Nov. 1, 1966 R. E. STAUFFER 3,282,441

HYDRAULIC SYSTEM FOR SWINGING A CRANE BOOM

Original Filed Dec. 26, 1963 3 Sheets-Sheet 1

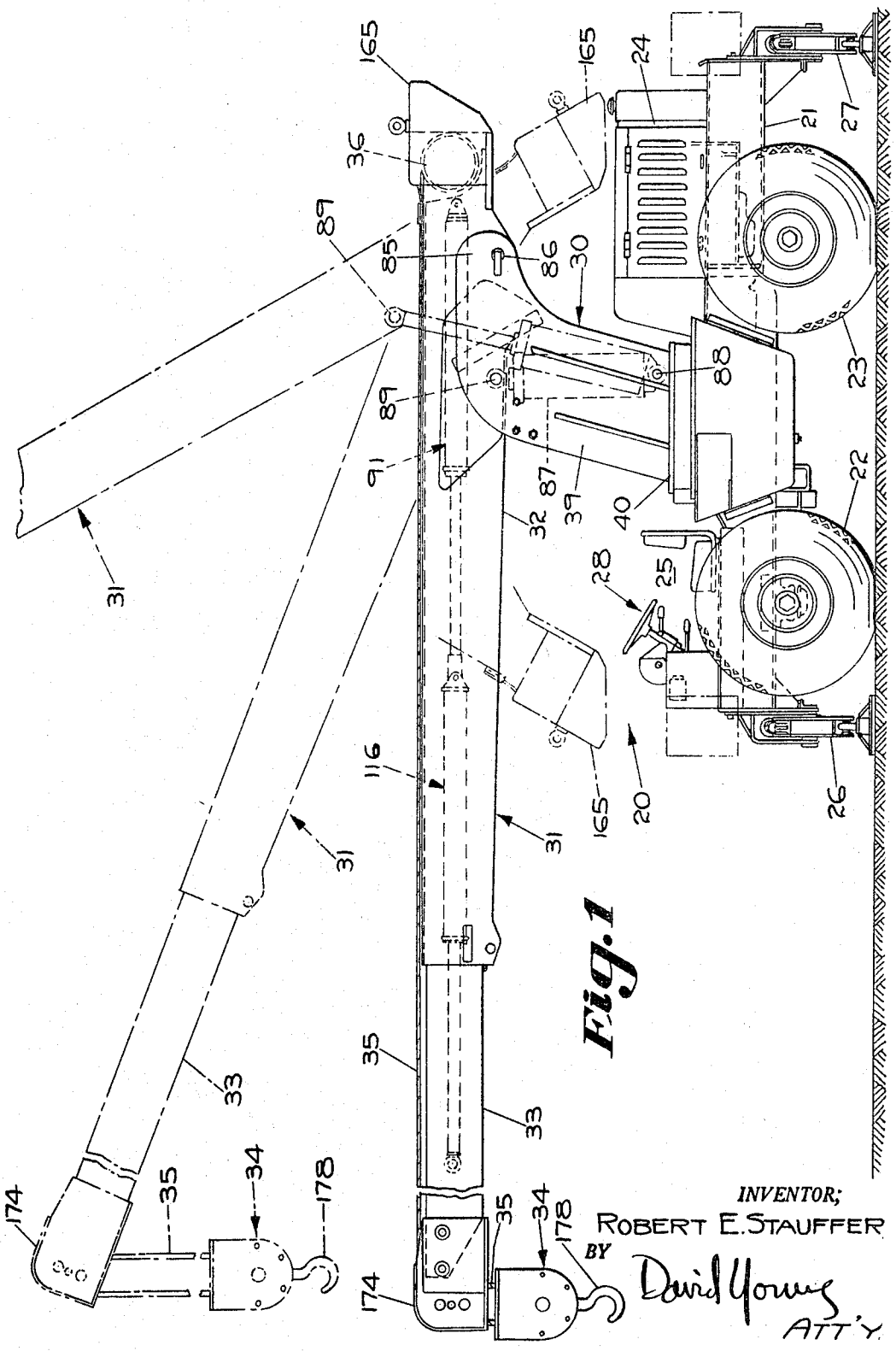


Fig. 1

INVENTOR;
ROBERT E. STAUFFER
BY David Young
ATT'Y.

