Jan. 12, 1960 G. E. SUDEROW 2,920,870

SYSTEM OF JACKING AND CONTROLS THEREFOR

Filed July 31, 1956 2 Sheets-Sheet 1

FIG. 1.

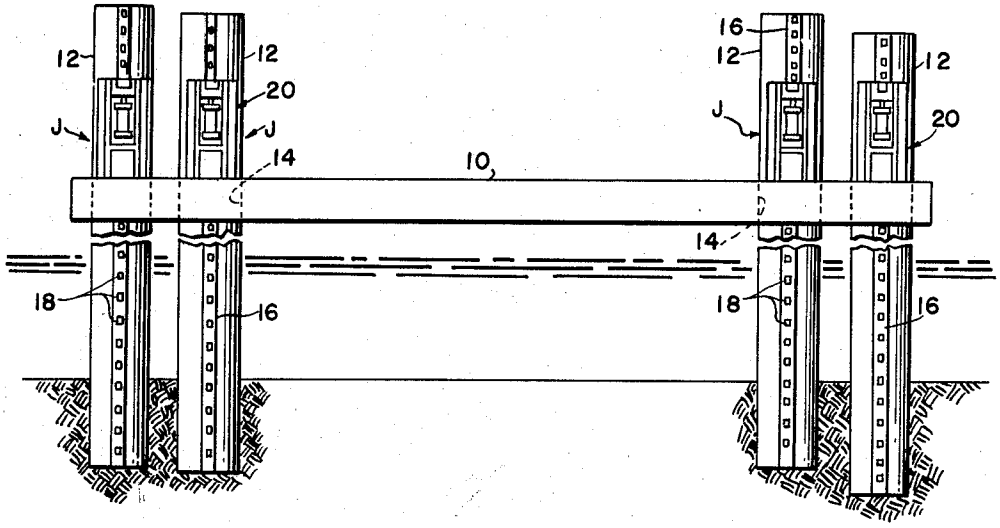
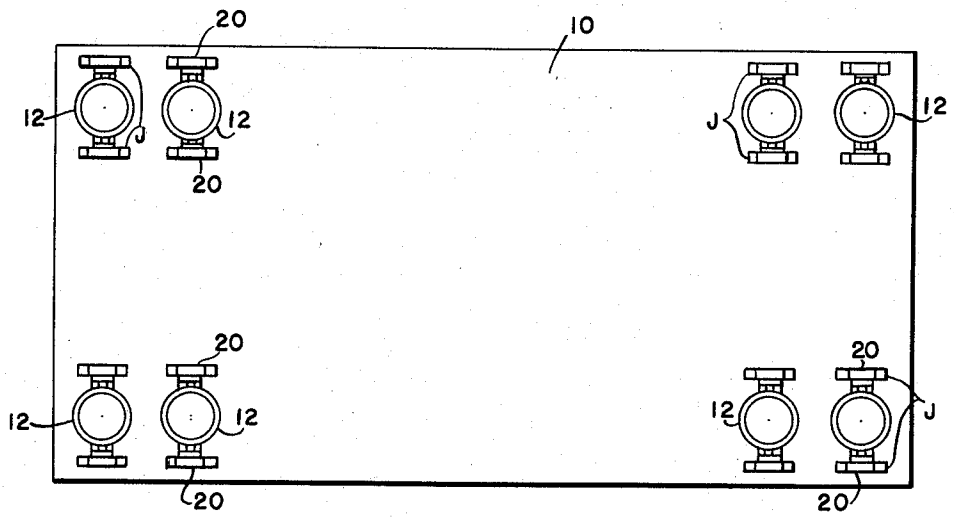


FIG. 2.



