

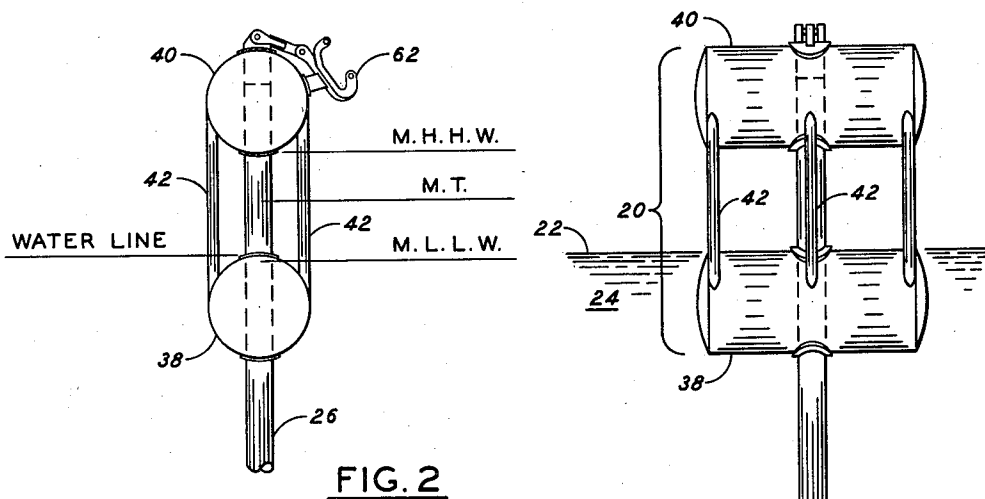
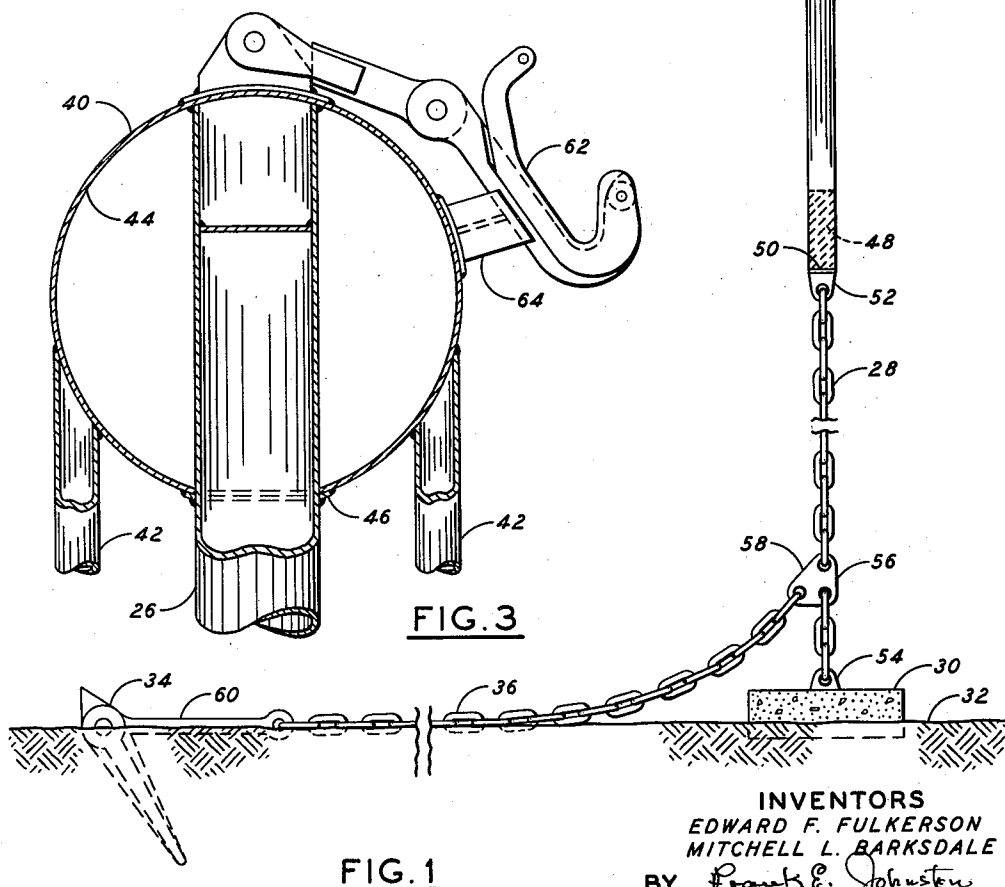
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MOORING BUOY

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MOORING BUOY

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This invention relates to mooring buoys, and more particularly to an arrangement for prolonging the useful life of a mooring buoy assembly installed at an offshore location while decreasing the amount of periodic maintenance it requires.

