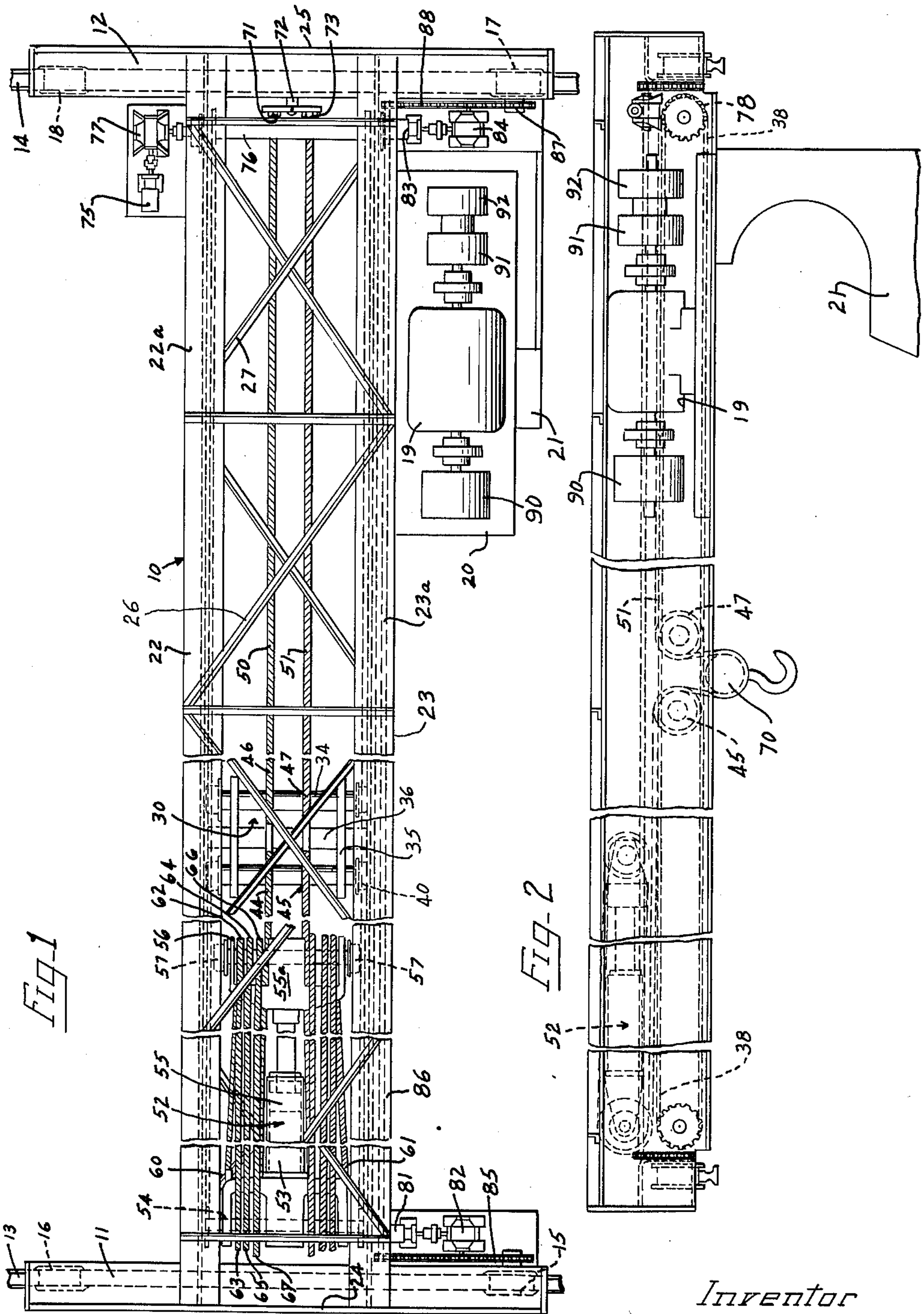
Jan. 30, 1962 J. E. MINTY 3,018,902

HYDRAULIC CRANE

Original Filed Dec. 6, 1955 3 Sheets-Sheet 1



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HYDRAULIC CRANE

Original Filed Dec. 6, 1955 — 3 Sheets-Sheet 2

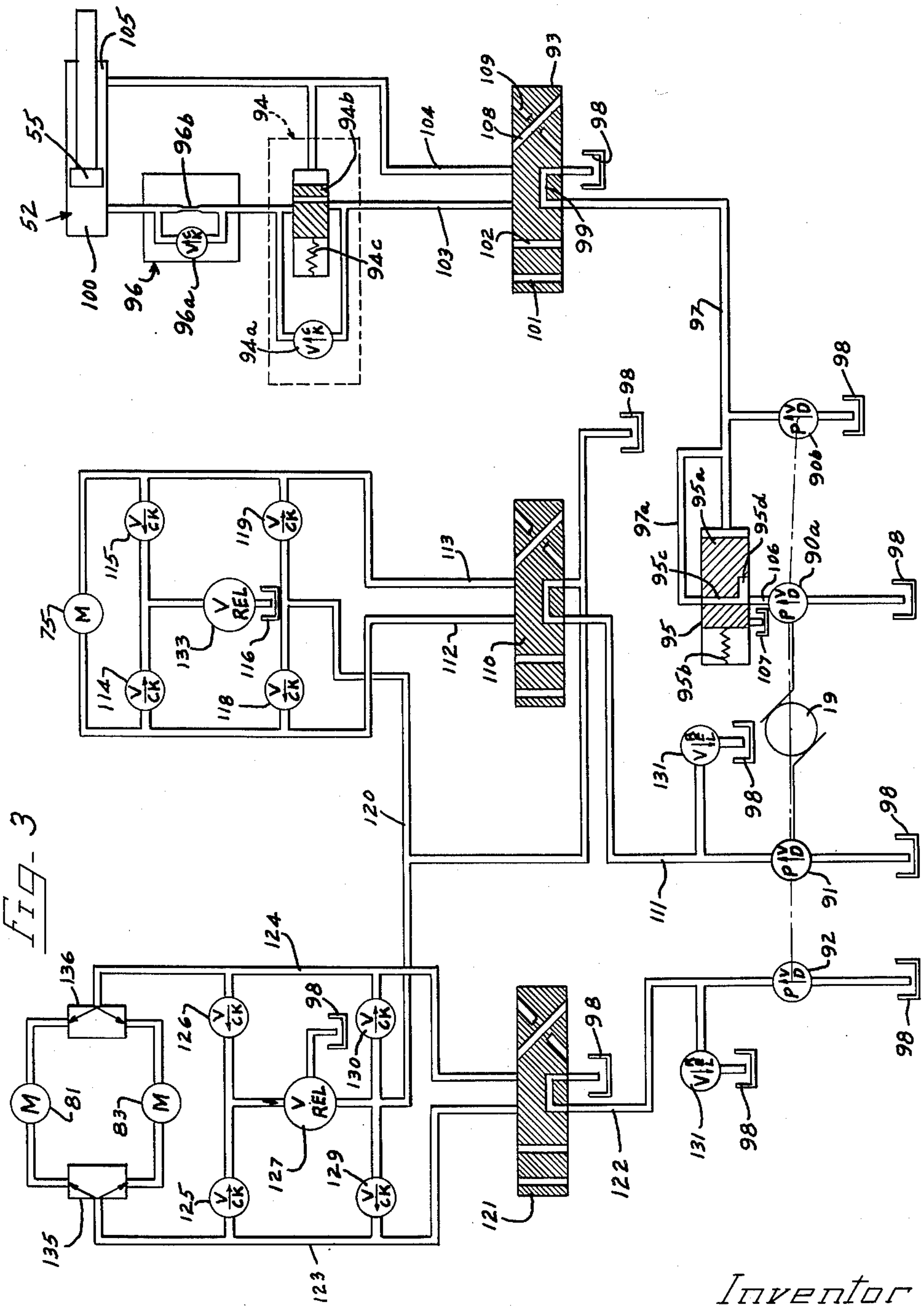

Fig. 3

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HYDRAULIC CRANE

Original Filed Dec. 6, 1955 3 Sheets-Sheet 3

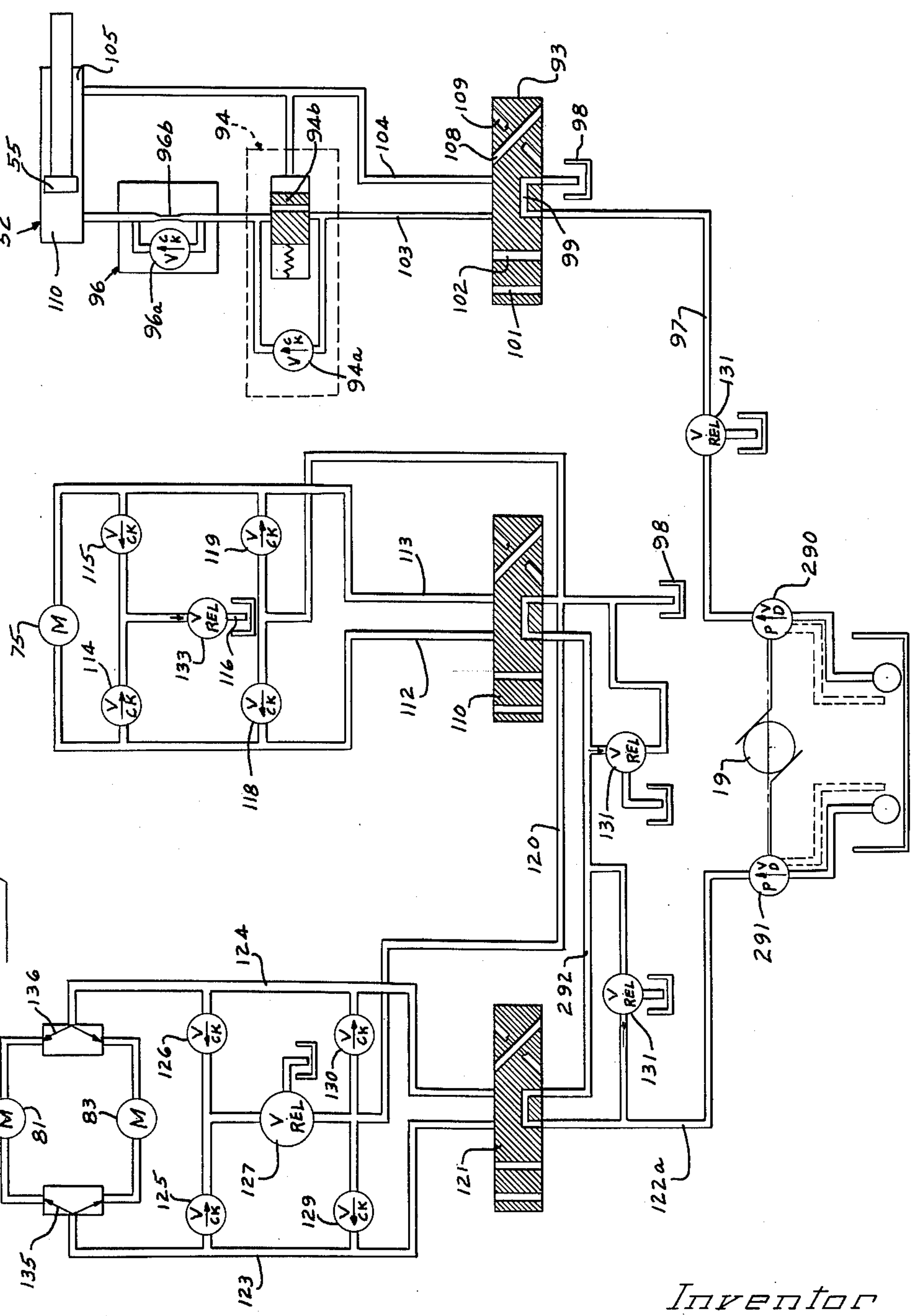

FIG. 4

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3,018,902
HYDRAULIC CRANE

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Original application Dec. 6, 1955, Ser. No. 551,398, now Patent No. 2,906,413, dated Sept. 29, 1959. Divided and this application July 27, 1959, Ser. No. 829,777
7 Claims. (Cl. 212—20)

The present invention relates to crane construction and is, more particularly, concerned with the provision of a novel and substantially improved heavy duty overhead traveling crane having three motions each of which is hydraulically actuated and controlled. This application is a division of my copending application Serial No. 551,-398, filed December 6, 1955, now United States Letters Patent No. 2,906,413, dated September 29, 1959.

As those skilled in the art of crane construction are aware, many structural problems exist in the manufacture of heavy duty cranes of long span. Entirely aside from problems resulting from limited head room, prior art long span cranes require elaborate structural bracing, torsional resistance to the crane bridge drive operating electric motor torques, and complex methods of obtaining speed control. Substantially all such cranes presently in operation comprise electric motor driven structures employing a large, heavy trolley for traversing the span of the crane and carrying the wire rope winding drums as well as the large electric motors used for operating the load lifting hook and the trolley traverse. Such electrically powered trolleys are, where heavy duty cranes are concerned, extremely heavy and extremely bulky and are ordinarily supported for movement along the top of a pair of I or box beams. This arrangement has traditionally taken substantial amounts of head room and elaborate bracing of the separate support beams since movement of the trolley over the tops of the beams prevents satisfactory inter-bracing between the beams.