INVENTOR

GEORGE E. SUDEROW

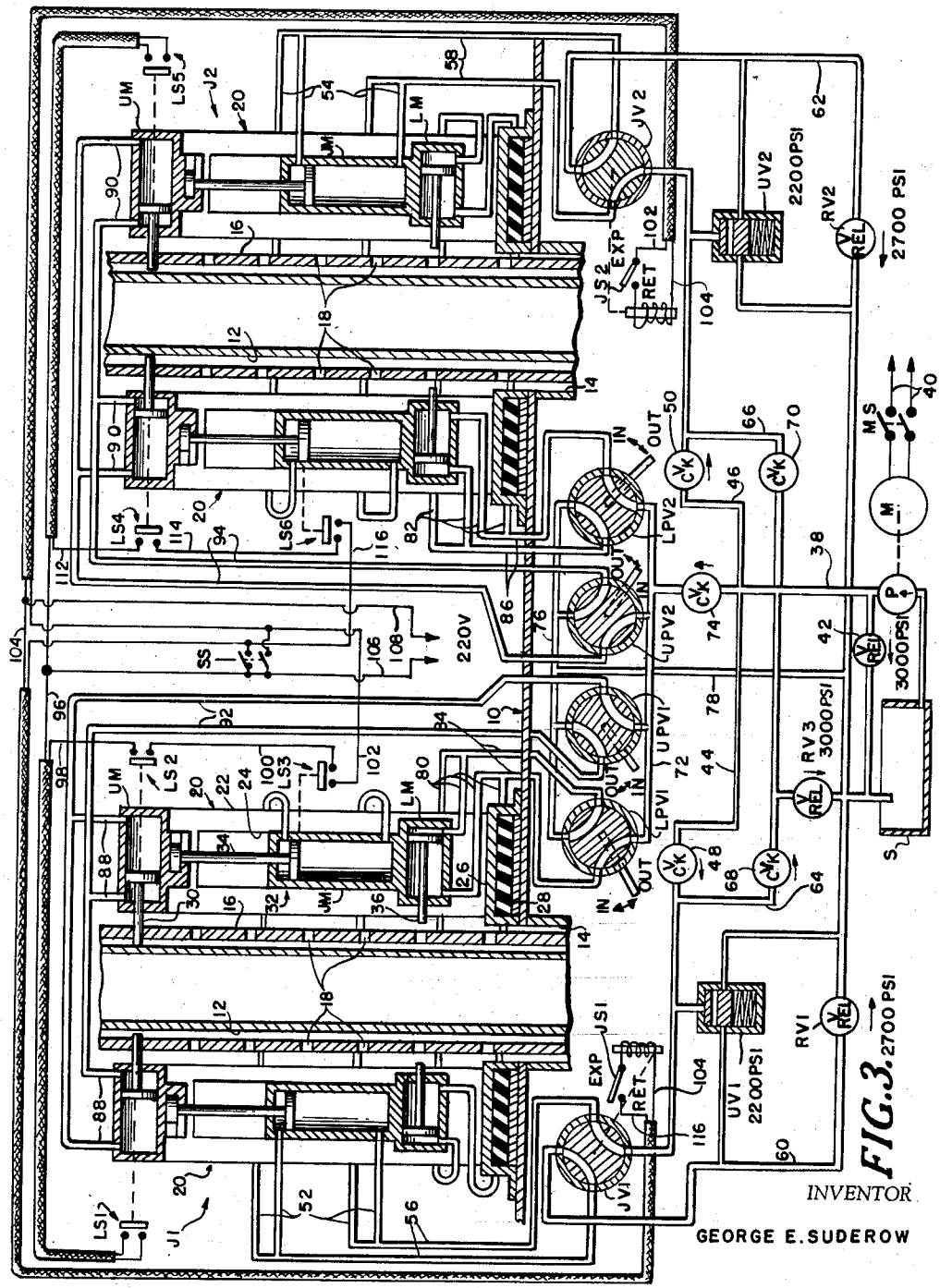
BY Cushman, Darby & Cushman

ATTORNEYS

Jan. 12, 1960 G. E. SUDEROW 2,920,870

SYSTEM OF JACKING AND CONTROLS THEREFOR

Filed July 31, 1956 2 Sheets-Sheet 2



BY Cushman, Darby & Cushman

ATTORNEYS

United States Patent Office 2,920,870
Patented Jan. 12, 1960

2,920,870

SYSTEM OF JACKING AND CONTROLS THEREFOR

George E. Suderow, New York, N.Y., assignor to De Long Corporation, New York, N.Y., a corporation of Delaware

Application July 31, 1956, Serial No. 601,226

10 Claims. (Cl. 254—93)

This invention relates to an improved system of manual controls for jacking apparatus of the type disclosed in my copending application Serial No. 523,323.

In the aforementioned application, there is disclosed an improved type of jacking mechanism for effecting or restraining step-by-step relative vertical movement between a platform and supporting legs therefor. More particularly, such jacking mechanism includes vertically spaced pins or bolts that are reciprocable laterally of a supporting leg for insertion into or withdrawal from one of a longitudinal row or series of holes in the leg. Obviously, when a pin projects into a hole in a leg, the pin is locked against longitudinal or vertical movement relative to such leg. One of the pins is secured to the platform against vertical movement relative thereto, while the other pin is reciprocable, by power, in a vertical direction relative to the other pin.

When a marine platform, usually in a nature of a barge or the like, is equipped with supporting legs and jacking mechanisms of the aforedescribed type, the barge can be towed to a marine erection site, and when the site is reached, the legs can be moved down into engagement with the marine bottom, and by operation of the jacking mechanisms the entire barge can be raised on the supporting legs to an elevation well above wave action. After marine operations, such as well drilling or the like, have been completed at the site, the barge can be lowered back down into the water by operation of the jacking mechanisms, and the supporting legs pulled up by the jacking mechanisms so that the entire assembly can be floated to another erection site.

In the aforementioned co-pending application there is disclosed a system of automatic controls for operation of the jacking mechanisms. Fully automatic controls for such jacking mechanisms are not always desirable, however, because of their somewhat inherent lack of flexibility of control. Furthermore, in some instances manual control of the jacking mechanisms is quite desirable, both because of its flexibility of control and because of its ready adaptability to take care of any situation which suddenly may arise in a jacking operation.

Pin jacks of the type under consideration give rise to the problem of coordinating the operation of the jacking mechanisms operating on several supporting legs. It will be seen that when the supporting legs are engaged with a marine bottom, such legs may sink thereinto to various depths. Consequently, the apertures or holes of a row in a particular supporting leg may not be aligned horizontally with the pin-receiving holes of a corresponding series in another supporting leg. If all of the jacking mechanisms are operating simultaneously throughout the full stroke of their jacking cycles, it will be seen that the aforedescribed horizontal disalignment of the pin-receiving holes in the supporting legs will cause the barge or platform to be out of level during such a jacking operation.

In the above-mentioned co-pending application, means are provided for compensating for such a difficulty and

for coordinating the operation of all of the jacking mechanisms in such a manner that a barge or platform will be maintained level during a jacking operation to raise or lower a barge on its supporting legs. As previously stated, however, such compensating means are included as a part of automatic controls for the jacking mechanism, and it has been found that manual controls for jacking mechanisms can be manipulated in a manner which obviates the need for such automatic compensating means, at least during the operation of raising a barge on its supporting legs.

