Sept. 28, 1971 J. E. MANUEL 3,608,316

BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

Filed Sept. 15, 1969 6 Sheets-Sheet 1

Fig. 1.

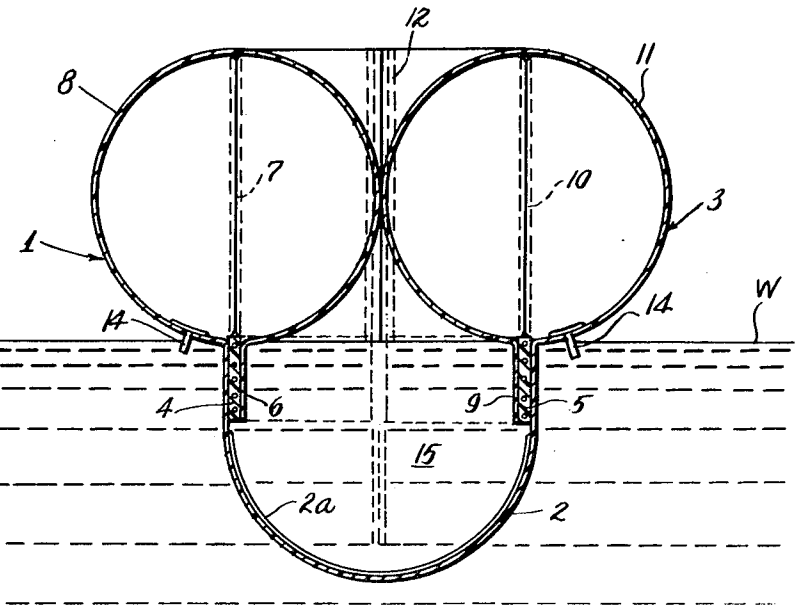
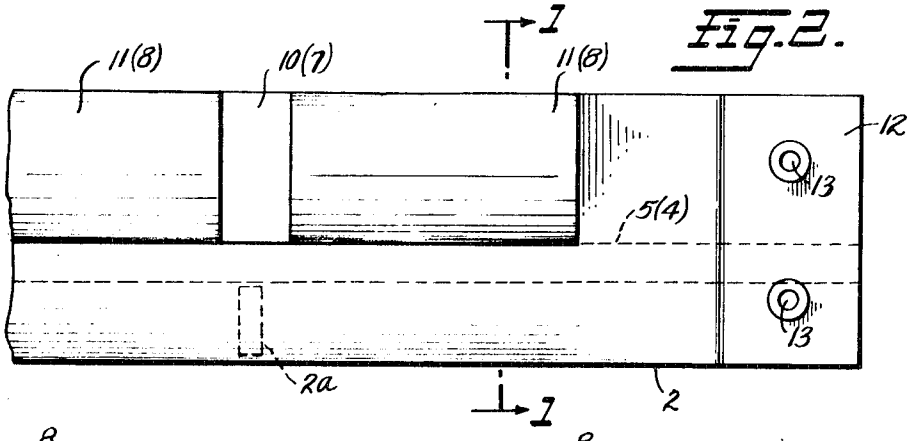


Fig. 2.



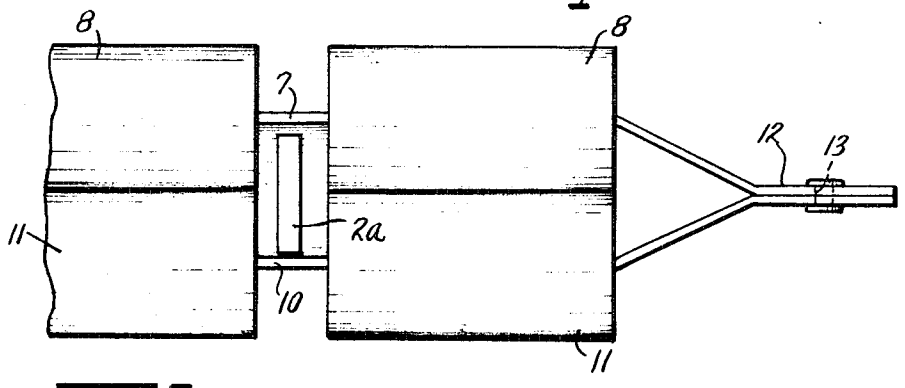


Fig. 3.

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BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

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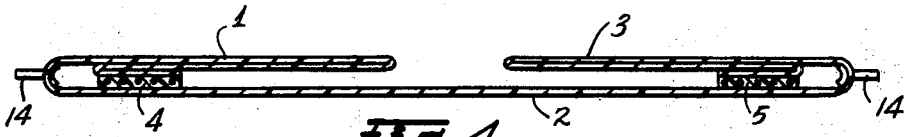


Fig. 4.

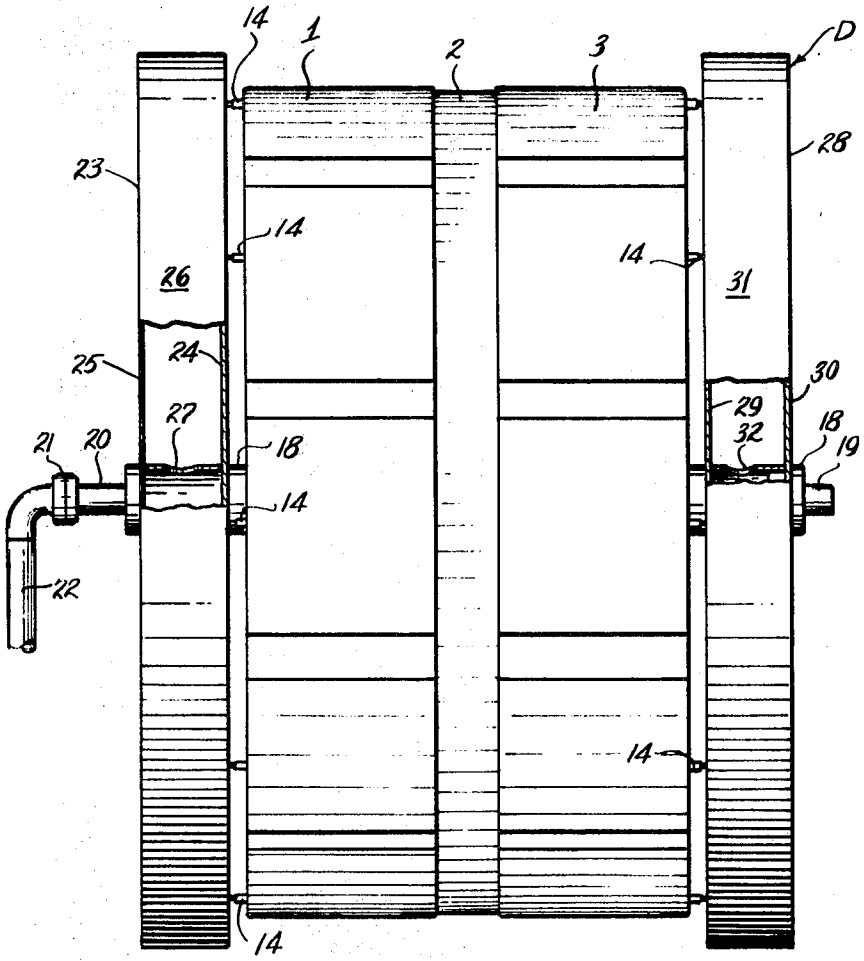


Fig. 5.

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Sept. 28, 1971 J. E. MANUEL 3,608,316

BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

Filed Sept. 15, 1969 6 Sheets-Sheet 3

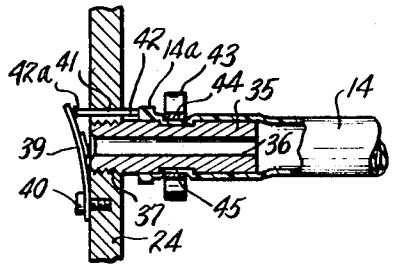


Fig. 6.

