United States Patent

McCabe

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[54] **DYNAMIC BOAT FENDERING SYSTEM**

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[52] **U.S. Cl.** **61/46,** 61/48

[51] **Int. Cl.** **E02b 3/22**

[58] **Field of Search** 61/46, 48; 114/219

[56] **References Cited**

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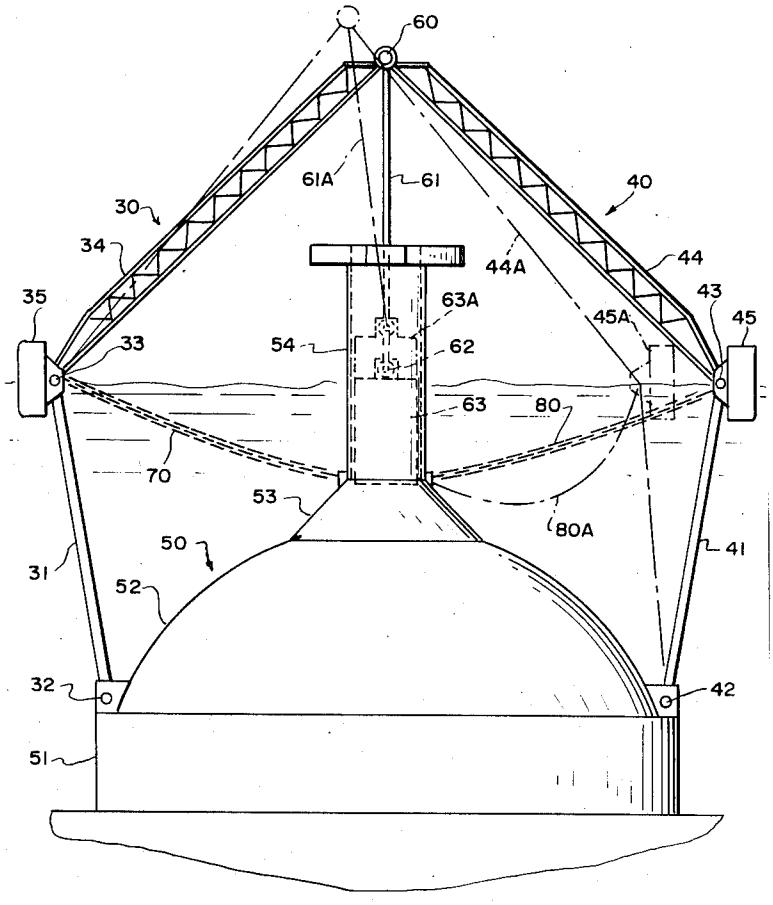
[57] **ABSTRACT**

A dynamic fender for mooring ships having an elongated lower member joined at its lower end to one or more bodies attached to land above or below a sea and pivotally connected at its upper end to the lower end of an elongated upper member. The upper end of the elongated upper member is displaceably mounted to means above sea level which continually applies a compressive force to the elongated upper member. A bumper is joined at about sea level to either the lower member or upper member or both. A restraining means limits outward movement of the bumper and permits inward movement of the bumper when horizontal pressure is applied, as by a ship, to the bumper.