In view of the foregoing, it is an object of this invention to provide an improved system of manual controls for jacking mechanisms of the type under consideration.

It is another object of this invention to provide improved methods of manipulating manual controls for jacking mechanisms of the type under consideration, wherein such manipulation is effective to maintain a platform level during the operation of raising such platform on a plurality of supporting legs.

Other objects and advantages of the invention will become apparent from the following description and accompanying drawings in which:

Figure 1 is a side elevational view of a buoyant marine platform or barge provided with vertically movable supporting legs operable by jacking mechanisms of the type with which this invention is concerned. The barge is shown supported on the legs above water.

Figure 2 is a plan view of the marine platform shown in Figure 1.

Figure 3 is a diagrammatic view of manually operable hydraulic and electric controls for operating the jacking mechanisms of an adjacent pair of supporting legs of the platform shown in Figures 1 and 2.

Referring now to the drawings, there is shown in Figures 1 and 2 a buoyant body **10** in the form of a barge which is generally rectangular in plan view and equipped with a plurality of supporting legs **12**. Each such legs **12** are shown in the drawings, two at each corner of the barge **10** for stably supporting the latter. Each supporting leg **12** extends through a guiding opening or well **14** extending vertically through the barge **10**, as shown in Figures 1 and 3, so that the legs can move substantially vertically relative to the barge. Although the supporting legs **12** are shown in the drawings as being in the form of hollow cylinders or caissons, it will be realized that the supporting legs may equally well be in the form of openwork towers that may be of various cross-sectional configurations, e.g., square, rectangular, triangular, etc. Each supporting leg **12** is movable vertically relative to the barge **10** by a jacking mechanism J secured to the latter, and since all of the jacking mechanisms are identical, a description of one will suffice for all. Because a detailed disclosure of the jacking mechanisms J is included in the aforementioned application of Suderow, there is no need for an extremely detailed description here. Consequently, there follows a description only sufficiently detailed for a complete understanding of this invention.

Each supporting leg **12** has secured thereto, as by welding, on diametrically opposite sides thereof, a channel shaped member **16** extending longitudinally of the leg and having its web spaced outwardly of the leg. The web of each channel shaped member **16** has a row of uniformly spaced pin-receiving apertures or holes **18** therein, and the holes on all of the members on each leg **12** are aligned horizontally, i.e., aligned transversely of the leg. The walls of the guiding wells or openings **14** in the barge **10** conform to the exterior configuration of the legs **12** including the channel shaped members **16**. Each jacking mechanism J includes two jacks **20** operable in unison, one cooperating with each of the two rows

of holes 18 in the supporting leg 12. In this connection, it will be seen that although only two diametrically opposite rows of holes are shown for each supporting leg 12, any number of rows together with a corresponding number of jacks 20 can be associated with each leg, provided only that the rows and jacks are disposed uniformly or symmetrically about each leg. With such a disposition, when opposed forces are effected by the jacks between each leg and the platform, there will be no tendency for such forces to effect a canting of the leg relative to the barge. Since all of the separate jacks 20 are identical, a description of one will suffice for all.

Each jack includes a vertically elongated body 22 (Figure 3) having a central, vertically-extending slideway 24. The lower end of the body 22 is secured to the barge 10, closely adjacent the corresponding leg-guiding well, as by a yoke-like member 26 which extends through an opening in the body and is secured at its opposite ends to the barge. Preferably, a rubber cushioning element 28 is interposed between the yoke-like member 26 and the body 22. From this construction, it will be seen that the jack 20 may effect an upward force on the barge 10 by pulling on the yoke member 26 and effect a downward force on the barge by engagement of the lower end of the jack body 22 against the opposed portion of the barge therebeneath.

Securely affixed to the top portion of the jack body 22 is a hydraulic double-acting cylinder or motor UM, and reciprocable by the motor is a locking pin 30 that is disposed transversely of the corresponding leg 12 in alignment with a row of apertures 18 therein, and insertable into an aperture when aligned therewith. A slide 32 is reciprocable in the slideway 24 by a hydraulic, double-acting jacking cylinder or motor JM that is affixed to the slide and has the outer end of its piston rod 34 fastened to the upper portion of the jack body 22 against vertical movement relative thereto. The full stroke of the motor JM preferably is slightly greater than the spacing between the pin-receiving apertures 18 in each row. The slide 32 also carries a double-acting pin-operating cylinder or motor LM which reciprocates a locking pin 36 that is also carried by the slide in alignment with the same row of apertures 18 in the leg 12 as the upper pin 30. From this construction it will be seen that by appropriate operation of the pin motors UM and LM and the jacking motor JM, the leg 12 may be held against vertical movement relative to the barge 10 or step-by-step vertical relative movement may be effected in either direction between the leg and the barge.

THE CONTROLS

The controls shown in Figure 3 of the drawings are designed for operation of both of the jacking mechanisms J1 and J2 that operate on the two supporting legs 12 at a corner of the barge 10, but it will be realized that similar controls will be used for the jacking mechanisms of each of the other pairs of supporting legs. Furthermore, such controls may be linked together, in a manner obvious to one skilled in the art, so that all of the jacking mechanisms for all of the legs can be operated in unison during portions of their jacking cycles.

