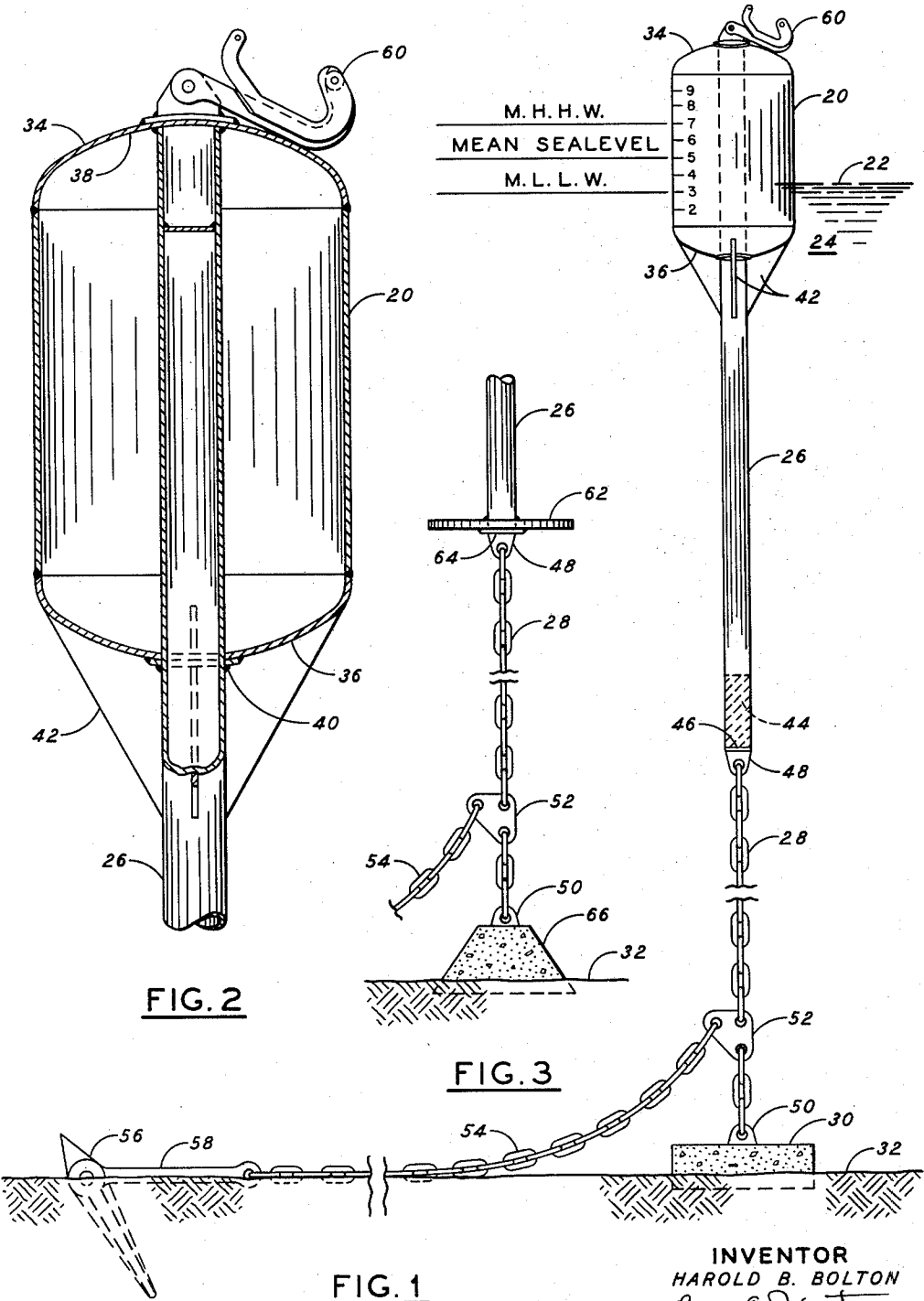


Sept. 10, 1963

H. B. BOLTON
MOORING BUOY ASSEMBLY
Filed Sept. 13, 1960

3,103,020



INVENTOR
HAROLD B. BOLTON
BY Frank E. Johnston
Charles J. Gibbons
ATTORNEYS

1

3,103,020

MOORING BUOY ASSEMBLY

Harold B. Bolton, San Rafael, Calif., assignor to California Research Corporation, San Francisco, Calif., a corporation of Delaware

Filed Sept. 13, 1960, Ser. No. 55,652

7 Claims. (Cl. 9—8)

This invention relates to mooring buoys, and more particularly to a mooring buoy assembly which has improved performance characteristics and which functions at an offshore location for an extended period of time without frequent maintenance.

