July 12, 1932. W. FERRIS 1,866,801

HYDRAULIC CRANE

Filed Feb. 13, 1926 2 Sheets-Sheet 1

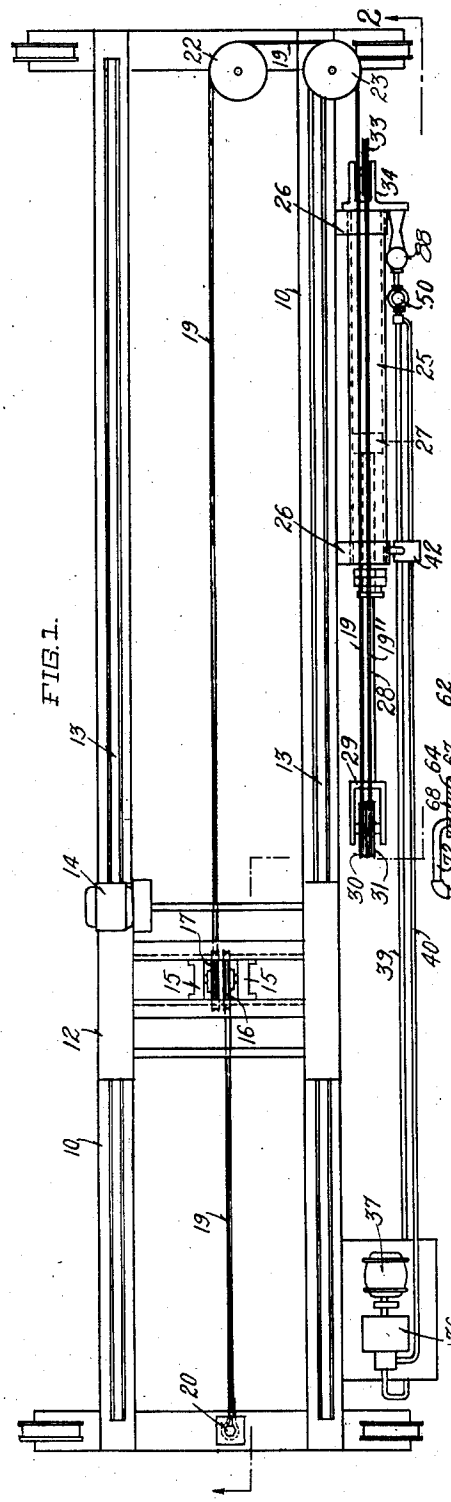


FIG. 1.

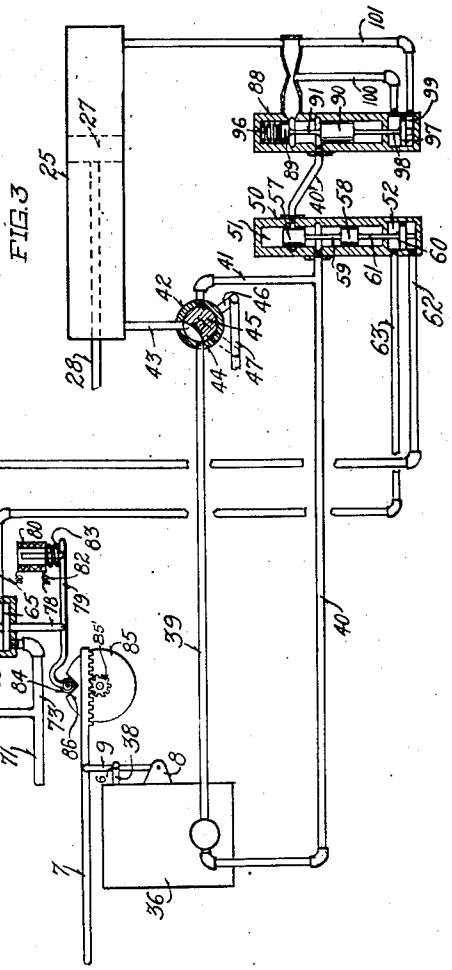


FIG. 3

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July 12, 1932. W. FERRIS 1,866,801

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Filed Feb. 13, 1926 2 Sheets-Sheet 2

FIG. 2.

