United States Patent

Hogan

[15] 3,645,104

[45] Feb. 29, 1972

[54] TOWER STRUCTURE

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[73] Assignee: **Phillips Petroleum Company**

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[52] **U.S. Cl.** **61/46.5**

[51] **Int. Cl.** **E02b 17/00**

[58] **Field of Search** 61/46, 46.5; 52/224, 648, 653

[56] **References Cited**

UNITED STATES PATENTS

3,304,351	2/1967	Sweeney	52/224 X
3,429,133	2/1969	Hauber	61/46.5
3,488,967	1/1970	Toossi	61/46.5

FOREIGN PATENTS OR APPLICATIONS

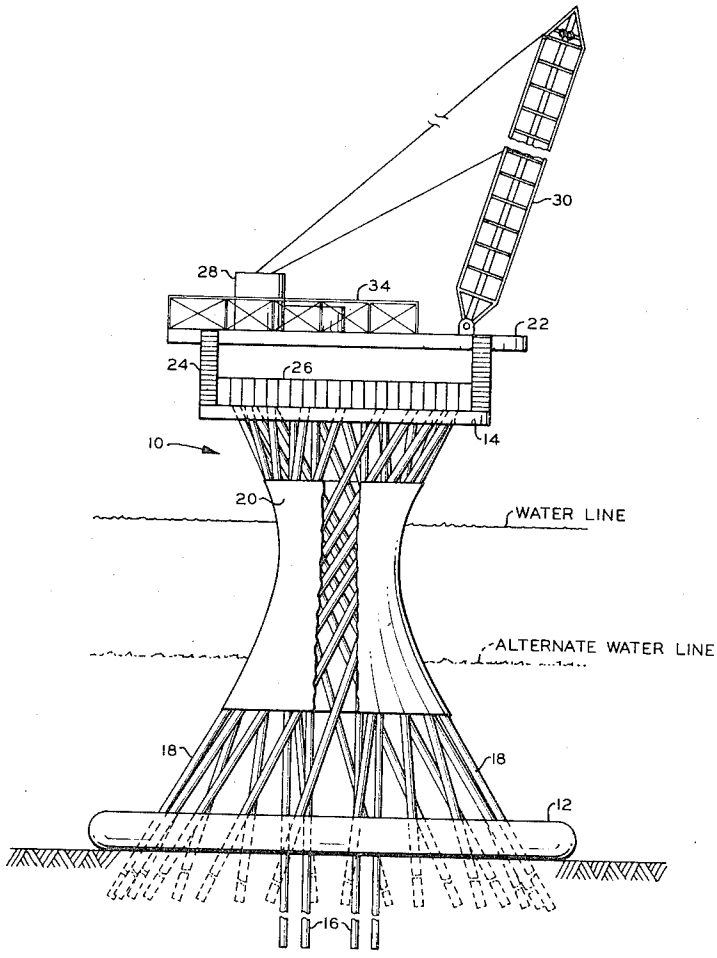
Add. 65,249	10/1955	France	52/648
383,306	11/1932	Great Britain	52/648

Primary Examiner—David J. Williamowsky
Assistant Examiner—David H. Corbin
Attorney—Young and Quigg

[57] **ABSTRACT**

A tower structure embodying the geometric properties of a hyperboloid of one sheet. Said tower comprises a lower base, an upper platform, and a plurality of inclined legs extending between said base and said platform. Said inclined legs are so inclined and so spaced, with respect to a central axis, so that upon revolution of any one of said legs about said axis at an essentially constant angle of inclination there is described a surface of revolution which defines said hyperboloid.