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 its mooring lines to the float member. The restraining anchoring force is transmitted from the bottom anchor, through the interconnected anchor chain to the float member, and thence through the attached mooring lines 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 vessel increases, tending to restore the vessel to its initial position, and assisting the bottom anchor in restraining the vessel.

In situations where it is desired to restrict the transverse and longitudinal 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 changes continuously. This movement is transmitted to the anchor chain which secures it to the bottom anchor. The constant abrasive 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 of the chain adjacent the ocean floor, where the chain curves from the vertical to a horizontal direction. 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 require less frequent maintenance while assuring that the

2

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 existing 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;

FIG. 2 illustrates in side elevation and partly in section details of the construction of the buoyant member of this assemblage;

FIG. 3 illustrates in side elevation a portion of a mooring buoy assemblage embodying a modification of this invention.

The illustration of FIG. 1 represents the mooring buoy installed in a body of water in an operating position. A buoyant member 20 is located at the surface 22 of the body of water 24 and is connected through a rigidly extending element 26 affixed to it and an anchor chain 28 to a mass 30 which is seated on the submerged land surface 32. The buoyant member preferably is of cylindrical form with domed ends 34 and 36 and in its operating position is set with its longitudinal axis disposed in a vertical position in smooth water. The rigid element 26 preferably, although not necessarily, is a length of thick-walled pipe placed longitudinally through the cylindrical buoyant member in coaxial relationship and is secured at its upper end to the interior wall 38 of the top domed end 34 of the buoyant member. The element 26 passes through the lower domed end 36 of the buoyant member, to which it is rigidly connected in a fluid-tight manner, as by the weld 40, and projects downwardly from the buoyant member in coaxial relationship therewith. Strengthening webs, such as are represented by the web 42, are secured between the buoyant member and the projecting element 26 to strengthen and rigidify the structure.

It will be understood that a particle on the surface of a body of water influenced by wave action will move in a trochoidal or semielliptical orbit 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. Preferably the element 26 projects downwardly from the buoyant member 20 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 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.

The lower end of the element 26 is weighted with a dense material, as represented by the cement 44, in a sufficient amount to maintain the axis of the assembled element 26 and the buoyant member 20 in a vertical position when this portion of the assemblage is floating freely in the water. The weighting in the element 26 assists in stabilizing the assembly under all operating conditions.

The lower end of the element 26 is closed in a fluid-tight manner by a closure member 46, and to it is affixed a connector member 48 to which the length of anchor chain 28 is pivotally connected. The anchor chain 28 extends downwardly through the water and is pivotally connected at its lower end through a connector 50 to

3

the weighted mass 30 which in its normal operating position engages the submerged land surface 32.

One of the links 52 of the anchor chain, preferably located in a position near the bottom of the chain, is of triangular form, and to it is pivotally connected a second length 54 of anchor chain which extends laterally from a position vertically below the buoyant member to a bottom anchor 56 to which it is pivotally connected, as through a linkage 58. This bottom anchor ultimately will supply the anchoring force to hold a moored vessel in position, and may be of any form found useful for this purpose.

It is within the concept of this invention that during normal water conditions and within a predetermined range of variations of the elevation of the water surface through tidal action, the buoyant member 20 will be held at a fixed elevation above the underwater bottom and will be restrained from following or moving vertically with the changing elevation of the water surface. To this end, the weight of the mass 30 is selected to hold the lower portion of the buoyant member submerged in the water an amount greater than would occur with the buoyant member detached from this mass, this condition being established for a predetermined elevation of the water surface below the mean sea level. The weight of the mass 30, however, is not sufficient to hold the buoyant member stationary in elevation when the elevation of the water surface exceeds a predetermined amount above the mean sea level.

It will be appreciated that, as the water level rises with relation to the buoyant member 20, the buoyant force exerted by the latter on the bottom mass increases. The parts are proportioned to cause the buoyant force of the member 20 to lift the mass 30 off bottom when the water level reaches the predetermined elevation above mean sea level. When this occurs, the buoyant member 20 will rise and fall with increased and decreased elevations of the water surface above the predetermined elevation.

As explained heretofore, the effectiveness of a mooring buoy system is due in part to the restoring force of the buoyant member as it tends to be pulled downwardly into the water through the action of a mooring line from a vessel connected to it working against the restraining force of the bottom anchor. The restoring force of the buoy is related to the volume of the latter extending above the surface of the water when the assemblage is in its operating position. Hence, if the buoy of the present invention were restrained by a bottom mass of sufficient weight to permit the buoy to become completely submerged, the restoring force it would generate on a ship's anchor line would, under this condition, become negligible. If, on the other hand, the buoyant member should be made of such dimensions as to extend above the surface of the water under all conditions of surface elevation and with sufficient buoyant capacity in its top portion to produce an appreciable restoring force to a vessel's mooring line, the physical structure of the buoyant member would become cumbersome and impractical for anchoring a vessel to it in an efficient manner.