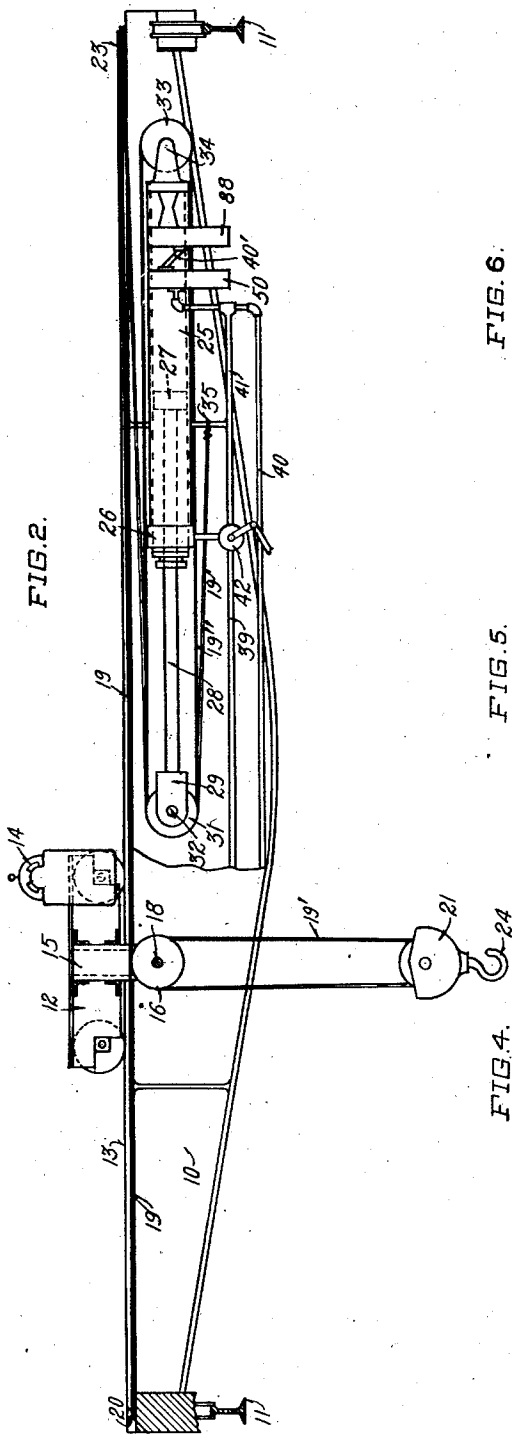


FIG. 6.

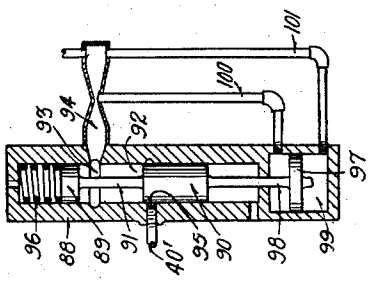


FIG. 5.

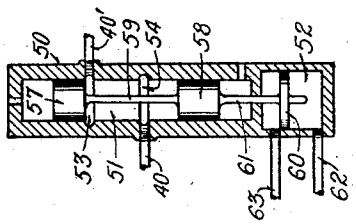
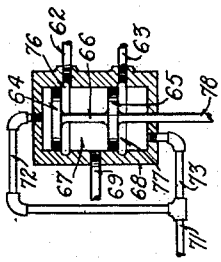


FIG. 4.



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HYDRAULIC CRANE

Application filed February 13, 1926. Serial No. 88,114.

This invention relates to cranes and more particularly to hydraulic drives therefor.

One object of the present invention is the provision of a hydraulic drive for cranes so constructed and arranged as to return to the power source a large portion of the energy ordinarily lost during lowering of the load.

Another object is the provision of a hydraulic drive for cranes and the like in which two distinct hoisting speeds are available.

Another object is the provision of safety devices for drives of this character which will operate automatically to check the fall of the load in the event of failure in the power circuit or in the hydraulic connection.

Another object is the provision in a hydraulic circuit of the type involving a reversible flow pump, of mechanism automatically operable to prevent movement of the motor when pump displacement is zero.

Another object is the provision in a crane of a system of reaving which will permit the mounting of the hoisting motor on the bridge without interfering with the hoisting functions or with the free travel of the carriage along the bridge.

Other objects and advantages will appear from the following description of an illustrative embodiment of the present invention.

In the drawings:—

Figure 1 is a plan view of a crane embodying the novel features of the present invention.

Fig. 2 is a view partly in section and partly in side elevation of the crane of Figure 1, taken substantially along the line 2—2 of Figure 1.

Fig. 3 is a diagram of the hydraulic connections.

Fig. 4, 5, and 6 are sectional views of three valves, respectively, shown in Figure 3.