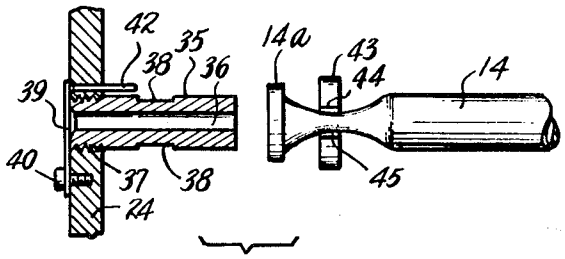


Fig. 6A.

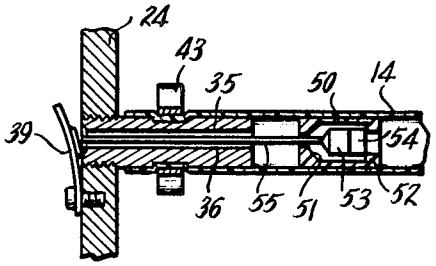


Fig. 7.

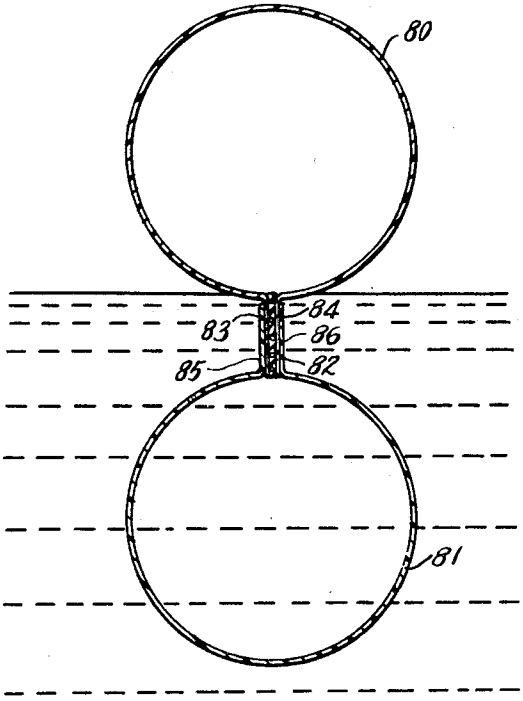


Fig. 15.

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BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

Filed Sept. 15, 1969 6 Sheets-Sheet 4

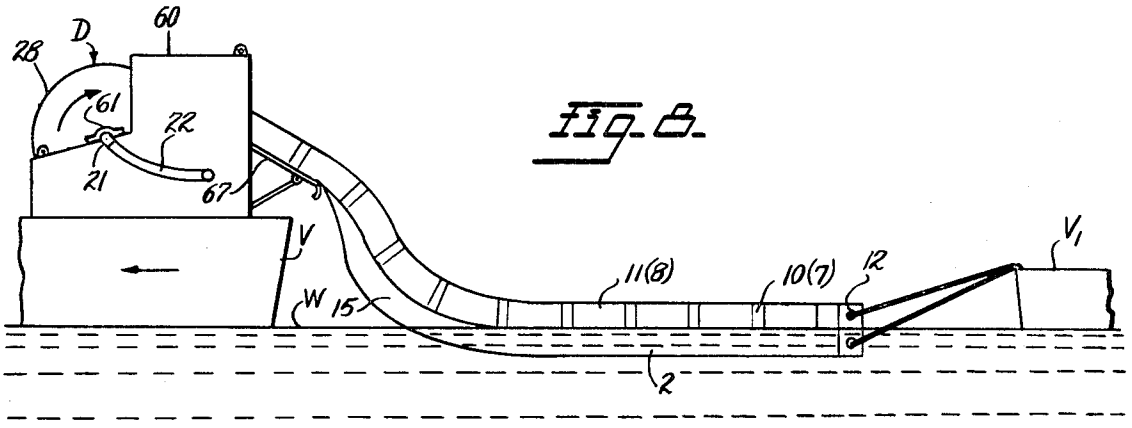


Fig. 8.

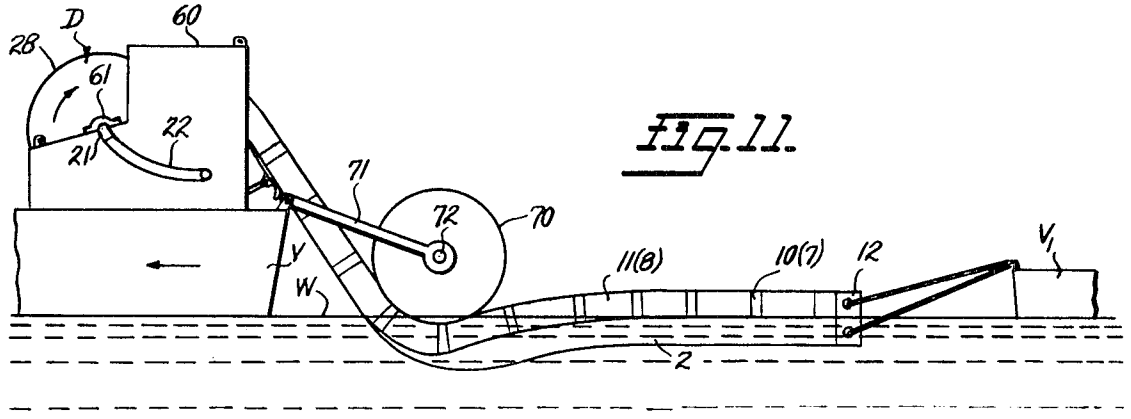
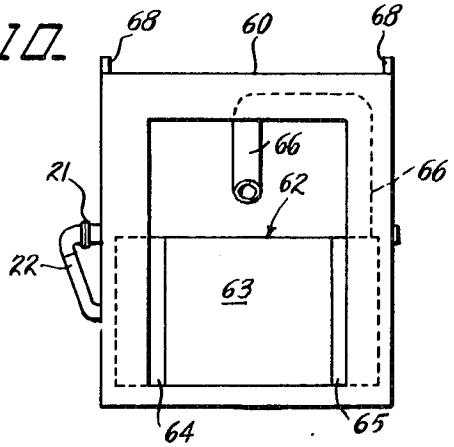


Fig. 11.

Fig. 10.



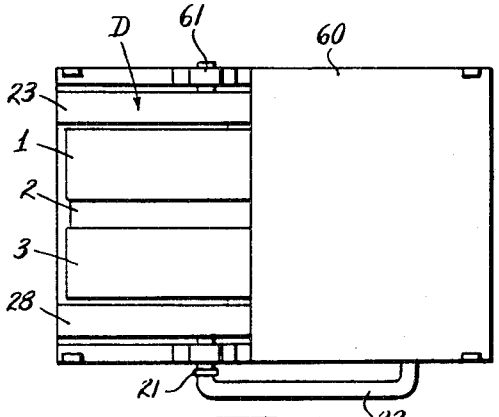


Fig. 9.

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BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