3 Claims, 5 Drawing Figures



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3 Sheets-Sheet 1

FIG.1

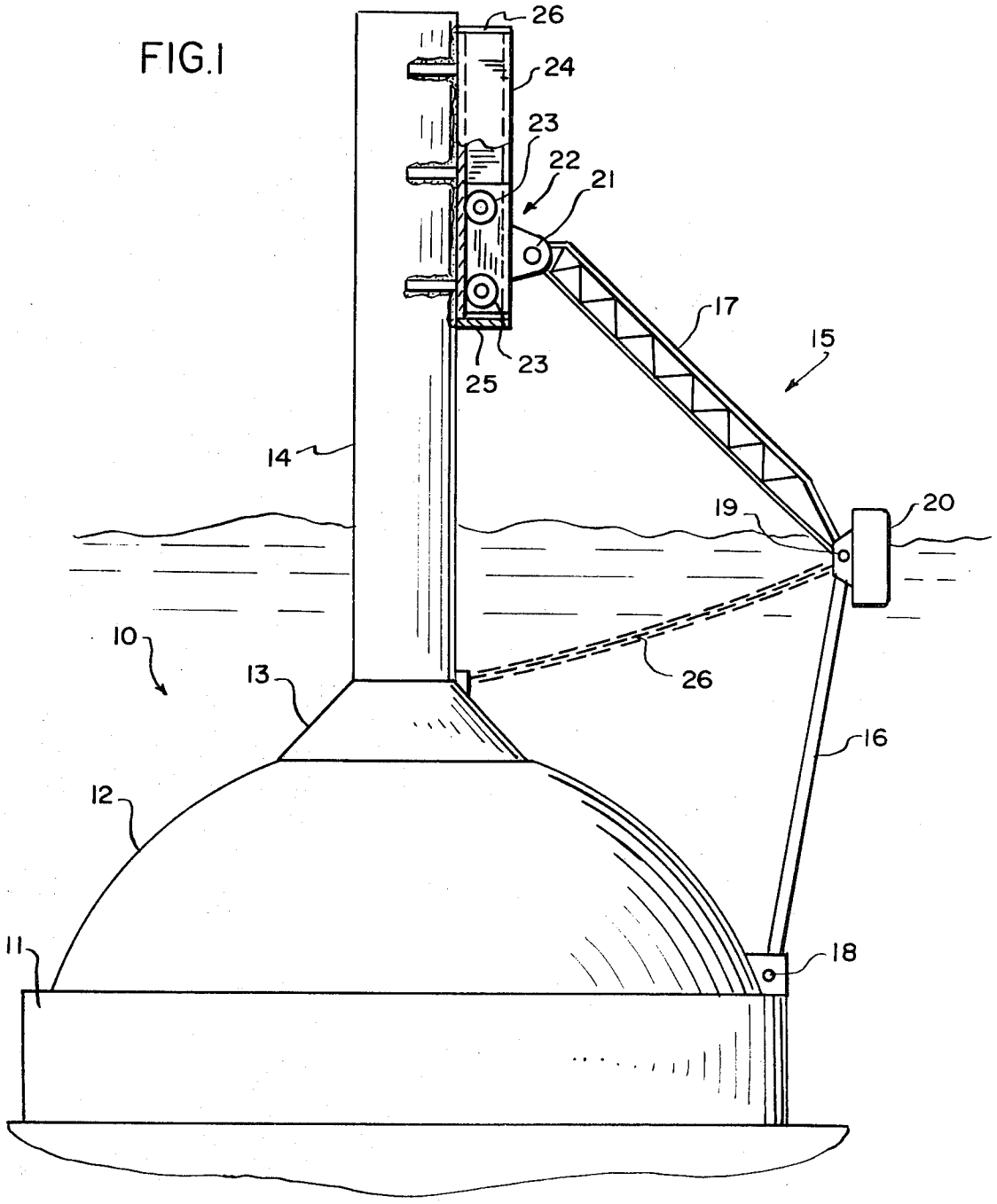
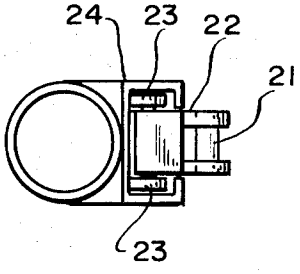


