

March 26, 1963

J. R. SUTTON

3,082,607

OFFSHORE EQUIPMENT SUPPORTS

Filed Aug. 29, 1957

8 Sheets-Sheet 1

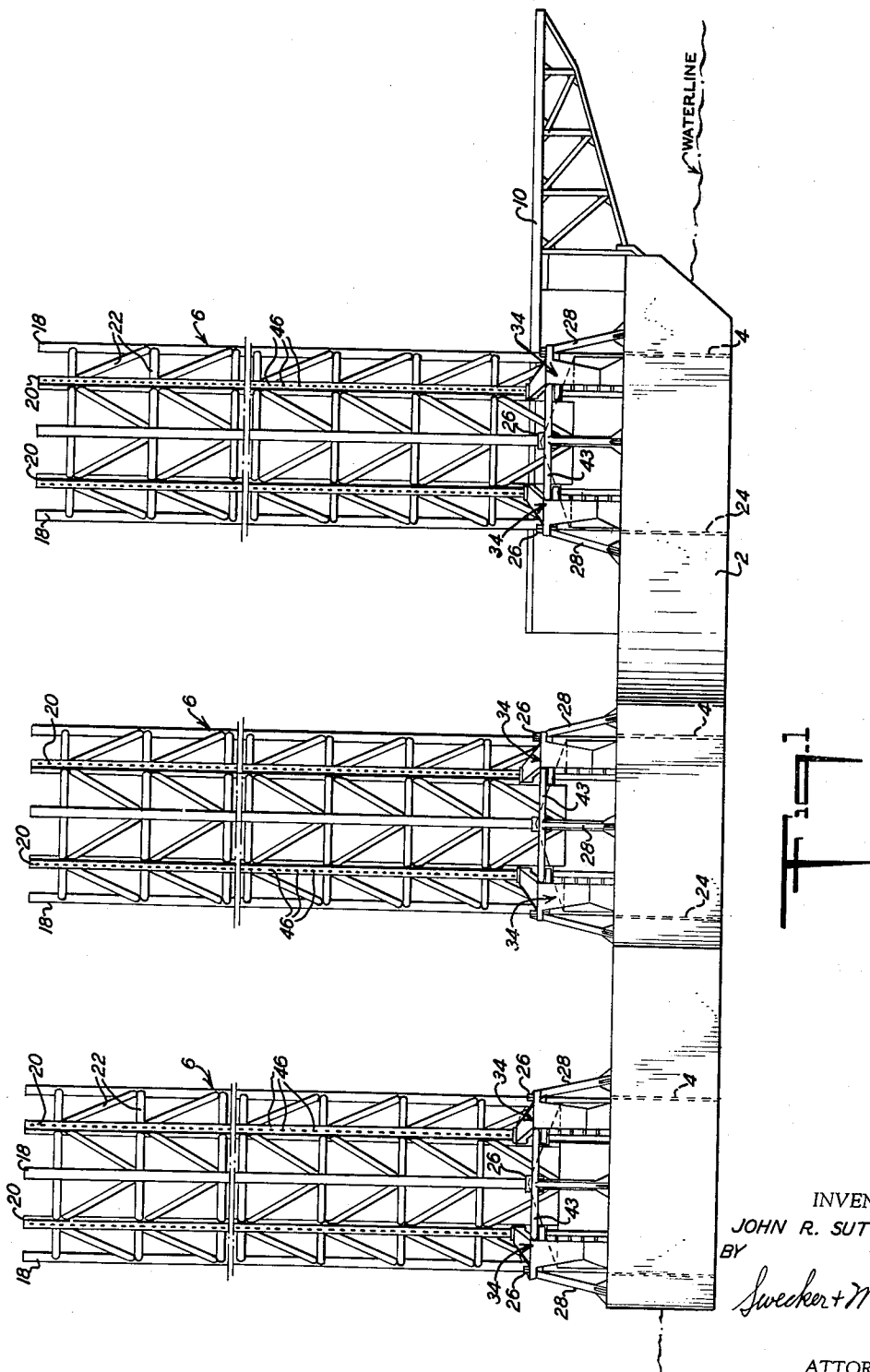


Fig. 1

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March 26, 1963

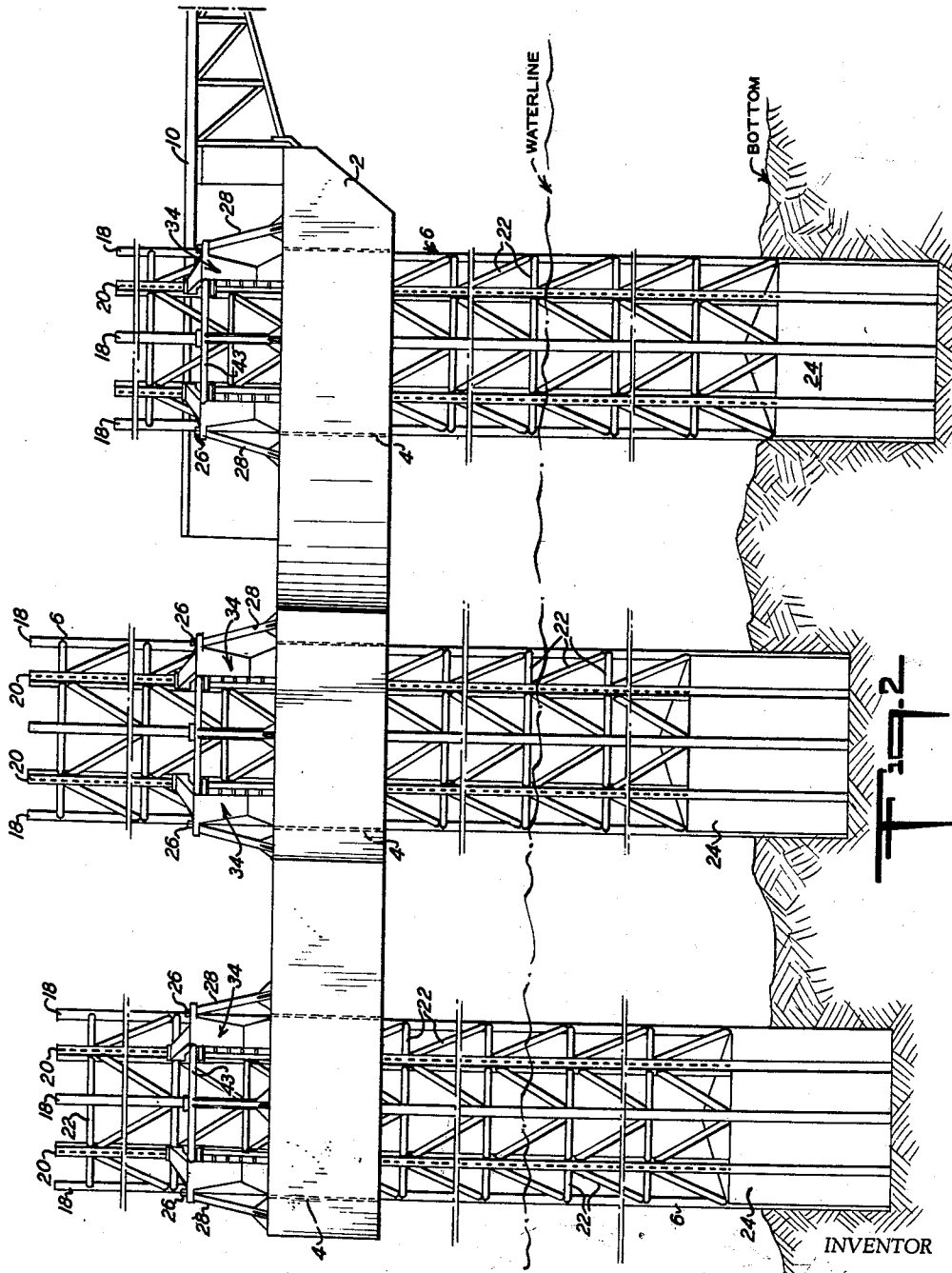
