

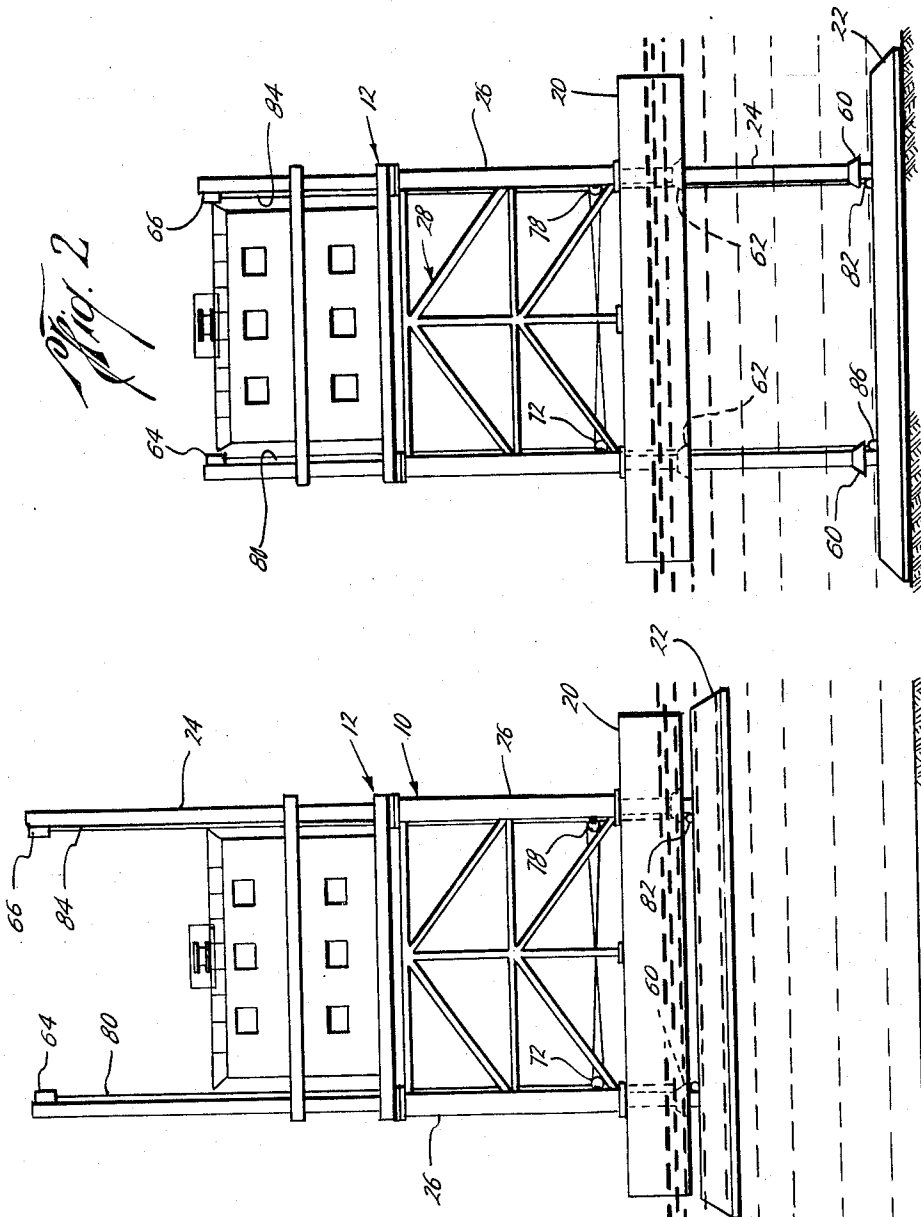
Sept. 27, 1960

L. B. CHRISTENSON
SUBMERSIBLE BARGE ASSEMBLY

2,953,904

Filed April 3, 1958

5 Sheets-Sheet 1