19 Claims, 13 Drawing Figures



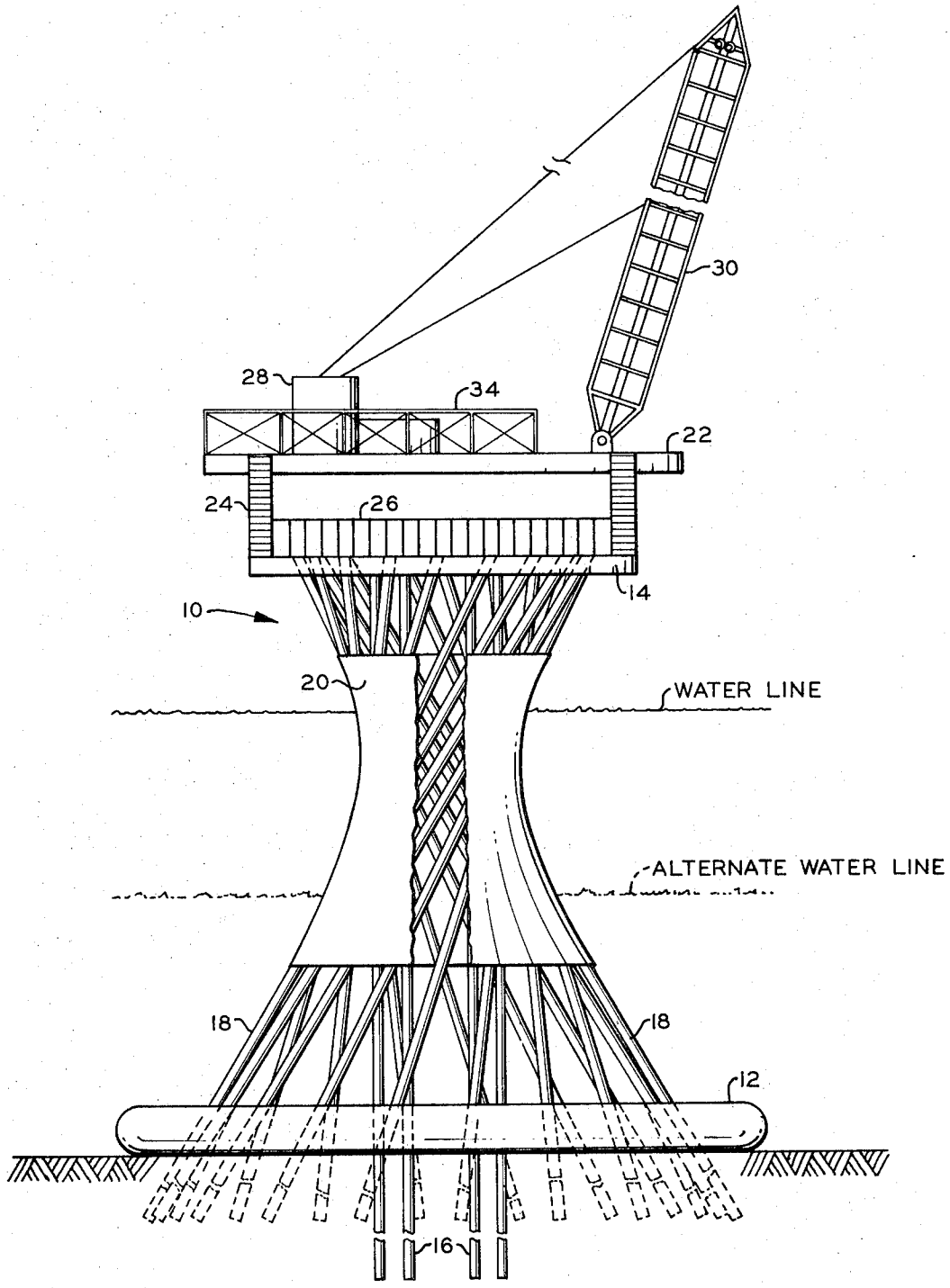


FIG. 1

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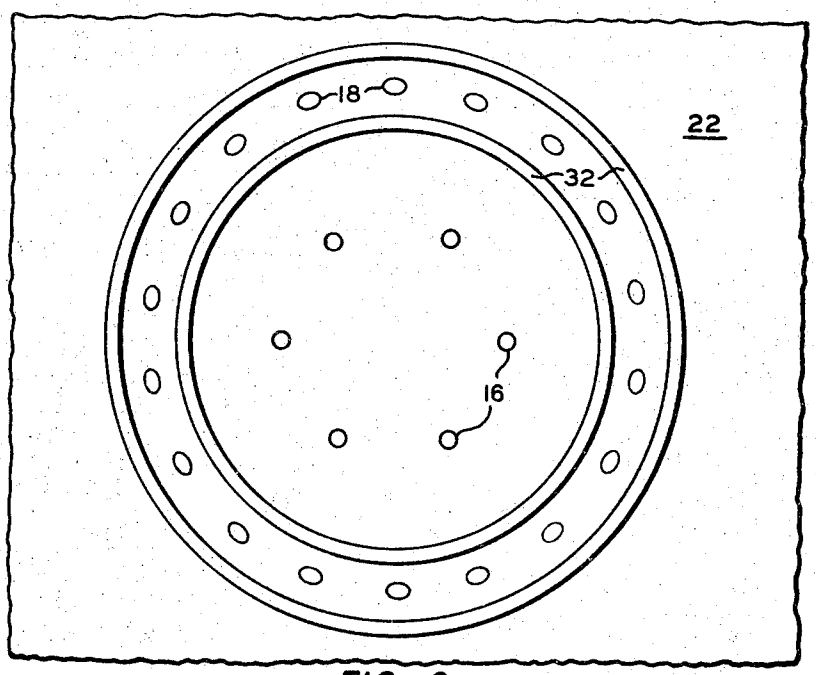


FIG. 2

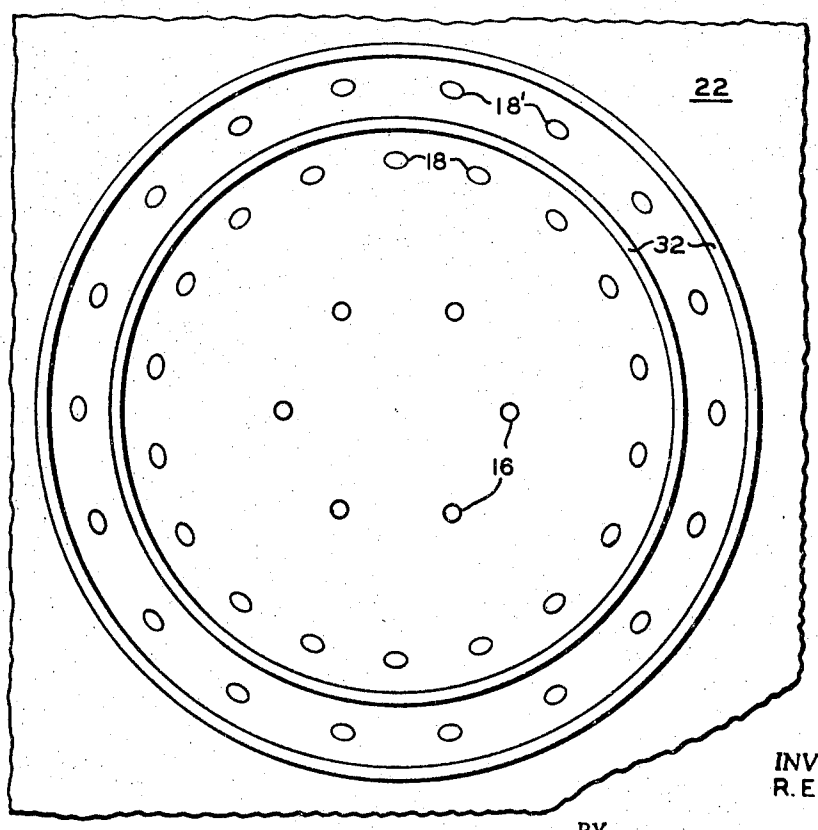


FIG. 3

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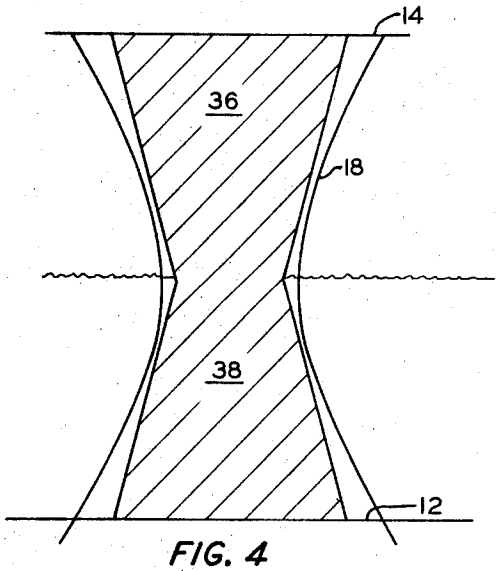


