use in ports and in relatively calm water. This is due to the fact that none of them has the necessary qualities which enable them first of all to enclose and subsequently to restrict in a rough sea, a considerable layer of hydrocarbons. In fact, all these barriers are possessed of an insufficient degree of longitudinal flexibility. This is due to the longitudinal reinforcement which causes the skirt to extend continuously over the full length of the inflatable enclosure. In a rough sea, the lack of longitudinal flexibility results in substantial stresses which are greater than those permitted by the strength of the elements of the barrier and there is thus a risk of the elements breaking, and because these barriers have a marked tendency to behave like girders resting on the peak of two consecutive waves there is the risk that in the hollow of the waves the layer of hydrocarbons may escape and pass beneath the skirt. In order to obviate the risk of rupture, it has been attempted to incorporate into these floating barriers, elements which impart mechanical strength. Thus, certain of these barriers are provided with two metal cables which run parallel to the inflatable enclosure and are located one on the lower part and the other on the upper part of the skirt, this arrangement of cables also having the effect of longitudinally stiffening the skirt which, as has been explained above, is not desirable. In other cases, there have been provided, at the top and bottom of the inflatable enclosure, two external ropes which are connected to the said enclosure. This arrangement has a number of disadvantages, one of which is that it reduces the longitudinal flexibility of the barrier without, however, counteracting the tendency for the skirt to split. Certain other inflatable barriers have been provided with a strong external cable but this has the dual disadvantage of causing stresses which are not acceptable at the points at which the cable is secured and of leaving the skirt still liable to split or rupture. Finally, certain barriers have a skirt forming a sort of pocket on the lower part of which there passes a chain serving as ballast. These barriers, with no mechanical strength of their own, are designed for use in ports and cannot be used on the high seas.

In other words, all existing floating barriers are possessed of an insufficient degree of longitudinal flexibility. Most of them are not provided with means for increasing their mechanical resistance and the elements provided in some cases to increase mechanical resistance have the effect of further reducing the longitudinal flexibility or else of setting up unacceptable stresses at the point at which the members are secured.

It is an object of the invention to provide a floating barrier which is also constituted by an inflatable enclosure and a skirt, but which has none of the disadvantages above mentioned and which, in particular, is possessed of a high degree of longitudinal flexibility which allows it to adjust to the swell of the sea; it is a further object that the barrier shall have sufficient mechanical strength for a tensile stress to be applied at each of its ends in order to draw them together.

A barrier according to the invention is composed of a series of floating elements, each of which is characterized by the fact that it comprises both an inflatable tube and a flexible skirt connected to the inflatable tube and formed of two elements each of which constitutes an elementary skirt, the two elements being juxtaposed and connected together at the top and only at the top, and having vertical splits spaced at regular distances apart, the splits in one element being offset relatively to those of the other element, a flexible member having considerable mechanical strength, such as a cable or assembly of cables being located in the upper portion of the skirt.

According to a preferred embodiment of the invention, the flexible reinforcing member is located in a passage provided in the upper portion of the skirt.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings showing an embodiment thereof by way of example, and in which:

FIG. 1 shows a sectional view through a barrier element in position,

FIG. 2 shows a sectional view of the element shown in FIG. 1 before it is brought into position,

FIG. 3 shows an elevational view of the assembly of the two elements of the barrier,

FIG. 4 shows an elevational view of a portion of the barrier in position,

FIG. 5 shows a cross section through another form of barrier element having an inflatable tube, but before the tube is inflated,

FIG. 6 shows a cross section through the barrier element shown in FIG. 5 when the tube has been inflated,

FIG. 7 shows a cross section through the center portion (corresponding to part A in FIGS. 5 and 6) of a barrier element before the flexible longitudinal reinforcing element has been placed in position, and

FIGS. 8 and 9 show cross sections through the center portion of the barrier elements after a flexible longitudinal reinforcement element has been placed in position.

The barrier elements are made of a plastics material or an elastomer such as rubber which is resistant to sea water, hydrocarbons and bad weather of all types.

Referring now to the drawings, the barrier shown comprises an inflatable enclosure 1 having a tubular form when inflated which acts as a float and constitutes the upper portion of the barrier proper, a flexible skirt 2 and a flexible element 3, having a substantial resistance to traction and made of the material of which the top portion of the flexible skirt 2 is made. The flexible skirt 2 is formed of two portions 2*a* and 2*b* which are connected together at the top. Each portion 2*a* and 2*b* of the skirt in fact constitutes an elementary skirt, and this is how they will be referred to in the remainder of the description.

Each of the elementary skirts 2*a* and 2*b* is provided with splits 4*a* and 4*b* which are perpendicular to the axis of the inflatable enclosure and are spaced regularly apart. The splits 4*a* in the elementary skirt 2*a* do not coincide with the splits 4*b* in the elementary skirt 2*b* and may, for example, be arranged arbitrarily.