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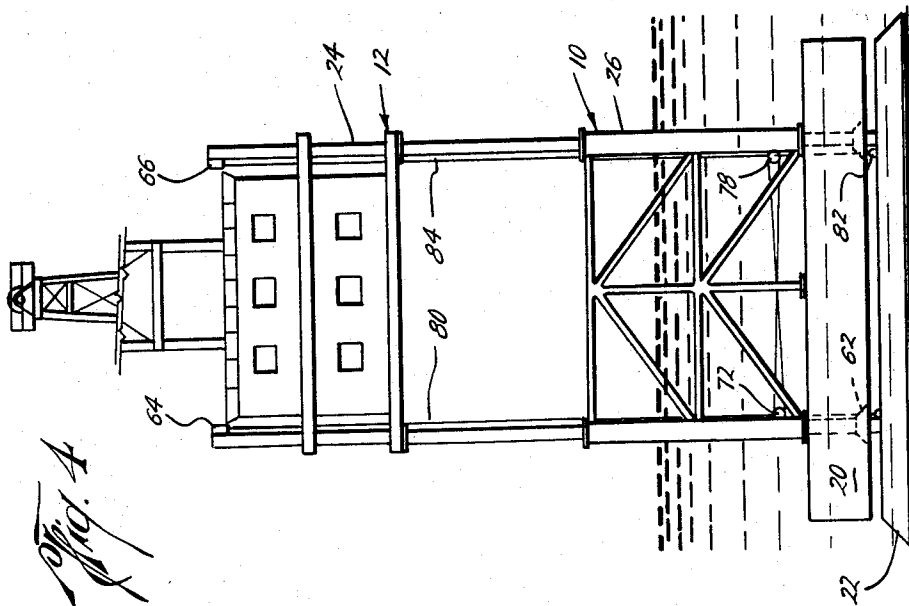
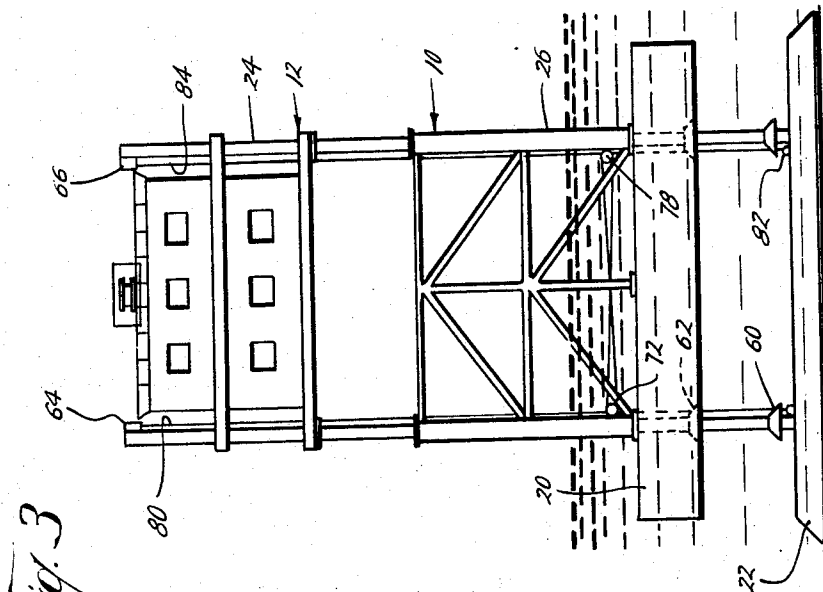