In addition to the problems of beam construction, trolley construction and operation, electric cranes have also suffered other serious defects. For example, substantially all heavy duty electrical cranes have an entirely separate small motor driven hoist for handling small items since the speed control in the conventional heavy duty electrical motors for the main lift hook is insufficiently flexible to permit operation of the large hook at rapid speeds under light load. Further, in the electrical systems with which I am familiar, serious dangers of trolley destruction arise from the possibility of failure of the lift hook limit switches so that the lift hook has frequently been lifted up against the rope or cable winding drum crushing the latter as well as the lift hook block sheaves before the motor can be stopped.

While the utilization of other means of powering cranes has, of course, been considered in the past, and while, specifically, hydraulic cranes have been considered, to my knowledge none of the heretofore known hydraulic crane structures have satisfactorily overcome all of the objections above voiced relative to electrical crane structures. In accordance with the principles of the present invention, a hydraulic crane is provided which utilizes an absolute minimum of head room, provides extremely rigid cross bracing between trolley support means, provides a system wherein over-travel of the load lifting hook and block assembly is impossible and which provides superior speed control in the hoisting and lowering operation while utilizing inexpensive and very simple working components.

In accordance with the present invention, a crane is provided comprising a pair of generally conventional bridge supports adapted to carry a crane bridge along a

pair of widely spaced overhead crane rails. The bridge comprises, preferably, a pair of spaced beams extending between the bridge supports and, in the embodiment illustrated, comprising I beams. A crane trolley comprising a body supported by four trolley wheels runs on rails extending the full length of the bridge I beams and secured to the top side of the lower flange thereof. Hoisting power is applied to the rope or cable carried by the trolley by means of a reciprocal hydraulic motor of relatively long stroke supported immediately above the path of the trolley and, preferably, wholly contained below the top level of the I beams.