FIG.2



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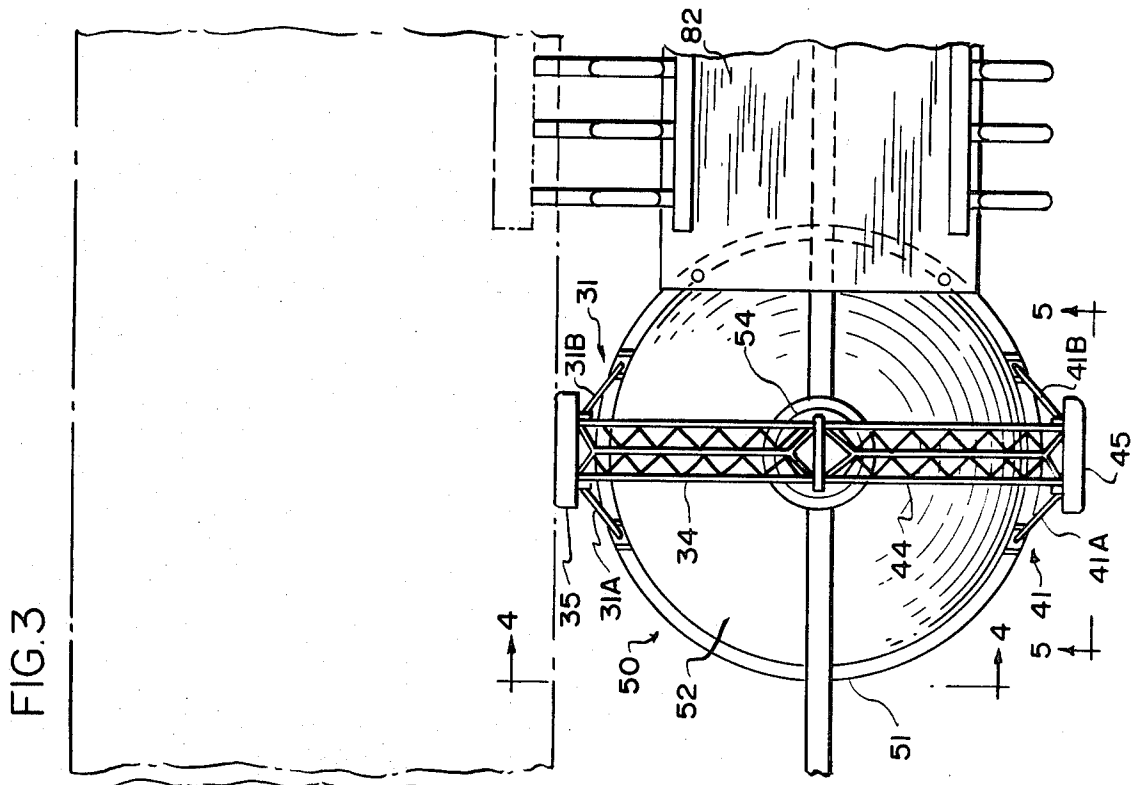

