June 23, 1970 A. J. TOKOLA 3,516,259

OFFSHORE STRUCTURE METHOD AND APPARATUS

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Fig. 1

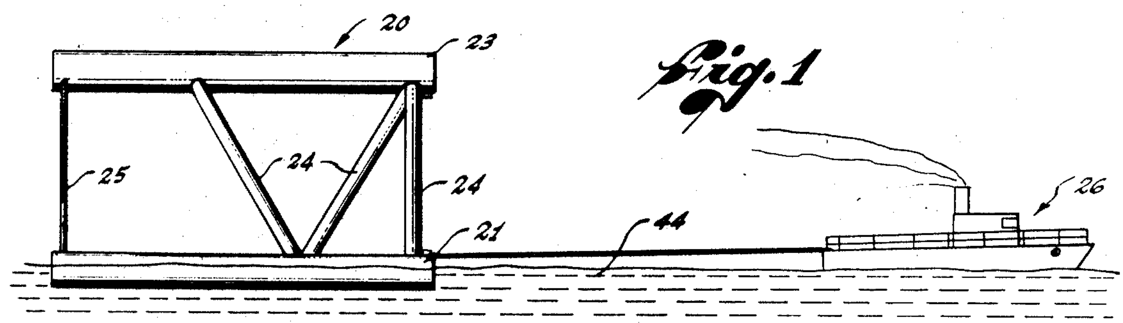


Fig. 2

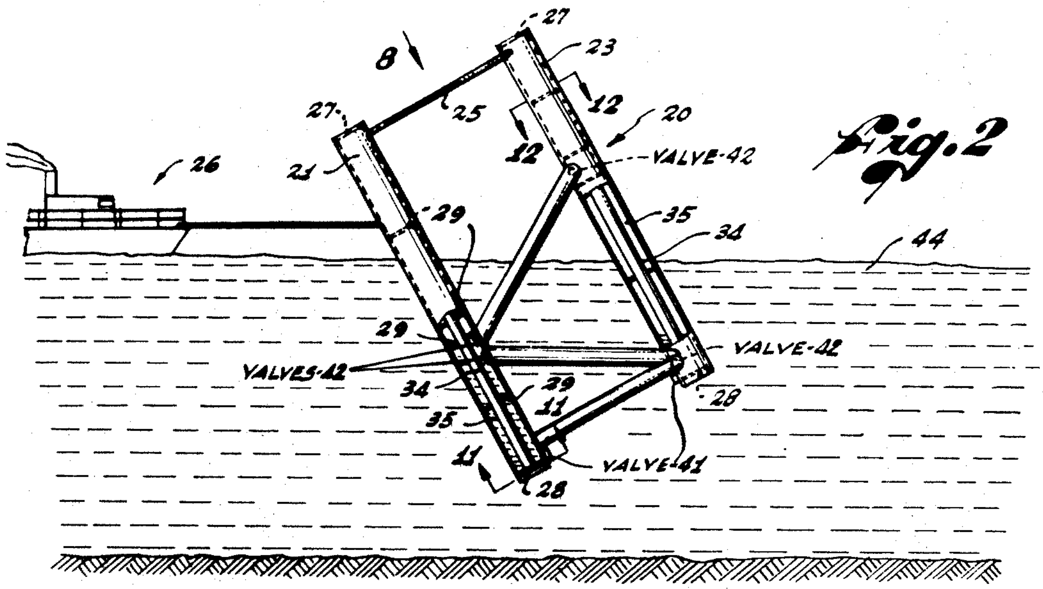


Fig. 3

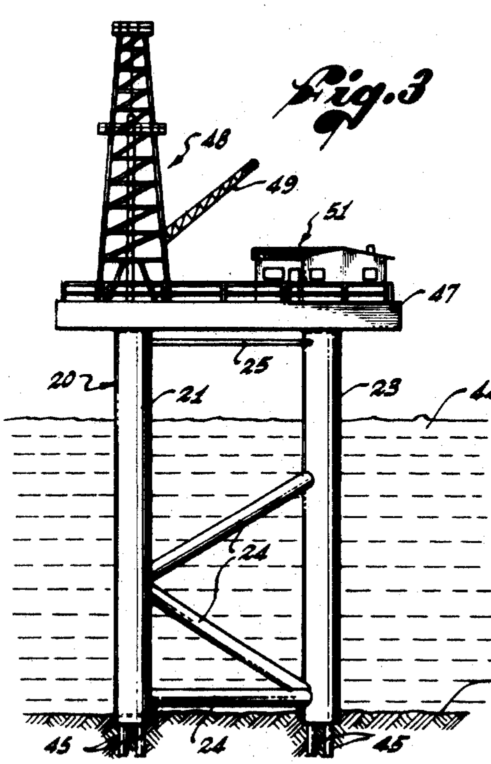
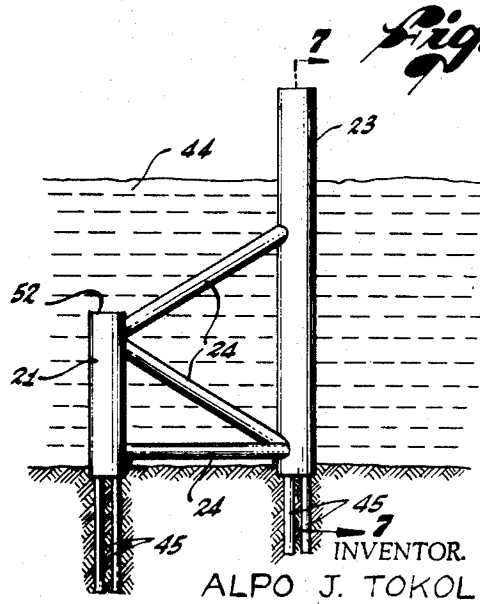


Fig. 4



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OFFSHORE STRUCTURE METHOD AND APPARATUS

