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Kouka

[11] **3,756,033**

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[54] **OFFSHORE STRUCTURE WITH ROTATING AND INDEXING MECHANISM FOR PLACING PILES**

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[52] **U.S. Cl.** **61/46.5,** 61/50, 61/53.5

[51] **Int. Cl.** **E02b 17/00,** B63b 35/44

[58] **Field of Search** 61/46, 53.5, 46.5, 61/52, 50; 64/16, 17; 9/8; 287/138

[56] **References Cited**

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[57] **ABSTRACT**

An offshore structure having a base resting on a sea floor, a plurality of vertical pile-receiving sleeves in the base, an elongated rigid vertical member joined to the base by a connection which permits angular pivotal displacement and rotation of the vertical member, and at least one vertical pile-guiding means positioned on the vertical member to be axially alignable with a plurality of the vertical pile-receiving sleeves on an individual sleeve basis upon rotation of the vertical member about its vertical axis.

9 Claims, 7 Drawing Figures

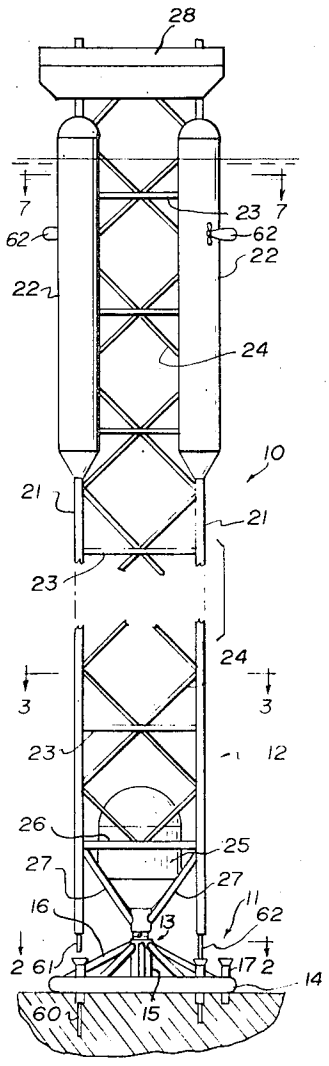


FIG.1

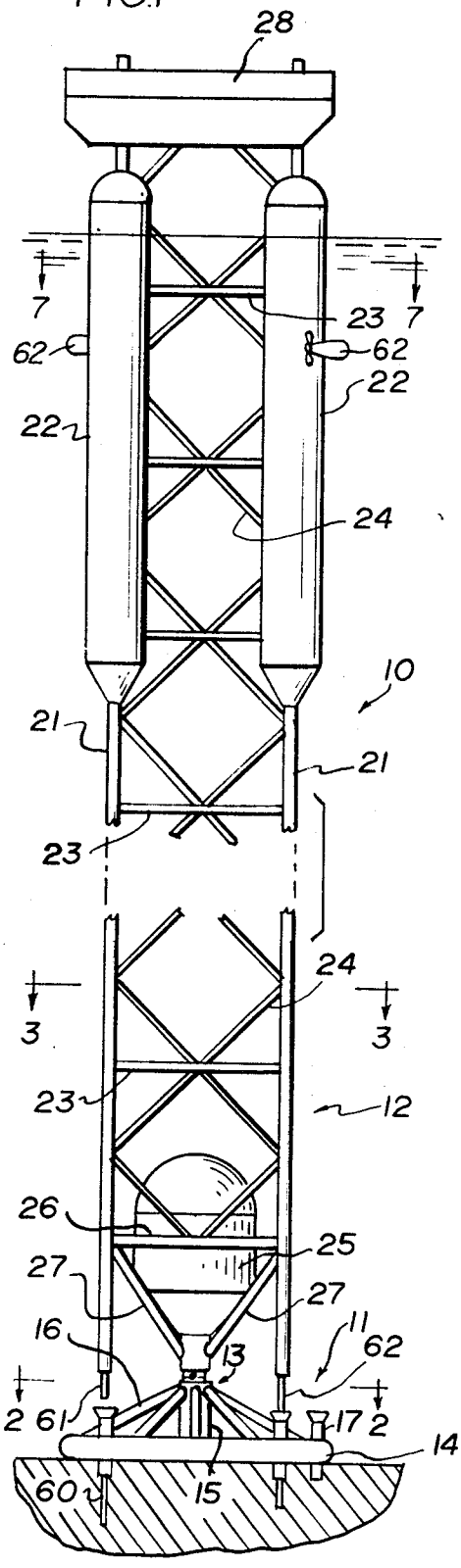


FIG.2

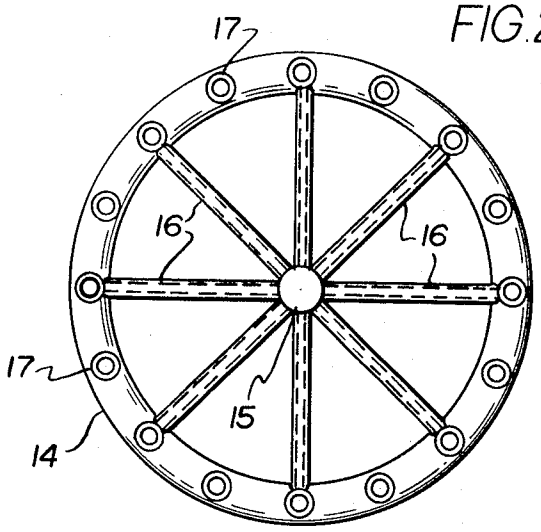


FIG.3

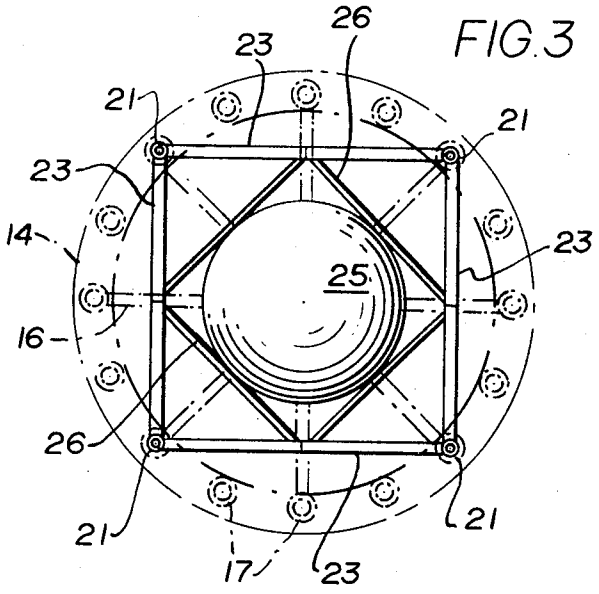


FIG.7

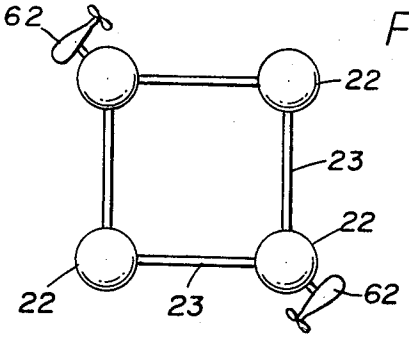


FIG. 4

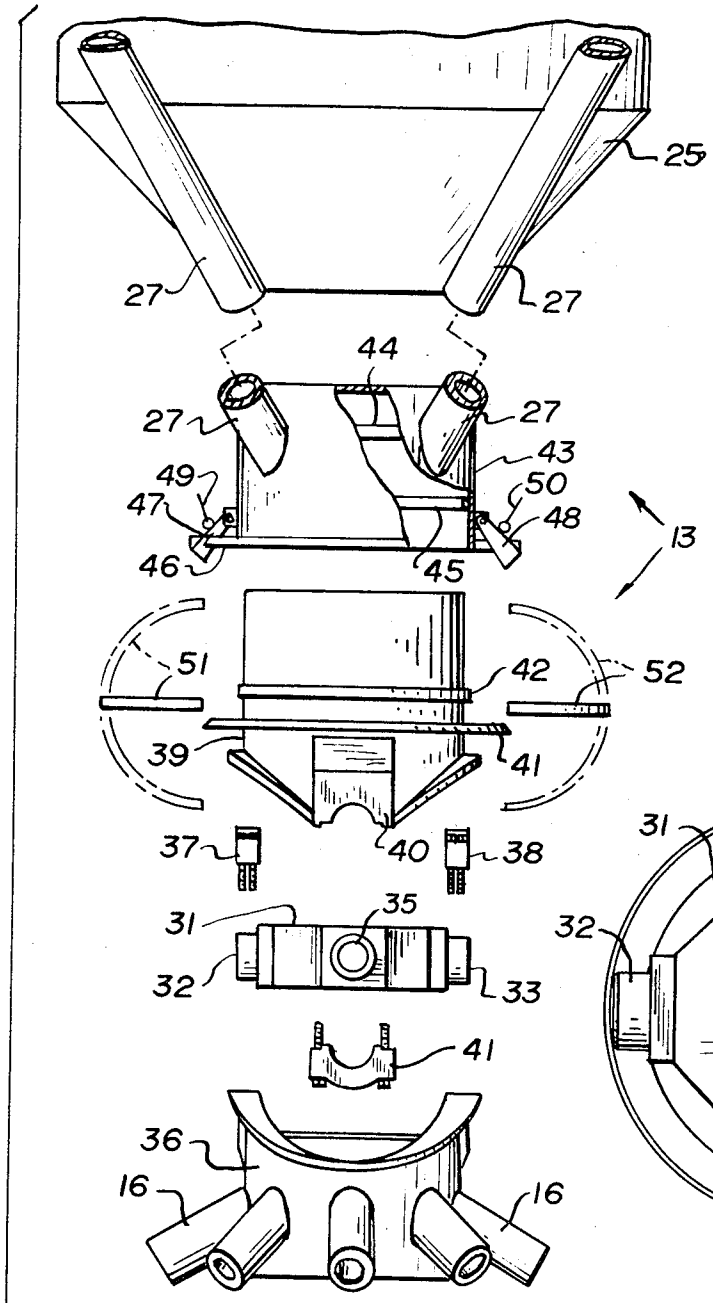


FIG. 6

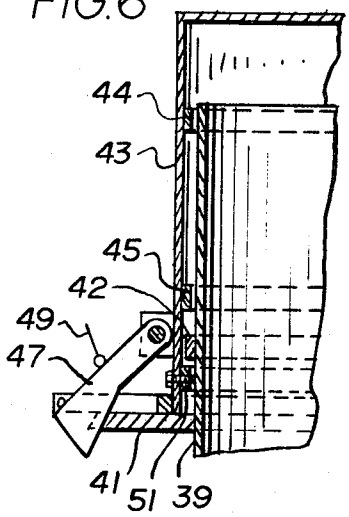
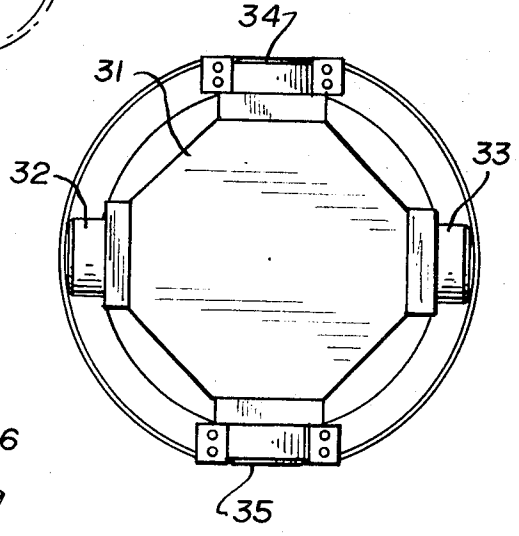


FIG. 5



OFFSHORE STRUCTURE WITH ROTATING AND INDEXING MECHANISM FOR PLACING PILES

This invention relates to offshore structures such as are used for the exploration and production of oil, as well as for ship moorings and other purposes.

In the production and exploration for oil offshore, it is quite common to use structures which rest on the sea floor. Such structures can be used for well drilling and also for use in producing oil after it is found. Various types of offshore structures have been developed and are in use for such purposes. Most such structures however are only suitable for use in relatively shallow water such as up to about 250 feet in depth. Offshore structures for use in deeper water generally must be designed differently than those used in shallow water. Chamberlin et al. U.S. Pat. No. 3,553,969 discloses an offshore structure for use in deep water. That structure comprises a base or foundation which rests on a sea floor and a vertical shaft or tube which is connected at its lower end by a pivotal connection, such as a universal joint, to the base or foundation. The shaft or tube extends upright to above sea level and has sufficient buoyancy to maintain it in an upright, vertical position when no significant wind or sea forces are applied to it. When sea or wind forces are applied, it pivots angularly from its pivot connection at its lower end but the tilting is not excessive because of the buoyancy which the shaft possesses.