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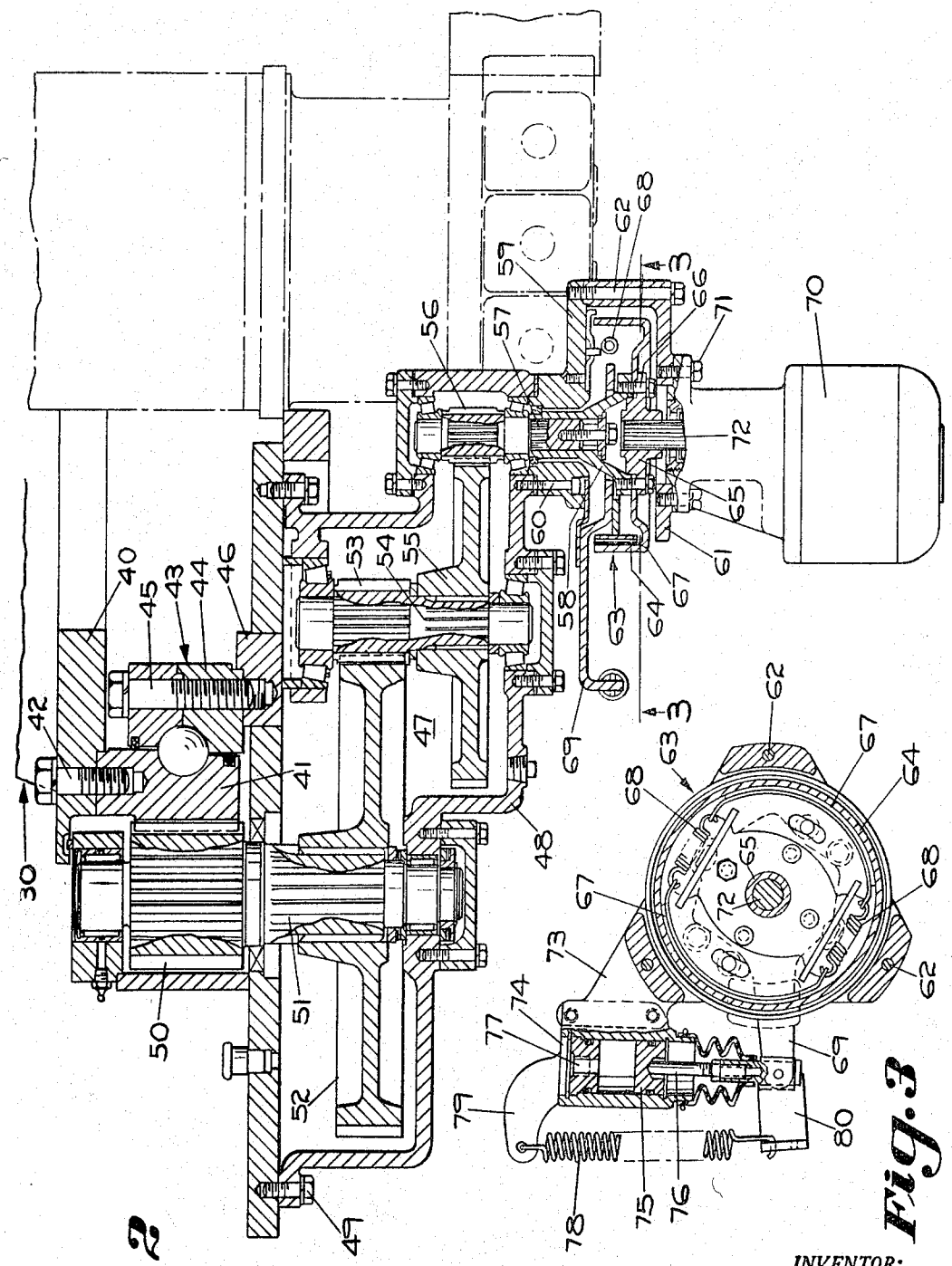


Fig. 2

Fig. 3

INVENTOR;
ROBERT E. STAUFFER,
BY David Young
ATT'Y.