A mooring buoy, as is well understood in the art, comprises a buoy or float member which is anchored at an offshore location by a slack anchor chain attached to a heavy bottom anchor. A vessel is moored by attaching it to the float member by a mooring line, and the restraining anchoring force is transmitted from the bottom anchor through the float member to the vessel. As the vessel exerts increased force on the mooring buoy installation under the influence of wind and water forces at the surface of the water attempting to move the vessel from its moored position, the float member is pulled downwardly into the water. The resistant force this member exerts on the system increases as it is submerged, tending to restore the vessel to its initial position, and assisting the bottom anchor in restraining the movement of the vessel.

In situations where it is desired to restrict the movement of the vessel to a very limited area, such as occurs, for instance, in offshore loading and unloading terminals for oil tankers, mooring stations are established wherein several mooring buoys are displaced around the area in which the vessel is to be maintained. The vessel is maneuvered into position in a particular location within the surrounding buoys and secured to them by bow and stern mooring lines, and in some cases by mooring lines placed amidships of the vessel. All of the buoys then act on the vessel to maintain it in the desired position where the appropriate hoses can be connected to it without danger of rupture while the cargo is being loaded or unloaded.

Mooring buoy stations commonly are installed in open-water locations where the buoys are exposed to constantly applied wave forces as well as tidal variations in the elevation of the surface of the water. These forces cause the buoy to be in constant movement and its elevation above the underwater bottom to change continuously, and this movement is transmitted to the anchor chain which secures it to the bottom anchor. The constant wear on the anchor chain, which results from such movement, added to the well-known corrosive effects of a salt-water environment, reduces the useful life of the anchor chain to a marked degree, particularly in the dip section, where the chain curves from a vertical to a horizontal direction adjacent the ocean floor. It is good practice, at a well-maintained offshore terminal, to pull the mooring buoys out of the water and inspect the anchor chains at least once each year, since experience has proved that normally at least some of the anchor chain links must be replaced in this period of time. With equipment of the size used to moor oil tankers, the cost of maintaining the offshore terminal can be very appreciable and may approximate \$10,000 per year for the maintenance of the buoys.

It is among the objects of this invention to provide a novel mooring buoy assemblage which functions in a manner to extend its useful life beyond that of the mooring buoy installations now commonly in use, which will

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require less frequent maintenance while assuring that the elements of the assemblage are in safe working condition, which will increase the ease with which a vessel can be moored to an offshore terminal, and which will maintain the moored vessel in position with less periodic increased strain in the anchor lines due to the rolling and pitching of the vessel than is presently experienced with mooring buoys.

Other objects of this invention will become apparent as the description of it proceeds in conjunction with the accompanying drawings which form part of the specification and in which:

FIG. 1 illustrates in side elevation a mooring buoy assemblage made in accordance with this invention and installed in a body of water. For the purpose of better illustrating the inventive concept, the buoyant portion of the assemblage is shown rotated horizontally 90° from the position it normally will assume when a vessel is moored to it.

FIG. 2 is an end elevation of the top portion of the assemblage illustrated in FIG. 1.

FIG. 3 illustrates in end elevation and partly in section details of the construction of the topmost buoyant member of the assemblage illustrated in FIG. 1.

The illustration of FIG. 1 represents a mooring buoy assembly installed in a body of water in an operative condition. A buoyant portion 20 is located at the surface 22 of the body of water 24 and, through a rigidly extending element 26 affixed to it and to an anchor line 28, is connected to a mass 30 which is seated on the submerged land surface 32. A laterally disposed bottom anchor 34 is connected through a second anchor chain 36 to the first anchor chain 28 in a location adjacent the mass 30, all in a manner to be described in more detail hereinafter.

The buoyant portion of the assembly preferably is formed of two float sections which are affixed to each other in vertically spaced relationship by connecting members which provide a reduced effective cross-sectional area and reduced effective buoyancy throughout the region between the float sections. The float sections and the means for connecting them together may have various forms, or the buoyant portion may be formed of a single float with a midsection of reduced area and shaped in a manner which will be effective for the purposes of this invention.

