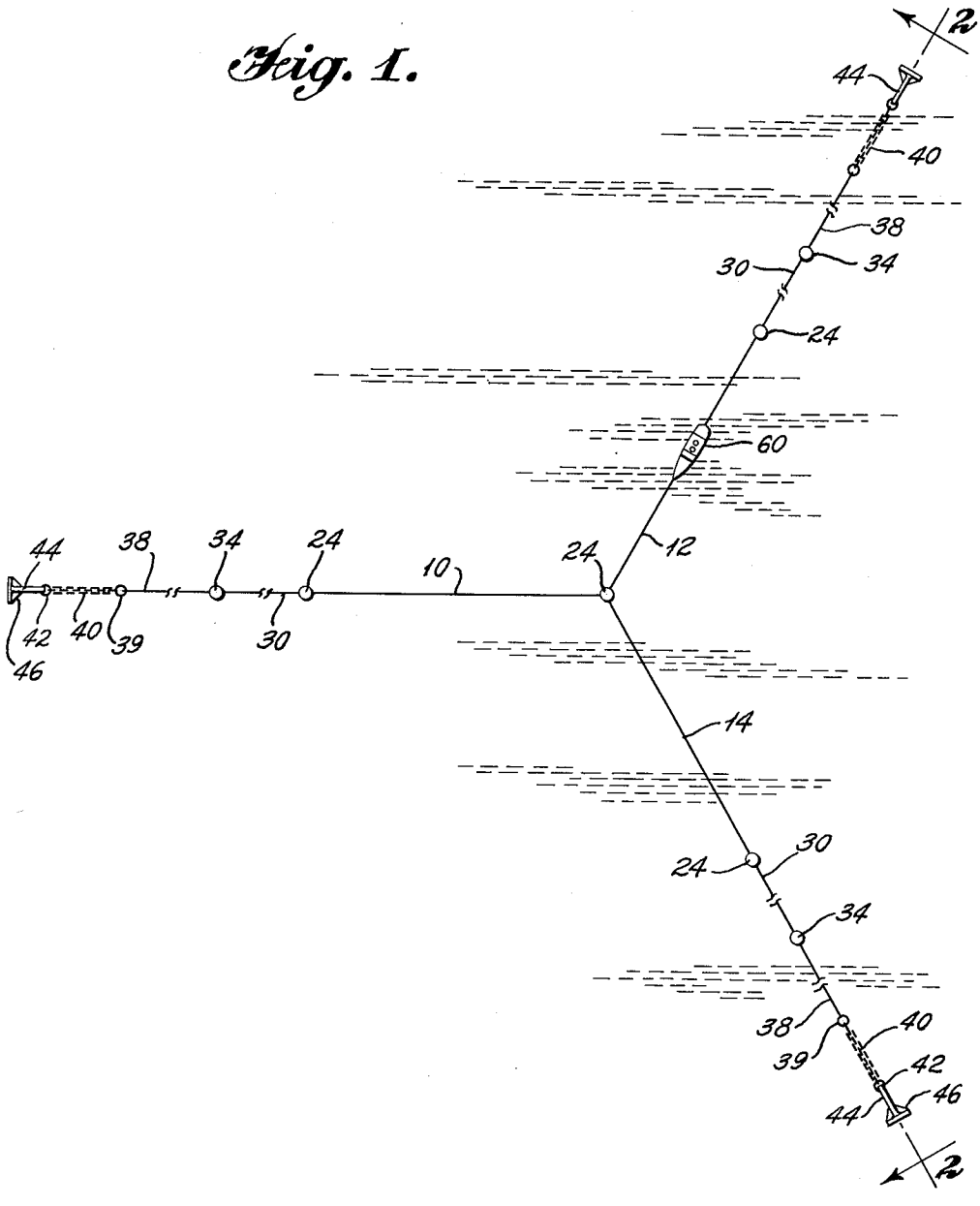
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MOORING DEVICE

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Fig. 1.