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Fig. 5

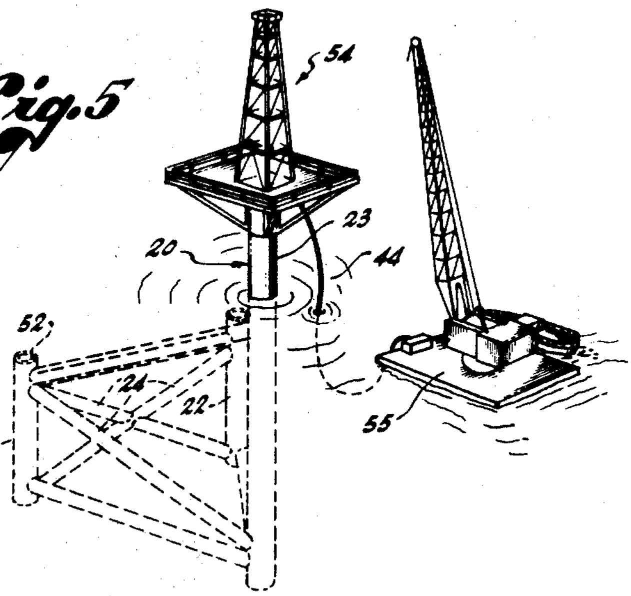


Fig. 6

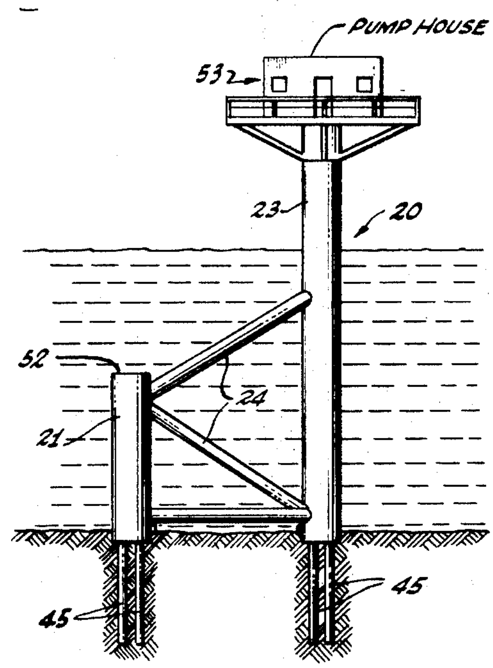
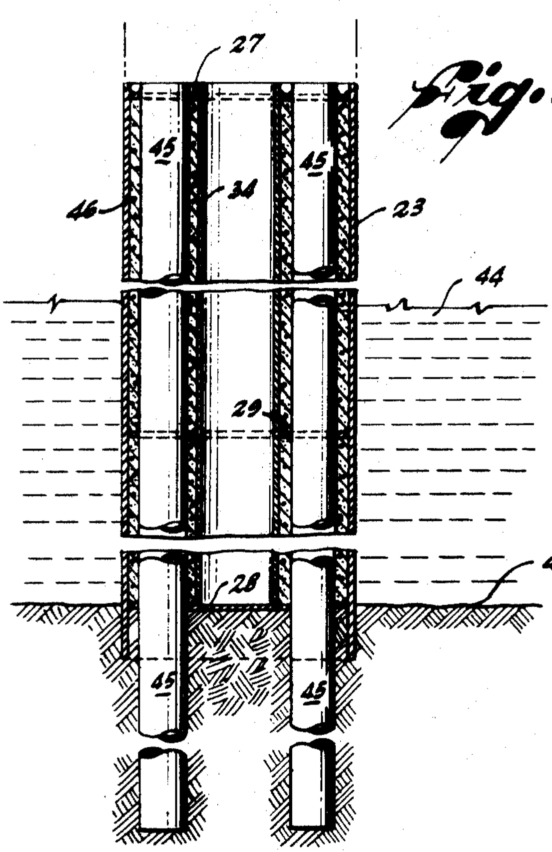


Fig. 7



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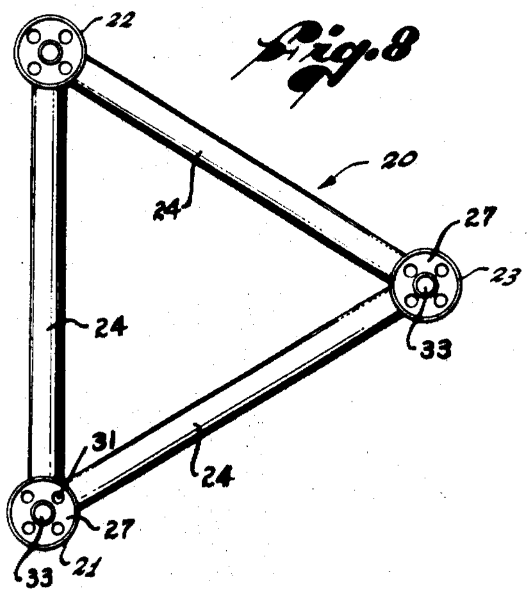