Motive power for operation of the hoisting apparatus is, in accordance with the present invention, hydraulic fluid under pressure supplied by an electric motor driven pump. The same motor likewise may also drive auxiliary pumps for separately supplying motive power to the hydraulic motors driving the bridge trucks along the crane rails and to a fluid motor for actuating the trolley. It is also satisfactory to use but one pump of sufficient capacity to drive all the three fluid motors and the hoisting cylinder. Controls are provided for the several motors in the form of reversing hydraulic valves and accordingly a simple, though relatively powerful, electric motor may be utilized for powering the crane. This motor need not, of course, be designed for variable speed operation and hence may comprise a relatively inexpensive A.C. or D.C. high torque motor of the constant speed variety. Since the valves necessary for the control of the several motors are relatively simple in construction and require no flexible hydraulic lines for their connection to the various motors, an extremely simple control network may be utilized and accordingly only a very nominal space requirement for the power source is necessary. In accordance with the form illustrated herein, the electric motor and pumps or single pump may be positioned in such a manners as to prevent any interference whatever with overhead objects and the control equipment may all readily be carried in a small control station suspended to one side of and below the crane structure.

It is, accordingly, an object of the present invention to provide a novel, compact, highly efficient heavy duty three-motion crane.

Still a further object of the present invention is to provide a novel fully hydraulic crane.

Yet another object of the present invention is to provide a hydraulic crane having simplified fully automatic preventive means for preventing overhauling of the load carried by the crane during the load-lowering operation.

A feature of the invention is the utilization of an inexpensive constant speed electric motor for powering all three crane motions.