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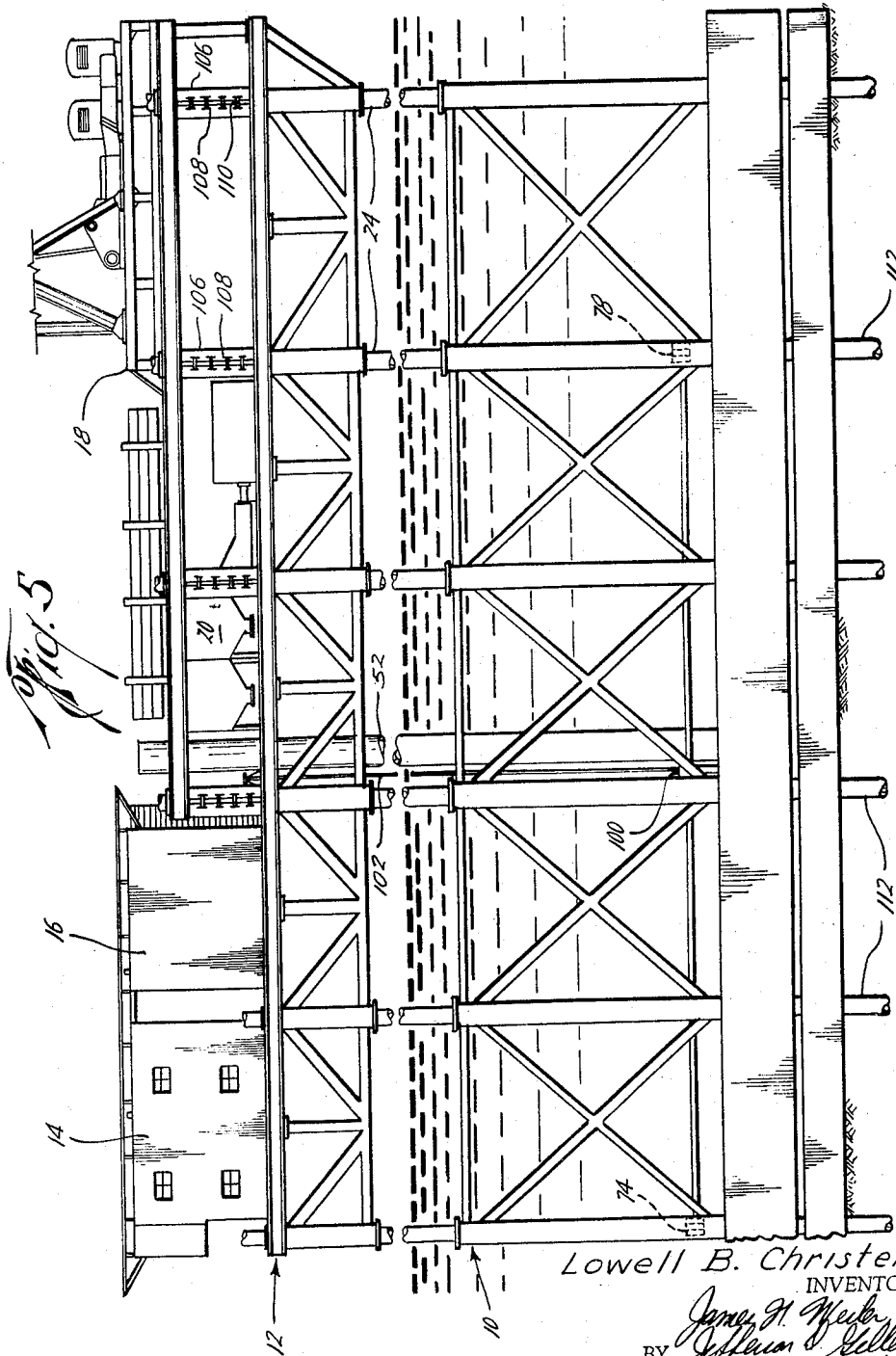
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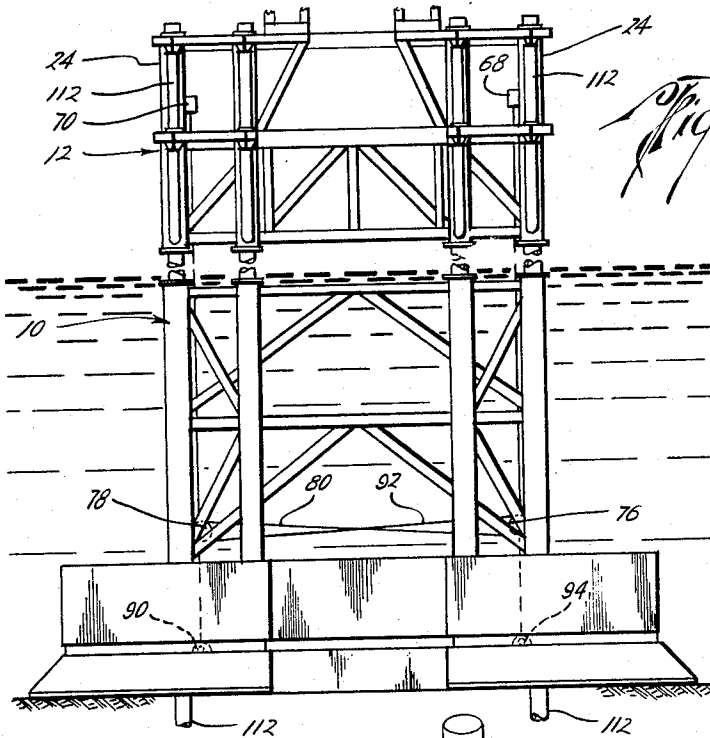
