United States Patent

Pogonowski

[15] **3,638,436**

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[54] REVERSED SLOPE SKIRT PILE MARINE PLATFORM ANCHORING

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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; 52/158

[56] **References Cited**

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[57] **ABSTRACT**

The invention relates to a marine platform for supporting a deck or a similar working structure above the water's surface at an offshore location. The platform includes an uprightly positioned support jacket that extends to the sea floor, having anchoring means at the lower end for fixedly positioning the jacket in place. The anchoring means is so arranged with respect to the jacket to firmly locate the latter even though the anchoring substratum be underconsolidated, or characterized by generally poor holding ability. Said anchoring means embodies a series of peripherally located skirt piles that are sloped inwardly at an angle toward the support jacket interior to increase the resistance of the jacket to being displaced or upset from a vertical disposition. Lateral storm loads imposed against the jacket are thus transferred to the foundation strata by axial pile loads only. Safety, stability against overturning and total collapse of the entire marine structure is thereby improved.

6 Claims, 6 Drawing Figures

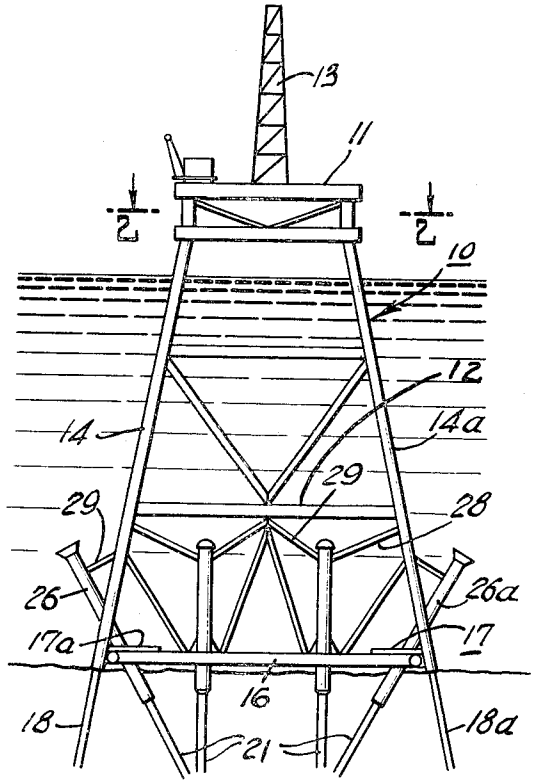


Fig. 1.

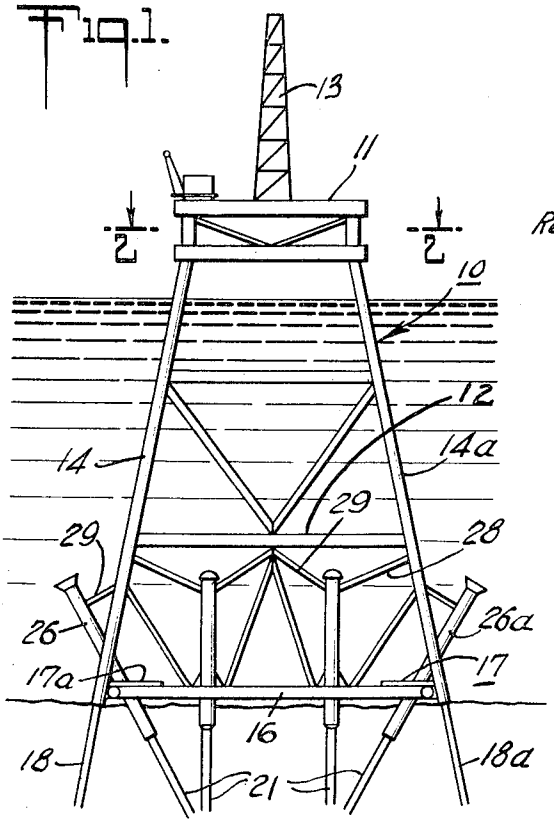


Fig. 3.

