United States Patent

Clement

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[54] **BIASED TAUT LINE MOORING SYSTEM**

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[22] Filed: **Sept. 4, 1970**

[21] Appl. No.: **69,954**

Related U.S. Application Data

[63] Continuation of Ser. No. 778,388, Nov. 25, 1968, abandoned.

[52] **U.S. Cl.** ..... **114/230,** 9/8 R

[51] **Int. Cl.** **B63b 21/00,** B63b 21/52

[58] **Field of Search** ..... 114/230; 9/8 R

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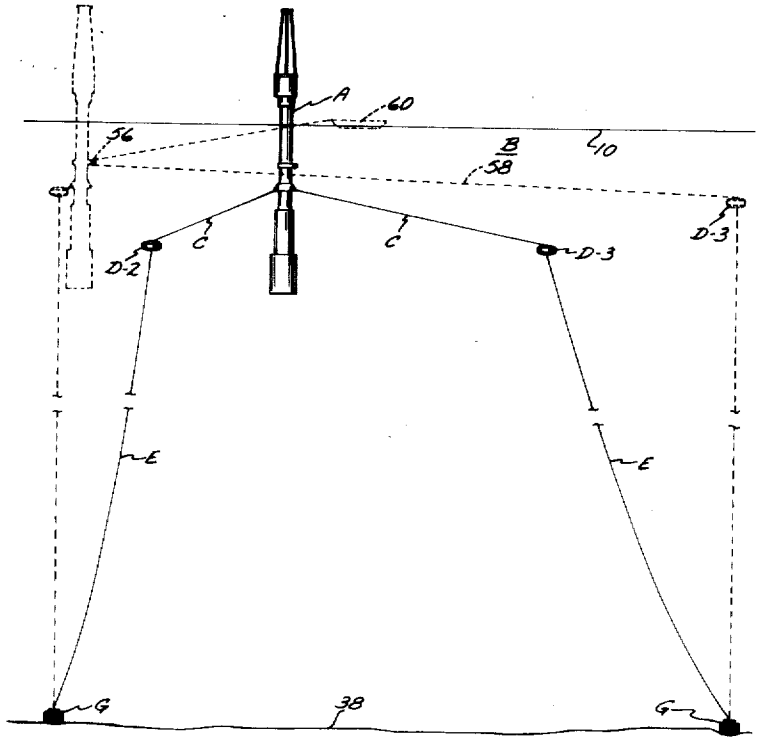
Attorney—Fulwider, Patton, Rieber, Lee & Utecht

[57] **ABSTRACT**

A buoyant surface object that tends to at all times occupy a fixed predetermined position due to the tensioning of at least two pennant lines that extend outwardly therefrom. Each pennant line is connected to a submerged float.

The floats are in turn connected to mooring lines that extend downwardly and outwardly therefrom. The lower ends of the mooring lines are secured to anchors. The floats due to their buoyancy tend to move to positions where their mooring lines would be vertically disposed. This tendency to so move is prevented by the pennant lines. The pennant lines as a result of tending to restrain the buoys from moving are tensioned and when no exterior force is exerted on the surface object maintain the surface object in the predetermined position. In the event that an external force moves the surface object from said predetermined position, the tension on at least one of the pennant lines is increased, and the tension on another of the pennant lines decreased, and an unbalanced force system prevails. As soon as the external force ceases to act on the surface object, the floats move to their initial positions to exert balanced forces on the pennant lines, and the surface object returning to said predetermined position.