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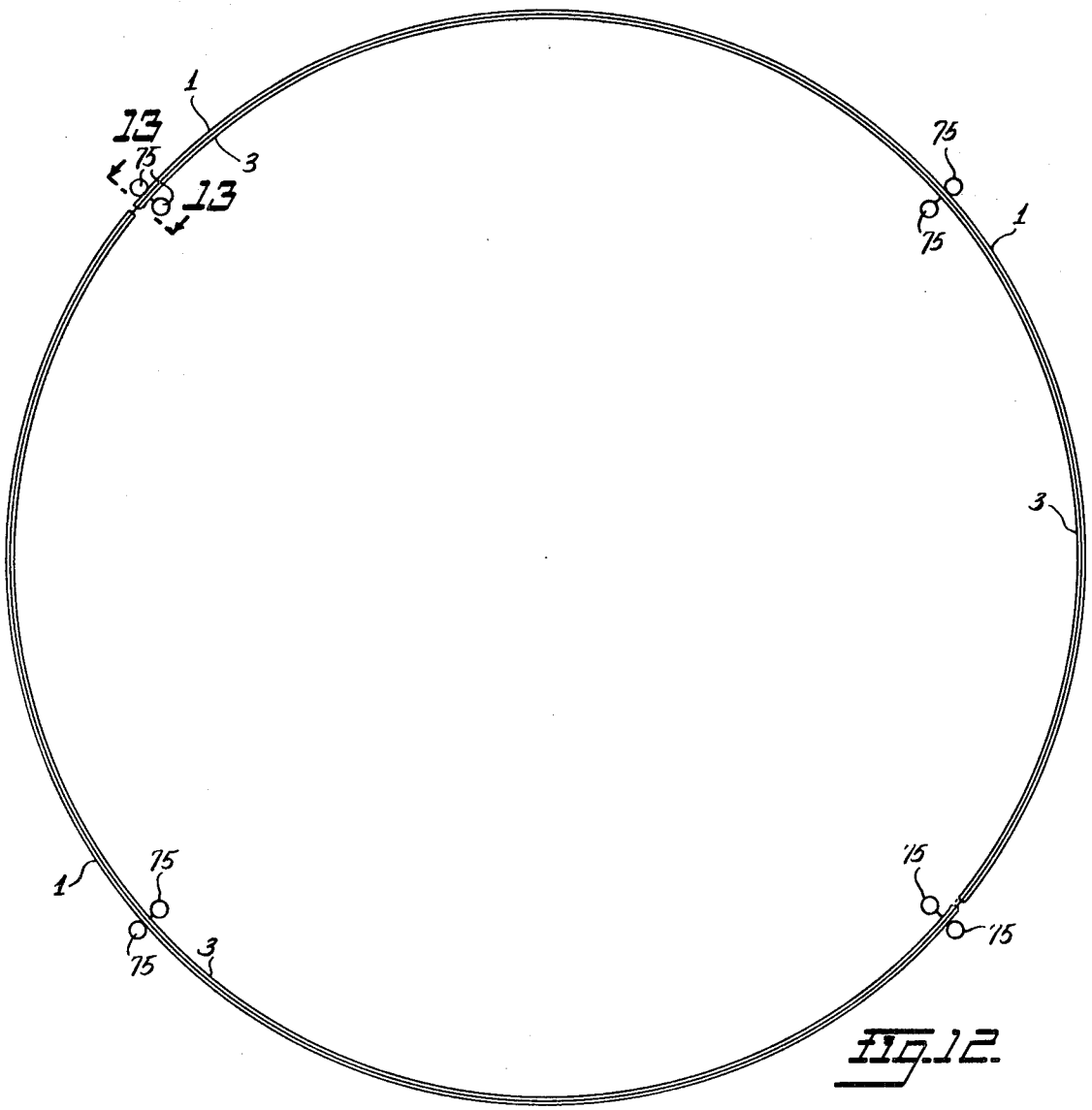


FIG. 12.

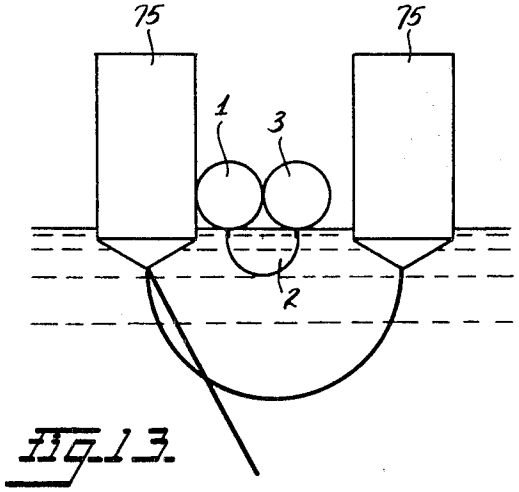


FIG. 13.

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BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

Filed Sept. 15, 1969 6 Sheets-Sheet 6

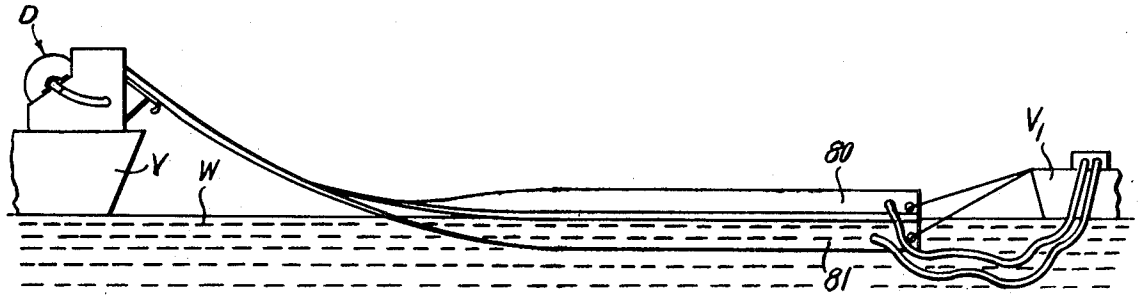
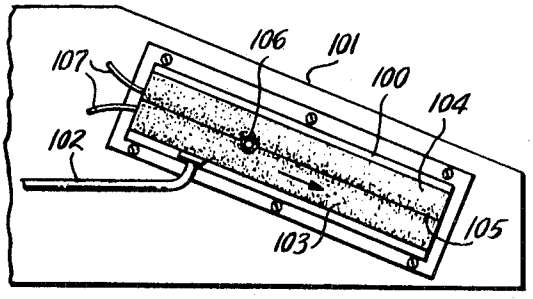


Fig. 16.

Fig. 14.



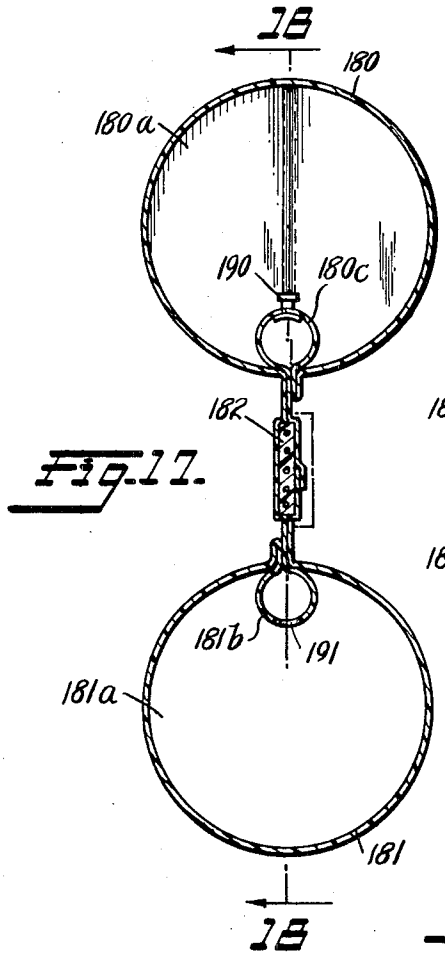


Fig. 17.

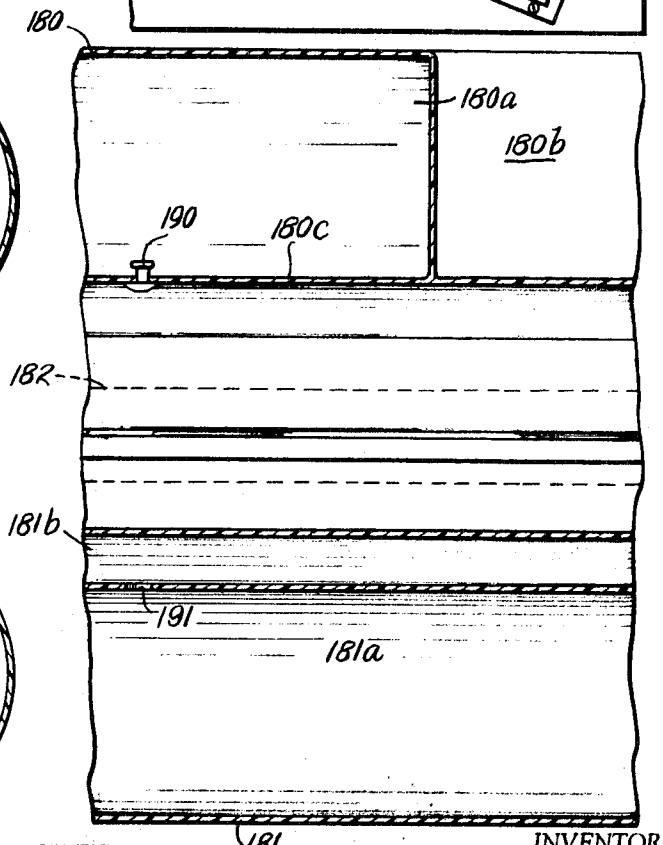


Fig. 18.