FIG. 4

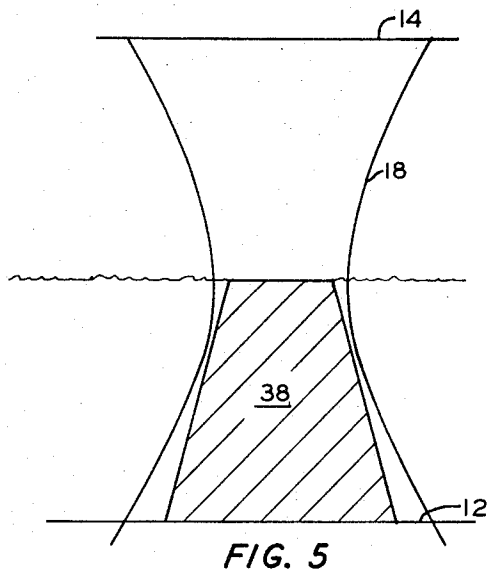


FIG. 5

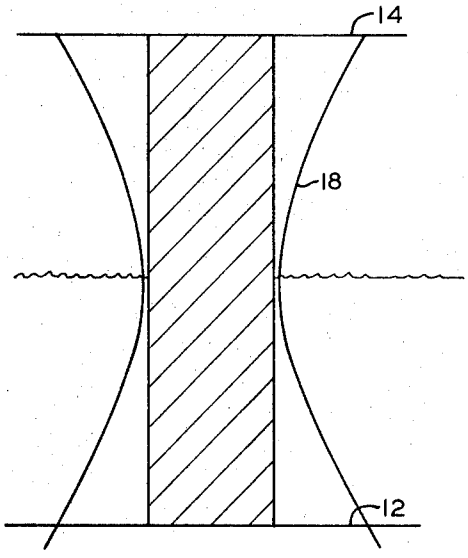


FIG. 6

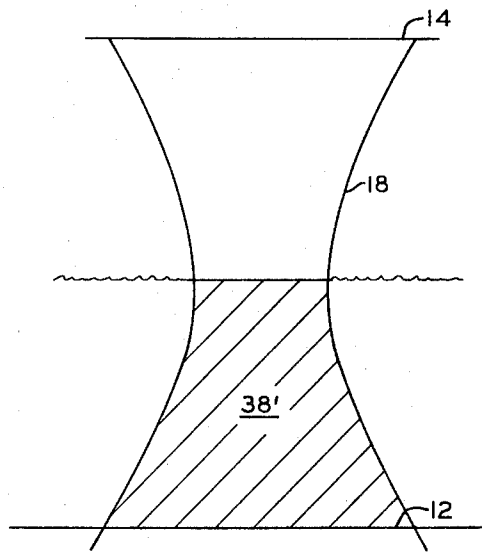


FIG. 7

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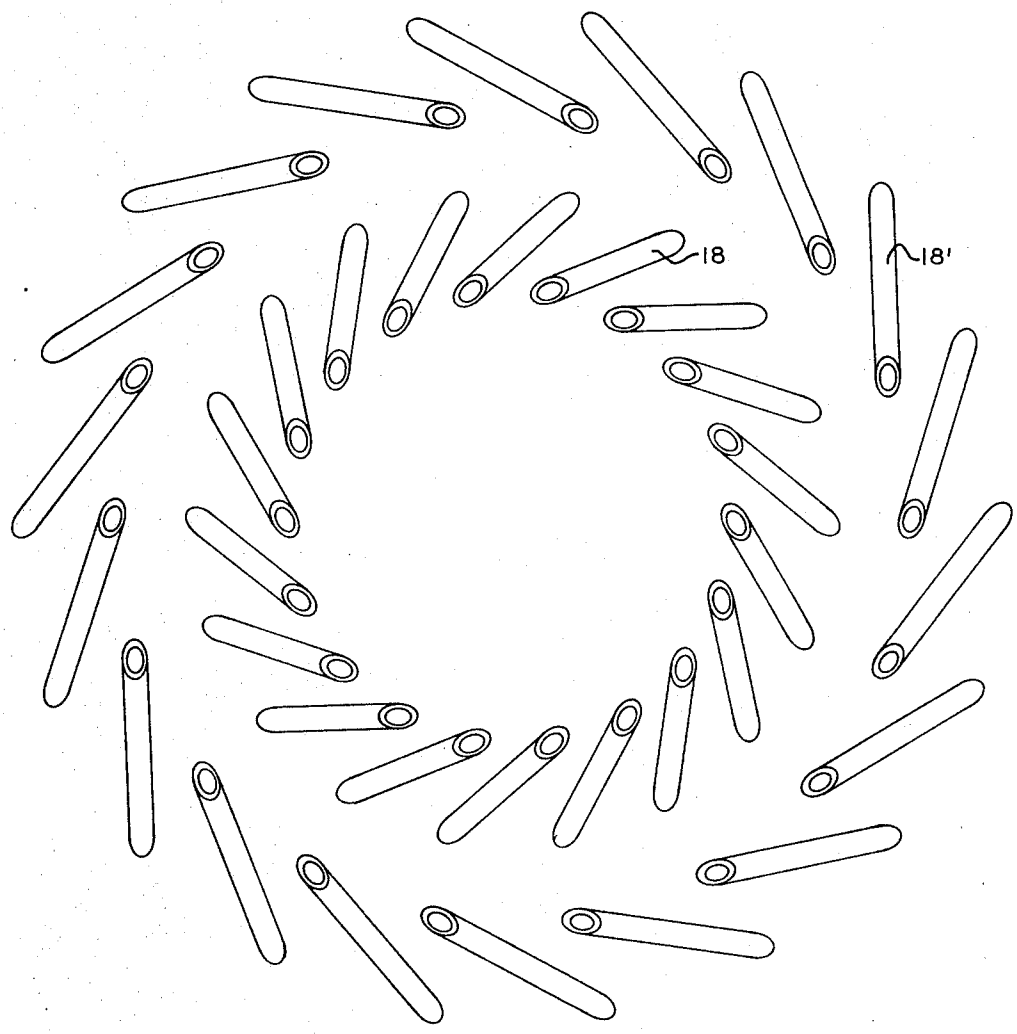


