United States Patent [19]

Gambel

[11] **3,783,622**

[45] **Jan. 8, 1974**

[54] **METHOD AND SYSTEM FOR THE CONTAINMENT AND SALVAGE OF CHEMICALS AND OILS AT SEA**

[76] Inventor: **Charles L. Gambel,** 3500 Monticello Ave., New Orleans, La. 70118

[22] Filed: **Sept. 16, 1971**

[21] Appl. No.: **181,162**

[52] **U.S. Cl.** ..... **61/1 F**

[51] **Int. Cl.** **E02b 15/04**

[58] **Field of Search** ..... 61/1 F, 46, 46.5; 114/.5 T

[56] **References Cited**

UNITED STATES PATENTS

3,476,246	11/1969	Dahan	61/1 F
3,327,667	6/1967	Manning	114/.5 T
3,618,327	11/1971	Frein et al.	61/46
3,608,316	9/1971	Manuel	61/1 F
3,567,019	3/1969	Headrick	61/1 F
3,503,512	3/1970	Desty et al.	61/1 F

FOREIGN PATENTS OR APPLICATIONS

1,305,469	8/1962	France	61/1 F
739,171	10/1932	France	61/1 F

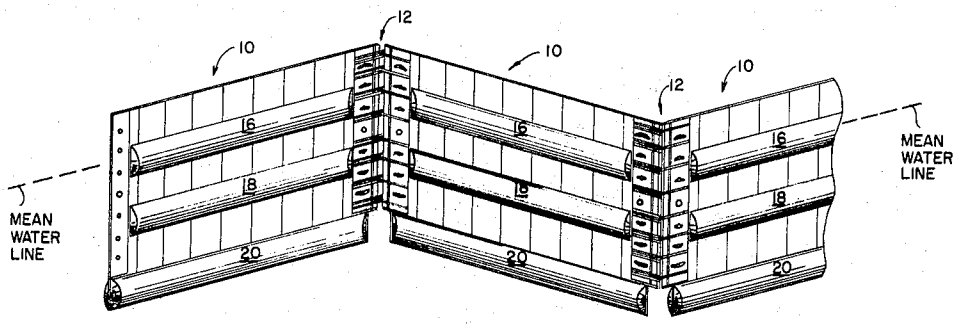
Primary Examiner—Peter M. Caun

Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

A rigid barrier unit for use in assembling an enclosure around a surface area of a body of water is provided with adjustable buoyancy and ballasting chambers so that a nearly neutral buoyancy condition can be established with substantially all of the mass of the unit below the turbulence level of a body of water in which the barrier unit is placed. A method of deployment of such units involves a floatation of the units in horizontal attitudes to the area to be enclosed, followed by a ballasting of the units into vertical attitudes so as to extend around an oil or chemical spill area.