The offshore structure of the type shown in Chamberlin et al is considered to have wide usefulness. However, to be suitably employed in deep water, it is necessary that the base or foundation be well secured to the sea floor by means of piles. The implacement of piles in deep water is most difficult as well as expensive. Even when the base or foundation is previously provided with suitable pile-receiving sleeves or tubes, it is time consuming and troublesome to direct a pile from the sea surface into such a pile-receiving sleeve. It is difficult to make alingment and, even when alignment is achieved, it is often lost through action of wave and sea currents before the pile can be threaded or slipped into the pile-receiving sleeve. It is accordingly necessary in many instances to employ the services of a deep sea diver to properly position the pile. Deep sea divers however cannot actively work in deep water for more than one-half to one hour without emerging for an extended period. Furthermore, they must employ special equipment including the use of a breathing system which employs unique gas mixtures such as oxygen and helium. It is therefore believed clear that there is a great need for means to facilitate the installation of piles into the base or foundation of an offshore structure, paricularly of the type shown in Chamberlin et al.

According to the present invention there is provided an offshore structure adapted to be supported on a sea floor comprising a base adapted to rest on a sea floor, a plurality of substantialy hollow vertical pile-receiving sleeves in the base for receiving piles to be driven into the sea floor, an elongated rigid normally substantially vertical member joined to the base by a mechanical connection means which permits angular pivotal displacement of the vertical member about said connection, said connection permitting rotation of the vertical member about the axis of said vertical member, and said vertical member having at least one vertical pile-guiding means positioned thereon which is axially

alignable with a plurality of the vertical pile-receiving sleeves, on an individual sleeve basis, upon rotation of the vertical member about its vertical axis. The offshore structure also advisably includes means to align and position the pile-guiding means axially to pile-receiving sleeves on an individual sleeve basis. The pile-receiving sleeves are advisably positioned an equal distance radially from the mechanical connection means or, in other words, more or less in a circular arrangement in the base or foundation structure. Furthermore, the pile-guiding means is also positioned the same distance radially from the mechanical connection means as are the pile-receiving sleeves.

The invention also provides a method of securing such an offshore structure to a sea floor by piles. The described structure is employed in such method. In performing the method, a pile is placed in the pile-guiding means and by means of such guide it is fed into a pile-receiving sleeve. The pile is then driven into the sea floor. After that the vertical member is rotated until the pile-guiding means is in alignment with a second pile-receiving sleeve. A pile is then placed in the pile-guiding means and fed by it into a second pile-receiving sleeve following which the pile is driven into the sea floor. This procedure is repeated until the piles are driven into the sea floor. The piles can be grouted or cemented to the base or foundation after the driving of each is completed or after a plurality of all of the piles have been driven into the sea floor.

The invention will now be described further in conjunction with the attached drawings in which:

FIG. 1 is an elevational view of an offshore structure provided according to the invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 1;

FIG. 4 is an expanded view of the mechanical connection member elements;

FIG. 5 is a plan view of the trunnion block of the mechanical connection shown in FIG. 4;

FIG. 6 is a vertical sectional view of the telescoping tubular members of the mechanical connection of FIG. 4 which holds the mechanical connection together while permitting rotation and indexing of the pile-guiding means with the pile-receiving sleeves; and

FIG. 7 is a diagrammatical sectional view taken along the line 7—7 of FIG. 1 and shows thrusters for rotating the structure.

So far as is practical, the various parts and elements which appear in the different views of the drawings will be identified by the same numbers.

With reference to FIGS. 1 to 3, the offshore structure 10 has a base or foundation 11, a vertical member 12 and a mechanical connection 13 at the lower end of the vertical member which joins it to the base 11.

Base 11 comprises a toroidal member 14 which is joined to a vertical cylindrical centrally located supporting post member 15 by a purality of spokes 16. A plurality of pile-receiving sleeves 17 are vertically positioned in toroidal member 14. Normally there will be far more pile-receiving sleeves than are shown in FIGS. 1 to 3 but, for purposes of clarity, only a limited number thereof have been shown in the drawings. The spokes 16 are shown in FIG. 1 to be inclined at an angle. It should be understood that additional horizontal spokes extend from member 14 to the central post 15

to further strengthen the structure. Furthermore, the base as illustrated by FIGS. 1 to 3 is only representative of bases or foundations which can be employed in the offshore structure. Other shapes and designs can be used for the base provided they have the necessary pile-receiving sleeves and means for joining with, or receiving, a mechanical connection which permits the desired angular movement or displacement and axial rotation of vertical member 12.