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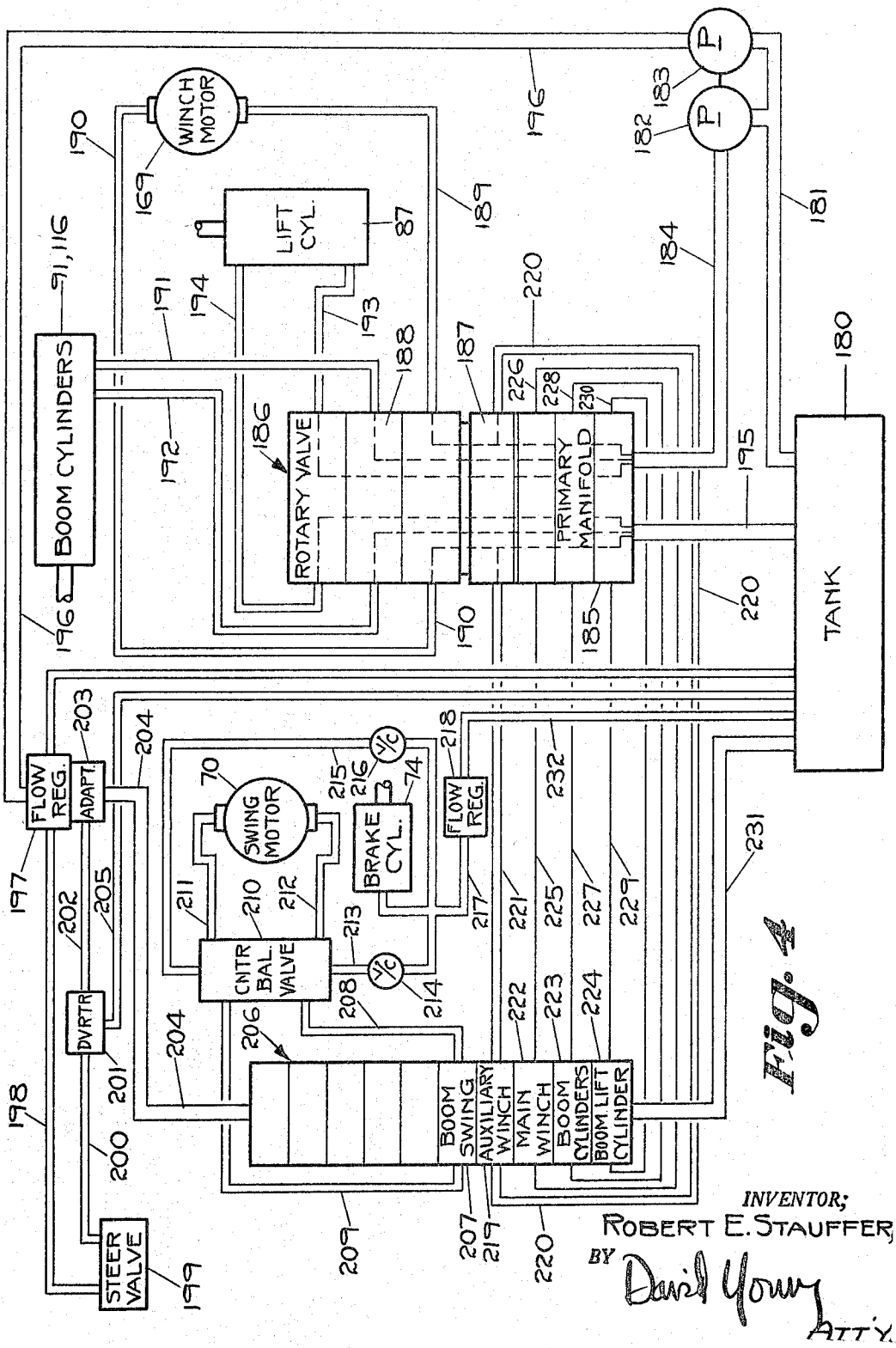


Fig. 1

INVENTOR;
ROBERT E. STAUFFER,
BY David Young
ATT'Y.

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HYDRAULIC SYSTEM FOR SWINGING A CRANE BOOM

Robert E. Stauffer, Galion, Ohio, assignor to Jeffrey Galion Manufacturing Company, a corporation of Ohio

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3 Claims. (Cl. 212—35)

This application is a division of application, Serial No. 333,322, filed December 26, 1963.

The instant invention relates to cranes, and more particularly, to improved operating means for the operation of elements of such cranes.

It is an object of the instant invention to provide improved operating means for swinging a crane boom, including means for stopping such movement of the boom and holding the boom in stationary position.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the drawings:

FIG. 1 is a side elevational view of a crane constructed in accordance with the instant invention;

FIG. 2 is a sectional view of the mechanical drive for swinging the boom;

FIG. 3 is a sectional view of the brake mechanism, taken on the line 3—3 in FIG. 2; and

FIG. 4 is a schematic drawing of the hydraulic operating system for the crane.

Referring to the drawings, particularly FIG. 1, there is illustrated therein a crane 20, which is constructed in accordance with, and embodies the instant invention. The crane 20, which is illustrated herein by way of example, is commonly referred to as a portable or mobile hydraulic crane, by reason of the fact that it is a self propelled machine that may be driven under its own power, and the operating system for the crane mechanisms is of the hydraulic type.

The crane 20 has a main frame or chassis 21 which is mounted on front wheels 22 and rear wheels 23, all of which are driven for propulsion of the crane 20. Both the front wheels 22 and the rear wheels 23 are steerable to provide the crane 20 with a high degree of mobility. At the rear of the chassis 21 there is provided an engine 24, which provides the power for driving the crane 20, including the hydraulic operating system for the various crane mechanisms. At the front of the chassis 21 there is provided an operator's station 25 at which there are placed the various controls 28 for the crane 20.