14 Claims, 8 Drawing Figures



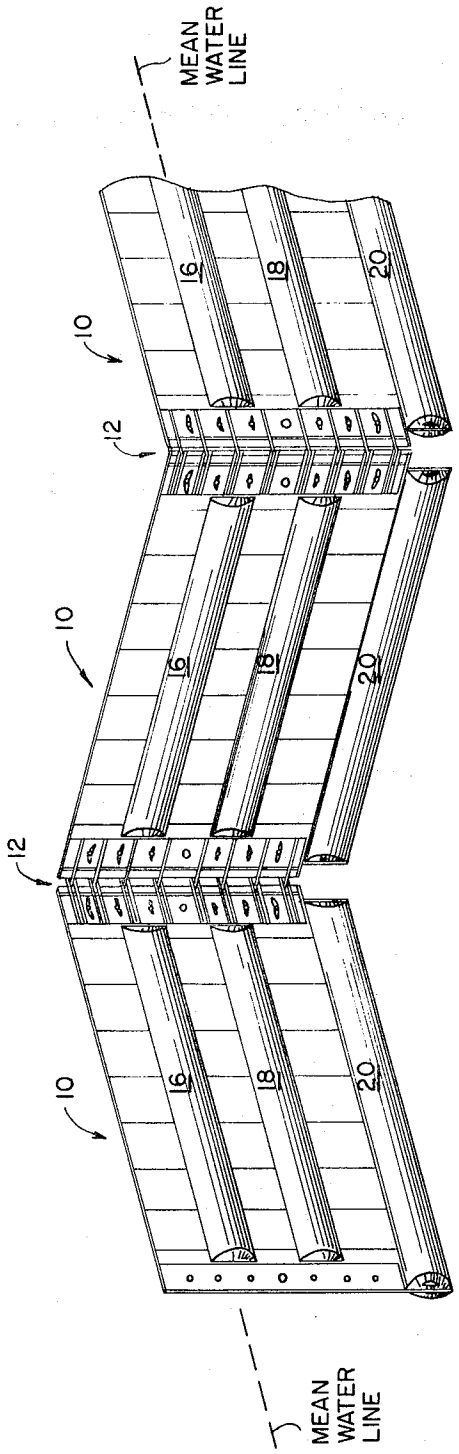


FIG. 1

INVENTOR
CHARLES L. GAMBEL

BY Cushman, Darby & Cushman
ATTORNEYS

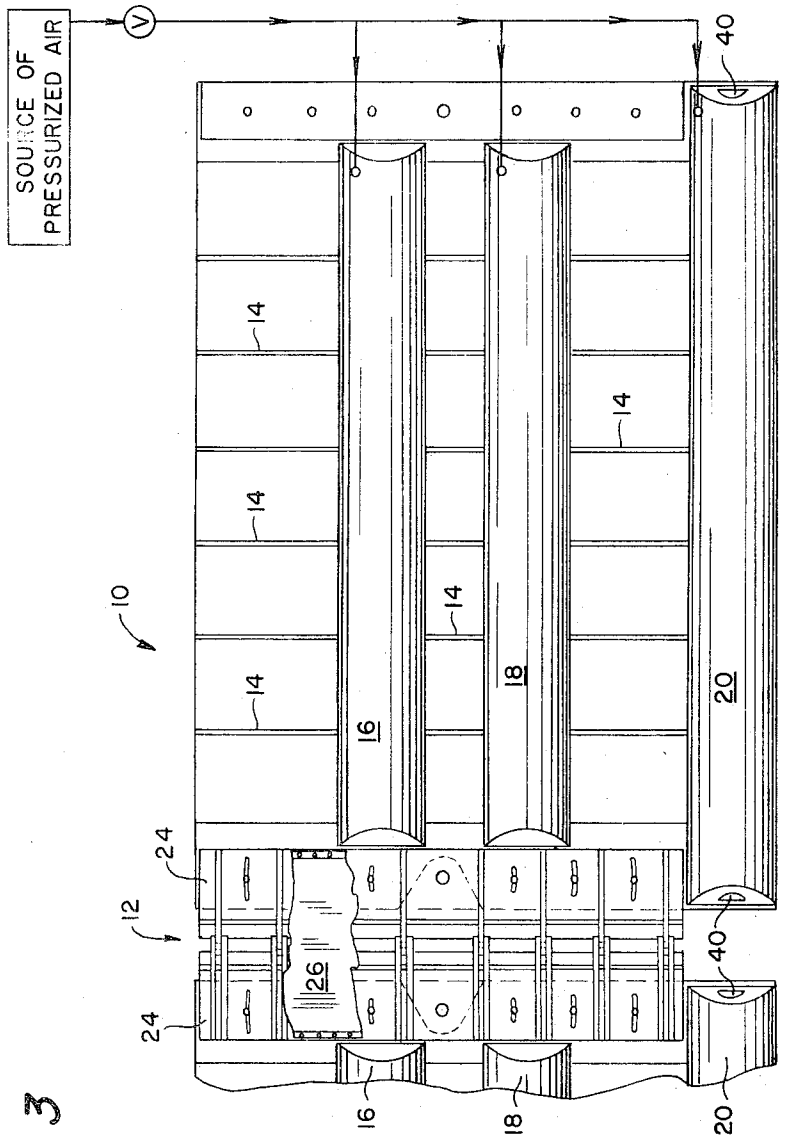
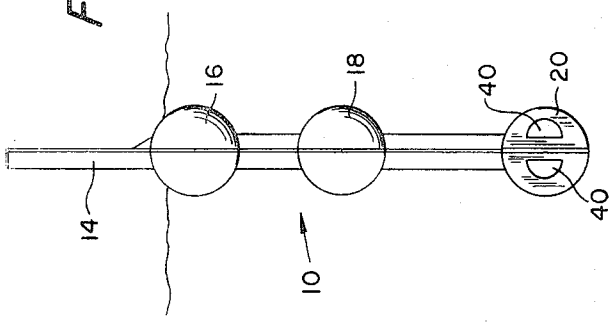