Fig. 8

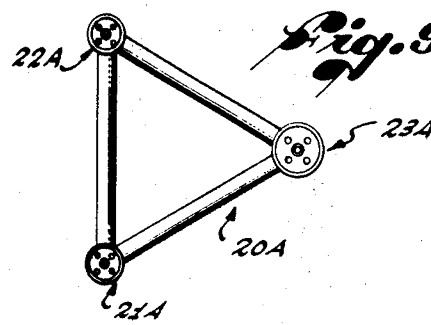

Fig. 9

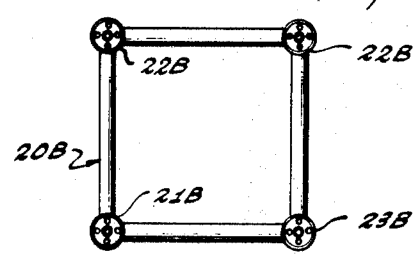

Fig. 10

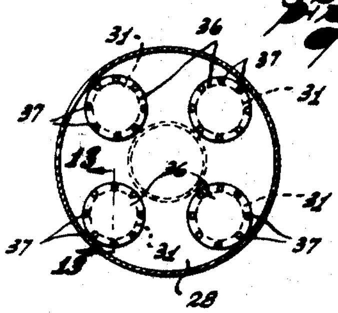

Fig. 11

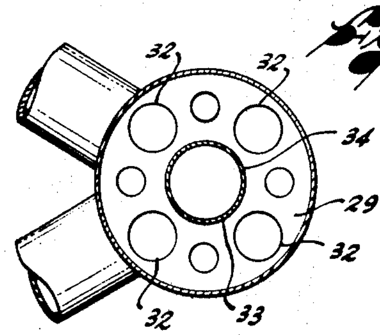

Fig. 12

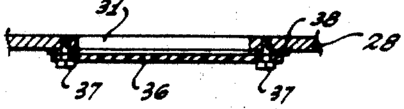

Fig. 13

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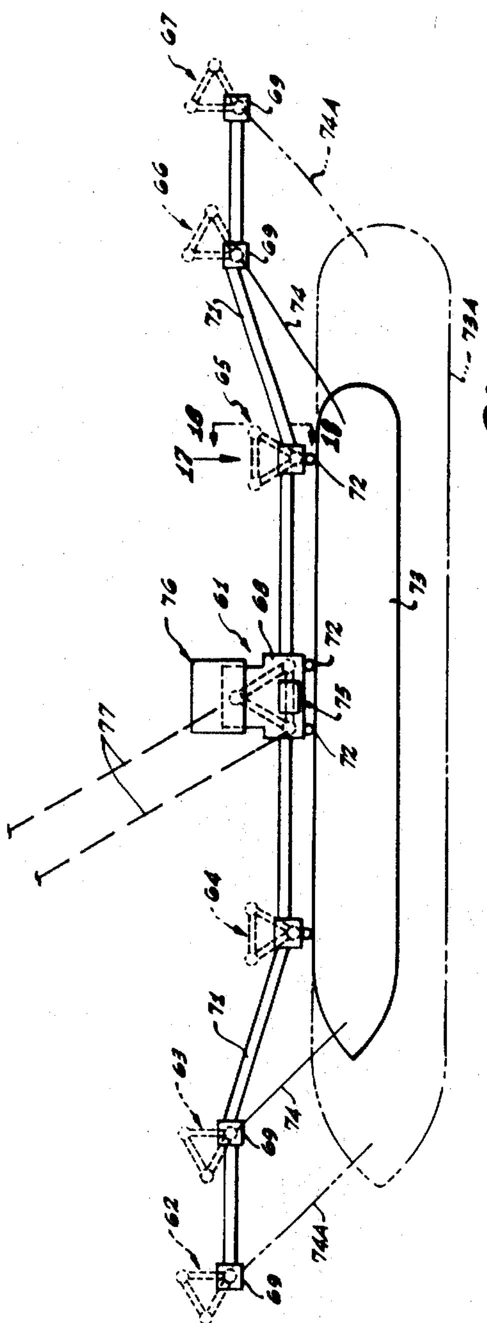

Fig. 14

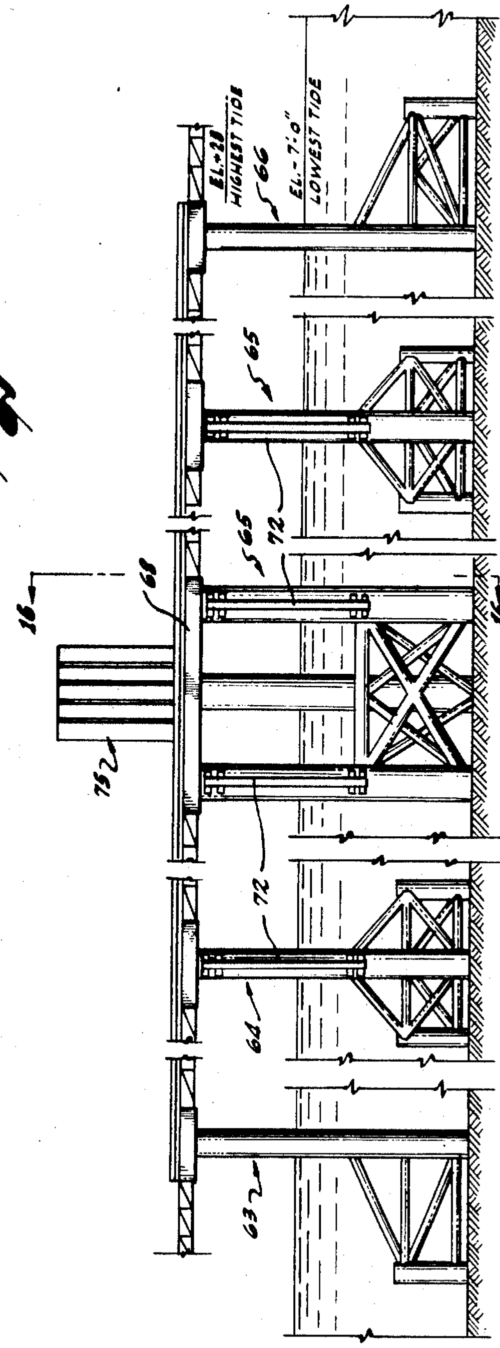

Fig. 15

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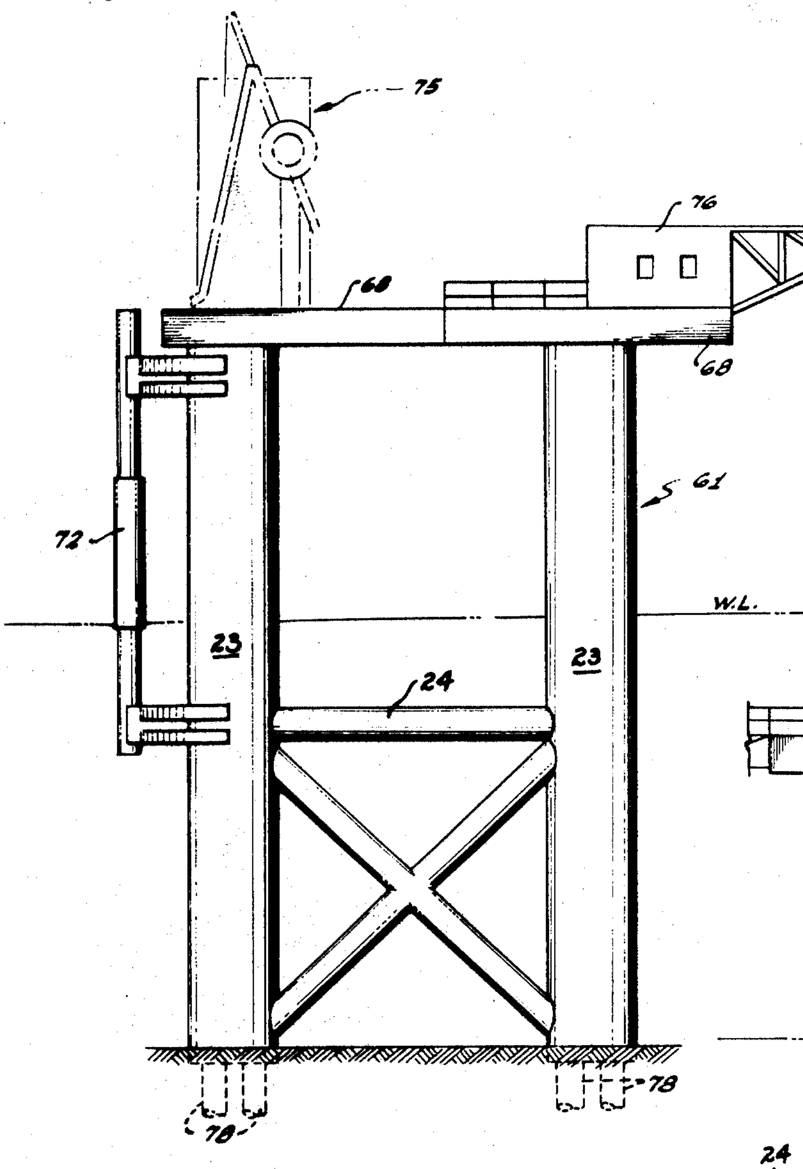
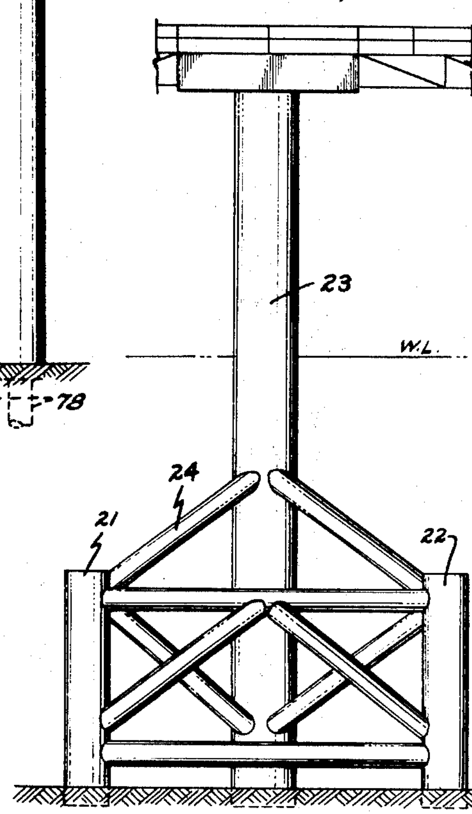