FIG. 3

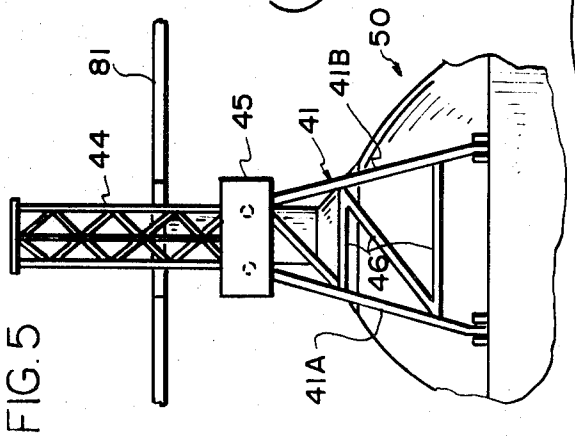

FIG. 5

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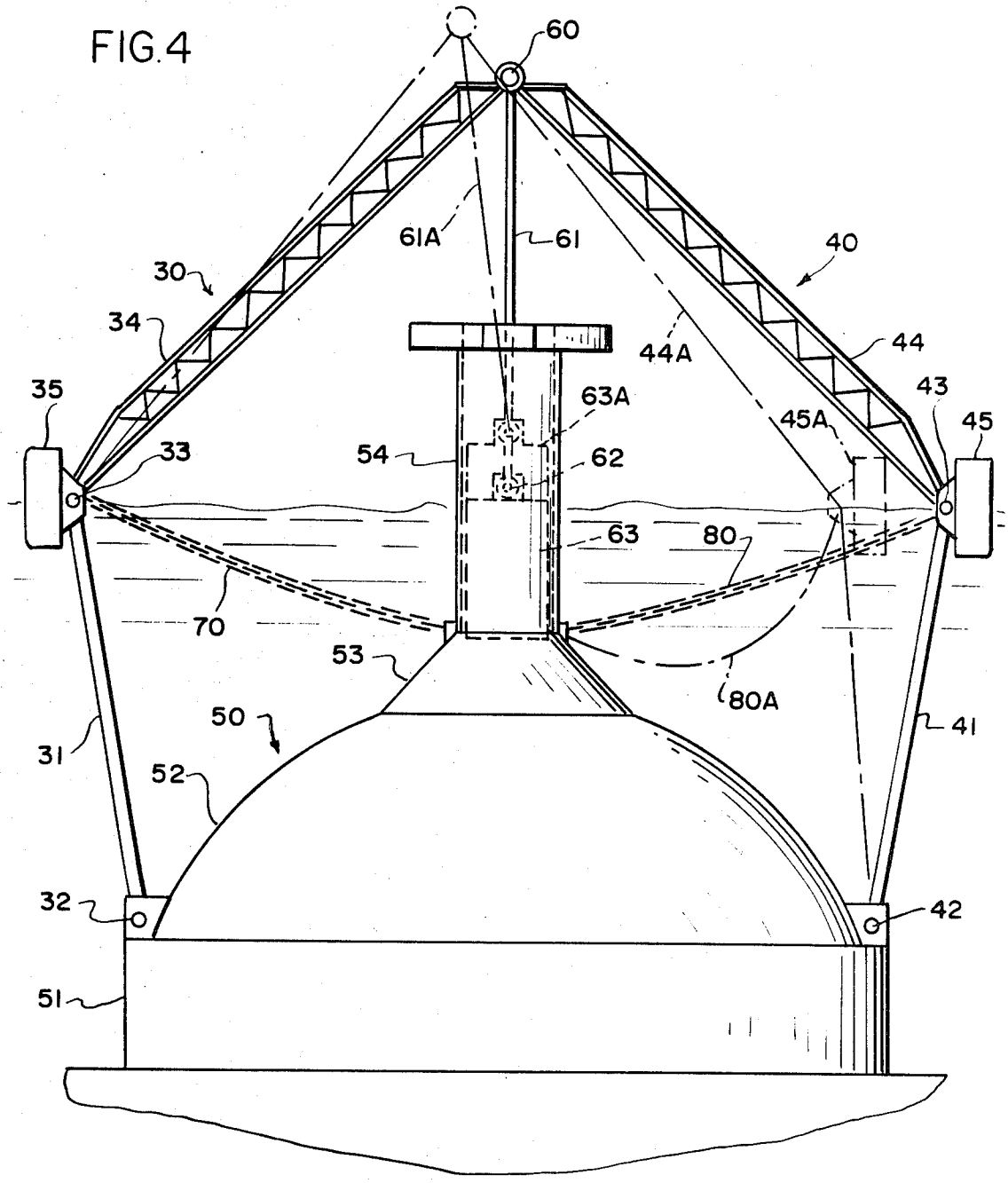
FIG. 4



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DYNAMIC BOAT FENDERING SYSTEM

This invention relates to structures useful for mooring ships. More particularly, this invention is concerned with a novel dynamic fender structure for breast mooring of ships.

It is common practice in the mooring of ships to place either the port side or starboard side of the ship adjacent to and aligned with the edge of a wharf or dock. Such mooring is often referred to as breast mooring. To prevent damage and wear on the ship and the wharf or dock it is customary to employ bumpers or fenders between the side of the ship and the wharf or dock or other structure to which the ship is breast moored. The bumpers or fenders are usually made of a resilient or yieldable material which can withstand shocks and absorb the compressive forces applied by movement of the ship. While such fendering systems have served adequately for smaller sized ships, they are and have been quite inadequate for adequate mooring of large vessels, particularly the large oil tankers now in service, as well as warships and passenger liners. Conventional fendering systems do not yield quickly enough or sufficiently enough to withstand and absorb the tremendous forces exerted by such large ships during mooring, and as a result damage results to the ship as well as to the mooring structure.

In addition to the need for improved fendering systems where the mooring is adjacent the shore, such as at a wharf or dock, there is a need for fendering systems for use in mooring ships at offshore locations for the discharge or loading of cargo. Thus, oil tankers are often loaded with oil at sea-island terminals located offshore and in water of considerable depth. The construction of conventional wharfs and docks offshore is inadvisable because of the water depth involved and the costs involved in driving bulkheads and piles into the sea bed. It is thus highly advisable in offshore mooring structures to utilize a minimum number of stationary structures supported by the sea bed. To protect such structures and yet permit mooring of large ships with adequate protection to the ship, fendering devices are needed which can successfully absorb the large forces involved.

