United States Patent

Hayes

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[54] **SPACED MULTI-WALL CONSTRUCTION UNIT**

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[51] **Int. Cl.**.....**E04b 1/22**, E04h 7/22

[58] **Field of Search**.....52/426, 425, 249, 248, 245, 52/223 R, 224, 562, 424

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[57] **ABSTRACT**

A construction unit for constructing large pressure vessels such as offshore platforms and other pressure vessels which are subjected to high internal and/or external pressures wherein the construction unit comprises a multi-wall structure having a plurality of laterally spaced walls joined together at their upper and lower ends, respectively, and at their opposite sides to form an enclosure, and having a plurality of tensioning means for prestressing the construction unit prior to filling the enclosure with aggregate, concrete, grout or other suitable substantially incompressible material. The invention also includes the method of erecting off-shore vessels constructed of the spaced multi-wall construction units.

7 Claims, 5 Drawing Figures

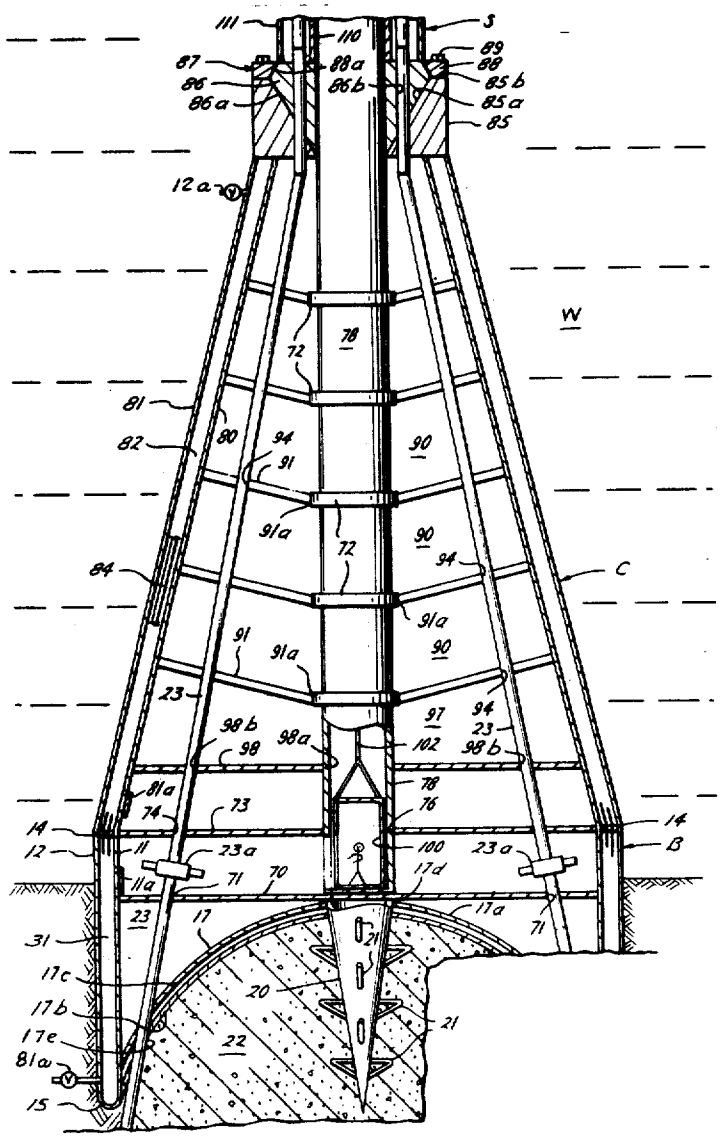

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Fig. 1

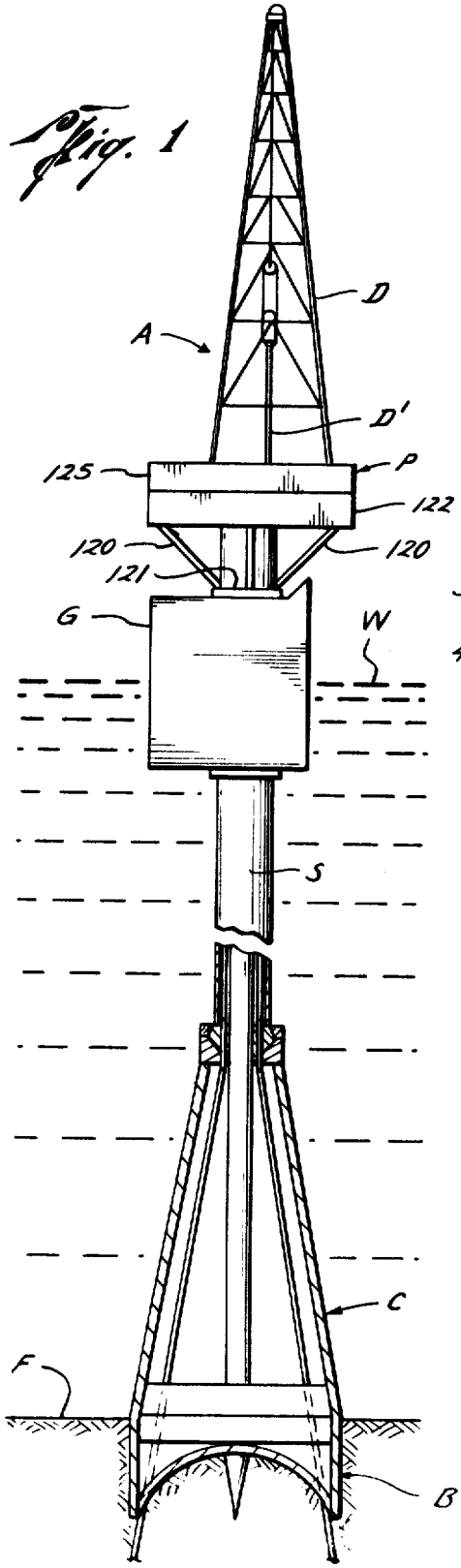
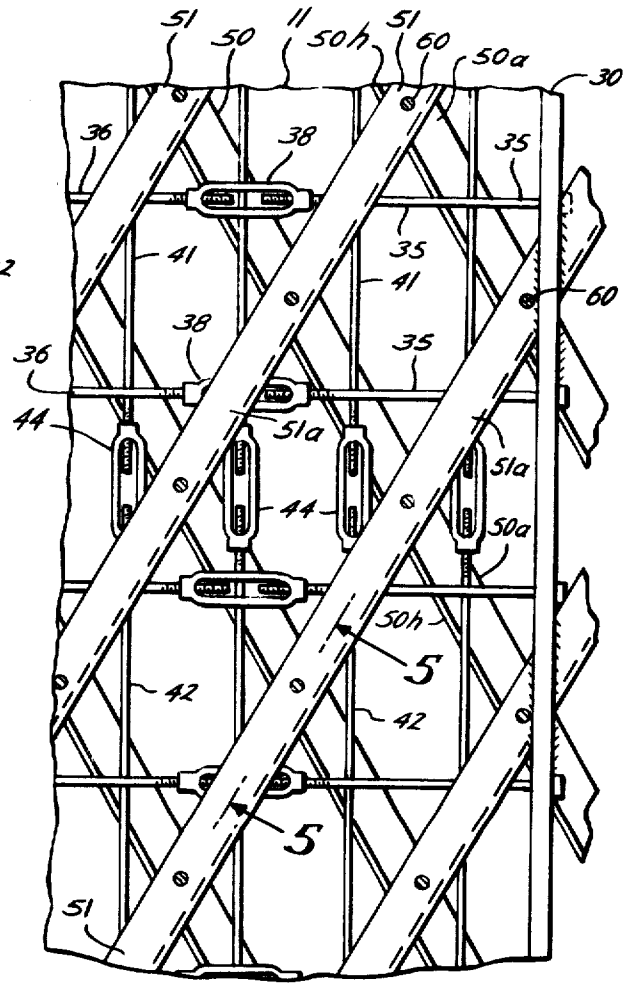