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United States Patent Office 3,608,316 Patented Sept. 28, 1971

3,608,316

BUOYANT BARRIER AND METHOD FOR INSTALLING THE SAME

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Filed Sept. 15, 1969, Ser. No. 857,792
Int. Cl. E02b 15/04
U.S. Cl. 61—1F 20 Claims

ABSTRACT OF THE DISCLOSURE

A buoyant barrier is provided, as well as a method for installing the same, which makes it possible to establish the barrier to confine an oil spill at a remote location in a relatively short time after the spill has occurred. The barrier structure can be of flexible sheet material and is provided in light weight packaged form, ready for delivery by air, the structure being such that very high rates of deployment onto the surface of a body of water are practical. In its packaged form, the barrier structure is completely free of weights. In deployed form, the weight of the structure is supported by air-inflated buoyancy chambers, and the structure is stabilized by a chamber or chambers filled with water from the body of water on which the structure is deployed.

This invention relates to buoyant barriers and methods for installing them. Though the invention is of broader utility, it offers particular advantage in the containment of floating pollutants, typically spilled oil.

In recent years, there has been a rapidly increasing need for an effective way to contain flowable pollutant materials spilled on the surface of a body of water. The problem is particularly critical with respect to oil spills which can occur, for example at offshore wells or from tankers, refueling buoys, dock installations, and the like. Prior-art workers have proposed to employ for this purpose various kinds of buoyant enclosures, the enclosure usually being made up of a series of floats, typically of foamed polymeric material, with the floats each being provided with a skirt which depends into the water for a significant distance, the combination of float bodies and skirts combining to present a confining surface of considerable area. It has also been proposed to make the floats in the form of an inflatable structure fabricated from flexible sheet material. In such prior-art proposals weight means is provided along the skirt, with the weight means having a specific gravity greater than that of water, to hold the skirt in its dependent position and to stabilize the overall structure. While such proposals have received considerable attention, and are frequently employed under those conditions where lengthy transport of the structure is not involved (as in the case of the problem of enclosing a tanker at dockside), the structures hereinbefore proposed have not been capable of being quickly and easily transported for long distances and then speedily installed at the point of use.

A general object of the invention is accordingly to devise a buoyant barrier, especially suitable for use in containing oil spills, which employs only structure and equipment which can be quickly transported, as by aircraft, delivered to the point of installation, and then quickly deployed on the surface of a body of water to contain the floating pollutant or other material.

Another object is to provide an elongated barrier structure which can be supplied in a single, light weight package and which does not embody any weight means of a character which must be transported therewith.

A further object is to provide a buoyant barrier structure which is fabricated from flexible sheet material and can be deployed more quickly than has heretofore been possible.

Yet another object is to provide an improved method for installing a buoyant barrier, which method makes it possible to deliver the structure to a remote location and install the barrier quickly so that containment of an oil spill, for example, can be accomplished during that relatively short time available before the spill spreads excessively or is dispersed.

Stated generally, the invention involves an elongated barrier structure formed of flexible material in such fashion that a first portion of the structure defines at least one gas-inflatable buoyancy chamber extending for the length of the structure, while a second portion defines a water chamber when the structure is deployed on the water with the buoyancy chamber or chambers inflated. When so deployed, and with the water chamber filled, the structure is supported by the buoyancy chamber and stabilized by the water-filled chamber, the overall structure having a lateral area sufficient to confine, for example, an oil spill. Since the water-filled chamber serves to stabilize the barrier structure in proper position, the structure itself embodies no weights or ballast material, and is of very light weight. The barrier structure is stored in flattened, folded condition, with sections thereof as long as 1000′ wound on a storage and deployment drum. One such drum is stored in combination with a deployment unit in which all ancillary equipment, such as a unit for supporting the drum, is included. Both the wound drums and the complete deployment unit are readily transportable by air, typically by helicopter, so that delivery from a storage point to the remote location of an offshore oil spill, for example, can be accomplished quickly. The deployment unit is first delivered and is installed on a deployment vessel. The barrier structure is then deployed at relatively high speed, e.g., 10′ per second. To make such high speed deployment possible, the invention includes a method embodiment whereby the buoyancy and water chambers are filled as the barrier structure is unwound from the drum on which it was stored.

In order that the manner in which the foregoing and other objects are attained in accordance with the invention can be understood in detail, particularly advantageous embodiments thereof will be described with reference to the accompanying drawings, in which form a part of the original disclosure of this application, and wherein:

FIG. 1 is a transverse sectional view of a buoyant barrier structure according to one particularly advantageout embodiment of the invention, with buoyancy chambers inflated and the structure illustrated in typical position on the surface of a body of water;

FIG. 2 is a side elevational view of an end portion of the barrier structure of FIG. 1;

FIG. 3 is a top plan view of structure illustrated in FIG. 2;

FIG. 4 is a transverse sectional view of the barrier structure of FIG. 1, but with the structure in the collapsed and folded condition in which the same is stored;

FIG. 5 is a front elevational view of a storage and deployment drum with the barrier structure of FIG. 1 wound thereon;

FIG. 6 is a fragmentary sectional view, on larger scale than FIG. 1, illustrating one type of buoyancy chamber inflation means useful with the barrier structure of FIG. 1;

FIG. 6A is a view similar to FIG. 6 but showing parts in their relative positions after the inflation tube has been stripped away from the plenum chamber during deployment of the barrier structure;

FIG. 7 is a view similar to FIG. 6 illustrating another buoyancy chamber inflation means useful with the barrier structure of FIG. 1;

FIG. 8 is a side elevational view of a deployment unit, including the drum of FIG. 5, mounted on a deployment vessel, the barrier structure of FIG. 1 being shown in the process of being deployed;

FIG. 9 is a top elevational view of the deployment unit of FIG. 8;

FIG. 10 is a delivery end elevational view of the deployment unit of FIG. 8, with deployment chute deleted;

FIG. 11 is a view similar to FIG. 8 but illustrating another manner of deploying the barrier structure of FIG. 1;

FIG. 12 is a top plan view of a completed containment barrier installed according to the invention and employing the barrier structure of FIG. 1;

FIG. 13 is a sectional view taken generally on line **13—13**, FIG. 12;

FIG. 14 is a front elevational view of another form of buoyancy chamber filling device useful in accordance with the invention;

FIG. 15 is a transverse sectional view illustrating another form of buoyant barrier structure according to the invention;

FIG. 16 is a semi-diagrammatic view illustrating one manner in which the barrier structure of FIG. 15 can be deployed;

FIG. 17 is a transverse sectional view illustrating still another form of buoyant barrier structure according to the invention; and

FIG. 18 is a view, partly in longitudinal section and partly in side elevation, taken generally on line **18—18**, FIG. 17.

Referring now to the drawings, FIGS. 1–4 illustrate an elongated barrier structure constructed in accordance with one particularly advantageous embodiment of the invention. This structure is fabricated from a single sheet of thin, fluid-impervious sheet material and comprises a first elongated portion **1**, a second elongated portion **2**, and a third elongated portion **3**, portions **1** and **3** constituting the side portions of the elongated sheet and portion **2** constituting the elongated central portion of the sheet. Two normally flat, flexible reinforcing strips **4** and **5** are employed, each extending along a different longitudinal edge of intermediate portion **2**, both of the reinforcing strips **4**, **5** being secured continuously to the same face of portion **2**. Portion **1** is folded over upon itself in a direction such that the extreme edge portion **6** thereof overlies reinforcing strip **4**. Edge portion **6** is secured throughout its length, in continuous fashion, to reinforcing strip **4**.