8 Claims, 7 Drawing Figures



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SHEET 1 OF 2

FIG.1

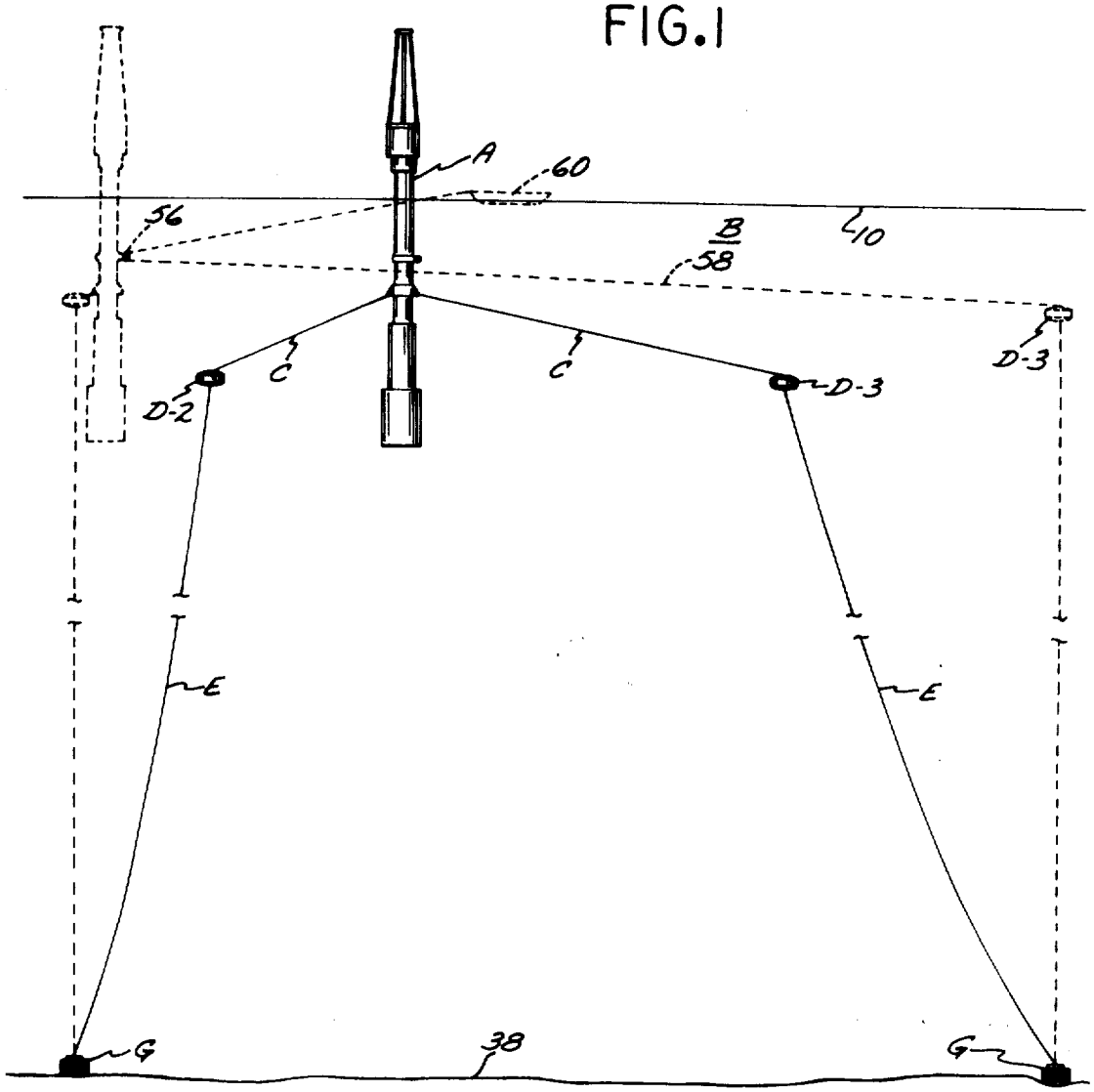


FIG.6

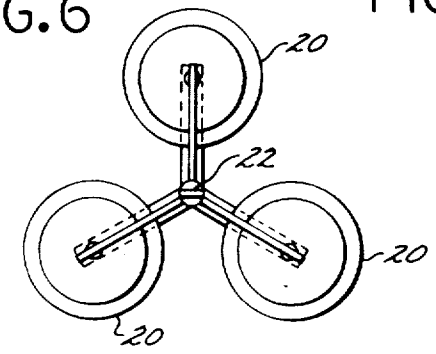
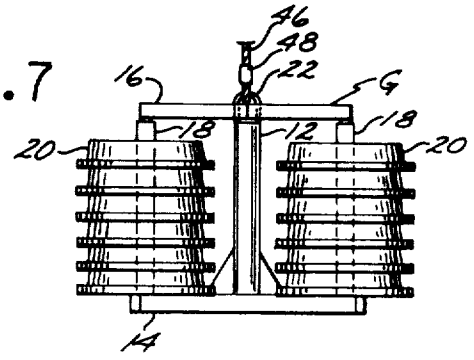