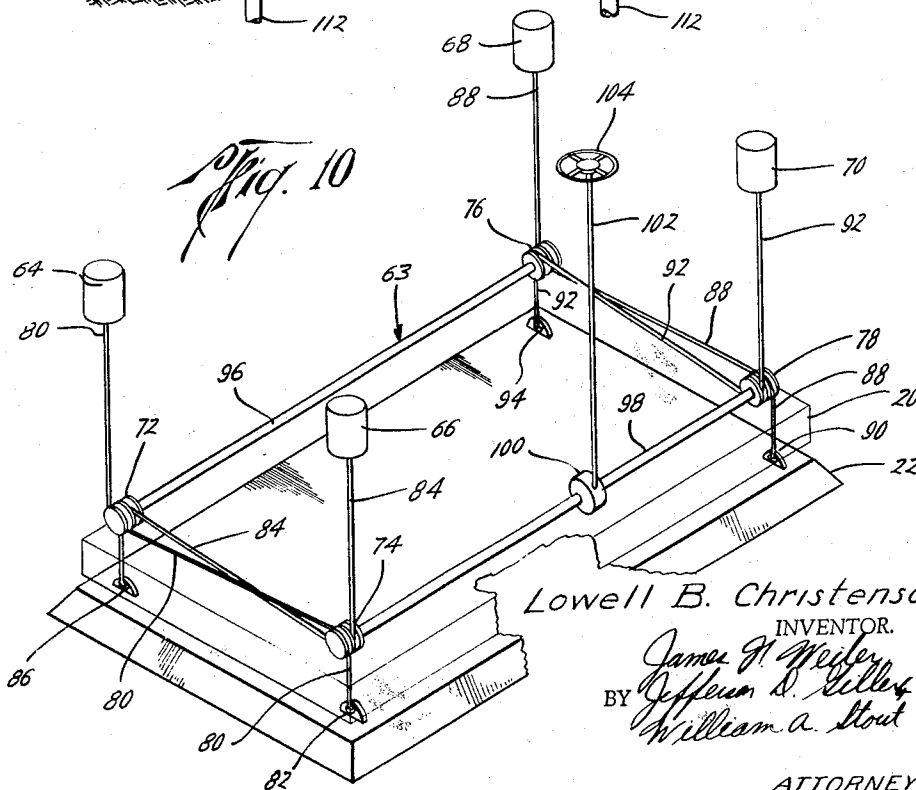
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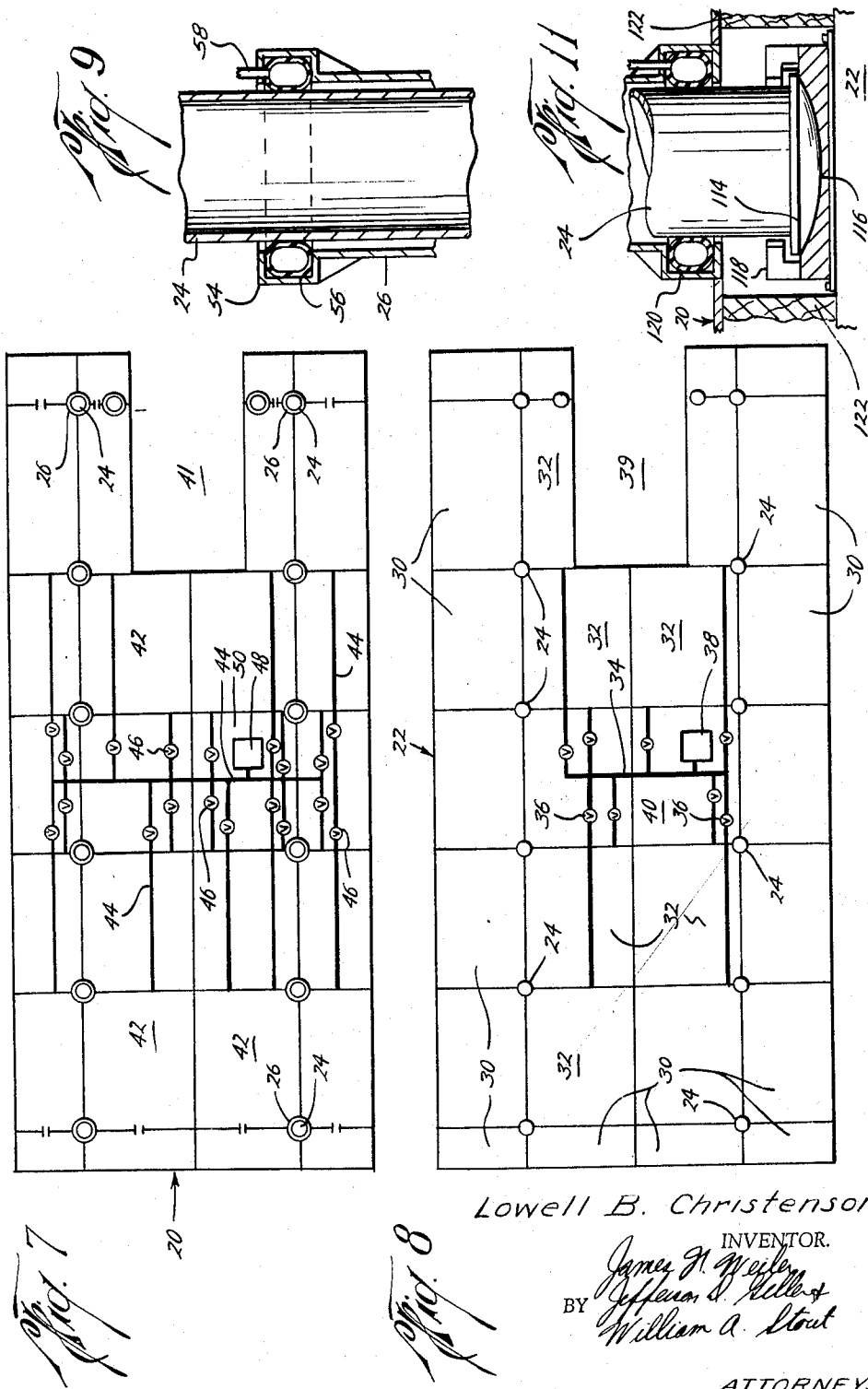
L. B. CHRISTENSON