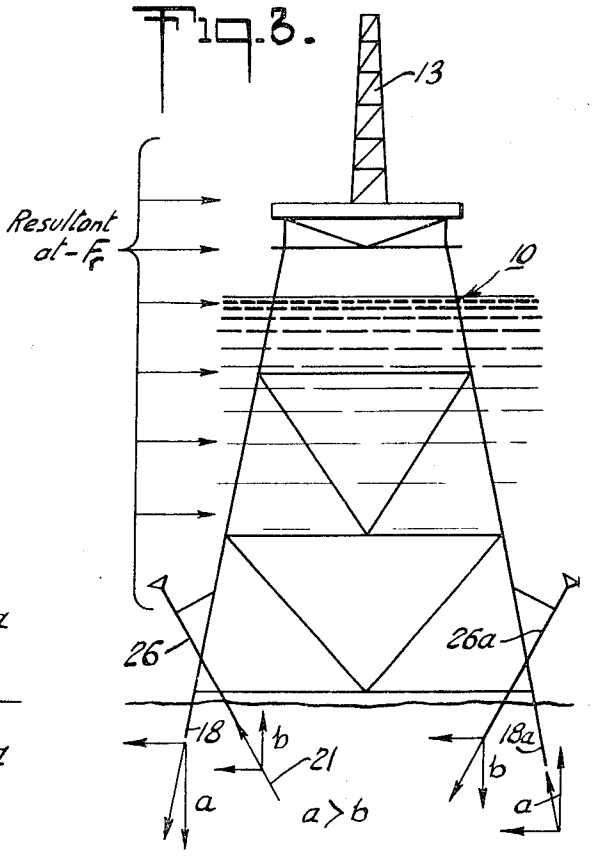


Fig. 2.

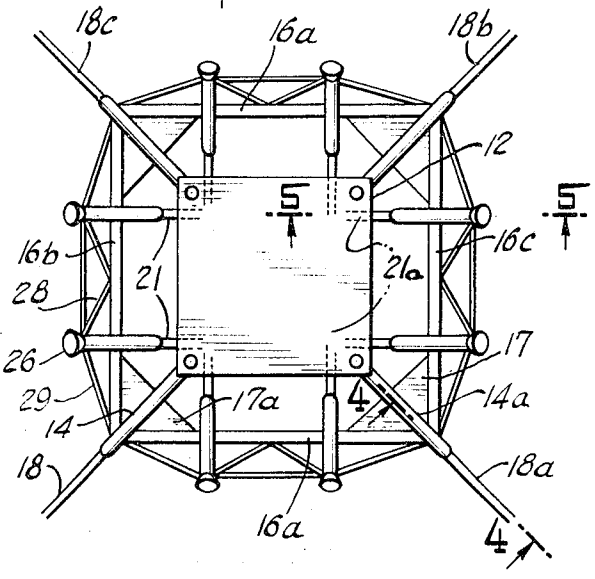


Fig. 4.

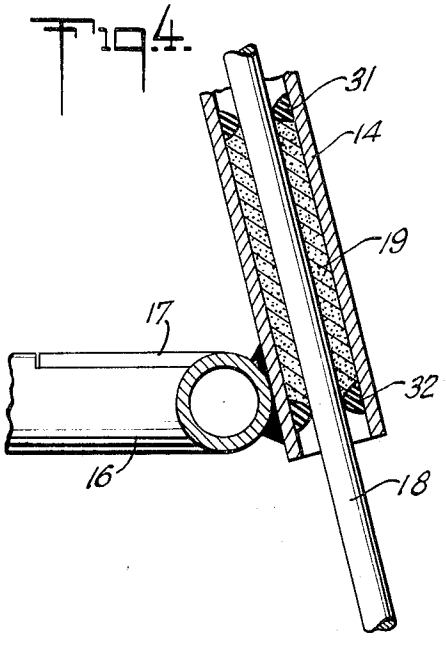


Fig. 5.