The sheet of flexible material from which the barrier structure is formed is of substantial length, e.g., 1000′. Thus, securing of edge portion **6** to the exposed face of reinforcing strip **4** brings side portion **1** into the form of a greatly elongated tube. At a plurality of points, advantageously equally spaced throughout the length of this tube, the tube is flattened into the plane of reinforcing strip **4** and sealed in such flattened condition, with the result that the structure includes a plurality of essentially solid but flexible flat portions **7**. Between each pair of portions **7**, the flexible sheet material of side portion **1** of the structure defines a buoyancy chamber, as indicated at **8**.

In identical fashion, side portion **3** of the elongated sheet of flexible material is folded and sealed so that its edge portion **9** is continuously secured to the exposed face of reinforcing strip **5**, a plurality of spaced flattened and sealed portions **10** are provided, and the portions between each adjacent pair of flattened portions **10** are thus caused to define a plurality of buoyancy chambers **11**.

At each end of the elongated structure, the material of the sheet is flattened and folded upon itself and sealed in essentially solid form to provide a flat but flexible attachment portion **12** which, in normal position, lies in a plane containing the center line of portion **2** of the structure, as will be clear from a comparison of FIGS. 1–3. Each portion **12** is provided with at least a pair of apertures **13**, circularly reinforced in any conventional fashion, to accommodate suitable fasteners for securing two of the end portions together in overlapped relation in the complete barrier installation.

Each of the buoyancy chambers **8** and **11** is provided with an inflation tube **14** which extends through an aperture in the material which defines the buoyancy portion and is suitably sealed and secured to the sheet material surrounding that aperture. Each inflation tube **14** projects for a significant distance away from the outer surface of the sheet material defining the buoyancy portion. Since flattened portions **7**, **10** and the sealed connections between edge portions **6**, **9** and reinforcing strips **4**, **5**, respectively, are impervious to fluid, the buoyancy chambers indicated at **8** and **11** are gas-inflatable and, when inflated, are water impervious. Inflation of the buoyancy chambers is accomplished via tubes **14**, as hereinafter described. The inflation tubes **14** for all of the buoyancy chambers **8** lie on a longitudinally extending line which is near and parallel to the side edge of reinforcing strip **4** which is directed toward the interiors of the buoyancy chambers. Similarly, all of the inflation tubes **14** for the spaced series of buoyancy chambers **11** lie on a common longitudinally extending line which is near and parallel to the adjacent edge of reinforcing strip **5**.

FIGS. 1–3 illustrate the barrier structure in its deployed condition, with the buoyancy chambers **8**, **11** supporting the structure on the surface of the body of water W, FIG. 1, and with the intermediate or central portion **2** of the structure depending from the two series of inflated buoyancy chambers **8**, **11** in trough-like fashion. When the structure is thus deployed, the trough-like water chamber **15**, FIG. 1, defined by portion 2 is continuous for the entire length of the structure between attachment portions **12** and is filled with water, as hereinafter described. As best seen in FIGS. 1 and 3, transversely extending forming springs **2***a* of thin arcuate configuration can be secured to the upper surface of portion **2** to aid in establishing chamber **15**.

One advantage of barrier structures according to the invention lies in their capability of being folded, flattened and wound spirally on a suitable drum for storage in the form of a light weight, easily transportable package. FIG. 4 illustrates the manner in which the barrier structure of FIG. 1 is prepared for such storage. The structure is laid flat, with portion **2** supported in its flat condition. Under these circumstances, the reinforcing strips **4** and **5** extend in flat condition, as shown. The material defining buoyancy chambers **8** of side portion **1** is flattened, and the entire side portion **1** is folded upwardly and over toward the center of portion **2**, until all of the material of side portion **1** overlies the corresponding half of portion **2**. Side portion **3** is flattened and then folded upwardly and over until the material of this side portion overlies the adjacent half of portion **2**. With the two side portions thus arranged, all of the inflation tubes **14** for the buoyancy chambers **8** project outwardly from one longitudinal edge of the folded and flattended structure. Similarly, all of the inflation tubes **14** for the buoyancy chambers **11** project outwardly from the opposite longitudinal edge of the folded and flattened structure.

Thus folded and flattened, the barrier structure of FIG. 1 is wound upon the drum assembly seen in FIG. 5, for storage, transport and deployment. The drum assembly includes a drum D comprising a central cylindrical hollow hub **18** closed at one end by a solid stub shaft **19** and at the other end by a hollow shaft **20**. Shaft **20** is equipped with a conventional swivel pipe coupling **21** adapted for quick connection and disconnection of a flexible air hose **22**. At the end of hub **18** adjacent hollow shaft **20**, there is secured rigidly to the hub a circular plenum chamber indicated generally at **23** and formed by two flat circular

wall members 24, 25 and a peripheral cylindrical wall member 26. Wall members 24, 25 have circular central openings which are engaged over the end portion of hub 18 and the two wall members are welded to the hub in air-tight fashion. Similarly, cylindrical wall 26 is welded to the peripheral edges of wall members 24, 25 in fluid-tight fashion. The portion of hub 18 which is enclosed by the combination of walls 24–26 is provided with a port 27. The opposite end portion of the hollow hub 18 carries a plenum chamber 28 defined by spaced flat circular wall members 29, 30 and a cylindrical peripheral wall 31. This end portion of hub 18 is provided with a port 32 which communicates with the interior of plenum chamber 28.

The folded and flattened barrier structure hereinbefore described is wound on hub 18 between the plenuma chambers 23 and 28. The axial spacing between wall 25 of plenum chamber 23 and wall 29 of chamber 28 is such that, when the barrier structure is properly wound on hub 18, the longitudinal edges of the wound barrier structure will be spaced respectively from walls 25 and 29 by a distance slightly greater than the exposed length of the inflation tubes 14. When the barrier structure is wound on the hub, the inflation tubes are connected to the respective plenum chambers, as hereinafter described.

FIGS. 6 and 6A illustrate one typical way in which the buoyancy chambers 8, 11 can be air-inflated as the barrier structure is unwound from the drum, with both the buoyancy chambers and the plenum chambers being sealed against loss of air under pressure after the inflation tubes have been stripped away. Referring to FIGS. 6, 6A, wall 24 of the plenum chamber adjacent the wound edge of the barrier structure on the drum is provided with a plurality of hollow stems 35 equal in number to the inflating tubes 14 provided on the adjacent edge of the wound barrier structure. Each stem 35 has a through bore 36 and a threaded end 37 which is engaged and sealed in an appropriately threaded port in wall 24. The stem 35 projects away from the outer surface of wall 24 and, in a location spaced outwardly from the wall is provided with exterior opposed notches 38. For each stem 35, there is provided on the inner surface of wall 24 a resilient valve element 39 which is secured to wall 24, as by screw 40. A small through bore 41 is provided in wall 24 immediately adjacent to the port in which stem 35 is mounted. Valve element 39 includes a leaf spring body which extends from screw 40 across the adjacent end of stem 35 and, further across the inner end of through bore 41. A push rod 42 extends slidably through bore 41 and is of a length significantly greater than the thickness of wall 24. Comparing FIGS. 6 and 6A, it will be seen that, when the push rod is moved to the left, as viewed, it serves to resiliently distort valve element 39 to open the through bore in stem 35. On the other hand, when push rod 42 is freed to move to the right, as viewed, valve element 39 is allowed to move to its normal, relaxed position, closing the through bore in stem 35.

Inflation tube 14 is of flexible polymeric material and has a diameter such as to allow the end thereof to be forced over the outer end portion of stem 35. A spring metal clip 43, having a C-shaped body portion and two flat arms 44 and 45, is employed to force wall portions of tube 14 into notches 38 on stem 35, thus firmly retaining tube 14 in place. The free tip of tube 14 enlarged, providing a transverse annular shoulder portion 14*a* which is disposed immediately adjacent to notches 38, but on the side thereof facing wall 24, when assembly is in place. With the assembly properly made, as seen in FIG. 6, the shoulder 14*a* of tube 14 is engaged with the outer end of push rod 42 and holds the push rod in an inner position such that valve 39 is held open.