In a preferred embodiment of the invention, as illustrated in FIG. 1, the float sections are cylindrical in form and similar in size, and in an operating position are disposed with their longitudinal axes parallel to each other and to the surface of the water. The bottom float section 38 is rigidly connected to the top float section 40 by a plurality of struts 42 which extend between the float sections and are laterally spaced apart from each other. The dimensions of the struts are chosen to supply the desired rigidity to the structure while decreasing the area exposed to wave forces in the region between the float sections and also while decreasing the buoyancy of the assembly in this region. Additionally, the rigid element 26 passes through each float section along the aligned transverse symmetrical axis common to them and is secured to each float section in a water-tight connection, as by welding.

The struts are not only structural elements for securing the float sections together, but function also as a fender system for operating and maintenance launches to reduce the hazard of damage to the floats by small craft impinging on or between them.

The rigid element 26 preferably, although not necessarily, is a length of thick-walled pipe which is secured at its upper end to the interior wall 44 of the topmost

portion of the buoyant section 40 and extends downwardly and passes through the bottom wall of this buoyant section in a water-tight connection, as indicated at 46 in FIG. 3. The element 26 continues vertically through the lower buoyant section 38, to the top and bottom walls of which it is sealed in a water-tight connection, and projects downwardly into the water in coaxial relationship to the common axis of symmetry of these buoyant members.

Preferably, the lower end of the element 26 is weighted with a dense material, as represented by the cement 48, in a sufficient amount to maintain the common symmetrical axis of the assembled buoyant sections and element 26 in a vertical position when this portion of the assemblage is floating freely in the water. This arrangement assists in stabilizing the assembly under all operating conditions.

It will be understood that a particle on the surface of a body of water influenced by wave action will move in an orbital path with a vertical displacement approximately equal to the total surface wave height. Within the body of water, the orbital motion of the particle decreases with increasing depth until, at the ocean bottom, this motion becomes substantially zero. The element 26 may project downwardly from the lower buoyant member 38 a sufficient distance to place the lower end of it at a depth in the water where the transverse forces imposed on it by the orbital movement of the water particles at this depth will be negligible. For example, in an installation in 60 feet of water, the lower end of the element 26 may be located approximately 30 feet below the surface of the water. This distance will, of course, be influenced by the depth and water conditions at a particular location where the mooring buoy is to be installed.

The lower end of the element 26 is closed in a fluid-tight manner by a closure member 50, and to it is affixed a connector 52 to which the length of anchor chain 28 is connected. The anchor chain 28 extends downwardly through the water and is pivotally connected at its lower end through a connector 54 to the weighted mass 30, which in its normal position engages the submerged land surface 32.

The lengths of the element 26 and anchor chain 28 and the weight of the mass 30 are selected to hold the buoyant section 38 submerged below its free floating position for certain water conditions, and with the anchor chain 28 taut, for reasons to be explained hereinafter.

One of the links 56 of the anchor chain 28, preferably located in a position near the bottom of the chain, is formed with a laterally extending portion 58 to which is pivotally connected a second length 36 of anchor chain. The anchor chain 36 extends laterally of the first anchor chain 28 to a bottom anchor 34 to which it is pivotally connected, as through a linkage 60. This bottom anchor ultimately will supply the anchoring forces to hold a moored vessel in position and may be of any known form found useful for this purpose.

In accordance with the concept of this invention, during normal water conditions and within a predetermined range of variations of the elevation of the water surface above the submerged land through wave and tidal action, the buoyant portion 20 will be held at a fixed elevation above the underwater bottom and will be restrained from following or moving with the changing elevation of the water surface. To this end, the weight of the mass 30 is selected to hold the lower buoyant section 38 substantially completely submerged in the water for a predetermined elevation of the water surface below the mean tide level and of course for elevations of the water surface which exceed this minimum. At this predetermined elevation, the upper buoyant section 40, which is vertically spaced apart from the lower buoyant section, is held above the surface of the water at a distance which will permit the elevation of the water surface to increase a prede-

termined amount before contacting this upper buoyant section.

Between these upper and lower limits of water movement, the openwork nature of the structure connecting the lower and the upper buoyancy sections permits waves to wash through the region between the buoyant sections without imposing substantial additional transverse force on the assembly and additional movement in the submerged anchor chains to which the buoys are connected. Of more importance, the reduced cross-sectional area and reduced buoyancy of the portion of the structure between the buoyant sections permits the water to rise in the region between them without increasing substantially the buoyant force created by the buoy portion on the submerged parts of the assemblage, and hence does not induce in these parts changing stresses and movement which might otherwise occur.

When the water level reaches the upper buoyant section 40 and rises along it, the additional buoyant force transmitted to the submerged portions of the assemblage will lift the mass 30 off bottom. When this occurs, and so long as the water level remains above the predetermined maximum limit, the buoy portion and the interconnected parts will rise and fall with increased and decreased elevations of the water surface.