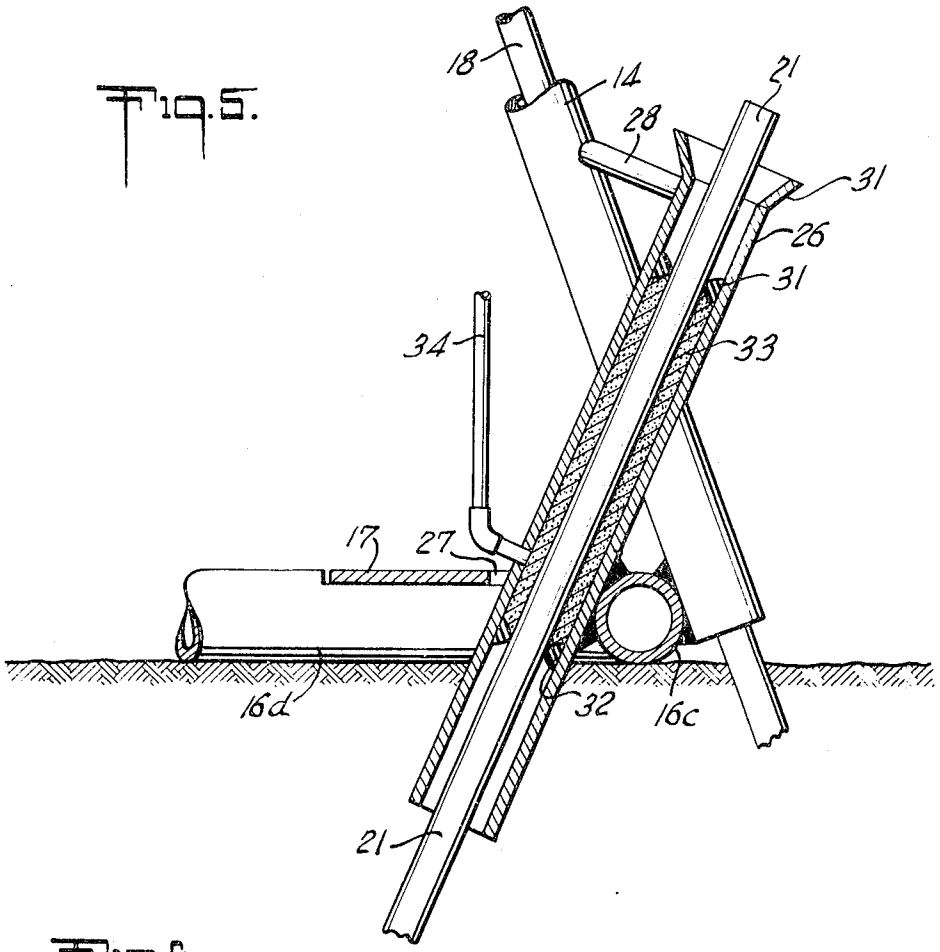
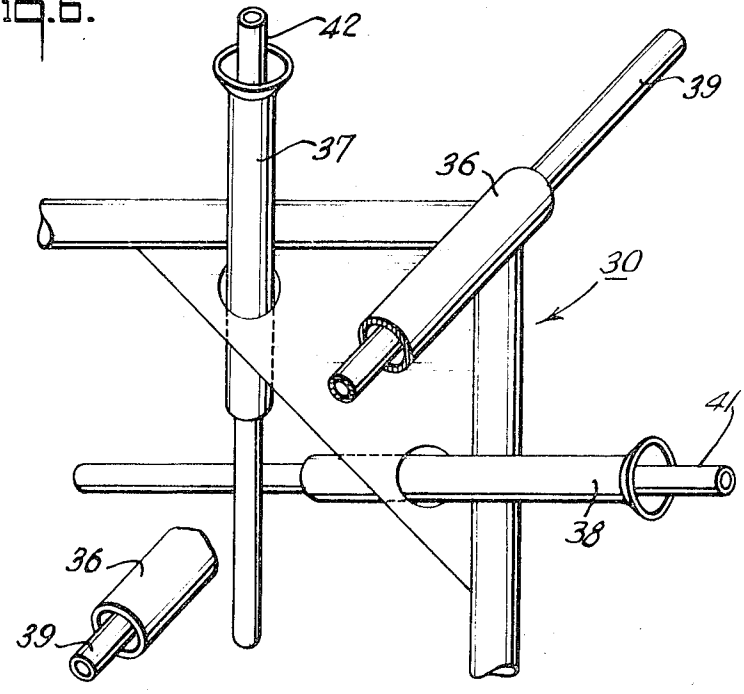

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16c
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Fig. 6.


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REVERSED SLOPE SKIRT PILE MARINE PLATFORM ANCHORING

BACKGROUND OF THE INVENTION

One of the primary difficulties encountered in anchoring fixedly positioned marine platforms in an offshore body of water is the need to stabilize and anchor the platform against lateral forces such as the above-surface wind forces, storm waves, and ocean currents. Predominant among these, are violent storms of hurricane proportion which tend to create oscillating forces that act against the platform and often pose a greater potential danger than a steady upsetting force would. Further, these extraordinary forces of nature tend to strain both anchoring piles and structural members, often to the point of fracture or permanent deformation.