FIG. 2

FIG. 3



INVENTOR
CHARLES L. GAMBEL

BY Cushman, Darby & Cushman
ATTORNEYS

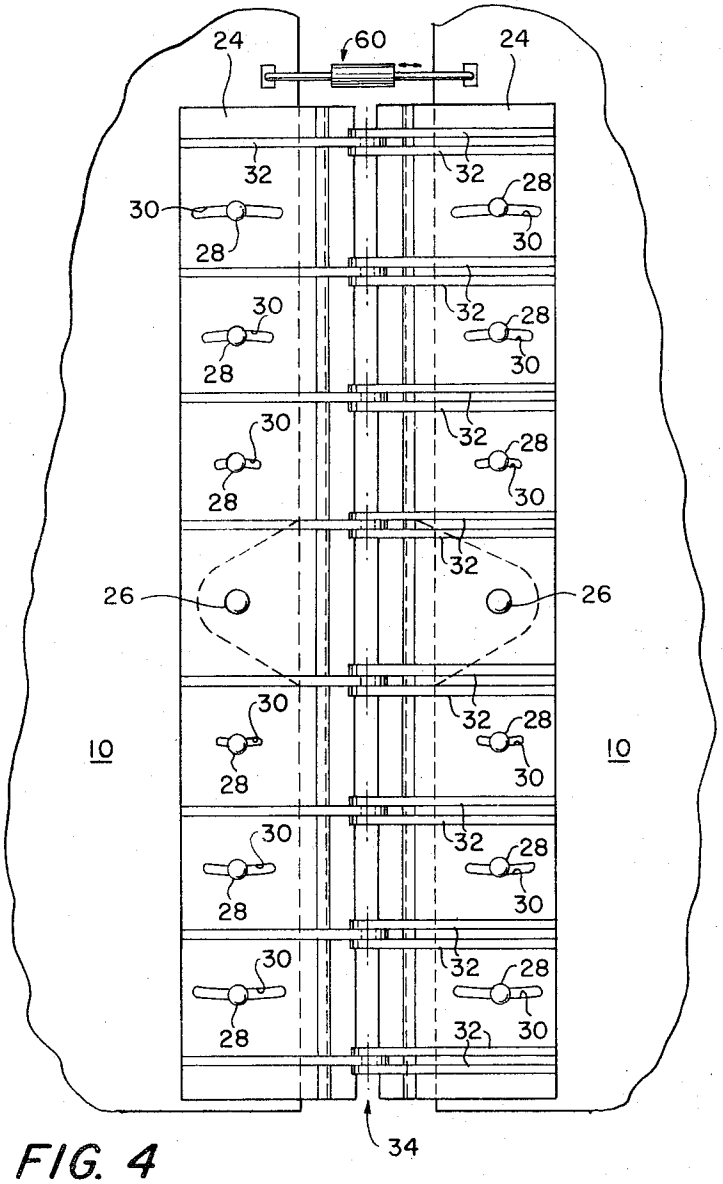


FIG. 4

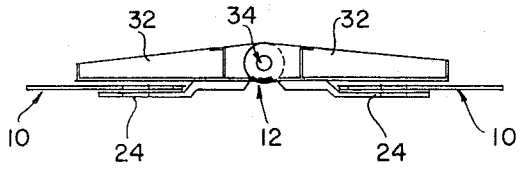


FIG. 5

INVENTOR
CHARLES L. GAMBEL

BY Cushman, Darby & Cushman
ATTORNEYS

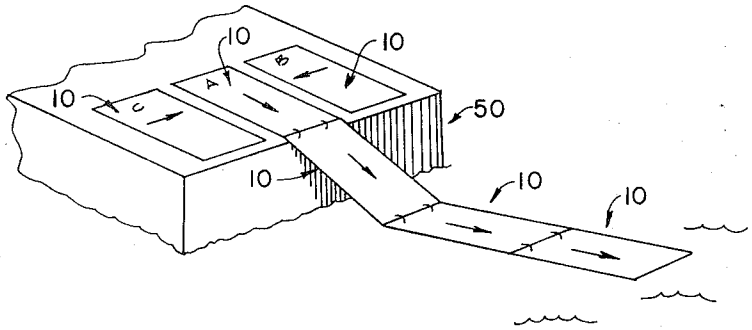


FIG. 6

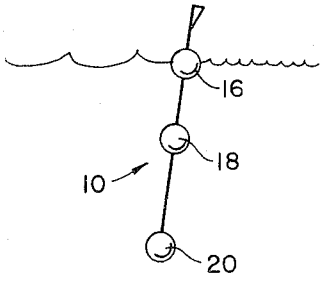


FIG. 7

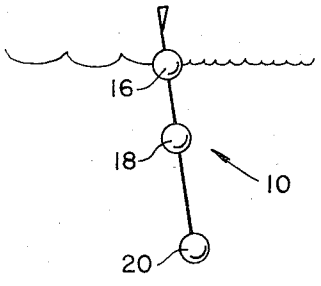


FIG. 8

INVENTOR
CHARLES L. GAMBEL

BY
Cushman, Darby & Cushman
ATTORNEYS

METHOD AND SYSTEM FOR THE CONTAINMENT AND SALVAGE OF CHEMICALS AND OILS AT SEA

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to systems and methods for enclosing areas of the sea, or other bodies of water, so as to provide a containment area which prevents spreading of oil or other chemicals from the containment area.

As the need for energy fuels increases and the proven reserves in the continental United States and elsewhere in the world diminishes, the oil industry is being forced to sea bottoms, such as the Continental Shelf areas, for new oil reserves. Likewise, oil is being transported by tankers ever increasing in size over ever lengthening routes, to a point where the total quantity of oil afloat enroute from source to market has now reached substantial proportions. Offshore operations, whether for discovery of oil or for maintenance of drilling rigs, together with the great mass of oil afloat in vessels present a recognized threat to the shores and beaches of the continents of the world and to the ecology of the sea, against which no truly effective defense has yet been provided. Even simple maintenance of multiple well offshore platforms raises a very real and foreseeable risk of disastrous oil spills.

Thus, hardware capable of easy deployment and recovery at the start and completion of offshore work to enclose a work or spill area is urgently required. Without such hardware every offshore job or transportation of oil at sea will present a fractional risk of loss or damage that will eventually accumulate into a much greater risk of possible loss of life and ecological damage as well as a potentially fantastic loss of fuel resources that may be burned off to prevent water and shore pollution.

It is within these broad limits that the present invention is calculated to operate to provide a reasonable means of easy and prompt deployment of devices capable of containing a spill or blowout, under sea conditions ranging from low water level to gale, and to hold and accumulate the effluent or spill for a period of time which will permit orderly draw-off and salvage by scheduled equipment operating on a routine and not an emergency basis.

Although the invention has special application to needs for containing oil spill areas, resulting from offshore work or tanker spillage, the invention can also be used in other applications requiring containment of a water area, or the establishment of a barrier at sea.