At least one ballast member 6 is secured to the lower portion of each part of the elementary skirt 2*a* or 2*b* contained between two successive grooves 4*a* or 4*b*. These ballast members 6 are attached directly to each elementary skirt as shown in FIG. 3, or are suspended by means of a cable as shown in FIG. 4. Generally, this latter arrangement is preferred when the stresses to which the barrier is subjected are considerable. Particularly on the open sea, the length of the cables then varies in the same direction as the stresses. This is why the ballast member in FIG. 3 is particularly well adapted to operation near the coast.

In the embodiment shown, the flexible element 3 having a high tensile strength takes the form of a cable. It might also take the form of a number of metal or textile ropes.

The inflatable enclosure 1, which comprises one or more valves 5 used for purposes of inflation, acts as a float and constitutes the upper portion of the barrier as described above.

A floating barrier of this type is possessed of a high degree of longitudinal flexibility. The division of the skirt into two elementary skirts which are not connected at the bottom, and the provision of vertical splits 4*a* and 4*b* cause the skirt not to stiffen the barrier which is also not stiffened by the flexible reinforcing element located in the upper portion of the skirt. When, under the action of the swell of the sea, the inflatable tube is deformed, the skirt is also deformed in the same way without thereby causing particular stresses to be set up and without the skirt tending to lie flat as is the case in the majority of existing floating barriers. The fact that the grooves 4*a* and 4*b* are offset relatively to one another, means that in spite of the interruption between the elementary skirts, the barrier remains sealed relatively to the layer of floating hydrocarbons, such as oil. It has, moreover, been found that surprisingly enough the presence of the grooves 4*a* and 4*b* improves the stability of the skirts when the ends of the barrier are brought together in order to enclose the layer of oil.

This longitudinal flexibility, which is the result of the particular structure of the skirt and which prevents excessive stresses from being set up, means that the flexible reinforcing element may be relatively small in size. It has to withstand only the tensile stresses requires to shift the barrier. However, it is important that its presence should only increase slightly, if at all, the longitudinal rigidity of the barrier. In barriers according to the invention, this result is obtained by providing a flexible element or assembly of flexible elements of high mechanical strength in the upper portion of the skirt.

The elements of the barrier include a frame constructed of one or more layers of flexible elements In order to form each layer, it is possible either to use a biassed fabric or a corded fabric, that is to say, an assembly of elements such as wires or cables located parallel to one another and embedded in an elastic material which makes possible the cohesion of these various elements.

If a biassed fabric such as a plain weave for example is used, this is generally arranged in such a manner that the elements form an angle of 45° to the longitudinal direction of the barrier.

If a corded fabric is used, this is generally arranged so that the elements form with the longitudinal direction of the barrier an angle of between 40° and 70° and preferably of the order of 55°.

This particular arrangement of biassed or corded fabrics has a number of advantages, particularly the fact that since the inflatable tube is not provided with reinforcing elements parallel to its axis, it has a high degree of longitudinal flexibility.

In the embodiment of FIGS. 1 to 4, the elements of the barrier are formed from a sheet of elastomer having a reinforcement 7 constituted by two layers of corded fabric which are superimposed and crossed so that their elements form, with the longitudinal direction of the barrier, equal but opposite angles, of approximately 55°.

This sheet is subsequently bent back on itself on either side of a strip of elastomer which constitutes the flexible reinforcing element 3. During this arrangement the reinforcement 8 is also placed in position, the said reinforcement also being formed of two layers of corded fabric which are crossed and arranged at 55° relatively to the longitudinal direction of the barrier so that the inflatable enclosure is reinforced over its full periphery.

On either side of each barrier element, the elements 3 of high mechanical strength exceed a certain length. This makes it possible to attach them to one another by means of a flexible connection 9. At these connections, the watertightness of the barrier is ensured by means of a flexible panel 10 which is secured to the two barrier elements and rests upon the skirt 2 of the said elements; the panel 10 is located at the side of the layer 11 of hydrocarbons.

The arrangement of the elements of the fabric in the cases of a biassed fabric and a corded fabric respectively may be seen from the diagrammatic enlargements shown at 20 and 21 of portions 22 and 23 of the embodiment shown in FIG. 3 The fabric shown at 20 has a weave in which the elements 24 and 25 are each arranged at angles of 45° to the longitudinal direction 26 of the barrier. At 21 there are shown the elements 27 of one skirt made from a corded material and, visible through the slit 4*a* in this skirt, the elements 28 of the other skirt also made from a corded material. The elements 27 and 28 are arranged at angles 55° with respect to the longitudinal direction 29 of the barrier.

When in position, the barrier cuts off the layer 11 of hydrocarbons from the rest of the sea surface 12 in a remarkably effective manner as has been described above. The provision of the flexible reinforcing element 3 not only makes it possible for the barrier to be highly resistant to natural stresses due to the movement of the sea, but also for it to be moved by pulling the end members and to reduce the surface of the layer of hydrocarbons so as to make it possible to pump this layer away under optimum conditions.