The controls for the jacking mechanisms J1 and J2 operable on each pair of the supporting legs 12 include a source of fluid under pressure, such as a pump P which draws fluid from a sump S and discharges the fluid pressure into a main supply conduit 38. The pump P may be driven by an electric motor M controlled by a manually operable switch MS connected into conductors 40 leading to a source of electric power. Preferably, the pressure developed by the pump in the main supply conduit 38 is limited to a predetermined maximum, e.g., 3,000 p.s.i., by a pressure relief valve 42 connected between the discharge side of the pump P and the sump S. The jacking motors JM of the two jacking mechanisms J1 and J2 are controlled, respectively, by solenoid operated four-way control valves JV1 and JV2 operable, respectively, by manually-operable switches JS1 and JS2, while the upper pin motors UM and the lower pin motors LM of the two jacking mechanisms are controlled, respectively, by manually operable four-way control valves UPV1, UPV2, LPV1, and LPV2. When the switch JS1 or JS2 is open, the valve JV1 or JV2 operates to expand the corresponding jacking motors JM, i.e., to move the corresponding slides down, and when closed to retract the motors JM, i.e., to move the slides up.

The valves JV1 and JV2 are supplied with fluid under pressure from the supply conduit 38 via conduits 44 and 46, respectively, having check valves 48 and 50 interposed therein to prevent back-flow of fluid in case of failure of the pump P or the supply conduit 38. The opposite ends of the jacking motors JM of each jacking mechanism J1 and J2 are connected in parallel for simultaneous operation by branch conduits 52 and 54, respectively, and to their respective control valves JV1 and JV2 by conduits 56 and 58, respectively. Connected between the control valves JV1 and JV2 and the sump S are exhaust or return flow conduits 60 and 62, respectively, having pressure relief valves RV1 and RV2, respectively, interposed therein. These relief valves RV1 and RV2 are set to open at a predetermined pressure less than the maximum pressure in the supply conduit, as for example 2,700 p.s.i. The relief valves RV1 and RV2 are by-passed by pilot-operated unloading valves UV1 and UV2, respectively, connected thereto. The unloading valves UV1 and UV2 are normally closed, but are open when subjected to a predetermined pilot pressure less than that for which the valves RV1 and RV2 are set, as for example, 2,200 p.s.i. This pilot pressure constitutes the pressure which exists in the supply conduits 44 and 46, respectively, between their respective check valves 48 and 50 and their solenoid operated valves JV1 and JV2. The conduits 44 and 46, between their check valves 48 and 50 and their control valves JV1 and JV2, respectively, are connected to a pressure relief valve RV3 via the conduits 64 and 66, respectively, having check valves 68 and 70, respectively, interposed therein. The pressure relief valve RV3 is set to open at a predetermined pressure equal to the maximum pressure in the supply conduit 38, i.e., 3,000 p.s.i., and the overflow from such valve is conducted back to the sump S.

The pin motor controlling valves UPV and LPV is supplied with fluid under pressure from a common conduit 72 that receives fluid under pressure from the supply conduit 38 through a check valve 74 to prevent back-flow of fluid. The four pin motor controlling valves UPV and LPV are also connected to a common exhaust conduit 76, that is connected via a conduit 78 to the sump S. The opposite ends of the lower pin motors LM of each of the jacking mechanisms J1 and J2 are connected in parallel for operation in unison by branch conduits 80 and 82, respectively, and are connected to their respective valves LPV1 and LPV2 via the conduits 84 and 86, respectively. Similarly, the opposite ends of the upper pin motors UM of each jacking mechanism J1 and J2 are connected in parallel by branch conduits 88 and 90, respectively, and to their respective control valves UPV1 and UPV2 via the conduits 92 and 94, respectively.

Associated with the upper pin motors UM of each jacking mechanism J1 and J2 are limit switches LS1, LS2, LS4, and LS5 each having a pair of normally-open contacts that will be closed when the pin 30 of the corresponding motor UM is fully withdrawn from engagement with the supporting leg 12. Associated with one of the slides 32 of each jacking mechanism J are limit switches LS3 and LS6, respectively, each having a pair of contacts that will be open when the slides of the corresponding jacking mechanism are in their uppermost position and closed when the slides of the corresponding jacking mechanism are in their lowermost position. The limit switches LS1, LS2, and LS3 of the jacking mechanism J1 and the

manually operable switch JS2 controlling the solenoid valve JV2 of the jacking mechanism J2 are connected in series via the conductors **96, 98, 100, 102,** and **104,** across an appropriate source of electrical power, such as the conductors **106** and **108.** Similarly, the limit switches LS4, LS5, and LS6 of the jacking mechanism J2 and the manually operated switch JS1 for the control valve JV1 are connected in series across the power conductors **106** and **108** via the conductors **96, 112, 114, 116,** and **104.** The two series connections, of the limit switches LS1, LS2, and LS3, and the limit switches LS4, LS5, and LS6, can be shunted out, however, by a manually operable switch SS having two sets of contacts, one of which is connected across the conductors **106** and **102** and the other of which is connected across the conductors **106** and **116.** Consequently, it will be seen that when the switch SS is closed, each of the solenoid valves JV can be operated directly by manual operation of the corresponding switch JS, irrespective of the position of the several limit switches LS.

Operation—lower legs

Referring again to Figure 3 of the drawings, the operation of lowering the supporting legs **12** down into engagement with the marine bottom after the entire assembly has reached an erection site, will now be described. In this connection, it will be assumed that the lower pins **36** of both jacking mechanisms J are retracted, i.e., out, and the upper pins **30** are extended, i.e., in, so that the latter support the legs **12** from the barge **10.** It also will be assumed that the jacking motors JM are expanded, i.e., the several slides **32** are in their lowermost positions.