The crane shown in Figures 1 and 2 includes the usual bridge 10 mounted for transverse travel along the fixed rails 11 in the usual manner, and supporting a carriage 12 mounted to travel along the usual rails 13 extending lengthwise of the bridge. The carriage is driven by any appropriate means such as an electric motor 14 geared to the driving wheels of the carriage in a manner well known. A pair of sheaves 16 and 17 are rotatably supported upon a shaft 18 fixed at its opposite ends in spaced brackets 15 fixed to and depending from the central portion of the carriage. The sheaves 16 and 17 are arranged side by side in vertical parallel planes extending lengthwise of the bridge.

A hoisting cable 19, anchored as at 20 at one end of the bridge, is trained over sheave 16, downwardly beneath a padlock sheave 21, upwardly over the sheave 17, and then around horizontal sheaves 22 and 23 rotatably fixed at the other end of the bridge. The other end of the cable is operatively connected with a hydraulic motor to be hereinafter described. Sheave 22 and sheaves 16 and 17 are preferably so disposed that the lengths of cable between the anchorage 20 and sheave 16 and between the sheave 17 and sheave 22 lie substantially in one straight line, so that the loop 19′ of the cable between sheaves 16 and 17 and sheave 21 remains substantially the same length during travel of the carriage 12 along the bridge. The sheave 21 is equipped with a hook 24 or other appropriate load engaging means.

The hoisting cable is actuated and controlled by a hydraulic motor which is herein shown as a power cylinder 25 supported in fixed horizontal position in appropriate brackets 26 secured to the side of the bridge. A piston 27 within the cylinder is provided with the usual piston rod 28 which carries at its outer end a yoke 29, supporting a pair of sheaves 30 and 31 freely rotatable on a shaft 32 fixed in the yoke 29. A sheave 33 is mounted in a bracket 34 fixed to the opposite end of the cylinder 25. The cable 19 extends from the sheave 23 over sheave 30 on the piston rod, then back over the sheave 33 on the cylinder, over the other sheave 31 on the piston rod, and finally to the bridge where it is firmly anchored as at 35. As the piston 27 travels toward the left, sheaves 30 and 31 move accordingly and the loop 19″ of that portion of the cable between sheave 33 and sheaves 30 and 31 is extended. This obviously shortens the loop 19′ of the cable and the hook 24 is lifted. As the piston 27 travels toward the

right loop 19'' is shortened and loop 19' lengthened to lower the hook 24.

The piston 27 is actuated by a hydraulic circuit, without an accumulator, which circuit is fed by an appropriate pump 36. The pump shown is a reversible flow, variable displacement pump of the type fully described in my application, Serial No. 682,056, filed December 21, 1923, which has matured into Patent No. 1,558,002, issued October 20, 1925. It will suffice here to say that this pump is driven at substantially constant speed by any appropriate means such as an electric motor 37 and that pump displacement is varied from zero to full delivery in either direction by a control stem 38. When the stem is in the neutral position shown pump displacement is zero. When the stem is shifted lengthwise into the pump casing liquid is forced by the pump through pipe 40 and returned to the pump through pipe 39, the rate of flow being determined by the extent of movement of the control stem from neutral position. By shifting the stem lengthwise in a direction away from the casing liquid flows from the pump through pipe 39 and returns to the pump through pipe 40. In this instance the stem is operated by a lever 9, pivotally supported at its lower end upon an appropriate bracket 8 fixed to the pump casing, and pivotally connected at its upper end with a rod 7 under the control of the operator through appropriate linkage not shown. The stem is pivotally connected with the lever 9, as at 6.

Under some conditions of operation the pump 36 acts as a motor, under the pressure of liquid returning thereto through the pipe 40, and when so acting delivers a driving torque to the electric motor 37. In order to utilize this torque the electric motor 37 is of the regenerative type, such as a constant speed, alternating current induction motor, or a constant speed shunt wound direct current motor, which, when driven at a speed above normal, will act as a generator and feed back into the power circuit.

In the circuit diagram illustrated in Figure 3 it will be noted that the pipe 40 is connected to the right end of cylinder 25 through valve mechanisms, hereinafter described, which remain open during normal operation of the crane. Pipe 40 is also connected through a branch pipe 41 with a valve 42 under the control of the operator. A pipe 43 connects this valve with the left end of the cylinder. Pipe 39 is also connected with this valve 42. Valve 42 is adjustable to connect either pipe 39 or pipe 41 with the left end of the cylinder. Although this valve may assume various forms, that shown comprises a cylindrical housing 44 enclosing a rotatable piston 45 under the control of the operator through appropriate linkage including a rod 47 and arm 46 connected with the piston 45. The piston is cut away so as to open communication between pipes 39 and 43 when in the full line position shown and to open communication between pipes 43 and 41 when in the dotted line position shown.