In the embodiment of the invention illustrated in FIG. 1, the parts of the assemblage are proportioned to hold the buoyant sections stationary in elevation between the limits of mean lower low water and mean higher high water. Within these limits, since the buoyant portion will not change elevation as the surface of the water changes, the amount of movement in the length of the anchor chain 28 and in the interconnected anchor chain 36 will be reduced considerably below that which occurs in the mooring buoy installations now commonly in use. The amount of wear on the anchor chain in the dip section of it adjacent the submerged land surface, where it is more exposed to abrasive particles entrained in the water, is proportional to the amount of movement and rubbing action occurring between the links of the chain. Thus, by reducing the movement of the chain in this region, the wear of the chain is proportionately reduced and its useful life is extended.

The elements of the assemblage of the present invention are proportioned to hold the buoyant portion stationary in elevation under water conditions which occur during the greater portion of the year. However, when the elevation of the water surface exceeds the maximum elevation for which this function of the mooring buoy assembly is designed, for example, when the elevation of the water surface exceeds the level of mean higher high water, the mass 30 lifts off bottom and the buoyant portion 20 floats with substantially all of the top buoyant section 40 exposed above the surface of the water. Thus, under all water conditions the resistant force of buoyant section 40 is available to provide the restoring force desired in an anchor system of this type.

It would be possible, of course, to proportion the parts of the assembly in a manner to cause the buoy portion to remain stationary throughout a longer period of time than that described heretofore. This, however, would require that the size and masses of the pertinent elements would be increased proportionately and would result in an assemblage which would be more cumbersome in structure and to which it would be more difficult to anchor a vessel in an efficient manner. This practical consideration, however, does not limit the effective operability of this invention to ranges of water level between mean lower low water and mean higher high water, and it is apparent that the mooring buoy of this invention will function effectively when constructed to operate in other ranges of water level than those mentioned.

A vessel is moored to this assemblage by securing a mooring line from the vessel to the hook 62 pivotally

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mounted on the top portion of the upper buoyant section 40. Normally this pivoted hook rests against a bumper element 64 which is secured to the outer wall of the buoyant section 40 and protects the shell of the buoy from damage by the hook. The tension of the mooring line lifts the hook from the bumper and is transmitted through the hook and the element 26 to the length of anchor chain 28, and thus, under conditions to be explained hereinafter, through the connecting link 58 to the length of anchor chain 36, and finally to the bottom anchor 34. As the force imposed by the vessel on the anchoring system increases, the buoyant portion and the interconnected element 26 are canted from the vertical to bring the parts more nearly into alignment between the vessel and the bottom-engaging mass 30 as the buoy sections are being pulled downwardly into the water. As the force from the vessel increases, the resultant of the forces in the members connecting the vessel with the bottom anchor 34 causes the mass 30 to be lifted off bottom and suspended in the water. The weight of the mass 30 continues to exert a force attempting to restore the buoy assembly to its vertical position. This force, coupled with the buoyant force of the buoy section, acts as a damper for sudden increases in the tension of the mooring line connecting the assemblage to the vessel and tends to smooth out such sudden increases of tension and hold them within more acceptable working limits.

The mass 30 preferably is made with a large transverse area, such as occurs in a flat disc, and will react with the water to resist sudden surges or sudden movements of the mooring system while this mass is lifted off bottom. This damping action of the disc-shaped mass will be effective to smooth out and reduce the amplitude of the movement of the float portion, and hence the movement of the anchor chains to which it is attached, both in the situation where high water has caused the float portion to rise sufficiently to lift the mass 30 off bottom, and in the situation where there are surges in the tension of the mooring line from the vessel. The damping action of the system tends to smooth out the resultant variations in the force applied to the bottom anchor 34, and the holding power of the bottom anchor is thus effectively increased.

It is apparent from the foregoing description that the assemblage of this invention provides a means for reducing to a marked degree the period of time when there is an appreciable relative movement between adjacent links of the anchor chains, particularly in the dip section where the largest amount of wear normally occurs. Since the wear in the anchor chain in this section is related to the amount of movement occurring there between the links of the chain, this invention provides a means for reducing the wear in these links and thus increases the normal operating life of the mooring buoy. The described structure of the buoyant portion 20 provides a substantially constant restoring force under water conditions which are experienced during most of the year and assists in mooring the vessel and keeping it within the prescribed area of the offshore terminal.