For this operation, the shunt switch SS is closed and the switches JS closed to thereby operate the control valves JV to cause the jacking motors JM of both jacking mechanisms J to retract, i.e., to move their respective slides **32** up, when pressure fluid is supplied to such motors JM through their control valves. At the same time, and if not already so positioned, the valves LPV are moved to their pin-out position and the valves UPV to their pin-in position. The pump motor M is then started by closing the switch MS so that fluid will be supplied via the conduits **44** and **46** to the control valves JV. Before the motors JM can retract, fluid in the lower portion of their cylinders will have to be exhausted to the sump S. It will be noted that the return lines **60** and **62** are blocked, however, by the relief valves RV1 and RV2 and by the pilot-operated unloading valves UV1 and UV2. Consequently, the pressure in the supply lines **44** and **46** will build up and as soon as it reaches a pressure of 2,200 p.s.i., the unloading valves UV will open to permit exhaust flow of fluid from the jacking motors JM so that the latter will thereupon move their slides **32** up.

As soon as the slides **32** start to move up, the control valves LPV are moved to their pin-in positions so that the pin motors LM will project the lower pins **36** into engagement with the supporting legs **12.** These pins **36,** however, will not move into an opening **18** in such legs **12** and will slide up on the web of the channel members **16** until the lower pins have been raised sufficiently to become aligned with such opening, i.e., a distance almost equal to a full stroke of the jacking motors JM. As soon as the lower pins **36** project into their respective aligned holes in the supporting legs **12,** the valves UPV are moved to their pin-out position to retract the upper pins **30.** These pins **30** will not retract immediately, however, because of the load of the leg **12** thereon, but since the jacking motors JM are still moving the slides **32** up, such load will be transferred from the upper to the lower pins **36.** On such transfer, the upper pins **30** will retract.

As soon as the upper pins **30** pull out, the switches US are opened to thereby reverse the flow of fluid in the conduits **56** and **58** and so operate the jacking motors JM to expand, i.e., move their slides **32** down. In this connection, it will be seen that the weight of the legs **12** on the lower pins **36** adds to the pressure in the upper ends of the cylinders of the jacking motors JM. This weight alone will develop a pressure in such upper ends of about 1,800 p.s.i, which is insufficient to open the relief valves RV1 and RV2 in the return lines **60** and **62.** Consequently, fluid from the supply lines **64** and **66** will build up pressure in the lower ends of the jacking motor cylinders until sufficient pressure, i.e., 2,700 p.s.i., is built up to open the relief valves RV1 and RV2. On this occurrence, the slides **32** will move down to thereby lower the supporting legs **12.**

As soon as, or shortly after, the slides **32** start to move down, the upper pin valves UPV are manually operated to move the upper pins **30** into engagement with the supporting legs **12.** These legs **12** will slide along the front edges of these pins **30,** however, until the next upper holes **18** in the several rows are brought into alignment with the pins, and at such time the upper pins **30** will project into their holes. As soon as the upper pins **30** have been projected into their holes in the legs **12,** the lower pin valves LPV are manually operated to cause the lower pins **36** to retract. This will occur as soon as the slides **32** have moved down sufficiently to transfer the load of the legs **12** from the lower pins **36** to the upper pins **30.**

The foregoing cycles of operation are continued until both of the legs **12** are moved down into engagement with the marine bottom. When the legs **12** reach the marine bottom, it will be seen that, because of the unevenness thereof, one leg may engage with the bottom before the other, and also that one leg, because of bottom variations, may penetrate more deeply into the marine bottom than the other. Consequently, when one or both of the legs **12** come into engagement with the marine bottom, the control valves JV, UPV, and LPV for each jacking mechanism J1 and J2 are operated independently until the corresponding leg has been driven to refusal into the marine bottom. In this connection, when a leg **12** has been driven to a bearing sufficient to support its own weight, the use of the upper pins **30** to support the leg **12** during recycling of the jacking motors JM may be discontinued. It also is pointed out here that with the stated pressures each jacking mechanism J1 or J2 alone is not powerful enough to lift the corresponding corner of the barge **10** on a single leg **12.**

Operation—raise barge

After both legs **12** of the pair at each corner of the barge **10** have been driven to refusal, as aforedescribed, continued operation of the jacking mechanisms J1 and J2, as aforedescribed, will be effective to raise the barge on all of the legs **12.** For this purpose, the controls for each pair of legs at each corner of the barge may be operated in coordination with the controls for all of the other pairs of legs to maintain the barge substantially level while it is being raised on all of the legs **12.**

Referring next to the raise-barge operation of the controls for the jacking mechanisms J1 and J2 for a pair of the legs **12,** it will be assumed that the holes **18** in the two legs **12** at each corner are not aligned horizontally after such legs have been driven to refusal in the marine bottom. Furthermore, it will be seen that when such refusal point is reached, the normal situation will be that the upper pins **30** are retracted, the lower pins **36** are extended and engaged with holes **18** in their corresponding legs **12,** and the jacking motors JM of both of the jacking mechanisms J1 and J2 are in the course of an expanding stroke.