FIG. 8

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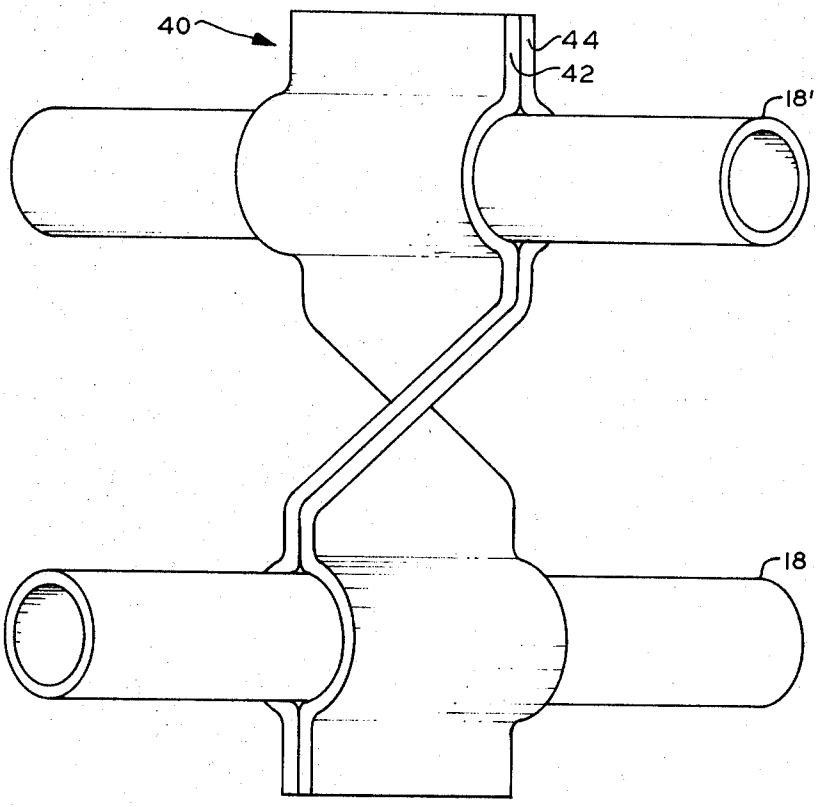


FIG. 9

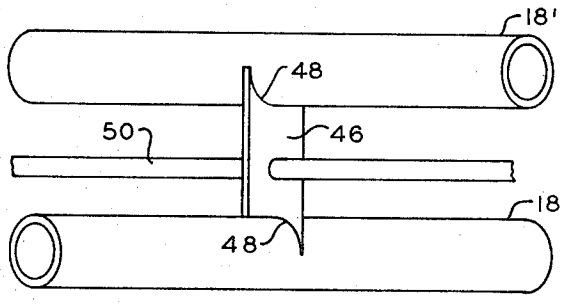


FIG. 10

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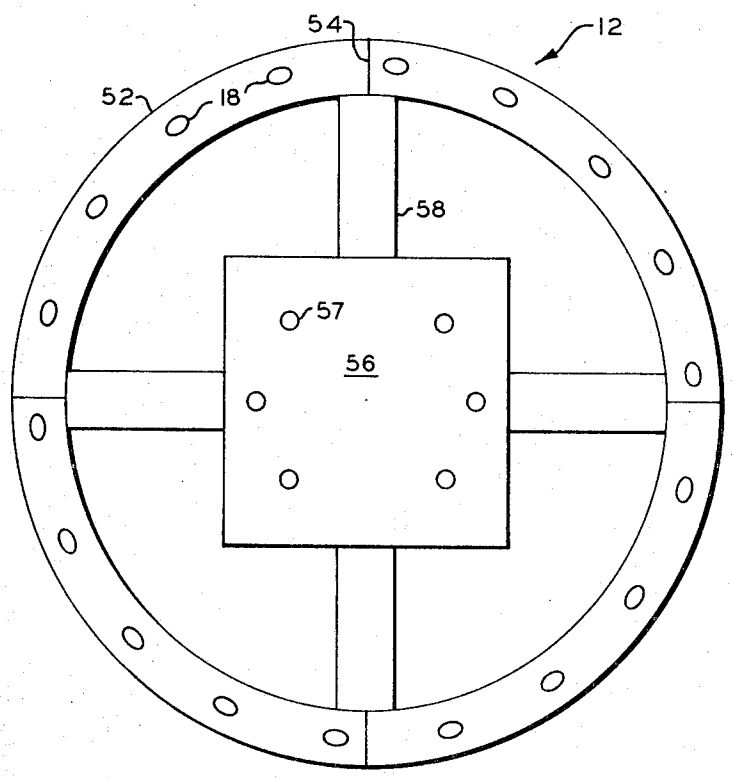


FIG. 11

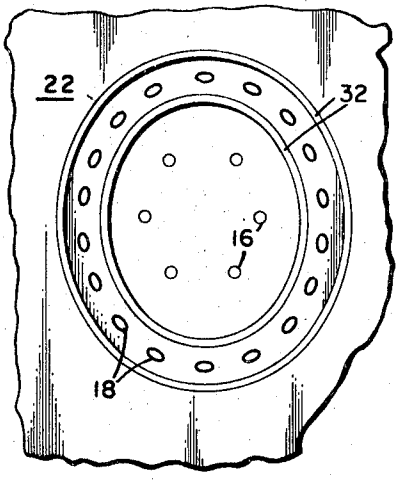


FIG. 13

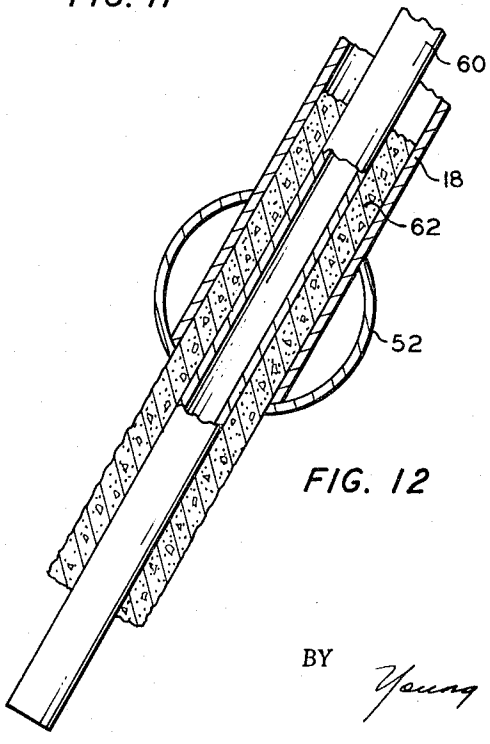


FIG. 12

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TOWER STRUCTURE

This invention relates to a tower structure which is adaptable for both onshore and offshore installations.