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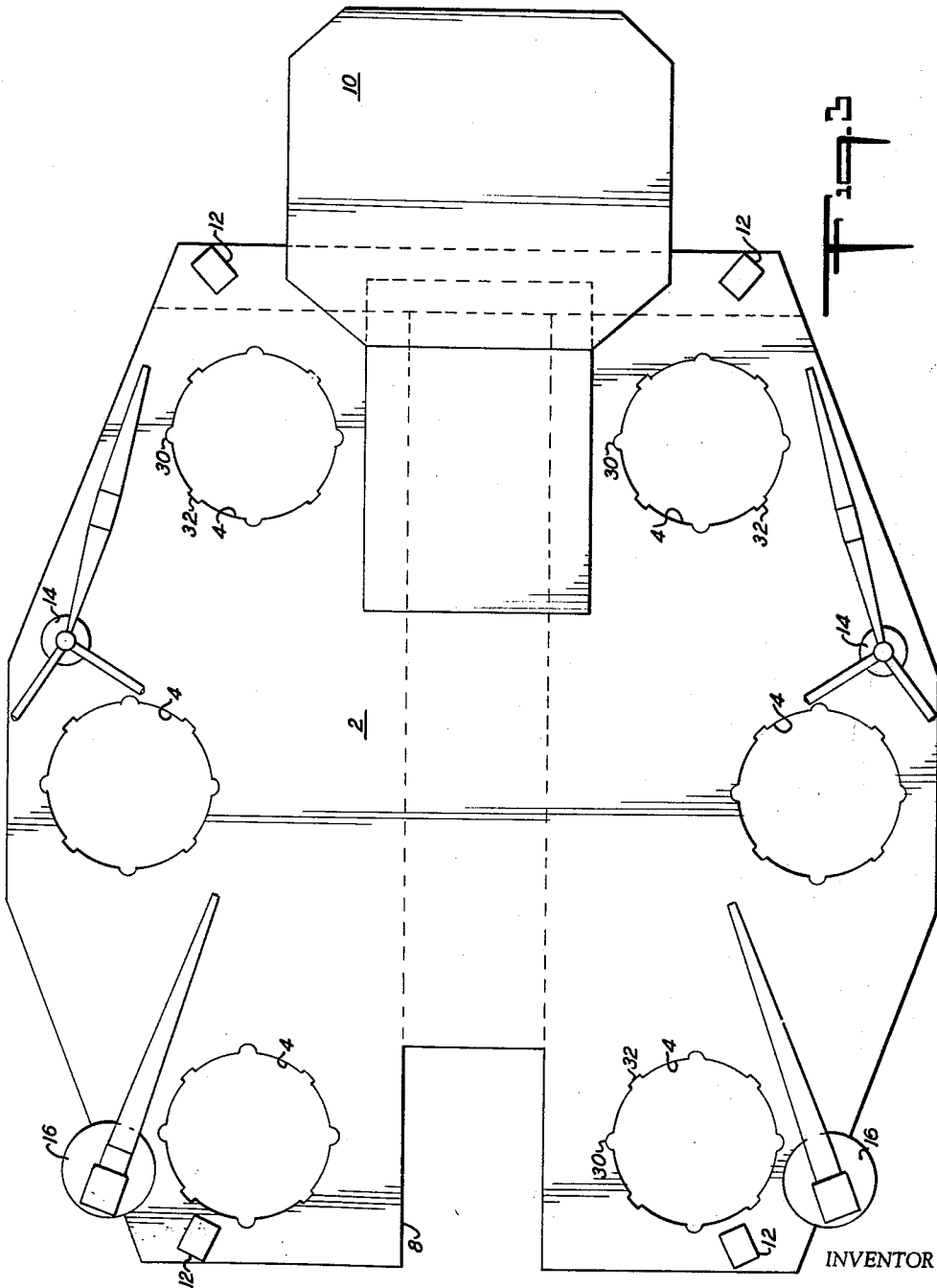
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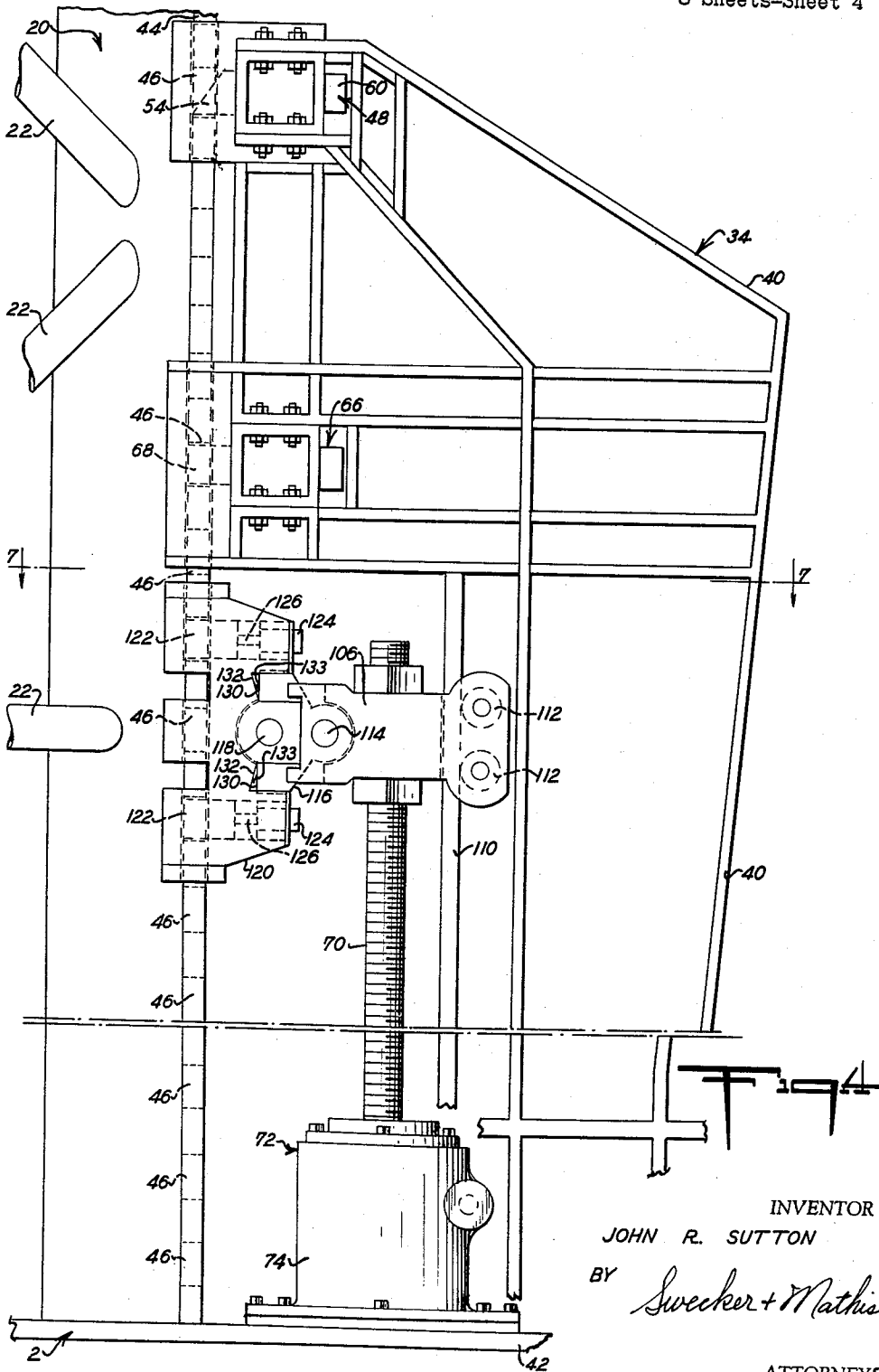
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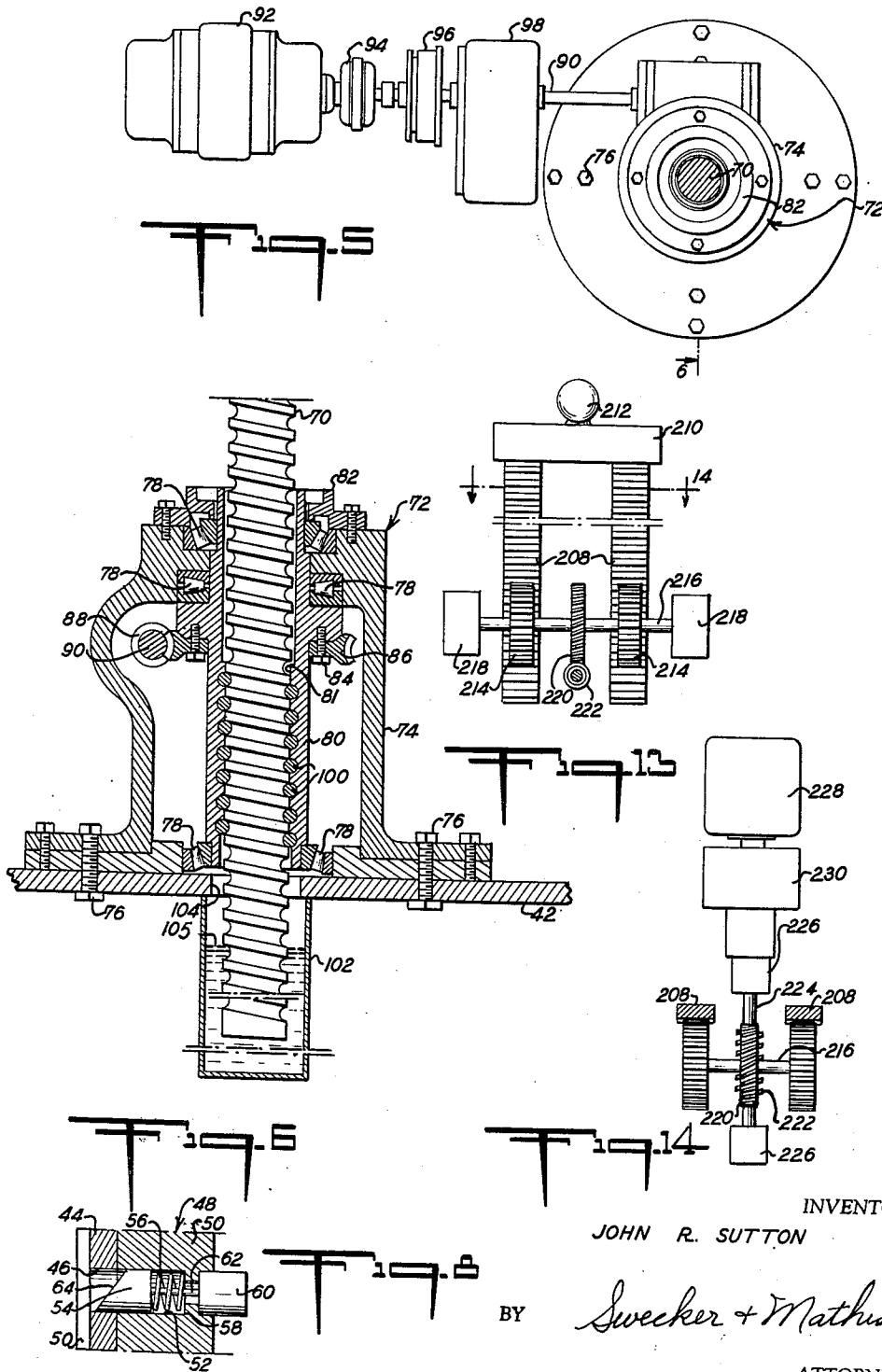
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8 Sheets-Sheet 5