Fig. 16

Fig. 17



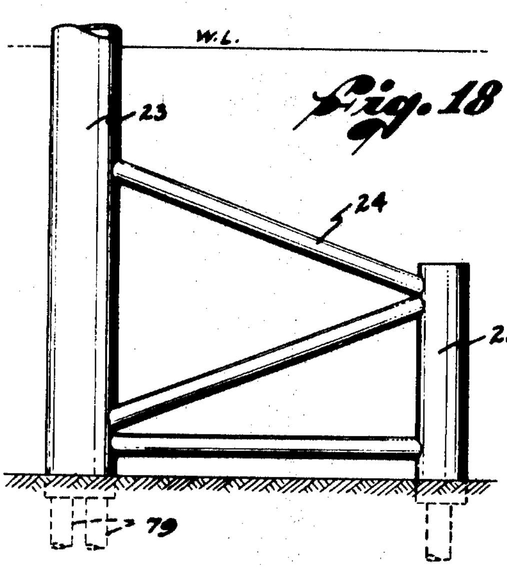


Fig. 18

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United States Patent Office

3,516,259
Patented June 23, 1970

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OFFSHORE STRUCTURE METHOD AND APPARATUS

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Filed Sept. 12, 1966, Ser. No. 578,681
Int. Cl. E02d *21/00*
U.S. Cl. 61—46.5 6 Claims

ABSTRACT OF THE DISCLOSURE

Method of constructing and installing an offshore supporting structure and the resulting structure wherein the structure is initially provided with a plurality of legs disposed in a polygonal arrangement and in a spaced relationship to one another and wherein at a preselected time and after installation of the structure at an offshore site the tops of all but one of the legs of the structure are caused to be terminated at a level substantially below a selected water level at the site.

The present invention relates to off-shore supporting structures and to methods of constructing and conducting various operations from such structures. Such structures are particularly adapted for supporting oil and gas well drilling and production units and for use as wharves and moorings. While one embodiment of this invention is adapted for all climatic conditions, the invention finds its greatest utility in permanent or fixed type supporting structures located in climates where appreciable floating ice is encountered during various months of the year.

With the discovery of extensive oil and gas fields under continental shelves and under bays and seas, off-shore well drilling operations have assumed increasing importance over the entire world.

Since the time that the first true off-shore drilling structure became operational some years ago in relatively shallow water, there has been a steady increase in the number and size of off-shore structures and drilling units as well as the depth of water in which they can effectively operate such that today the investment in off-shore drilling structures amounts to many millions of dollars. A number of these structures are capable of drilling wells in many hundreds of feet of water. Many of these off-shore structures are exceedingly large, massive and expensive. These are desirably prefabricated to a major extent on land and they can then be self-floated or carried on barges in a horizontal position to the drilling site where they are lowered to the bottom in a vertical position and secured in the desired drilling location by means of piles extending into the bottom earth to a considerable distance. The piles can be either welded to the above-ground structure, in a semi-permanent arrangement, or cemented in with concrete to form a fully permanent installation. In this connection a discussion of the installation of an off-shore marine structure of one particular design is contained in the patent to Borrmann, No. 3,209,544, granted Oct. 5, 1965 for Marine Structure. While Borrmann is mainly concerned with the stability of his supporting structure in various towing and upending operations, he discusses the present practice of extensive piling which is required in all of the legs of his supporting structure to give the required strength. It will be noted that in all cases Borrmann maintains multiple leg support at the top of the structure which must be piled at the bottom not only to resist the tilting and shifting of the structure that can result from wind and wave action but also to withstand the forces exerted by floating ice when the structure is used in cold climates.

When the Borrmann supporting structure, which is

representative of certain structures in use today, is used in cold climates, floe ice in cold weather will pack against the multiple leg structure and exert great forces thereon.

Frequently this floe ice will not only be several feet thick but also miles in extent whereby it reaches a tremendous mass. The packing of the ice at and about the legs of the structure in the manner of a log jam results in the overriding of loose ice slabs upon other loose or packed ice. As a consequence there can be a deleterious build up in the thickness of the ice adjacent the structure which further increases the mass of the surrounding ice and the forces exerted on the legs of the supporting structure as well as other operational hazards. It is, therefore, necessary in the case of the Borrmann marine structure to pile very extensively at the bottom to prevent the structure from tipping over or shifting under the influence of the ice floes and even when piled to a maximum the ice may still pack to a sufficient mass to cause structural damage adjacent the top of the support even if the bottom remains stable, despite the serious stresses thereon.

In the off-shore supporting structures and methods according to the present invention, at least during periods of cold weather when the usual floe ice is expected, the structure will advantageously expose to the ice a single leg upon which a production platform, a drilling rig or the like is supported, the other legs of the structure being cut off below the expected low ice level. The floe ice encountering the single and preferably cylindrical leg will usually either be simply diverted away from the structure upon finding no pocket in the supporting legs of the structure within which it can become lodged or it will be readily crushed and split so that materially reduced forces are exerted upon the structure and the bottom piling can be kept to a minimum while maintaining a broad stable base.

Since piling is an on-site operation, it is quite expensive and time consuming. By practice of the instant invention, considerable savings in time and money in the off-shore drilling structures and methods can be effected in that the instant invention provides within practical limits minimum piling as against the costly maximum piling required in the normal multiple leg supporting structures, such as used by Borrmann, particularly where such structures are to be installed and operated in a climate in which floating ice is encountered.

The advantages stated above with respect to combatting floe ice in cold weather operations are also present to a lesser degree in warm weather operations where a single above water leg extends from the supporting structure. In such construction, the broad base bottom support is still retained for purposes of stability but the piling need be only sufficient to resist the action of wind and wave on the single exposed leg extending through the upper water where the maximum wave action is encountered. Again, with the other legs cut off below the level of extensive wave action the piling may be kept to a minimum and the cost of the installation greatly reduced.