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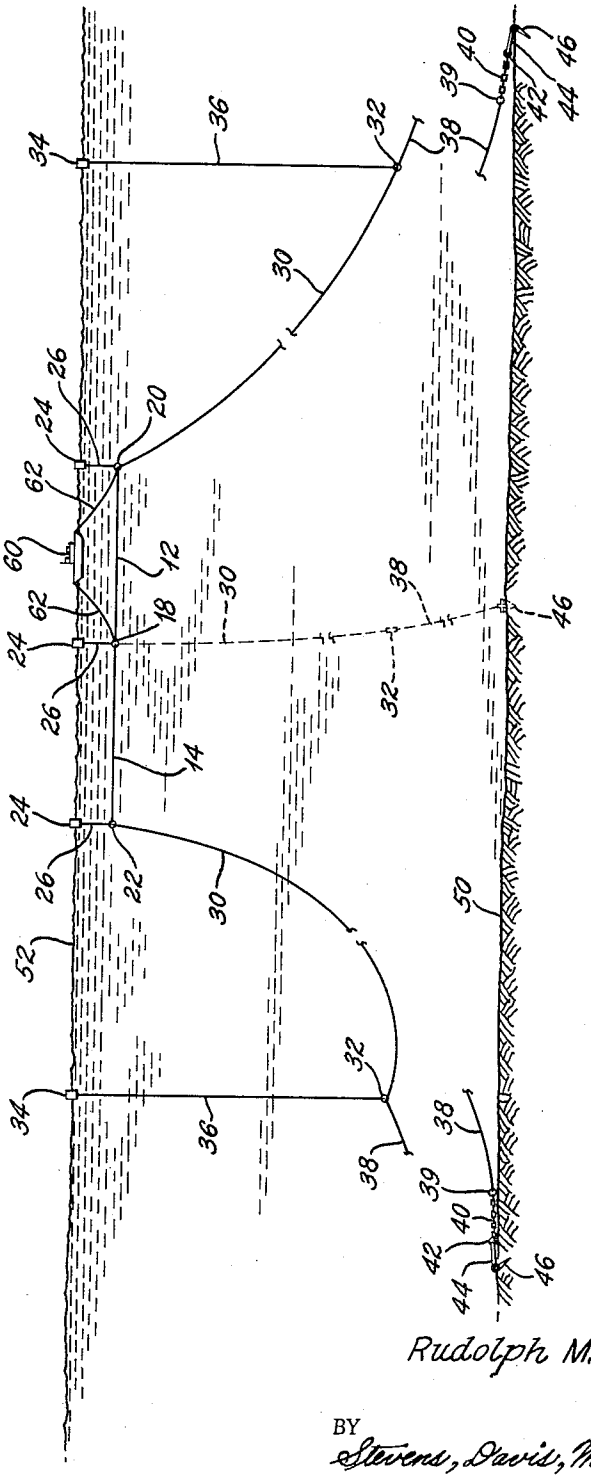
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Fig. 2.