According to the invention there is provided a novel dynamic fender which can be utilized for the offshore breast mooring of ships as well as for breast mooring of ships adjacent to shore. Forces applied against the fender by mooring of a ship are dynamically resisted by displacement of the fender with concomitant continued application of force against the ship which results in deceleration of ship movement and its ultimate stopping.

In a broad embodiment of the invention the fender comprises an elongated lower member pivotally joined at its lower end to a body attached to land above or below a sea and pivotally connected at its upper end to the lower end of an elongated upper member, with the upper end of the elongated upper member displaceably mounted to means above sea level which continually applies a compressive force to the elongated upper member, a bumper joined at about sea level to either the lower member or upper member or both, and a restraining means which limits outward pivotal movement of the junction of the two members and of the bumper and permits inward movement of the junction when horizontal pressure is applied, as by a ship, to the bumper.

The invention will now be described further in conjunction with the attached drawings in which:

FIG. 1 is a side elevational view of a dynamic fender of this invention mounted on an offshore oil tank resting on a sea floor;

FIG. 2 is a partial plan view of FIG. 1 and shows the roller truck linkage to which the upper member of the fender is pivotally connected;

FIG. 3 is a partial plan view showing a dual fendering system provided by this invention as mounted on an offshore oil tank;

FIG. 4 is a side elevational view of the fendering system taken along the line 4—4 of FIG. 3; and

FIG. 5 is a front elevational view of the fendering system taken along the line 5—5 of FIG. 3.

With reference to FIG. 1, the offshore oil storage tank **10** has a lower base ring **11** of concrete and a more or less hemispherical domed section **12** joined thereto at its lower edge and having its upper edge joined to a conical section **13** from which a hollow column or tube **14** projects above sea level. Tank **10** rests on the sea floor and has an open bottom. It stores oil by the water displacement principle. Under conditions of use, oil occupies the interior of column **14**. When empty or essentially empty, sea water fills the column. Of course, if desired, a barrier wall can be placed in the column to prevent oil or water from occupying any of the column interior.

Dynamic fender **15** is composed of an articulated arm made up of two elongated members, which are lower member **16** and upper member **17**. Lower member **16** is joined by pivot **18** to the lower part of tank **10**. The upper end of lower member **16** and the lower end of upper member **17** are pivotally connected together by pivot **19**. Bumper **20** is also pivotally mounted to pivot **19**. Bumper **20** provides a suitable contact surface against which the side of a ship can bump or press during mooring operations.

Bumper **20** can be a buoyant member, if desired, or it can be nonbuoyant. It is sometimes advisable to make bumper **20** of a highly dense material and to position it such that it is mostly below sea level. When it is caused to move above sea level through force applied against it by a mooring ship, the added apparent weight thereby induced results in additional force applied against the side of the ship to resist forces applied through action of the ship against it.

The upper end of upper member **17** is joined by pivot **21** to a weight in the form of roller truck **22** having four wheels **23** mounted in a pair of axles as is additionally shown in FIG. 2. The roller truck **22** is heavily weighted. It can contain a hollow chamber which can be filled with variable quantities of a fluid to obtain the desired weight to tune the fender to apply the proper force. Channel member **24** is vertically connected to column **14** and has a track in which roller truck **22** can move vertically up and down. Stopper plate **25** may be positioned at the bottom of track **24** and stopper plate **26** mounted at the top thereof to limit vertical displacement of roller truck **22** in the track. Plates **25** and **26** are not essential but are a desirable safety feature.

Nonrigid tension applying member **26**, such as a chain or cable, is connected at one end to tank **10** and

at the other to arm **15**, such as on or adjacent to pivot **19**, although it can be joined to either lower member **16** or upper member **17**. Tension applying member **26** serves to restrict outward movement of the junction of the upper and lower members. By outward movement is meant movement that results in displacement of the junction and bumper **20** to the right as shown in FIG. **1**. Conversely, inward movement is intended to mean displacement of the junction and bumper **20** to the left in FIG. **1**.

