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Beck et al.

[11] **3,903,705**

[45] **Sept. 9, 1975**

[54] **APPARATUS FOR ANCHORING MARINE STRUCTURES**

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[52] **U.S. Cl.** **61/46;** 114/206

[51] **Int. Cl.²** **E02D 21/00;** B63B 21/00; B63B 21/24

[58] **Field of Search** ..... 61/46.5, 46; 114/206 R, 114/230, .5 D, .5 T

[56] **References Cited**

UNITED STATES PATENTS

3,082,608	3/1963	Daniell	61/46.5
3,111,926	11/1963	Shatto	114/230 X
3,712,260	1/1973	Mott et al.	114/230

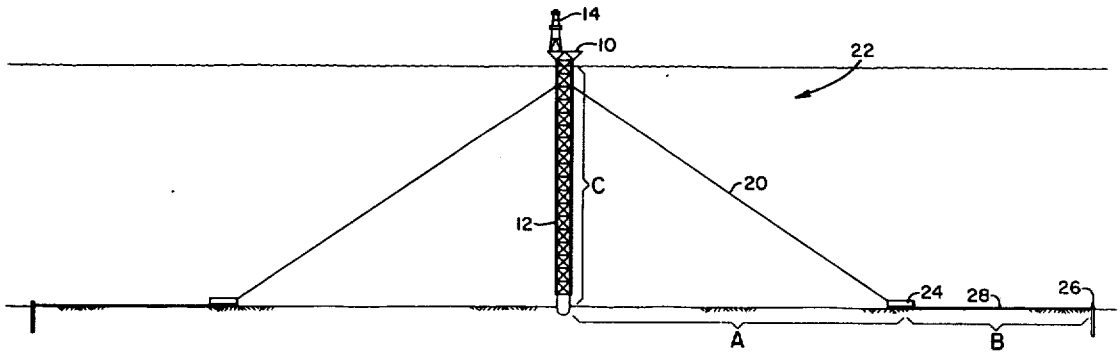
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[57] **ABSTRACT**

A marine structure, e.g., a drilling and production platform and apparatus for guying such marine structure in a body of water so as to withstand extreme environmental forces, the marine structure being anchored by means of a plurality of anchored guy wires, each guy wire having associated therewith a clump weight adapted to be at least partially supported above the floor of a body of water under normal operating conditions but lift off the sea floor under extreme environmental forces, thereby allowing the marine structure to withstand conditions which, absent the clump weight, would cause failure of the marine structure and guying apparatus. The clump weight is positioned along the guy wire a sufficient distance from an anchor to maintain the forces on the anchor substantially horizontal even when the clump weight is lifted off the sea floor by extreme environmental forces. A longitudinally articulated clump weight is preferred for guyed marine structures. Such a clump weight can comprise a plurality of chain segments arranged in parallel or other suitable longitudinally articulated weight segments.