FIG.7



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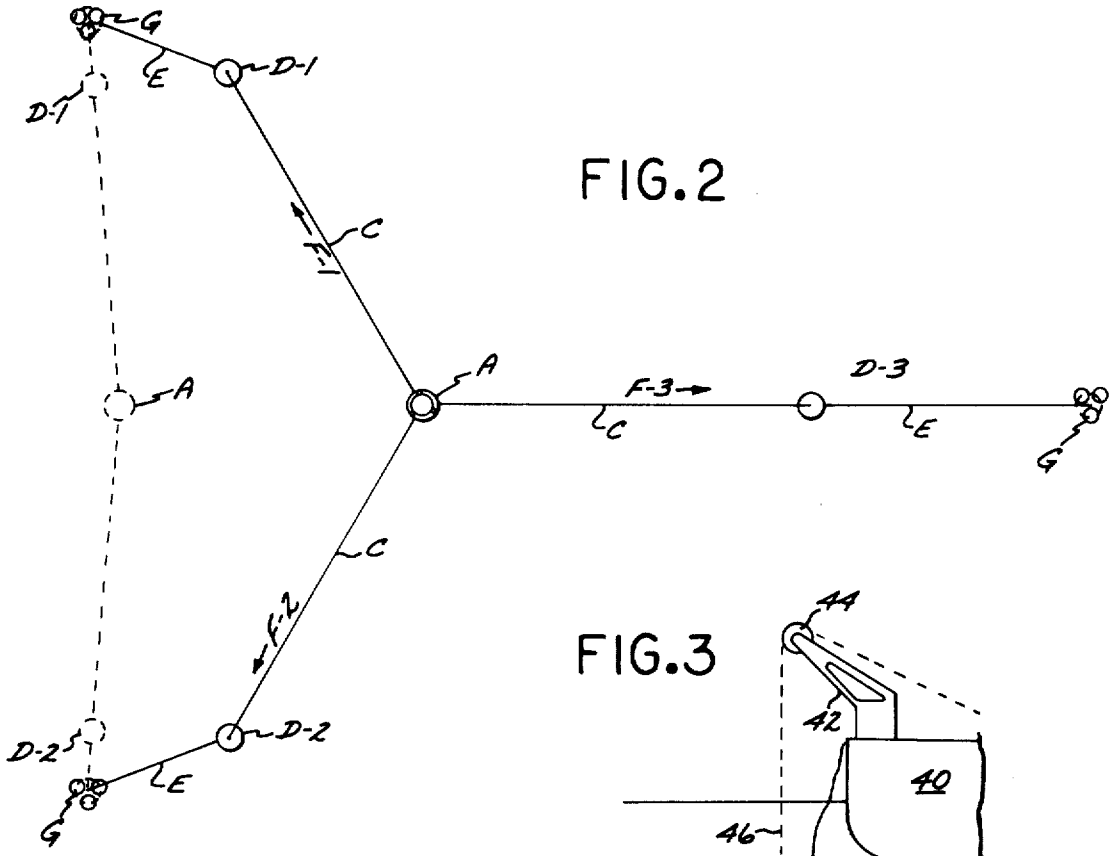