The off-short supporting structure according to the present invention may be constructed with three or four, or more if desired, main and preferably cylindrical columns or legs of, for example, steel piping 8 feet to 20 feet in diameter and of a thickness on the order of 1 inch. The length of the legs is such that they will desirably be from about 40 to 50 feet above high water where the structure is to be erected in the open ocean, and down to as little as 10 feet above high water when the structure is to be located inside protected bays. The spacing between the legs and the bracing therebetween will vary widely with the depth of the water in which the structure is to be erected. For example, the spacing may vary from 30 feet in shallow water to as much as 250 feet for water of 1,000 foot depth. The bracing between the legs of the structure may likewise be of cylindrical pipe suitably welded or otherwise secured to the main legs of the structure.

The fabrication of the major components of the supporting structure is preferably performed on land in a suitable yard or drydock. The fabricated structure may be self-floated at the construction yard with its columnar legs in a substantially horizontal position and for this purpose the ends of the legs are appropriately sealed against entrance of water to lend buoyancy to the structure. The floating structure is then towed in a horizontal position to the off-shore site where water is admitted to the legs to tilt the strucure into the desired erect or partially erect position in which it is finally controllably lowered and brought into proper contact with the bottom at the desired location.

Alternatively, smaller structures need not be sealed and self-floated but may be floated on barges to the drilling site and dropped by a derrick into the desired vertical supporting position at the site.

Although drilling site factors such as soil conditions alternate modes of operation, etc. will influence to some extent the amount of piling which must be utilized to give the bottom strength required for the off-shore supporting structure, still and all considerably less piling will be needed than in the case of the structures in use today. In the first manner of operation a large drilling platform is constructed upon all of the legs of the structure and the drilling carried out from this platform during the period of mild weather before substantial ice is encountered. With the drilling completed, the legs of the structure, other than a single leg left to support a production platform, are cut off below the water line and the lowest expected ice level. The structure then can operate in the winter months with but a single leg presented to the floating ice to minimize the stress on the supporting structure.

With this manner of operation the structure is pinned and piled to have a bottom strength sufficient to effectively resist the forces of the wind and waves acting upon the drilling platform and all of the various legs of the supporting structure as well as the forces of the floating ice acting on the single fully exposed leg remaining in the production mode. The structure is therefore piled to resist whichever of these forces is the greater. This piling will, in any event, be considerably less than the piling required if all of the legs of the structure were exposed to floe ice. As explained heretofore, a multiple leg construction results in tremendous forces being exerted on the structure from the great mass of ice which packs and overrides as it engages the multiple legs.

A second manner of operating with the off-shore structure according to this invention involves the cutting off of all but the single leg substantially immediately after the structure is lowered to the bottom and piled. In this instance the legs to be cut-off are still desirably fabricated initially in long lengths for several reasons, including the need for stability of the structure as it is towed to the off-shore site and the need for the tops of these legs being accessible above water to facilitate the insertion of piling therethrough. In this manner of operation, the single remaining leg has a lightweight drilling rig mounted thereon and the main auxiliaries for the drilling operation, including the supplies and the power supply units, are carried on a service barge or tender associated with the installation. This mode of operation requires that the resulting structure be piled to resist the greater of (1) the forces resulting from wind and wave action on the single leg, and (2) the forces exerted by ice on the single leg. In this instance a lesser piling requirement may result than in the first manner of operation if the wind and wave forces on the multiple leg structure are greater than the force exerted by ice on the single leg.

The multiple lower leg and single upper or fully exposed leg configuration is also desirable to lessen the piling requirements for mooring dolphins and the like used for off-short wharves where tankers or other vessels may dock, as for the loading of oil, gasoline and other materials. Such wharf structures present problems similar to those discussed above for drilling and production units in that the amount of piling which is required will depend upon the forces which are exerted on the upper part of the supporting structures. These forces are considerably less in the case of the single upper leg with structural stability maintained by spaced short legs on the bottom. One aspect of this invention therefore is directed to wharves and mooring dolphins employing supporting structures constructed in accordance with the teachings hereof.

The foregoing and other objects and features of the invention will be apparent to those skilled in the art from the following specification and the appended drawings in which:

FIG. 1 is a side elevational view of a self-floated, prefabricated supporting structure being towed to an off-shore site;

FIG. 2 is a view partially in section of the structure of FIG. 1 being rotated into a vertical position at the off-short site;

FIG. 3 is an elevational view of the supporting structure and a drilling platform thereon when installed at an off-short drilling site;

FIG. 4 is an elevational view of the supporting structure with all but a single leg cut off below the water line and expected low ice level;

FIG. 5 is a view of an alternate drilling arrangement in which a drilling rig is mounted on a single supporting leg and wherein main auxiliaries for the rig are disposed on or carried by a service barge or tender;

FIG. 6 is an elevational view of a permanent production unit on a single supporting leg evolved from the drilling operation of either FIG. 3 or FIG. 5;

FIG. 7 is a broken and enlarged vertical sectional view through the main supporting leg of the structure, as at **7—7** of FIG. 4;

FIG. 8 is a plan view of a supporting structure, looking in the direction of the arrow **8** of FIG. 2;

FIG. 9 is a plan view similar to FIG. 8 on a different scale and showing modified leg dimensions;

FIG. 10 is a plan view of a supporting structure using a four-leg configuration;

FIG. 11 is an enlarged transverse sectional view generally taken along the line **11—11** of FIG. 2 and with parts omitted for the sake of simplicity;

FIG. 12 is an enlarged transverse sectional view taken on the line **12—12** of FIG. 2;

FIG. 13 is an enlarged detailed sectional view taken generally along the line **13—13** of FIG. 11;

FIG. 14 is a generally diagrammatic representation of a mooring wharf employing supporting structure according to the present invention;

FIG. 15 is an elevational view of the mooring wharf of FIG. 14;

FIG. 16 is an elevational view of the principal service structure of the wharf of FIG. 14;

FIG. 17 is an elevational view of a mooring dolphin of the wharf of FIG. 14 taken in the direction of the arrow **17**; and

FIG. 18 is a partial elevational view of the mooring dolphin of FIG. 17 taken from the plane **18—18** of FIG. 14.

With further reference to the drawings and in particular FIGS. 1, 2, 8, 11 and 12 of the drawings, the prefabricated supporting structure **20** therein illustrated and representing one preferred embodiment of this invention comprises three columnar legs **21**, **22** and **23** in the form of abutting sections of hollow pipe which may be, by way of example only, 8 feet to 20 feet in diameter and of a wall thickness of the order of 1 inch. These columns or legs **21–23** are preferably disposed at the apexes of an equilateral triangle, as shown in FIG. 8, and are secured together in substantial parallel relation by means of bracing pipes **24** extending therebetween and with the uppermost portion of every bracing pipe **24**, for example, that connecting to leg **23**, being disposed below the expected low level of the ice to be encountered at the off-shore site. Temporary bracing pipes **25** interconnect the tops of the legs **21–23**.