8 Claims, 6 Drawing Figures



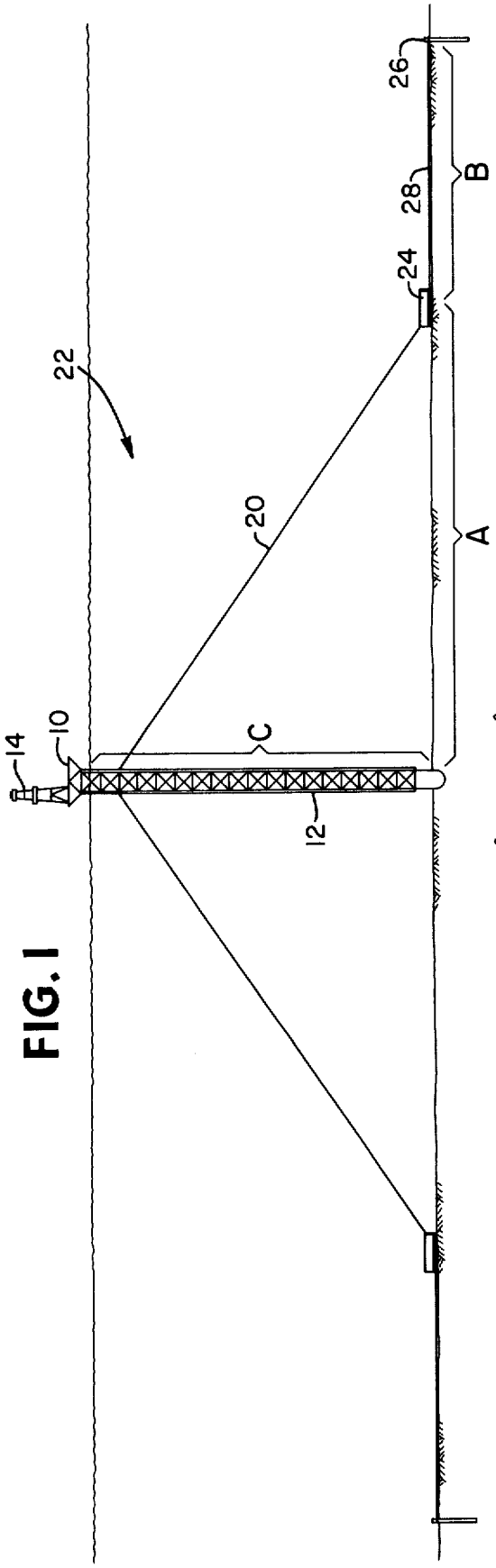


FIG. 1

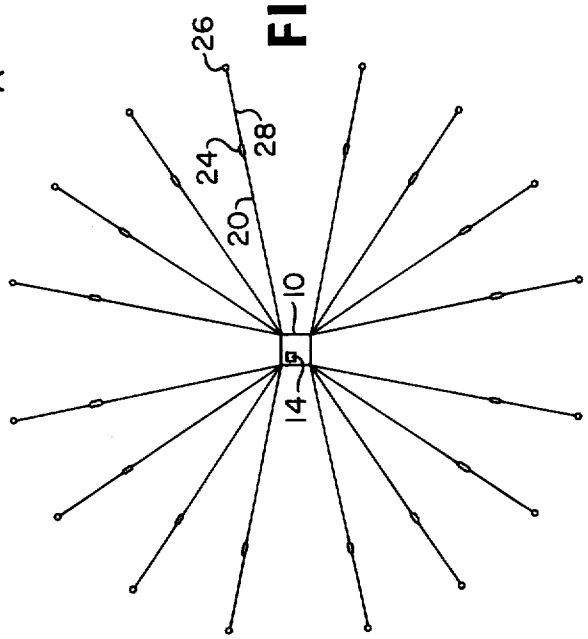


FIG. 2

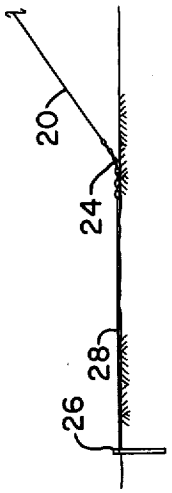
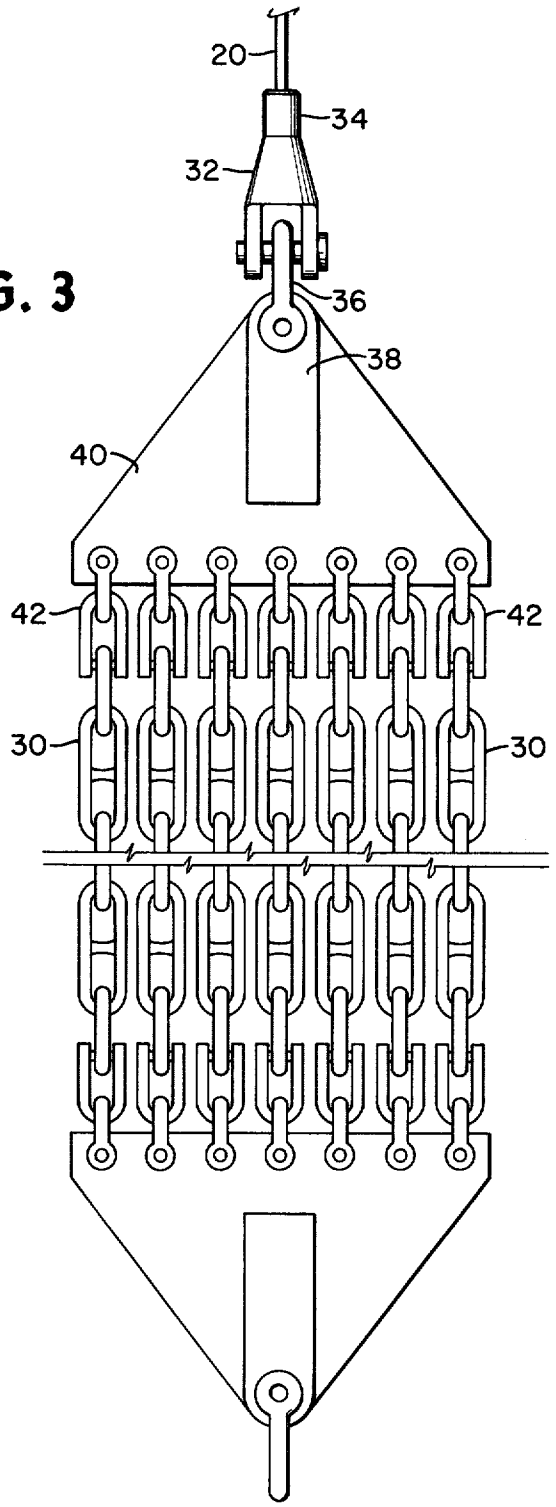