Towers of various structural designs are widely employed in both onshore and offshore installations to support water tanks, observation platforms, drilling platforms, radar equipment, etc. In many instances, the ultimate use or location requires that the tower structure be specifically designed for specific uses or locations. It would be desirable to have one basic tower structure which can be adapted with minimum modification for a wide variety of uses and/or locations. The present invention provides such a tower structure. The tower structure of the present invention is particularly adapted for offshore locations to support a work platform, such as a drilling platform, for the drilling of oil and/or gas wells.

In recent years the number of wells drilled for oil and/or gas in fields situated below the surface of a body of water, such as the ocean or a lake, has greatly increased. Drilling in such locations requires a tower structure which is adapted to rest upon the bed of the body of water with a portion of the tower extending above the surface of the water. It is also required as a matter of economics that such towers support a platform from which multiple wells can be drilled.

This is a major factor which not only affects the economics, but also affects the design of such towers. The number of wells that can be drilled from such a tower is a function of both well spacing and the depth to the top of the producing formation. The capability to start drilling initially at a high deviation angle is advantageous since it greatly increases the horizontal displacement available at a given depth.

I have discovered that a tower design concept embodying the geometric properties of a hyperboloid of one sheet of revolution provides an excellent solution to the problem of drilling a maximum number of wells at a predetermined angle of inclination from a minimum size platform. Additionally, the hyperboloid concept provides an ideal initial pattern for drilling wells with minimum interference at the surface, and provides maximum platform strength with minimum tonnage and fabrication requirements.

An object of this invention is to provide an improved tower structure which is adapted for supporting a load or work platform in either an onshore or an offshore location. Another object of this invention is to provide a tower structure which is particularly adapted for installation in offshore locations. Another object of this invention is to provide a tower structure which is especially advantageous for the slant hole drilling of wells to relatively shallow producing formations. Another object of this invention is to provide an improved offshore tower structure from which the maximum number of wells can be drilled with or from a minimum size drilling platform configuration. Another object of this invention is to provide an improved tower structure which provides maximum structural strength with minimum structural material requirements. Another object of this invention is to provide an offshore tower structure which is particularly adapted for location in ice areas. Another object of this invention is to provide an offshore tower structure which employs platform space and storage space to maximum efficiency. Other aspects, objects, and advantages of the invention will be apparent to those skilled in the art in view of this disclosure.

Thus, according to the invention, there is provided a tower comprising: a lower base; an upper platform; a plurality of spaced apart, essentially vertically disposed legs, connected to said platform and extending between said base and said platform, and arranged about a central vertical axis; a plurality of upwardly extending, spaced apart, inclined legs connected to and extending between said base and said platform, arranged about said axis at distances greater than the distances of said vertically disposed legs from said axis, and each inclined with respect to said axis so that upon revolution of any one of said inclined legs about said axis at an essentially constant angle of inclination there is described a surface of revolution which defines a hyperboloid of one sheet. Stated another way, the longitudinal axis of each of said legs lies within a surface of revolution which defines a hyperboloid of one sheet.

FIG. 1 is a view in elevation illustrating a tower constructed in accordance with the invention wherein each inclined leg represents a line of form (or ruling, as mathematically defined) of a hyperboloid.

FIG. 2 and FIG. 3 are partial plan views of two representative drilling decks which can be employed in a tower structure of the invention.

FIG. 4, FIG. 5, FIG. 6, and FIG. 7 are diagrammatic views illustrating various storage arrangements which can be employed in the tower structures of the invention.

FIG. 8 is a diagrammatic plan view taken through the gorge of a hyperboloid tower structure, similar to that illustrated in FIG. 1, but wherein two rows of inclined legs are employed.

FIG. 9 and FIG. 10 illustrate two types of clamp arrangements which can be employed in connecting adjacent legs of a tower structure wherein two rows of oppositely inclined legs are employed.

FIG. 11 is a diagrammatic plan view of one type of base structure which can be employed in a tower structure of the invention.

FIG. 12 is a view in cross section illustrating one means for anchoring the inclined legs of a tower structure of the invention to the earth.

FIG. 13 is a partial plan view of another drilling deck which can be employed in a tower structure of the invention, and showing the tops of elliptically arranged inclined legs.

Referring now to said drawings, wherein like reference numerals have been employed to denote like elements, the invention will be more fully explained. FIG. 1 illustrates the hyperboloid concept of the tower of the invention wherein a plurality of inclined legs extend between an upper platform or deck and a lower base. The basic properties of the hyperboloid, e.g., the diameter of the gorge, the angle of inclination of the legs, and the vertical location of the gorge, can be varied to provide the desired leg inclination, gorge size, gorge location, platform size, etc., to adapt the tower structure to a particular location. Thus, the invention provides a basic tower structure which can be adapted for a wide variety of locations and conditions of use.

Referring more specifically to FIG. 1, there are illustrated several embodiments of a tower in accordance with the invention. For convenience, but not by way of limitation, the tower will be further described with particular reference to being used in an offshore location. Said tower is designated generally by the reference numeral 10. Said tower comprises a lower base 12 and an upper platform or well head deck 14. A plurality of spaced apart, essentially vertically disposed, generally straight legs 16 are arranged about a central vertical axis, are connected to said platform 14, and extend between said base 12 and said platform 14. If desired, said vertically disposed legs 16 can also be connected to said base 12, as by grouting, as discussed hereafter. The number of said vertically disposed legs will depend upon tower size, location, use, and other factors, and the invention is not limited to any particular number thereof. However, generally speaking, the number of said vertical legs will usually be in the range of from four to 12. A plurality of spaced apart, inclined, generally straight legs 18 are also arranged about said axis at predetermined distances which are greater than the distances of said vertically disposed legs 16 from said axis. Each of said inclined legs 18 is connected to and extends between said base 12 and said well head deck or platform 14. Each of said inclined legs 18 is inclined in essentially the same direction with respect to the leg adjacent thereto and preferably at essentially the same angle with respect to said axis. Each of said inclined legs 18 is spaced apart symmetrically from said axis, preferably at essentially the same predetermined distance at any given generally horizontal plane located between the extremities of said legs. Said predetermined distance is less at a point intermediate the extremities of said legs than is the distance at said extremities. This lesser distance at said intermediate point defines the gorge of the hyperboloid structure. Said lesser distance can be varied vertically to vary the location of said gorge and thus locate the gorge either at the water line, above the water line,