When, during unwinding of the barrier structure, the tube 14 is pulled away from the plenum chamber, spring clip 43 yields, allowing the tube to slip off of stem 35. However, spring clip 43 remains on tube 14 after the tube has slipped from the end of stem 35, the spring clip being retained if necessary by the end shoulder 14*a* on the tube. The design and construction of spring clip 43 is such that the C-body thereof provides a spring force adequate to force arms 44 and 45 sufficiently toward each other to close tube 14 in pinch-valve fashion, as seen in FIG. 6A. Stripping of tube 14 from stem 35, with shoulder 14*a* departing from engagement with push rod 42, allows push rod 42 to move to the right, as viewed, under the spring force provided by valve element 39. The inner tip 42*a* of push rod 42 is formed as a valve element operative to close the inner end of bore 41 when valve element 39 urges the push rod into its extreme outer position, as seen in FIG. 6A. While the structure of FIGS. 6 and 6A has been illustrated in connection with wall 24 of plenum chamber 23, it will be understood that the same inflation devices are provided on wall 29 of plenum chamber 28 to cooperate with the inflation tubes 14 which are spaced along the adjacent edge of the wound barrier structure.

Alternatively, as seen in FIG. 7, each of the inflation tubes 14 can be provided with a check valve comprising a hollow body 50 secured within tube 14 and including an annular valve seat 51 and, spaced therefrom in the direction of the interior of the associated buoyancy chamber, and annular stop shoulder 52. A movable check valve element 53 is disposed between valve seat 51 and shoulder 52, one end of the check valve element being formed to cooperate with seat 51 and the other end having a reduced axially projecting flange 54 for engagement with stop shoulder 52, flange 54 being relatively thin and allowing air to pass the check valve element and flow through the opening defined by shoulder 52, when the valve is open. The mechanism also includes a push rod 55 which is rigidly secured to valve element 53 and projects axially through, beyond the free end of tube 14.

As the barrier structure is wound on the drum, each tube 14 is again slipped over the hollow stem 35 projecting from the adjacent plenum wall. As this is done, push rod 55 extends through the bore of the hollow stem and, as tube 14 is pushed into final position, rod 55 forces valve 39 to its open position and holds the valve open so long as tube 14 is in place, movement of push rod 55 to the right, as viewed, being prevented by shoulder 52. In this embodiment, spring clip 43 is employed only to hold tube 14 on stem 35 and need not provide sufficient spring force to pinch the tube closed.

It will be understood that, for any particular oil spill or like pollutant to be confined, the finally installed barrier may be of a length considerably greater than, e.g., 1000'. Accordingly, an appropriate number of the drum assemblies just described with reference to FIGS. 5–7 are maintained in storage at some convenient location. Further, one of these drum assemblies is stored in combination with the deployment unit illustrated in FIGS. 8–10, that particular drum and the deployment unit being intended for transport together.

The deployment unit comprises a frame, indicated generally at 60, the spaced side walls of the frame supporting transversally aligned bearings 61 for rotational support of the drum assembly D. In front of the drum assembly, frame 60 houses and supports a power module 62 including any suitable rotary power device, such as an electrical motor or an internal combustion engine, indicated diagrammatically at 63. The rotary power device drives a rotary air pump and a rotary water pump, indicated diagrammatically at 64 and 65 respectively, FIG. 10. When operated, air pump 64 supplies air under pressure via air hose 22, to the two plenum chambers 23, 28 of the drum assembly. Suitable conventional controls are provided to maintain a constant relatively low positive pressure, e.g., 5 lbs. p.s.i., in both plenum chambers throughout the time during which the barrier structure is being deployed from the drum assembly. The intake of water pump 65 is connected by a suitable hose (not shown) to the body of water onto which the barrier structure is to be deployed. The output of water pump 65 is connected to a discharge

pipe **66**, FIG. 10, disposed to discharge water into the trough-like water chamber **15** as the barrier structure is being deployed.

An inclined deployment chute **67** is provided, the chute being carried by frame **60** in such fashion that the input end of the chute is adjacent the front of drum assembly D, and the body of the chute slants downwardly and forwardly through the open front of the frame. As seen in FIG. 8, the barrier structure is led down chute **67**, buoyancy chambers **8**, **11** having of course been fully inflated by the time the barrier structure reaches the chute. At this stage, the intermediate portion **2** of the barrier structure simply slides along the flat surface provided by the chute and the trough-like water chamber **15** forms inherently as the barrier structure is led away from the discharge end of the chute. In this connection, water continually discharged from pipe **66** flows between the two series of buoyancy chambers **8** and **11**, these two series of buoyancy chambers having not yet been brought into immediate proximity, that is, into the position seen in FIG. 1, since the intermediate portion **2** of the structure has not at that stage been filled with water.

The deployment unit can be lowered from a helicopter, for example, by lines connected to handling fittings **68**. The deployment unit can be lowered directly onto the deck of a deployment vessel V and secured in place in any conventional fashion. Deployment can be accomplished simply by securing the first end portion **12** of the barrier structure to a stationary object, typically to a buoy or a second vessel, and then moving the deployment vessel V away from that point, the barrier structure deploying over the surface of the body of water in the fashion seen in FIG. 8.

In some applications, an alternative method of deployment, eliminating the buoy or second vessel V, offers distinct advantages when the barrier structure is constructed according to FIGS. 1–4. According to this alternative method, the free end of the barrier structure carried by drum D is pulled onto deployment chute **67**, with air-inflation of buoyancy chambers **8**, **11** and water supply via pipe **66** occurring as earlier explained. As the weight of water in chamber **15** increases, the drag offered by the barrier structure serves the same purpose as does attachment of the free end of the barrier structure to a buoy or vessel, and deployment therefore continues as hereinbefore described, as the deploying vessel moves off. If necessary, the initial portion of the barrier structure can be paid out by hand until enough drag occurs to assure deployment at the desired speed of the deployment vessel.

From the foregoing, it will be clear that the method of the invention comprises providing the flattened and spirally rolled barrier structure as a storable package, transporting the package to the point of use, and then deploying the flexible barrier structure by unwinding it from the roll and substantially simultaneously inflating the buoyancy chambers and filling the water chamber.

The method embodiment described with reference to FIGS. 8–10 can be modified, to eliminate the need for a water pump, by employing the procedure illustrated in FIG. 11. Here, the deployment unit remains the same as just described, save for elimination of the water pump and the step of discharging water into the trough-like chamber **15** immediately adjacent the deployment unit. Instead, an inflatable roller **70**, rotatably supported by a pair of pivoted arms **71** carried by the deployment vessel, is employed to cause the barrier structure to pass through a stage of complete submergence in the body of water, so that water flows over the sides of the barrier structure and into the trough-like water chamber **15**. The inherent buoyancy of the deployed barrier structure causes the same to rise to its final position, illustrated in FIG. 1, as soon as the barrier structure has passed beneath the roller **70**. Roller **70** can be made from flexible sheet material and transported in collapsed form, its only rigid component being a central shaft **72** journaled in the ends of the supporting arms **71**. The roller **70** is inflated, at time of use on the deployment vessel, with water from the body of water and air supplied from the air pump **64** of the deployment unit, the proportions of water and air being selected to afford an effective roller weight adequate to assure submergence of the barirer structure.

FIGS. 12 and 13 illustrate a completed barrier installation comprising two lengths of the barrier structure described with reference to FIGS. 1–4. To accomplish such an installation, one roll of the barrier structure is transported to the deployment vessel along with the deployment unit of FIGS. 8–10, such transport being accomplished with the roll in place in the deployment unit, and the second roll is transported at the same time, but apart from the deployment unit, so that all of the necessary components are simultaneously delivered to the deployment vessel. The vessel roll is then deployed as just described, the drum assembly for that roll then removed from the deployment unit, and the second drum assembly installed in the deployment unit and the length of barrier structure thereon is then deployed, the first end portion **12** thereof having first been attached to the end of the barrier structure just deployed. The deployed barrier can be retained essentially in a given position by pairs of interconnected inflated buoys **75**, the buoys of each pair being disposed each on a different side of the deployed barrier. The buoys **75** can be anchored in any suitable conventional fashion.