Another feature of the invention is the utilization of a hydraulic motor for load lowering and lifting functions, in combination with hydraulic means for varying load lifting and lowering speed.

Still a further feature of the invention is the provision of an extremely small light weight crane trolley which is required to carry no hoisting apparatus, such as for example hoisting motors, winding drums, and the like ordinarily associated with crane trolleys, thereby providing the crane with substantially improved speed control and minimizing the head room necessary for installation of the crane.

Still other and further objects and features will at once become apparent to those skilled in the art from a consideration of the attached drawings wherein a preferred embodiment of the present invention is shown by way of illustration only, and wherein:

FIGURE 1 is a plan view of an hydraulic crane constructed in accordance with the principles of the present invention;

FIGURE 2 is a side elevational view of the crane shown in FIGURE 1;

FIGURE 3 is a schematic illustration of a hydraulic circuit suitable for control and operation of the hydraulic crane of the present invention; and

FIGURE 4 is a modified form of hydraulic circuit for use with the crane of the present invention.

As shown on the drawings:

As may be seen from a consideration of FIGURES 1 and 2, the crane of the present invention comprises a bridge generally indicated at **10** rigidly carried by a pair of bridge supports **11** and **12** which are in turn supported on the respective longitudinally extending crane rails **13** and **14** by means of wheels **15**, **16**, **17** and **18**. Power for operating the crane is supplied by an electric motor **19** carried on an outrigger platform **20** and supplied with electrical energy by any suitable means, such as for example through the provision of a conventional third rail (not shown) running parallel to the longitudinal rail **14**. The controls for the crane may be conveniently provided in an operator's compartment **21** secured beneath the motor support **20**.

As may be seen the bridge **10** comprises a pair of longitudinally spaced transversely extending I beams **22** and **23** rigidly secured, as for example by welding, to the heavy plate end walls **24** and **25** of the bridge supports **11** and **12**, respectively. It will, of course, be appreciated by those skilled in the art that a mere rectangular structure as thus far described has relatively little stability as far as bridge twist is concerned or as far as movement of one of the bridge supports **11** or **12** along the rails **13** and **14** a greater distance than the other. Twist and angular deformation must be eliminated in any practical crane bridge and are overcome in the present instance through a very simple bracing structure which in no way interferes with crane operation.

The novel bracing arrangement of the present invention comprises a plurality of angle braces **26** rigidly secured to the top flanges **22*a*** and **23*a*** of the respective bridge beams **22** and **23**. Additional angle braces **27** are secured to the main web or body portion of the beams **22** and **23**, respectively, with the angle of installation being reversed from that of the braces **26**, as shown in FIGURE 1. As a result of the angle bracing between the beams **22** and **23**, as well as the rectangular connection between the beams **22** and **23** and the end support walls **24** and **25**, an extremely rigid bridge structure is provided which resists twist as well as angular deflection to a remarkable degree. At the same time, as will be more fully set forth below, the bracing members **26** and **27** of the present invention do not in any way interfere with the efficient operation of the crane as would such braces in conventional cranes utilizing overhead-mounted trolleys and other similar conventional equipment.

The cross braced bridge structure above described carries a trolley generally indicated at **30** by means of a pair of trolley rails supported by the base flanges of the bridge beams **22** and **23**. The trolley **30** comprises a pair of non-rotating axle members secured together by side frame members **35** which in turn are rigidly connected to a cross tie **36** carrying attachment means for connection to trolley drive chains **38**. The fixed axles **34** carry wheels at their ends mounted for anti-friction rotation. The fixed axles **34** carry pulleys **44**, **45**, **46** and **47** mounted for anti-friction rotation on bearings. The pulleys **44**, **46** and **45**, **47** carry the respective hoist ropes or cables **50** and **51** as set forth in more detail below.

Power for hoisting is supplied by means of a long stroke reciprocating fluid motor **52** comprising a cylinder **53** secured to the beams **22** and **23** by means of pulley shaft **54**, and a piston rod **55** carrying a pulley yoke or cross head member **55*a***. The yoke **55*a*** supports a pulley shaft **56** which in turn pivotally supports a pair of guide wheels **57** and a plurality of rope pulleys. The guide wheels **57** roll between the angle iron flanges or tracks on the respective beams **22** and **23** and the upper flanges **22*a*** and **23*a*** thereof, thereby requiring the fluid motor **52** to operate in substantially horizontal position. The hoisting cables **50** and **51** are secured at **60** and **61** to the fixed cylinder **53** and are sequentially trained around the pulleys on the pulley shafts **56** and **54** as shown in FIGURE 1. Thus, as may be seen, the rope **50** leaves the connection **60** toward the right as viewed in FIGURE 1, passes under the first pulley **62**, leaves the pulley **62** at the top thereof and passes over pulley **63** on shaft **54**, passes under the second pulley **64** on shaft **56** and thereover to the second pulley **65** on shaft **54**, then passes to the innermost pulley **66** on shaft **56** and from thence to the innermost large diameter pulley **67** on shaft **54**. From the large diameter pulley **67** the rope passes under the bracing **27**, as shown in FIGURE 1, to pulley **44** on the trolley. The rope then drops downwardly and around the hoist pulley block **70**, upwardly over pulley **46** and from thence to a point of securement **71** on the pivotal equalizer bar **72**. As may be seen from a consideration of FIGURE 1, the rope **51** follows a path substantially symmetrical to that above described relative to rope **50** and is finally secured at **73** to the pivotal equalizer bar **72**. It will be understood that the connections **71** and **72** are preferably adjustable to permit taking up any excessive unevenness in the lengths of the cables **50** and **51** and that the pivotal movement of the equalizer bar **72** will permit slight differences in the length of the cables **50** and **51** without adversely affecting the operation of the hoisting apparatus.