At the front of the chassis 21 there is provided a pair of outriggers 26, and likewise, at the rear there is provided a pair of outriggers 27, which are alike in all respects. The outriggers 26, 27 at the front and rear extend to opposite sides of the chassis 21, and may be lowered into bearing contact with the ground, as illustrated in FIG. 1, to provide added support for the crane 20 and thereby to stabilize it.

A pedestal 30 is disposed in a substantially centrally located position on the chassis 21 and extends upwardly therefrom. The pedestal 30 supports the boom assembly 31, and is rotatable in opposite directions on the chassis 21 about an upright axis, whereby the boom assembly 31 may be swung continuously in a full circle. The boom assembly 31 is pivotally mounted on the pedestal 30 and may be raised and lowered, as illustrated in FIG. 1. The boom assembly 31 includes a lower boom 32 and an upper boom 33, the latter being telescoped within the former, and being extensible and retractable relatively to the lower boom 32, whereby the boom assembly 31 may be lengthened and shortened, as needed, to reach various places

where it is desired to either pick up or set down a load. At the outer end of the upper boom 33 there is a hook block 34 which depends from the end of the upper boom 33 on a cable 35. A winch 36 is supported on the end of the lower boom 32 for paying out and taking up the cable 35 to raise and lower the hook block 34 as required.

The pedestal 30 comprises laterally spaced side plates 39 which are secured to a turntable base plate 40 having a circular configuration. The turntable base plate 40 is secured to a main gear 41 by a plurality of bolts 42, as best seen in FIG. 2. The main gear 41 is the outer race of a large bearing 43 on which the pedestal 30 is rotatably supported. The inner race 44 of the bearing 43 is secured by a plurality of bolts 45 to a base plate 46, which in turn is secured to the chassis 21. Thus, the inner race 44 is fixed and the outer race 41 may rotate, thereby rotating the pedestal 30.

The main gear 41 is rotated by a reduction gear drive 47 that is enclosed within a housing 48 that is secured to the base plate 46 by a plurality of bolts 49. The main gear 41 is rotated by a main pinion 50 having a depending shaft 51 on which there is secured a second gear 52. A second pinion 53 drives the second gear 52, and it is formed with a depending shaft 54, to which there is secured a third gear 55. A third pinion 56 drives the third gear 55. The third pinion 56 is formed with a depending shaft 57, to the splined end of which there is secured an input drive flange 58. The gears together form the reduction gear drive 47, with the power being supplied to drive the gears by the input drive flange 58 which extends below the housing 48.

A brake adapter 59 is secured to the housing 48 by a plurality of bolts 60. A brake spider 61 is secured to the brake adapter 59 by a plurality of bolts 62, with the brake 63 being disposed within the brake adapter 59 and the brake spider 61. The brake 63 includes a rotatable brake drum 64. A motor drive flange 65 is secured to the input drive flange 58 by a plurality of bolts 66, with the brake drum 64 being disposed between the flanges 58, 65, and is secured thereto. Within the brake drum 64 there is a pair of brake shoes 67 that are oppositely disposed. Springs 68 are connected to the opposite ends of the brake shoes 67 and act to maintain the latter out of engagement with the brake drum 64, whereby the latter is free to rotate. A lever 69 is provided for moving the brake shoes 67 by a camming action into engagement with the brake drum 64, to prevent rotation thereof. Such braking action on the brake drum 64 is applied to the reduction gear drive 47 and thence to the pedestal 30, to hold it and the boom assembly 31 in a stationary position, and thereby prevents the latter from swinging.

A hydraulic drive motor 70 is secured to the brake spider 61 by a plurality of bolts 71, and the shaft 72 thereof extends upwardly into engagement with the motor drive flange 65 for rotation of the latter by the motor 70. The power of the hydraulic motor 70 is transmitted by the motor drive flange 65 to the input drive flange, 58 and thence to the reduction gear drive 47 for rotating the pedestal 30 to swing the boom assembly 31. The motor 70 is rotatable in opposite directions, whereby the boom assembly 31 may be swung in opposite directions as desired.

The brake adapter 59 has a braket 73, on which there is mounted a hydraulic cylinder 74 having a piston 75 with a piston rod 76 that is connected to the lever 69. The hydraulic drive motor 70 is driven by hydraulic fluid under pressure that is supplied thereto by a pump. A portion of such hydraulic fluid is delivered to the cylinder 74 through the port 77 to move the piston 75 outwardly and to move the lever 69 in a counterclockwise direction, as viewed in FIG. 3, thereby releasing the brake 63 to permit rotation of the gears of the reduction gear drive 47.