The prefabricated structure **20** may be carried to the off-shore site in a horizontal position on suitable barges, or may be self-floated as in FIG. 1 wherein the legs **21** and **22** float in the water in a substantially horizontal plane with the leg **23** being supported in the air thereabove by the bracing pipes **24** and **25**. The self-floated structure **20** may be towed to the off-shore site by one or more tugs **26**.

The construction of the columnar legs **21–23** may take many forms and that specifically shown and described herein is to be considered only exemplary of one optional form of such construction. As illustrated, the legs **21–23** are provided with transverse and apertured diaphragm plates **27** at the top and **28** at the bottom and with intermediate diaphragm plates **29** throughout their lengths. The diaphragm plates **27** are welded or otherwise secured to the upper ends of the legs **21–23** in watertight relation. The diaphragm plates **27** at the top and **28** at the bottom have openings **31** therethrough for the passage of piling pipe and the diaphragms **29** have like openings **32** therethrough for the passage of the piling. The openings **31** and **32** are symmetrically disposed and are vertically aligned for the passage of vertical piling pipe therethrough. The openings in plates **27** and **28** are, of course, covered or closed by appropriate means when the structure provided with the same is to be self-floated during launching and towing.

The diaphragm plates **27** and **29** are also provided with central openings **33** therethrough in which may be disposed optional pipes **34** sealably closed at their bottoms by appropriate means. The diaphragms **27–29** are rigidly secured to the columnar legs **21–23**, as by welding, and are likewise rigidly secured to the central pipes **34** to strengthen the column structure. The pipes **34** are therefore concentric with the columnar legs **21–23** and provide an annular space **35** therebetween through which extend the piling pipes, as will be later described. The spaces within the central pipes **34** may be used for any desired storage purpose at the off-shore site, such as for water, fuel, produced oil, etc.

To render the bottom ends of the columnar legs **21–23** watertight and as indicated particularly in FIGS. 11 and 13, the openings **31** through the diaphragm plate **28** are covered by circular plates **36** mounted against the bottoms of the diaphragms **28** by bolts **37** drawn up against sealing rings **38**. The plates **36** may be formed of plastic or other readily frangible material so that the piles may be driven directly therethrough.

To control the tilting of the supporting structure at the drilling site, the bottom ends of the columnar legs **21–23** are desirably provided with valves **41** and entrance to the interiors of the bracing pipes **24** may be secured through valves **42**. The valves **41, 42** may optionally be of appropriate pneumatic, hydraulic or electrically operated types and controlled by lines leading from associated tenders or platforms at the top of the water. Likewise, air pressure lines may communicate with the chambers **35** interiorly of the columnar legs **21–23** by suitable connections, not shown, adjacent the top ends of the legs. Control of the pressure within the legs and of the valves **41** and **42** maintains precise control over the tilting and lowering action of the supporting structure at the off-shore site. As shown in FIG. 2, water has been admitted to a considerable portion of the lower end of the legs **21** and **22** and to a lesser extent of the legs **23**, the structure **20** being in the process of erection into a vertical position at the off-shore site. When vertical, the structure is dropped or allowed to settle to the bottom **43** at which time the lower ends of the legs **21–23** rest on the bottom **43** while the upper ends of the legs extend above the water level **44** in the manner shown in FIG. 3.

With the supporting structure resting on the bottom, as in FIG. 3, the columnar legs **21–23** are adjusted to the desired vertical positions and leveled to take care of any irregularity in the bottom, in a manner well known in the art. Piling is now passed through the legs **21–23** into the bottom **43** and secured to the legs. The piling **45** can be in the form of pipes of substantially the diameter of the openings **31, 32** through the diaphragms **27, 28** and **29** and it is through the piling pipes **45** that future drilling operations may be effected, although it is obvious that drilling may be accomplished outside of the columnar legs where desired.

To emplace the piling **45** and in the event diaphragms **27** at the top of legs **21–23** are imperforate, diaphragms **27** are cut at the job site to provide openings in alignment with and of the same size of the openings **31** and **32** in diaphragms **28** and **29**. In addition to openings **31** in diaphragms **27** which can be made at the job site, as noted above, the diaphragms **27** may also have central openings cut on the job site if necessary of the size of the openings **33** so as to provide for passage of pipes **34**. The piling pipes **45** are then passed downwardly into the legs **21–23** through the newly cut openings in the diaphragms **27**, the openings **32** in the diaphragms **29** and the openings **31** in the diaphragms **28**. When the lower end of a piling pipe engages a plate **36** closing an opening **31** it is driven or forced through this plate and into the ground forming the bottom **43**. Preferably, the piling pipes are driven into the ground a sufficient distance to perform their desired supporting function but where the character of the ground material is such that the piling pipes cannot be driven, holes may be previously drilled, the bottoms of the piling pipes inserted in the holes and cemented in the ground, in the manner disclosed in the Borrmann patent. The piling pipes **45** preferably terminate adjacent the tops of the columnar legs **21–23** and in semi-permanent installations, they may be secured to the legs by welding thereat to facilitate disassembly of the piles when the supporting structure is to be disassembled or moved. However, in ordinary installations a permanent mounting is secured as illustrated in FIG. 7, where the piling pipes **45** are shown cemented to the columnar leg **23** and its internal pipe **34** by means of concrete **46** which may completely fill the space **35** between the leg **23** and the internal pipe **34** about the piling pipes **45**.

The piles **45** carry the weight of the supporting structure **20** and whatever superstructures are mounted thereon and prevent tilting and shifting of the supporting structure upon the application of external forces thereto due to wave action, floe ice, wind pressure and like elemental forces. The amount of piling necessary to provide the desired strength and stability to the supporting structure will depend, as previously explained, on the type of operation carried out during use of the supporting structure and the various climatic and environmental conditions to be encountered. FIGS. 3 and 5 represent alternate drilling operations using the structure according to the present invention, with the end result in both cases of securing a permanent production installation as in FIG. 6.

In the drilling operation of FIG. 3, the supporting structure **20** is preferably towed to the drilling site and erected in warm or mild weather after the disappearance of surface ice so that the full-height, multiple-leg structure of FIG. 3 is not subjected to the action of ice floes. After erection and levelling and with piling **45** in place, a large heavy-duty drilling platform **47** is mounted on all of the legs **21–23**. Thereafter a drilling derrick **48**, hoisting crane **49** and housing **51** for personnel, auxiliaries, power, etc., are all installed on platform **47** so that the platform **47** is substantially self-contained for drilling operations and need be visited only periodically by a supply barge or tender. The full-height, multiple-leg structure of FIG. 3 will be subjected to wind and wave action during the drilling operation and the piling **45** must be of sufficient depth and strength to accommodate the weight of the supporting structure, the platform **47** and the drilling accessories thereon while at the same time preventing tilting and shifting of the supporting structure **20** under the expected forces, and stresses exerted by the elements. The drilling operations are desirably conducted directly through the piling pipes **45** at any and all of the legs **21–23** and the drilling rig **48** is desirably shiftable in location for that purpose. Additional well holes may be drilled exteriorly of the legs **21–23** when desired. The schedule is such as to complete the drilling operation prior to the advent of winter and the coming of floe ice to the drilling site.