The roller truck structure **22** shown in FIGS. **1** and **2** can be replaced by other means which permits vertical controlled movement of the upper end of upper member **17**. Thus, a large sphere can be placed on the upper end of member **17** to slide vertically in a tube having a vertical axial cut-out portion adapted to permit movement of the end of member **17**. Pressure could be applied to member **17** by suspending a weight from it downwardly with the top of the weight advisably at about sea level. As pressure would be applied to the bumper, the weight would rise from the water and its apparent weight would increase thereby increasing pressure applied to the bumper.

Member **17**, as shown in FIG. **1**, is a truss but it can be a rod or tube or other structure capable of withstanding the compressive forces to which it will be subjected. Lower member **16** can also be one of such structures.

It is not essential to the invention that the lower end of member **16** be joined to an offshore tank since it can be joined to any body of foundation, particularly one secured to the sea floor, including a dock or wharf at the shore. In addition, the upper end of upper member **17** can be joined to any suitable structure offshore or on shore. It is important, however, that the lower end of lower member **16** and the upper end of upper member **17** be joined to a body or bodies or structures which maintain a predetermined relationship of those elements which guide or govern the spatial arrangement or positioning of the fender structure. Included within the concept of the invention, therefore, is the mounting of the dynamic fender on a floating body, and particularly a floating body anchored to a sea floor.

FIGS. **3** to **5** illustrate a dynamic fender system provided by this invention which utilizes a dual arrangement of the fender principle illustrated in FIGS. **1** and **2**, but without a roller truck at the top of the upper member to provide for vertical displacement in a guided relationship. The fender system shown in FIGS. **3** to **5** has two identical arms **30** and **40**. Arm **30** has a lower member **31** joined by pivot **32** at its lower end to tank **50**. The upper end of lower member **31** is joined by pivot **33** to the lower end of upper member **34**. Bumper **35** is also supported by pivot **33** although it can be appropriately placed on either of lower member **31** or upper member **34**. Arm **40** has a lower member **41** joined by pivot **42** to the lower part of tank **50**. The upper end of lower member **41** is joined by pivot **43** to the lower end of upper member **44**. Bumper **45** is also joined to the arm by pivot **43**.

Tank **50** is circular in horizontal section. It has a vertical lower walled cylindrical ring **51** from which hemispherical section **52** curves upwardly to join with the lower end of conical section **53** from which column or tubular member **54** extends vertically upwardly. It is essentially like tank **10**.

As shown more clearly in FIGS. **3** and **5**, the lower members **31** and **41**, of each of the arms **30** and **40** respectively, are composed of two legs and supporting framework. Thus, lower member **41** has a leg **41A** and a leg **41B**, which together comprise the lower member together with struts **46**. The lower end of each of these legs is pivotally connected to tank **50** and the upper end is connected to pivot **43**. Similarly, lower member **31** of arm **30** has two legs **31A** and **31B** as shown in FIG. **3**, and each of these legs is pivotally connected at its lower end to tank **50** and at their upper ends to pivot **33**.

The upper end of upper members **34** and **44** are pivotally connected together by pivot **60**. Depending downwardly from pivot **60** is arm **61** which is connected by pivot **62** to a weight **63** shown in phantom in FIG. **4**. The internal space of column **54** is filled with sea water or oil. Weight **63** is positioned so that when the fender system has no force applied to bumpers **35** and **45** its top surface is at about the level of liquid in column **54**. When a ship applies a force against bumper **45** it is displaced such as to location **45A** shown in phantom in FIG. **4**. When bumper **45** is displaced by the action of a ship against it, such as to position **45A**, tension applying member **80**, such as a chain or cable, is permitted to relax and hang downwardly to position **80A**. Also upper member **44** is displaced to position **44A** and rod **61** is pulled upwardly and to one side thereby raising weight **63** until its upper surface is at position **63A**. As weight **63** is raised above sea level its apparent weight increases and thereby applies a greater force on pivot **60**. This force is transferred through the upper members of arms **30** and **40**, causing bumpers **35** and **45** to be urged outwardly. Outward movement of bumper **35** is restricted by nonrigid tension applying member **70** extending from tank **50** to arm **30**, and specifically to the pivot **33**. As a result, the force applied by the ship is dynamically resisted by the fender and it opposes further movement of the ship. Nonrigid tension applying member **80** extends from tank **50** to pivot **43** and functions in the same way as tension applying member **70** when a ship is moored against bumper **35**.