Fig. 4



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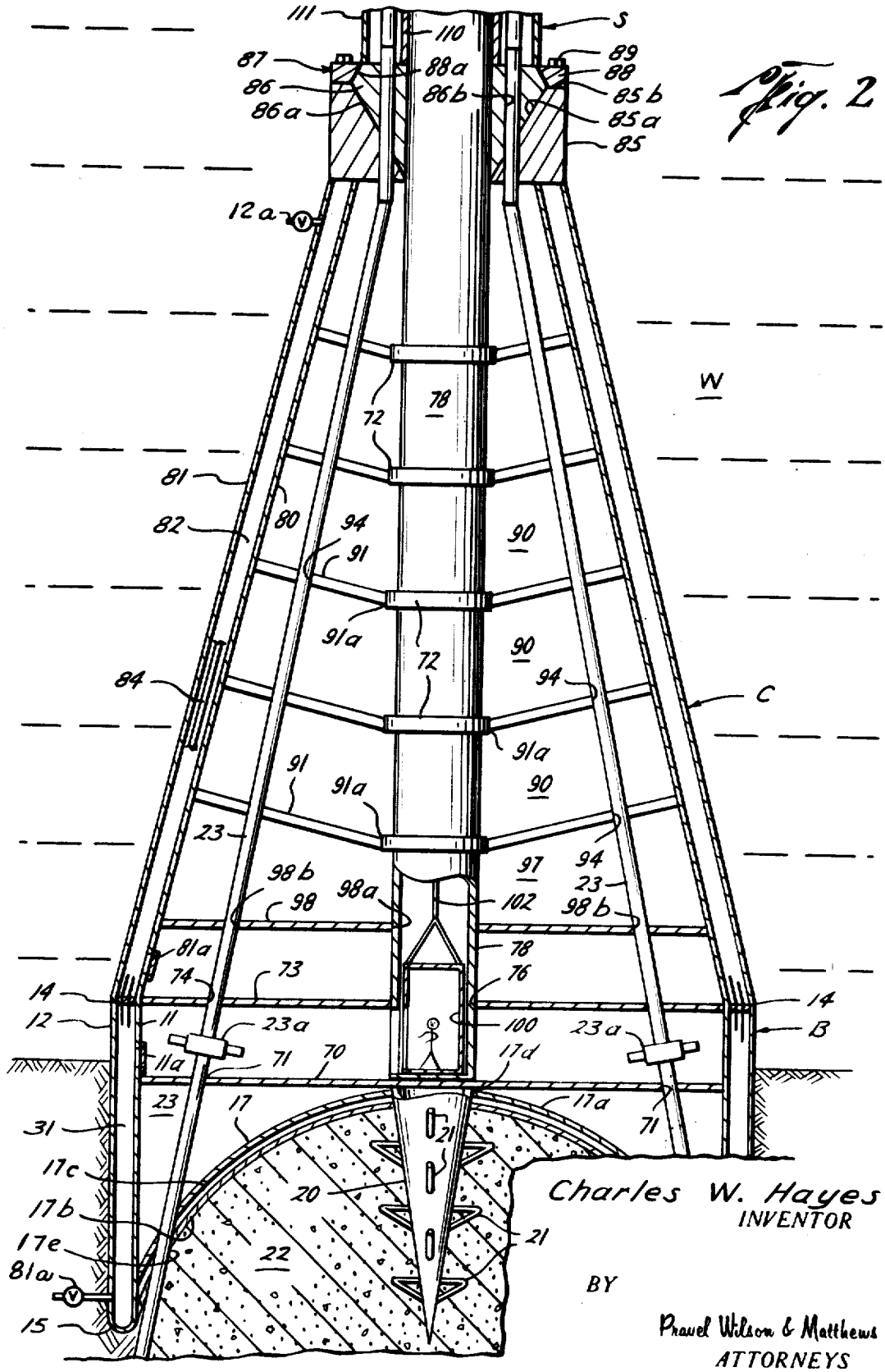