FIG. 5

FIG. 3



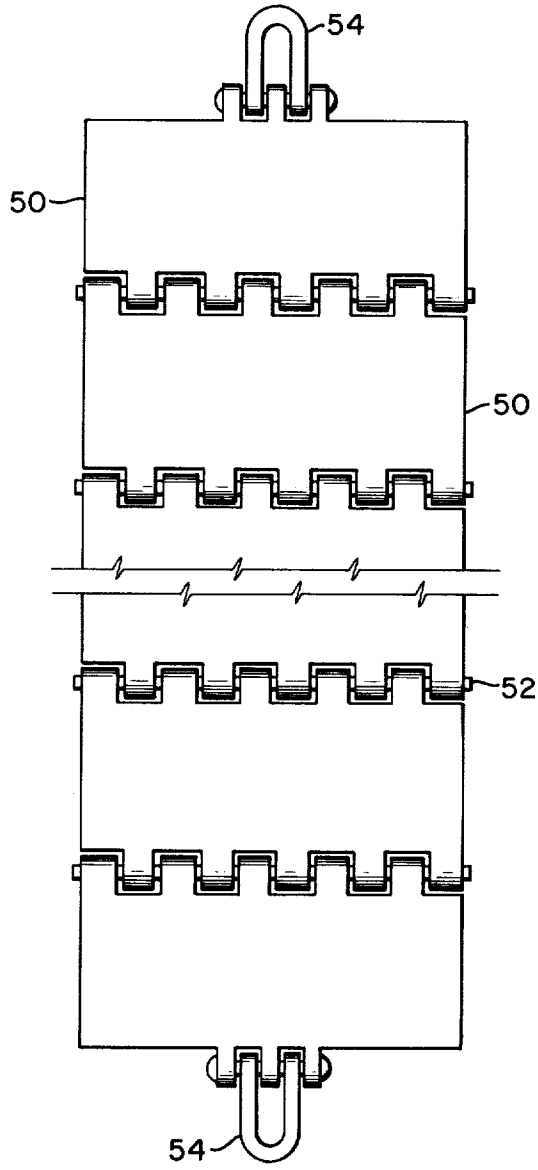


FIG. 4

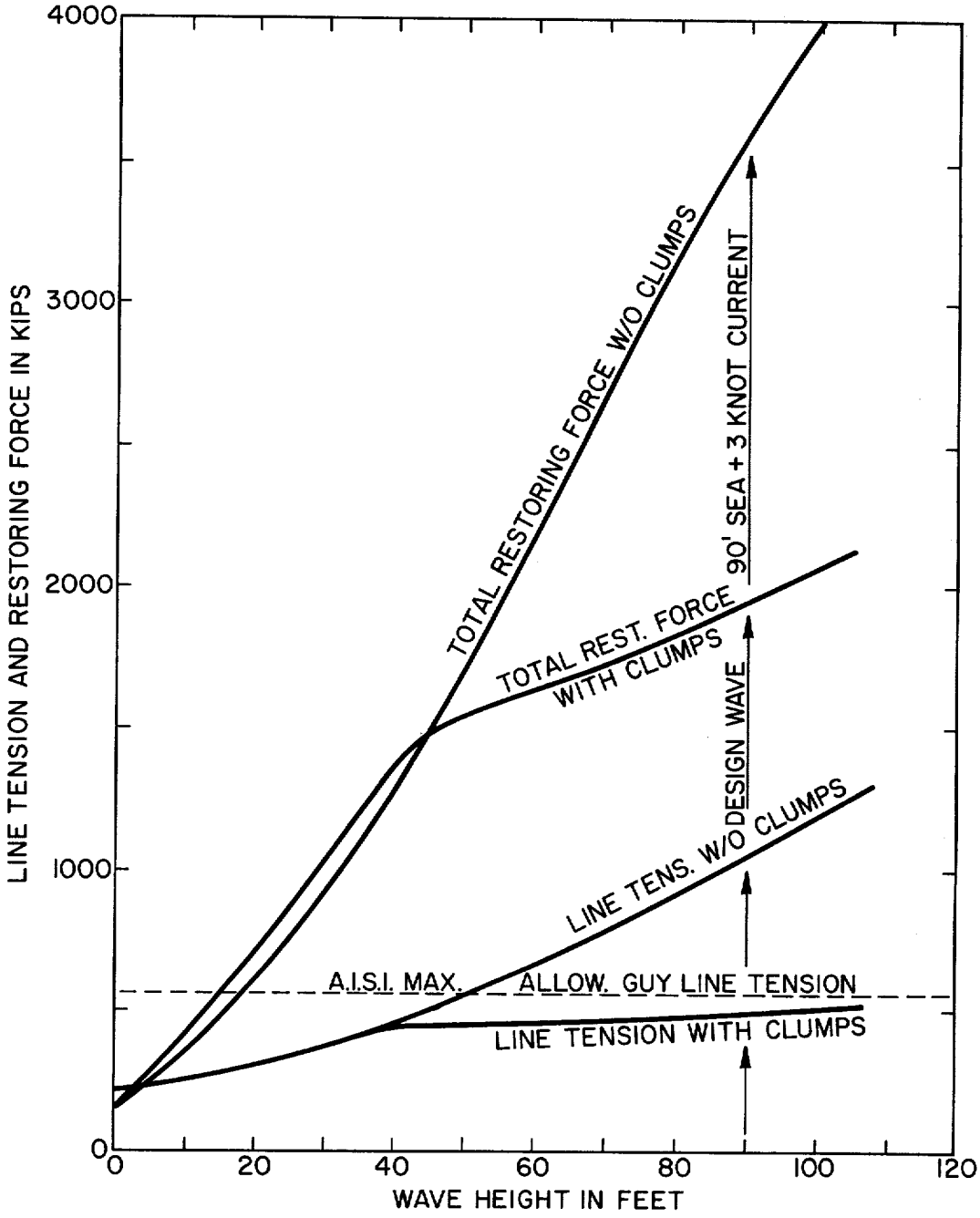

4000
3000
2000
1000
0
0
20
40
60
80
100
120
LINE TENSION AND RESTORING FORCE IN KIPS
WAVE HEIGHT IN FEET
TOTAL RESTORING FORCE W/O CLUMPS
90' SEA + 3 KNOT CURRENT
TOTAL REST. FORCE WITH CLUMPS
DESIGN WAVE
LINE TENS. W/O CLUMPS
A.I.S.I. MAX. ALLOW. GUY LINE TENSION
LINE TENSION WITH CLUMPS

FIG. 6

APPARATUS FOR ANCHORING MARINE STRUCTURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a marine structure and apparatus for anchoring the marine structure in a body of water; more specifically, this invention relates to such marine structure, e.g., a drilling and production platform and apparatus for guying the marine structure in a body of water so as to withstand extreme environmental forces, the guying apparatus including a clump weight means associated with each of a plurality of anchored guy wires.

2. Description of the Prior Art

To meet the ever increasing need for petroleum products, exploration and production of oil has been extended from land to offshore locations. While well drilling in offshore locations can be effected from floating platforms, it is generally more efficient to support the drilling platform above the water's surface with members which rest on the floor of the body of water, normally the ocean floor. As offshore drilling progresses into deeper water, the problems involved in erecting a marine structure to hold the drilling platform and anchoring it in a stationary position at the drilling site become increasingly more severe and the cost of the marine structure rises accordingly. While various systems have been proposed and employed for offshore drilling, those systems which required the marine structure to be anchored in a fixed position relative to the bottom of the body of water by an anchoring system which is for the most part external or auxiliary to the marine structure itself are of particular importance and have seen widespread investigation. Such a drilling structure may comprise, for example, a drilling platform supported on buoyant members and held in position at the well-site by anchor lines extending to fixed anchors at the ocean bottom. Another typical structure which has been proposed and utilized comprises a slender column or mast which is seated on the ocean floor and extends vertically through the water to support a drilling platform above its surface. The slender column or mast is held in a vertical position primarily by anchor or guy line means which extend outwardly from the top portion of the slender column or mast to a fixed anchor at the bottom of the body of water. In this type of system, the anchor or guy line means become component parts of the support structure and act as tensile members which restrain the column from being displaced from a vertical position by the transversely directed wind and water forces acting on it, particularly those forces which act on the uppermost portions of the slender column or mast which support the drilling platform.