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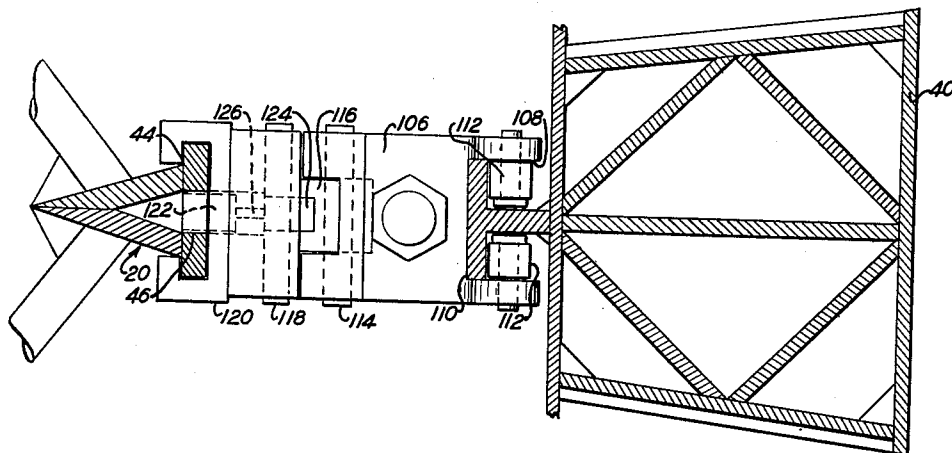


Fig. 7

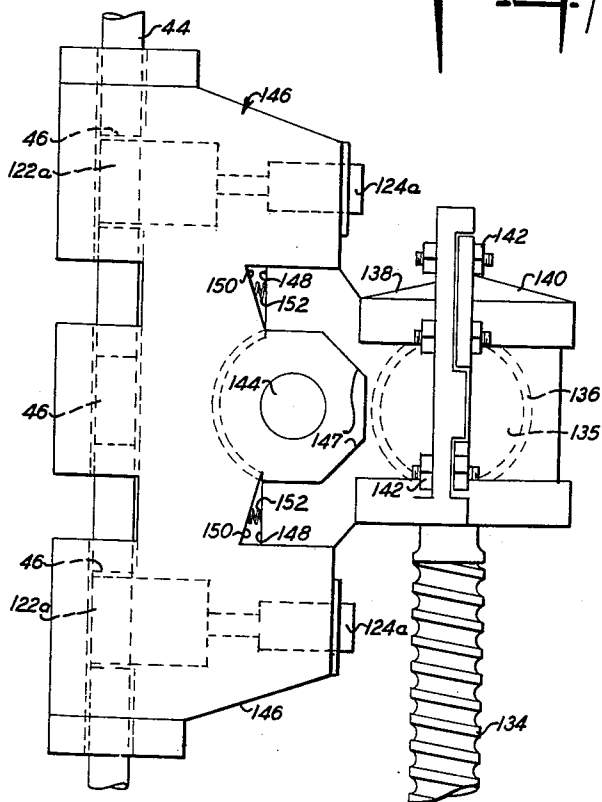


Fig. 8

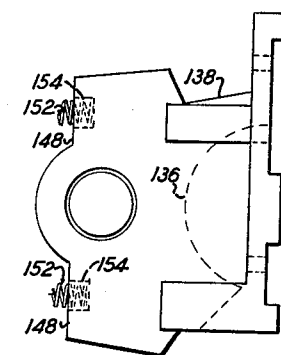


Fig. 9

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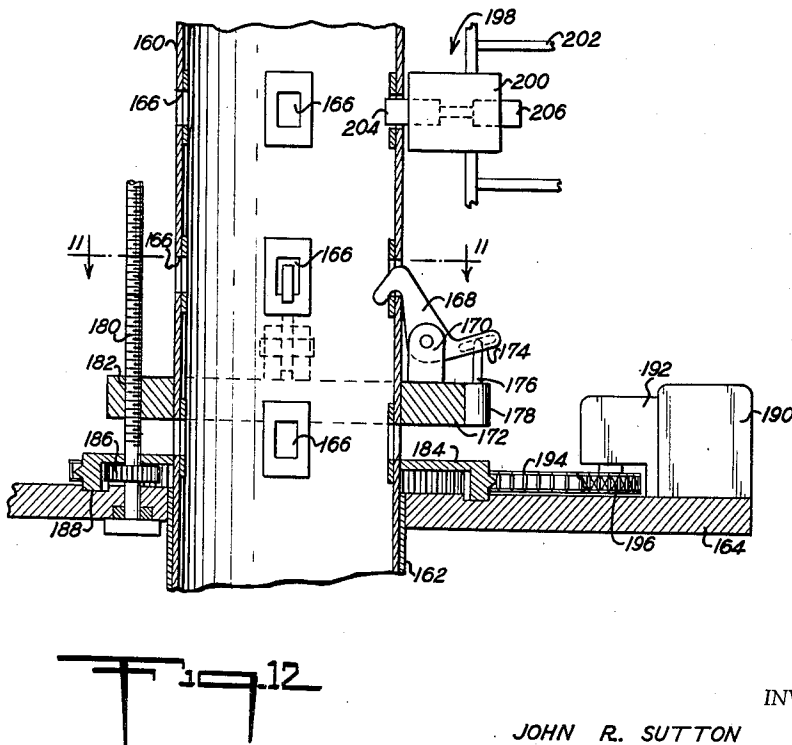
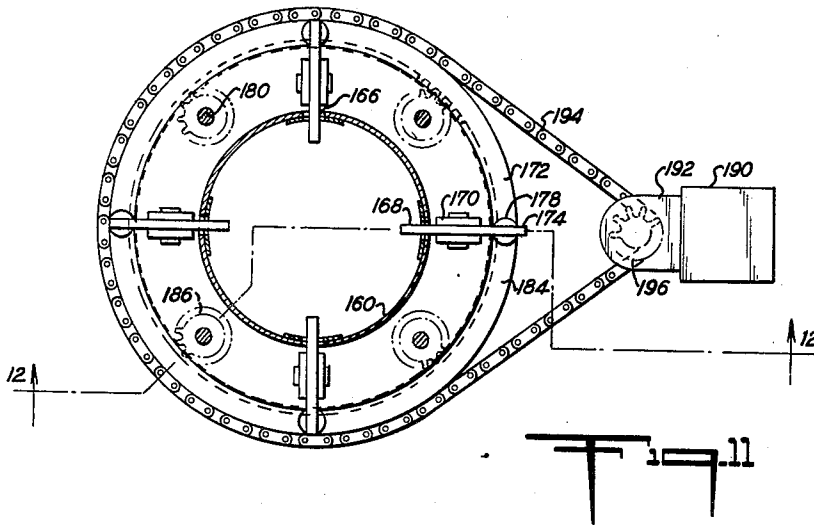
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8 Sheets-Sheet 7