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Fig. 2

Fig. 3

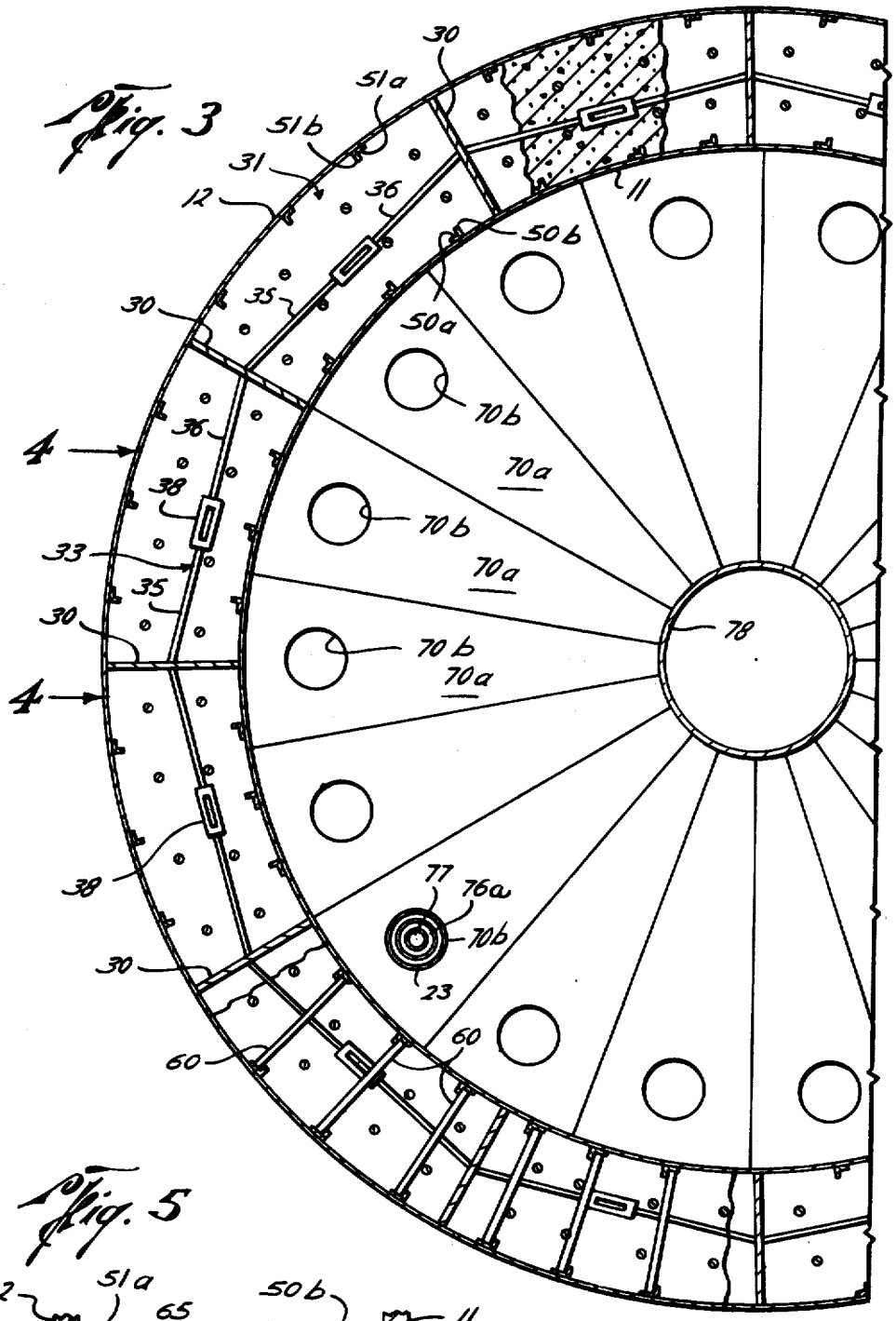
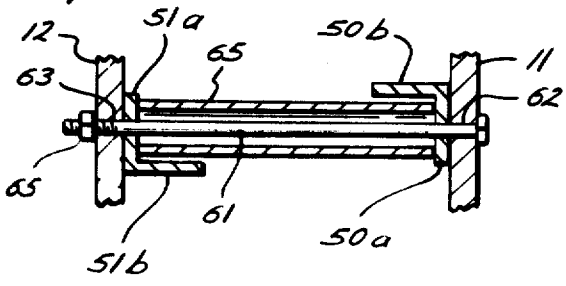


