Sept. 24, 1968 C. R. STEELE 3,402,557

SUPPORTING STRUCTURE FOR OFFSHORE DRILLING RIGS

Filed Aug. 24, 1966 4 Sheets-Sheet 1

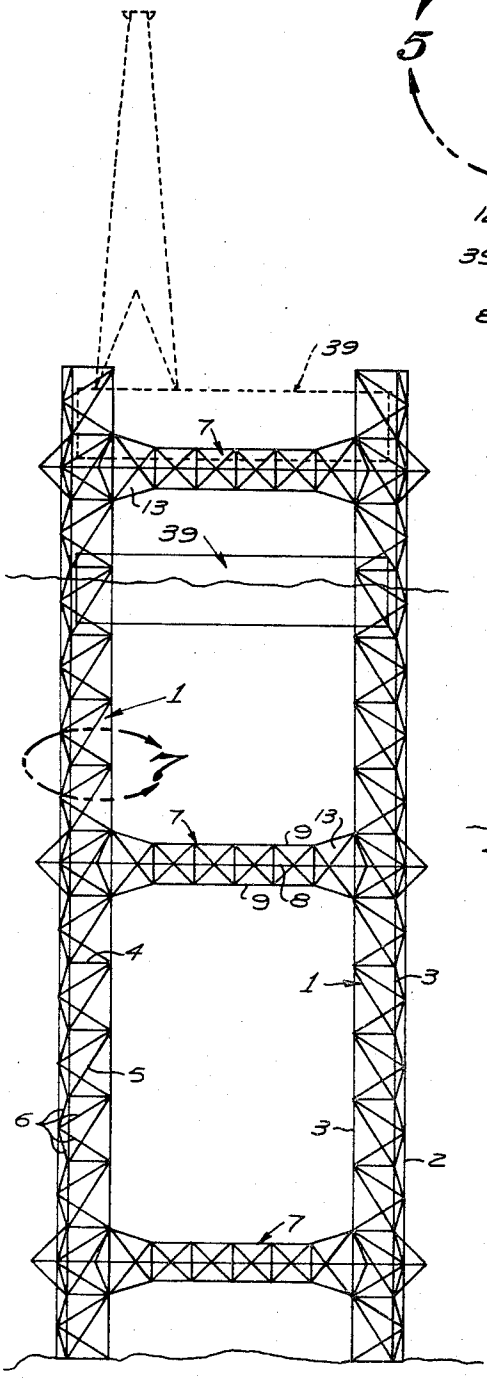


FIG. 1

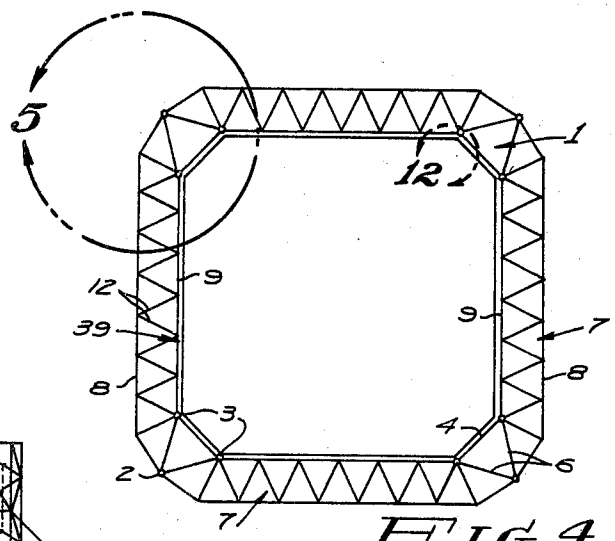


FIG. 4

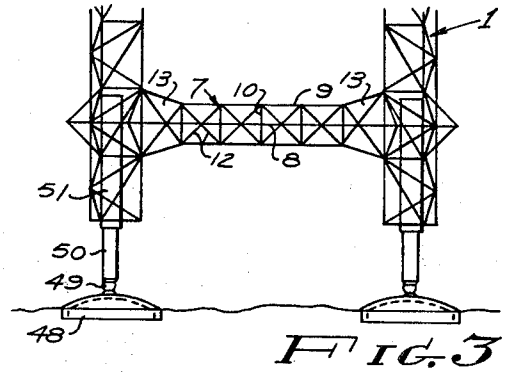


