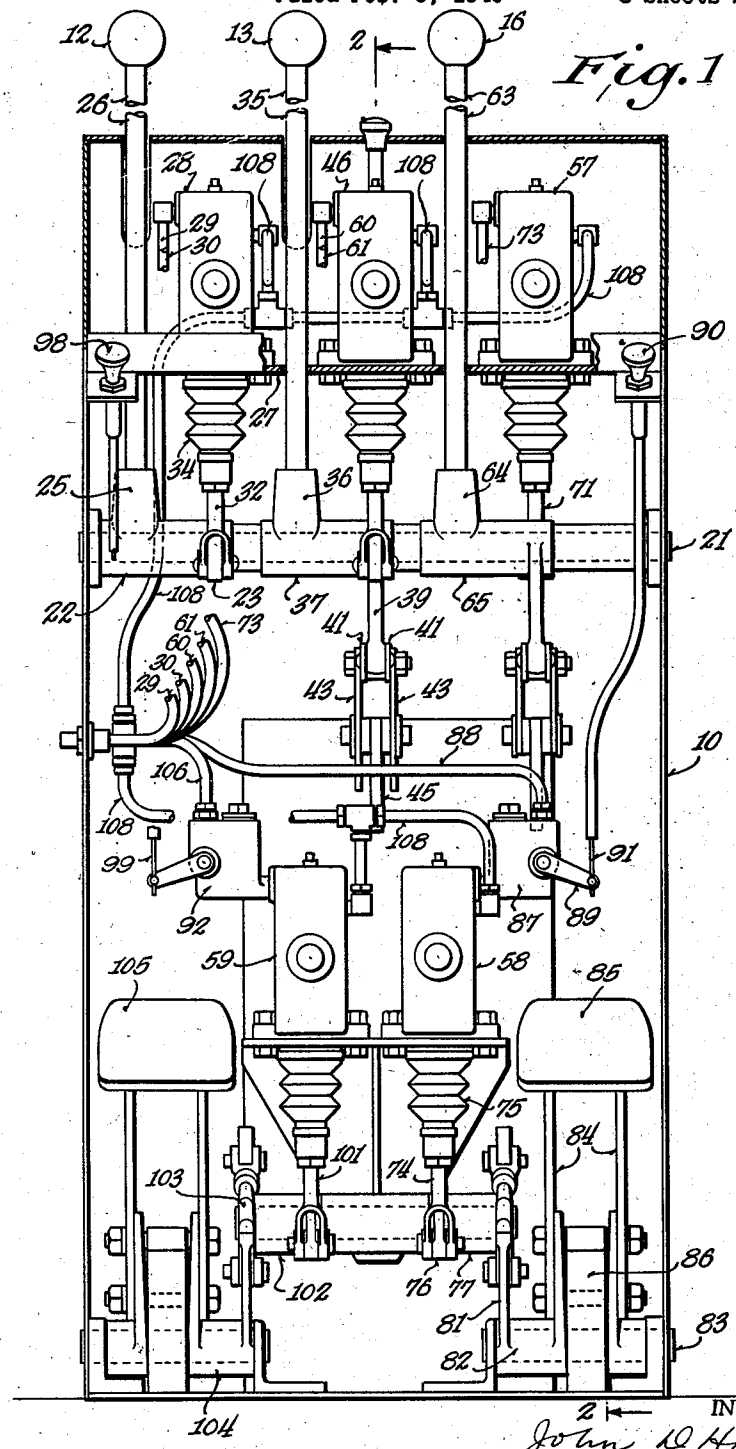
Aug. 22, 1944. J. D. HALE 2,356,517

HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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Fig. 1



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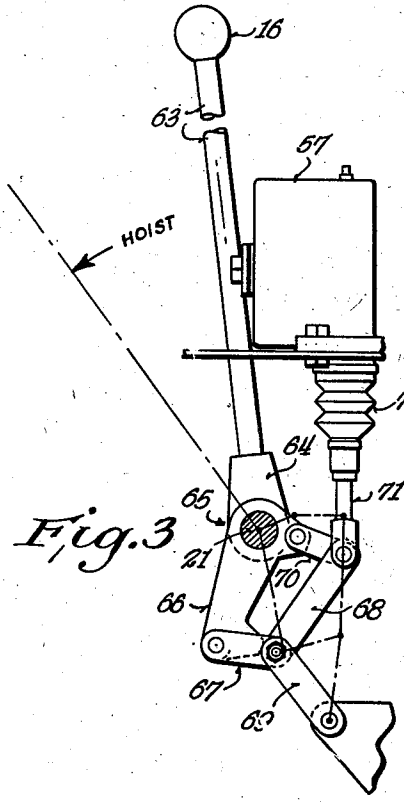