Fig. 5



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SPACED MULTI-WALL CONSTRUCTION UNIT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to a spaced multi-wall construction unit for large pressure vessels such as offshore platforms and other vessels subjected to high internal and/or external pressures and to a method for erecting such vessels.

2. Description of the Prior Art

In the prior art pressure vessel construction, the walls of the pressure vessel are typically made of substantially solid steel, either by forming a single thick plate of steel into a vessel or by building up a laminated or multi-layer vessel from a plurality of relatively thin plates of steel which are joined together so as to form a substantially continuous steel wall structure. The difficulty and expense involved in forming large vessels of relatively thick steel plate, or of a plurality of thin layers, renders these types of construction highly impractical for forming large pressure vessels suitable for use at the pressures encountered in relatively deep water. In addition to the material and labor cost involved and capital equipment required for forming large steel plates, there is the additional expense of heating and reheating a plate for successive passes through the heating equipment when the vessel is made of a single steel plate, the expense of radiographing and stress relieving a vessel once it is completed as well as the transportation problems inherent in handling large, very heavy steel wall vessels.

SUMMARY OF THE INVENTION

The present invention comprises a spaced multi-wall construction unit comprising an inner skin and an outer skin spaced laterally apart and joined together at opposite ends by transverse plates to form a relatively lightweight enclosure with tension means connecting the inner and outer skins and transverse plates for prestressing the construction unit. The individual construction units can be prestressed to approximately the pressures expected to be encountered in use after they have been joined together to form a vessel or other construction, after which the space between the inner and outer skins can be filled with aggregate, concrete, grout or other suitable material to form a rigid spaced multi-wall construction unit suitable for use in constructing large pressure vessels. In some applications where low pressures are encountered, such as in shallow water, the prestressed laterally spaced wall construction can be used without filling the area between the walls, if desired.

It is also an object of the present invention to provide a new and improved method for erecting a structure or vessel for use in the ocean or offshore on the ocean bottom, comprising assembling a vessel or structure from a plurality of prefabricated construction units, each having laterally spaced inner and outer walls with means for joining the edges of such walls to form an enclosure, joining the sections together or form an assembled structure, prestressing each of such units the desired amount, floating the assembled structure to the location for erection, and filling the space between the laterally spaced walls with fine aggregate, concrete, grout or other suitable material beginning at the lower end of such assembled structure to cause the lower end

to sink to the ocean floor with the bottom of such structure grounded thereon, and then excavating or dredging mud and silt from beneath the bottom of the structure and filling the excavated area with grout, concrete or other stabilizing material.