FIG. 3

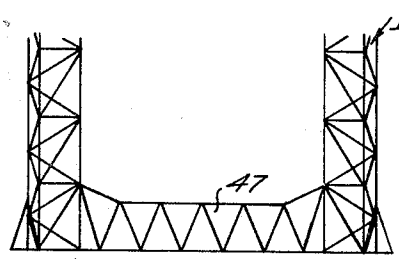


FIG. 2

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SUPPORTING STRUCTURE FOR OFFSHORE DRILLING RIGS

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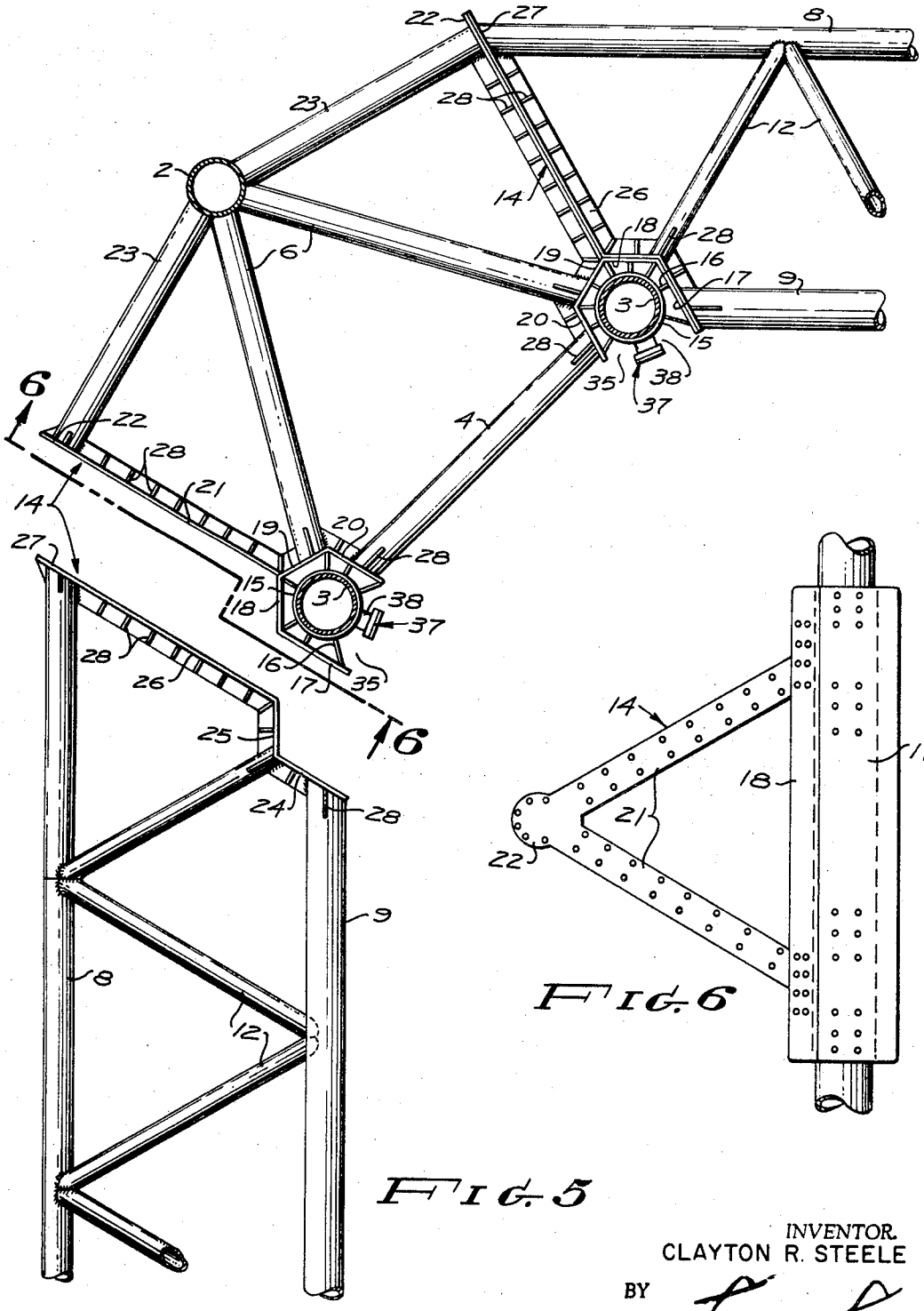