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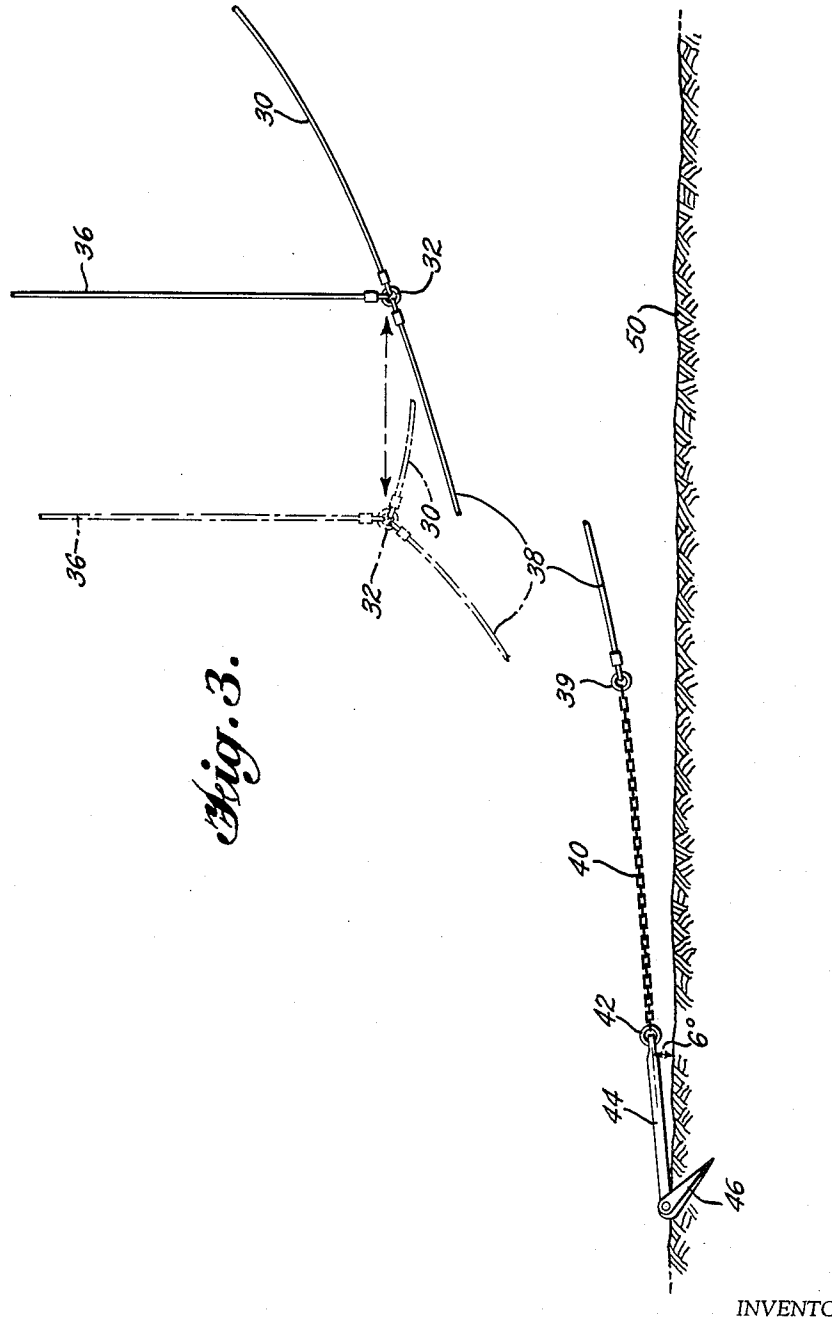


Fig. 3.

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MOORING DEVICE

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6 Claims. (Cl. 114—230)

The present invention relates to a mooring device, and, more particularly, to a device of this nature which is capable of being located in a part of the ocean characterized by a relatively great depth.

At the present time, there is activity to develop a deep sea mooring device having precision and stability in operation and which will be capable of a substantial life. It will be appreciated that devices of this nature, located in the ocean at depths greater than 2000 or 3000 feet, require large quantities of materials such as wire rope, chain clumps, and anchors and, therefore, are costly. Consequently, it is important that any such device be capable of good performance and a fairly long life in order to offset the high initial cost.

One difficulty that has been experienced in attempting to devise a satisfactory deep sea moor has been encountered in positioning the mooring device in the ocean. The component parts of the mooring device are of substantial weight in order to impart sufficient strength to the device and consequently, it is sometimes arranged that the component parts of the device are brought to the mooring site in a variety of ships. The component parts must then be put into the water and assembled and this is not easily accomplished due to the weight of the component parts and the difficulty of maneuvering the various ships involved in the laying of the moor.

It has already been proposed that a deep sea moor be provided utilizing a surface or near-surface structure anchored to the bottom by means of a series of anchor legs each comprised of flexible members, such as wire rope, extending from the surface or near-surface structure to the ocean floor with an anchor attached to the bottom end of the wire rope. This approach, although theoretically feasible, is not really satisfactory because of abrading of the flexible line due to contact with the ocean floor when the mooring device is subject to the motions normally encountered in its environment.