Another object of the present invention is to provide a new and improved construction unit for relatively large pressure vessels for use in relatively deep water wherein such units are formed of relatively thin laterally spaced walls having a plurality of longitudinal braces secured to each wall with the braces on one wall disposed at an angle with respect to the braces on the other wall to form a lattice type network of braces with transverse tension means connecting intersecting portions of such longitudinal braces.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view partly in section of an offshore drilling and production platform constructed of laterally spaced multi-wall construction units;

FIG. 2 is an enlarged sectional view showing details of the base of such offshore platform.

FIG. 3 is a view partly in section and partly in elevation showing additional details of the base construction;

FIG. 4 is a side elevation of a portion of the construction unit with the outer skin removed showing longitudinally extending supports and tensioning means for prestressing the units; and

FIG. 5 is a sectional view taken on line 5—5 of FIG. 4 showing details of the transverse tensioning means in the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention comprises a plurality of spaced multi-wall construction units as shown in the drawings, arranged so as to form a deep water drilling and production platform designated generally A in FIG. 1. It will be appreciated that the construction units may be formed into various other configurations of vessels and structures besides the drilling platform shown without departing from the present invention.

As shown in FIG. 1, the drilling and production platform A is positioned with its base B embedded in the ocean floor F with a work and storage platform P supported above the surface of the water W by means of a longitudinally extending stem S which extends upwardly from the base B. Between the base B and the stem S is an underwater work and storage chamber C for storing oil produced from the production platform and also providing an underwater work area. A drilling derrick D is shown rotatably mounted on the platform P for conducting drilling operations from such platform through the stem S and a rotatable wave guard G is mounted on the stem S below the platform P for protecting the drilling platform from ice or high waves.

Considering now the apparatus of the present invention in more detail, the sidewalls of the base portion B, the storage chamber C and the stem S are formed of a plurality of laterally spaced multi-wall construction units of the present invention.

As best seen in FIG. 2 of the drawings, the construction units forming the base portion B comprise inner

and outer cylindrical sidewalls 11 and 12, respectively, which are laterally spaced relative to each other and which are supported in such laterally spaced relationship by an upper transverse plate 14 and a lower U-shaped transverse plate or member 15. Such members may be welded or otherwise suitably secured to the laterally spaced walls or inner and outer skin 11 and 12, respectively. A hemispherical bottom closure 17 comprises a spaced inner wall 17*a* and an outer wall 17*b* with a space 17*c* therebetween. Such walls 17*a* and 17*b* are secured to the inner wall 11 near its lower edge by welding or other suitable means to provide a lower closure for the base B.

A dredge or conduit 20 is provided below the hemispherical bottom 17 for removing mud or sand or silt from beneath the base B and filling the excavated area with concrete or other stabilizing material for supporting the drilling and production platform A thereon. Such conduit 20 comprises a central conical member having a plurality of laterally extending conduits 21 circumferentially spaced therearound and projecting outwardly therefrom through which sand or silt can be removed from the ocean floor F beneath the hemispherical bottom 17 by a suitable dredging apparatus (not shown) and through which stabilizing material such as concrete 22 or other suitable material can be injected to the excavated area. As shown, openings 17*d* are provided near the top of the hemispherical members 17*a* and 17*b* through which the upper end of the conduit 20 extends. It will be appreciated that suitable conductor pipes (not shown) can be connected to the conduits 21 for conducting excavated material to the surface or for discharging it onto the ocean floor near the platform base B as well as for conducting stabilizing material or fill to the excavated area from the drilling platform P at the surface of the water.

A plurality of circumferentially spaced openings 17*e* are provided in the hemispherical shell or plates 17*a* and 17*b* for receiving conductor guides 23 through which drilling and production pipes extend as will be described in detail hereinafter. Blow out preventers 23*a* are preferably provided on the conductor pipes 23.

As best seen in FIG. 3 of the drawings, the inner and outer skins 11 and 12 are spaced radially apart by a plurality of radially extending plate separators 30 which connect the laterally spaced cylindrical walls forming the base B at circumferentially spaced points. A construction unit preferably comprises a wall section including a pair of adjacent plate separators 30 and the inner and outer skins 11 and 12 extending between such adjacent plate separators. The skins 11 and 12 may be formed on a continuous strip or of a plurality of sections, and depending on the height of the individual unit, may include a plurality of strips placed one above the other.

Such units are provided with circumferentially extending tension means for imposing a tension prestress on the separator plates 30. In the preferred form of this invention, such tension means include tension bars 35 and 36 whose outer ends are welded to adjacent plates 30 and whose inner adjacent ends are threaded to receive turnbuckles 38 to impose the desired amount of tension on the separator plates to which the opposite ends of such bars 35 and 36 are secured. Such bars may either be welded to the separator plates 30 or may extend through suitable openings through such plates and be secured by means of a nut or other securing device attached to the ends of the rods 35 and 36, respectively.