The vertical member 12, as shown in FIGS. 1 and 3, has four vertical hollow tubes 21. Each of the tubes 21 extends through a buoyancy tank 22 positioned around the upper end of each tube. Horizontal braces 23 join adjacent tubes 21 and adjacent floatation tanks 22 together. Diagonal braces 24 also extend from adjacent tubular members 21 and adjacent floatation tanks 22 and are joined thereto to reinforce the entire vertical member 12 and thereby form a truss-like structure. Tank 25 is located in the lower or bottom portion of vertical member 12 to provide a means for applying ballast to the bottom part of the vertical member to thereby obtain a structure having a center of gravity such that the vertical member 12 will normally be upright when the structure is in water. Tank 25 is held in position by means of braces 26 and downwardly extending spokes 27 (FIGS. 1 and 4). On top of vertical member 12 there is positioned a platform 28 which can be used as desired. It is located to be above wave action of the sea.

The mechanical connection 13 which joins the vertical member 12 to the base 11 is shown in greater detail in FIGS. 4 to 6. With reference to FIGS. 4 and 5, trunnion block 31 has opposing trunnions 32 and 33, and at right angle thereto it has opposing trunnions 34 and 35. Trunnions 32 and 33 rest in bearing blocks provided in supporting member 36 which is held in fixed position by welding it to the ends of diagonal spokes 16. Bearing elements 37 and 38 are employed to secure trunnions 32 and 33 respectively to supporting member 36 in a manner which permits axial rotation of the trunnion block 31 by means of trunnions 32 and 33. Upper supporting member 39 has a pair of spaced-apart opposing bearing blocks 40 which receive trunnions 34 and 35, and such trunnions are held in place by a pair of bearing elements 41. The resulting mechanical connection is a universal joint which permits member 39, and any element attached thereto, to be angularly displaced.

The upper supporting member 39 is provided with base plate 41 and a spacing, retaining ring 42. The upper supporting member 39 is of generally tubular shape and telescopes inside of tubular cylindrical rotatable member 43. The ends of diagonally located spokes 27 are welded to rotatable member 43 to secure it to the bottom portion of vertical member 12. Guide and spacing rings 44 and 45 are positioned on the inside wall of rotatable member 43. A contact plate 46 is positioned along the lower outer edge of rotatable member 43 and it has a plurality of slots in the perimeter thereof to receive pawls 47 and 48 which are pivotably joined at their upper ends to rotatable member 43. Cables 49 and 50 are joined to pawls 47 and 48 respectively and extend to platform 28 to raise the pawls from such slots to disengage them from plate 41 as will be subsequently further explained. Suitable mechanical means such as a pneumatic or hydraulic actuated rams can be used in place of cables 49 and 50 to raise and lower the pawls.

Member 39 is telescoped into rotatable member 43 until plate 46 contacts plate 41 as shown in the sectional view of FIG. 6. The two half-circle rings 51 and 52 (FIGS. 4 and 6) are then bolted to the inside lower surface of rotatable member 43 at a location below spacer ring 42 on member 39. When an upward force is applied to member 43, the half circle rings 51 and 52 come into contact with ring 42 and thereby prevent further upward movement thereof.

Appropriate slots are provided in plate 41 to receive pawls 47 and 48 when at least one of the vertical tubular members 21 is axially aligned with at least one of the pile-receiving sleeves 17. When alignment is thereby effected, a pile threaded through tubular member 21 will be guided and directed into a pile-receiving sleeve without any additional means being required for such orientation. Of course, the pile-receiving sleeves 17 can be so spaced as to have two or more of the vertical tubular elements 21 aligned with respective pile-receiving sleeves 17 at any one time when the pawls are positioned in receiving slots in plate 41. For such an arrangement vertical tubular elements 21 are positioned radially from the vertical axis of vertical member 12 at a distance substantially equal to the radial distance that the pile-receiving sleeves 17 are located from the vertical axis of the base or foundation 11. Such radial distance can conveniently be measured from the central axis of the mechanical connection means which, in the case as illustrated, is a universal joint.