Fig. 3

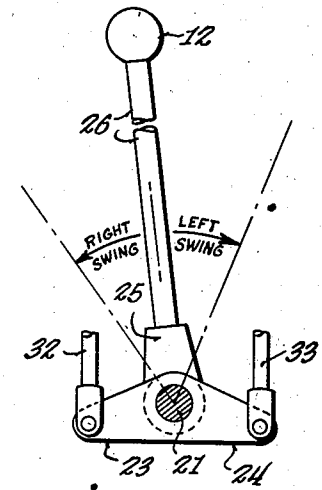
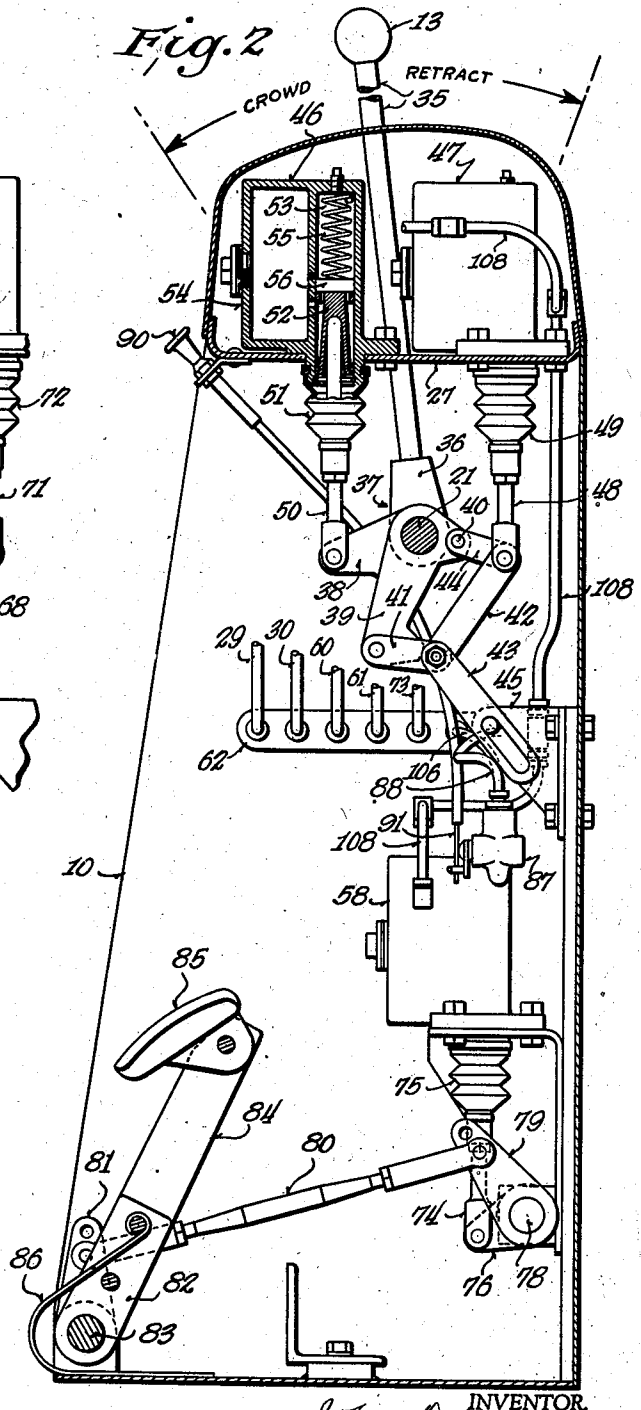