When the drilling operation with the structure of FIG. 3 is completed, the drilling derrick and auxiliaries are removed by suitable barges and the platform **47** likewise dismantled and removed. The legs **21** and **22** are now cut down to the level **52** indicated in FIG. 4 which is substantially below the lowest level of floating ice expected at the drill site. The original lengths of the legs **21–23** will be determined by the depth of the water **44**, the tide at the drill site, the expected wave action and other factors. In the open ocean it is desirable that the height of the legs **21–23** be about 40 to 50 feet clear of high water, while inside bays and other protected water they may be as low as 10 feet above high water. The level **52** to which the pipes **21, 22** are cut should be at least 10 to 12 feet below the low water level whereby the upper ends of these legs will terminate substantially below the low water level at the site to adequately clear floe ice encountered at the drill site and may be cut just above the connection of the bracing pipes **24** thereto, as shown in FIG. 4. The leg **23** may remain its original length or be somewhat foreshortened if desired and there is mounted thereon a production facility **53**, as shown in FIG. 6. The wells which were drilled from the platform **47** are now to be considered producing wells which are pumped or otherwise controlled from the facility **53** through relatively permanent pipelines, barges or tankers not shown, to an on-shore storage or refining installation. The structure of FIG. 6 is the producing structure which is maintained permanently while the wells are producing and which is subject to exposure of the winter ice at the drill site. With only a single cylindrical leg **23** being contactable or engageable by floe ice, the stresses exerted on the overall supporting structure **20** by the ice are materially minimized since the ice slabs will either be readily diverted away from leg **23** and structure **20** without becoming fully engaged or locked to the structure **20** or be readily cracked and crushed at the rounded leg **23** so that minimum shifting and tilting forces are exerted on the supporting structure in its final evolution of FIG. 6.

With the space **35** in the leg **23** filled with concrete **46**, as in FIG. 7, the leg **23** offers major resistance to structural damage to itself while at the same time the legs **21** and **22** and the bracing pipes **24** provide a wide, stable base for the production facility **53** and its supporting leg **23**.

In the above description it has been assumed that the piling necessary to support the installation of FIG. 3 will be sufficient to enable the single leg **23** to resist the action of floe ice in the final production construction of FIG. 6. However, if the piling **45** required to resist the action of floe ice is greater than that required to resist the action of wind and wave in the FIG. 3 construction, the original piling for the structure should be that required for the winter operation. In either case, the piling will still be considerably less than that required to provide for winter

operation with all of the legs **21–23** at their full height and exposed to the action of floe ice. There is therefore a considerable savings in time and cost in the lessened piling requirement for winter operation with the production construction of FIG. 6.

An alternate drilling operation is shown in FIG. 5. In this operation the legs **21** and **22** are cut off substantially immediately after the supporting structure **20** is erected and the piling **45** emplaced.

With this mode of operation a drilling derrick **54** is supported on the top of the single leg **23** and the supplies, power, etc. are carried on a tender or barge **55** which remains anchored adjacent the supporting structure. With this arrangement there is no prior construction or assemblage of a large heavy-duty drilling platform which with its auxiliaries must be disassembled at the conclusion of the drilling operation and prior to the pumping operation as in the case of the mode of operation of FIGS. 3 and 6. When drilling is completed with the arrangement of FIG. 5 the drilling rig **54** is removed and the production facility **53** simply mounted on the leg **23** and substituted for rig **54**.

The arrangement of FIG. 5 may also be used where it is desired to drill further the next year after winter production from the structure of FIG. 6, the production facility **53** having a drilling rig like **54** added thereto.

Using the arrangement of FIG. 5 initially instead of the platform drilling arrangement of FIG. 3 can result in a further saving in the piling needed for the supporting structure where the piling required for the full length legs **21–23**, platform **47** and associated auxiliaries is greater than the piling required for the single leg winter operation of FIG. 6.

Where the supporting structure is to be used in a more moderate climate where winter ice does not present a problem, the drilling structure of FIG. 5 can still effect a considerable savings in the extent of piling required since the action of the environmental elements on the structure of FIG. 5 will be considerably less than the action on the structure of FIG. 3. Again, in addition to the savings in the piling required the cost of the platform and the assembly and disassembly is avoided. Against this, however, must be weighed the cost and inconvenience of the floating tender or barge **55**. Thus the economics of the different operations as determined by the character of the drilling sites, the climatic conditions and the extent of the drilling to be carried out will dictate the most practical mode of operation to be used in practicing the instant invention. In this connection it is to be observed that where the structure **20** of FIGS. 3, and 6 or 5 is installed and used in the open sea where minimal floe ice conditions exist, if at all, legs **21** and **22** would be cut off below the mean water level in the manner aforedescribed and as far below the surface as is practical to minimize the effects of major wind and wave action on the structure at the particular drill site while at the same time taking into account the various economic and drill site conditions involved.

The supporting structure **20A** of FIG. 9 is substantially the same as the supporting structure **20** of FIG. 8 except that the legs **21A** and **22A** have been reduced in diameter over the legs **21** and **22** of the structure **20**. In the structure **20A**, since the leg **23A** will be the main supporting leg to carry, for example, the production facility **53**, it can be made larger in diameter than legs **21A** and **22A**. Since the legs **21A** and **22A** do not encounter the surface ice and are used to supply a broad, stable base for the structure they have been made of reduced diameter.

The supporting structure **20B** of FIG. 10 shows a rectangular configuration for the supporting legs **21B, 22B, 22B′** and **23B** at the corners of the rectangle. The supporting structure **20B** may be operated under the conditions of any or all of FIGS. 3, 5 and 6, the legs **21B, 22B** and **22B′** being cut off to the level **52**, leaving only the leg **23B** for FIG. 5 and FIG. 6 type operations.

FIGS. 14–18 illustrate further applications of the instant invention and how supporting structures according to the present invention may be utilized for the construction of wharves and for mooring dolphins. Any combination of units may be utilized in that all of the structures may be of the cutoff, single leg configuration of FIGS. 4 and 6 or one or more may employ all full length legs as in the example illustrated in FIGS. 14–16. In the exemplification shown the wharf is composed of a central, all-full-length leg supporting structure **61** and auxiliary single leg supporting structures at each side thereof **62**, **63**, **64**, **65**, **66** and **67**. The supporting structure **61** has a platform **68** thereon at the desired height above high water and the supporting structures **62–67** have smaller platforms **69** on their single long legs, with the platforms **68** and **69** connected by conventional hanging catwalks **71**. The supporting structures may carry suitable bumpers **72** illustrated on the structures **61**, **64** and **65** which are engaged by vessels **73**, **73A** moored to the wharf by suitable mooring lines such as lines **74** connected to the structures **63** and **66** for the vessel **73**, and by lines **74A** connected to the structures **62** and **67** for the vessel **73A**. The central platform **68** may carry suitable auxiliaries and accessory gear **75** and **76** and may serve to load the vessels **73**, **73A** from on-shore installations through suitable lines diagrammatically illustrated at **77**.