To be an effective anchoring system for anchoring a deepwater drilling structure, the anchoring system, be it guy wires or other means, must be capable of restraining the structure from movement arising through the action of the several separate forces which act on the marine structure simultaneously. One of these forces is obviously a periodic wave motion of the water surface. It should be recognized, however, that the periodic wave motion of the water surface by itself would not be too significant under ordinary fair-weather conditions and most anchoring means including the conventionally employed guy wires are effective to prevent unwarranted movement of the marine structure under

those conditions ordinarily encountered during the useful life of the marine structure. As can be readily appreciated, however, one of the major problems in the design of offshore marine structures is that the risk of catastrophic failure must be reduced to as close to zero as possible, since the potential for economic loss and environmental pollution from such a catastrophic failure is too great to accept any significant risk in the design. Accordingly, the anchoring system for a marine structure is often designed for the most extreme environmental forces that could be postulated for a period of several hundred years even though the structure itself might have an expected economic life of only about **20** to **40** years.

In a guyed marine structure the guying means will inherently produce a complication in that together with the marine structure they form an elastic system which is susceptible to forced vibrations under periodically applied forces. If an attempt is made to solve this problem by slacking the guy lines, the upper part of the structure will tilt at an angle from the vertical and thus increase the difficulty of conducting drilling or producing operations. If an attempt is made to change the vibration characteristics of the system by tightening the guy lines, the elastic system becomes resonant at higher frequencies and, as a result, more susceptible to forced oscillation by the smaller, high frequency water waves and a greater stress is placed on the guy lines, thereby necessitating the use of heavier equipment. Since the cost of a lateral guying system is almost proportional to its holding capacity, disregarding other considerations, it has been thought to be economically unattractive to make a guying system strong enough to withstand directly all of the extreme environmental forces which might be imposed upon the marine structure.

Notwithstanding the above, various systems have been proposed for utilization in combination with guy wire anchoring means so as to allow the marine structure to withstand extreme environmental forces. For example, U.S. Pat. No. **2,986,888** describes a method and apparatus for anchoring marine structures wherein floats are associated with each of the guy wires so as to provide controlled, forced vibration characteristics thereby controlling the stresses placed on the anchoring lines so as to hold them below a predetermined maximum amount. A further attempt to achieve this same result is described in U.S. Pat. No. **3,524,323**, which describes in combination with an offshore storage tank a self-contained guy wire system which includes a plurality of guy lines joined at their lower ends to a plurality of weight means regularly arranged around the elongated shaft of the marine structure, the weight means being disposed for vertical displacement upon tilting of the shaft beyond a predetermined tilt and being substantially unsupported by the guy lines when the shaft is vertical. A complicated and costly self-contained guy system is described to achieve this result.