FIG. 2

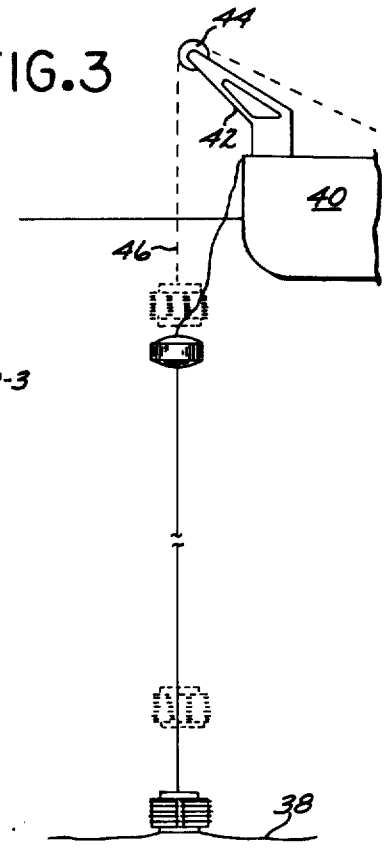


FIG. 3

FIG. 4

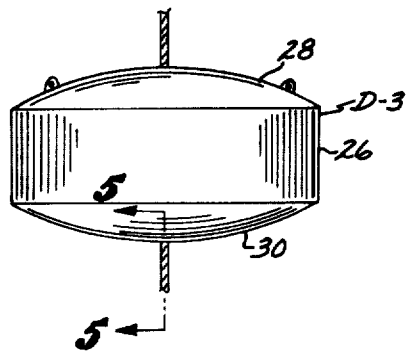
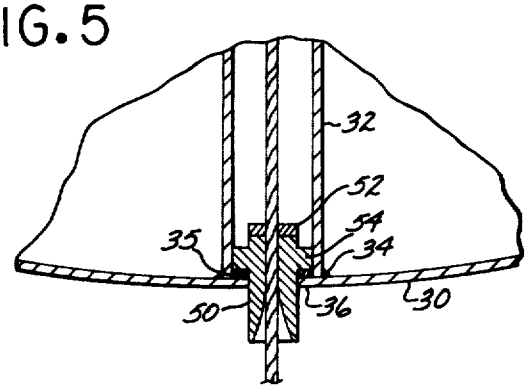


FIG. 5



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BIASED TAUT LINE MOORING SYSTEM

This application is a continuation of application Ser. No. 778,388 filed Nov. 25, 1968 and now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

A mooring system, and method of forming same, which system at all times tends to maintain an object at a predetermined position on or below the surface of a body of water, even when said object is subjected to forces of variable magnitude such as those generated by currents, wave action, wind, and the like.

2. Description of the Prior Art

In oceanographic work it is frequently desirable to maintain a buoyant surface object, such as an instrumentation buoy, research platform, or the like, at a predetermined position upon a body of water. An anchored, buoyant surface object is subjected to variable forces caused by the action of currents, waves, and the wind, that may act both individually and in concert to move the anchored object a substantial distance from its initial predetermined position.

In the past, no mooring system has been available for use with a buoyant surface object to automatically exert restraining forces on the object that increases in magnitude proportional to the displaced distance of the object from the initial position thereof, which forces at all times tend to return the object to its initial predetermined position. This failure to heretofore provide a buoyant surface object that will not deviate a substantial distance from a predetermined position when subjected to forces of variable magnitude has been detrimental to the effective carrying out of many oceanographic operations.

A major object of the present invention is to supply a biased taut line mooring system for a buoyant surface object of relatively simple mechanical structure that is easy to set, and automatically tends at all times to return a buoyant surface object to a predetermined position when it is subjected to drag-generating forces arising from winds, currents, and wave action, and to maintain the buoyant surface object in said predetermined location.

A further object of the invention is to provide movable submerged float means that are so anchored as to generate a plurality of outwardly directed forces which are at all times exerted on the buoyant surface object in such a manner as to tend to maintain said object in a predetermined position where said forces are in equilibrium and of substantially the same magnitude.

Another object of the invention is to supply a method of setting a buoyant surface object at a predetermined fixed location where it at all times tends to remain due to outwardly directed forces impressed on a plurality of pennant lines extending from said object and connected thereto.