As an improvement to this basic approach, it has been proposed that the bottom portion of each leg be comprised of heavy shots of flexible chain or other chafing gear interposed between the bottom end of the wire rope and the anchor. In this design, the optimum conditions are that almost all of the chain or chafing gear rests on the ocean floor and the bottom end of the wire rope is just off the ocean floor at minimum stress conditions, and at maximum stress conditions, substantially all of the chain is lifted off the ocean bottom but the shank of the anchor is not elevated more than about 6 degrees. With this arrangement, some limited success has been achieved under circumstances where the demands on the moor were not too severe for the water depth. The greatest difficulty seems to be in properly designing the lengths of wire rope and chain to satisfy all optimum stress conditions which are mutually conflicting. Since the mooring device is located in the deep ocean, it would not be uncommon to use flexible line segments more than a mile in length. Since the flexible line segments are connected only at the top and bottom, they will assume a natural curve which tends to be tangent at the ocean floor when the horizontal pull on the anchors is low. Thus, the bottom portions of the flexible line segments are in reality very close to the ocean floor or portions of them actually are in contact with the ocean floor. Therefore, the difficulties experienced with simple mooring devices noted above are also experienced in this improved approach unless exorbitant amounts of heavy elements are used with

accompanying great expenditure of effort and risk in handling.

It is the principal object of the present invention to provide a mooring device that will avoid the difficulties experienced by mooring devices heretofore known in that the bottom portion of a flexible segment, such as wire rope, will be kept out of contact with the ocean floor and thereby the flexible segment will not be subject to abrasion in use and the life of the mooring device will be greatly increased.

It is a further object of the present invention to provide an improved mooring device wherein each moor leg is comprised of a branched flexible line interconnecting a surface or near-surface structure with chafing gear and an anchor positioned on the ocean floor.

Other and further objects of the invention will become readily apparent from the following detailed description of a preferred embodiment of the present invention when taken in conjunction with the drawings in which:

FIGURE 1 is a representative view in top plan of the mooring device of the present invention;

FIGURE 2 is a representative view in side elevation showing the mooring device of the present invention with one leg in its minimum stress condition and another leg in its maximum stress condition; and

FIGURE 3 is an enlarged view of the lower end of the moor leg subjected to maximum stress.

Referring now to the drawings, a preferred embodiment of the present invention will be described. As evident from the figures, the mooring device is comprised of a surface or near-surface structure consisting of a triangular wire rope structure supported in the water by buoys. The triangular structure may, for example, consist of three wire rope arms **10**, **12** and **14** which are all connected together at one end to a ring **16**. The outer or free ends of arms **10**, **12** and **14** have attached to them rings **18** (not shown), **20** and **22**, respectively.

The triangular structure, as described, is positioned in the ocean below the surface, for example, about 200 feet down, and is supported by a series of three or four buoys or floats **24** and vertical wire ropes **26** attached to the rings **18**, **20** and **22**. The central buoy may be omitted or reduced in capacity. The vertical wire ropes **26** are attached to the buoys **24** by any suitable means and since this attachment is well known in the art, no attempt has been made to show it in detail. Whereas there are four buoys **24**, only three show in FIGURE 2, one being hidden from view.

The structure described thus far constitutes the surface or near-surface structure of the mooring device and this structure is anchored to the ocean floor by means of moor legs extending from each ring **18**, **20** and **22**. All three moor legs are identical in construction and thus, only one will be described in detail. The moor leg attached to the ring **22** consists of a length of wire rope **30** (broken to show the great length) that extends to a point spaced above the ocean floor. A ring **32** is attached to the bottom end of the wire rope **30** and is supported at this location by means of a float or buoy **34** at the surface of the ocean and a wire rope **36** attached at one end to the float or buoy **34** and at its other end to the ring **32**. A second length of wire rope **38** (broken to show the great length) is also attached at one end to the ring **32** with its other end attached by ring **39** to one end of a heavy chain **40**. The other end of the heavy chain **40** is attached to a ring **42** integral with one end of the shank **44** of a suitable anchor. The anchor may be provided with one or more flukes **46** adapted to embed into the ocean floor. In the description just given, the ocean floor is generally designated by the reference numeral **50** and the ocean surface is generally designated by the reference numeral **52**.