As pressure fluid continues to be supplied to the jacking motors JM, the pressure therewithin will build up sufficiently so that the two jacking mechanisms J will raise the barge **10** on the legs **12.** In this connection it will be seen that this pressure will be greater than 2,200 p.s.i., so that the unloading valves UV will open. This raising

movement will continue until one of the jacking mechanisms J reaches the end of its raising stroke before the other, remembering that it has been assumed that the holes **18** in one of the legs **12** are out of horizontal alignment with the holes in the other leg. For purposes of illustration, it will be assumed that jacking mechanism J2 reaches the end of its lifting or raising stroke before the other mechanism J1.

Prior to the end of this raising stroke, the upper pin valves UPV of both the jacking mechanisms J are operated to extend the upper pins **30**. When the jacking motors JM of the jacking mechanism J2 near the end of their expansion and barge-raising strokes, the upper pins **30** of the jacking mechanism J2 will project into holes in the corresponding leg **12**. As soon as the upper pins **30** of the jacking mechanism J2 have become so set, the switch JS2 is closed to operate the jacking motors JM of the jacking mechanism J2 to retract. At the same time, the valve LPV2 is moved to its "pin-out" position to withdraw the lower pins **36** of the jacking mechanism J2. As before, however, these pins **36** will not withdraw until the load of the barge is transferred to the upper pins **30**. As the motors JM of the jacking mechanism J2 commence to retract, the load will be transferred from the lower pins **36** to the upper pins **30** of the jacking mechanism J2, so that the lower pins **36** will disengage from the corresponding leg **12**. During such load transfer, however, the upper pins **30**, and consequently the barge, must actually be lowered slightly.

As this load-transfer action takes place, it is pointed out that the jacking mechanism J1 is still being operated to raise the barge on its corresponding leg. When the jacking mechanism J2 actually slightly lowers the barge **10**, the entire corner load of the barge tends to be transferred to the leg with which the jacking mechanism J1 is associated. This load transfer will stall the raising stroke of the jacking mechanism J1 and increase the pressure in the lower portions of the cylinders of its jacking motors JM. As this pressure begins to build up, it will be relieved through the relief valve RV3 when it becomes in excess of 3,000 p.s.i. Consequently, during the time when the barge is actually being lowered slightly by the jacking mechanism J2, the barge is also lowered slightly by the jacking mechanism J1 by the bleeding of pressure fluid through valve RV3, so that the aforedescribed pin load transfer of the jacking mechanism J2 can be effected.

As soon as the lower pins **36** of the jacking mechanism J2 become disengaged from the corresponding leg **12**, and the jacking motors JM of the jacking mechanism J2 commence to move their slides **32** up, the valve LPV2 is operated to move the corresponding lower pins **36** back into engagement with the corresponding leg. When the jacking motors JM of the jacking mechanism J2 near the end of their retracting stroke, their lower pins **36** will reset into corresponding holes **18** in the leg **12**. As soon as these lower pins **36** become so engaged, the switch JS2 is opened to thereby operate the jacking motors JM of the jacking mechanism J2 to expand for another barge lifting stroke. At the same time, the valve UPV2 is operated to withdraw the upper pins **30** from engagement with the leg **12**. As the jacking motors of the jacking mechanism J2 commence to expand, the load of the barge is transferred from the upper pins **30** to the lower pins **36** so that the upper pins will pull out. Thereafter, both the jacking mechanisms J1 and J2 operate together to lift the barge on both of the legs **12** until the jacking mechanism J1 reaches the end of its lifting stroke. Thereupon, the jacking mechanism J1 is recycled in the same manner aforedescribed in respect to the jacking mechanism J2. During the recycling of the jacking mechanism J1 it is again pointed out that the jacking mechanism J2 will be stalled, and will actually operate to allow the corner of the barge to settle slightly, because of the relief valve RV3, during the transfer of the loads from the lower to the upper pins of the jacking mechanism J1.

The aforedescribed barge lifting operations of both jacking mechanisms J are continued until the barge reaches a desired elevation on the legs. At that time, it will be assumed that both jacking mechanisms J are in the course of a barge-lifting step and by merely opening the switch MS and thereby stopping further operation of the pump P, it will be seen that because of the presence of the check valves **48** and **50** and of the pressure relief valve RV3, the barge will be supported in a level position on the legs **12** by the lower pins **36** of both jacking mechanisms J.

Operation—lower barge

Prior to the beginning of a barge lowering operation, the shunt switch SS is opened, so that the valve JV1 can be moved to its "retract" position only when the switches LS4, LS5, and LS6 are closed, and the valve JV2 can be moved to its "retract" position only when the switches LS1, LS2, and LS3 are closed. Consequently, at the same time that the switch SS is closed, the limit switches LS3 and LS6 are tripped to their closed positions by manual operation and the switches JS are closed to operate the control valves JV to condition the jacking motors JM for retraction. In this connection, the weight of the barge is not sufficient to develop enough pressure in the lower portions of the cylinders of the jacking motors JM to open the relief valves RV1 and RV2. The switch MS is then closed to start the pump P which positively operates the jacking motors JM to retract and thereby begin to lower the barge **10**.

As both of the jacking mechanisms J so lower the barge, the valves UPV are operated to extend the upper pins **30** of both jacking mechanisms J. At this point, it will again be assumed that the pin-receiving openings **18** of one leg **12** are not aligned horizontally with those of the other leg. Consequently, it will be assumed that the jacking mechanism J1 will reach the end of its barge-lowering stroke before the jacking mechanism J2. As the jacking mechanism J1 nears the end of its barge-lowering stroke, the limit switch LS3 will be opened, thereby de-energizing the solenoid valve JV2 and causing this valve to move to its "expand" position. Consequently, the jacking mechanism J2 will be operated to lift the barge. The jacking mechanism J2 is incapable of lifting the entire corner weight of the barge, however, so that the jacking mechanicm J2 will stall.