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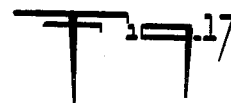
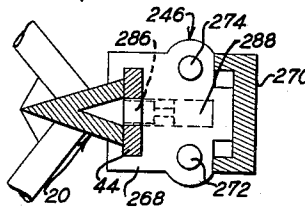
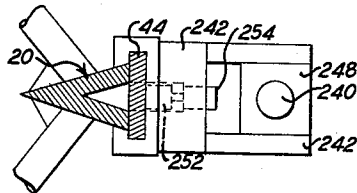
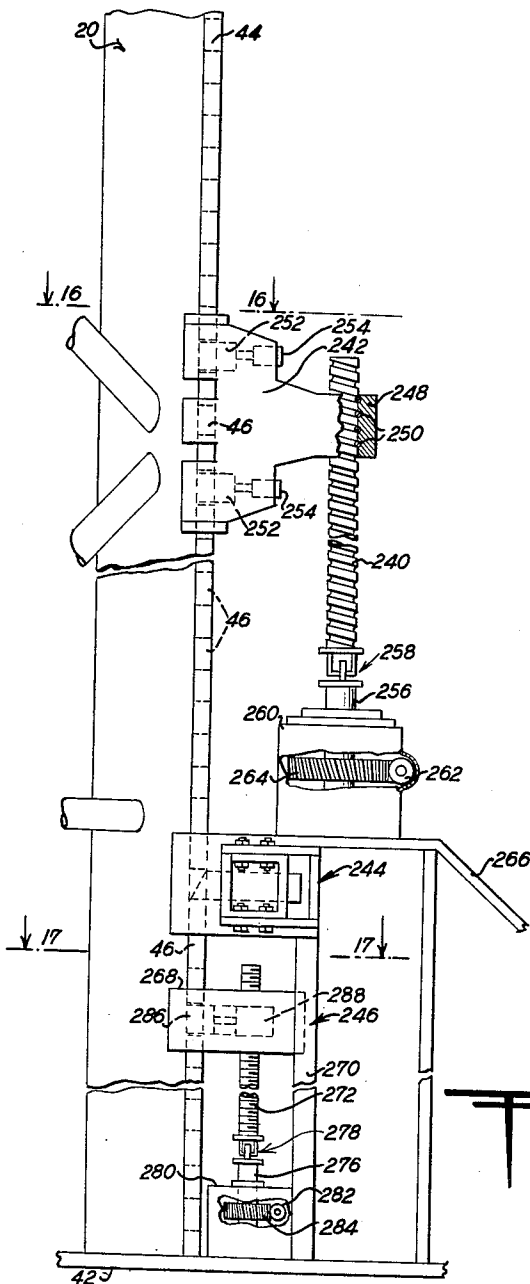
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3,082,607
OFFSHORE EQUIPMENT SUPPORTS
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 Filed Aug. 29, 1957, Ser. No. 681,057
 3 Claims. (Cl. 61—46.5)

This invention relates to offshore equipment supports. Although particular reference will be made to the use of such supports in oil recovery operations, other uses, such as for offshore radar stations, for example, will be apparent. This application is a continuation in part of my copending application Serial No. 578,021, filed April 13, 1956, now Patent No. 2,979,911.

In recent years much attention has been devoted to the recovery of oil, gas, and other natural resources from lands located beneath bodies of water. In general, the procedure followed has included the erection of a stable equipment support structure or island at the site of the proposed well. Such supports may be formed of one or more barges which may be floated to the desired location in the body of water and then fixed against movement relative to the bottom of the body of water. The support structures carry all or a part of the machinery and other equipment required for the oil recovery operations to be performed, and they provide living quarters for operating personnel. Tender boats having additional machinery may be used in cooperation with the support structures when desired.

When such supports are to be employed in bodies of water where large waves may be anticipated from time to time, it is essential that they present relatively little resistance to wave action at the surface of the water. This result may be accomplished by constructing a support so that the actual equipment platform is disposed a substantial distance above the surface of the water and is supported upon towers or columns which offer little resistance to wave action. This principle has been used extensively, and several approaches have been taken to the problem of disposing the equipment platform at the required elevation above the surface of the water.

One approach has been to lift the platform out of the water after the apparatus has reached the desired offshore location. Supports of this type usually include a floatable equipment platform, a plurality of vertically movable support columns, and jacks for raising the platform along the columns. In use, the platform is floated to location with the columns in an elevated position, the columns are lowered into contact with the bottom of the body of water, and then the equipment platform is elevated along the columns to a position well above the surface of the water.

As will be evident to persons skilled in the art, supports of this type must include provisions for the development and application of very large forces in order that the heavy equipment platform may be elevated in a desired manner. Moreover, the structures must permit close control of the relative movements between the columns and the equipment platform so that the loads may be distributed in such a manner as to maintain the stability of the support at all times.

As an example of another approach to the problem of disposing the equipment platform above the zone of wave action, reference is made to Wilson Patent No. 2,603,068, granted July 15, 1952. According to the disclosure of this patent, the equipment platform is elevated above the surface of the water before the structure is moved to the offshore location where it is to be used, and is supported in its elevated position by a number of separately controllable barge units. During the towing of the barge structure to the desired offshore location,

the equipment platform is supported by all of the barge units. When the desired location is reached, however, the barges are sunk to the bottom in groups. First the platform is supported from the submerged barges while the remaining ones are sunk to the bottom, and then the platform is supported from the surmerged barges while the rest of the barges are being sunk to the bottom also. Thus, the entire load is transferred to the bottom without lowering the platform itself.

Although this approach eliminates the need for actually lifting the equipment platform at the offshore location, it is desirable that the apparatus employed include means for developing and applying substantial forces to control the relative movement between the equipment platform and the barge units. Such means may be employed to control the descent of the barge units, to drive the barge units firmly into the bottom of the body of water, and to raise or lower the equipment platform relative to individual ones of the barge units so that the loads may be controlled and distributed properly.

Whatever approach may be taken to the elevation of the equipment platform, it is essential also that the support columns be arranged so that the completely erected structure will be stable under all conditions. The magnitude of this problem can be appreciated fully only by envisioning the tremendous forces developed during violent storms.

A general object of this invention is to provide improved offshore equipment supports which will be easier to erect and which will be more stable than the supports used heretofore.

A more specific object of the invention is to provide a simple durable power-actuated mechanical system for moving the equipment platform of an offshore equipment support relative to its vertical supports in either direction.

Another object of the invention is to provide a novel arrangement of the vertical supports or legs of an offshore equipment support which will enhance the stability of the support.

The foregoing objects are accomplished, according to a preferred embodiment of the invention, by the provision of an elongated equipment platform and two groups of three vertical support towers or columns extending through openings in such platform. The two groups of support towers are disposed on opposite sides of the center line of the equipment platform, and the towers of each group are arranged to form the apices of an elongated triangle extending along a side of the equipment platform to give the structure a high degree of stability. Disposed about each of the support towers is a group of large, vertically elongated screws which may be operated to lift or lower the equipment platform relative to the support towers. Latching means also are provided for connecting the equipment platform directly to the vertical support towers when desired.

The construction is such that it is possible to produce any desired relative vertical movement between the equipment platform and the support towers. For example, when it is desired to elevate the equipment platform along the support towers, the screws may be actuated in a two stroke cycle. During the power stroke of the cycle, the screws are connected to both the support towers and the equipment platform and are operated so as to move the platform upwardly along the towers. During the return or idle stroke of the cycle, the connections between the screws and the towers are released so that no forces are transmitted. This cycle may be repeated as many times as is necessary in order to bring the equipment platform to the desired height above the surface of the water, the latching means being used during idle strokes of the screws to prevent undesired relative movement between the platform and the support towers.