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SUBMERSIBLE BARGE ASSEMBLY

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5 Sheets-Sheet 5



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2,953,904

SUBMERSIBLE BARGE ASSEMBLY

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7 Claims. (Cl. 61—46.5)

This invention relates to a submersible barge assembly and more particularly to one in use with off-shore drilling of oil and gas wells.

With the advent of drilling oil and gas wells in water in off-shore locations numerous structures have been developed to support the equipment necessary to drill such wells. These structures are either fixed or movable with the fixed structure being erected on the location usually by driving pilings into the ocean floor. The movable structures are usually floated to the site of operation and then anchored in position by sinking various parts of the structure to the ocean floor and driving temporary pilings to serve as additional anchoring means. The fixed form of structure has the obvious disadvantage of being immovable and the movable structures now in operation have various disadvantages including lack of stability during anchoring operations and initiating of the removal to a new location and difficulty with proper submerging of various parts of the structure. It is to an improved type of movable structure that the present invention is directed.

It is a general object of the present invention to provide a submersible barge assembly supporting a work platform which assembly includes upper and lower hulls each of which may be lowered to and raised from the ocean floor as a unit on vertical columns.

Another object is to provide such an assembly including means preventing binding of the hulls on the columns during vertical movement of the hulls.

Another object of the present invention is to provide a submersible barge assembly having upper and lower hulls each of which may be lowered to and raised from the ocean floor as a unit on columns with the upper hull carrying with it a bracing structure.

A further object is to provide a submersible barge assembly having upper and lower hulls with vertical columns from the lower hull extending upwardly and freely slidable through the upper hull and vertical casings extending above the upper hull and having novel means to releasably secure the casings to the columns.

A still further object of the present invention is to provide a submersible barge assembly including upper and lower hulls with the upper hull adapted to be used conveniently as under water storage for oil.

A still further object of the present invention is the provision of a submersible barge assembly having upper and lower hulls and vertical columns tiltably secured to the lower hull and extending slidably through the upper hull with said columns remaining vertical even though the ocean floor on which the lower hull rests may be slanted.

Other objects and advantages will be more apparent from the following description of preferred examples of the invention, given for the purpose of disclosure, taken in conjunction with the accompanying drawings, where like character references refer to like parts throughout the several views and where,

Figure 1 is an end view of the present invention with

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the upper and lower hulls raised for moving to and from drilling sites,

Figure 2 is an end view of the structure of the present invention in position with the lower hull resting on the ocean floor,

Figure 3 is a view similar to Figure 2 illustrating the lowering or raising of the upper hull,

Figure 4 is a view similar to Figure 3 illustrating the structure after the upper hull has been fully lowered,

Figure 5 is a side elevation illustrating the structure of the present invention with both hulls lowered and anchoring pilings in position,

Figure 6 is an end view of the right end of the structure of Figure 5,

Figure 7 is a schematic plan view of the upper hull,

Figure 8 is a schematic plan view of the lower hull,

Figure 9 is an enlarged fragmentary elevation of the upper end of a casing through which slidably extends a column with expansible gripping means to releasably grip the column,

Figure 10 is a partially schematic perspective view illustrating the novel relative movement control means for lowering and raising the two hulls, and

Figure 11 is an enlarged fragmentary view of a modified form of connection of a column to the lower hull.

Referring now to the drawings, and particularly to Figure 5, there is illustrated the submersible barge assembly indicated generally by the numeral 10 supporting a conventional work platform 12 on which are located various structures such as living quarters 14, work shops 16, a drilling platform 18, mud tanks 20 and the like. This work platform 12 and the various structures on it are conventional, as such do not constitute the present invention, and no further description of them is necessary.

Referring to Figures 1 through 4, the submersible barge assembly 10 includes an upper hull 20, a lower hull 22, a plurality of spaced vertical columns 24 secured to the lower hull 22 and extending slidably upwardly through the upper hull 20 and casings 26 secured to the upper hull 20. The columns 24 are releasably secured to the work platform 12 and the casings 26 are rigidly interconnected and held in vertical position by a bracing structure 28 formed by a network of structural members. The entire structure illustrated in Figures 1 through 4 when being moved is supported by a buoyancy of the upper hull 20 with the lower hull 22 having only sufficient buoyancy in water to support itself.

As illustrated in Figure 8 the lower hull 22 includes a plurality of compartments of which the compartments 30 around the periphery are open to the sea and filled with water at all times. To give the desired negative or positive buoyancy there are provided centrally located water tight and individually controlled buoyancy compartments 32 connected by a system of conduits through individually controlled valves 36 to a pump 38 in a pumphoom 40. The individual compartments 32 are vented, preferably through the columns 24, and the pump 38 has a connection, not shown, to sea water. The pump 38 is electrically controlled and the valves 36 are hydraulically controlled from the work platform 12 by any conventional system. A drilling slot 39 is formed at one end of the lower hull 22 through which slot 39 drilling is performed.

As illustrated in Figure 7, the upper hull 20 is substantially co-extensive with the lower hull 22 and includes a drilling slot 41 in line with the drilling slot 39. The upper hull 20 is provided with a plurality of water tight buoyancy compartments 42 with each such compartment 42 being individually connected by a conduit system 44 through hydraulically controlled valves 46 to a pump 48 in a pumphoom 50 so that each compartment 42 may

be flooded or emptied to give the desired negative or positive buoyancy to the upper hull 20. The compartments 42 are vented in any preferred manner and the pump 48 has a connection to sea water. Access to the pumproom 50 in the upper hull 20 is provided by the telescoping access tube 52 (Figure 5) extending to the work platform 12.

As illustrated in Figures 1 through 4, the lower hull 22 is moved vertically relative to the upper hull 20 by sliding movement of the hollow columns 24 through the hollow casings 26 and once the lower hull 22 is in position on the ocean floor the upper hull 20 is moved vertically with respect to the lower hull 22 by a sliding movement of the casings 26 relative to the columns 24. A loose fit (Figure 9) giving considerable clearance between the hollow columns 24 and the casings 26 is provided to prevent undue friction and bending during such movement. However, this loose fit is undesirable when the upper and lower hulls 20 and 24 respectively are not being moved relative to each other as wave action will cause undesirable vibration and movement. To prevent such undesirable movement the upper end of each of the casings 26 is provided with an annular metal housing 54 containing an inflatable pneumatic ring 56 with the pneumatic ring 56 being connected to an air supply through the lead 58. Any conventional source of air pressure located on the work platform 12 may be connected to the leads 58 to supply air pressure to and drain it from the pneumatic rings 56. Inflation of the pneumatic rings 56 securely locks the upper end of the casings 26 to the columns 24 and deflation of the pneumatic rings 56 permits free sliding movement between the columns 24 and casings 26.