During this stalling of the jacking mechanism J2 the jacking mechanism J1 is still lowering the barge and as soon as the upper pins **30** of the jacking mechanism J1 become aligned with the next lower holes **18**, they will be projected into such holes. The continued barge lowering action of the jacking mechanism J1 builds up excessive pressure in the lower portions of the jacking motors JM of the jacking mechanism J2. When this pressure reaches 3,000 p.s.i., it will be relieved through the pressure relief valve RV3, so that such bleeding of pressure fluid will permit the jacking mechanism J2 to move the corner of the barge downward through the slight distances necessary for the pins **30** of the jacking mechanism J1 to set, as described above.

As soon as the upper pins **30** of the jacking mechanism J1 become so set, the limit switches LS1 and LS2 are automatically opened, and thereupon the valve LPV1 is operated manually to withdraw the lower pins **36** of the jacking mechanism J1. Consequently, since the jacking mechanism J1 is still lowering the barge, as soon as the load of the latter is transferred to the upper pins **30** of this jacking mechanism, the lower pins **36** will withdraw. Thereupon, the switch JS1 is opened manually to cause the jacking motors of the jacking mechanism J1 to expand. As soon as these motors start to expand, the valve LPV1 is moved manually to its "in" position so that as soon as the lower pins **36** of the jacking mechanism become aligned with the next lower series of open-

ings 18, they will be projected thereinto. As the jacking motors JM of the jacking mechanism J1 near the end of their expanding stroke, the limit switch LS3 will be closed.

As soon as the lower pins 36 of the jacking mechanism J1 become set as described above, the valve UPV1 is moved manually to its "pin-out" position. The jacking motors of the jacking mechanism J1 are continuing to expand, however, so that as soon as the load of the barge has been transferred from the upper pins 30 to the lower pins 36, the upper pins 30 will pull out and close the limit switches L1 and L2. The closing of these latter limit switches completes the energizing circuit for the solenoid valve JV2 so that the jacking motors JM of the jacking mechanism J2 again are operated to retract. Consequently, both of the jacking mechanisms J1 and J2 are in their retracting cycle and the barge will begin to be lowered thereby.

The aforedescribed lowering of the barge continues until the jacking mechanism J2 reaches the end of its lowering stroke, whereupon the jacking mechanism J2 is recycled in a manner similar to that described above for the jacking mechanism J1. Both of the jacking mechanisms J1 and J2 are continued to be operated in the aforedescribed manner until the barge has been lowered back down into the water and is afloat. At this time the pump P is stopped by opening the switch MS to cease further barge-lowering operation of the jacking mechanisms J. On this occurrence, a typical situation would be for both of the jacking mechanisms J to be in a retracting stroke so that the lower pins 36 would be engaged with both of the legs 12 and the upper pins 30 would be withdrawn therefrom.

Operation—raise legs

Assuming that the situation exists as described immediately above, i.e., that the lower pins 36 of both jacking mechanisms J are engaged with the legs 12 and the upper pins 30 are disengaged therefrom, for the purpose of raising the legs the shunt switch SS is first closed, so that the jacking valves JV can be operated independently of the several limit switches LS. The switches JS are opened to operate the valves JV to condition the jacking motors JM of both jacking mechanisms J to retract. Since it has been assumed that the lower pins 36 are engaged with the legs, and the upper pins 30 disengaged, it also will be assumed that the valves LPV are in their pin-in positions and the valves UPV are in their pin-out positions. Hence, the valves UPV are moved to their pin-in positions.

The switch MS is then closed to start the pump P so that fluid under pressure will enter the upper ends of the cylinders of the jacking motors JM. At this point, it is pointed out that in all probability both of the legs 12 will be embedded in the marine bottom so that an upward force, greater than the weight of each leg, will have to be applied to each leg to pull it free from the marine bottom. Consequently, a pressure greater than 2,200 p.s.i. probably will be necessary to be applied in the upper ends of the cylinders of the jacking motors JM to pull the legs 12 loose from the marine bottom. Hence, fluid pressure will build up in the upper ends of the cylinders of the jacking motors JM until such pressure is sufficient to open the unloading valves UV, whereupon the jacking motors JM will retract and thus raise the legs 12 when the pressure force developed in the jacking motors is sufficient to pull the legs loose from the marine bottom.

When the pump P is started, the pin motors UM move the upper pins 30 into engagement with the legs 12. Consequently, as the legs move upwardly by the upward movement of the lower pins 36, the upper pins 30 will project into holes 18 in the legs as soon as such holes become aligned with the upper pins 30.

At this point, it is again pointed out that at the beginning of the leg raising operation, the holes 18 in one leg probably will not be aligned horizontally with corresponding holes in the other leg. Consequently, one of the jacking means J, e.g., J1, will reach the end of its leg-lifting stroke before the other. This is of no consequence, however, because of the jacking motors JM of the mechanism J2 simply will continue to operate until the latter reaches the end of its leg-lifting stroke, at which time its upper pins 30 will project into engagement with holes in the corresponding leg.