A particular advantage of the method and apparatus embodiments of the invention is the fact that the structure which is stored and transported is completely free of any ballast or weighting means. This is made possible by use of the trough-like water chamber **15**, in the particular fashion described, so that water from the body of water on which the device is deployed is used for ballasting and stabilizing purposes. In this connection, and referring to FIG. 1, it will be evident that the buoyancy provided by chambers **8**, **11** is used only to support the weight of the barrier structure itself and none of the buoyant effect is used to support ballasting structure.

The barrier structure can be fabricated from various types of commercially available flexible and fluid-impervious sheet materials. One particularly advantageous sheet material is extruded polyvinyl chloride sheet with a thickness on the order of .006–.01 in. Simple extruded sheet can be employed, or flexible sheets reinforced with filaments can be used. Fabrication can involve heat sealing, or can be by use of adhesive techniques.

Though such sheet materials provide more than adequate strength of accommodating normal forces to which the deployed barrier will be subjected, the reinforcing strips **4** and **5** are provided to accommodate the larger tensile forces which can be encountered, for example, during high speed deployment of the barrier structure. Such reinforcing strips can be of any suitable construction which can be continuously adhered to the surface of the flexible sheet material in fluid-tight fashion. Typically, an extruded body of flexible polyvinyl chloride reinforced by a number of parallel nylon cords can be used .

While the embodiment illustrated in FIGS. 1–4 is particularly advantageous, other configurations can be used which also provide buoyancy, for flotation, and water containment, for stabilization. Such an alternative structure is illustrated in FIG. **14**. Here, the barrier structure is formed from a first portion **80** of flexible fluid-impervious sheet material, a second portion **81** of such material, and a single elongated reinforcing strip **82**. The longitudinal edge portions **83** and **84** of first portion **80** overlie the respective major surfaces of reinforcing strip **82** and are continuously sealed thereto throughout the length of the structure in fluid-tight fashion. Edge portions **85** and **86** of second portion **81** respectively overlie edge portions **83** and **84** and are continuously sealed thereto in fluid-tight fashion throughout the length of

the structure. The ends of the structure can be closed in any suitable fashion, as by the flattening and sealing procedure used to provide end attachment portion **12**, FIG. 2. Accordingly, portion **80** defines a continuous air-inflatable buoyancy chamber, and portion **81** defines a continuous water chamber. One end of each chamber is provided with a suitable filling connection or fitting (not shown) via which air pressure and water supply hoses can be connected.

The barrier structure illustrated in FIG. 15 can be deployed according to the procedure illustrated in FIG. 16. Again the barrier structure is stored in a roll, supported by a suitable drum, as indicated at **90**. The drum is suitably supported on deployment vessel V. The end of the barrier structure which is outermost on the drum is secured to a second vessel VI. Suitable air and water supplying hoses are connected to the fittings for the buoyancy and water chambers, respectively, these hoses being supplied with air and water from suitable pumps carried by vessel VI. Deployment is then accomplished by moving the deployment vessel, vessel VI remaining stationary and serving only to supply air to inflate the buoyancy chamber and water to fill the water chamber.

Alternatively, an anchored buoy (not shown) can be substituted for vessel VI, the buoy supporting conventional air and water pumps, the buoy and pumps being recovered after deployment.

It will be obvious to those skilled in the art that the structure just described with reference to FIG. 15 can be modified by dividing portion **80** into inflatable and non-inflatable sections as hereinbefore described with reference to FIGS. 1–4. Provision of a plurality of buoyancy chambers has the advantage of redundancy, the chambers being independent of each other so that occurrance of a leak in one chamber does not render the device non-buoyant.

Though the inflation devices referred to with reference to FIGS. 6 and 7 are particularly advantageous, it will be obvious to those skilled in the art that various other devices can be employed. Thus, as seen in FIG. 14, the air plenums of the embodiment of FIGS. 1–7 can be replaced each by a relatively small air chamber **100** carried by a frame member **101** and supplied with air under pressure via a tube **102**. One exposed wall of air chamber **100** comprises two resiliently deformable strips **103** and **104** maintained in edge-to-edge mutual contact along line **105**. Strips **103** and **104** can be, for example, of closed cell sponge rubber and are maintained under interengaging pressure sufficiently large to cause the two strips to seal along line **105** against the relatively low positive pressure retained in chamber **100**. The inflation tubes **106** of the flexible barrier structure are made sufficiently rigid to enter between the two strips **103** and **104**, as the barrier structure is unwound and moves past chamber **100** at least generally in the direction defined by line **105**. The resiliently compressible nature of strips **103** and **104** allows entry of the inflation tube between the two strips, yet closes relatively tightly about the inflation tube to prevent excessive air loss from the chamber. Convergent guide plates **107** are provided to guide the inflation tubes properly into engagement between the two strips **103** and **104**.

Barrier structures according to the invention can also be provided with air-supply and water supply tubes extending throughout the length of the barrier structure, as illustrated for example in FIGS. 17 and 18. Here, the barrier structure is again formed from a single thin sheet of flexible, fluid-impervious material, the sheet being folded and sealed so that a first portion **180** thereof defines a plurality of inflatable buoyancy chambers **108***a* separated by flattened and sealed portions **180***b*, and a second portion **181** thereof defines a continuous water chamber **181***a*. Additionally, portion **180** defines a tube **180***c* which extends for the entire length of the barrier structure and passes through each buoyancy chamber **180***a*. Portion **181** also defines a tube **181***b* which extends for the entire length of the barrier structure. Tube **180***c* is equipped with a plurality of conventional check valves **190** each disposed in a different one of the buoyancy chambers **180***a* and arranged to allow air under pressure to flow from tube **180***c* into the respective buoyancy chamber **180***a*. Tube **181***b* is provided with a plurality of longitudinally spaced ports **191** which allow water to flow from tube **181***b* into chamber **181***a*. Suitable fittings (not shown) are provided on tubes **180***c* and **181***b* at one end of the barrier structure to allow connection to air and water supply conduits (not shown), as in the fashion illustrated in FIG. 16. The barrier structure is completed by a tension reinforcing strip **182** which is continuously secured to the flexible sheet material along a line between and parallel to portions **180** and **181**. Considering the structure to be fabricated by heat sealing techniques, it will be understood that all layers of the sheet material between tubes **180***c* and **181***b* in FIG. 17 are securely sealed to one another throughout the length of the structure.

It will be clear from the foregoing that, while particularly advantageous embodiment have been disclosed to illustrate the invention, various changes and modifications can be made therein without departing from the scope of the appended claims. Thus, for example, the water chamber can be partitioned into a plurality of short chambers arranged in a longitudinal extending series, rather than being continuous. Similarly, the continuous water chamber **15**, for example, can be provided with conventional anti-slosh means of any suitable type.

What is claimed is:

1. In a buoyant barrier for confining material, such as spilled oil floating on the surface of a body of water, the combination of:

a greatly elongated sheet of flexible material;

first flexible means defining a first series of inflatable buoyancy chambers joined to one long edge of said elongated sheet; and

second flexible means defining a second series of inflatable buoyancy chambers joined to the other long edge of said elongated sheet,

the combination of said elongated sheet, said first flexible means, and said second flexible means being of such overall flexibility as to be capable of being wound on a reel, with said buoyancy chambers collapsed, and also capable of being deployed on the surface of the body of water, with said buoyancy chambers inflated with gas, when the barrier is in use,

said sheet being of such width that, when said buoyancy chambers are inflated to float on the surface of the body of water, said sheet depends therefrom in trough-like configuration to define at least one water chamber.

2. Apparatus for confining a material such as spilled oil floating on the surface of a body of water comprising the combination of:

a vessel;

reel means mounted on the vessel;

buoyant barrier means comprising two greatly elongated flexible portions, each defining at least one buoyancy chamber capable of being inflated with gas, and a third greatly elongated flexible portion in the form of a sheet having its side edges joined each to a different one of said two flexible portions,

said barrier means being wound on said reel means, with said buoyancy chambers flattened,

said barrier means being deployable onto the surface of the body of water by unwinding the same from said reel means as the vessel is moved along the surface of the body of water;

means for inflating said buoyancy chambers with gas as said barrier means is unwound from said reel means,

said third portion depending from said two portions in trough-like fashion to define a water chamber in the deployed barrier means; and

roller means carried by said vessel and occupying a position at the surface of the body of water such that, as said barrier means is deployed, said barrier means passes beneath said roller means,

said roller means operating to cause said barrier means to be submerged, to fill said water chamber, as said barrier means passes beneath said roller means.