SUMMARY OF THE INVENTION

A mooring system and method of forming the same for maintaining a surface buoyant object at a predetermined position on a body of water which includes a plurality of equally spaced pennant lines extending outwardly from said body to a plurality of floats, with said floats being so movably anchored as to at all times tend to move outwardly and away from said object, and with said floats generating a plurality of opposing forces on said cables that are in equilibrium, only when said object is in said predetermined position.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of a surface buoyant object and mooring system therefor, which mooring system tends at all times to maintain said object at a predetermined position on a body of water, and with the position of the system, prior to the setting operation, being illustrated in phantom line;

FIG. 2 is a top plan view of the surface buoyant object and mooring system associated therewith, with positioning of the mooring line, floats, and pennant lines prior to the setting operation being indicated in phantom line;

FIG. 3 is a diagrammatic view illustrating the steps involved in setting one of the anchors and the float associated therewith;

FIG. 4 is a side elevational view of one of the floats;

FIG. 5 is a fragmentary, vertical, cross-sectional view of one of the floats, taken on the lines 5—5 of FIG. 4;

FIG. 6 is a top plan view of one of the anchors that may be used with the mooring system; an

FIG. 7 is a side elevational view of the anchor shown in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The buoyant surface object A to be anchored at a predetermined position on the surface of a body of water B is illustrated in FIGS. 1 and 2 as being a spar buoy. Three pennant lines C extend outwardly and downwardly from the object A, which lines are in equally spaced relationship. In the illustration of the invention shown in FIGS. 1 and 2, three pennant lines are provided.

Three floats D-1, D-2 and D-3 are provided, which are connected to outwardly disposed ends of the pennant lines C. Mooring lines E depend from floats D-1, D-2 and D-3, which lines are connected to individual anchors G. The mooring lines E are of such length that the floats D-1, D-2 and D-3 are disposed a substantial distance below the surface 10 of the body of water B to minimize the effect of wave action thereupon.

The length of pennant lines C is such that the floats D-1, D-2 and D-3 are disposed inwardly towards the object A a substantial distance relative to the anchors G. Due to the buoyancy of each float D-1, D-2 and D-3, it tends at all times to move to a position where it is located directly above the anchor G associated therewith. The tendency of floats D-1, D-2 and D-3 to move to positions above the anchors G, causes tensioning of the pennant lines C by outwardly directed forces F-1, F-2 and F-3 thereon, as shown in FIG. 2.

The forces F-1, F-2 and F-3 are of substantially the same magnitude when the object A is in said predetermined position and in equilibrium.

Should currents, winds, or wave action tend to move object A towards one of the floats D-1, D-2 or D-3, the force F-1, F-2 or F-3 on that pennant line C of the float towards which the object moves, is decreased, and the forces on the other two pennant lines are increased. In such case, forces F-1, F-2 and F-3 are no longer in equilibrium whereby the mooring system is in an unstable condition, but with the forces F-1, F-2 and F-3

tending to return to a balanced condition in which they are in equilibrium. However, the forces F-1, F-2 and F-3 can only be in equilibrium when the object A is in the initial predetermined position. Thus, it will be seen that the object A will automatically return to its initial predetermined position due to the action of the floats D-1, D-2 and D-3, as soon as the current, wind or wave action which caused an excursion of the object A from its initial position, has abated.

FIGS. 6 and 7 illustrate the structure of one of the anchors G that is suitable for use with the present mooring system. Each anchor G includes an upwardly extending elongate center member 12 provided with three equally spaced first legs 14 extending radially from the bottom thereof, as well as three second legs 16 which extend from the top of the member.

First and second legs 14 and 16 are in vertical alignment, and uprights 18 extend therebetween. Each upright 18 projects through the center openings of a number of stacked railroad car wheels 20. The upper end of the member 12 is provided with an eye 22 to permit the anchor G to be lowered to a desired location on the bottom 24 of the body of water B by means of a cable.

The floats D-1, D-2 and D-3 are structurally identical and one of these floats is shown in detail in FIGS. 4 and 5. The exterior configuration of floats D-1, D-2 and D-3 is preferably that of a surface of revolution to minimize any tendency of the floats to pivot or rotate relative to the mooring lines E to which they are connected. The float D-3 (FIG. 4) includes a rigid cylindrical shell 26 having an opposed convex top 28 and convex bottom 30. A tube 32, as shown in FIG. 5, extends downwardly through the center interior of float D-3, and is in communication with an opening (not shown) in the top 28. The lower end of the tube 32 is secured to the interior surface of the bottom 30 by welding 34, or the like. The bottom 30 and lower portion of the tube 32 cooperatively define a cylindrical body shoulder 36. A ring-shaped bearing 35 is secured to the upper surface of shoulder 36.