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A better understanding of the invention, and an awareness of still other objects and advantages of it, will become apparent upon consideration of the following detailed description of certain embodiments illustrated in the accompanying drawings, in which:

FIG. 1 is a side elevational view of an offshore equipment support according to the present invention, showing the parts in the positions they occupy when the support is being towed to the desired offshore location;

FIG. 2 is a side elevational view of the embodiment illustrated in FIG. 1, showing the parts in the positions they occupy when the support is set up at the offshore location;

FIG. 3 is a plan view of the equipment platform of the offshore equipment support illustrated in FIGS. 1 and 2, with certain items of equipment in position thereon;

FIG. 4 is a side elevational view showing an embodiment of the means which cooperates with each of the support towers to control the relative movements between the equipment platform and the support towers of the offshore equipment support;

FIG. 5 is a somewhat diagrammatic horizontal cross sectional view illustrating means for applying power to the device of FIG. 4;

FIG. 6 is a detail vertical cross sectional view taken along the line 6—6 in FIG. 5;

FIG. 7 is a horizontal cross sectional view taken along the line 7—7 in FIG. 4;

FIG. 8 is a detail vertical cross sectional view of a safety latch for preventing accidental downward movements of the equipment platform relative to its support towers;

FIG. 9 is a partial side elevational view of another form of means for releasably connecting the support towers to devices for applying power to them;

FIG. 10 is a side elevational view of one of the parts illustrated in FIG. 9;

FIG. 11 is a horizontal cross sectional view taken along the line 11—11 in FIG. 12 and illustrating another embodiment of the invention;

FIG. 12 is a vertical cross sectional view taken along the line 12—12 in FIG. 11;

FIG. 13 is a somewhat diagrammatic elevational view of still another embodiment of the invention;

FIG. 14 is a horizontal cross sectional view taken along the line 14—14 in FIG. 13;

FIG. 15 is a side elevational view of yet another embodiment of the invention with certain portions of the construction being broken away;

FIG. 16 is a horizontal cross sectional view taken along the line 16—16 in FIG. 15; and

FIG. 17 is a horizontal cross sectional view taken along the line 17—17 in FIG. 15.

Referring initially to FIGS. 1, 2, and 3, it will be seen that the offshore equipment support of this invention includes an elongated equipment platform 2 having six vertical openings 4 extending therethrough for the reception of elongated vertical support towers 6. As is customary in apparatus of this type, the equipment platform 2 carries the heavy equipment needed in connection with the recovery of oil at an offshore location and also provides living quarters for a crew to operate such equipment. Much of this equipment has been omitted from the drawings in the interest of clarity.

However, some major items of equipment have been illustrated in FIG. 3, to suggest a desirable arrangement of such items for stability purposes. Near one of its ends the equipment platform 2 is provided with a drilling slot 8 for the reception of a drill shaft extending downwardly from a derrick (not illustrated) disposed above the slot 8 into the bottom of the body of water. Near its other end the equipment support 2 carries a helicopter platform 10 which preferably protrudes from the main body of the equipment platform 2 so that unrestricted access may be had to the helicopter platform 10 from the air. The

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equipment platform 2 also carries, at locations on opposite sides of its longitudinal center line, electric winches 12, cranes 14 of the "stiff leg" type, and swinging hoists or "whirlies" 16. As will be apparent to persons skilled in the art, still other equipment may be mounted upon the equipment platform 2, if desired.

Still referring to FIG. 3, it is pointed out that the equipment platform 2 is generally hexagonal in shape and that the vertical openings 4 for the support towers 6 are arranged in two groups of three each with the openings 4 of each group being disposed on opposite sides of the center line of the equipment platform 2. The openings of each group form the apices of an elongated triangle, extending along a side of the equipment platform 2, so that the support towers 6 extending through the three openings 4 of a group form a three legged support of greater stability than any number of towers arranged in a straight row.

Each of the support towers 6 is generally circular in horizontal cross section and includes a number of support columns 18 and vertical tracks 20 rigidly connected together by suitable braces or the like 22. At its lower end, each support tower 6 is provided with a large bottom-engaging foot 24 which may be a controllable buoyancy compartment for buoyantly supporting all or a part of the weight of the support tower 6, when desired.

The support towers 6 are adapted to move vertically relative to the equipment platform 2, and they are guided during such movements by the walls of the openings 4 and by guide plates 26, disposed about the individual support towers 6 and fixed rigidly to the equipment platform 2 by braces 28. As shown in FIG. 3, each of the openings 4 has a number of circular recesses 30 and flat recesses 32 spaced about its periphery for the reception of the columns 18 and tracks 20, respectively, of a support tower 6. The guide plates 26 are arcuate and engage the columns 18 of the towers 6 at points above the upper surface of the equipment platform 2 so as to minimize tilting of the towers 6.

Intermediate adjacent ones of the guide plates 26, there are disposed devices 34 for controlling the relative movements between the support towers 6 and the equipment platform 2. One of these devices is shown in FIG. 4, and will be described in detail hereinafter. At this point, however, it will be sufficient to point out that the devices 34 include means for holding the towers 6 against relative movement with respect to the equipment platform 2, and power actuated means for positively causing such movements in either direction when desired.

It is believed that the procedure for utilizing the offshore equipment support of FIGS. 1 to 3 now will be evident. FIG. 1 illustrates the positions occupied by the parts when the structure is being towed to an offshore location. The equipment platform 2 is sufficiently buoyant to permit the entire structure to float, and during towing, it is generally desirable that the support towers 6 occupy their uppermost positions relative to the equipment platform 2 so as to minimize the resistance encountered in moving the structure through the water.

When the structure reaches the desired offshore location, it may be fixed in position by lowering the support towers 6 to the bottom of the body of water, forcing the feet 24 on these towers far enough into the bottom to firmly anchor them in place, and then elevating the equipment platform 2 along the support towers 6 to a position far enough above the surface of the water to remove it from the zone of anticipated wave action.

The final relative positions of the equipment platform 2 and the support towers 6 are illustrated in FIG. 2. It is pointed out that even though the bottom of the body of water is not completely level, and even though the feet 24 on the support towers 6 penetrate the bottom to different depths depending upon the consistency of the bottom at the points contacted by the feet 24, the equipment platform 2 is maintained in a horizontal position.

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This result is achieved by controlling the relative movements between the equipment platform 2 and each of the towers 6 independently.

If, at any time, it becomes desirable to move the structure to a different location in the body of water, the parts may be returned to the positions they occupy in FIG. 1, by reversing the procedure outlined above. The devices 34 are actuated to lower the equipment platform 2 to the surface of the water and then to raise the support towers 6 to their uppermost positions. It is important, in this connection, that the devices 34 be capable of applying substantial upward forces to the towers 6 so that the feet 24 may be freed from engagement with the bottom of the body of water.

Turning now to FIG. 4, it is pointed out that each of the devices 34 includes a structural framework 40 securely and rigidly fixed to the equipment platform 2, the upper deck of which is designated by the numeral 32 in FIG. 4. The framework 40 must be quite rigid, and it is preferred that the several frameworks 40 disposed about a given support tower 6 be connected together and to the guide plates 26, as by braces 43 (FIGS. 1 and 2). Each of the devices 34 is arranged to cooperate with one of the vertical tracks 20 of a support tower 6 to both guide such track and control its vertical movements.

As shown best perhaps in FIG. 7, each of the tracks 20 is hollow and is provided with a perforated guide plate 44 along its outermost face. The holes 46 in the plate 44 are spaced apart to form a series which extends vertically for substantially the entire length of the track 20 so that wherever the lower end of the tower 6 may be relative to the equipment platform 2, certain of the holes 46 will be in position to cooperate with the device 34.

Each of the devices 34 includes several elements which cooperate with the guide plate 44 of the adjacent track 20. One of these is a safety latch 48 disposed near the top of the device 34 and illustrated in detail in FIG. 8. It includes a guide block 50 secured rigidly to the framework 40 and disposed in embracing relationship with respect to the lateral edges of the track plate 44. The block 50 is provided with a bore 52 which receives a pin 54 for movement along a horizontal path into and out of the holes 46 in the plate 44 of the track 20. The pin 54 is biased toward its forwardmost position, i.e., the position in which it is disposed within a hole 46 in the plate 44, by means of a compression spring 56 disposed between the pin 54 and a shoulder 53 in the bore 52. However, the pin 54 may be moved rearwardly out of engagement with the holes 46 in the plate 44 by means of a hydraulic cylinder 60 fixed with respect to the block 50 and having a piston rod 62 attached to the pin 54.