FIG. 5

FIG. 6

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SUPPORTING STRUCTURE FOR OFFSHORE DRILLING RIGS

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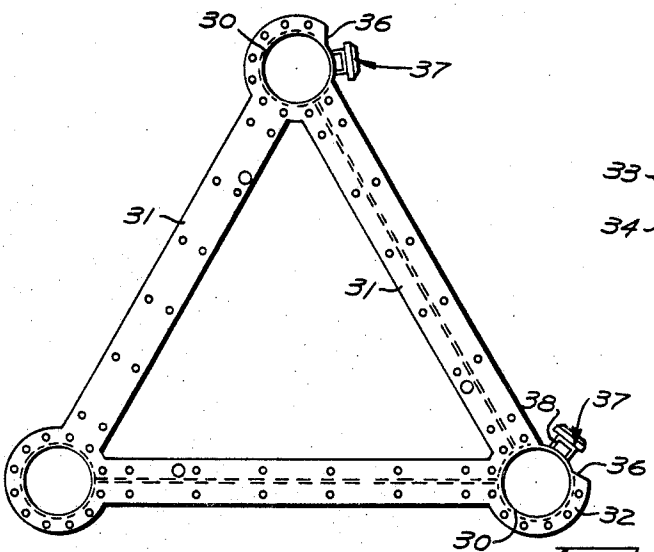