In the embodiment described above, mention has been made of a barrier element in which the flexible element of high resistance to traction takes the form of a cable or assembly of cables which are embedded in the material constituting the barrier element and forming part thereof. It has been found that in certain cases this embodiment possesses certain disadvantages. In fact, if the cable happens to break or be damaged accidentally, the barrier element becomes useless or extremely difficult to repair.

Another difficulty in certain cases lies in the method by which they are to be produced.

In fact, once these elements have been manufactured, they take the form of a flat strip which may be easily vulcanized using a flat cable press or a rotary press which are part of equipment common in the rubber industry. However, this implies that the flat strip does not possess an excess thickness and that the thickness of the element does not exceed a certain value which is itself only a fraction of the thickness of the element of the barrier at the location of the strengthening element. These disadvantages may be obviated by making a channel in which is located the flexible element or elements providing mechanical reinforcement.

This second embodiment shows in greater detail in FIGS. 5 to 9 this particular form, referring to which, the barrier element similarly includes an inflatable enclosure 1, a skirt 2 formed by two elementary skirts 2*a* and 2*b* and a flexible element 3 of high tensile strength located in the upper portion A of the skirt.

The flexible longitudinal reinforcing member 3, which in the case of the embodiment shown in a metal cable, is located in a channel 13. It will be noticed that this causes excess thickness due to the relatively thickness of its cross section.

If this cable had been embedded in the barrier element during manufacture, this excess thickness will have made it impossible to use a rotary or plate-type press or the vulcanizing process. However, a plate-type or rotary press may now easily be used in order to manufacture this second embodiment since vulcanization is effected while the flexible longitudinal reinforcing element 3 is not yet in place and the barrier element takes the form of a flat strip.

In the embodiment above described, the manufacture of the barrier element is effected essentially by bending back on its self a sheet of elastomer comprising a reinforcement 7. In the center region A, there is provided a recess, the wall of which is covered with an antibonding agent which prevents them from sticking together during the vulcanizing operation. The result is the formation of a channel 13 in which the longitudinal reinforcing element is subsequently inserted.

The walls of the channel 13 are preferably provided with a reinforcement 14, which may take the form of one or more layers of fabric or any other suitable material capable of adhering to the elastomer or the plastomer of the barrier element. This reinforcement protects the barrier element from the friction of the element 3 against the wall of the channel and thus does away with any risk of rupture which might occur while the element 3 is being inserted in the channel 13.

During manufacture of the barrier element, there may be located in the channel **13** a continuous element hereinafter referred to as a drawing or pulling element, such as a wire, strip or cable of small diameter which is coated with antibonding agent and which extends beyond the two ends of the channel. This pulling or drawing agent will subsequently be used for inserting the longitudinal reinforcement element **3**.

Before and after vulcanization the center portion A of the barrier element takes the form shown in FIG. **7**. It will be seen to be quite flat, thus making possible the use of a plate-type or a rotary press for vulcanization.

When the barrier element has been vulcanized the drawing or pulling element, which is located in the channel **13**, is connected to the longitudinal reinforcing element **3**, the channel **13** is inflated and the pulling element is drawn so as to slide in the channel **13** and draw with it the flexible longitudinal reinforcing element.

The longitudinal reinforcing element is thus located in the channel **13**. In the case shown in FIG. **8**, this element **3** is a cable whereas in the embodiment shown in FIG. **9** the element **3***a* is a chain.

I claim:

1. A barrier element comprising an inflatable tube and a skirt connected to said tube, wherein said skirt consists of two flexible members, each of which constitutes an elementary skirt, connection means connecting said elementary skirts by their upper portions and the lower portions of said elementary skirts being vertically split at a uniformly spaced distance, the splits in one elementary skirt being offset relatively to those in the other elementary skirt, and at least one flexible mechanical reinforcing element being located in the upper portion of said skirt.

2. A barrier element according to claim **1**, wherein said at least one flexible reinforcing element is located in a channel provided in the upper portion of said skirt.

3. A barrier element according to claim **1**, which is made of an elastomer or a plastomer and comprising a reinforcement comprising at least one layer of a fabric in which wires are located at right angles, none of the wires in the fabric being parallel to the axis of the inflatable tube.

4. A barrier element according to claim **3**, wherein the wires in the fabric form with the axis of the inflatable tube an angle of approximately 45°.

5. A barrier element according to claim **1**, which is made of an elastomer or a plastomer and comprising a reinforcement constituted by at least two layers of elements which are parallel to one another, wherein these layers are crossed relatively to one another so that their elements form with the direction of the axis of the inflatable tube oppositely directed but equal angles of between 40° and 70°.

6. A barrier element as claimed in claim **5**, wherein the angle formed by the axis of the inflatable tube and each of the elements in each layer is of the order of 55°.