The outermost end of the pin 54 has a tapered upper surface 64. This configuration permits the safety latch 48 to function automatically, when the hydraulic cylinder 60 is inactivated, to prevent downward movement of the equipment platform 2 with respect to the support tower 6 while permitting upward movement of such platform 2. The guide block 50 is fixed with respect to the platform 2, and downward movement of the block 50 along the guide plate 44 would be prevented by engagement of the straight lower face of the pin 54 with the upper edge of an opening 46 in the plate 44. However, if the block 50 were moved upwardly, the tapered upper surface 64 of the pin would be brought into engagement with the upper edge of the opening 46 and cammed inwardly out of the opening 46 against the bias of the spring 56. Continued upward movement of the block 50 eventually would bring the pin 54 in position to move into another of the holes 46 in the plate 44, as will be apparent. Thus, when the hydraulic cylinder 60 is inactive, the safety latch 48 is effective to prevent downward movement of the platform 2 a distance greater than the distance between successive ones of the holes 46 in the plates 44 of the tracks 20, so that a power failure would not result in a collapse of the structure.

Each of the devices 34 also is provided with a holding

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latch 66 (FIG. 4) which may be substantially identical to the safety latch 48, except that its hole-engaging pin 68 has a squared-off end in position to cooperate with the holes 46 in the plate 44 of the track 20. The holding latch 66 serves to prevent relative movement between the support tower 6 and the equipment platform 2 in both directions when its pin is disposed within one of the holes 46 in the plate 44, and it must be positively released when relative movement is desired.

Disposed below the holding latch 66 in each of the devices 34 is a mechanism for positively moving the support tower 6 relative to the equipment platform 2. A preferred embodiment of this mechanism is illustrated in FIGS. 4, 5, 6, and 7. It includes a large vertically reciprocable screw 70 supported and driven by means 72 fixed to the deck plate 42 of the equipment platform 2.

The means 72 is illustrated best in FIGS. 5 and 6. It includes a housing 74 secured by bolts 76 to the deck plate 42 of the equipment platform and having a plurality of bearings 78 therein for supporting a rotatable member or nut 80 having an axial threaded bore 81. Fixed to the exterior of the nut 80, by screws 84 or other suitable means, is a gear 86 which meshes with a worm gear 88 on a power shaft 90 extending outwardly from the housing 74 through suitable bearings. A cover plate 82 serves to prevent the entrance of foreign matter into the housing 74.

The power shaft 90 may be driven in either direction and at a controlled rate of speed by an electric motor 92 connected to the shaft 90 through a fluid coupling 94, a clutch 96, and a suitable reduction gear device 98. These elements are individually well known in the art and need not be described in detail here. However, it should be noted that the combination is a particularly advantageous one, because the rate of power application can be controlled closely and because the fluid coupling 94 automatically tends to equalize the loads carried by the several devices 34 associated with a given support tower 6.

As illustrated in FIG. 6, the vertical screw 70 is received within the axial bore 81 of the nut 80 and is driven thereby through a plurality of ball bearings 100 rotatably mounted in the threads of the nut 80 in position to engage the threads on the screw 70. Hence, upon rotation of the power shaft 90, the nut 80 rotates about a vertical axis, and the screws 70 moves vertically.

Since the environmental conditions to which the offshore equipment supports of this invention are normally subjected tend to promote rapid corrosion, it is desirable that provisions be made for thoroughly lubricating the screw 70. This can be accomplished in the embodiment of the invention illustrated in FIGS. 4 to 8 by disposing an oil chamber 102 (FIG. 6) below each of the nuts 80 in position to receive the lower end portion of the screw 70 actuated thereby. An opening 104 in the deck plate 42 of the equipment platform 2 permits movement of the lower end portion of the screw 70 into and out of the chamber 102 and a body of oil 105 substantially fills the chamber 102. It will be seen, therefore, that as the screw 70 moves downwardly to its lowermost position, its surface is brought into intimate contact with the oil 105. Then, when the screw 70 moves upwardly, a film of oil is carried with it to the ball bearings 100 and the threaded portion of the nut 80 to thoroughly lubricate the parts.

Of course, if the screw 70 is to reciprocate in the desired manner, it must not rotate about its own axis. In some situations, the tendency of the screw 70 to rotate with the nut 80 poses no particular problem, because the very substantial frictional forces developed when the screw 70 is loaded counteract such tendency. However, it is preferred that means be provided for positively holding the screw 70 against rotation. Such means is illustrated in FIGS. 4 and 7.

A head member 106 fixed rigidly to the upper end portion of the screw 70 by welding or other suitable means,

is bifurcated at one of its ends to provide a notch 108 for the reception of a vertical guide 110 fixed rigidly to and forming a part of the framework 40 of the device 34. The walls of the notch 108 embrace the guide 110 in such a manner as to prevent angular movement of the head 106 relative to the guide 110 but to permit vertical movement of the head 106 along the guide 110. Rollers 112, mounted upon the side walls of the notch 108 are disposed to roll along the rear face of the guide 110 and to prevent bending of the screw 70 under load.

The opposite end of the head 106 carries a shaft 114 which serves as a pivot pin for a forwardly extending link 116 pivotally mounted upon a shaft 118 carried by a slide member 120. The slide member 120 cooperates with the plate 44 of the track 20 in a manner similar to the guide block 50 of the safety latch 48, in that it is shaped to embrace the lateral edges of the plate 44 and prevent extensive relative movements other than vertical reciprocation. The slide 120 is also provided with two horizontally reciprocable pins 122, similar to the holding pin 68 of the latch 66, which may be moved into and out of engagement with holes 46 in the plate 44 under the control of hydraulic cylinders 124 connected to the pins 122 by piston rods 126.

As will be evident, the parts just described cooperate to releasably connect the upper end portion of the screw 70 to the track 20. When the pins 122 are in their forwardmost positions, the slide 120 is fixed relative to the plate 44. When, however, the pins 122 are withdrawn from the holes 46, the slide 120 is free to slide along the track 44.

Moreover, the embodiment illustrated in FIGS. 4 and 7 has been constructed so that, when the screw 70 is loaded in either direction, the slide 120 tends to wedge into frictional engagement with the plate 44 of the track 20. The link 116 has a pair of shoulders 130 disposed above and below the shaft 118 in position to bear against abutments 132 on the rear face of the slide member 120 when the link 116 moves a short distance about the axis of the shaft 118. FIG. 4 illustrates the positions of the parts when no load is being transmitted to the screw 70, and neither of the shoulders 130 on the link 116 is in contact with an abutment 132 on the slide 120, but it is believed that persons skilled in the art will have no difficulty in visualizing the effects produced when the screw 70 is loaded.

Consider, for example, what occurs when the screw 70 is moved upwardly with the pins 122 in engagement with the holes 46 in the plate 44. As the head 106 begins to move, the shaft 114 will move to a level slightly above the shaft 118, and the link 116 will swing so as to bring its upper shoulder 130 into contact with the upper abutment 132 on the slide 120. Continued movement of the head 106 upwardly then will transmit forces to the slide 120 in such a fashion that the slide 120 not only moves upwardly but also tends to rotate in a counter-clockwise direction, as viewed in FIG. 4. This tendency causes portions of the slide 120 to wedge against the plate 44.

It will be apparent that a similar situation is created when the screw 70 is moved downwardly. In this event, the lower of the two shoulders 130 on the link 116 moves into contact with the lower of the abutments 132 on the slide 120, and the slide 120 is subjected to forces tending to rotate it in a clockwise direction as viewed in FIG. 4.

Although twisting of the slide 120 is desirable when forces are being transmitted from the screw 70 to the plate 44, there are times when the slide 120 must move freely along the plate 44. At such times, the pins 122 are withdrawn from engagement with the holes 46 in the plate 44, so that the weight of the slide provides the only force tending to swing the link 116 about the shafts 114 and 118. In most cases, it is anticipated that friction between the link 116 and the shafts 114 and 118 will serve to prevent swinging movement of link 116 under such conditions. However, this result can be assured by the use

of relatively light springs 133 disposed to urge the link 116 into the position illustrated in FIG. 4.

By way of summary, the operations required of the devices 34 in order to move the equipment platform 2 and the vertical support towers 6 between the positions shown in FIGS. 1 and 2 now will be described. Although references will be made to a single one of the devices 34, it will be understood that similar operations are carried out by the other devices 34 and that all of the devices 34 associated with a single tower 6 are operated simultaneously.

In order to lower a support tower 6 associated with a device 34, either of two procedures may be followed. If it is unnecessary to control the rate of descent of the tower 6, all that need be done is to actuate the hydraulic cylinder of the holding latch 66 and the hydraulic cylinders 124 carried by the slide 120 so as to remove the pins 68 and 122 from engagement with the holes 46 in the track plate 44. This frees the track 20 for downward movement under the influence of gravity and the tower 6 may sink to the bottom when its buoyant foot 24 is flooded.