In operation, it will be apparent that the position of the trolley **30** has no effect whatever on the raising and lowering of the lifting block **70** and that actuation of the piston **55** toward the right as viewed in FIGURE 1 will raise the block to its uppermost position as shown in FIGURE 2. Movement of the piston **55** toward the left as viewed in FIGURE 1, away from its extreme right hand position as there shown, will permit the block **70** to lower.

While it will, of course, be apparent that the individual lengths of the ropes will vary with different cranes, it has been found that in a crane having a 60 foot span, such as illustrated in the drawings, a 30 foot lift will be provided by a piston **55** having a stroke of 10.0 feet. This will be seen from the fact that the use of three pulleys or sheaves provides a 6 to 1 ratio of lift to piston movement while the hoisting block pulleys **70** provide a 1 to 2 ratio of lift to piston movement, the net, over-all ratio therefore being 3 to 1. The diameter of the hydraulic cylinder **53** and the piston **55** will, of course, depend upon the amount of load intended to be applied to the hoisting block **70** and the fluid pressure utilized.

In considering the size of the piston **55** it will be noted that in the arrangement shown in the drawings the hydraulic motor **52** acts, in lifting, under a compressive load, with pressurized fluid acting against the left hand face of the piston **55** as viewed in FIGURE 1. This arrangement is to be preferred in heavy cranes since it permits a larger lifting piston area for any given piston diameter while at the same time permitting a relatively large diameter piston rod. Since the load itself will aid in the lowering of the block **70**, and hence in the contraction of the motor **52**, the reduced area of the piston, on the right side thereof, will not be detrimental to operation of the hoist. In the situation in which light loads are involved, it will be apparent that a pull, or tension, type reciprocal fluid motor would be adequate and it is, accordingly, within the scope of the present invention to employ such a mechanism rather than the push, or compression, type illustrated. Of course, the piston rod can be reduced in diameter if it is loaded in tension rather than in compression in view of the elimination of columnar effects.

Movement of the trolley 30 back and forth along the rails 32 and 33 is accomplished by means of a fluid motor 75 of the rotary type. The motor 75 drives a shaft 76 through reduction gearing 77. The shaft 76 carries a pair of sprocket wheels 78 which are fixedly secured thereto and which drive the chains 38. As may be seen the chain 38 is rigidly secured to the cross plate 36, and accordingly reciprocates the trolley 30 in opposite directions as the motor 75 is reversed. Angle iron guides may be secured to the vertical webs of the respective beams 22 and 23 to carry the upper portion of the chains 38 to prevent any possible entanglements or kinking thereof.

The bridge may be moved along the rails 13 and 14 by applying power to the bridge support wheels. This has been accomplished in the present invention by fluid motors 81 and 83 which rotate the bridge support wheels 15 and 17, respectively, through reduction gearing 82 and 84, respectively. The drive connection between the reduction gearing and the individual wheels may, of course, comprise any conventional mechanism but as illustrated, as shown in FIGURE 1, comprises a roller chain drive 85, 87. In the form illustrated the power is applied to the chain drive 85, 87. In the form illustrated the power applied to the wheels 15 and 17 is synchronized by means of a cross shaft 86 which may be roller chain driven from the reduction gearing 82, 84 by a roller chain shown at 88. This synchronism may be desirable but is not essential in the present invention where the fluid motors 81 and 83 each receive substantially identical energization. Such an arrangement will be discussed below in connection with the description of the preferred embodiments of the hydraulic circuits used in controlling the crane motions.

It will, of course, be apparent that various hydraulic circuits may be utilized for accomplishing efficient operation of the crane above described. The crane may effectively be operated, if desired, by providing a simple hydraulic pump for supplying fluid under pressure to the hydraulic motor 52 and a separate, independent, pump may be provided for supplying pressurized fluid to the bridge controlling motors 81 and 83 and the trolley position controlling motor 75. Likewise a single large capacity pump may be provided to supply pressurized fluid to all of the motors in parallel through individual control valves. While the hydraulic circuitry and control may, accordingly, be very rudimentary and provide satisfactory crane operation, two improved control circuits are illustrated in FIGURES 3 and 4 of the drawings.

In the form of hydraulic circuitry illustrated in FIGURE 3 the electric motor 19 operates to drive four individual hydraulic pumps 90*a*, 90*b*, 91 and 92. The pumps 90*a* and 90*b* are, respectively, a high volume low pressure pump and a low volume high pressure pump, preferably positioned in one housing 90, shown in FIGURE 1, and operative to actuate the hoisting motor 52. The pumps 91 and 92 supply hydraulic fluid under pressure to the trolley operating fluid motors 75 and the bridge driving motors 81, 83. In the circuit illustrated in FIGURE 3, automatic high speed-low speed hoisting is accomplished, hydraulically equalized control is provided for the separate bridge driving motors 81 and 83, and an anti-load overhauling control valve is provided in the hoisting circuit.

Details of the control circuit in FIGURE 3 may be considered separately insofar as the three separate motions are concerned. The hoisting motor 52 is under the control of a manually reciprocable control valve 93, an anti-load overhauling valve 94, and automatic pump unloading valve 95. In addition, a one-way restrictor 96 is utilized. As shown, the control valve 93 is in a neutral position in which no lifting is desired. Under such circumstances fluid pumped from the pumps 90*a* and 90*b* travels through the pressure conduit 97 and is by-passed to a low pressure hydraulic sump 98 by means of the valve port 99.