When the supply of hydraulic fluid under pressure to the hydraulic drive motor 70 is stopped, the hydraulic pressure on the piston 75 drops, and the piston 75 moves inwardly in the cylinder 74 under the force of the spring 78, thereby rotating the lever 69 in a clockwise direction, as viewed in FIG. 3, to move the brake shoes 67 into engagement with the brake drum 64 for the purpose of holding the reduction gear drive 47 in a stationary position, and likewise, to hold the pedestal 30 and the boom assembly 31 in a stationary position. A post 79 extends outwardly from the cylinder 74 and has one end of the spring 78 secured thereto. The other end of the spring 78 is secured to a bracket 80, which in turn is secured to the lever 69 as an extension thereof. Thus, the spring 78 acts in a direction to apply the brake 63, and the force of the hydraulic fluid acting on the piston 75 is in a direction opposite to that of the spring force, to overcome the latter for releasing the brake 63.

The laterally spaced side plates 39 of the pedestal 30 extend upwardly and rearwardly and terminate in overhanging mounting arms 85 on which the boom assembly 31 is pivotally mounted. A pivot pin 86 extends laterally between the opposite arms 85 of the side plates 39 and through the lower boom 32, whereby the pivot pin 86 pivotally connects the boom assembly 31 to the pedestal 30. A lift cylinder and piston mechanism 87 has its cylinder end secured to the turntable base plate 40 by a pin 88, and its piston rod end is secured to the lower boom 32 by a pin 89. The lift cylinder and piston mechanism 87 is disposed in an upright position between the turntable base plate 40 and the boom assembly 31, between the opposite side plates 39. The lift cylinder and piston mechanism 87 may be extended to raise the boom assembly 31 by swinging it upwardly on the pivot pin 86, and contracted to lower the boom assembly 31 by swinging it downwardly. The lift cylinder and piston mechanism 87 is operated by hydraulic fluid under pressure that is supplied thereto for moving its piston and piston rod upwardly and downwardly within the cylinder 87.

Operating means is provided for extending and retracting the upper boom 33 with respect to the lower boom 32, thereby adjusting the length or reach of the boom assembly 31. Such adjustment of the boom assembly 31 may be made in any position thereof, whereby the crane 20 has a high degree of flexibility in its operation.

Heretofore, reference has been made to the lower boom 32 and the upper boom 33. The use of the terms "lower" and "upper" for the respective booms 32, 33 is accepted usage, and derives from the fact that the boom assembly 31 most often is disposed in an upwardly extending position in which the upper boom 33 is above the lower boom 32.

The assembly, including the lower cylinder and piston mechanism 91 and the upper cylinder and piston mechanism 116, is connected to the lower end of the lower boom 32 and to the upper boom 33 near the upper end thereof, whereby extension of the cylinder and piston mechanisms 91, 116 extends the upper boom 33 with respect to the lower boom 32, and likewise, contraction of the cylinder and piston mechanisms 91, 116 retracts the upper boom 33 with respect to the lower boom 32.

Referring now to FIG. 4, there is a schematic illustration of the portions of the hydraulic operating system of the crane 20 that are relevant to the instant invention. Such hydraulic operating system includes a tank 180 for hydraulic fluid which is the operating medium in the system. A line 181 leads from the tank 180 to a first pump 182 and a second pump 183 which are adapted to be driven together, and draw hydraulic fluid from the tank 180, and deliver such hydraulic fluid under pressure into the system to supply the same to the several operating mechanisms in the system. The first pump 182 supplies hydraulic fluid under pressure for the main crane functions, these being the lift cylinder and piston mechanism 87 by which the boom assembly 31 is raised and lowered, the boom cylinder and piston mechanisms 91, 116 by which the upper boom 33 is extended and retracted relatively to the lower boom 32, and the winch motor 169 by which the winch 36 is operated. The second pump 183 supplies hydraulic fluid under pressure into the system for supplying operating medium to other operating mechanisms of the crane 20, including the hydraulic drive motor 70 for swinging the boom assembly 31, as will appear hereinafter. In the embodiment of the invention disclosed herein, the first and second pumps 182, 183 each delivers hydraulic fluid under pressure at a different volume rate of flow, in accordance with the requirements of the operating mechanisms supplied by the pumps 182, 183, respectively.