or below the water line, as may be desired for any particular location. When each of said legs 18 is spaced equidistant from said axis along or on a given generally horizontal plane located between the extremities of said inclined legs, and when said legs are all inclined at essentially the same angle, there is obtained what can be called a circular hyperboloid, i.e., a hyperboloid in which the extremities of said legs 18 define a circle at the base and also define a circle at the well head platform 14. However, it is within the scope of the invention to vary the distance of the legs 18 from said axis on any given generally horizontal plane so that the extremities of said legs 18 at said base 12 and at said platform 14 will define an ellipse, or any other desired geometric design. Said legs 18 can terminate at said base 12 as illustrated in FIG. 12, or can extend below said base a short distance, e.g., 1 to 4 feet, as indicated by the dotted lines in FIG. 1, depending upon the nature of the sea bed or other location. For example, said legs can extend below base 12 when the sea bed is soft mud. Any suitable number of legs 18 can be employed. The number illustrated in FIG. 1 has been reduced from the number frequently employed so as to simplify the drawing.

When a tower of the invention is employed in an offshore location, as is illustrated in FIG. 1, the tower can, if desired, be employed in ice areas, such as Cook Inlet, Alaska. This can be done very effectively by sheathing the legs 18 with a suitable plate sheathing 20 through the water line area. By so doing and otherwise adjusting the geometric properties of the tower so as to give the legs 18 the desired inclination, the ice sheet will "ride up" the sheathed section and ultimately break under its own weight and disperse, especially when it changes direction at the gorge. This is an exceptionally effective technique for ice breaking. In many instances, depending upon the amount of ice present, it will be preferred to locate the gorge of the hyperboloid above the water line so as to enhance the movement of ice up the sheathing on the legs 18. This is illustrated in FIG. 1 by the alternate water line location. It will be noted that the tower of the invention is omnidirectional with respect to its exposure to dynamic forces such as waves, wind, etc., and likewise with respect to its structural strength. The employment of the plate sheathing 20 in ice areas completes the omnidirectional properties of the tower in ice areas. Employing the ice sheathing 20 presents only a smooth symmetrical surface to the forces of the ice. This is a distinct advantage over towers which have a plurality of legs extending into the water and each of which can be encountered by the ice. the

Said base 12 can be adapted to rest on the bed of a body of water, as illustrated in FIG. 1, or can be adapted to rest on a dry shore location. Said base 12 can be any suitable type of base, as is discussed further hereinafter, for either of said locations. Said well head deck 14 can be any type of platform suitable for the main purpose of the tower. A drilling deck 22 is disposed above said well head deck 14 and supported therefrom by any suitable structural means (not shown). Ladders 24 are provided between said decks 14 and 22. A guard rail 26, of any suitable design, can be provided around the well head deck 14, if desired.

FIG. 2 is a diagrammatic plan view of one embodiment of a drilling deck 22. Shown thereon are the tops of the vertically disposed legs 16 and the upwardly extending inclined legs 18. The tops of said legs 16 and said legs 18 are open. Piling or conductor tubes of a hollow tubular type are driven downwardly through said vertical legs 16 into the earth below base 12 by conventional pile driving equipment. Said pilings are generally coextensive with said legs 18 and provide very effective support for the tower and prevent both vertical and lateral movement of the tower. If desired, the hollow tubular piling or conductor tubes driven through said legs 16 can also be employed for conducting a drill string down therethrough and into the earth for the drilling of wells. It will be noted that the central space of the drilling deck is relatively vacant. This provides space for the location of auxiliary drilling equipment, such as mud tanks 28, mud pumps, generators, etc., which can remain stationary in the center of the platform. Preferably, the drilling derrick 30 and related equipment will be mounted on wheels adapted to be moved over tracks 32 from one well to another. If desired, a guard rail 34 can be provided around the top of drilling deck 22.

FIG. 3 illustrates an alternate type of drilling deck which can be employed in the practice of the invention, such as when two rows of inclined legs 18 are installed.

FIGS. 4, 5, and 6 illustrate various storage arrangements which can be installed in the towers of the invention. In FIG. 4 a semiconical storage tank, having both an upper component 36 and a lower component 38, has been installed within the space defined by the inner surfaces of the inclined legs 18. In FIG. 5 a semiconical storage tank having only a lower component 38 has been installed in the lower portion of the space defined by the inner surfaces of the inclined legs 18. In FIG. 6 a cylindrical storage tank has been installed within the space defined by said inner surfaces of said inclined legs 18. The storage tank of FIG. 7 has been fabricated by sheathing the inner surfaces of the inclined legs 18 with plate sheathing so as to provide a lower component 38' which makes maximum use of the space within said legs 18. If desired, a storage tank could also be constructed within the upper portion of the hyperboloid in FIG. 7. Placing sheathing on the inner walls of the inclined legs 18 as shown in FIG. 7 also adds to the structural strength of the tower. It will be understood that any suitable type of conventional liquid filling and emptying means (not shown) can be employed in connection with the storage tanks illustrated in FIGS. 4, 5, 6, and 7. In most instances, the storage volume provided within the interior of the hyperboloid will be sufficiently large to permit discharge of the oil, or other liquid stored therein, directly to a tanker or barges through a monomooring buoy. Additionally, if desired, the storage tank(s) may also be employed to serve as buoying or flotation chambers to assist in field erection in offshore locations.

FIG. 8 illustrates one presently preferred embodiment of the invention which can be employed when maximum structural strength is desired. Said FIG. 8 is a diagrammatic plan view taken through the gorge of a tower similar to the tower illustrated in FIG. 1. In FIG. 8 there are shown two rows of inclined legs 18 and 18'. The second plurality of spaced apart, inclined, generally straight legs 18' can be inclined in the same direction as said first row of legs 18, if desired. However, for maximum structural strength said second row of legs 18' is preferably inclined in a direction opposite to, and preferably at the same angle, as said first row of legs 18. The legs in said second row of inclined legs 18' are arranged about the central axis at predetermined distances which are greater than the distances of the legs 18 in the first row of inclined legs. Each leg in said second row of legs 18' is preferably connected to and extends between said base 12 and said well head deck 14, similarly as the first row of legs 18. Said second row of legs 18' greatly increases the structural strength and stability of the tower, particularly when said second row of legs 18' is inclined oppositely to the first row of inclined legs 18. Piling or conductor tubes can be installed within said legs 18', and employed for drilling purposes, in a manner similar to said first row of inclined legs 18.