If a relatively light load is applied to the lifting block 70, fluid may be fed from the pressure conduit 97 to the chamber 100 of the motor 52 to move the piston 55 to the right, in the load lifting direction by moving the valve 93 to the right as viewed in FIGURE 3. This movement will connect the pressure conduit 97 with the load lifting conduit 103 through port 101 and the sump 98 with the load lowering conduit 104 through port 102. Accordingly, fluid from the pumps 90*a* and 90*b* will flow through the check valve 94*a* of the anti-load overhauling valve 94 and through the check valve 96*a* of the restrictor 96 to the chamber 100. At the same time, the chamber 105 of the motor 52 is vented to the sump 98 through conduit 104 and port 102 thereby permitting the piston 55 to lift the load.

As above noted, under a light load condition fluid will flow from both pumps 90*a* and 90*b* into the pressure conduit 97 since the valve core 95*a* of the unloading valve 95 will be positioned in its right hand extreme position by compression spring 95*b* such that port 95*c* will permit the passage of fluid from pump outlet conduit 106 to pressure conduit branch 97*a*. During light load conditions, the output of the pump 90*b*, which is of a small output type will be negligible compared to the output of the pump 90*a* and will not affect the general operation of the system. However, during the lifting of a heavy load which requires a greater pressure than the design output pressure of pump 90*a*, the pump 90*b* takes over the operation to lift the load. This is accomplished by means of the application of the pressure in line 97 to the right hand end of the unloading valve core 95*a*, causing it to move against the pressure of the spring 95*b* to close off the connection between conduits 106 and 97*a* and vent conduit 106 to sump outlet 107 via the port output 95*d*. At such time, the pump 90*a* is entirely disconnected from the system and the low volume high pressure fluid from pump 90*b* operates to lift the heavy load at a substantially slower rate than the rate of load lifting provided by the high output pump 90*a* under light loads.

In view of the dual pump, automatic arrangement above described, the crane of the present invention operates to lift lighter loads at a very rapid rate and heavier loads at a slower rate. This variation in load lifting speed and capability provides a universally adaptable hoist usable in shops where high speed operations are desirable when carrying small objects about but where extremely heavy duty operations are also necessary. In prior art crane structures it has been the practice to provide an entirely separate small light load hoist for light duty work since it has been considered substantially impractical to provide a rapid speed for the main lifting block 70. By providing hydraulic actuation as above described great versatility is achieved and the cost of such versatility is substantially less than the cost of versatility with previously known systems.

In lowering the load fluid control valve 93 is moved to the left as viewed in FIGURE 3 until port 108 connects conduit 103 with the sump 98 and port 109 connects the lowering conduit 104 with pressure conduit 97. With the valve in this position fluid under pressure is applied to conduit 104 forcing the piston 55 to the left as viewed in FIGURE 3. Movement of the piston 55 toward the left is, however, carefully considered in order to permit lowering of the load at a desired speed. In the first place, a restrictor 96 is provided having a check valve 96*a* which permits the flow of pressurized fluid only into the chamber 100 rather than out of it. On flow out of the chamber 100, on the load lowering cycle, fluid must flow through the restrictor 96*b*, thereby limiting the rate of load descent.

If for any reason the load should overhaul the system or, in other words, tend to move faster than the fluid flow through conduits 97 and 104 will permit, such overhaul is absolutely prevented by the present system. This is accomplished by means of anti-overhauling valve core 94*b* which normally prevents passage of fluid through conduit 103 in the downward direction. Flow is permitted only when the pressure in the conduit 104 builds up sufficiently to force the core 94*b* to the left against spring 94*c*. Pressure is, of course, built up in conduit 104 when pressure is applied tending to lower the lifting block 70, but only when such pressure is applied. If the load attempts to overhaul the system and descend at a rate greater than the fluid pressure in conduit 104 forces it, the pressure in the conduit 104 will decrease and the valve 94*b* will prevent further egress of fluid from chamber 100 until such time as a pressure again builds up in conduit 104. As a result of this arrangement an absolute positive pressure is essential in the chamber 105, tending to force the load downwardly, before any movement whatever of the load is permitted.

The trolley motor of the crane, namely motor 75 is under control of a manually actuated valve 110 which is identical to the valve 93 in operation. Accordingly, fluid pressure from pump 91 travels through conduit 111 to a forward direction motor actuating conduit 112 and thence to motor 75. Rotation of the motor in the opposite direction is achieved by connection of conduit 111 with conduit 113 by mvement of the control valve in the opposite direction from that providing positive energization of the conduit 112. Overloads developing in the system at the motor 75 are prevented by means of check valves 114 and 115 which vent, respectively, pressure conduits 112 and 113 to a sump 116. Valves 118 and 119 which connect the pressure conduits 112 and 113 respectively to sump conduit 120, operate to prevent damage to the system by closure of the valve 110 abruptly. Upon such abrupt action inertia of the trolley motor 75, which is directly connected to the trolley by the chain 38 would tend to cause continued rotation of the motor after the supply of pressure fluid had been cut off, resulting in the creation of a vacuum in the line 112 or 113, depending upon the direction of trolley movement. The check valves 118 and 119 eliminate any possibility of the creation of a vacuum in the pressure line by permitting the inlet of fluid from the sump line 120 as soon as the pressure in the conduits 112 or 113 drops below atmospheric pressure.