A line 184 connects the first pump 182 to a primary manifold 185 which is connected to the stationary base 187 of a rotary valve 186. There are flow connections from the primary manifold 185 to the stationary base 187, providing three delivery and return paths of flow for hydraulic fluid. A rotary valve part 188 is rotatably mounted on the stationary base 187, with the three paths of flow connecting to ports in the rotary valve part 188. Lines 189, 190 connect from the rotary valve part 188 to the opposite sides of the winch motor 169 for delivery of hydraulic fluid under pressure to the winch motor 169 to operate the same, and for the return of such hydraulic fluid. Hydraulic fluid under pressure is supplied to the winch motor 169 through one or the other of lines 189, 190, depending on the direction of operation thereof, and is returned through the other of the lines 189, 190. Lines 191, 192 connect from the rotary valve part 188 to the ports of the lower cylinder and piston mechanism 91 and thence to the upper cylinder and piston mechanism 116. Hydraulic fluid under pressure is supplied to the cylinder and piston mechanisms 91, 116 through one or the other of the lines 191, 192, and is returned through the other of these lines. Lines 193, 194 connect from the rotating valve part 188 to the lift cylinder and piston mechanism 87 for the delivery and return of hydraulic fluid thereto, to raise and lower the boom assembly 31, as may be desired. The stationary base 187 of the rotary valve 186 is secured in a suitable manner to the chassis of the crane 20, and the rotary valve part 188 is secured to the turntable base plate 40 to be rotatable with the boom assembly 31.

The primary manifold 185 includes three control valves, which may be of a conventional construction, which in their neutral position permit the hydraulic fluid supplied by the pump 182 to flow through the primary manifold 185 and return to the tank 180 through the line 195. Such control valves have two flow positions, and the selection of one or the other determines the direction of flow of the hydraulic fluid under pressure to the winch motor 169, the boom cylinder and piston mechanisms 91, 116, and the lift cylinder and piston mechanism 87. The several control valves in the primary manifold 185 are preferably pilot operated valves which are moved to one or the other of their control positions by pilot hydraulic fluid pressure applied thereto.

The second pump 183 is connected by a line 196 to a flow regulator valve 197. A regulated volume rate of flow of hydraulic fluid under pressure flows from the flow regulator valve 197 through a line 198 to a steering valve 199 for supplying the hydraulic steering mechanism of the crane 20. A return line 200 connects the steering valve 199 to a diverter valve 201. A line 202 connects the diverter valve 201 to a flow regulator adapter 203, to return hydraulic fluid from the steering valve 199 to the line 204. If the pressure of the fluid in this part of the system becomes excessive, then the diverter valve 201 acts to connect the line 204 to the line 205, through which the hydraulic fluid is returned to the tank 180. The line 204 connects to the secondary manifold 206 which consists of a plurality of individual control valves connected to each other, by which there is controlled the delivery of

hydraulic fluid under pressure to the several operating mechanisms of the crane **20**.

The schematic representation in FIG. 4 of the secondary manifold **206** includes a plurality of rectangles, each of which represents a control valve. The upper five of such rectangles are left blank, for the reason that these are, one of control of the steering of the rear wheels, and the other four for control of the outrigger cylinder and piston mechanisms by which the outriggers **26**, **27** are placed in ground engaging position and are withdrawn therefrom. This portion of the system may be constructed in the usual manner known in the art, and therefore, it is not deemed necessary to include a detailed description thereof. Insofar as the steering of the front wheels, this is accomplished by means of a steering wheel operating a conventional hydraulic power steering mechanism which includes the steering valve **199**.

The secondary manifold **206** has a control valve **207** for controlling the delivery of hydraulic fluid under pressure to the swing motor **70**. Lines **208**, **209** connect from the control valve **207** to a counterbalance valve **210**. Lines **211**, **212** connect from the counterbalance valve to the swing motor **70**. By selective operation of the control valve **207**, hydraulic fluid under pressure is selectively delivered through lines **208**, **212** or through lines **209**, **211**, in accordance with the desired direction of rotation of the swing motor **70**, and the hydraulic fluid is returned from the swing motor **70** through the other of said lines, respectively.

The operation of the swing motor **70** is started by initiating the supply of the hydraulic fluid under pressure thereto, and is stopped by cutting off the supply of hydraulic fluid, such control being effected by operation of the control valve **207**. As seen in FIG. 2, the reduction gear drive **47** consists of high efficiency spur gears, so that when the supply of hydraulic fluid under pressure to the swing motor **70** is stopped, the inertia of the mass that is swung by the swing motor **70** will tend to continue the mass in motion and thereby to continue the rotation of the swing motor **70**. In this condition the swing motor **70** operates as a pump on the hydraulic fluid in the lines **211**, **212**. Since the control valve **207** is closed to cut off the supply of hydraulic fluid under pressure, the pressure of the hydraulic fluid in the line **211** or the line **212** rises by reason of the swing motor **70** acting as a pump. The counterbalance valve **210** includes pressure relief valve means by which such increased pressure of the hydraulic fluid is released, with the effect of dissipating the energy of the swing motor **70**. Such system avoids the high shock loads that would otherwise be imposed on the reduction gear drive **47** and other elements of the crane **20**, due to quick stopping of the boom swing.