FIG. 9 and FIG. 10 illustrate two types of connecting or clamping means which can be provided between the tangent or adjacent legs of the first plurality of inclined legs 18 and the second plurality of inclined legs 18'. In FIG. 9 the clamping means, designated generally by the reference numeral 40, is comprised of two separable members 42 and 44 which are held together by means of bolts (not shown) which can be inserted through the holes illustrated. In use, the two members 42 and 44 are placed about legs in the adjacent rows of inclined legs in the manner illustrated and then bolted together. In FIG. 10 the clamping means comprises a sheet or bar of metal 46 having in each end thereof an arcuate surface 48 adapted to engage the surface of a leg 18 or a leg 18'. If desired, the arcuate surface(s) 48 can be welded to the legs 18 and 18'. To provide additional strength a rod 50 extending

through the plate 46 can be provided to extend around the tower structure. In both FIG. 9 and FIG. 10, it will be understood that said clamping means can be employed between each pair of adjacent legs 18 and 18', between alternate pairs of adjacent legs 18 and 18', or any other lesser number of clamping means can be employed, such as on every third, fourth, or fifth pair of adjacent legs 18 and 18'.

FIG. 11 illustrates diagrammatically one form of base 12 which can be employed in the towers of the invention. Said base can be of any suitable geometric arrangement depending upon tower size, the requirements of a particular location, etc. As here illustrated, said base comprises a generally circular member 52 of generally circular cross section which is divided into four compartments by means of bulkheads 54. It will be understood to be within the scope of the invention to provide more than four compartments by increasing the number of bulkheads 54. Said compartments can be provided with conventional filling and emptying means, not shown. In one embodiment, legs 18 extend through and terminate at member 52, as shown more clearly in FIG. 12. In another embodiment, said legs 18 can extend through member 52 into the earth as illustrated in FIG. 1. A centrally disposed sheet or plate of steel 56 is disposed in the center of the circular member 52. Said plate of steel 56 is supported and connected to circular member 52 by means of I-beams 58 or other suitable structural members. Vertical legs 16 extend through openings or guides 57 provided in said sheet of metal 56. If desired, said vertical legs can be connected to said sheet 56 as by grouting around openings or guides 57 after legs 16 are in place. Said guides 57 can be any suitable type such as an enlarged tube, or a tube having an upper funnellike or conical opening. If desired, member 56 instead of being a sheet of steel can be a compartmented structure, similar to the outer circular member 52. It will be understood that when an outer row of inclined legs 18' is employed, the circular member 52 can be enlarged sufficient to accommodate said outer row of legs 18', similarly as for legs 18, or a second circular member 52 can be employed if desired.

Referring now to FIG. 12, each leg 18 can extend through the circular member 52 of base 12 and be connected to said member 52 at its points of intersection therewith, as by welding. Said legs 18 can terminate at member 52, as shown in FIG. 12, or can extend therethrough as shown in FIG. 1. In order to enable a tower to be more positively anchored to the bed beneath the body of water, or to the surface of the earth, each of the inclined legs 18 has disposed therein a generally coextensive, concentric conductor tube 60 which is of a size somewhat smaller than the interior of leg 18. Each conductor tube 60 may be driven downwardly and partially out the lower extremity of leg 18 by means of conventional pile driving technique and equipment. Grouting 62 can be pumped downwardly through the annulus between leg 18 and conductor 60 from the open upper end thereof so as to fill said annulus, or suitable connecting means can be provided adjacent and above circular member 52 for pumping said grouting into the lower portion of said annular space, as desired. Generally speaking, it is usually preferred to fill at least a substantial portion of said annulus with grouting. As shown, a portion of the grouting is preferably forced out into the earth beyond the end of leg 18.

Towers constructed in accordance with the invention can be fabricated in any convenient manner. In one presently preferred manner of fabrication, an assembly comprising a base 12, a platform or well head deck 14, and an inner row of inclined legs 18 is prefabricated. If the tower is to be employed in an offshore location, it can then be floated (by the buoyancy provided by base 12) to said location in either an "upright" or horizontal position employing known techniques. If desired, or necessary, the well head deck end of the structure can be supported by any suitable temporary buoyancy means. Any suitable temporary sealing means can be employed to seal the legs 16 and 18 to exclude water and provide additional buoyancy if desired. Said base 12 can be partially filled, if desired, so as to partially sink the tower in the water and make it more maneuverable. Upon arrival at the offshore location the tower is upended, if not previously done, and caused to settle onto the sea bed by flooding the compartments in base 12. Hollow, tubular, vertical conductor tubes or piling are then driven downwardly through the vertical legs 16, out the bottom thereof, and into the earth for a suitable distance to serve as piling to anchor and support the tower. Said conductor tubes can be driven through said legs 16 by conventional pile driving techniques. Next, inclined conductor tubes 60 are driven through the inclined legs 18, starting on one side and then driving an alternate conductor on the opposite side, etc. The remainder of the tower and associated equipment can then be installed employing conventional techniques. In drilling operations said conductor tubes in vertical legs 16 and inclined legs 18 serve to conduct a drill string down into the earth.

The following Table I will serve to illustrate various embodiments of the invention.

TABLE I

Height, ft., base to well head deck	Radius [1] at gorge, ft.	Angle of inclination, degrees	Radius [1] at well head deck, ft.	No. of wells [2]	Well spacing, ft.	Storage, bbls. ½ cone core [3]	Storage, bbls. Cylinder core [4]
200	15	30	59.6	37	10.1	82,000	21,000
		15	30.7	37	5.2	27,000	21,000
200	20	30	61.1	50	7.7	94,000	39,000
		15	33.4	50	4.2	37,000	39,000
200	25	30	62.9	62	6.4	109,000	63,000
		15	36.6	62	3.7	50,000	63,000
200	30	30	65.1	75	5.5	128,000	93,000
		15	40.2	75	3.4	65,000	93,000

[1] Of longitudinal centerline of legs 18 (see FIGURE 1).
[2] Based on 30" o.d. pipe size for legs 18; use of 24" o.d. pipe would increase number of wells by about 25%.
[3] See FIGURE 5.
[4] See FIGURE 6.