As an illustration of the setting operation of the mooring system described herein, it will be assumed that the object A is to be set at a predetermined surface position in a body of water B which is 3,000 feet deep. The three anchors G are set on the bottom 38 600 to 900 feet outwardly from the predetermined location of the object A at the apexes of an imaginary equilateral triangle. The anchors G are, of course, equally spaced apart. The floats D-1, D-2, and D-3 are set at a depth of approximately 60 feet below the surface 10 of the body of water B, and then biased in toward the object A a horizontal distance of 300 to 400 feet from the anchor G associated therewith. This biasing of the floats D-1, D-2, and D-3 requires a tension of eight hundred to eleven hundred pounds on each pennant line C, depending on the positive displacement of the floats D. The biased floats D-1, D-2, and D-3 are at a depth of 80 to 100 feet below the surface 10.

The length of each pennant line C should not be less than 300 feet because the angle thereof becomes excessive. Also, the pennant lines C should not be too long, because of excessive drag imposed thereon by currents. A length of between 300 and 500 feet for each pennant line C is desirable.

The mooring system is preferably set when the body of water B is calm, the wind low, and a minimum current is running. Also, the predetermined location selected for the object A should be such that the slope of the bottom of the body of water 38 is no greater than 1 in 20 and the bottom should not be crossed with peaks and chasms where the anchors could be set too high or too low. The setting operation is conveniently carried out by use of a tugboat 40 (FIG. 3) from which a boom 42 projects outwardly and on the upper end of which a sheave 44 is mounted. The tugboat 40 is provided with a power-driven winch (not shown) from which a cable 46 extends to pass over the sheave 44 and downwardly therefrom.

A swivel or hook 48 is affixed to the free end of cable 46, as shown in FIG. 7, and is capable of engaging one of the eyes 22. The anchors G and the floats D-1, D-2 and D-3 are supported on the deck of the tugboat 40. The anchors G are raised sequentially from the deck by auxiliary equipment (not shown) and disposed in positions where they may be connected to the end of a length of cable 46 that extends downwardly over the sheave 44.

Each cable 46 also passes downwardly through one of the tubes 32 associated with one of the floats D-1, D-2, D-3, which float has been moved outwardly from the tugboat 40 to a floating position. A bottom detector (not shown) is supported about 60 feet below each anchor G, and the anchor is then lowered by use of a winch (not shown) on the tugboat 40 until the bottom detector indicates that the bottom 38 has been reached. Thereafter, the winch (not shown) is stopped. After cessation of downward movement of cable 46, a cable rotation member 50 and stop 52 are mounted on the cable.

A circular flange 54 projects from each cable rotation housing 50 and seats on one of the bearings 35 when one of the cables 46 is lowered relative to one of the floats D-1, D-2, or D-3. After one of the cables 46 has been lowered to the extent that the stop 52 thereon is in contact with the cable rotation housing 50 as shown in FIG. 5, the cable is lowered until the anchor G associated therewith rests on the bottom 38. The cable is then severed by an electric guillotine or other cutting means, with the set float D-1, D-2, or D-3 then being submerged approximately 60 feet below the surface 10 of the body of water B. The cable 46 above described and shown in phantom line in FIG. 3 provides the mooring line E illustrated in FIG. 1.

Prior to being set, a length of pennant lines C are connected to floats D-1 and D-2, with the free ends of the pennant lines being connected to small buoys (not shown). The object A is then placed in a floating position between the two floats D-1, D-2 and the positions of these floats and the object A are shown in phantom line in FIG. 2. Two half pennant lines C also extend from object A that are also connected to small buoys (not shown). The buoys (not shown) are removed from the half pennant lines C, and the free ends of these lines are then connected to provide the two lines (FIG. 2) that are connected to the floats D-1 and D-2. The position of the floats D-1 and D-2, and the object A as initially set are shown in phantom line in FIG. 1.

At the time the object A is placed in a floating position as illustrated in FIG. 1, a pulley block 56 is

removably secured thereto. The pulley block **56** is engaged by a cable **58**, one end of which is secured to the float D-3 shown in phantom line in FIG. **1**, and the other end to a power-driven vessel **60**. Object A and float D-3 both have pennant lines of half length connected thereto, with the free ends of these half lengths being connected to small buoys (not shown).