Fig. 4

Fig. 2



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HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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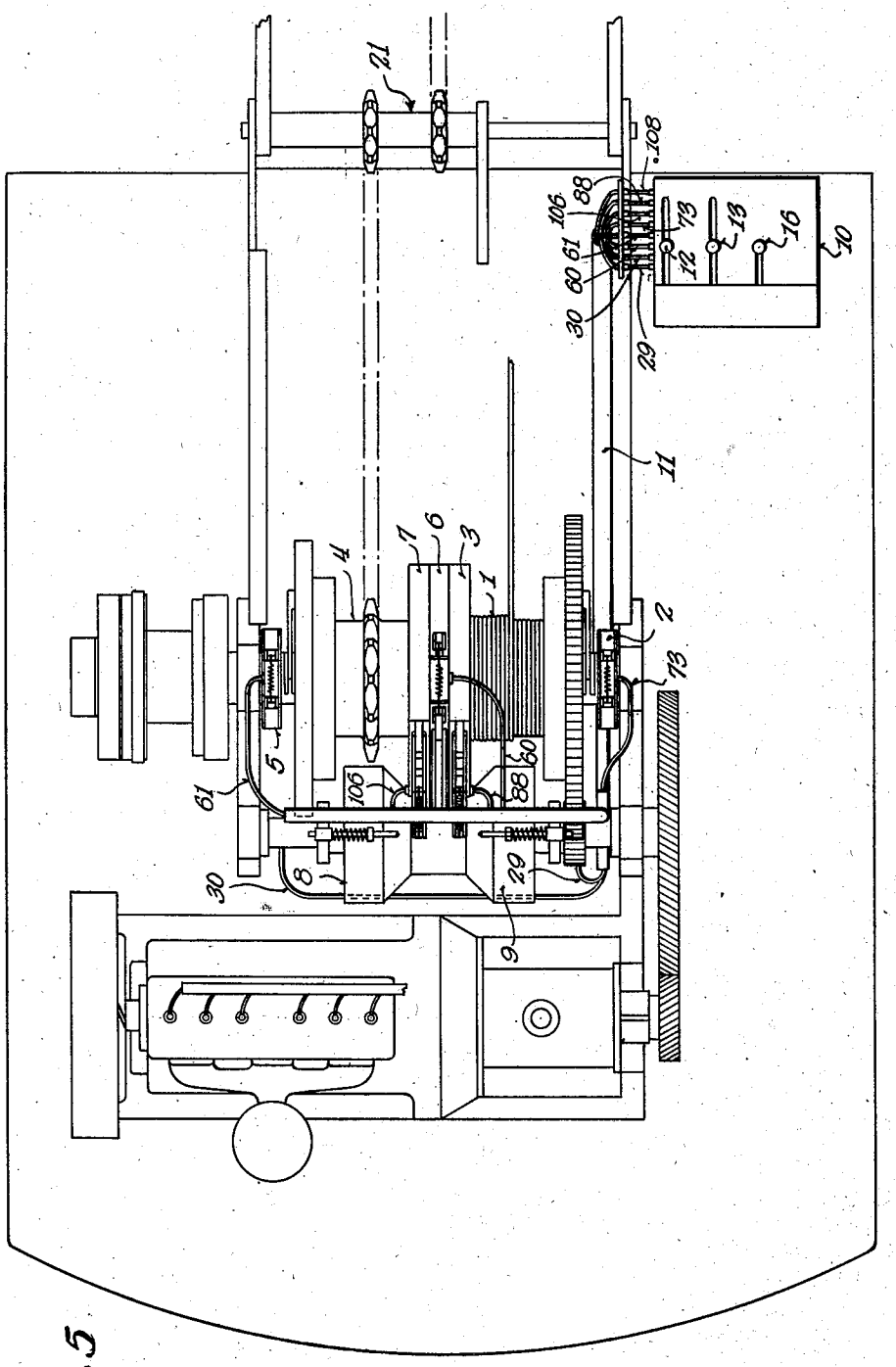