As shown in FIG. 4 of the drawings, the plurality of substantially horizontal and parallel tensioning means 33 are positioned one above another and connect adjacent plate separators 30 so as to place then under tension. Similarly, the base B is provided with a plurality of substantially vertical tension means comprising rods or bars 41 and 42, with the upper end of rod 41 connected to the annular wall 14 and the lower end of rod 42 connected to the annular wall 15. The inner adjacent ends of the rods 41 and 42 are threaded to receive turnbuckles 44 which are provided for imposing tension on the plates 14 and 15, respectively. A manhole or other suitable opening 11*a* is provided in the inner wall to provide access for a workman to the area 31 between the walls 11 and 12 for tightening the turnbuckles 38 and 44, respectively. The outer ends of the rods 41 and 42 can be secured by welding or other suitable means to such annular walls 14 and 15, as desired.

Also, as shown in FIGS. 3 and 4 of the drawings, a plurality of diagonally extending braces 50 is provided on the inner skin 11 and a plurality of similar braces 51 is provided on the outer skin 12. Such braces 51 extend diagonally in an opposite direction to the braces 50. Such braces 50 and 51 are preferably longitudinally extending strips of angle iron having a pair of diverging legs such as 50*a* and 50*b* which are disposed at right angles to each other. The leg 50*a* is positioned adjacent to the inner skin 11 and welded or otherwise secured thereto with the leg 50*b* projecting toward the outer skin 12.

Similarly, the braces 51 comprise longitudinally extending right angle members having legs 51*a* and 51*b* which are disposed at substantially right angles relative to each other. As shown, the braces 51 are arranged with the legs 51*a* engaging the inner surface of the outer skin 12 and welded or otherwise secured thereto with the legs 51*b* projecting laterally inwardly toward the inner wall 11. The opposite ends of the braces 50 and 51 are connected by welds to the plate separators 30.

As best seen in FIGS. 4 and 5 of the drawings, transverse connecting means 60 are provided at each intersection of the diagonal braces 50 and 51, respectively, for holding the skins 11 and 12 in laterally spaced relationship and to prevent buckling when tension is applied thereto. Such transverse connecting means comprises a longitudinally extending shaft or bolt 61 which extends through a suitable opening 62 in the inner skin 11 and also in the adjacent leg 50*a* and through a similar opening 63 that is formed in the outer skin 12 and in the adjacent brace leg 51*a*. A nut 65 or other suitable securing means is provided on the end of threaded shaft or bolt 61 for securing the skins 11 and 12 and cross-braces 50 and 51, respectively, to the bolt 61.

A tubular stiffener 65 extends transversely between the adjacent legs 50*a* and 51*a* of the braces 50 and 51, respectively, and surrounds the shaft 61 which extends therethrough. As shown in FIG. 5 of the drawings, the angular braces 50 and 51 are arranged so that the inwardly projecting leg 50*b* on the brace 50 is disposed

on an opposite side of the tubular stiffener **65** from the angular leg **51***b* of the brace **51**.

It will be appreciated that with the structure of the construction units of this invention as shown in the drawings, the horizontal rods **35** and **36**, the vertical rods **41** and **42** and the transverse shafts or bolts **61** may each be individually tightened so as to prestress the construction unit prior to filling the area **31** between the walls **11** and **12** with concrete, aggregate, grout or the like. A valve **12***a* is connected to the outer wall **12** for filling the space **31** between the inner and outer skins **11** and **12** with concrete, etc.

It will also be appreciated that the preferred construction of the hemispherical base **17** is similar to the construction of the sides of the cylindrical base B in that similar tensioning means (not shown) are used in prestressing the bottom member **17**.

A lower working platform or floor **70** is provided in the base B and extends transversely of the inner cylindrical wall or skin **11** and is welded or otherwise secured thereto. Such floor **70** is provided with openings **71** through which the conductor pipes or guides **23** extend.

An intermediate floor **73**, which extends transversely of the base B adjacent the upper edge thereof, is welded or otherwise secured to the inner cylindrical wall **11** for supporting such floor **73** vertically above the floor **70**. Suitable openings **74** are also provided in the floor **70** for receiving the conductor pipes **23**. An opening **76** is provided for receiving the cylindrical elevator shaft **78** that extends upwardly from the floor **70** through the stem S to the work platform P above the surface of the water W. The floors **70** and **73** provide storage or working space for production and workover equipment or the like in the base B. The floors **70** and **73** each preferably comprise a plurality of sections **70***a* with an opening **70***b* therein for receiving a tubular conductor guide **23** which is normally disposed in such openings. A casing **76***a* is disposed in the tubular conductor guide **23** and, as shown in the drawings, receives the string of drill pipe **77** such as is used in rotary drilling of oil and gas wells and the like.