While systems such as proposed in the above have some effect on the stability of the marine structure and its ability to withstand extreme environmental forces, the systems proposed to date are complicated and costly and will not allow the marine structure to withstand those forces which would otherwise provide for the catastrophic failure of the marine structure, for example, wave heights in the vicinity of **90** feet or more, which wave heights may or may not be encountered in

the expected economic life of the marine structure. Accordingly, in the area of anchored marine structures utilizing guy wire systems, the art has lacked an anchoring system which will allow the marine structure to withstand extreme environmental forces while not prohibitively increasing the cost of the marine structure.

SUMMARY OF THE INVENTION

The foregoing disadvantages of previously proposed systems are eliminated through the provision of the present invention which comprises a marine structure, e.g., a drilling and production platform and apparatus for guying the marine structure in a body of water, i.e., guying the marine structure to the ocean floor so that the marine structure can withstand extreme environmental forces. The marine structure in accordance with the present invention is anchored by means of a plurality of anchored guy wires, each guy wire having associated therewith a clump weight adapted to be supported at least in part above the ocean floor under normal operating and environmental conditions, but lift off the ocean floor under conditions of extreme environmental forces, i.e., those forces which, absent the clump weight means, would damage or destroy the marine structure.

The clump weight is positioned along each guy wire a sufficient distance from an anchor attached to the guy wire to maintain the forces on the anchor substantially horizontal even when the entire clump weight is lifted off the ocean floor under the action of the extreme environmental forces. This allows for an effective increase in the environmental forces which can be withstood by the marine structure without causing significant uplift on the anchoring system. In one preferred embodiment of the present invention, the clump weight comprises a plurality of chains arranged in parallel, the chains being partially supported above the ocean floor under normal conditions but totally lifted off the ocean floor under conditions of extreme environmental forces. In another preferred embodiment of the invention the clump weight consists of a plurality of hinged metal segments pinned together to form a longitudinally flexible clump weight.

Accordingly, it is a principal object of the present invention to provide a novel marine structure and apparatus for guying such marine structure in a body of water wherein the apparatus for anchoring allows the marine structure to withstand extreme environmental forces in a manner not heretofore possible with conventional systems.

It is a further object of the present invention to provide such marine structure, e.g., a drilling and production platform and apparatus for guying the drilling platform so as to withstand extreme environmental forces, the drilling platform being anchored by means of a plurality of guy wires, each guy wire having associated therewith a clump weight adapted to at least partially remain on the sea floor under normal operating conditions but lift completely off the sea floor under extreme environmental forces.

It is yet a further object of the present invention to provide such marine structure and apparatus for guying the marine structure in a body of water wherein each of a plurality of guy wires has associated therewith a clump weight means positioned along the guy wire a sufficient distance from an anchor to maintain the forces on the anchor substantially horizontal even when the clump weight is lifted completely off the sea floor in response to extreme environmental forces, thereby allowing the marine structure to withstand conditions which, absent the clump weight means, would cause damage to or failure of the marine structure and guying apparatus.

A still further object of the present invention comprises such marine structure and apparatus for guying the marine structure in a body of water wherein the clump weight means associated with each of the plurality of guy wires comprises a plurality of chains arranged in parallel or articulated segments.

Still further objects and advantages of the novel marine structure and anchoring apparatus of the present invention will become more apparent from the following more detailed description thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic longitudinal view illustrating an anchored marine structure in accordance with the present invention;

FIG. **2** is a top view of a marine structure illustrating the employment of **16** anchored guy wires each employing the clump weight means of the present invention;

FIG. **3** is a view illustrating a preferred clump weight comprising a plurality of chains in parallel;

FIG. **4** is a view illustrating an alternate preferred type of clump weight comprising a plurality of hinged metal segments pinned together to form a longitudinally flexible clump weight;

FIG. **5** is a schematic longitudinal view of a portion of an anchored guy wire including a flexible clump weight as illustrated in FIG. **3** or FIG. **4**; and

FIG. **6** is a graph plotting line tension and restoring force in kips versus wave height in feet.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The foregoing objects and advantages of the present invention are achieved through the provision of a marine structure, e.g., a drilling and production platform and apparatus for guying such marine structure in a body of water so as to withstand extreme environmental forces, wherein the marine structure is anchored by means of a plurality of anchored guy wires, each guy wire having associated therewith a clump weight adapted to be at least partially supported above the ocean floor under normal operating conditions but lift off the ocean floor under extreme environmental forces. In this way the marine structure can withstand conditions which, absent the clump weight, would cause failure of the marine structure and anchoring apparatus.

While the clump weight utilized in accordance with the present invention can take many forms, in a preferred embodiment of the present invention the clump weight takes a flexible form comprising a plurality of chains arranged in parallel or hinged segments forming a longitudinally flexible clump weight. Other forms, of course, are within the scope of the present invention and any and all possible forms provide the advantage of allowing the marine structure to withstand extreme environmental forces, i.e., waves up to **90** feet and greater. The marine structure and guying apparatus of the present invention will become more apparent from a review of the drawings.