The counterbalance valve **210** also includes anticavitation valve means by which the speed of operation of the swing motor **70** and the swing speed of the boom assembly **31** is maintained proportional to the rate of delivery of hydraulic fluid by the pump **183**, irrespective of the magnitude of the load on the boom assembly **31**. Thus, if the inertia of the swinging load on the boom assembly **31** tends to increase the swing speed thereof, this action will reflect back through the swing motor **70** to the anticavitation valve means of the counterbalance valve **210**, and the anticavitation valve means will throttle the flow of return hydraulic fluid from the swing motor **70**, thereby maintaining the speed thereof proportional to the rate of delivery of hydraulic fluid from the pump **183**.

A line **213** connects to one side of the counterbalance valve and includes a check valve **214**, and a line **215** connects to the other side of the counterbalance valve **210** and includes a check valve **216**. The lines **213**, **215** are joined and connect to the brake cylinder **74**. One or the other of the lines **213**, **215** receives a regulated flow of hydraulic fluid from the counterbalance valve **210** to operate the piston **75** of the brake cylinder **74** to release the brake **63** when the swing motor **70** is operated. A line **217** connects to the lines **213**, **215** and includes a flow regulator valve **218**, by which the flow of hydraulic fluid from the lines **213**, **215** is regulated, and is limited to a very small rate of flow. A line **232** connects from the flow regulator valve **218** to the tank.

When the operation of the swing motor **70** is stopped by cutting off the supply of hydraulic fluid to the same, the supply of hydraulic fluid to the brake cylinder **74** is likewise cut off, and the brake **63** is then applied by the spring **78**, as previously explained. However, the operation of the swing motor **70** and the swinging function is stopped by cutting off the supply of hydraulic fluid, as described above. In the interval during which the energy of the swing motor **70** is dissipated through the pressure relief means of the counterbalance valve **210**, the application of the brake **63** is delayed. After the swing motor **70** and the swing function has been effectively stopped, then the brake **63** is applied to maintain the reduction gear drive **47**, the pedestal **30** and the boom assembly **31** in a stationary position. The anticavitation valve means of the counterbalance valve **210** effectively isolates the brake cylinder **74** from the swing motor **70** so that the static pressure from the swing motor **70** doesn't act in the brake cylinder **74** to hold it released.

The secondary manifold **206** has a control valve **219** connected by lines **220**, **221** to the stationary base **187** of the rotary valve **186**. The lines **220**, **221** are internally connected in the rotary valve **186** to the lines **189**, **190**, respectively, which connect from the rotory valve part **188** to the winch motor **169**. By operation of the control valve **219**, hydraulic fluid under pressure may be supplied to the winch motor **169** to drive the latter in either direction, in accordance with the direction of operation of the control valve **219**. The control valve **219** is the auxiliary or low speed winch control. The hydraulic fluid supplied through the control valve **219** for operation of the winch motor **169** comes from the second pump **183** which normally would have a lower rate of delivery of hydraulic fluid than the first pump **182**. The winch motor **169** may be operated solely by hydraulic fluid from the second pump **183**.

The secondary manifold **206** further includes a main winch control valve **222**, a boom cylinder and piston control valve **223** and a boom lift cylinder and piston control valve **224**. The control valve **222** is connected to the primary manifold by lines **225**, **226**. The control valve **223** is connected to the main manifold by lines **227**, **228**. The control valve **224** is connected to the primary manifold by lines **229**, **230**. The control valves **222**, **223**, **224** control the supply of pilot hydraulic fluid under pressure to the pilots of the several flow control valves included in the primary manifold **185**, whereby these valves are operated to control the supply of hydraulic fluid from the first pump **182** to the winch motor **169**, the boom cylinder and piston mechanisms **91**, **116**, and the lift cylinder and piston mechanism **87**.

The control valve **222** may be used to control the supply of hydraulic fluid under pressure to the winch motor **169** from the first pump **182**, to the exclusion of hydraulic fluid from the second pump **183**. Since the first pump **182** is intended to supply hydraulic fluid under pressure at a higher rate of flow than the second pump **183**, operation of the winch motor **169** by the control valve **222** would be at a higher speed than the operation of the winch motor **169** by the control valve **219** alone. The two control valves **219**, **222** for the winch motor are located adjacent each other in the secondary manifold **206**, and these may be operated together, with the effect that hydraulic fluid under pressure is supplied to the winch motor **169** from the first and second pumps **182**, **183**, whereby the winch motor **169** is operated at a still higher speed than the speed of the winch motor **169** when it is operated by the control valve **222** alone. The secondary manifold **206** is connected by a line **231** to the tank **180** for return flow of the hydraulic fluid thereto.