2. Description of the Prior Art

There is considerable prior art on the general subject of devices for floatation around a sea area. Generally, there has been an emphasis on inflatable devices, often made of fabric, some with depending skirts, some with oleophilic screens, and some self-propelled. Such prior art devices make no claim of sea-keeping capability, and in fact are more concerned with oil slick problems that might be encountered at relatively shallow depths where there is little sea action. These devices do not provide for functioning systems capable of resisting forces of sea action or wave action, as might be encountered in a high seas area of a substantial oil spill.

Other prior art devices have been of non-inflatable, rigid, designs, but again, there has been a general emphasis on shallow water needs which do not present the same problems as encountered in deeper waters and rougher seas.

Representative patents showing various prior art structures on this subject include U. S. Pat. Nos. 1,004,718; 2,240,567; 2,330,508; 2,391,059; 2,682,151; 2,908,393; 2,968,928; 3,146,598; 3,184,923; 3,221,884; 3,369,664; 3,438,205; 3,476,246; 3,494,132; 3,503,512; 3,537,587; 3,592,005; 3,592,007; 3,592,008, and British Pat. Nos. 829,756; 843,131; 911,963; and German Pat. No. 1,032,121.

SUMMARY OF THE INVENTION

The present invention provides for a method and system for enclosing and containing a surface area of a body of water with a plurality of barrier unit devices constructed to function under a variety of sea conditions.

In accordance with the invention, relatively rigid barrier units, of special construction and design, are deployed around a surface area of a body of water which is to be enclosed. One method of deployment involves a floating of individual barrier units in substantially horizontal attitudes to the enclosure area, followed by a step of re-orienting the individual barrier units to substantially vertical orientations once they are on location. The individual barrier units are linked together with linking means which permit universal relative movement between adjoining barrier units of a series, and control systems may be provided for assisting in defining the final shape of a complete encirclement of a series of vertically oriented barrier units about the enclosure area.

Each barrier unit comprises a relatively rigid structure of sufficient size and strength to maintain its shape and integrity against wave action and turbulence that might be encountered at the place of deployment. In addition, each rigid barrier unit is provided with adjustable buoyancy means which function to allow a control of ballasting and buoyancy of the individual barrier units so as to establish a nearly neutral buoyancy with the substantial mass of the entire unit carried at a level below the turbulence level of the body of water in which the barrier unit is placed. In the context of the present invention, reference will be made to "turbulence level" as contrasted with the surface of a body of water to define a zone of wave and water activity which is typically encountered for a distance above and below a mean water level line of a given sea area. This area and water activity includes surface forces created by waves themselves as well as the sub-surface activity resulting from wave movement or a resistance of such movement by a barrier placed in the water. One of the features of the present invention is to provide for a low level ballasting of each barrier unit of a system so that the substantial mass of the individual barrier unit is below the turbulence level of a body of water. In a practical sense, individual barrier units may be constructed with dimensions which include a height of approximately fifteen feet (when viewed in a deployed, vertical orientation for enclosing a water area) and a length of twenty-six feet. More than fifty percent of the effective buoyancy of each unit is kept at a level below four or five feet beneath the surface of a quiet sea, and this is sufficient to place the main mass and ballasting of each unit below the above-described turbulence level of an active sea. The adjustment and placement

of buoyancy in a barrier unit, as provided by the present invention, offers substantial advantages in stabilizing relatively large and rigid units operating in active sea conditions, while minimizing requirements for massive reinforcement of such barrier units in critical areas at the surface level of the sea and at points of interconnection with adjacent units of a series.

In a preferred embodiment of the invention, the adjustable buoyancy means of each barrier unit comprises three air-tight buoyancy chambers or tanks arranged at different levels along the length of the main body of the barrier unit. One of the air-tight buoyancy chambers or tanks is positioned at a lowermost level of the barrier unit (when viewed in its vertical orientation) to function as the main ballasting tank for the unit. The two remaining buoyancy chambers or tanks are positioned at levels above the ballasting tank so as to place an uppermost buoyancy chamber close to the waterline of the barrier unit with a second of the buoyancy chambers located at an intermediate level between the uppermost and lowermost positions. The two upper buoyancy chambers or tanks provide for an adjustment of buoyancy of the entire barrier unit so as to establish a nearly neutral buoyancy condition when the unit is vertically oriented in a body of water.

The buoyancy tanks of each barrier unit are provided with controls which permit flooding and blowing of the individual tanks. This allows all tanks to be filled with air and sealed so that individual barrier units can be floated to an enclosure area in horizontal attitudes, much like individual barges, for ease of handling. After being deployed to the enclosure area, the buoyancy tanks can be selectively flooded, with a complete flooding of the lower ballasting tank of each barrier unit, so as to change the attitude of each barrier unit from a generally horizontal disposition to a generally vertical disposition. In the vertical disposition the barrier units are in readiness for being linked up and drawn around a containment area, and nearly neutral buoyancies can be established to stabilize the train of linked barrier units. Approximately five feet of height of each unit will extend above the surface level of the water to resist wave action and spillage from within the enclosure area (there being a lesser concern about greater wave action and spillage of sea into the enclosure area since the main function of such a system is to prevent escape of oil, chemicals or other materials being enclosed).