The storage body C which is positioned on the base B comprises a truncated cone which includes laterally spaced inner and outer skins or walls **80** and **81**, respectively, which are spaced relative to each other so as to provide an opening **82** therebetween for receiving tensioning means as well as concrete, aggregate, grout or the like. A valve **81***a* is provided in the outer skin **81** for injecting concrete, grout, etc. into the space **82** between the walls **80** and **81**. The structure of such conical storage member C includes longitudinally extending tensioning means **84** connecting the annular plate or member **14** at the lower edge of the spaced walls **80** and **81** with the stem attachment ring **85** which extends circumferentially of the stem S and secures such stem S to the upper end of the truncated conical storage section C as will be described in detail hereinafter. A manhole or other suitable opening **81a** is provided in the inner skin **81** for providing access by a workman to the space **82** for tightening the turnbuckles (not shown) on the tensioning means **84**.

In the preferred form of this invention, the inner and outer skins or laterally spaced walls **80** and **81**, respectively, are each provided with diagonally extending angular braces (not shown) such as the braces **50** and **51** shown and described in connection with the cylindrical base portion B of this invention. The diagonal braces in the conical section C may not be positioned parallel to each other but instead, they are preferably arranged so that their adjacent upper ends are closer together at the top of the conical section C then their adjacent lower ends at the bottom of the conical section C. Additionally, the conical storage section C is preferably formed of a plurality of individual segments which include transversely extending plate separators (not shown) which connect such inner and outer conical walls **80** and **81** at circumferentially spaced points to provide a plurality of structural segments for multi-wall construction units. Transverse tension means (not shown) is similar to the transverse tension means **60** and are provided at spaced intervals around the inclined walls **80** and **81**, respectively. Thus, it will be appreciated that although the inclined walls **80** and **81** form a conical housing C rather than a cylindrical housing such as the case with the base B, such conical housing is divided into a plurality of segment sections or construction units suitable for pre-fabrication prior to final assembly and that such construction units can be pre-tensioned after final assembly by tightening the tensioning means provided therein.

A plurality of storage compartments **90** are provided in the conical storage housing C for storing oil or other material, as desired. Such compartments **90** are formed by a plurality of vertically spaced inclined plates which extend radially outwardly from adjacent the cylindrical elevator shaft **78** to the inner skin or wall **80**. Support rings **72** are welded or otherwise secured to the cylindrical shaft **78** at longitudinally spaced intervals for receiving the inner edges **91***a* of the inclined plates **91** forming the storage compartments **90**. Each of such plates **91** is provided with suitable openings **94** for receiving the conductor guides **23**.

Below the storage compartments **90** are a pair of storage areas or work areas **96** and **97** formed in the conical member C by means of substantially horizontally extending plates **98**. These areas may be used for work or storage areas, as desired. An opening **98***a* is provided in the plate **98** for receiving a cylindrical elevator shaft **78** and openings **98***b* are provided for receiving the conductor guides **23**.

As illustrated schematically in FIG. **2**, an elevator **100** is positioned in the central shaft **78**. Such elevator may be suspended by a cable **102** which extends upwardly through the shaft **78** to a suitable lifting and lowering means (not shown) preferably located on the drilling platform P for operating the elevator **100**.

The stem S which extends upwardly from the top of the conical storage chamber C for supporting the drilling platform P above the surface of the water W is preferably a cylindrical structure formed in substantially the same manner as the laterally spaced multi-wall construction of the cylindrical base B, including inner and outer skins **110** and **111**, which are provided with a lattice type network of supporting beams (not shown) similar to the diagonal supports **50** and **51** as well as transverse tension means, vertical, longitudinal and circumferential tension means for prestressing the stem structure prior to filling the area between the inner and outer skins **110** and **111**, respectively, with concrete, grout or other suitable material.

As shown in FIG. 2 of the drawings, the stem connecting ring **85** comprises an outer cylindrical housing having an inner surface **85***a* tapered inwardly and downwardly forming an inverted conical recess for receiving an inner ring or stem base **86** which comprises a ring having an inwardly and downwardly tapered surface **86***a* having a generally conical configuration which is received in the inverted conical depression **85***a* in the outer connecting ring **85**. Such inner ring **86** is also provided with an upper inclined or tapered shoulder **87** which is inclined inwardly and upwardly for receiving a lock ring **88** which is normally seated on the annular shoulder **85***b* of the cylindrical housing **85**. Such lock ring **88** is provided with an outwardly and downwardly inclined surface **88***a* which is inclined at substantially the same angle as the surface **87**. Such lock ring **88** is provided with a plurality of circumferentially spaced openings for receiving locking bolts **89** which are provided for securing such lock ring to the connecting ring **85**. A plurality of circumferentially spaced openings **86***b* extend through the rings **85** and **86** for receiving the conductor tubes **23** which extend downwardly through the stem S from the platform P.