The vessel **60** is caused to move away from the floats D-1 and D-2, and in so doing, the object A is moved from the positions shown in phantom line in FIGS. **1** and **2** to the positions shown in solid line in these figures. The free ends of the half length pennant lines from object A to Float D-3 are then connected together to provide the pennant line C shown in FIG. **1**. The pulley block **56** may thereafter be removed from the object A and the setting of the mooring system for the object is completed. Due to the buoyancy of the floats DO1, D-2, and D-3 and the positioning of the anchors G associated therewith, these floats at all times tend to move away from the object A and exert forces F-1, F-2, and F-3 on the pennant lines, which forces are in equilibrium only so long as the object A is in the predetermined position shown in solid line in FIGS. **1** and **2**.

Although the mooring system above described is preferred, the object A can be moored in a desired position by the use of but two floats D-1 and D-2 and two anchors G that are in axial alignment with the object, as shown in phantom line in FIG. **2**. It will, of course, be apparent that a mooring system employing more than three floats and three anchors may be used if desired.

The invention has been illustrated as tending to maintain a buoyant object at a fixed position on a body of water. However, the invention may be used for a like purpose with a non-buoyant object, for the pennant lines will not only maintain the non-buoyant object in a fixed position but will support the non-buoyant object as well.

I claim:

1. A biased taut line mooring system tending to maintain a buoyant object at a predetermined position on the surface of a body of water subject to wind, current or wave action including:

a plurality of anchors disposed radially outwardly of said position and resting upon the bottom of said body of water;

a plurality of mooring lines extending generally upwardly from and radially inwardly of said anchors, said mooring lines terminating below the surface of said body of water;

a plurality of buoyant floats connected to the upper extremities of said mooring lines, all of said floats being submerged radially inwardly of said anchors below the effect of surface wave action and exerting biases tending to vertically orient said mooring lines; and

a plurality of pennant lines extending from said object to said floats and all rendered taut and maintained in tension by said biases of said floats, said tension in said pennant lines automatically varying according to movement of said object out of said predetermined position and tending to locate said object in said predetermined position when said tension in said pennant lines reaches a balanced condition.

2. A mooring system as defined in claim **1** wherein said anchors are substantially equally spaced from one another.

3. A mooring system as defined in claim **1** wherein said anchors are substantially equally spaced from one another and from said object.

4. A mooring system as defined in claim **1** wherein said floats are submerged sufficiently below said surface that they are generally unaffected by wave action on said body of water.

5. A mooring system as defined in claim **1** wherein said floats each includes:

a central tube extending therethrough;

bearing means mounted in one end of said tube;

a cable rotation housing disposed in said tube upon said bearing means, and one of said mooring lines extending through said housing; an

a stop in said tube in abutment with said housing, said stop being affixed to said mooring line, whereby said float is rotatable relative to said housing, said stop and said mooring line.

6. A mooring system as defined in claim **1** wherein said anchors and floats are each three in number and disposed at the apices of imaginary, concentric, equilateral triangles in which said predetermined position is centered.

7. A mooring system as defined in claim **1** wherein said anchors and floats are each two in number, with said anchors and floats being in alignment, and with said object being located at equal distances from said floats when in said predetermined position.

8. A method of mooring a buoyant surface object to float at a predetermined position on the surface of a body of water by the use of a plurality of anchors, floats, mooring lines, and pennant lines, which method includes the steps of:

setting said anchors on the bottom of said body of water in equally spaced relationship to said predetermined position and to one another;

connecting said floats to said anchors by said mooring lines to locate all of said floats in positions below said surface of said body of water and below the effect of surface wave action;

pulling said floats radially inwardly of said anchors and toward said object; and

connecting said pennant lines to said floats and to said object, whereby the buoyancy of said floats renders said pennant lines taut and under continuous tension and whereby any movement of said object away from said predetermined position develops a varying bias in each of said pennant lines automatically tending to locate said object in said predetermined position.

* * * * *