Provision is preferably made for automatically blocking the escape of liquid from the right end of cylinder 25 to thereby automatically lock the piston against movement when pump displacement has been reduced to zero or in the event of failure in the power source. The hook 24 and load supported thereby is thus held against falling when either of the above conditions arise. For this purpose a valve of appropriate type is interposed between the pipe 40 and the right end of the cylinder 25, and this valve is placed under the control of a pilot valve which responds to adjustment of the pump and to the condition of the power circuit. A valve for this purpose is shown in Figures 1, 2, 3, and 5. This valve comprises a cylindrical housing 50 having two separate chambers 51 and 52. Two spaced similar grooves 53 and 54 are formed in the wall of the chamber 51, groove 54 communicating with pipe 40 and groove 54 communicating with a pipe 40'. A piston comprising two heads 57 and 58, connected by a reduced portion 59 is closely fitted for lengthwise reciprocation in the chamber 51. The arrangement is such that when the piston is in the upper position shown in Figure 5, piston head 57 is above both grooves 53 and 54 and piston head 58 is below both grooves so that pipe 40 is in open communication with pipe 40'. This is the position of the piston during normal operation of the crane. When the piston is in the lower position shown in Figure 3, piston head 57 covers groove 53 and communication is effectively closed between pipes 40 and 40'. The piston is controlled by a piston 60 connected thereto by a stem 61 and closely fitted for reciprocation in the chamber 52. The opposite ends of chamber 52 are in open communication with pipes 62 and 63, respectively, controlled by a pilot valve of any appropriate type.

The pilot valve shown comprises a piston having two heads 64 and 65, connected by a reduced portion 66, and closely fitted for lengthwise reciprocation in the cylindrical bore 67 of a casing 68. The space between the piston heads is maintained flooded with liquid under pressure supplied from a convenient pressure source through pipe 69 connected midway of the length of the bore 67. The opposite ends of the bore communicate at all times with a discharge pipe 71, through branch pipes 72 and 73. A groove 76 in the wall of the casing is controlled by the piston head 64 and a groove 77 is controlled by the piston head 65. Pipe 62 is connected with groove 76 and pipe 63 with groove 77. The arrangement is such that when the piston is in the lower position of Figure 3, pipe 63 com-

municates with pressure pipe 69 and pipe 62 with branch pipe 72 and discharge pipe 71, and when the piston is in the upper position of Figure 4 pipe 62 communicates with pressure pipe 69 and pipe 63 with branch pipe 73 and discharge pipe 71. The piston is controlled by a stem 78.

The pilot valve in this instance is placed under the joint control of the pump control mechanism and a solenoid which responds to the condition of the electric power circuit for the motor 37. In the mechanism shown this is accomplished by mounting a floating lever 79 upon the stem 78 of the valve. This lever is pivotally connected intermediate its ends to the stem. The right end of the lever is connected with the armature of a solenoid 80. The solenoid is connected through leads 81 and 82 with the opposite sides of the electric power circuit for the motor 37. During the active condition of the power circuit the solenoid is energized and holds the end of the floating lever 79 in elevated position against the action of the spring 83. Should the power circuit fail, however, the solenoid is deenergized and the end of the lever falls under the action of the spring. A roller 84 journaled within the left end of the floating lever 79 rides upon a rotary cam 85 actuated by the control rod 7 through a rack and pinion 85′. With the rod 7, lever 9, and pump control stem 38 in the neutral position of Figure 3, in which position pump displacement is zero, the cam roller is engaged in the depressed portion 86 of the cam 85 and the left end of the lever 79 is depressed. Upon movement of the control rod 7, in either direction from this position, so as to cause the pump to deliver liquid in one direction or the other, the cam 85 is rotated accordingly and the cam roller 84 rises out of the depressed portion 86, lifting the left end of the floating lever and the valve stem 78.