A ship 60 is shown moored by lines 62 to the device of the present invention to illustrate the general technique for tying to the mooring device. As shown in the drawings, the moor leg attached to ring 22 is shown in its minimum stress condition and the moor leg attached to ring 20 is shown in its maximum stress condition.

In order to afford a better understanding of the present invention, the following is a specific example of a mooring device according to the present invention arranged in a portion of the ocean that extends to a depth of 3000 feet. The minimum stress condition is taken at 10,000 pounds and is considered to be a force applied horizontally to the mooring device. The maximum stress condition is taken at 50,000 pounds and also is considered to be a force applied horizontally to the mooring device. The wire ropes 10, 12 and 14 are of one inch in diameter and approximately 1000 feet in length. The wire ropes 26 are of one inch in diameter and approximately 200 feet in length. The buoys 24 are all of standard construction having a reserve buoyance of 50,000 pounds. The branches 30 are each wire rope which weigh 1.39 pounds per foot in water and 12,500 feet in length. The branches 38 are each wire rope which weighs 1.39 pounds per foot in water and 3000 feet in length. The chains 40 are each 450 feet in length and weigh 7500 pounds. The ring 32 is located at a depth of approximately 2200 feet and the buoy 34 is of conventional construction and has a reserve buoyancy equal to 50,000 pounds. The anchor 40 weighs approximately 4000 pounds.

For these particular specifications the various requirements are all satisfied, the anchor holding power is retained at high stress and the wire rope is lifted off the bottom at low stress. The surface floats are sufficient to support branches 38 at low stress and are not taxed at high stress. The moor legs can be installed in part and finished at a later time.

It will be evident from the foregoing description that the moor leg is deviced as a branched device comprised of branches 30 and 36 both attached to branch 38. In the minimum stress condition, as shown in FIGURE 2 for the moor leg attached to ring 22 and in dotted lines in FIGURE 3, the branch 38 is so arranged that all of the branch is lifted off the ocean floor 50, the chain 40 lies for its entire length on the ocean floor 50 and the anchor is in its reposed position. In the maximum stress condition, as illustrated in FIGURE 2 for the moor leg attached to ring 20, and in FIGURE 3, the ring 32 has been shifted horizontally and the two branches 30 and 38 have been stressed to positions substantially in alinement. At this time, the chain 40 is entirely lifted off the ocean floor 50 and the shank 44 of the anchor has been slightly elevated, not more than about 6 degrees.

If branch 36 had not been present, the combined length of 30 plus 38 would have been so great that at low stress a substantial amount would have touched the bottom. If branch 36 were made too short, it would have lowered the effectiveness of the combined length at high stress conditions.

It will be appreciated from the foregoing description that the moor leg, although shown and described as comprised of two branches, may be further modified and be comprised of three, four, five or more branches. The significant contribution of the present invention is the provision of a branched moor leg since this basic concept gives rise to substantially more flexible installation procedures, improved performance of the moor, and a substantially longer useful life for the moor. In addition, the moor device as described, without being a hazard to navigation, is more stable and difficuties can be detected more readily and hence, can be corrected without serious impairment to the life or function of the moor device.

It is also within the purview of the present invention to utilize materials for the components or branches of the moor leg that may be lighter than water and hence, would have a buoyant tendency as opposed to a sinking tendency in the water. Thus, the branches 30, 36 or 38 may be comprised of a material lighter than water, in which case it might not be necessary to utilize the surface float or buoy 34, but rather this element of the invention would be replaced by a weight to be located on the ocean floor for the purpose of holding down the ring 32 under high stress conditions. The operation of the device in all other respects would be similar to what has already been described. Such an arrangement is particularly easy to compute and design and could be relatively simple to install.