FIG. 8

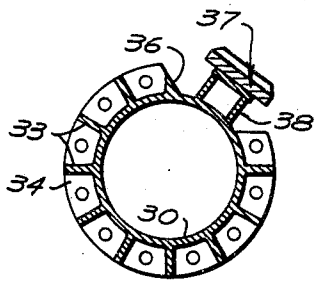


FIG. 9

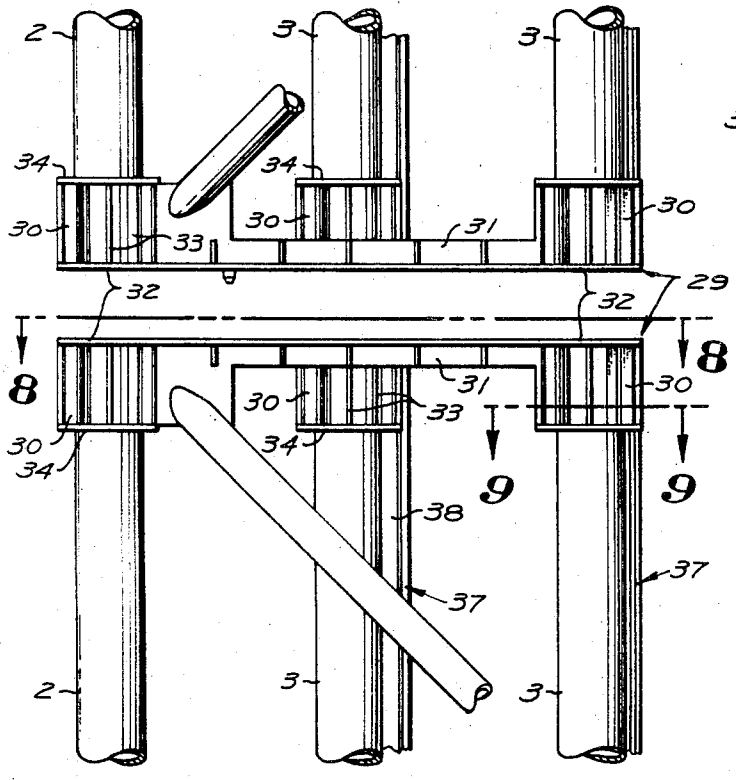


FIG. 7

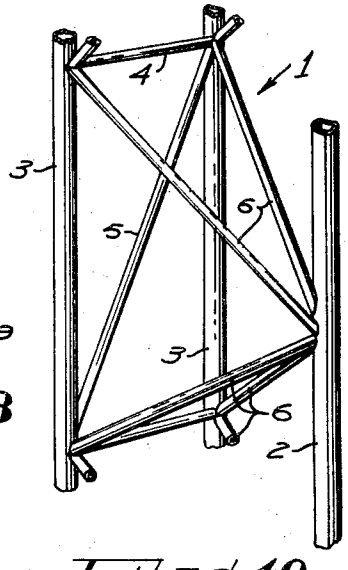


FIG. 10

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SUPPORTING STRUCTURE FOR OFFSHORE DRILLING RIGS

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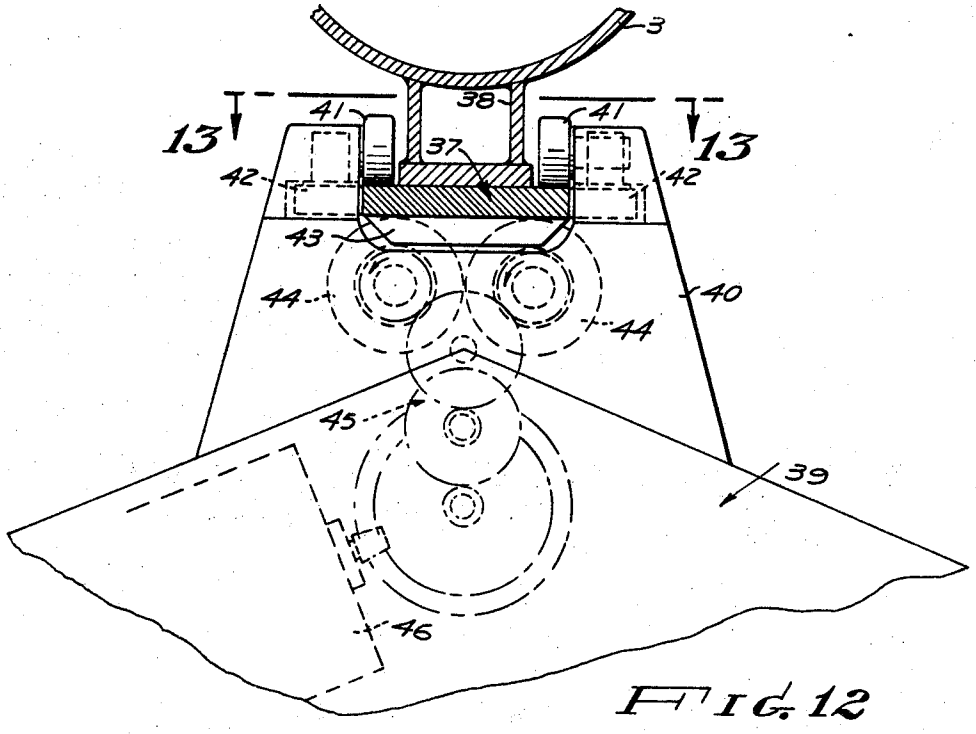