A further feature of the present invention provides for universal linking means between adjoining barrier units which are assembled in a train to enclose a surface area of a body of water. The universal linking means include hinge sections positioned at the ends of individual barrier units, and the hinge sections are mounted to move relative to their respective barrier units about horizontal axes that are perpendicular to the main longitudinal axis of the barrier unit. Hinge sections of a given barrier unit can be coupled with hinge sections of a next barrier unit so as to provide for pivotal movement about a common vertical axis at the line of pivotal connection between the two barrier units.

These and other details and features of the present invention will become apparent in the more detailed discussion which follows. In that discussion reference will be made to the accompanying drawings as briefly described below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective, elevational view of a barrier system assembled from a plurality of individual barrier units;

FIG. **2** is a side, elevational view of one barrier unit linked in end-to-end relationship with a second barrier unit, only a portion of which is illustrated, this view being in larger scale than the scale used in FIG. **1**;

FIG. **3** is an end, elevational view of an individual barrier unit, shown in the same scale as used in FIG. **2**;

FIG. **4** is a greatly enlarged view, in side elevation, of a hinge structure used for linking two barrier units together;

FIG. **5** is a top plan view of the hinge structure of FIG. **4**;

FIG. **6** is a diagrammatic illustration of a method of deployment of a string of barrier units from a barge or other vessel;

FIG. **7** is a schematic depiction of an attitude of each barrier unit of a series when the tops of the series are drawn together to form a generally frusto-conical shape of enclosure; and

FIG. **8** is a depiction similar to FIG. **7** but showing an inverted frusto-conical shape of enclosure obtained by drawing together the bottom ends of adjacent barrier units of a series.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. **1** illustrates general details of a barrier system assembled in accordance with the present invention from a plurality of individual barrier units **10.** The individual barrier units **10** are linked together by linking means **12** (shown in greater detail in FIGS. **2** and **4**) carried at the ends of each barrier unit **10** so that a series of such barrier units can be coupled or linked together in end-to-end relationships. The relative positions of the barrier units in the FIG. **1** view show the high degree of flexibility of the linking means **12** about vertical axes at points of coupling of adjacent barrier units. Typically, a long chain of barrier units would be linked together and drawn around a water area to be enclosed to form an encirclement or enclosure. The dashed line of FIG. **1** illustrates a mean waterline which for purposes of this specification may be considered as the surface level of a calm body of water. The barrier system is intended to float in a generally vertical orientation in a body of water with a substantial portion of the mass of the system below the surface level of the body of water. The purpose in this arrangement is one of stabilizing individual barrier units of a series against turbulence encountered just above and below the mean waterline so that the preferred orientation of the barrier system is maintained over a wide range of sea conditions.

FIGS. **2** and **3** illustrate further details of the individual barrier units of the present invention. Generally, each barrier unit **10** comprises a relatively rigid member having a rectangular shape (when viewed in the FIG. **2** plan of view) and which is of a sufficient size and strength to maintain its shape and integrity against wave action and other sea conditions where it is to be used. The main body of each barrier unit **10** comprises a bulkhead type of construction, and the main body section is fabricated from plate steel, aluminum, or other metal by known techniques. The bulkhead may

be constructed as a single layer of plate metal to which reinforcing ribs **14** are welded or secured, or it may be formed as a double walled structure for its below-water portions with a single plate extending upwardly above the water as a wave and sea shield.

Each barrier unit **10** is provided with adjustable buoyancy means for controlling floatation and ballasting of the barrier unit. The function of the adjustable buoyancy means is to permit establishment of a nearly neutral buoyancy for the entire barrier unit **10** with substantially all ballasting of the unit carried at a level which is below the turbulence level of a body of water in which the barrier system is to be utilized. FIGS. **2** and **3** illustrate a preferred buoyancy means comprising a series of air-tight buoyancy chambers or tanks **16, 18,** and **20.** It has been found that a series of three such tanks, as illustrated, provides for desired controls of buoyancy, attitude, and ballasting for the barrier units **10** if the buoyancy tanks are arranged at different levels along the length of the main body of the barrier unit, as shown. The preferred arrangement provides for an uppermost buoyancy tank or chamber **16** positioned close to the expected waterline (which for purposes of calculation would be the surface level of a calm sea) so that its major mass is just below that waterline. A second buoyancy tank or chamber is located at an intermediate level between the uppermost tank **16** and the position of a third buoyancy tank **20** carried at the lowermost level of the barrier unit **10.** Each of the illustrated buoyancy tanks is fabricated from metal or other material to provide an air-tight cylinder. Valving and control means are provided for flooding and blowing the interior space of each cylinder in accordance with known techniques. Flooding may be accomplished by water inlets (not shown) which include known valve means for being opened and closed by remote control, and blowing is provided by air inlets in the tanks connected to a source of pressurized air by way of hoses or conduits which can be interconnected and controlled between individual barrier units of a system of such barrier units deployed in a body of water. FIG. **2** schematically illustrates means for blowing the individual buoyancy tanks **16, 18,** and **20.** Of course, means are provided for venting the individual buoyancy tanks during flooding, and water is exhausted from the tanks when they are being filled with air.