On the other hand, if it is desirable to control the rate of descent of the support tower 6, the tower 6 can be lowered in a sequence of steps. Initially, the holding latch 66 is brought into holding engagement with the holes 46 of the track plate 44, the pins 122 on the slide 120 are removed from engagement with the holes 46, and the screw 70 is actuated to move its head 106 upwardly as far as possible. Then, the pins 122 are moved into the holes 46 in the track 44, the holding latch 66 is released, and the screw 70 is moved downwardly to its lowermost position, carrying with it the track 20. This cycle of operation may be repeated as many times as may be required in order to bring the foot 24 of the tower 6 into contact with the bottom of water. Moreover, it will be apparent that continued repetition of this cycle of operations of the device 34 after the foot 24 is in contact with the bottom will cause the foot 24 to be imbedded in the bottom and then will cause the equipment platform 2 to rise along the tower 6.

The lowering of the equipment platform 2 along the support tower 6 may be accomplished through similar operations of the devices 34. However, in this instance it is necessary that the pins 122 on the slide 120 be in engagement with the holes 46 in the track plate 44 during upward movements of the screw 70 and that they be disengaged from the holes 46 during downward movements of the screw 70. It is also necessary that the safety latch 48 be inactivated during the lowering of the equipment platform 2.

FIGS. 9 and 10 illustrate a modified form of means for connecting the plate 44 of the track 20 to a vertically reciprocable screw 134, which is comparable to the screw 70. The screw 134 has a ball 135 secured rigidly to its upper end, and this ball 135 is engaged by a socket 136 formed in head members 138 and 140 detachably connected together by bolts 142 or other suitable means. In the interest of clarity, the head member 138 has been shown alone in FIG. 10. It is laterally elongated and is connected at its end directly to a pivot pin or shaft 144 on a slide 146.

The slide 146 may be substantially identical to the slide 120 of the embodiment illustrated in FIGS. 4 and 7, the only change being that the portions of the slide 146 adjacent the shaft 144 are cut away, as at 147, so that the head member 138 may swing freely about the shaft 144. Reference numerals 122a and 124a have been applied to the pins and hydraulic cylinders on the slide 146 to suggest that these are comparable to the pins 122 and cylinders 124 in FIG. 4.

The head members 138 and 140 perform the functions of both the head member 106 and the link 116 of the embodiment illustrated in FIG. 4. As in the case of the link 116, the head member 138 has bearing faces 148 disposed above and below the shaft 144 in position to

cooperate with abutments 150 on the slide 146 so as to impart a twisting moment to the slide 146 when the screw 134 is under load. A pair of compression springs 152 are disposed in recesses 154 in the bearing faces 148 of the head member 138 and extend outwardly from such recesses into contact with the abutments 150 on the slide member 146. These springs serve to maintain the bearing faces 148 out of contact with the abutments 150 when no load is being applied to the screw 132.

Still other modifications of the inventions may be desirable in order to meet certain use conditions most effectively. Several of these are suggested in the embodiment illustrated in FIGS. 11 and 12.

In some offshore equipment supports the vertical legs which carry the equipment platform may be simple tubular columns rather than the open towers 6 illustrated in FIG. 1. In FIGS. 11 and 12 the column 160 represents such a member. It is mounted for sliding movement in a sleeve 162 extending through an equipment platform, the deck plate of which has been designated 164 in FIG. 12.

The column 160 is provided with suitably reinforced holes or openings 166 spaced about its periphery and forming four series of vertically spaced openings extending substantially the full length of the column 160. These openings correspond to the holes 46 in the several track plates 44 of the support towers 6 illustrated in FIGS. 1 to 10.

Cooperating with the holes 166 in the column 160 are a plurality of latches 168 mounted for pivoting movements upon vertically extending ears 170 carried by a yoke or ring 172 which surrounds the column 160. Each latch 168 is in the form of a bell crank, and includes a control arm 174 connected to a piston rod 176 of a hydraulic cylinder 178, so that upon actuation of the hydraulic cylinder 178, the other arm of the latch 168 may be moved into or out of one of the holes 166 in the column 160.

The yoke 172 is mounted upon a plurality of vertically extending screws 180 extending through threaded openings 182 therein. These screws 180 are mounted rotatably in the deck plate 164 of the equipment platform and are driven simultaneously by a ring gear 184 which meshes with gears 186 fixed to the several screws 180.

The ring gear 184 has a depending flange 188 which rides in an annular groove in the upper face of the deck plate 164. It is driven by an electric motor 190 through a reduction gear 192 and a drive chain 194 which engages sprocket teeth on the exterior of the ring gear 184 and also engages a sprocket 196 fixed to the output shaft of the reduction gear 192.

Disposed above the latches 168 is a holding latch 198 which corresponds in function to the holding latch 66 in the embodiment of FIG. 4. Although only one holding latch 198 has been illustrated in FIG. 12, it will be apparent that several of these latches may be positioned about the column 160 to cooperate with as many of the vertical series of holes 166 as may be desirable. The holding latch 198 includes a block 200 fixed by a suitable framework 202 to the deck plate 164 or other rigid member of the equipment platform, a reciprocable latching pin 204, and a hydraulic cylinder 206 for actuating the pin 204.

The operation of the embodiment of FIGS. 11 and 12 is similar to that of the embodiment of FIG. 4. When, for example, it is desired to elevate the equipment platform along the column 160, the screws 180 are rotated to bring the latches 168 to their uppermost positions relative to the deck plate 164. Then, the hydraulic cylinders 178 are actuated so as to swing the latches 168 into engagement with holes 166 in the support column 160, and the direction of rotation of the screws 180 is reversed to cause the yoke 172 to move downwardly relative to the column 160. During this period, it is of course essential that the holding latch or latches 198 be disengaged from the column 160, but when the lowermost position

of the yoke 172 is reached, the latches 198 are actuated to bring the pins 204 into engagement with holes 166 in the column 160. The parts may be conditioned for another lifting movement by disengaging the latches 168 from the column 160 and elevating the yoke 172 again to its uppermost position.

This cycle may be repeated as many times as necessary in order to effect the desired elevation of the equipment platform. Similarly, the cycle may be reversed in order to bring about a controlled lowering of the equipment platform relative to the support column 160.

Certain of the features of the embodiment illustrated in FIGS. 11 and 12 should receive special attention because they might be employed in modifications of the embodiment illustrated in FIG. 4, for example. One of these is that the several screws 180 associated with a single support column 160 are driven as a unit. This concept could be applied readily to the embodiment of FIG. 4, if desired, by using a common power source for the several nuts 80 disposed about each of the support towers 6.

Another feature of the embodiment of FIGS. 11 and 12 which might be employed advantageously in modifications of the embodiment of FIG. 4 is the use of a yoke for connecting together for unitary vertical movements the vertically reciprocable members associated with a single column. Such an arrangement would decrease the flexibility of the system of FIG. 4, but it would simplify the problem of control.

Another embodiment of the invention is illustrated in FIGS. 13 and 14. In this embodiment a rack and pinion drive has been substituted for the screw drives of the embodiments of FIGS. 1 to 10. In place of each of the screws 70 or 134, there are a pair of vertical racks 208 connected rigidly together at their upper ends by suitable means 210. As illustrated, the means 210 carries a ball 212 corresponding to the ball 135 in FIG. 9 and adapted to cooperate with a head structure and a slide member in the same fashion as the ball 135.

The racks 208 are driven by pinions 214 mounted on a horizontal shaft 216 supported in bearings 218 fixed upon the equipment platform. A central portion of the shaft 216 carries a gear 220 adapted to be driven by a worm 222 on a power shaft 224 supported in suitable bearings 226 and driven by a motor 228 through a reduction gear 230. The pinions 214 may be rotated in either direction to cause the racks 208 to move up or down as required.

It will be apparent that the use of two racks 208 at each station is not essential in all cases. A single rack might be used if desired. It should be recognized, however, that there is a practical limit upon the load which may be carried by a set of meshing gear teeth. If in a given application, the loads are very large, it may be preferable to use a plurality of sets of meshing teeth acting together in lieu of a single set. This observation is applicable also to the screw drives of FIGS. 1 to 12. In any of these embodiments, it is feasible to employ a plurality of commonly driven and controlled screws in place of the individual screws illustrated in the drawings.

Yet another embodiment of the invention is illustrated in FIGS. 15, 16 and 17. This embodiment is similar to the embodiment of FIG. 4, in that it includes a vertically elongated screw 240, a slide member 242 cooperating with the track plate 44 of a track 20 on a support tower of the off-shore equipment support, a safety latch 244, and a holding latch 246. However, there are several significant differences in the construction and arrangement of these parts.