To prevent these latter difficulties, the elements of the assemblage of the present invention are proportioned to hold the buoyant member stationary in elevation under water conditions which occur during the greater portion of the yearly cycles of changing water conditions, but permit the mass 30 to lift off bottom and the buoyant member 20 to float with an appreciable portion of it exposed above the water surface to provide the desired restoring force in the mooring system when the elevation of the water surface exceeds the predetermined upper limit.

In the embodiment of the invention illustrated in FIG. 1, the parts of the assemblage are proportioned to hold the buoyant member stationary in elevation between the

4

limits of mean lower low water and mean higher high water. Within these limits, since the buoyant member will not change elevation as the surface of the water changes, the amount and frequency of movement in the length of anchor chain 28 will be reduced considerably below that which occurs in the mooring buoy installations now commonly in use. The amount of wear of the anchor chain in the dip section 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.

A vessel is moored to this assemblage by securing a mooring line from the vessel to the hook 60 which is pivotally mounted on the top end portion of the buoyant member 20. The tension of the mooring line is transmitted through the element 26 to the length of anchor chain 28, thence under conditions to be explained hereinafter, through the connecting link 52 to the second length of anchor chain 54, and finally to the bottom anchor 56. As the force imposed by the vessel on the mooring system increases, the buoyant member 20 and the element 26 are canted from the vertical to bring the parts more nearly into alignment between the vessel and the bottom-engaging mass 30 while the buoyant member is 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 56 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 buoyant member to its vertical position. This force, coupled with the buoyant force of the member 20, acts as a damper for sudden increases in the tension of the anchor line connecting the buoyant member to the vessel and tends to smooth out such sudden increases of tension and hold the tension in the anchor line 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 surges or sudden movements of the mooring system while the mass 30 is lifted off bottom. This damping action of the disc-shaped mass will be effective to smooth out and reduce the amplitude of the movements of the float member, and hence the movements of the anchor chains to which it is attached, both in the situation where high water has caused the float member 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 connecting the float member with a vessel.

FIG. 3 illustrates a modification of a portion of the mooring buoy assembly of this invention, with the same numerals being used to indicate comparable elements to those previously described. In this embodiment, the hydrodynamic damping of the float member is achieved by securing a disc 62 to the element 26. Preferably this disc is secured to the lower end of element 26 and is made with sufficient weight to replace the weight of the cement 44 indicated in the previously described embodiment.

The disc 62 may conveniently be formed with a central opening through which the element 26 is inserted. A flange 64, which also functions as a water-tight closure member for the lower end of element 26 and as a means for securing the connector member 48 to it, serves to support and position the disc 62 on the element 26. The disc may be secured both to the flange and to the element 26 to hold it rigidly in place.

The weighted mass 66 used in this embodiment of the invention may be of any convenient form and need not have an expanded area to act as a hydrodynamic damper, since this function is assumed by the disc 62. However, in some installations it will be desirable to employ both the disc 62 and a disc-shaped mass 30 in the

same mooring buoy assembly to provide an increased damping effect over what either of these elements alone would provide.

These above-described functions of the mooring assemblage not only tend to smooth out sudden variations in the tensions impressed on the interconnected parts, but, as a corollary, tend to smooth out the resultant variations in the force applied to the bottom anchor 56 and increase its effective holding power.

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 in the dip region where the largest amount of wear occurs in the anchor chains of mooring buoys heretofore employed at marine terminals. Since the wear in the anchor chain in the dip region 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 anchor chains and thus increasing their normal operating life.

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.

I claim:

1. A mooring buoy assembly comprising a substantially cylindrical buoyant member, an elongated rigid element secured at one end to said buoyant member and extending therefrom in coaxial relationship with the longitudinal axis thereof, a weight at the other end of said rigid element to maintain said longitudinal axis of said buoyant member disposed vertically when the mooring buoy assembly is installed in a body of water, a length of anchor chain connected to the said other end of said rigid element, a mass connected to said length of anchor chain, said mass being of sufficient weight to engage the land submerged under said body of water while holding said anchor chain in tension between said mass and said rigid element to submerge the lower portion of said buoyant member in said body of water a predetermined maximum amount greater than the amount of submergence of said buoyant member when said mass is not connected to the mooring buoy assembly, the weight of said mass being selected to prevent said buoyant member from moving vertically upwardly when acted on by upward changes in the elevation of the surface of said water when said changes are below a predetermined maximum elevation above the submerged land and to cause said buoyant member to lift said mass out of contact with said submerged land when the amount of submergence of said buoyant member exceeds said predetermined maximum amount, said predetermined maximum amount occurring when the surface of said water is substantially at the elevation of mean higher high water, a second length of anchor chain connected to the first said length of anchor chain, an anchor means connected to said second length of anchor chain and disposable laterally from a position vertically below said buoyant member, and hook means pivotally mounted on the upper end of said buoyant member for attaching a mooring line from a vessel thereto.