FIG. 12

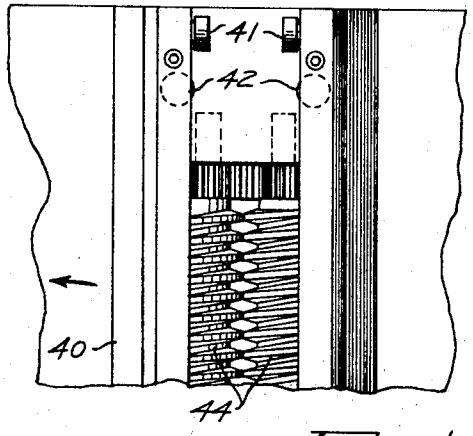


FIG. 13

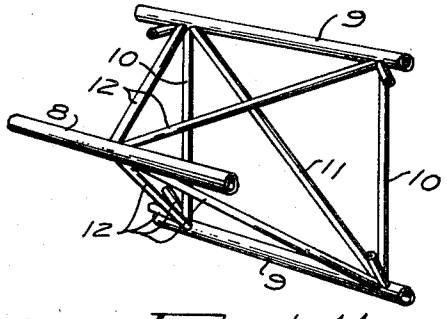


FIG. 11

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3,402,557

SUPPORTING STRUCTURE FOR OFFSHORE DRILLING RIGS

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Filed Aug. 24, 1966, Ser. No. 574,677
11 Claims. (Cl. 61—46.5)

ABSTRACT OF THE DISCLOSURE

A supporting structure for offshore drilling rigs in which a column structure of polygonal end aspect, having a column member at each apex joined by braces defining the sides of the column structure define the corners of the supporting structure. The column structures are joined at intervals by beam structures, each being polygonal in end aspect and having a beam member at each apex joined by braces defining the sides of the beam structure. The column structures are provided with vertical tracks which support a drilling platform within the space defined by the column and beam structures.

Summary of the invention

This invention relates to supporting structures for offshore drilling rigs and included in the objects of this invention are:

First, to provide a supporting structure for offshore drilling rigs which rests on the sea bottom and extends upwardly therefrom to an elevation above sea level, the supporting structure being particularly adapted for use in relatively deep water; that is, 300 to 600 foot depth or a substantially greater depth, the maximum depth being determined principally by the cost of construction and installation.

Second, to provide a supporting structure for offshore drilling rigs which utilizes corner columns, and beams of triangular cross section, preferably formed of tubing elements; the column and beams being joined together by unique corner forming assemblies to provide an essentially rigid framework.

Third, to provide a supporting structure for offshore drilling rigs in which its framework defines an internal space, essentially square, in plan aspect which is free of obstruction so that a drilling platform may be supported within and vertically guided by the framework, and which incorporates novelly arranged tracks and platform drive means for raising and lowering the platform.

Fourth, to provide a supporting structure for offshore drilling rigs wherein the columns and beams are adapted to be fabricated in sections, then transported to the site of use and assembled; this being accomplished by special column connectors and by other special connectors at the extremities of the beams.

With the above and other objects in view, as may appear hereinafter, reference is directed to the accompanying drawings in which:

FIGURE 1 is a diagrammatical side view of the supporting structure for offshore drilling rigs, indicating the drilling platform in a buoyant condition by solid outline, and indicating by dotted lines, the drilling platform in its raised position, and indicating also by dotted outline, a drilling rig mounted thereon.

FIGURE 2 is a similar diagrammatical side view showing the lower end of the supporting structure and one means whereby the supporting structure may rest on the sea floor.

FIGURE 3 is another fragmentary, essentially diagrammatical side view showing another means of mounting the structure of the sea floor.

FIGURE 4 is a diagrammatical top view of the supporting structure indicating the drilling platform in outline.

FIGURE 5 is an enlarged fragmentary sectional view taken within circle 5 of FIGURE 4 and illustrating the manner in which a column structure is joined to the beam structures, one beam structure being shown separated from the column structure.

FIGURE 6 is a fragmentary transverse view in elevation, taken from 6—6 of FIGURE 5, showing one component of the connector between the column structure and a beam structure.

FIGURE 7 is an enlarged fragmentary view taken within circle 7 of FIGURE 1, showing a connector for joining sections of the column structure, the elements of the connector being separated.

FIGURE 8 is an end view, taken from 8—8 of FIGURE 7.

FIGURE 9 is an enlarged sectional view taken through 9—9 of FIGURE 7.

FIGURE 10 is a fragmentary perspective view, showing a single column unit or bay.

FIGURE 11 is a fragmentary perspective view of a beam structure showing a single beam unit or bay.