Such drilling platform P is supported at the upper end of the stem S by a plurality of braces **120** which extend upwardly from a supporting ring **121** to the base **122** of such platform P. The drilling ring D is shown positioned eccentrically of the stem S and the upper portion **125** of such platform P which rotatably supports the derrick D with regard to the base **122** so as to permit the drill pipe D' that is supported in the derrick D to be aligned with each of the circumferentially arranged conductor guides **23** that are circumferentially spaced in the stem S. Thus, it will be appreciated that drilling operations may be conducted through one of such circumferentially disposed conductor guides **23** and after such operations have been completed, the upper portion **125** of the platform P may be rotated to thus align the derrick D above another of the circumferentially spaced conductor guides **23** for further drilling or reworking operations. Also, in the preferred form of this invention, the derrick D comprises a hexagonal derrick having a total of six legs rather than a conventional derrick having only four legs.

Thus, in using the spaced multi-wall construction unit of the present invention for constructing a deep water drilling and production vessel or platform, a plurality of prefabricated construction units or segments of the structure may be shop fabricated and thereafter assembled in a drydock facility so as to form the cylindrical base portion B, the conical storage chamber C and the stem S which projects vertically above the top of the conical storage section C and thereafter the entire structure may be floated to the particular location at which it is to be erected and after being prestressed so as to place the inner and outer skins and the plate separators in tension to the desired amount, the space between the inner and outer skins may be then filled with concrete, aggregate, grout or other suitable substantially incompressible material which will cause the base portion of the structure to sink to the bottom of the ocean. The area immediately beneath the bottom B can then be excavated by means of a dredge apparatus connected through the conduits **21** to thereby sink the bottom of the base B into the ocean floor F. With the structure thus positioned the excavated area beneath the hemispherical bottom closure **17** can then be filled with cement or grout or other stabilizing material pumping such material through the conduits **21** to provide a stable bottom for the base B. It will be appreciated that with suitable ground anchors in position for adding further support and stability to the apparatus A, that then drilling operations may be conducted through the plurality of circumferentially spaced conductor guides **23**. As drilling proceeds, casing **76***a* can be set in each of the holes drilled through such guides and, in the event production is obtained, oil or molten sulphur or other material may be stored in the various storage compartments **90** in the storage housing C until it is desired to transport such material to shore.

Also, it will be appreciated that the spaced multi-wall construction unit of the present invention may be employed for constructing other types of structures that are subjected to high internal and/or external pressure in a plurality of pre-fabricated units which are lightweight and relatively easily transportable. Such construction units can be prestressed after final assembly and then filled with aggregate, concrete or other suitable material to form a rigid pressure vessel structure.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape, and materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

I claim:

1. A spaced multi-wall construction unit for constructing vessels or structures subjected to high internal or external pressures comprising:
   a. a plurality of laterally spaced walls positioned side by side;
   b. an upper transversely extending member connecting the adjacent upper edges of said laterally spaced walls, a lower transversely extending member connecting the adjacent lower edges of said laterally spaced walls and a pair of transversely extending side members connecting the adjacent side edges, respectively, of said walls to form an enclosure; and
   c. first tension means connecting said upper and lower transverse members and second tension means connecting said pair of transversely extending side members to tension said multi-wall construction unit.

2. The apparatus of claim 1 including a substantially incompressible material disposed in the space between said laterally spaced walls to form a rigid construction unit.

3. The apparatus of claim 1 including a plurality of radially extending tension bars connecting said laterally spaced walls.

4. The invention of claim 3 wherein said radially extending tension means includes means extending radially from one of said walls to another of said walls to prevent buckling thereof including a longitudinally extending shaft extending through said walls, a tubular stiffener surrounding said shaft and means for adjusting the length of said shaft for securing said walls to said buckle resistant means.

5. The apparatus of claim 1 wherein said tension means are adjustable to permit the desired amount of tension to be imposed on said construction units.

6. A spaced multi-wall construction for constructing vessels or structures subjected to high internal or external pressure comprising:

a. a plurality of laterally spaced walls positioned side by side;

b. an upper transversely extending member connecting the adjacent upper edges of said laterally spaced walls, a lower transversely extending member connecting the adjacent lower edges of said laterally spaced walls and a pair of transversely extending side members connecting the adjacent side edges, respectively of said walls to form an enclosure; and

c. first tension means connecting said upper and lower transverse members and second tension means connecting said pair of transversely extending side members to tension said multi-wall construction unit with longitudinally extending braces secured to one wall and extending diagonally in one direction with longitudinally extending braces secured to the other wall and extending diagonally in another direction.

7. The invention of claim 6 wherein said longitudinally extending braces comprise angle straps having a pair of divergent legs, one of said legs being secured to one of said walls and the other leg projecting laterally toward the other wall.

* * * * *