The motors 81 and 83 used for moving the crane bridge are operated in unison through a system substantially identical to that used in the motor 75. Thus, control valve 121 operates to connect pressure conduit 122 to a forward movement line 123 or a reverse movement line 124. Check valves 125 and 126 provide for flow from the conduits 123 and 124, respectively, to the relief valve 127 leading to the sump conduit 120. As in the case of the motor 75, the check valves 125 and 126 prevent the possibility of an over-pressure occurring in the lines 123 or 124 upon movement of valve core 121 to trap fluid therein, or for any other reason. Likewise, check valves 129 and 130 permit flow from the low pressure sump conduit 120 into the lines 123 or 124, respectively, during situations of overtravel of the bridge or other possible circumstances in which a vacuum is induced in the line 123 or 124 as a result of actuation of the valve 121. Of course, in all instances, pressure relief valves 131 are provided on the pumps 91 and 92 to prevent a build up of excessive pressure in the lines 111 or 122 as a result of valve movement to block the pressure conduits, or an overload in the lines 123 or 124 with simultaneous failure of the relief valve 127 or 133.

As was described above, the crane of the present invention may provide a mechanical interconnection between the motors 81 and 83, in the form of a transversely extending connecting shaft 86. In veiw of the expense of this mechanical interconnection, however, it is preferred that hydraulic equalizing valves of any conventional structure be provided at 135 and 136. These equalizers or flow dividers automatically provide equal flow to the motors 81 and 83 in either the forward or reverse direction of rotation and provide sufficiently accurate synchronization between the motors 81 and 83 in most cranes to permit elimination of the synchronizing shaft 86.

Further, it has been found in actual practice that where the conduits leading to the motors 81 and 83 are of substantially the same hydraulic resistance special equalizer valves are not needed and a conventional T or Y conduit connection may be employed at 135 and 136 with satisfactory results. It will thus be understood that the synchronizing shaft 86 and the flow dividers may be used individually or together, or in suitable cases eliminated entirely.

In the embodiment of the hydraulic circuit illustrated in FIGURE 4, a system is provided in which only two fluid pumps are utilized. The reciprocating hydraulic motor 52 is supplied with pressurized fluid from pump 290 via valve 93, conduits 103, 104 and control valves 94 and 96 in the manner fully discussed above. However, pump 290 differs materially from pumps 90*a* and 90*b* in that it provides automatic volume control responsive to pressure in the conduit 97. The pump 290 is constructed to provide an initial high volume output at low pressure, which volume automatically decreases as the pressure at the pump output increases. The pressure responsive variable volume pump may be of any conventional construction, for example, the well known radial piston pump having a transversely adjustable rotor having decreasing eccentricity with increased output pressure, thereby decreasing the pump stroke with such increasing pressure. It will be understood, however, that any of a large number of automatically controlled pumps having a reduced output with increased output pressure may be satisfactorily used. When such pumps are used, light loads lifted by the block 70 will be lifted rapidly while heavier loads will be lifted at a decreasingly rapid rate as the weight of the load increases. Accordingly, the crane of the present invention is utilized very satisfactorily with small load operations in which conventional large cranes are unsatisfactory due to their extremely slow rate of load lifting.

In addition to the difference in the pump operating the lifting motor 52, the system shown in FIGURE 4 provides only a single pump 291 which supplies motors 81, 83 and 75. As will be seen, the output of pump 291 is initially directed through conduit 122*a* to valve 121 for direction in equal amounts to the motors 81 and 83 through flow equalizers 135, 136. If the valve 121 is in its neutral position as shown in FIGURE 4, the bridge motors 81 and 83 are motionless and fluid under pressure flows from the pump 291 into conduit 292 which leads directly to valve 110. Fluid under pressure arriving at the valve 110 via conduit 292 may be directed to the fluid motor 75, as described above relative to the embodiment shown in FIGURE 3 when the valve is in either of its extreme left or right hand positions. When the valve 110 is in neutral, however, hydraulic flow is to the sump 98. As in the case of the embodiment shown in FIGURE 3, the sump line 120 leads to valves 129 and 130 as well as valves 118 and 119 to prevent evacuation of the system which might otherwise result upon rapid movement of valves 121 or 110 into a neutral, blocking condition.

In the embodiment shown in FIGURE 4, the use of one pump 291 provides a satisfactory system for most installations. It will be appreciated, however, that in view of the series relationship between the valve 121 and the valve 110, the pressure available to motor 75 will be substantially reduced if the motors 81 and 83 are being operated. This will be apparent when it is noted that conduit 292 is the exhaust conduit of the motors 81 and 83 during either forward or reverse operation of the bridge. Therefore, where extreme maneuverability and fast action are considered particularly important, the dual pump system shown in FIGURE 3 is, of course, preferably utilized.

It will thus be seen that I have provided a novel and substantially improved crane having a maximum versatility while requiring an absolute minimum of space. Since all three motions of the crane, namely motions of the bridge, trolley, and load, are controlled by hydraulic fluid under pressure, no torques from the electric drive motor 19 are transmitted to the frame of the crane in a twisting manner, as in electric motor controlled cranes of the prior art. Since no winding drums are incorporated in the instant crane, as in prior art electrical cranes, the width of the bridge, between the I beams 22 and 23 may be substantially reduced from that required in prior art structures in which the length of the cable winding drums was the determinate factor in such dimension. As a result of the arrangement of parts, cross bracing has been introduced into the bridge to prevent twist of the bridge and extreme stability of the entire crane structure is accordingly provided. Since the trolley of the present crane is not required to carry any lifting motors or other intricate mechanism it may be extremely light and easily moved and may be constructed without any space consuming machinery thereon. Accordingly, the trolley of the present invention may be placed between the I beams rather than above them and the head room on the crane substantially reduced. Additionally, since the maximum lift of the present crane is controlled by the length of the stroke of the fluid motor 52, the length of the rope and the stroke may readily be adjusted to prevent any possibility of drawing the lifting block 70 up into the trolley in a bottoming condition. This is extremely important since it automatically prevents overtravel of the lifting block 70 which is a common failure in prior art cranes and which is a cause of very great damage and time loss. Further advantages of extreme importance in the construction herein described are the complete elimination of gearing as well as mechanical load lowering brakes designed to prevent overhauling of the load. In the present construction, load overhauling is automatically prevented by hydraulic means. Still further, a unidirectional electric motor of the least expensive type may be used in the present invention rather than the extremely expensive reversible, rapid start and stop, high torque electric motors ordinarily used. Overload damage to the motor of the present crane is impossible since upon the application of such overload the pressure relief valves 131 merely open thereby preventing any damage to the crane and also preventing damage to personnel by automatically preventing operation of the crane with unsafe loads.