In the instance of an ocean area characterized by a relatively firm substratum, the anchoring medium such as piling or the like, as well as the cost factor of the entire marine platform, are substantially minimized. Where, however, the ocean substratum is essentially of an underconsolidated consistency such as is found in a deltaic environment, the normal upright anchor piling arrangement is frequently found to be inadequate and requires reinforcement if it is to be at all effective.

For example, in certain offshore areas in the Gulf of Mexico, the deltaiclike substratum extends for several hundred feet beneath the ocean floor such that normal anchor piling has to extend to an abnormal depth before being received in a suitable retaining medium. Even in the instance where the normal (vertical) anchor piling is utilized which extends downwardly through the legs of a platform and into the substratum, effective holding power is minimized due to the lack of adequate lateral support of piles. Not only is a relatively soft substratum lacking in ability to resist horizontal displacement but it further promotes bending of anchoring piles. Such bending stress is inevitably transferred to the jacket structure members and base. With progressive pile bending the latter may eventually fracture thus leading to subsequent failure or even collapse of the jacket.

One expediency found to be successful in strengthening the anchoring of a marine platform is through the use of a series of skirt piles disposed about the platform lower end and which are imbedded vertically into the substratum. Such piles, are usually guidably held in an upright position and driven by a pile hammer suspended from a derrick barge or from the platform itself. As presently practiced, the skirt piles are fastened to the platform's lower end by cementing or other appropriate means. The number of skirt piles, when used in any installation, is determinable by several factors including the previously mentioned holding ability of the substratum and the strength capability of the main pile system.

It is therefore one of the objects of the invention to provide an offshore platform adapted to be firmly fixed into a relatively soft substratum. A further object is to provide a fixed offshore platform which utilizes pile anchoring to establish a firm position in the ocean floor whereby to successfully counteract displacing forces both above and below the water's surface. A still further object is to provide a marine platform of the type contemplated in which the holding ability of main pile members extending through the platform support legs, is supplemented by a series of inwardly sloped skirt piles disposed about the platform lower end. Still another object is to provide an offshore platform which utilizes a pile anchoring arrangement in the jacket adapted to provide concentrated holding power at the platform's respective corners, while reducing the jacket truss load which results from piles bending in a soft strata.

In overcoming the foregoing objects and operating difficulties peculiar to a marine platform located in tidal waters, and toward achieving the stated objectives, there is presently provided a platform which is normally positioned at the floor of a body of water and which supports a working deck above the water's surface. The working deck is adapted to hold materials essential to a well drilling and/or producing operation. The platform further comprises a support structure or jacket in the form of a plurality of main legs incorporated into the structure, which legs extend from an elevation above the water's surface to the ocean floor. The respective main legs are normally disposed in a substantially vertical disposition, but are advantageously directed slightly outwardly from a vertical posture whereby to afford a wider, more stable platform foundation.

The platform lower end at the ocean floor is provided with a series of peripherally arranged skirt piles which are connected to the jacket base and are imbedded into the substratum. The skirt piles, in contrast to the angle of imbedment of the main piles, are directed inwardly toward the jacket center whereby to minimize pile bending and to supplement and improve the holding ability of the combined pile system. In effect, the platform is provided with a main pile anchoring system which is supplemented by a secondary anchoring system.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a vertical elevation showing the marine platform anchored into a relatively soft or underconsolidated substratum by means of the presently described piling system.

FIG. **2** is a plan view taken along line **2—2** in FIG. **1**.

FIG. **3** is a force diagram of the platform shown in FIG. **1** illustrating vectorially the strains exerted by primary and secondary piling systems as a result of a lateral displacing force.

FIG. **4** is a segmentary view on an enlarged scale and in partial cross section taken along line **4—4** in FIG. **2**.

FIG. **5** is a segmentary view on an enlarged scale and in cross section taken a long line **5—5** in FIG. **2**.

FIG. **6** is a segmentary view on an enlarged scale and in cross section showing an alternate embodiment of a corner leg anchor in the platform of FIG. **1**.

Referring to FIG. **1**, platform **10** consists of a working deck **11** normally supported **50** or **60** feet above the water's surface by an elongated superstructure or jacket **12**. Jacket **12**, in its normal upright submerged position, extends from a point above the water's surface to the ocean floor. Working deck **11** carries an upstanding derrick **13** together with a crown block for supporting drill pipe strings, tools and other equipment which are lowered through an opening in the deck to the ocean substratum.