FIG. 1 illustrates an offshore drilling platform designed for installation in deep water, a portion of the structure being above the surface of the water and a portion of the structure being below the surface of the water. The particular construction illustrated in FIG. 1 is adapted for installation in approximately 1000 feet of water. As illustrated, the drilling and production platform 10 is supported by a tower 12, in this case a tower of uniform cross section throughout its length, the tower being cross braced to provide the necessary structural stiffness for the particular application of an offshore drilling and production platform in 1000 feet of water. A typical tower will have a uniform cross section of 50 feet on each side throughout its length. Of course, other tower constructions can be suitably utilized in conjunction with the guying apparatus of the present invention. As illustrated in FIG. 1, a derrick 14 is located on the drilling and production platform 10. It should be readily apparent that the drilling and production platform 10 will also have supported thereon additional drilling and production equipment not illustrated.

The guying system illustrated in FIG. 1 and FIG. 2 comprises a plurality of similar guy means disposed in equiangular relationship around the circumference of tower 12 and extending therefrom in a generally radial direction. In order to achieve the objects and advantages of the present invention, the guying means all impose substantially equal restraining forces on the tower 12 when it is in equilibrium position but, if the top portion of tower 12 moves in a transverse or lateral direction from the vertical the guying means on the side of the tower 12 away from the direction of motion will increase their restoring force on tower 12 while simultaneously the guying means on the side of tower 12 toward the direction of the transverse motion will decrease their restoring force, and thus the tower 12 will tend to return to the vertical. In this way the guying means of the present invention allow the marine structure to withstand extreme environmental forces, i.e., those environmental forces which, absent the particular guy means of the present invention, would cause failure of the structure.

While FIG. 1 illustrates two such guy means, it can be seen from FIG. 2 that, with regard to the tower illustrated, 16 guy wires 20 are arranged radially and equiangularly around the tower 12, the upper end of each guy wire 20 being attached to the tower 12 below the surface of the body of water 22. While the means for attaching each guy wire 20 to tower 12 are not illustrated, it should be apparent that the guy wires 20 can be attached to tower 12 by any conventional means employed in the installation of guyed marine structures.

As illustrated in both FIG. 1 and FIG. 2 the guying system of the present invention involves a plurality of guy wires 20 each of which has associated therewith a clump weight 24 and a pile anchor or heavy drag anchor 26 at the end of each guy wire 20 opposite its attachment to tower 12. In one embodiment of the present invention the clump weight 24 is simply a large, heavy object, e.g., a cement block which is attached at one point to guy wire 20 and at another point to a wire 28 of similar construction as guy wire 20 ending in the pile anchor or heavy drag anchor 26. In accordance with the present invention both guy wire 20 and wire 28 are composed of the same material which in the case of a tower having a uniform cross section of 50 feet on one side throughout its length in 1000 feet of water can appropriately be 3½ inch diameter galvanized bridge rope.

The clump weight 24 which is attached to each guy wire 20 is adapted to be at least partially supported above the sea floor under normal operating conditions, i.e., conditions of stress less than that which would cause substantial movement of the marine structure, but lift completely off the sea floor under conditions of extreme environmental forces thereby allowing the marine structure to withstand stresses which, absent the clump weight, would cause failure of the marine structure and guying apparatus. In accordance with the present invention, the clump weight 24 is positioned a sufficient distance from the base of tower 12 and from the pile anchor or drag anchor 26 that even when the clump weight 24 is forced upwardly off the sea floor under extreme environmental forces, the forces on the pile anchor or drag anchor 26 remain substantially horizontal so as to eliminate significant vertical uplift thereon, thereby maintaining the pile anchors or drag anchors 26 in position. Accordingly through this provision the marine structure can withstand extreme conditions.

The utilization of the clump weight and the guying apparatus for the marine structure of the present invention provides several advantages not associated with conventional systems for supporting guyed towers at sea. In this regard, the clump weight system of the present invention is stiff for all waves except very large design waves so that tower motion is restricted under all normal environmental conditions. This produces an advantage in that wear on well risers is minimized. Still further, since the clump weight system of the present invention becomes limber through the rare and possibly never experienced very large waves, it is possible to stay within allowable design criteria for the largest conceivable waves while still providing a stiff system for the normally occurring waves. Also the stresses on the tower itself are reduced very significantly in large waves since the clump weight system limits loads transmitted to the tower by the guy lines. Furthermore, clump weights in accordance with the present invention eliminate any significant vertical uplift on the pile anchors even in the largest waves thereby decreasing the possibility of pile anchor pullout. This also permits the use of drag anchors which are generally less costly than pile anchors thereby making the system economically attractive.