The above Table I illustrates the remarkable flexibility in the towers of the invention which are fabricated in accordance with the hyperboloid concept. For example it will be noted that the number of wells can be increased approximately 25 percent by merely decreasing the outside diameter of the legs 18' from 30 inches to 24 inches. Another advantage of the towers of the invention is that said vertical legs 16 and said inclined legs 18 (and 18' if present) can be the sole support for platforms 14 and 22. No other supporting framework is required. The hyperboloid concept also makes possible the placing of the wells on a larger radius, i.e., adjacent the edges of the well head and the drilling deck, than has been possible in towers of the prior art. This permits greater spacing between wells. If desired, still more space can be obtained on the well head deck by placing well head equipment on alternate wells at higher elevations.

While certain embodiments of the invention have been described for illustrative purposes, the invention is not limited thereto. Various other modifications of the invention will be apparent to those skilled in the art in view of this disclosure. Such modifications are within the spirit and scope of the disclosure.

I claim:

1. A tower comprising: a lower base; an upper platform; a plurality of spaced apart, essentially vertically disposed legs, connected to said platform and extending between said base and said platform, and arranged about and spaced apart from a central vertical axis; a plurality of upwardly extending, spaced apart, inclined legs connected to and extending between said base and said platform, arranged throughout their length about said axis at distances greater than the distances of said vertically disposed legs from said axis, and each said inclined leg being inclined with respect to said axis at an essentially constant angle of inclination so that the longitudinal axis of each of said inclined legs lies within a surface of revolution which defines a hyperboloid of one sheet; and said vertically disposed legs and said upwardly extending inclined legs being the sole support extending between said platform and said base.

2. A tower comprising: a lower base; an upper platform; a plurality of spaced apart, essentially vertically disposed, generally straight legs arranged about and spaced apart from a central vertical axis, connected to said platform, and extending between said base and said platform; and a plurality of spaced apart, inclined, generally straight legs, arranged throughout their length about said axis at distances greater than the distances of said vertically disposed legs from said axis, each said inclined leg being connected to and extending between said base and said platform, each said inclined leg being inclined in essentially the same direction with respect to the leg adjacent thereto and at essentially the same angle with respect to said axis, and each said inclined leg being spaced from said axis at a symmetrically arranged predetermined distance at any given generally horizontal plane located between the extremities of said inclined legs with said predetermined distance being less at a point intermediate said leg extremities than at said leg extremities; said vertically disposed legs and said upwardly extending inclined legs being the sole support extending between said platform and said base.

3. A tower according to claim 2 wherein: each of said essentially vertical legs extends through said base and into the earth so as to anchor said tower; each of said inclined legs is tubular, has a hollow interior, and has open upper and lower extremities; an inner conductor tube is installed within at least some of said inclined legs; and at least some of said conductor tubes extend out the lower extremity of its associated inclined leg and into the earth so as to further anchor said tower.

4. A tower according to claim 3 wherein: said tower is an offshore tower; said base is adapted to rest upon the bed of a body of water with a portion of said tower extending above the surface of the water; and said conductor tube is adapted to receive a drill string and conduct same downwardly into the earth at an inclination to the vertical.

5. A tower according to claim 4 wherein: said conductor tube is generally coextensive with the inclined leg in which it is installed so as to form an annulus between said conductor tube and said inclined leg; and said annulus is at least partially filled with grouting.

6. A tower according to claim 4 wherein: each of said vertically disposed legs is tubular, has a hollow interior, has open upper and lower extremities, and is adapted to receive a drill string and conduct same downwardly into the earth.

7. A tower according to claim 1 wherein liquid storage tank means is disposed below said upper platform and is supported on said base within the region defined by the inner edges of said inclined legs.

8. A tower according to claim 4 wherein: at least a portion of the outer edges of said inclined legs are covered with a continuous sheath of metal plate.

9. A tower according to claim 2 wherein: there is provided a second plurality of spaced apart, inclined, generally straight legs, arranged about said axis at distances greater than the distances of said first plurality of inclined legs from said axis, each connected to said platform and extending between said base and said platform, and each being inclined with respect to each other in the same direction and at essentially the same angle with respect to said axis as the legs of said first plurality of inclined legs.

10. A tower according to claim 9 wherein the inclined legs in said second plurality of inclined legs are each inclined with respect to each other in a direction opposite to the direction of the legs of said first plurality of inclined legs.

11. A tower according to claim 10 wherein connecting means are provided between tangent or adjacent legs of said first plurality of inclined legs and said second plurality of inclined legs.

12. A tower according to claim 9 wherein: each of said essentially vertical legs extends through said base and into the earth so as to anchor said tower; each of said inclined legs is tubular, has a hollow interior, and has open upper and lower extremities; an inner conductor tube is installed within at least some of said inclined legs; and at least some of said conductor tubes extend out the lower extremity of its associated inclined leg and into the earth so as to further anchor said tower.

13. A tower according to claim 12 wherein: said tower is an offshore tower; said base is adapted to rest upon the bed of a body of water with a portion of said tower extending above the surface of the water; and said conductor tube is adapted to receive a drill string and conduct same downwardly into the earth at an inclination to the vertical.

14. A tower according to claim 13 wherein: each of said vertically disposed legs is tubular, has a hollow interior, has open upper and lower extremities, and is adapted to receive a drill string and conduct same downwardly into the earth.

15. A tower according to claim 13 wherein: liquid storage tank means is disposed below said upper platform and is supported on said base within the region defined by the inner edges of said inclined legs.

16. A tower according to claim 11 wherein: at least a portion of the outer edges of said outer row of inclined legs are covered with a continuous sheath of metal plate.

17. A tower according to claim 2 wherein each of said inclined legs is spaced equidistant from said axis at any given generally horizontal plane located between the extremities of said legs and said extremities of said legs are spaced equidistant from said axis to form a generally circular pattern at said extremities of said inclined legs; said vertical legs and said inclined legs providing a support structure which is omnidirectional between said base and said platform with respect to dynamic environmental forces such as wind, ice, and water.

18. A tower according to claim 2 wherein each of said inclined legs is spaced from said axis in a manner to form a generally elliptical pattern at said extremities of said inclined legs.

19. A tower according to claim 1 wherein said vertically disposed legs and said upwardly extending inclined legs provide a support structure which is omnidirectional between said base and said platform with respect to dynamic environmental forces such as wind, ice, and water.

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