Supporting jacket **12** includes a generally open trusswork of structural members interconnected to form a rigid unit offering minimum resistance to water flow forces. The elongated platform is generally shaped such that when disposed in a normal upright position, it is characterized by a relatively constricted upper end at the water's surface, that widens to a broader base at the lower or opposite end. The unit is thus afforded a greater degree of stability when positioned than there would be in the instance of a narrower base platform.

Jacket **12** further includes a plurality of elongated legs **14** that extend downwardly from the upper end, to the jacket base. In that the jacket is normally prefabricated for a particular location or water depth, the length of legs **14** is similarly predetermined and made sufficiently long to raise the jacket's upper end beyond the water's surface. When so disposed, working deck **11** is either fixedly or movably received on the jacket upper end as needed.

Jacket **12** lower foundation or base, consists of a series of cylindrical members **16***a* through *d* inclusive, formed to interconnect with the remote ends of the respective corner legs **14** thereby to define a suitable foundation for resting on a soft ocean floor. Each corner of jacket **12** may also include an enlarged gusset or bearing plate **17** and **17***a* welded between adjacent corner legs to brace the latter and offer further resistance toward the jacket sinking into a relatively soft substratum. The respective base members, as a feature to aid in manipulating the jacket while in the water, may be made controllably buoyant. This feature is particularly desirable for

regulating the attitude of the jacket as the latter is being lowered to a subsea anchorage subsequent to being floated to the latter by barge or other means.

The primary means for fixedly positioning jacket **12** at the sea floor comprises one or more elongated anchor piles **18** disposed in and connected to respective corner legs **14**. It is appreciated that while the present embodiment of jacket **12** includes four corners, and consequently four corner legs **14**, the jacket could similarly contain a lesser or greater number of such legs and function to support working deck **11** as herein mentioned.

As shown in FIG. **1** main piles **18** and **18***a* extending downwardly through the respective corner legs **14** and **14***a*, consist of a single pile for each leg. Alternately, a grouping of piles all of which are fastened within a single leg could be utilized to form a rigid connection to the latter. The normal means for forming such a leg to pile connection is through welding of the jacket leg to the pile above sea level. A hardened, grouted joint also extends for a distance between the wall of the leg and the pile, which grout although originally fluid, hardens into a rigid annular collar **19** about the pile below the water surface.

Each corner leg **14** and **14***a* thus functions as a pile guide in the main anchoring system. Referring to FIG. **2**, the pile pattern, when seen from a plan view, would comprise a plurality of piles **18**, **18***a*, **18***b* and **18***c* which radiate outwardly from the jacket lower end. In the instance of a geometrically square base, the piles, when projected upwardly onto a horizontal plane would form a juncture at a hypothetical common point in the vicinity of the center of the jacket.

This form of corner pile anchoring is generally known and widely used in the industry, and ordinarily provides a platform which a high degree of capability to resist both laterally applied displacement and/or upsetting forces. For deltaic and underconsolidated substratum soils which exhibit a lesser degree of holding power however, the corner holding anchoring arrangement is not always effectual.

Further, in accordance with the invention, there is presently provided a secondary anchoring system which functions to supplement the holding ability of the main leg piles **18**, **18***a*, **18***b* and **18***c*. Said secondary anchoring system includes a plurality of skirt piles **21** spaced about the periphery of the jacket **12** base. The respective skirt piles **21** may, although not necessarily, be equispaced one from the other. As shown in FIG. **2**, skirt piles such as **21** and **21***a* are distributed in pairs along each base edge. However, the number of skirt piles used, and their intermediate spacing, is best determined in accordance with the relative holding ability of the substratum and the contemplated lateral force applied to the platform at a particular location.

Referring to FIGS. **1** and **5** in one embodiment of the supplementary anchoring system, an elongated pile guide tube **26** is fixed to the jacket base member **16**, preferably by braces and/or connecting brackets. Tube **26** is supported on member **16** and registers in opening **27** through bearing plate **17**. Guide tube **26** comprises in one form a cylindrical member having an elongated axial passage extending the length thereof, said passage being of a sufficient diameter to slidably receive one or more skirt piles **21**. Diagonal braces **28** and **29** depending outwardly from guide tube **26** upper end engage a horizontal unit connecting the jacket legs. Guide tube **26** is thus firmly disposed in a predetermined relationship with the platform and at a desired angle of entry with the sea floor. Guide tube **26** upper end is further provided with a flared entry collar **31** which tapers inwardly to direct a downwardly moving skirt pile into the guide tube prior to driving the latter into the substratum.