A whole series of tanks **50** can be placed in a line and supplied with a fender system as described in conjunction with FIGS. **3** to **5**. The fenders can be made of such size and constructed with appropriate resisting capacity to permit safe and ready breast mooring of even the largest oil tankers now in service or under construction, such as those of 300,000 tons. In addition, an offshore oil tank **90**, similar to tank **50**, can be utilized for attaching mooring lines to hold a moored ship in secure but yieldable position. A cat walk **81** can extend between the offshore oil tanks and a platform **82** can be mounted on and between adjacent tanks to support mechanical equipment for pumping oil from the tanks to a ship.

In the dynamic fender dual arrangement of FIGS. **3** to **5**, the lower ends of lower members **31** and **41** need not be connected to the same body, such as tank **50**, or to some other body or bodies or foundation. Either or both of the lower ends of lower members **31** and **41** can be joined to foundations in the sea floor or to a dock or wharf off-shore or on-shore or to any other body so long as a predetermined relationship of these elements is maintained to permit operation of the dual fender system. In addition, the dual fender system can also be

employed mounted on a floating body, particularly one anchored to a sea floor.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom as modifications will be obvious to those skilled in the art.

What is claimed is:

1. A fender comprising:
a pair of opposite arms, with each arm comprising a lower member and an upper member;
the upper end of the lower member and the lower end of the upper member being pivotally joined together by a juncture outwardly positioned in a horizontal direction beyond the lower ends of the lower members and the upper ends of the upper members;
the upper ends of the upper members being pivotally joined together;
the lower end of each lower member being pivotally joined to a stationary location on a body attached to a sea floor;
a bumper joined at about sea level to each arm;
a restraining means which limits outward pivotal movement of each lower member and permits inward movement of the lower member when horizontal pressure is applied to the bumper;
a weight suspended at least partially below sea level from at least one of the upper members when the lower members are at maximum outwardly extended position and with inward progressive positioning of at least one of the lower members by pressure applied to the bumper associated therewith the weight is vertically progressively positioned higher with respect to sea level thereby increasing its apparent weight and increasing the pressure applied to the said bumper.

2. A dynamic fender for mooring ships comprising:
an arm comprising an elongated lower member and an elongated upper member;
said elongated lower member pivotally joined at its lower end to a stationary location on a body attached to a sea floor
the upper end of the lower member and the lower end of the upper member being pivotally joined together by a juncture outwardly positioned in a horizontal direction beyond the lower end of the lower member and the upper end of the upper member;
a bumper joined at about sea level to said arm;
a restraining means which limits outward pivotal movement of the juncture of the two members and of the bumper and which permits inward movement of the juncture when horizontal pressure is applied, as by a ship, to the bumper;
the upper end of the elongated upper member being attached to a weight means movable substantially vertical in guide means to continually apply a compressive force to the elongated upper member; and
said weight means including a weight which is at least partially below sea level when the lower member is at a maximum outwardly extended position and with inward progressive positioning of the lower member the weight is vertically progressively positioned higher with respect to the sea level thereby increasing its apparent weight and increasing the pressure applied to the said bumper.

3. A fender comprising:
a pair of arms, with each arm comprising a lower member and an upper member;
the upper end of the lower member and the lower end of the upper member being pivotally joined together by a juncture outwardly positioned in a horizontal direction beyond the lower ends of the lower members and the upper ends of the upper members;
the upper ends of the upper members being pivotally joined together;
the lower ends of the lower members being pivotally joined in spaced apart relationship from each other to a body attached to a sea floor;
said body having a vertical tubular column extending above sea level;
a bumper joined at about sea level to each arm; and
a restraining means which limits outward pivotal movement of each lower member and which permits inward movement of the lower member when horizontal pressure is applied to the bumper;
a weight suspended from at least one of the upper members inside of the tubular column at least partially beneath sea water therein and at least partially below sea level when the lower members are at maximum outwardly extended position and with inward progressive positioning of at least one of the lower members the weight is vertically progressively positioned higher with respect to sea level thereby increasing its apparent weight and increasing the pressure applied to the said bumper.

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