FIGURE 12 is an enlarged fragmentary view taken within circle 12 of FIGURE 4, illustrating the means whereby the platform is supported within the column structures and indicating the means whereby the platform may be raised and lowered.

FIGURE 13 is a reduced fragmentary side view of the platform mounting means, taken from 13—13 of FIGURE 12.

The supporting structure for offshore well drilling rigs utilizes four column structures 1; each column structure is triangular in end aspect, the apices of the triangle being defined by an outside column member 2 and two inside column members 3. The column members are tubular. The column structures are so positioned that the inside column members form the beveled corners of an otherwise square figure.

The two inside column members of each column structure are joined by a series of inside horizontal braces 4 and by diagonal braces 5, extending between the horizontal braces. The two inside column members are joined to the outside column member by sets of inside-outside braces 6 which originate at the extremities of the horizontal braces 4 and converge as they extend outwardly, forming an apex of a pyramid which is joined to the outside column member, as shown best in FIGURE 10. Each set of braces 4, 5, and 6 form a column unit or bay of the column structure.

The column structures are joined by sets of beam structures 7; each set comprising four beam structures located in a common plane. Each beam structure is triangular in end aspect and the apices of the triangle are defined by an outside beam member 8 and a pair of inside beam members 9. Each pair of inside beam members define a vertical plane. The inside beam members are connected by inside vertical braces 10 and inside diagonal braces 11. Four inside-outside braces 12 converge outwardly from each pair of vertical braces 10, forming a pyramid, the apex of which is joined to the outside beam member 8. Each set of braces 10, 11, and 12 define a beam unit or bay.

It will be noted that the column structures and beam structures are identical in construction, except that the dimensions of the column structures are greater than those of the beam structures. While the supporting structure may vary in size, it should be noted that in any case, the structure is quite large. For example, the column structures may be spaced 120 feet or more. The tubular column members may be 3 feet in diameter, the tubular beam

members 2 feet in diameter, and the braces, which are also tubular, are appropriately dimensioned.

In order that the beam structures be mated to the column structures, the inside beam members **9**, forming a part of the end units **13**, of each beam diverge from each other. That is, the spacing between the extremities of the inside beam members **9** is increased to correspond to the spacing between the inside horizontal braces **4** of the column structure. If desired, the spacing between the inside beam members **9**, throughout their length, may equal the corresponding spacing of the braces **4**.

The beam structures are joined to the column structures by means of column-beam connectors **14**, illustrated in FIGURES 5 and 6. Each column-beam connector includes a sleeve **15** which fits an inside column member **3** and is provided with radiating ribs **16**, joined to vertical plates **17**, **18**, **19**, and **20**. The plates are joined edge to edge to define four sides of a six-sided figure. The extreme plates **17** and **20** are separated from each other. Joined to the juncture of the plates **18** and **19**, near their upper and lower extremities, is a pair of struts **21**, which are T-shaped in cross section. The struts are joined at their extremities to an end flange **22**. The end flange is joined to a strut **23** which extends perpendicular to the plane of the struts **21** and is joined to the outside column member **2**. The struts **21** and strut **23** form with the adjacent brace **6**, a triangular bay extending laterally from the column structure. The extremities of each beam structure are provided with vertically extending end plates **24** and **25**, which mate with the plates **17** and **18**, respectively. A pair of converging struts **26**, corresponding to the struts **21**, are joined to the end plate **25** and terminate in an end flange **27**, mating the end flange **22**. The mating components of the column-beam connector, namely the plates **17** and **24**, **18** and **25**, the converging struts **21** and **26** and the end flanges **22** and **27** are joined together by bolts, not shown. The plates **19**, **20**, **24**, and **25**, as well as the converging struts **21** and **26**, and the end flanges **22** and **27**, are reinforced by gussets **28**.