It will be recalled that the screw 70 in FIG. 4 is reciprocable in a vertical plane. In contrast, the screw 240 is not reciprocable; it is merely rotatable about its central axis, and it cooperates with a nut 248 fixed rigidly to the slide member 242 by welding or other suitable means. When the screw 240 is rotated in one direction, the nut 248 and the attached slide member 242 move upwardly;

when the screw 240 is rotated in the opposite direction, the nut 248 moves downwardly. It is preferred that the nut 248 be provided with bearing balls 250 to minimize friction between the screw 240 and the threaded portion of the nut 248.

The slide member 242 carries a pair of horizontally reciprocable pins 252 in position for cooperation with the holes 46 in the track plate 44. These pins 252 are under the control of hydraulic cylinders 254, and they serve to releasably connect the slide member 242 to the track plate 44. It will be understood in this connection that, when the equipment platform is to be raised along the track 20, the pins 252 will be disposed within the holes 46 in the track plate 44 during downward strokes of the nut 248 and will be withdrawn from the holes 46 during upward strokes of the nut 248.

The screw 240 is rotated by a vertical shaft 256 coupled to the lower end of the screw 240 by means of a universal joint 258. The shaft 256 is mounted in suitable bearings disposed in a housing 260 and is driven by a worm 262 which cooperates with a gear 264 fixed to the shaft 256. The drive system for the worm 262 may be identical to the drive system shown in FIG. 5.

The universal joint 258 is an important feature of the embodiment of the invention illustrated in FIGS. 15, 16 and 17. It permits the screw 240 to assume various inclinations with respect to the vertical so as to minimize the lateral stresses imposed upon it. As a result, the screw 240 may be substantially longer than the screw 70 without exceeding the permissible load limitations, and the track 20 need not be exactly vertical at all times. If the track 20 sways slightly in response to the forces of the wind and the waves, the screw 240 will sway with it and no damage will be done.

Moreover, it should be noted that the use of the universal joint 258 in the support for the screw 240 makes it possible to connect the slide member 242 and the nut 248 together in a rigid manner. There is no need for the pivoting connections characteristic of the embodiments of FIGS. 4 and 9. In this respect the embodiment of FIGS. 15 to 17 is somewhat simpler than the embodiments described heretofore.

The housing 260 is mounted upon the upper end of a structural framework 266 which may be substantially similar to the framework 40 shown in FIG. 4. The disposition of the screw 240 above the structural framework 266 permits this screw 240 to be as long as may be desired in a particular installation, without any interference between the screw 240 and the other structural components.

The safety latch 244 and the holding latch 246 are disposed within the confines of the structural framework 266. The safety latch 244 is identical in all respects to the safety latch 48 shown in FIG. 4. However, the holding latch 246 is a distinctive feature of the embodiment illustrated in FIGS. 15, 16 and 17.

The holding latch 246 includes a slide member 268 cooperating at its forward end portion with the track plate 44 and bearing at its rear end against a backing plate 270 attached rigidly to the structural framework 266. The slide member 268 is mounted for vertical movement along two screw members 272 and 274 which pass through threaded holes in the guide member 268. Each of these screws is mounted and driven as suggested in FIG. 15. It is connected at its lower end to a rotatable shaft 276 by means of a universal joint 278, and the shaft 276 is supported in suitable bearings disposed within a housing 280. Also disposed within the housing 280 is a worm 282 which cooperates with a gear 284 secured to the shaft 276 to rotate the shaft in either direction. It will be understood in this connection that the two screws 272 and 274 work together in moving the slide member 268 up and down.

The slide member 268 carries a reciprocable pin 286 which may be moved by a hydraulic cylinder 288 into or

out of the holes 46 in the track plate 44. When the pin 286 is disposed within one of the holes 46, the slide member 268 of the holding latch 246 will be locked against vertical movement relative to the track plate 44. This relationship is essentially the same as that described in connection with FIG. 4.

In operation, the holding latch 246 may function to hold the equipment platform of the off-shore equipment support against vertical movement relative to a track 20 on one of the support towers during those intervals when the pins 252 carried by the slide member 242 of the lifting device are withdrawn from the holes 46 in the track plate 44. Coordination between the lifting device and the holding latch 246 is greatly facilitated by the use of the power driven screws 272 and 274 for supporting the slide member 268 of the holding latch 246. It sometimes happens that at the end of a stroke of the lifting device, the track plate 44 is disposed at such a location that there is no hole 46 in position to cooperate with the pin 286 of the holding latch 246. As will be apparent, however, such a situation may be met very easily in the embodiment of FIGS. 15 to 17, because the slide member 268 of the holding latch 246 may be moved up or down, as necessary, to position the holding pin 286 adjacent one of the holes 46.

Other modes of operation are possible in connection with the embodiment of FIGS. 15 to 17. For example, the holding latch 246 may be caused to operate as a lifting device, simply by rotating the screws 272 and 274 while the locking pin 286 is in engagement with one of the holes 46 in the track plate 44. Moreover, when so used, the holding latch 246 may make a power-transmitting stroke simultaneously with the power-transmitting stroke of the slide 242 of the lifting device, or the power strokes of the holding latch 246 may be alternated with the power strokes of the primary lifting device. It will be seen, therefore, that the construction of FIGS. 15 to 17 has enough flexibility in its mode of operation to permit its use in a variety of situations which might be encountered in connection with an off-shore equipment support.

In describing the several embodiments of the invention illustrated in the drawings, reference has been made to hydraulic cylinders for actuating the various pins or latching elements 54, 68, 122, 122a, 168, 204, 252 and 286, which cooperate with the holes 46 in the track plate 44 of the support tower. It will be understood, however, that pneumatic cylinders, solenoids, or other suitable control devices may be used in lieu of these hydraulic cylinders, if desired.

It will be understood also that the shapes of the tracks 20 and the track plates may be varied from those illustrated. For example, the tracks 20 may be simple tubular columns and the track plates 44 may be arcuate in horizontal cross section, if desired. Moreover, it is contemplated that lugs may be used instead of the holes 46 for establishing connections between the tracks and the various elements which cooperate therewith.

Still other modifications and variations of the invention will be apparent to persons skilled in the art. It is intended, therefore, that the foregoing detailed description be considered as exemplary only, and that the scope of the invention be ascertained from the following claims.

I claim:

1. An offshore equipment supporting apparatus comprising a platform to be elevated above the surface of a body of water, a plurality of vertically elongated supports mounted for vertical movement relative to the platform and adapted to be moved into contact with the bottom of the body of water so as to provide a supporting foundation for the platform, a series of vertically spaced bearing surfaces along each support facing alternately upwardly and downwardly, a track fixed on each support and extending therealong adjacent the bearing surfaces, a jack device mounted on the platform associated with each

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series of bearing surfaces and each track, each of said jack devices comprising first slide means mounted on the track for guided movement along the track, a first pin mounted on the first slide means and movable in reciprocating fashion with respect thereto toward and away from the support, means for moving the first pin into engagement with the upwardly and downwardly facing bearing surfaces on the support to connect the first slide means with the support or out of engagement with the surfaces to allow the first slide means to move along the track, a threaded portion in the first slide means, an elongated screw spaced from and extending generally parallel to the support, said elongated screw extending through the threaded portion of the first slide means and cooperating therewith so that rotation of the elongated screw may move the first slide means vertically with respect to the platform, a vertically extending shaft securely mounted to the platform for rotational movement only, a universal joint adjacent the bottom of the elongated screw connecting the elongated screw and the shaft and allowing the elongated screw to remain generally parallel to the support in the event the support should tip with respect to the platform, first power means for rotating the shaft in either rotational direction for in turn rotating the elongated screw, and latch means between the platform and the support for preventing relative vertical movement between the platform and the support when the pin is not engaged with one of the bearing surfaces on the support, said latch means comprising second slide means mounted on the track below said first slide means for guided movement along the track, a second pin mounted on the second slide means for selective engagement or disengagement with one of the bearing surfaces on the support, a vertically extending screw in threaded engagement with the second slide means and securely mounted to the platform for rotational movement only, and second power means for rotating the second named screw in either ro-

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tational direction for moving the second slide means vertically with respect to the platform so that, in the event that movement of said support results in a condition wherein neither of said first or second pins are aligned with any of said bearing surfaces on said support, said second slide means may be moved vertically relative to the platform by said second power means to facilitate engagement of said second pin of said slide means with one of said bearing surfaces without entailing relative movement between said support and said platform.

2. An offshore equipment supporting apparatus according to claim 1 wherein a second vertically extending screw is provided in threaded engagement with said second slide means and said second pin in said second slide means is positioned between the said vertically extending screws engaging said second slide means.

3. An offshore equipment supporting apparatus according to claim 2 wherein ball bearing means are disposed between the elongated screw and the threaded portion of the first slide means.

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