3. Apparatus according to claim 2, wherein said roller means comprises:

a flexible hollow roller structure inflatable with water and a gas to provide the roller structure with a predetermined buoyancy, and

means supporting said hollow roller structure for rotation about a horizontal axis.

4. In a buoyant barrier for confining material, such as spilled oil floating on the surface of a body of water, the combination of:

a first elongated portion formed of flexible material and defining at least one buoyancy chamber capable of being inflated with gas;

a second elongated portion formed of flexible material; and

a third elongated portion formed of flexible material and defining at least one buoyancy chamber capable of being inflated with gas,

said second portion extending along and being joined to said first and third portions;

the combination of said first, second and third portions being of such overall flexibility as to be capable of being wound on a reel, with said first and third portions deflated, and also capable of being deployed on the surface of the body of water, with said first and third portions inflated with gas, when the barrier is in use,

said second portion having a width such that, when said buoyancy chambers of said first and third portions are inflated and deployed to float on the surface of the body of water, said second portion depends from said first and third portions in trough-like configuration to define at least one water chamber.

5. The combination according to claim 4, and further comprising:

two elongated flexible longitudinal reinforcing means, one of said reinforcing means being secured to and extending along said first and second portions in a location generally therebetween, the other of said reinforcing means being secured to and extending along said second and third portions in a location generally therebetween.

6. The combination defined in claim 9, and further comprising:

first flexible inflation tube means extending longitudinally along said first portion and having a plurality of spaced openings each communicating with a different one of the buoyancy chambers defined by said first portion; and

second flexible inflation tube means extending longitudinally along said third portion and having a plurality of spaced openings each communicating with a different one of the buoyancy chambers defined by said third portion.

7. The combination defined in claim 6, wherein:

each of said inflation tube means extends longitudinally through each of the buoyancy chambers defined by the respective one of said first and third portions.

8. The combination according to claim 7, wherein:

said buoyant chambers when inflated are of such transverse dimensions that, when the trough-like water chamber defined by said second portion is effectively filled with water and said buoyant chambers are

inflated, with the barrier deployed on the surface of the body of water, said at least one buoyant chamber of said first portion coact with said at least one buoyant chamber of said third portion to effectively close the top of said water chamber.

9. The combination according to claim 8 wherein:

said first and third portions each define a plurality of individual buoyancy chambers arranged in a series of extending lengthwise of the barrier.

10. The combination according to claim 9, wherein:

said first and third portions are provided with a plurality of filling tubes each operatively connected to a different one of said buoyancy chambers,

the barrier being foldable, when said buoyancy chambers are deflated, into a form suitable for reeling, in which form said second portion is flat and said first and third portions are flattened and overlie the respective side edge portions of said second portion, said filling tubes projecting laterally from the respective edges of the folded barrier.

11. The combination according to claim 8, and further comprising:

a plurality of resilient forming members secured to said second portion,

said forming members being of arcuate shape when in undistorted condition and being spaced apart in a series which extends longitudinally of the barriers, each of said forming members extending transversely of said second portion.

12. A packaged buoyant barrier adapted to be transported from a storage location to a point of use and there quickly deployed on the surface of a body of water, comprising in combination

winding drum means;

means carried by said drum means and defining at least one plenum chamber;

an elongated barrier structure of flexible sheet material comprising:

a first longitudinally extending portion defining a plurality of gas-inflatable buoyancy chambers disposed in a series which extends lengthwise of the barrier structure,

a second longitudinally extending portion joined to and extending along said first portion and defining a continuous water chamber which is located generally below said first portion when said buoyancy chambers are inflated and the barrier is deployed upon the surface of the body of water, and

a plurality of inflation tubes connected to said first portion and each communicating with a different one of said buoyancy chambers,

said barrier structure being flattened to reelable condition and wound on said drum means with said inflation tubes extending from a longitudinal edge of the flattened, wound barrier structure toward said plenum chamber; and

means releasably connecting said inflation tubes to said plenum chamber, for inflation of said buoyancy chambers as said barrier structure is deployed from said drum means.

13. A packaged buoyant barrier according to claim 12, wherein:

said means defining said plenum chamber includes a wall located at one end of said drum means and extending adjacent to but spaced from said longitudinal edge of the flattened, wound barrier structure,

said wall having a plurality of ports and a plurality of hollow stems each projecting from a different one of said ports toward said longitudinal edge of the flattened, wound barrier structure,

each of said inflation tubes being releasably engaged over one of said stems,

the respective combinations of said ports, stems and inflation tubes placing each of said buoyancy

chambers in communication with said plenum chamber;

filling of said plenum chamber with a gas under a low positive pressure being effective to cause said buoyancy chambers each to be inflated from said plenum chamber as the portion of said barrier structure comprising the buoyancy chamber is unwound from said drum means during deployment of said barrier structure.

14. A packaged buoyant barrier according to claim **13**, and further comprising:

a plurality of resilient retainers each engaged over a different one of said inflation tubes in a location to clamp the inflation tubes against the one of said stems over which the inflation tube is engaged,

said retainers being so constructed and arranged that, when the combination of the retainer and its associated inflation tube is stripped from the corresponding one of said stems as the barrier structure is deployed from said drum means, the retainer closes the inflation tube in pinch-valve fashion.

15. A packaged buoyant barrier according to claim **13**, and further comprising:

check valve means operatively associated with each of said inflation tubes to close the same, preventing escape of gas from the corresponding one of said buoyancy chambers, when the inflation tube has been stripped from the one of said stems over which it was engaged.

16. A packaged buoyant barrier according to claim **13**, and further comprising:

a plurality of valve devices each operatively disposed with respect to a different one of said ports; and

means operatively associated with each of said valve devices to operate the same to close the corresponding one of said ports in response to removal of the one of said inflation tubes engaged over the stem associated with said one port.

17. The method for containing material floating on the surface of a body of water, comprising:

providing a packaged buoyant barrier structure in the form of an elongated barrier structure of flexible material comprising:

a first elongated portion defining at least one gas-inflatable buoyancy chamber,

a second elongated portion extending along and joined to said first portion and defining a water chamber when the barrier is deployed on the surface of the body of water with said buoyancy chamber inflated, and

longitudinally extending reinforcing means extending along and joined to said first and second portions in a location therebetween,

said barrier structure being in flattened condition and wound as a helical roll;

supporting said roll above the surface of the body of water for rotation about the axis thereof;

unwinding said barrier structure from said roll to deploy the same on the surface of the body of water; and

inflating said at least one buoyancy chamber with a gas and filling said water chamber with water from the body of water as said barrier structure is unwound and deployed.

18. The method according to claim **17**, wherein:

said first portion defines a plurality of buoyancy chambers arranged in a series extending longitudinally of said barrier structure; and

each of said buoyancy chambers is inflated as the portion of said barrier structure comprising the same is unwound from said roll.

19. The method according to claim **17**, wherein:

said barrier structure comprises a third elongated portion defining at least one gas-inflatable buoyancy chamber;

said second portion comprises an elongated sheet having its side edge portions joined each to a different one of said first and third portions;

the buoyancy chambers defined by said first and third portions are inflated simultaneously,

said second portion depending from the inflated first and third portions in trough-like fashion; and

the step of filling said water chamber is accomplished by pumping water into the space which is above said second portion and between said first and third portions.

20. The method according to claim **17**, wherein:

said barrier structure comprises a third elongated portion defining at least one gas-inflatable buoyancy chamber;

said second portion comprises an elongated sheet having its side edge portions joined each to a different one of said first and third portions;

the buoyancy chambers defined by said first and third portions are inflated simultaneously; and

the step of filling said water chamber is accomplished by causing said barrier structure, with said buoyancy chambers inflated, to pass through a submerged condition as it is being deployed.

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