To prevent movement between the lower surface of the upper hull 20 and the upper surface of the lower hull 22 there is provided on the columns 24 immediately above the lower hull 22 (Figures 1-4) an upwardly directed cone shaped projection 60 and in the lower surface of the upper hull 20 a mating cone shaped recess 62 which mating projections and recesses are engaged when the upper and lower hulls are in close proximity as illustrated in Figures 1 and 4 and prevent any horizontal movement between the columns 24 and casings 26 in the vicinity of these projections 60. These projections 60 are preferably spaced slightly above the upper surface of the lower hull 22 to prevent contact between the upper and lower hulls 20 and 22 when the structure is either floating as illustrated in Figure 1 or when both hulls are submerged as illustrated in Figure 4. This space between the hulls prevents suction from developing when initiating vertical movement of one hull in relation to the other and prevents debris which might collect on the upper surface of the lower hull 22 from damaging either of the hulls.

Because the upper and lower hulls 20 and 22 are moved vertically in relation to one another all the columns 24 simultaneously move through all the casings 26 and any tilting of one hull relative to the other during such movement will cause binding between the columns 24 and the casings 26 resulting in jerky and dangerous movement and difficulty in control of the movement. The relative movement control system 63 to prevent such tilting is best illustrated in Figures 1, 5, and 10.

Secured at the top of a plurality of spaced columns 24, preferably four with two at each end of the lower hull 22, are shock absorbers 64, 66, 68, and 70 respectively, which may be of any conventional type and no detailed description of them is necessary. Secured to the casings 26 on each of these columns 24 adjacent the upper surface of the upper barge 20 are toothed double pulleys 72, 74, 76, and 78 respectively forming rotatable guide assemblies. From the shock absorber 64 a chain 80 forming a flexible connecting element passes vertically downwardly, under one side of the double pulley 72, across to and over one side of the double pulley 74, and downwardly through the upper hull 20 where it is secured to an opposite corner of the lower hull 22 by a bracket 82. Similarly, a chain 84

extends downwardly from the shock absorber 66 under the other side of the double pulley 74, across and over the other side of the double pulley 72, and downwardly through the upper hull 20 where it is connected to an opposite corner of the lower hull 22 at the bracket 86. At the opposite end of the hulls a chain 88 passes downwardly from the shock absorber 68, under one side of the double pulley 76, over one side of the double pulley 78 and downwardly through the upper hull 20 where it is connected by the bracket 90 to the lower hull 22. Likewise, a chain 92 extends downwardly from the shock absorber 70 under the other side of the double pulley 78, over the other side of the double pulley 76, and through the upper hull 20 where it is connected to the lower hull 22 by the bracket 94. As thus constructed, when the column 24 to which shock absorber 64 is connected moves vertically the opposite corner 82 at the same end of the lower hull 22 must move vertically at the same rate because they are connected by the chain 80. It is noted that the corner at the bracket 82 moves downwardly at the same rate as column 24 to which the shock absorber 64 is attached because the portion of the chain 80 leading from the bracket 82 to the double pulley 74 and the portion of chain 80 leading from the shock absorber 64 to the double pulley 72 are parallel to each other. This same control also results from the connection of the upper end of the column 24 to which the shock absorber 66 is connected because the portion of the chain 84 leading from the shock absorber 66 to the double pulley 74 is parallel to the portion of the chain 84 leading from the bracket 86 at the opposite corner on the same end of the lower hull 22 to the double pulley 72. A similar controlled movement is provided at the other end of the lower hull 22 by the chains and double pulleys located there. Because the double pulleys 72, 74, 76 and 78 are connected to the upper hull 20 through the connections of these double pulleys to the casings 26, all vertical movement of the upper hull 20 in relation to the lower hull 22 is likewise controlled.

To force the opposite ends of the hulls to move simultaneously, at least one of the double pulleys 72 or 74 at one end of the upper hull 20 is connected to at least one of the double pulleys 76 or 78 at the other end of the upper hull 20 and preferably, as illustrated in Figure 10, each of the double pulleys at one end of the upper hull 20 is connected to one of the double pulleys at the other end by a connector rod 96 secured between the double pulleys 72 and 76 and a connector rod 98 secured between the double pulleys 74 and 78 so that the double pulleys 72 and 76 must rotate at the same speed and likewise double pulleys 74 and 78 must rotate at the same speed. Because either of the chains 80 or 84 force the pulleys 72 and 74 to rotate at the same speed and either of the chains 88 or 92 force the pulleys 76 and 78 also to rotate at the same speed these connecting rods 96 and 98 require all four double pulleys to rotate at the same speed and cause uniform vertical movement of all four corners of the upper and lower hulls 20 and 22.