In as much as the column structures may have a length of 300 to 600 feet, or substantially longer, it is desirable that the column structure be formed in sections; therefore, at appropriate intervals, the column structures are provided with connectors **29**, shown in FIGURES 7, 8, and 9. Each column connector includes a pair of mating components which may be identical in construction. Each component includes three collars **30**, adapted to be welded or otherwise secured to the column members **2** and **3**. The confronting extremities of the collars, provided in the two connector components, are joined together by a triangular frame **31**, the sides of which are T-shaped in cross section. The apices of the frame terminate in flanges **32**, joined to the collars **30**. In addition, the collars are provided with radiating ribs **33** and their remote extremities are provided with flanges **34**. The pairs of collars are joined by bolts extending between the flanges **34** and other bolts extend between the frames **31**. The bolts are not shown.

The ends of the connectors **14**, directed into the area defined by the column structures, define clearance notches **35**. Similarly, the flanges **32** and **33** of the column connectors **29** are provided with clearance notches **36**. These notches permit the mounting of tracks **37**, which extend the length of the column structures, or any selected portion thereof. The tracks are preferably arranged in sections and are supported from ribs **38**, secured to the inside column members **3**. The column structures **1** and the beam structures **7** define a square area, the corners of which are beveled; or stated otherwise, the figure may be considered as eight-sided, comprising four major sides determined by the beam structures **7** and four minor sides determined by the spacing between the inside column members **3**. The space thus defined receives a drilling rig platform **39**, having corners which confront the tracks **37**. At these corners, the drilling rig platform is provided with housings **40**, which support guide rollers **41** and **42**, engageable with the tracks **37** so that the platform may be moved vertically within the supporting structure defined by the column structures **1** and the beam structures **7**.

In order to support and move the drilling rig platform, the tracks **37** are provided with rack teeth **43**. Contained in each housing **40** is a pair of screw drive members **44**, which mate with the rack teeth **43**. The drive members **44** are connected by a gear train **45** to a motor **46**. Operation of the motors **46** is synchronized by suitable means not shown so that the drilling platform may be maintained level as it is raised and lowered.

The supporting structure may be erected by different methods. For example, the drilling platform may be buoyant and therefore capable of being towed to the site. The tubular column structures, separated into segments, and the beam structures are also brought to the site. By reason of the tubular nature of the components of the column and beam structures, they may be sealed so that they may be buoyant, or nearly so, and therefore may be towed to the site with a minimum of effort.

The tracks **37** and the guide rollers **41** and **42** may be employed to support the sections of the column structure from the drilling platform, and the sections may be lowered by means of the screw drive members **44**. While thus held, the beam structures **7** are attached and as the parts of the supporting structure are added, the supporting structure is lowered toward the sea bottom.

The supporting structure may be anchored by various means. For example, piles, not shown, may be driven downward through the column members **2** and **3**. Alternatively, as shown in FIGURE 2, a base frame **47** may be provided. The base frame may be constructed similarly to the beam structures **7**, except that a side faces downward instead of inward. The base frame may rest directly on the ocean bottom or may be embedded or partially embedded in a concrete base or foundation.

Another arrangement involves the use of prefabricated pads **48**, such as shown in FIGURE 3, each pad being provided with a universal joint **49**, attached to a piston **50**, slidable in a cylinder **51**, secured in the lower ends of the column structures **1**. The pistons are axially adjustable so as to compensate for slope of the ocean bottom. When the supporting structure is in proper supporting condition, the platform is raised above the water, preferably above storm wave height.

The column structures and the beam structures are, by reason of their triangular configuration and the triangular relationship of the braces and columns or beam members, rigid structures. The manner in which the column structures and beam structures are joined cause these structures to reinforce and stiffen each other. Therefore, the supporting structures as a whole is ideally suited to resist the applied forces; that is, wave action and wind action applied at the top and water current action applied throughout the submerged portion of the supporting structure produce horizontal loads that are distributed throughout the supporting structure and transferred to the foundation.

The rigid connections provided between the beam structures and the column structures, resist and transfer to the beam and column structures, loads applied from various directions. The rigid frame formed by each set of beam structures holds the column structures straight and true, and gives the column structures the necessary stiffness to carry the imposed loads and force couples, even though the submerged portion of the supporting structure extends to a greater depth than has heretofore been feasible.