The idealized system in accordance with the present invention is one in which the distance along the ocean floor between the lower end of tower 12 and clump weight 24 is approximately twice the depth of the water in which the marine structure is located. Similarly in this idealized system, the length of wire 28 between the clump weight 24 and pile or drag anchor 26 along the bottom of the ocean floor is preferably about equal to the depth of the body of water. When viewed in light of the distances illustrated in FIG. 1, in accordance with the preferred embodiment of the present invention, the ratio of B/A is preferably at least ½, with the maximum ratio not larger than 1, although length B can be made longer where desired for particular purposes. In essence, however, as indicated previously the length of the wire 28 between the clump weight 24 and pile anchor or heavy weight anchor 26 must be such that

when the clump weight 24 is lifted off the sea floor by an extreme environmental force, the forces on the anchor remain substantially horizontal, thereby eliminating any tendency for uplift of the anchor. Within these guidelines it is therefore possible to determine the optimum lengths for any particular system.

The weight of the clump weight 24 which is attached to each guy wire 20 can vary within wide limits, the weight being to some extent a function of the tension and diameter of the guy wire. Still further, the weight which should be employed is a function of the breaking strength of the guy wire, which is that tension at which the guy wire will break absent any restraining forces. Since a guy wire will fail due to fatigue if subjected to forces close to the breaking strength, the maximum allowable guy wire tension is generally defined as one-half of the breaking strength. In accordance with the present invention, it has been discovered that a clump weight can adequately serve to eliminate the likelihood of guy wire breakage if the clump weight is 30 to 60% of the maximum allowable tension. For example, assuming a breaking tension of 1100 kips (1 kip = 1000 pounds), the maximum allowable guy wire tension will be 550 kips. Accordingly, the clump weight based on the above percentages should be a weight of from 165 to 330 kips. Preferably, for guy wires at a preferred angle of 30°, it has been determined that optimum results are achieved with a clump weight which is approximately 35 to 40%, preferably 36% of the maximum allowable guy wire tension. Accordingly, with these guidelines it is possible to determine the optimum weight for any particular system.

As indicated previously, the clump weight 20 illustrated in FIGS. 1 and 2 can take any form, as long as the weight is sufficient such that the clump weight remains at least partially supported above the sea floor under normal operating conditions but is lifted completely off under conditions of extreme environmental forces. While this is the case, in one preferred embodiment of the present invention, the clump weight takes the form of a plurality of chains in parallel as illustrated in FIG. 3 since the use of such parallel chains eliminates a problem of adhesion which might be associated with a large concrete block or similar mass.

FIG. 3 illustrates one type of preferred clump weight for use in accordance with the marine structure and anchoring apparatus of the present invention. As seen in FIG. 3, the clump weight comprises a plurality of chains 30 in parallel, seven chains being illustrated in the embodiment of FIG. 3. A suitable arrangement for attaching the chains in parallel to the guy wire 20 is illustrated in FIG. 3, it being noted of course that a similar connection is made between the chains 30 and wire 28 which connects the clump weight with the pile anchor or drag anchor 26. As illustrated in FIG. 3, the guy wire is attached to an open wire rope socket 32 including an extension 34, the extension being filled with an epoxy resin or zinc. The end of the guy wire 20 within the open wire rope socket 32 is broomed and the open wire rope socket 32 is filled with zinc so as to provide a secure connection between the open wire rope socket 32 and guy wire 20. The open wire rope socket 32 is connected to a steel fish plate 40 by means of a forged anchor shackle 36 connected to a steel plate gusset 38 welded to steel fish plate 40. Of course, other typical arrangements can be utilized to connect the guy wire 20 to the chains 30 constituting the clump weight in accordance with this preferred embodiment of the present invention. The chains 30 are connected to the steel fish plate 40 by means of forged anchor shackles 42 or similar means.

Assuming a tower is required for 1500 feet of water, a suitable anchoring system could be provided by utilizing 3000 feet of 3½ inch diameter galvanized bridge rope with a 200 kip clump weight in the form of seven parallel chains 150 feet in length, the chains being connected to an anchor pile by 1000 feet of the same 3½ inch anchored bridge rope. With such a configuration, the clump weight will be located a distance of approximately 2600 feet from the base of the tower, the clump weight being partially supported above the sea floor under ordinary operating conditions but capable of being lifted off the sea floor under conditions of extreme environmental forces. The parallel chains have the advantage that there is a lessened tendency for adhesion of the chains on the ocean floor.

A further preferred type of clump weight for use in the guying apparatus of the present invention includes a further flexible clump weight, in this case in the form of longitudinally articulated weight segments. This type of clump weight is illustrated in FIG. 4. As seen in FIG. 4, the clump weight in accordance with this embodiment of the present invention includes a plurality of hinged segments 50 each segment being hinged by means of pins 52. The segments which are hinged together are attached to the guy wire 20 and wire 28 by means of suitable attachments means such as anchor shackles 54 suitably attached to the end segments. In a suitable embodiment in accordance with this aspect of the present invention, the individual segments can be 5 feet by 10 feet by 1 foot in thickness with each segment weighing approximately 25 kips. Accordingly, the clump weight can be prepared in the desired weight by merely attaching the requisite number of segments thereby providing the desired longitudinally flexible clump weight.