To control the speed of vertical movement of the upper and lower hulls 20 and 22 a brake 100 is provided on the connecting bar 98 and is controlled by the telescoping brake rod 102 rising vertically to a brake wheel 104 situated on the work platform 12 (Figures 5 and 10).

In operation, when the structure is to be moved to a location it is in the position illustrated in Figure 1 with the various compartments 42 in the upper hull 20 being emptied of water to give sufficient positive buoyancy to float the entire structure above the upper hull 20. The lower hull 22 is raised against the upper hull 20 and given sufficient positive buoyancy in water by the buoyancy compartments 32 to float the lower hull 22 but not enough positive buoyancy to give any appreciable lift to the upper hull 20. The provision of the open compartments 30 in the lower hull 22 prevents a dangerous lifting effect from being given by the lower hull 22 and adds to the stability of the structure. When in the

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position illustrated in Figure 1 the mating projections and recesses 60 and 62 respectively adjacent the lower hull 22 and the lower surface of the upper hull 20 are engaged preventing horizontal movement between the two hulls and the pneumatic rings 56 at the upper end of the casings 26 are inflated tightly gripping the columns 24 preventing any vibration at the upper ends of the casings 26.

Upon reaching the desired location the pneumatic rings 56 are deflated, the brake 100 on the rod 98 is released, and the ballast compartments 32 in the lower hull 22 are flooded sufficiently to give the lower hull 22 a negative buoyancy causing it to descend carrying with it and being guided by the columns 24 moving downwardly through the work platform 12 and the casings 26. The relative movement control system 63 causes the four opposite corners of the lower hull 22 to move downwardly at the same rate of speed with the speed of descent being controlled by the brake 100. Because the four opposite corners of the lower hull 22 move downwardly evenly there is no binding between the columns 24 and the casings 26. Upon the lower hull 22 reaching the ocean floor as illustrated in Figure 2 the ballast compartments 32 may be completely flooded to give additional anchoring effect.

After the lower hull 22 is seated on the ocean floor and while the upper hull 20 is still supporting the work platform 12, the work platform 12 is secured to the columns 24 and supported thereby so there is no further relative movement between the columns 24 and the work platform 12. This may be done in any convenient manner such as by the slotted locking sleeves 106 (Figure 5) secured to the work platform 12 and through which extend the columns 24. Flanges 108 on each slotted locking sleeve 106 are pulled together by bolts 110 binding the slotted locking sleeve 106 tightly to the columns 24.

After the columns 24 are secured to the work platform 12 the various buoyancy compartments 42 of the upper hull 20 are flooded sufficiently to give the upper hull 20 a negative buoyancy whereupon the upper hull 20, the casings 26, and the bracing structure 28 are lowered as a unit down the columns 24 with all four corners of the upper hull 20 moving downwardly at an even rate through the operation of the relative movement control system 63 previously described. Upon the upper hull 20 reaching its lowermost position as illustrated in Figure 4 the mating projections and recesses 60 and 62 are engaged preventing horizontal movement between the upper and lower hulls 20 and 22 and the pneumatic rings 56 at the upper ends of the casings 26 are expanded gripping the upper ends of the casings 26 to the columns 24 so that horizontal movement of the upper hull 20, the casings 26, and the bracing structure 28 relative to the columns 24 and the lower hull 22 is prevented. After the upper hull is in its lowermost position it also may be completely flooded to give additional anchoring effect.

If desired, after both the upper and lower hulls 20 and 22 are on the ocean floor additional stability to the entire structure may be given by driving pilings 112 downwardly through the hollow columns 24 (Figures 5 and 6) into the ocean floor.

When it is desired to move the structure to a new location the pilings 112 are removed, the pneumatic rings 56 at the upper ends of the casings 26 are deflated, and sufficient positive buoyancy is given to the upper hull 20 by removing water from the buoyancy compartments 42 to cause the upper hull 20 to rise. By action of the relative movement control system 63 all four corners of the upper hull 20 will rise evenly preventing any binding between the columns 24 and the casings 26 and the speed of the upward movement of the upper hull 20 is controlled by both its buoyancy and the brake 100. When the upper hull 20 has reached its uppermost position as illustrated in Figure 2 all its buoyancy compartments

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42 are emptied, the slotted locking sleeves 106 are loosened so that the columns 24 may slide through them, and the ballast compartments 32 of the lower hull 22 are pumped out sufficiently to give it a positive buoyancy causing it to rise. Because the compartments 30 of the lower hull 22 are open to water and cannot be emptied a limit is placed upon the amount of positive buoyancy which can be given to the lower hull 22 with such limited positive buoyancy and the brake 100 limiting the rate of rise of the lower hull 22. The lower hull 22 and columns 24 will rise because the entire structure is then supported by the upper hull 20. The relative movement control system 63 prevents canting of the lower hull 22 relative to the upper hull 20 thus preventing binding between the casings 26 and columns 24. Upon the lower hull 22 reaching its uppermost position as illustrated in Figure 1 the mating projections 60 and 62 are re-engaged and the pneumatic rings 56 are again inflated.