The lowermost buoyancy tank **20** may be considered a ballasting means for the entire barrier unit **10.** The lower tank **20** is typically completely flooded when the barrier unit is deployed and oriented to the vertical orientation shown in FIGS. **2** and **3,** and this provides for a very low level of ballasting of the entire barrier unit at a level substantially below the active interface between the body of water and the atmosphere. The upper buoyancy tanks **16** and **18** function to control buoyancy and floatation of the barrier unit so that a nearly neutral buoyancy can be established for the entire unit. With these features of low level ballasting and neutral buoyancy control, it is possible to construct a rigid barrier unit **10** of substantial size and strength which can be stabilized in very active sea conditions to maintain a preferred vertical orientation of a series of such barrier units linked together. Further examples of preferred ballasting and floatation will be discussed at a later point in this specification.

FIG. **2** also shows a form of linking means which provides for universal relative movements between adjoining barrier units **10** of a series. The linking means **12** are shown in the form of hinge sections **24** mounted at the ends of the individual barrier units **10** for being coupled with corresponding hinge sections at a next adjacent barrier unit of a series. A liquid proof (impervious to oil when the system is to be used for controlling and containing oil spills) fabric or shield **26** is secured over the entire juncture area between articulated barrier units, although FIG. **2** shows only a portion of such a shield for purposes of exposing the hinge sections that would otherwise be covered over by the shield. The shield **26** functions to seal up the line of juncture between barrier units which are coupled together for universal relative movement.

FIGS. **4** and **5** illustrate further details of a universal hinging arrangement of the type generally shown in FIGS. **1** and **2.** As shown, each hinge section **24** is mounted to its respective barrier unit **10** at a fixed pivot point **26.** The fixed pivot point **26** is established by a pin or other fastening element which secures a hinge section to an end of a barrier unit **10** so as to permit pivotal movment of the hinge section **24** about an axis passing through the fixed pivot point **26.** Such an axis would be perpendicular to the main longitudinal axis of the barrier unit **10.** The individual hinge sections **24** are further secured to their respective barrier units **10** by fastening members **28** having enlarged head portions for retaining an associated hinge section against the face of the barrier unit to which it is secured. The fastening members **28** are fixed through openings formed in the plate metal of the main body of the barrier unit **10** (as shown at the righthand side of FIG. **2,** for example), and arcuate slots **30** are provided in the individual hinge sections **24** at the locations of the fastening members **28** so that each hinge section **24** may move about its fixed pivot axis **26.** The lengths of the arcuate slots determine the limits of movement of each hinge section relative to its associated barrier unit **10.**

Each hinge section **24** also includes projecting hinge elements **32** for mating engagement with similar projecting hinge elements carried by a hinge section of a next adjacent barrier unit. All of the hinge elements of adjoining barrier units are secured together on a common vertical axis at **34** so as to provide for relative rotation between adjoining barrier units about that axis. Typically, the hinge elements **32** are coupled to mating hinge elements of a next barrier unit by a pin or a series of pins extending along the vertical axis **34.**

The hinging arrangement shown in FIGS. **4** and **5** provides for relative movement between articulated barrier units of up to about 250° in a horizontal plane of movement and up to about ten percent in a vertical plane, above and below sea level, to provide for wave following capability.

Thus, there is provided a very strong linking means between adjoining barrier units **10,** and yet, there is also provided full flexibility of movement between adjoining barrier units. Flexibility of movement is very important to successful use of barrier units in active sea conditions, especially with large rigid units of the type contemplated by the present invention because normal cresting and troughing of waves along the length of a barrier system enclosure, or forces developed perpendicularly to the enclosure by wave action, could very well break up an enclosure system assembled from a series of articulated units. The illustrated hinging arrangement allows a string of articulated barrier units **10**

to float at substantially different levels resulting from high wave action, for example, as much as 5 feet of difference in level between adjoining units riding respectively in a wave trough and in a wave crest, by the provision of the pivotal axis at **26.** In addition, adjoining barrier units can move for substantial relative movement about the vertical axis **34** to accommodate sea conditions and requirements for shaping an enclosure system to the needs of a given operation. The lowermost ballasting tanks **20** may be provided with bumper elements **40** (see FIG. **2**) to prevent damage to adjacent units when there is an extreme folding of such units about the vertical hinge axis **34.**