2. A mooring buoy assembly in accordance with claim 1 wherein said mass is formed with a sufficiently large transverse area to function effectively as a hydrodynamic damper to resist surging movement of said buoyant member when said mass is lifted off bottom by the buoyant force of said buoyant member.

3. A mooring buoy assembly in accordance with claim 1 wherein said elongated rigid element is weighted at said other end thereof by a weight affixed to and projecting radially outwardly of said element and operative as a hydrodynamic damper to resist surging movement of said buoyant member.

4. A mooring buoy installation comprising a float member located at the surface of a body of water, a weight which engages the submerged land surface, a flexible connecting means connecting said float member to said weight, the amount of said weight and the length of said connecting means being selected to hold said connecting means in tension between said weight and said float member to restrain the bottom portion of said float member submerged in said body of water below the free-floating position of said float member to hold said float member substantially stationary in elevation with respect to said submerged land surface when said float member is affected by changes in the elevation of said surface of said water within the limits of approximately the elevations of mean lower low water and mean higher high water, and wherein the said amount of said weight is selected to cause said float member to lift said weight off of said submerged land surface when the elevation of said surface of said water changes to exceed approximately the elevation of mean higher high water above said submerged land surface, a bottom-engaging anchor means disposed laterally from the position of said weight means on said submerged land surface, a second flexible connecting means connecting said anchor means to the lower end portion of the first said flexible connecting means, and means to connect a mooring line from a vessel to said float member.

5. A mooring buoy assembly comprising a float member, a rigid element affixed at one end to said float member and extending outwardly therefrom, a weight, a flexible first anchor line means secured to and between the other end of said rigid element and said weight, the amount of said weight and the length of said first anchor line means being selected to place said first anchor line in tension between said weight and said float member to maintain said float member at a substantially constant elevation above a submerged land surface with said weight in contact with said land surface when installed in a body of water while the surface of said water changes in elevation with respect to said submerged land surface between the limits of approximately the elevations of mean lower low water and mean higher high water, but with the amount of said weight being such that said weight is lifted by said float member and said first anchor line out of contact with said submerged land surface when said surface of said water exceeds in elevation said mean higher water, an anchor means laterally displaceable from said first anchor line means, a flexible second anchor line means connecting said anchor means to said first anchor line means, and means to connect a mooring line from a vessel to said float member.

6. A mooring buoy assembly comprising a float member, a hook means pivotally mounted on the upper portion of said float member for detachably connecting a mooring line from a vessel thereto, a length of pipe rigidly affixed at its upper end portion to said float member and projecting downwardly from said float member along an axis of symmetry thereof, a weighting material disposed within the lower end portion of said length of pipe, a first anchor chain connected at one end to the lower end of said length of pipe and extending downwardly therefrom, an underwater-bottom-engaging weight element connected to the other end of said first anchor chain, the amount of said weight element and the length of said first anchor chain being selected to hold said first anchor chain in tension between said weight element and said length of pipe and with said weight element having an effective weight sufficient to prevent said float member from rising and falling with changes in elevation of the surface of a body of water in which a mooring buoy assembly is installed when said changes in elevation occur within approximately the limits of mean lower low water and mean higher high water above the underwater bottom and to be lifted from contact with said underwater bottom when the elevation of said surface exceeds ap-

7

proximately that of mean higher high water above said underwater bottom, a second anchor chain connected at one end to said first anchor chain at a position adjacent said weight element, a laterally disposed bottom anchor, said second anchor chain connected at its other end to said laterally disposed bottom anchor, said weight element being proportioned in weight to be lifted from contact with said underwater bottom when a force exceeding a predetermined amount is applied to said hook means in a direction away from said float member while the mooring buoy assembly is installed in a body of water.

7. A mooring buoy assembly in accordance with claim 4 wherein said underwater-bottom-engaging weight ele-

8

ment is constructed with a relatively large transverse area which will react with said body of water to resist vertical movement of said weight element therethrough.

References Cited in the file of this patent

UNITED STATES PATENTS

1,958,535	Elliott -----	May 15, 1934
2,856,616	Dodge -----	Oct. 21, 1958
2,903,716	Zasada -----	Sept. 15, 1959

FOREIGN PATENTS

146,774	Great Britain -----	July 15, 1920
184,424	Great Britain -----	Aug. 17, 1922