Internally pile guide **26** is provided with at least two longitudinally spaced annular rings **31** and **32** having an opening therein adapted to slidably receive a skirt pile as the latter is driven, and to form a tight annular seal with the pile external wall for grouting purposes. Spaced apart seals **31** and **32** define the upper and lower limits respectively of locking collar **33** formed by the grout as the latter hardens when passed into the annulus defined between the skirt pile outer surface and the surrounding pile wall is communicated with grout conduit **34** which in turn extends usually to the water's surface for connection to a source of fluidized grouting material. Thus, with a pile **21** suitably imbedded in the substratum, the grout is fed through conduit **34** to enter the annulus and form the desired elongated collar **33** which quickly hardens.

As shown in FIG. **5**, pile guide **26** may extend in a downwardly direction below the under surface of bearing plate **17**, and thereby become partially imbedded in the substratum as jacket **12** is lowered onto the sea bottom. However said guide **26** is positioned preferably at an acute angle of about 5° to 30° offset from the vertical, whereby guide tube is sloped in such an attitude to guidably direct a skirt pile inwardly toward the center of the jacket base as the pile becomes imbedded.

As shown in FIG. **6**, in one arrangement of the combination primary and secondary pile anchoring system, each corner leg **36** of jacket **30** is supplemented by at least a pair of supplementary pile guides **37** and **38** disposed adjacently of leg **14** to direct the skirt piles **37** and **38** disposed adjacently of leg **14** to direct the skirt piles **41** and **42** into substratum. The respective main pile **39**, and secondary piles **41** and **42**, when viewed from above, assume a generally radiating pattern within the substratum at each corner of the marine platform. Thus, in the instance of an upsetting force applied to upstanding jacket **30**, the reaction force exerted by the respective corner piles in opposition to the jacket overturning and shear forces will be at a maximum due to the relationship of skirt piles **41** and **42** which will not readily slide from their imbedded positions as upward and lateral forces are applied to one edge of the jacket.

As shown in FIG. **3**, the aggregate of reactive forces F_r executed by skirt piles **21** will extend along the entire length of the pile and will be constituted by the consistency of the substratum rather than solely by the friction exerted on the skirt pile surface. Further, the effect of the reactive forces on the respective piles **21** is that lateral displacing forces F acting on the platform will be transferred to the substratum without the pile being subjected to bending stresses.

Obviously, many modifications and variations of the invention, as hereinafter set forth, may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A marine platform adapted for being submerged and fixed to the floor of an offshore body of water and including; an uprightly disposed support jacket having a plurality of elongated legs extending the length of said jacket, said legs being disposed in a generally outward direction from the jacket, a base fixed to the jacket lower end and being mutually connected to the respective elongated legs, and anchoring means fixed to and depending from said jacket lower end whereby to anchor said platform to the floor of said offshore location, said anchoring means including;

   a. a first anchoring system comprising at least one main anchor pile connected to and depending from the end of each plurality of elongated legs, a portion of said main anchor piles being embedded into the substratum of said floor,

   b. a second anchoring system including a plurality of skirt piles depending downwardly from said jacket base and being embedded into said floor, said respective skirt piles being canted from a vertical disposition, inwardly toward the jacket interior.

2. In a marine platform as defined in claim **1** wherein; said base includes a continuous member extending peripherally about the jacket lower end in engagement with said respective plurality of elongated legs.

3. In a marine platform as defined in claim **1** wherein; said base includes a plurality of cylindrical base members being

terminally connected one to the other to define a continuous base extending peripherally about said jacket lower end in engagement with said respective plurality of elongated legs.

4. In a marine platform as defined in claim 1 wherein; said jacket includes at least three elongated legs extending longitudinally of said jacket, and each of said legs being spaced from at least two adjacently positioned skirt piles.

5. In a marine platform as defined in claim 4 wherein; said at least two adjacently disposed skirt piles include at least one of said piles being spaced at opposed sides of an elongated leg.

6. In a marine platform as defined in claim 1 wherein; said second anchoring system includes a plurality of skirt pile guides depending from said jacket base, each having the longitudinal axis thereof canted from a vertical disposition inwardly toward the jacket interior, and at least one skirt pile being fastened internally of each of said skirt pile guides, the lower end of said skirt pile being embedded in the substratum.

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