The arrangement is such that under normal conditions the right end of the floating lever is maintained in an elevated position by the solenoid 80. With the control rod 7 in the neutral position shown in Figure 3, pump displacement is zero, the cam roller 84 rests within the depressed portion 86 of the cam, the valve stem 78 is lowered, and the pilot valve is in such position as to effect communication between the pressure pipe 69 and pipe 63. Fluid pressure is thus applied above the piston 60 and the piston valve in chamber 51 assumes the lower position shown in this figure, and piston head 57 covers groove 53 so as to block communication between the pump and the right end of the power cylinder 25. When the pump is adjusted by longitudinal movement of the control rod 7 so as to cause delivery of liquid in one direction or the other, the cam 85 is actuated and the roller 84 rises out of the depressed portion thereof and lifts the left end of the floating lever, to thereby elevate the valve stem 78 and lift the pilot valve into the position of Figure 4. Communication is thus established between the pressure pipe 69 and pipe 62, the piston 60 moves upwardly, and the piston valve in chamber 51 assumes the upper position of Figure 5 and communication is established between pipes 40 and 40′. This condition is maintained until the control rod 7 is returned to neutral position or until failure in the electric power circuit. Should the power circuit fail the solenoid would become deenergized and the right end of the floating lever would fall under the pressure of the spring, so as to lower the pilot valve and thereby adjust the valve 50, so as to block the hydraulic circuit. Provision is also made for automatically shutting off the flow of liquid from the right end of the power cylinder 25 in the event that breakage occurs in the pressure pipe 40, to thereby sustain the hook 24 and load against falling. This is accomplished in this instance by inserting another valve in the hydraulic circuit between the pressure pipe 40′ and the right end of the cylinder and by making this valve respond to an excessive rate of flow from the right end of the cylinder to cut off the flow. A valve for this purpose is shown at 88 in Figures 1, 2, 3, and 6. The valve shown is similar to that shown in Figure 5 in that it comprises a piston having two heads 89 and 90 connected by a reduced portion 91 and reciprocating longitudinally in the cylindrical chamber 92 of the valve casing. The space between the heads 89 and 90 is always in open communication with the right end of the power cylinder 25 through a port 93, beneath the head 89, and through a Venturi tube 94 which communicates at all times with the right end of the cylinder. A similar groove 95, communicating with pipe 40′ is controlled by the head 90. The piston is normally retained in the lower position shown in Figure 3 by a compression spring 96 disposed in the upper end of the chamber 92. In this position the head 90 is below the groove 95 and pipe 40′ is in communication with the Venturi tube and the right end of the power cylinder. When shifted into the upper position of Figure 6, however, the head 90 covers the groove 95 and communication between pipe 40′ and the Venturi tube is blocked. The piston is raised by upward movement of a piston 97 to which it is connected through a stem 98.

The piston 97 reciprocates in a chamber 99 within the valve casing. A pipe 100 connects the upper end of chamber 99 with the restricted portion of the Venturi tube and a pipe 101 connects the lower end of chamber 99 with a wide portion of the Venturi tube. The arrangement is such that during normal operation of the crane the velocity of liquid

flow through the Venturi tube, to and from the right end of the cylinder 25, is such that the difference in fluid pressure at the restricted and wide portions of the Venturi tube is insufficient to raise the piston 97 and valve against the pressure of the spring 96. Should the hydraulic circuit fail, however, due for instance to a bursting of the pipe 40, so as to permit the high pressure liquid in the right end of the cylinder to escape through the venturi at high velocity, the difference in pressure in the pipes 100 and 101, due to this high velocity flow through the venturi, is sufficient to lift the piston 97 against the pressure of the spring 96, so as to lift the valve into the position shown in Figure 6. The head 90 then covers the groove 95 and thus effectively blocks the further escape of liquid from the cylinder. It is of course understood that the rate of flow from the cylinder during normal lowering is much less than upon rupture and not sufficient to cause actuation of the piston 97.

A brief description of the operation of the crane will now be given. Assume that the motor 37 is running, that the control rod 7 is in the neutral position shown so that pump displacement is zero, that the valves 42, 50, and 88 are in the positions shown in Figure 3, and that the hook 24 has been lowered to receive the load. To obtain a slow hoist the control rod 7 is shifted toward the left so as to shift the cam 85 toward the left and the pump control stem 38 into the pump casing. The pilot valve is thus lifted into the upper position of Figure 4, the valve 50 is raised so as to open communication between pipes 40 and 40′, and the pump delivers liquid through these pipes and through valve 88 and venturi 94 into the right end of the cylinder 25. The piston 27 is thus forced toward the left, expanding the loop 19″ of the cable 19 and contracting the loop 19′ of the cable to lift the load. During this movement of the piston 27 the fluid discharged from the left end of cylinder 25 is returned to the pump 36 through pipe 43, valve 42, and pipe 39.