As indicated previously, the clump weight in accordance with the present invention is adapted to be at least partially supported on the sea floor under normal operating conditions but to completely lift off the sea floor under conditions of extreme environmental forces. The use of a longitudinally flexible clump weight as illustrated in FIGS. 3 and 4 has the advantage when compared with the use of a large concrete block or similar mass in that the problem of adhesion of the large concrete block or similar mass to the ocean floor is eliminated or minimized to a great extent. Moreover, as seen from FIG. 5, the longitudinally flexible clump weight as illustrated in FIGS. 3 and 4 is only partially supported by the ocean floor under conditions of normal stress thereby again eliminating problems with regard to adhesion. Moreover, since the longitudinally flexible clump weight will be lifted off the ocean floor gradually with increasing stress upon the guy wires, an abrupt change in stress which would be associated with the employment of a large concrete block or similar mass is avoided. Accordingly, the embodiments of FIGS. 3 and 4 are preferred in accordance with the present invention.

The effectiveness achieved in utilizing the clump weights in accordance with the present invention can be seen with reference to FIG. 6 which plots the line tension and restoring force in kips versus the wave height in feet for a typical guy line system in accor-

dance with the present invention, the system being developed for a 50 foot square tower in 1000 feet of water, the tower being supported by 16 guy lines each of 3½ inch diameter bridge rope with and without 200 kip clump weights. Turning to FIG. 6 it is noted that the same illustrates the guy line system response in a 3 knot current and wave heights up to 90 feet. In the case of systems both with and without the clump weights, it can be seen from FIG. 6 that while both systems behave quite similarly in waves up to 40 feet high, in higher waves, in the system without clump weights, the line tension continues to rise and reaches the maximum allowable guy line tension at a wave height of about 50 feet. In the case with the clump weights, the clump weights on the windward lines lift off the bottom of the body of water in 40 foot waves and the line tension rises very slowly thereafter and is still below the maximum allowable guy line tension in the design 90 foot wave plus 3 knot current. Accordingly, this illustrates that the clump weights allow the marine structure, in this case an offshore drilling tower, to withstand those forces which, absent the clump weights, would cause failure of the marine tower and guying apparatus. Accordingly, the advantages of the present invention over those systems not containing the clump weights can be clearly seen with reference to FIG. 6.

It should be apparent from the foregoing that the present invention comprises a distinct improvement in the guying of marine structures, e.g., drilling platforms and apparatus for guying such marine structure in a body of water so as to allow the marine structure to withstand extreme environmental forces. Again the improvement in accordance with the present invention involves guying the marine structure by means of a plurality of anchored guy wires each guy wire having associated therewith a clump weight adapted to be at least partially supported above the sea floor under normal operating conditions but lift off the sea floor under extreme environmental forces thereby allowing the marine structure to withstand conditions which, absent the clump weight, would cause failure of the marine structure and guying apparatus. Again the clump weight is positioned along the guy wire a sufficient distance from a pile anchor or other suitable anchoring means to maintain the forces on the anchor substantially horizontal even when the clump weight is lifted off the sea floor by extreme environmental forces thereby eliminating any uplift of the anchor. Accordingly, through the apparatus of the present invention it is possible to provide a marine structure in which the risk of catastrophic failure is reduced to as near zero as possible.

While the present invention has been described primarily with regard to the foregoing specific exemplification, it should be understood that the present invention cannot under any circumstances be deemed limited thereto but rather must be construed as broadly as all or any equivalents thereof.

We claim:

1. A marine structure guyed against substantial movement in response to extreme environmental forces comprising:

a marine structure positioned in a body of water, a portion of said structure being above the surface of said body of water and a portion of said structure extending from the surface of said body of water to its floor;

a plurality of guy means attached at a first end to said marine structure below the surface of said body of water and at a point between the longitudinal midpoint of said structure and the top of said structure, said guy means being radially arranged around the periphery of said marine structure;

anchor means associated with each of said guy means, attached to a second end of each of said guy means to anchor each of said guy means to the floor of said body of water; and

clump weight means attached to each of said guy means between said first and second ends of said guy means, said clump weight means being adapted to be at least partially supported on the floor of said body of water under conditions of stress on said guy means less than that which would effect substantial movement of said marine structure absent said clump weight means and adapted to be raised off the floor of said body of water under conditions of greater stress and wherein the weight of each of said clump weight means is 30 to 60 percent of the maximum allowable tension of each of said guy means.

2. The marine structure of claim 1 wherein said clump weight attached to each of said guy means is located between said first and second ends at a point such that when said clump weight is lifted off the floor of said body of water, the forces on said anchor means remain substantially horizontal.

3. The marine structure of claim 1 wherein the weight of each of said clump weight is 35 to 40% of the maximum allowable tension of each of said guy means.

4. The marine structure of claim 1 wherein the ratio of the distance from each clump weight to the second end of each guy means to the distance from each clump weight to the first end of each guy means is at least ½.

5. The marine structure of claim 1 wherein said clump weight means are longitudinally flexible.

6. The marine structure of claim 5 wherein said clump weight means comprise a plurality of chains.

7. The marine structure of claim 6 wherein said plurality of chains are arranged in parallel.

8. The marine structure of claim 5 wherein said clump weight means comprise a plurality of segments hinged together to form a longitudinally flexible unit.

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