It will be obvious to those skilled in the art that variations and modifications may be made in accordance with the principles of the present invention without departing from the scope of the novel concepts thereof. Accordingly, it is my intention that the scope of the present invention be limited solely by that of the hereinafter appended claims.

I claim as my invention:

1. In combination in a crane, a hydraulic hoisting motor system, comprising a fluid motor, a source of fluid under pressure, a valve having a first port leading to said source and a second port leading to a sump, a first conduit connecting said valve to a first load-lifting chamber in said motor, a second conduit connecting said valve to a load lowering chamber in said motor, means in said valve whereby movement of said valve selectively connects said source to said sump or said first conduit to said source and said second conduit to said sump or said second conduit to said source and said first conduit to said sump, and fluid blocking means in said first conduit preventing flow from said first chamber unless a positive load lowering pressure exists in said second chamber.

2. In combination in a crane, a hydraulic hoisting motor system comprising a fluid motor, a source of fluid under pressure, a valve having a first port leading to said source and a second port leading to sump, a first conduit connecting said valve to a first load lifting chamber in said motor, a second conduit connecting said valve to a load lowering chamber in said motor, means in said valve whereby movement of said valve selectively connects said source to said sump or said first conduit to said source and said second conduit to said sump or said second conduit to said source and said first conduit to said sump, and means in said first conduit for restricting flow from said first chamber to a predetermined positive maximum value, and fluid blocking means in said first conduit for preventing flow from said first chamber unless a positive pressure exists in said second chamber.

3. In combination in a crane, a hydraulic hoisting motor system comprising a fluid motor, a source of fluid under pressure, a valve having a first port leading to said source and a second port leading to a sump, a first conduit connecting said valve to a first load lifting chamber in said motor, a second conduit connecting said valve to a load lowering chamber in said motor, means in said valve whereby movement of said valve selectively connects said source to said sump or said first conduit to said source and said second conduit to said sump or said second conduit to said source and said first conduit to said sump, and means in said first conduit for restricting flow from said first chamber to a predetermined positive maximum value, and fluid blocking means in said first conduit for preventing flow from said first chamber unless a positive pressure exists in said second chamber, said source comprising means providing high output volume at low output pressure and vice versa.

4. In combination in a crane, a hydraulic hoisting motor system comprisinng a fluid motor, a source of fluid under pressure, a valve having a first port leading to said source and a second port leading to a sump, a first conduit connecting said valve to a first load lifting chamber in said motor, a second conduit connecting said valve to a load lowering chamber in said motor, means in said valve whereby movement of said valve selectively connects said source to said sump or said first conduit to said source and said second conduit to said sump or said second conduit to said source and said first conduit to said sump, and means in said first conduit for restricting flow from said first chamber to a predetermined positive maximum value, and fluid blocking means in said first conduit for preventing flow from said first chamber unless a positive pressure exists in said second chamber, said source comprising a variable volume pump providing a decreasing output volume as the output or lifting pressure increases.

5. In combination in a crane, a hydraulic hoisting motor system comprising a fluid motor, a source of fluid under pressure, a valve having a first port leading to said source and a second port leading to a sump, a first conduit connecting said valve to a first load lifting chamber in said motor, a second conduit connecting said valve to a load lowering chamber in said motor, means in said valve whereby movement of said valve selectively connects said source to said sump or said first conduit to said source and said second conduit to said sump or said second conduit to said source and said first conduit to said sump, and means in said first conduit for restricting flow from said first chamber to a predetermined positive maximum value, and fluid blocking means in said first conduit for preventing flow from said first chamber unless a positive pressure exists in said second chamber, said source comprising a first high volume low pressure pump, a second low volume high pressure pump and automatically operable means responsive to pressure in said first conduit to by-pass said first pump when said pressure exceeds a predetermined value.

6. In combination in a crane having a bridge assembly and a load carrying means dependingly supported

from said bridge assembly for lifting and lowering loads therebeneath, a fluid motor supported by said bridge assembly and operatively connected to said means for effecting said lifting and lowering, a source of fluid pressure supported on said bridge assembly, a directional valve selectively communicating said source of fluid pressure with opposite sides of said fluid motor or to effect by-passing of pressurized fluid, and means responsive to a positive load lowering fluid pressure applied to said motor to prevent movement of said motor in the load lowering direction by the weight of the load.

7. In combination in a crane having a bridge assembly and a load carrying means dependingly supported from said bridge assembly for lifting and lowering loads therebeneath, a fluid motor supported by said bridge assembly and operatively connected to said means for effecting said lifting and lowering, a source of fluid pressure supported on said bridge assembly, a directional valve selectively communicating said source of fluid pressure with opposite sides of said fluid motor or to effect

by-passing of pressurized fluids, a fluid pressure actuated valve normally blocking flow between said directional valve and the side of said motor to which fluid under pressure is applied to raise the load, a check valve bypassing said fluid pressure actuated valve and permitting flow toward said motor only, said fluid pressure actuated valve being operated in response to positive pressure on the opposite side of said motor to unblock the normally blocked flow.

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