As an example of a construction of the barrier unit **10** of this invention, a unit is fabricated from plate steel with an overall length of about 26 feet and an overall height (both dimensions as viewed in FIG. **2**) of about 15 feet. Three buoyancy tanks **16, 18** and **20** are formed as steel cylinders with diameters of about 30 inches, and secured to the barrier unit by reinforced (by upright ribs **14**) main body sections extending between the three levels of buoyancy tanks illustrated in FIG. **2.** The upper two buoyancy tanks **16** and **18** are of a shorter length (about 24 feet) than the ballasting tank **20** (about 26 feet) so as to provide for attachment of a universal hinging means to the ends of the main body of the barrier unit. An upstanding wall section of reinforced plate steel extends upwardly from the uppermost buoyancy tank **16** to provide a relatively high, approximately 5 feet in height, barrier shield above the waterline. With this arrangement, the ballasting tank **20** is positioned approximately 10 feet below the expected waterline. Each barrier unit of this example weighs approximately 11,000 pounds in light condition, and has a mass of 18,400 pounds in its ballasted condition. In the ballasted condition, it has a vertical pendulum stability by virtue of the product of weight times distance below the center of buoyancy, versus the weight times the distance of structure above the center of buoyancy. With the lower ballasting tank **20** completely flooded, buoyancy is divided between the two upper buoyancy tanks **16** and **18,** which are filled with air, and the center of buoyancy for the barrier unit is established approximately midway between the two upper buoyancy tanks **16** and **18** when nearly neutral buoyancy is attained. When the barrier unit is ballasted and floated in the attitude shown in FIG. **3,** there will be approximately 1,450 pounds of residual buoyancy in the barrier unit, and the upper buoyancy tank **16** will be awash to within five or six inches of freeboard. Thus, in the example just given, more than fifty percent of the buoyancy of the barrier unit is below the turbulence level of the sea, and only a small residual buoyancy of the barrier unit is exposed to wave action. Even this small exposure to wave action is diminished because of the receding nature of the upper cylindrical surface of the upper buoyancy tank **16.**

One of the advantages of utilizing a series of buoyancy tanks to control ballasting and buoyancy is that a barrier unit of this design can be deployed and used in a novel method of establishing an enclosure around a surface area of a body of water. By blowing all of the buoyancy tanks **16, 18** and **20,** the entire barrier unit **10** can be floated in a generally horizontal attitude on the surface of a body of water, and this attitude permits ease of handling and deployment of a long train of such heavy, rigid barrier units at sea. In essence, a series of barrier units **10** can be towed, floated or deployed in horizontal attitudes so as to be handled or driven like a barge or other surface vessel to the enclosure location. Then, the series of linked barrier units can be reoriented by ballasting their lower buoyancy tanks **20** so as to change the atttitude of the entire series of barrier units from horizontal to vertical. Ballasting of the lower tanks **20** can be effected by remote control devices which open valves in all of the ballasting tanks to vent and flood the ballasting tanks. Control lines and hoses (not shown) can be interconnected between barrier units of a series so that control functions can be carried out from a single location.

FIG. **6** provides a schematic illustration of a type of deployment available with the barrier units of this invention. A barge or other surface vessel **50** can carry stacks of individual barrier units **10** for deployment onto the surface of a body of water. The stacks of barrier units can be carried on a deck of the vessel **50,** and one arrangement would provide for a lower level deck storage and a launching ways astern of the vessel. Typically, racks of barrier units could be arranged abreast of each other as shown in FIG. **6** so that individual barrier units can be moved to a centerline position for connection to the last of a string of barrier units being deployed. Once a series of such barrier units are deployed, they can be towed to the enclosure area and ballasted to a vertical orientation for final movement around the oil spill or whatever area is to be protected. Preferably deployment will be carried out in a manner to avoid broadside buffeting of any given barrier unit during placement and re-orientation.

Alternatively, the individual barrier units may be linked together in calm waters and towed to an offshore site in their horizontal attitudes until the site of a spill is reached. Then, the lead barrier unit can be anchored, and the ballasting tanks **20** of all units flooded so as to change the orientation of the series of articulated units. Pneumatic and other control connections are made when the individual units are linked together and prior to positioning at the enclosure site. When the lead barrier unit has been anchored, the last unit of the series can be towed around the enclosure area for a linkup with the lead barrier unit. This linkup should be made at an upwind area of the site, and it is feasible to keep the enclosure open until oil accumulates in the enclosure area and so that service equipment can move in and out for salvaging and recovery operations. Typically, the barrier units will be anchored once the enclosure is completed.

When the containment operation is completed, the units can be unlinked and their ballasts blown by displacing water from the ballasting tanks with air under pressure. Air can be supplied from a source common to a number of units, or each unit may carry its own supply of pressurized air for purposes of blowing ballast.

It is further contemplated that in the event of extreme weather and sea conditions, all of the buoyancy tanks of the barrier units can be flooded for sinking the entire barrier system to avoid loss or damage to the barrier units making up the system. Pneumatic lines can be buoyed to the surface for this purpose so that the buoyancy tanks can be blown after a sinking operation to raise the barrier system.

FIGS. **7** and **8** illustrate a feature of controlling the overall shape of an enclosure made up of a series of

barrier units **10.** Pneumatic devices of the type shown at **60** in FIG. **4** may be coupled at the upper and lower levels of articulated barrier units **10** so as to provide for a limited control of spacing between the ends of a coupled pair of such units. By drawing the upper ends of adjoining barrier units closer together, a generally frusto-conical shape can be imparted to a series of barrier units defining an enclosure at sea. FIG. **7** depicts, in somewhat exaggerated form, the general attitude that would be assumed by the individual barrier units for this type of control. In the FIG. **7** view, the enclosed surface area is represented at the righthand side of the figure by the smaller wave lines (as would be the case with a sea surface dampened by a heavy oil spill), and the open sea area is indicated to the left of the view with larger wave lines. An alternative control would be to draw the lower ends of adjacent barrier units of a series together so as to form an inverted frusto-conical shaping of an enclosure, as shown in FIG. **8.** Again, the enclosure area is shown to the right of the FIG. **8** view.