By reason of the inherently rigid connections between the beam structures and column structures, a square figure, free of internal bracing, and the attendant increased platform area is feasible. However, it should be noted

that the supporting structure may be a three-sided figure.

Stated otherwise, it is essential that the basic elements, namely the column structures and the beam structures, have the configuration illustrated. The vertical inner side of each beam structure comprising the beam members **9** and braces **10** and **11**, acts as a truss which is held true by the outer beam member **8** and brace **12**. Similarily, each side of each column structure is restrained from twisting by the beam member at the remaining apex and connecting braces. Also, each column or beam structure restrains the connected beam or column structure from twisting. In addition, the column structures are divided by the sets of beam structures into relatively short sections highly resistant to buckling, even though the overall supporting structure is of great length.

While particular embodiments of this invention have been shown and described, it is not intended to limit the same to the details of the constructions set forth, but instead, the invention embraces such changes, modifications and equivalents of the various parts and their relationships as come within the purview of the appended claims.

I claim:

1. A supporting structure for offshore drilling rigs, comprising:

(a) a set of column structures defining a polygonal area, each column structure defining a polygon in end aspect and including a vertical column member at each apex of the polygon and connecting braces at the sides thereof;

(b) sets of horizontal beam structures joining said column structures, each beam structure defining a polygon in end aspect and including a beam member at each apex of said polygon and connecting braces at the sides thereof;

(c) the ends of each of said beams being connected to said columns at a plurality of points whereby loads applied to said columns are transmitted in part to said beams and resisted thereby; and conversely, loads applied to said beams are transmitted in part to said columns and resisted thereby;

(d) means for supporting said column structures at their lower ends;

(e) vertical guide tracks carried by said column structures;

(f) and a drilling platform disposed within said polygonal area and including means guided by said tracks.

2. A structure, as defined in claim **1**, wherein:

(a) each of said column structures defines a triangle in end aspect;

(b) one side of said triangle faces said polygonal area and forms a minor side thereof;

(c) and one of said tracks is mounted at each of said minor sides.

3. A structure, as defined in claim **1**, wherein:

(a) each of said column structures defines a triangle in end aspect, and one side of said triangle faces said polygonal area to form a minor side thereof;

(b) each of said beam structures defines a triangle in end aspect, and one side of said triangle is vertical and faces toward said polygonal area.

4. A structure, as defined in claim **1**, wherein:

(a) the points of connection between each end of each beam and the corresponding column structure define a common vertical plane;

(b) and separable couplings are provided at said points.

5. A structure, as defined in claim **4**, wherein:

(a) coupling means divide each of said column structures into segments.

6. A structure, as defined in claim **1**, wherein:

(a) said tracks are provided with rack teeth;

(b) and said platform is provided with helical drive gears mating said rack teeth and drive means therefor for moving said platform vertically.

7. A supporting structure for offshore drilling rigs, comprising:

(a) a drilling platform having four major sides joined by four minor sides;

(b) a set of four column structures, each being polygonal in end aspect and including column members at the apices thereof, and connecting braces forming the sides thereof;

(c) and a series of sets of four beam structures, each set being located in a common plane and the members of each set joined to said column structures, each beam structure being polygonal in end aspect and including beam members at the apices thereof and braces forming the sides thereof and joined to said beam members;

(d) a side of each column structure facing inwardly and confronting a minor side of said drilling platform;

(e) and a side of each beam structure also facing inwardly and disposed in a vertical plane to confront said drilling platform.

8. A structure, as defined in claim **7**, wheerin:

(a) vertical tracks are disposed along the margins of the inwardly facing sides of said column structures;

(b) and said platform carries means guided by said tracks.

9. A structure, as defined in claim **8**, wherein:

(a) said tracks are provided with rack teeth;

(b) and said platform carries screw members engageable with said rack teeth and drive means therefor, for raising and lowering said platform.

10. A structure, as defined in claim **7**, wherein:

(a) separable connectors are interposed between the extremities of each beam structure and the confronting portions of said column structures;

(b) and other separable connectors divide each column structure into sections.

11. A structure, as defined in claim **7**, wherein:

(a) at least said column structures are triangular in end aspect.

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