As soon as the upper pins 30 of both mechanisms J have become engaged with their corresponding legs 12, the switches JS are opened to cause the jacking motors JM to expand, i.e., move the slides down and at the same time, the valves LPV are moved to their pin-out positions. As soon as the slides have moved down sufficiently to transfer the weight of the legs 12 from the lower pins 36 to the upper pins 30, the lower pins will thereupon be pulled out from engagement with the legs 12. As soon as the slides move down farther, the valves LPV are moved to their pin-in position so that the lower pins 36 will be projected into the next lower set of holes 18 on alignment therewith. When the lower pins 36 have so reset, the switches JS are closed and the valves UPV are moved to their pin-out positions. Consequently, the slides of the jack motors JM will commence to raise and to thereupon lift the legs 12 through another lifting stroke. As soon as the weight of the legs 12 has been transferred to the lower pins 36, the upper pins 30 will retract.

The jacking mechanisms J are continued to be operated in accordance with the foregoing cycles until the supporting legs 12 are pulled up any desired distance, normally until the lower ends of such legs are substantially flush with the bottom of the barge 10. Thereupon, the entire assembly can be towed to another erection site. In this connection, the legs 12 normally will be supported by the upper pins 30 during a towing operation.

It thus will be seen that the objects of this invention have been fully and effectively accomplished. It will be realized, however, that the foregoing specific embodiment has been shown and described only for the purpose of illustrating the principles of this invention and is subject to extensive change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claims.

I claim:

1. A control system for a jacking mechanism for selectively restraining or effecting substantially vertical relative movement in either direction between a buoyant body and a supporting leg therefor, and wherein the mechanism includes a pair of members adapted to be mounted on the body substantially in alignment longitudinally of the leg and each independently releasably engageable therewith against movement longitudinally thereof and further includes double-acting fluid motor means connected to the members for effecting relative movement therebetween selectively in either direction longitudinally of the leg, the combination comprising: four-way control valve means adapted to be connected to the motor means; a fluid pressure supply line and an exhaust line connected to said valve means; back-pressure valve means in said exhaust line for exhausting fluid only above a predetermined pressure therein; and unloading valve means connected in parallel with said back-pressure valve means and responsive to a predetermined pressure in said supply line less than said first-mentioned predetermined pressure to by-pass said back-pressure valve means.

2. The system defined in claim 1 in which the pressure developable in the motor means by the weight of the leg alone is less than the first-mentioned predetermined pressure.

3. The system defined in claim 1 including one-way valve means in the supply line upstream of the point

therein at which the unloading valve means is responsive to pressure, and including pressure relief valve means in said supply line downstream of said one-way valve means and set to open at a pressure greater than the said first-mentioned predetermined pressure.

4. The system defined in claim 3 including additional relief valve means in the supply line upstream of the one-way valve means and set to open at a pressure substantially equal to the said set opening pressure of the first-mentioned relief valve means.

5. A control system for at least two jacking mechanisms operable on a corresponding number of supporting legs for a buoyant body and effective to selectively effect or restrain substantially vertical relative movement in either direction between each leg and the body, and wherein each mechanism includes a pair of members adapted to be mounted on the body in alignment longitudinally of the corresponding leg with each member being releasably engageable with its leg against movement longitudinally thereof and further includes double-acting fluid motor means connected to each pair of members for effecting relative movement therebetween selectively in either direction longitudinally of the leg, the combination comprising: a source of pressure fluid; four-way control valve means adapted to be connected to each of the motor means; a fluid pressure supply line connected between each of said valve means and said source; an exhaust line connected to each of said valve means; back-pressure valve means in each of said exhaust lines for exhausting fluid only above the same predetermined pressure therein; and unloading valve means connected in parallel with each of said back-pressure valve means and responsive to the same predetermined pressure in the corresponding supply line less than said first-mentioned predetermined pressure to by-pass the corresponding back-pressure valve means.

6. The system defined in claim 5 including relief valve means for limiting the source to a predetermined pressure greater than the first-mentioned predetermined pressure.

7. The system defined in claim 5 in which the pressure developable in each motor means by the weight of the corresponding leg alone is less than the first-mentioned predetermined pressure.

8. The system defined in claim 5 including one-way valve means in each supply line, relief valve means connected to each supply line and responsive to a predetermined pressure greater than the first-mentioned predetermined pressure, and wherein the jacking force developable by one of the jacking mechanisms alone is insufficient to lift the body independently of the other jacking mechanism.

9. The system defined in claim 5 wherein the pressure developable in both motor means by the weight of the body alone is less than the first-mentioned predetermined pressure.

10. The structure defined in claim 5 in which one of the members of each jack mechanism is mounted on the body against upward movement relative to the latter, each member has a pin movable transversely of the corresponding leg selectively into and out of one of a longitudinal series of evenly spaced holes therein for locking or unlocking the member to the leg against relative movement longitudinally thereof, and each control valve means is electromagnetically operated, and including a separate manually-operable switch for controlling the operation of each of said control valve means, limit switch means associated with each of the said one members and adapted to be closed when the corresponding one member is disengaged from its leg, limit switch means associated with each jack mechanism and adapted to be closed when the corresponding members are substantially at the limit of their separation stroke, a first circuit for connecting all of said limit switch means of one jacking mechanism and said manually-operable switch means of the other jacking mechanism in series with a source of power, a second circuit for connecting all of said limit switch means of the other jacking mechanism and said manually-operable switch means of the one jacking mechanism in series with a source of power, and manually-operable switch means for shunting out all of said limit switch means.

References Cited in the file of this patent

FOREIGN PATENTS

158,029 Australia ---------- Aug. 3, 1954