FIG. 1 illustrates a pile 60 which has been driven into the sea floor and then cut-off from an upper pile extension 61. Pile 60 can then be grouted or cemented in the pile-receiving sleeve. Pile 62 (FIG. 1) is in process of being driven into the sea floor. After it has been driven to the desired depth it can be cut off above the pile-receiving sleeve 17. Then vertical member 12 can be rotated, after first raising pawls 47 and 48 from slots in plate 41, by any suitable means. When pawls 47 and 48 again fall into slots in plate 41, at least one of tubular members 21 is again in alignment with a pile-receiving sleeve 17. Another pile is then threaded through the tubular member 21 into a sleeve 17 and is then driven into the sea floor. Driving the piles can be effected from platform 28 above sea level. This operation is repeated until the piles are driven into place and grouted.

FIG. 7 shows a means of rotating vertical member 12 although other common means, such as a tugboat, can be used. Electric powered reversible-propeller thrusters 62, previously known in the art and not claimed herein, can be mounted on two opposing buoyancy tanks 22 to provide the desired rotation of vertical member 12.

After all the piles are driven into place, or earlier if only some of the piles are to be driven into place using the described system, the telescoping members 39 and 43 are secured together, such as by means of grout, to prevent further rotation of vertical member 12 about its vertical axis.

Although members 21 are shown as tubes or pipes, they can also be trough-like members with suitable bands Other to provide guide means for the piles. dother structures can also obviously be used to guide the piles to thread them into the pile-receiving sleeves so that it is not intended to limit the invention to any one particular structure suitable for this purpose.

While the mechanical connection 13 shown in the drawings is a universal joint, it is not intended to limit

the invention to such a structure since a ball and socket or other mechanically equivalent connection can be used which permits angular deflection or displacement of vertical member **12** when the sea and wind forces are applied thereto.

Cutting of the piles above the top of the sleeves may be unnecessary if piling of suitable lengths are employed and connected end-to-end by releasable connections. After the pile has been driven to a depth which places such a connection above the top of a sleeve the connection can be released and a new length of piling added to the top to ready the apparatus for driving a pile in a different sleeve.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom as modifications will be obvious to those skilled in the art.

What is claimed is:

1. An offshore structure adapted to be supported on a sea floor comprising:

a base adapted to rest on a sea floor;

a plurality of substantially hollow vertical pile-receiving sleeves in the base for receiving piles driven into the sea floor;

an elongated rigid normally substantially vertical member joined to the base by a mechanical connection having means for angular pivotal displacement of the vertical member about said connection, said connection having means for rotation of the vertical member about the axis of said vertical member; and

the vertical member having at least one vertical pile-guiding means positioned thereon to be axially alignable with a plurality of the vertical pile-receiving sleeves on an individual sleeve basis upon rotation of the vertical member about its vertical axis.

2. An offshore structure according to claim **1** having index means to align and position the pile-guiding means axially to pile-receiving sleeves on an individual sleeve basis.

3. An offshore structure according to claim **1** in which a substantial number of the pile-receiving sleeves are essentially equidistant radially from the mechanical connection means and the pile-guiding means is the same radial distance from the mechanical connection means.

4. An offshore structure according to claim **1** in which the pile-guiding means includes a hollow tube.

5. An offshore structure according to claim **1** having a plurality of pile-guiding means alignable simultaneously with a plurality of pile-receiving sleeves.

6. An offshore structure according to claim **1** in which the mechanical connection is a universal joint.

7. An offshore structure according to claim **1** in which the mechanical connection includes vertical telescoping cylindrical members, one of which is rotatable axially with respect to the other.

8. The method of securing an offshore structure to a sea floor by piles which comprises:

positioning the offshore structure in sea floor supporting position, said offshore structure having a base resting on the sea floor, a plurality of substantially hollow vertical pile-receiving sleeves in the base, an elongated rigid normally substantially vertical member joined to the base by a mechanical connection means which permits angular pivotal displacement of the vertical member about said connection and rotation of the vertical member about the axis of said vertical member, and at least one vertical pile-guiding means positioned on the vertical member to be axially alignable with a plurality of the pile-receiving sleeves on an individual sleeve basis upon rotation of the vertical member about its vertical axis;

aligning the pile-guiding means with a pile-receiving sleeve;

feeding a pile along the pile-guiding means into the aligned pile-receiving sleeve;

driving the pile into the sea floor;

rotating the vertical member until the pile-guiding means is in alignment with a second pile-receiving sleeve;

feeding a pile along the pile-guiding means into the aligned second pile-receiving sleeve;

driving the pile into the sea floor; and

repeating said method.

9. The method of claim **8** in which the pile are driven into the sea floor from a position on the vertical member above the sea.

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