In the case of the supporting structure **61** all of the legs thereof are of full height and will be subjected to the action of wind, waves and the ice encountered in a cold winter climate. Therefore, the piling **78** for the supporting structure **61** must be sufficiently heavy to resist the forces exerted on the full-height, exposed multiple-leg structure by the elements and will be considerably more extensive than that required on single exposed leg structures where, as previously explained, the forces to be resisted are considerably less. Therefore, the use of full-height, multiple-leg supporting structures **61** will be minimized in the wharf and, desirably, none would be used, there being illustrated a single one in the figures to cover the case where an exceptionally large heavy-duty platform **68** may be required.

The other supporting structures **62–67** have a single leg projecting into the paths of wind, waves and ice as illustrated in FIGS. 15, 17 and 18. Therefore, the piling **79** for these supporting structures may be considerably lighter than the piling **78** required for the full-length, multiple-leg supporting structure **61**.

Even though the arrangements of FIGS. 5 and 15 contemplate cut-off of the legs **21** and **22** as soon as the supporting structures are erected and piled, it is desirable to construct the prefabricated structure **20** with full length legs as shown in FIGS. 1 and 2. This not only gives symmetry and stability in the towing operation but also facilitates the insertion of the piling pipes through the accessible upper leg ends. However, by operating finally with a single exposed leg the extent of piling required to give the necessary support and to resist tilting and shifting of the supporting structure is still materially less than where the full-length, multiple-leg construction is employed. Further, while the invention has been discussed with particular reference to structures provided with simple elongated hollow columnar legs certain of which are cut off or severed below a predetermined water level, these legs may be made in the form of telescoping sections. In this instance all of the telescoping legs of the structure except one would be retracted instead of being sheared off whereby the tops of the telescoped legs would terminate at the desired distance below the water level. In addition, where telescoping legs are employed in the case of the modes of operation exemplified in FIGS. 3 and 6, the legs that are telescoped for winter operation could be distended or expanded for summer operation.

While certain preferred embodiments of the invention have been specifically illustrated and described it will be understood that the invention is not limited thereto as many variations will be apparent to those skilled in the art and the invention is to be given its broadest interpretation within the terms of the following claims, wherein,

What is claimed is:

1. The method of constructing, floating and installing an offshore supporting structure which comprises: fabricating a supporting structure comprising a plurality of columnar legs of a length substantially greater than the depth of the water at the proposed offshore operating site, said legs being disposed in a polygonal arrangement and in spaced relation to each other and having bracing members therebetween; floating said fabricated structure to the offshore site; sinking said structure at said site whereby said structure will stand on the bottom at said site with the legs thereof being substantially vertical and having their upper ends exposed above high water level; piling said structure; securing the piling; erecting a well drilling platform on said structure and drilling a well from said platform, removing said platform, causing the tops of all but one of said legs as well as the upper portions of said bracing members to be terminated at a substantial distance below the low water level at said site whereby said terminated legs and said bracing members can normally clear floating objects at the installation site; and then erecting a working structure on top of one of said legs for carrying out an operation with but one leg of said structure being exposed to the action of the elements.

2. The method defined in claim **1** including: erecting on said one of said legs after the top terminating operation on the other legs a producing structure.

3. The method of constructing and installing an offshore supporting structure which comprises: fabricating a supporting structure comprising a plurality of hollow columnar legs of a length substantially greater than the depth of the water at the proposed offshore operating site, said legs being disposed in a polygonal arrangement and spaced relation to each other and having bracing members therebetween; moving said fabricated structure to the offshore site; sinking said structure at said site whereby said structure will stand at the bottom of said site with the legs thereof being substantially vertical and having their upper ends exposed above high water level; piling said structure through said legs from the accessible upper ends thereof into the earth beneath the legs; securing the piling extending through each leg to that leg; erecting a well drilling platform on said legs, drilling a well from said platform; removing said platform, causing the tops of all but one of said legs as well as the upper portions of said bracing members to be terminated at a substantial distance below the water level at said site whereby said terminated legs and said bracing members can normally clear floating objects at the installation site; and thereafter erecting a working structure on top of one of said legs for carrying out an operation with but one leg of said structure being exposed to the action of the elements.

4. The method defined in claim **3** including: erecting on said one of said legs after the terminating operation on the other legs a producing structure.

5. An offshore wharf structure comprised of a series of spaced supporting structures, certain of said supporting structures comprising: a plurality of substantially vertical columnar legs disposed in a polygonal arrangement and a hoizontally spaced relation with bracing members arranged therebetween, said legs having their lower ends resting on the bottom, one only of said legs of said certain structures extending substantially above the water surface at the offshore location, the tops of the other of said legs of said certain structures terminating below the water surface and below the expected lowest level of major wave action and any normally expected ice floating at said offshore location; piling associated with each leg of said certain structures and extending through the said legs and into the earth therebeneath; means connecting said piling to each of the legs with which it is associated; a working platform mounted on said one leg of each of said certain structures that extends substantially above the water surface; each of said certain structures being supported and stabilized by all the piled legs thereof while presenting only said one leg thereof to the forces exerted by the elements, one of said supporting structures adjacent the middle of said wharf structure having all of its legs exposed above the water surface and carrying a large working platform thereon, and the piling for the legs of said middle supporting structure being of greater extent than the piling for said exposed one-leg structures to resist the action of the elements on said multiple exposed leg structure.

6. An offshore wharf structure comprised of a series of spaced supporting structures, certain of said supporting structures comprising: a plurality of substantially vertical hollow columnar legs disposed in a polygonal arrangement and a horizontally spaced relation with bracing members arranged therebetween, said legs having their lower ends resting on the bottom, one only of said legs of said certain structures extending substantially above the high water level at the offshore location, the tops of the other of said legs of said certain structures terminating below the expected lowest level of ice floating at said offshore location; piling extending through each of said legs of said certain structures and into the earth therebeneath; means connecting said piling to the legs through which it extends; a working platform mounted on said one leg of each of said certain structures that extends substantially above the high water level; each of said certain structures being supported and stabilized by all of the piled legs thereof while presenting only said one leg thereof to the forces exerted by the elements, one of said supporting structures adjacent the middle of said wharf structure having all of its legs exposed above the high water level and carrying a large working platform thereon; and the piling for the legs of said middle supporting structure being of greater extent than the piling for said exposed one-leg structures to resist the action of the elements on said multiple exposed leg structure.

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