One of the basic considerations of the structure of the present invention is that the design of the moor leg is such that the ring 32 moves substantially horizontally whenever the mooring device is subject to a stress. This is best illustrated in FIGURE 3. This is extremely important in order that the buoy 34 will not be submerged and collapsed nor will the wire rope 36 exert a lifting force on the anchor at high stress when such lift is detrimental. The structure described accomplishes this objective and, as already noted, the ring 32 moves horizontally in the water between the position illustrated in FIGURE 3 in dotted lines for minimum stress and the position illustrated in FIGURE 3 in solid lines for maximum stress.

Although the present invention has been shown and described in terms of a single preferred embodiment, nevertheless, changes and modifications will occur to those skilled in the art from a knowledge of these teachings, which changes and modifications do not depart from the inventive concept. Therefore, such changes and modifications are deemed to come within the purview of the invention.

What is claimed is:

1. A mooring device comprising a floating structure located in a body of water to which a ship can be moored, a plurality of moor legs, the upper ends of them being attached at said structure and the other ends of said legs extending laterally away from said structure to the bottom of the body of water, at least one of said moor legs comprising an anchor resting on said bottom, a line connected to said moor leg intermediate the ends thereof, said moor leg having a length greater than the distance between the anchor and the point where said moor leg is attached to said structure, and normally forming an apex where said line is attached to it, said line extending to the surface laterally spaced from said structure, a vessel connected to the upper end of said line and floating on the surface, said vessel having a reserve buoyancy greater than the weight of said line and an appreciable portion of the weight of the moor leg, the vertical force on the line due to the floating vessel diminishing when a horizontal component of force on the moor leg increases and the point at which the line is attached at the moor leg moving substantially in horizontal direction.

2. A mooring device according to claim 1, wherein said line is connected to said moor leg by means of a fitting, said fitting also connecting a first and a second section of said moor leg.

3. A mooring device comprising a floating structure located in a body of water to which a ship can be moored, a plurality of moor legs, the upper ends of them being attached at said structure and the other ends of said legs extending laterally away from said structure to the bottom of the body of water, at least one of said moor legs comprising an anchor resting on said bottom, a line connected to said moor leg intermediate the ends thereof, said moor leg having a length greater than the distance between the anchor and the point where said moor leg is attached to said structure, and normally forming an apex where said line is attached to it, said line extending to the surface laterally spaced from said structure, a vessel connected to the upper end of said line and floating on the surface, said vessel having a reserve buoyancy greater

than the weight of said line and an appreciable portion of the weight of the moor leg, the vertical force on the line due to the floating vessel diminishing when a horizontal component of force on the moor leg increases and the point at which the line is attached to the moor leg moving substantially in horizontal direction, said moor leg comprising one section formed of ropes and another section of the moor leg contacting the bottom of said body of water formed of a chain, the one end of said chain connected to said anchor.

4. A mooring device according to claim 3, wherein said line is connected to said moor leg by means of a fitting, said fitting also connecting a first and a second section of said moor leg.

5. A mooring device according to claim 1, said structure being composed of a series of interconnected flexible lines located in said body of water, a series of buoys supporting said structure in said body of water, said buoys being connected to end points of horizontal structure lines by further vertical lines.

6. A mooring device comprising a structure composed of a series of interconnected flexible lines located in a body of water to which a ship can be moored, a series of buoys supporting said structure in a body of water at a predetermined depth, a plurality of moor legs attached at one end to said structure at spaced points therearound and extending laterally away from said structure to the bottom of the body of water, at least one of said moor legs

comprised of an anchor to rest on the bottom, a chain attached to said anchor, a first flexible line attached to said chain, a second flexible line attached to said structure, a fitting interconnecting said first and second flexible line, a third flexible line attached to said fitting and extending substantially in vertical direction laterally spaced from said structure, and a vessel floating on the surface attached to said third flexible line, said vessel having a reserve buoyancy greater than the weight of the third flexible line and an appreciable portion of the weight of the first and the second flexible line and the chain, in repose, the vertical force acting on said third line due to the buoyancy of said vessel diminishing and said fitting moving substantially laterally away from said anchor, when the horizontal component of force on said second flexible line increases.

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