For rapid hoisting the valve 42 is adjusted into the dotted line position of Figure 3, so as to open communication between pipes 41 and 43. The volume of liquid discharged from the left end of the cylinder is thus directed to the right end thereof and added to the volume of liquid delivered by the pump to thereby obtain rapid travel of the piston 27 toward the right. Under this condition both ends of the cylinder are exposed to the delivery side of the pump, so that the unit fluid pressure on both sides of the piston 27 is the same. It will be noted however that the area of the left face of the piston is reduced by the area of the piston rod 28, so that the pressure available to move the piston corresponds to the difference in areas of the opposite faces thereof.

The hoisting operation continues until pump displacement is reduced to zero by returning the control rod 7 to the neutral position of Figure 3. In this position the cam roller 84 drops into the depressed portion 86 of the cam 85, so that the pilot valve is lowered and the valve 50 returned to the lower position of Figure 3, so as to block communication between pipes 40 and 40′. This prevents the escape of liquid from the right end of the cylinder 25 and the piston 27 is effectively retained against movement.

To effect lowering of the hook 24, the control rod 7 is shifted toward the right so as to adjust the pump control stem 38 toward the right, and to cause the cam roller 84 to rise out of the depressed portion 86. The valve 50 is thus caused to again assume the upper position of Figure 5, to reopen communication between pipes 40 and 40′, and the pump discharges into the pipe 39. During lowering, the valve 42 is set into the full line position of Figure 3 so that fluid delivered by the pump through pipe 39 passes through pipe 43 into the left end of the power cylinder. The piston 27 moves toward the right, the loop 19″ of the hoisting cable contracts and the loop 19′ expands, and the hook 24 lowers. Liquid discharged from the right end of the cylinder passes through the venturi 94, valve 88, pipe 40′, valve 50 and pipe 40 back to the pump.

When lowering under load the piston 27 is actuated primarily by the weight of the load on the hook 24 and by the consequent tension in the loop 19″ of the hoisting cable. Under this condition the pump tends to speed up under the pressure of the liquid forced from the cylinder 25 through pipe 40 thereto, and the pump thus acting as a hydraulic motor tends to speed up the electric motor 37 so as to cause the same to act as a generator and return power to the electric circuit.

Thus with a constant speed electric motor of the type hereinabove mentioned and a variable displacement pump various hoisting speeds in addition to the two above described, as well as various lowering speeds, may be obtained by adjusting pump displacement. During lowering under load, the liquid returning from the cylinder 25 to the pump 36, through pipe 40, is under pressure proportional to the load and, acting on the pump, causes the pump to act as a motor, which reacting on the electric motor 37, tends to increase the speed of the motor, thereby causing the same to act as a generator and to feed power back into the electric circuit. No matter what lowering speeds have been selected the above combination reconverts the energy of the falling load into power.

Various changes may be made in the embodiment of the invention hereinabove specifically described without departing from

or sacrificing any of the advantages of the invention as defined in the appended claims.

I claim:

1. In a hydraulic crane, the combination of a hoisting cable, a piston and cylinder for operating said cable, said piston having faces of unequal areas, a pump for delivering a driving liquid to said cylinder at a predetermined rate, and means adjustable to direct the liquid from said pump to one end of said cylinder for slow hoisting or to direct the liquid from said pump to both ends of said cylinder for rapid hoisting.

2. In a hydraulic crane or the like, the combination of a hydraulic motor, a variable displacement pump, hydraulic connections between said pump and motor through which said motor is operated, a valve in said connections, means for regulating pump displacement, and means responsive to movement of said regulating means for operating said valve to block the flow of liquid through said connections when pump displacement is zero.

3. In a hydraulic crane or the like, the combination of a hydraulic motor, a variable displacement pump for operating said motor, means for regulating pump displacement, and means automatically operable to block communication between said pump and motor when pump displacement is zero.

4. In a hydraulic crane or the like, the combination of a hydraulic motor, a pump for operating said motor, an electric motor for operating said pump and means responsive to a failure in said electric motor for blocking communication between said pump and hydraulic motor.

5. The combination of a hydraulic motor, a variable displacement pump for driving said motor, means for regulating pump displacement, means for driving said pump, a cut-off valve between said pump and motor, and means operable to close said valve when pump displacement is zero or in the event of failure in said pump driving means.

In witness whereof, I hereunto subscribe my name this 9th day of February, 1926.

WALTER FERRIS.