Referring now to Figure 11 there is illustrated a modification in the manner of connection of the lower ends of the columns 24 to the lower hull 22 by providing a tiltable connection so that if the ocean floor is slanted the lower hull 22 upon seating may slant and seat firmly on the ocean floor with the columns 24 still rising vertically. At the lower end of each column 24 in this modification is a flange 114 in the shape of a spherical segment resting on a mating concave seat 116 secured to the upper surface of the lower hull 22. An overturned ear 118 surrounds the lower end of the columns 24 above the spherical flange 114 and allows limited movement of the spherical flange 114 with respect to the mating seat 116 but prevents the lower end of the column 24 from being separated from the lower hull 22. As thus constructed the lower hull may tilt relative to the vertical position of the columns 24 allowing the lower hull 22 to conform to a slanting ocean floor.

To grip the lower surface of the upper hull 20 to the columns 24 in this modification when the upper hull 20 is in its lowermost position there is provided at the lower surface of the upper hull 20 a pneumatic ring 120 which is in all respects identical to the pneumatic ring 56 at the upper ends of the casings 26. To space the upper hull 20 above the lower hull 22 a plurality of wooden timbers 122 may be secured to the upper surface of the lower hull 22.

In operation of the modification illustrated in Figure 11, the upper and lower hulls are raised and lowered identically to the operation previously described except that the pneumatic ring 120 serves to hold the lower surface of the upper hull 22 securely around the columns 24 rather than the mating projections and recesses 60 and 62. When the lower hull 22 is seated on the ocean floor it will conform to a tilt in the ocean floor without tilting the columns 24 and all other structure above the lower hull 22.

Storage of oil at the site of an off-shore drilling structure is a problem that has in the past sought to be overcome by under water storage of oil in submerged pontoons of off-shore drilling structures. The submersible barge assembly of the present invention is particularly adapted for such purpose in that the upper hull 20 may be used for under water storage of oil when the upper hull 20 is in its lowermost position by merely displacing the water in the buoyancy compartments 42 with oil through conventional lines and pumps (not shown) and by displacing the oil with water when it is desired to withdraw the oil from the upper hull 20. In such storage of oil it is necessary that the container be periodically cleaned. Because the upper hull 20 may conveniently be raised for cleaning while the work platform is firmly anchored and braced the present invention provides an excellent means for oil storage.

The present invention, therefore, is well suited to carry out the objects and attain the advantages mentioned

as well as others inherent therein. Changes in details and rearrangements of parts will suggest themselves to those skilled in the art and accordingly it is desired to be limited only by the spirit of the invention as defined by the scope of the appended claims.

What is claimed is:

1. In a submersible barge assembly the improvement comprising, an upper hull having a positive buoyancy in water; a lower hull below the upper hull, said lower hull having a negative buoyancy in water; at least two spaced vertical columns secured to the lower hull and extending upwardly slidably through the upper hull; means to releasably secure said columns to the upper hull; at least four guide assemblies carried by the upper hull, at least two of which guide assemblies are rotatable, a first flexible connecting element connected to an upper portion of one of said columns and to the lower hull at a point spaced from said one column, said first flexible connecting element engaging one rotatable guide assembly and one other guide assembly, a second flexible connecting element connected to an upper portion of another said column and to the lower hull at a point spaced from said other column, said second flexible connecting element engaging the other rotatable guide assembly and another guide assembly, and connecting means connecting said rotatable guide assemblies together so constructed and arranged that the rotatable guide assemblies rotate at the same speed, in each said flexible connecting element the portion leading from the column and the portion leading from the lower hull being parallel to each other.

2. The invention of claim 1 wherein the rotatable guide assemblies include toothed elements and the flexible connecting elements include links engaging said toothed elements.

3. The invention of claim 1 including brake means operable from above the upper hull and associated with said rotatable guide assemblies whereby rotation of said rotatable guide assemblies may be stopped.

4. The invention of claim 1 wherein the connecting means is rigid.

5. The invention of claim 1 including at least one buoyancy compartment carried by the upper hull and buoyancy control means associated with the buoyancy compartment in the upper hull adapted to control its buoyancy in water.

6. In a submersible barge assembly the improvement comprising, an upper hull having a positive buoyancy in water; a lower hull below upper hull, said lower hull having a negative buoyancy in water; at least four spaced vertical columns secured to the lower hull and extending upwardly slidably through the upper hull; means releasably securing the columns to the upper hull; at least four double rotatable guide assemblies carried by the upper hull; four flexible connecting elements, one each of said connecting elements connected to an upper portion of one of said columns and to the lower hull at a point spaced from said column, two each of said flexible connecting elements passing through and engaging the first and second of said rotatable guide assemblies, the other two of said flexible connecting elements engaging the second and third of said rotatable guide assemblies, in each said flexible connecting element the portion leading from said column and the portion leading from the lower hull connection being parallel to each other; and connecting means connecting said first and third guide assemblies together so constructed and arranged that said first and third guide assemblies rotate at the same speed.

7. The invention of claim 6 including brake means operable from above the upper hull and associated with said rotatable guide assemblies whereby rotation of said double rotatable guide assemblies may be stopped.

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