It is apparent that modifications may be made to the exemplary embodiment of the apparatus described herein without departing from the inventive concept. Therefore, it is intended that the invention embrace all equivalents within the scope of the appended claims.

We claim:

1. A mooring buoy assembly comprising a float portion including a first float means and a second float means, said second float means affixed to and above said first float means in vertical spaced relationship thereto, a rigid element affixed to said float portion and projecting downwardly therefrom in coaxial relationship to a common axis of symmetry of said first and said second float means, a weighted mass, a length of anchor chain connected at one end to the lower end of said rigid element and at the other end to said weighted mass, the weight

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of said mass and the length of said rigid element and said anchor chain being proportioned to hold said length of anchor chain in tension with said first float means substantially submerged within a body of water and with said mass in contact with the land surface submerged under said body of water when the elevation of the surface of said body of water is greater than a predetermined minimum elevation above the submerged land surface, the weight of said mass being proportioned to cause said mass to be lifted from contact with said submerged land surface when the elevation of said surface of said body of water increases above said submerged land surface to engage said second float means a predetermined amount, a second length of anchor chain, a laterally displaceable bottom anchor means connected by said second length of anchor chain to said first length of anchor chain, and means mounted on said float portion for connecting a mooring line from a vessel thereto.

2. A mooring body assembly comprising a first float means, a second float means affixed to and above said first float means in vertically spaced relationship thereto, a rigid element affixed adjacent one end portion of said first float means and projecting downwardly therefrom in coaxial relationship to a common axis of symmetry of said first and said second float means, a weighted mass, a length of chain connected at one end to the lower end portion of said rigid element and at the other end to said weighted mass, the weight of said mass and the lengths of said rigid element and said length of chain being proportioned to hold said length of chain in tension with said first float means substantially submerged below the surface of a body of water with said mass in contact with the submerged land surface when the elevation of the surface of said body of water is greater than a predetermined minimum elevation above said submerged land surface, the weight of said mass being proportioned to cause said mass to be lifted from contact with said submerged land surface when said surface of said body of water engages said second float means, a second length of chain, a laterally displaceable bottom anchor means connected by said second length of chain to the first said length of chain, and means mounted on said second float means for connecting a mooring line from a vessel thereto.

3. A mooring buoy assembly comprising a first float means, a second float means affixed to said first float means in vertically spaced relationship by laterally spaced-apart connecting members, a length of pipe rigidly affixed at its upper end portion to said first float means and projecting downwardly therefrom in coaxial relationship to a common axis of symmetry of said first and said second float means, a weighted mass, a length of anchor chain pivotally connected at one end to the lower end of said length of pipe and at the other end to said weighted mass, the weight of said mass and the lengths of said pipe and said anchor chain being selected to hold said anchor chain in tension with said first float means substantially submerged below the surface of a body of water with said mass in contact with the land surface submerged under said body of water when the elevation of said surface of said water is greater than a predetermined minimum elevation above said land surface and to cause said mass to be lifted from contact with said land surface when said water surface increases in elevation above said land surface to engage said second float means a predetermined amount, a second length of another chain, a laterally displaceable anchor means connected by said second length of anchor chain to the lower end portion of the first said anchor chain, and hook means pivotally mounted on the top of said second float means for connecting a mooring line from a vessel thereto.

4. A mooring buoy assembly comprising a first float means, a second float means affixed to and above said first float means in vertically spaced relationship by laterally spaced-apart connecting members, a length of pipe rigidly affixed at its upper end portion to said first

and said second float means and projecting downwardly from said first float means in coaxial relationship with a common axis of symmetry of said first and said second float means, a weighting material disposed within the lower end portion of said length of pipe in an amount 5 to maintain said axis of symmetry in a vertically disposed position when said float means are placed in a body of water, a weighted mass, a length of anchor chain connected at one end to the lower end of said length of pipe and at the other end to said weighted mass, the weight of 10 said mass and the lengths of said pipe and said anchor chain being selected to hold said anchor chain in tension to maintain said first float means substantially submerged below the surface of said body of water with said mass in contact with the submerged land surface when the 15 elevation of said surface of said water is greater than a predetermined minimum elevation above said submerged land surface and to cause said mass to be lifted from contact with said submerged land surface when said water surface increases in elevation above said submerged land 20

surface to engage said second float means a predetermined amount, a second length of anchor chain, a laterally displaceable anchor means connected by said second length of anchor chain to the lower end portion of the first said length of anchor chain, and hook means pivotally mounted on the top of said second float means for connecting a mooring line from a vessel thereto.

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