The secondary manifold 206 is placed at the operator's station 25 among the controls 28, in position to have all the control valves conveniently available to the operator, along with the other controls for the crane 20, the latter being essentially for the engine 24.

The crane embodying the operating means as described herein operates smoothly and efficiently. The boom assembly is intended to lift substantial loads, and these subject the boom assembly to severe stress. Notwithstanding such loading, the upper boom may be extended and retracted easily by the upper and lower cylinder and piston mechanisms, the operation of which is not impeded by the boom loads.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and applicant therefore wishes not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of the invention, what it is desired to secure by Letters Patent of the United States is:

1. In a crane having a boom, a rotatable supporting structure on which the boom is mounted to swing the boom, means including a hydraulic motor for rotating said supporting structure and swinging the boom, means for controlling the supply of hydraulic fluid under pressure to said hydraulic motor in which said controlling means is opened to supply hydraulic fluid under pressure to the hydraulic motor to rotate said boom supporting structure and said controlling means is closed to stop the supply of hydraulic fluid under pressure to the hydraulic motor to stop rotation of said boom supporting structure, a counterbalance valve connected to said motor for flow of the hydraulic fluid through the counterbalance valve to and from the hydraulic motor, said counterbalance valve including hydraulic fluid pressure relief means for dissipating the energy of said motor when the supply of hydraulic fluid is stopped by closing said controlling means, brake means for holding said rotating means in stationary position, a hydraulic cylinder operative by hydraulic fluid to release the brake, means connecting said counterbalance valve to said hydraulic cylinder to supply hydraulic fluid under pressure to the hydraulic cylinder when said controlling means is opened thereby to release said brake by operation of the hydraulic cylinder and means for applying the brake when there is no hydraulic fluid supplied to the hydraulic motor.

2. In a crane having a boom, a rotatable supporting structure on which the boom is mounted to swing the boom, means including a hydraulic motor for rotating said supporting structure and swinging the boom in opposite directions reversible valve means for controlling the supply of hydraulic fluid under pressure to said hydraulic motor in which said reversible valve means is opened in one direction to supply hydraulic fluid under pressure to the hydraulic motor to rotate said boom supporting structure and said reversible valve means is closed to stop the supply of hydraulic fluid under pressure to the hydraulic motor to stop rotation of said boom supporting structure, a counterbalance valve having dual

connections to said motor for flow of the hydraulic fluid through the counterbalance valve to and from the hydraulic motor selectively in opposite directions, said counterbalance valve including dual hydraulic fluid pressure relief means for dissipating the energy of said motor in either direction of rotation thereof when the supply of hydraulic fluid is stopped by closing said reversible valve means, brake means for holding said rotating means in stationary position, a hydraulic cylinder operative by hydraulic fluid to release the brake, dual connections of said counterbalance valve to said hydraulic cylinder to supply hydraulic fluid under pressure to the hydraulic cylinder when said reversible valve means is opened thereby to release said brake by operation of the hydraulic cylinder, and means for applying the brake when there is no hydraulic fluid supplied to the hydraulic motor.

3. In a crane having a boom, a rotatable supporting structure on which the boom is mounted to swing the boom, means including a hydraulic motor for rotating said supporting structure and swinging the boom, means for controlling the supply of hydraulic fluid under pressure to said hydraulic motor in which said controlling means is opened to supply hydraulic fluid under pressure to the hydraulic motor to rotate said boom supporting structure and said controlling means is closed to stop the supply of hydraulic fluid under pressure to the hydraulic motor to stop rotation of said boom supporting structure, a counterbalance valve connected to said motor for flow of the hydraulic fluid through the counterbalance valve to and from the hydraulic motor, said counterbalance valve including hydraulic fluid pressure relief means for dissipating the energy of said motor when the supply of hydraulic fluid is stopped by closing said controlling means, brake means for holding said rotating means in stationary position, a hydraulic cylinder operative by hydraulic fluid to release the brake, means connecting said hydraulic cylinder to the counterbalance valve to supply hydraulic fluid under pressure to the cylinder when said controlling means is opened thereby to release said brake by operation of the hydraulic cylinder, flow regulator means connected to said hydraulic cylinder for regulating the volume of hydraulic fluid supplied to the cylinder, and means for applying the brake when there is no hydraulic fluid supplied to the hydraulic motor.

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ANDRES H. NIELSEN, *Primary Examiner.*

EVON C. BLUNK, *Examiner.*

A. L. LEVINE, *Assistant Examiner.*