Thus, it can be seen that the system of the present invention offers an improved type of barrier unit for use with heavy oil spills on a very active sea. The barrier units can be constructed to provide for a very deep draft that functions to contain heavy oil spills (as contrasted with light oil slicks), and yet, a substantial barrier is established above the surface of the sea for containing a spill and any wave action from within an enclosure area. A series of barrier units of this type can be articulated together with the linking means described above, or with other linking means, to provide for universal movement and compensation for wave action at sea. The barrier units are especially adaptable for being handled as surface vessels in horizontally disposed attitudes and for re-orientation as stable, deep draft barrier structures at an area to be protected. The barrier units may be deployed and maintained in position around offshore drilling platforms or other risk areas as a precautionary measure, or they may be carried to location for deployment and establishment of an enclosure after an oil spill or other accident occurs.

Although the invention has been described with reference to a specific embodiment, it will be appreciated that the concepts of this invention can be practiced with equivalent structures and methods. The barrier units may be fabricated in various sizes and shapes from those which have been discussed above, and all equivalent structures and methods to those disclosed herein are intended to be included within the scope of protection being sought.

What is claimed is:

1. A floatable barrier system for use in a large body of water such as a lake, ocean or the like, comprising:

a plurality of rigid buoyant barrier structures operable to be disposed in an operative position in said body of water wherein each extends generally vertically by virtue of a total of a plurality of separate buoyancy forces thereof acting above the center of gravity thereof;

a first buoyancy means disposed at an upper portion of each of said barrier structures when in said operative position for supplying a first buoyancy force necessary to be exerted on said barrier structures to maintain the same in said operative position;

a second buoyancy means disposed beneath each said first buoyancy means at a submerged position below the turbulance level of said body of water when said barrier structures are in said operative vertical position for supplying a second substantial buoyancy force necessary to be exerted on said barrier structures to maintain the same in said operative position and for applying said second buoyancy force on said barrier structures at a position below the turbulance level of said body of water;

each of said plurality of barrier structures having exposed barrier portions extending above the surface of said body of water when said barrier structures are in said operative position for reducing substantial wave action on a side of said barrier structures opposite the direction of movement of said wave action; and

linking means interconnecting said plurality of barrier structures for allowing relative articulated movement of said barrier structures with respect to one another caused by wave action while substantially maintaining the barrier effect thereof.

2. The barrier system of claim **1** wherein said first and second buoyancy means each comprises an air-tight chamber that includes controls for being flooded or blown so as to provide for ballasting and buoyancy controls for each said barrier structure.

3. The barrier system of claim **2** wherein said series of chambers are positioned between the waterline of the barrier unit and its lowermost edge, when in its vertical orientation, so as to provide for substantial ballasting of the barrier unit at a level below the turbulence level of the body of water in which it is placed.

4. The barrier system of claim **1** wherein said linking means comprises hinge sections carried at end portions of each of said barrier structures for linking engagement with hinge sections carried at the ends of adjacent barrier structures arranged in end-to-end relationship.

5. The barrier system of claim **4** wherein said hinge sections are mounted on each said barrier structure so as to pivot relative to the barrier structure about horizontal axes which are perpendicular to the longitudinal axis of the barrier unit, thereby providing for a flexing of a series of such barrier structures linked together.

6. The barrier system of claim **4** wherein hinge sections of adjoining barrier structures link together to pivot about a common vertical axis.

7. The barrier system of claim **4** and including means which can be interconnected between adjacent linked barrier structures to control the relative angular disposition of the adjacent barrier structures about said common vertical axis.

8. The barrier system of claim **1** and further including: ballast means disposed at the lower portion of each of said plurality of rigid barrier structures below said center of gravity when in said substantially vertical position for providing a buoyancy force which in association with said first and second buoyancy means will maintain each said barrier structure in a floating horizontal position, and which can be flooded with water to permit each said barrier structure to assume said substantially vertical position.

9. The barrier system of claim **1** wherein said plurality of barrier structures are linked by said linking means so as to form a generally circular enclosure to contain an oil spill within said system.

10. A method for providing a stable buoyant barrier system in a large body of water, comprising the steps of:

applying a total of a plurality of separate buoyancy forces to each of a plurality of rigid barrier struc-

tures above the center of gravity of each thereof, so as to maintain said barrier structures in a neutral buoyancy position;

applying a first buoyancy force to an upper portion of each of said plurality of barrier structures by means of a first buoyancy means;

applying a second buoyancy force beneath said first buoyancy force to each of said barrier structures at a position close to and below the turbulance level of said body of water by means of a second submerged buoyancy means separate from said first buoyancy means; and

linking together said plurality of rigid barrier structures so as to allow articulated movement thereof with respect to one another caused by wave action while substantially maintaining the barrier effect thereof.

11. The method of claim **10** and including the step of forming an enclosure with said barrier structures to contain an oil spill within said system.

12. The method of claim **10** and including a step of discharging said barrier structures from a floating vessel for being placed in said large body of water.

13. The method of claim **11** and including a further step of drawing said vertically oriented barrier structures together at their tops to form a frusto-conical enclosure around said area.

14. The method of claim **11** and including a further step of drawing said vertically oriented barrier structures together at their bottoms to form an inverted frusto-conical enclosure around said area.

* * * * *