Fig. 5

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HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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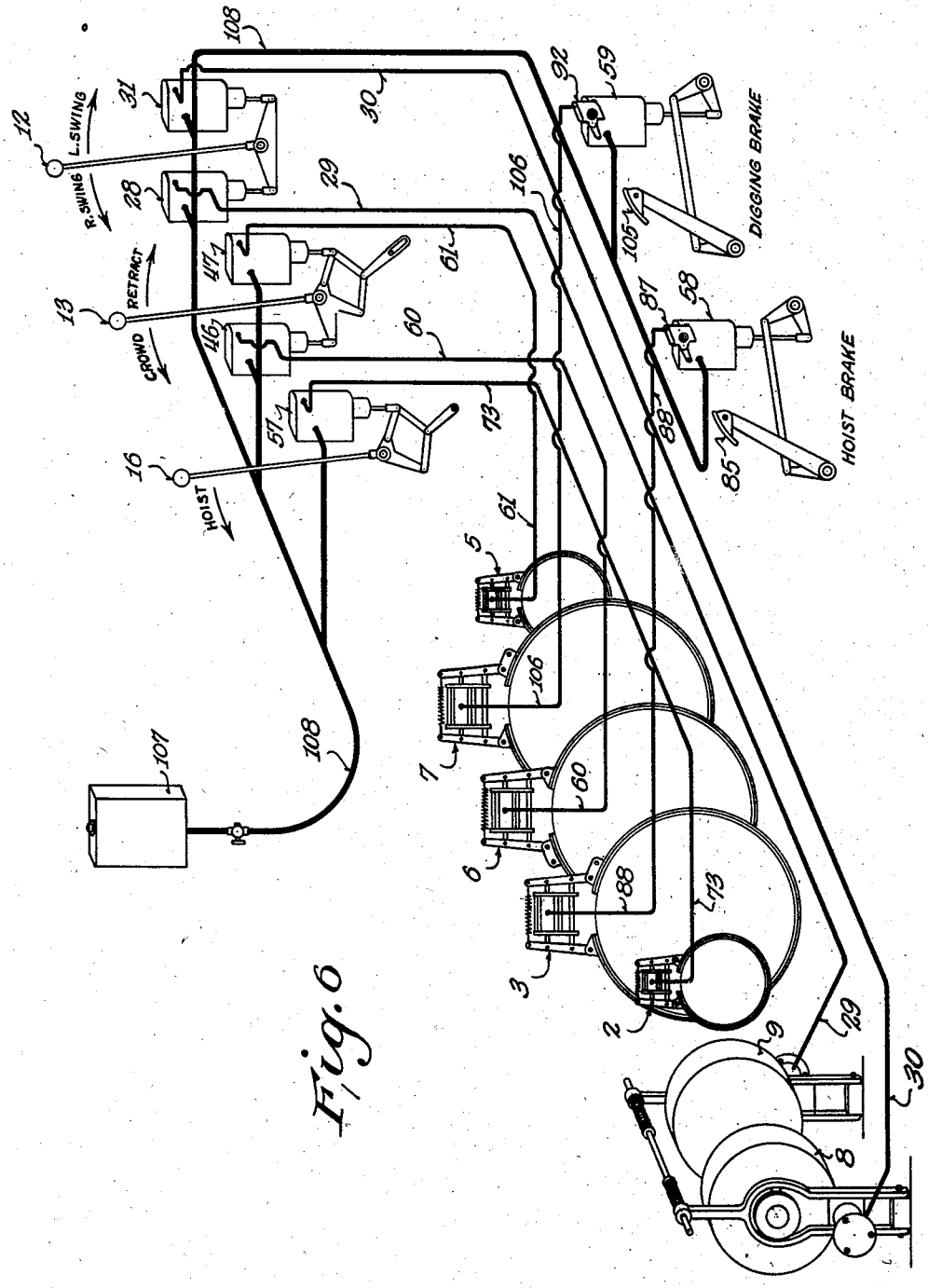


Fig. 6

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HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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Fig. 7

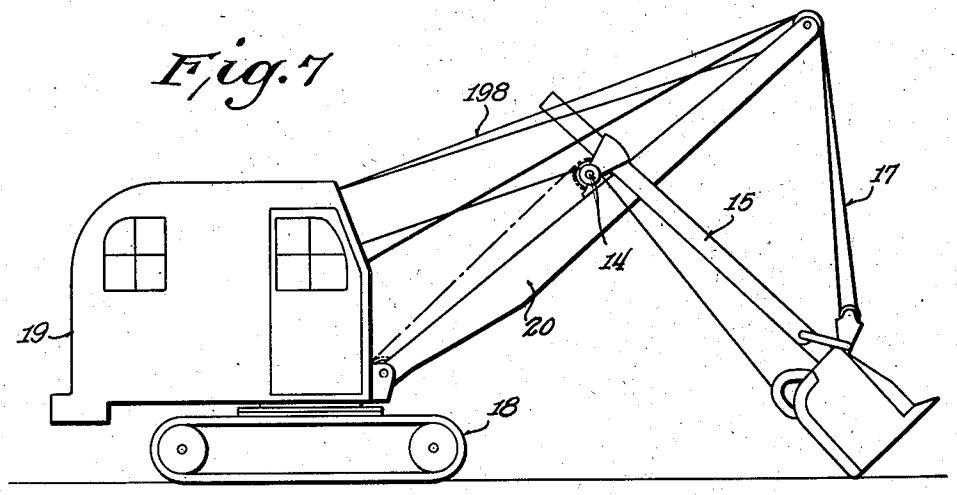


Fig. 8

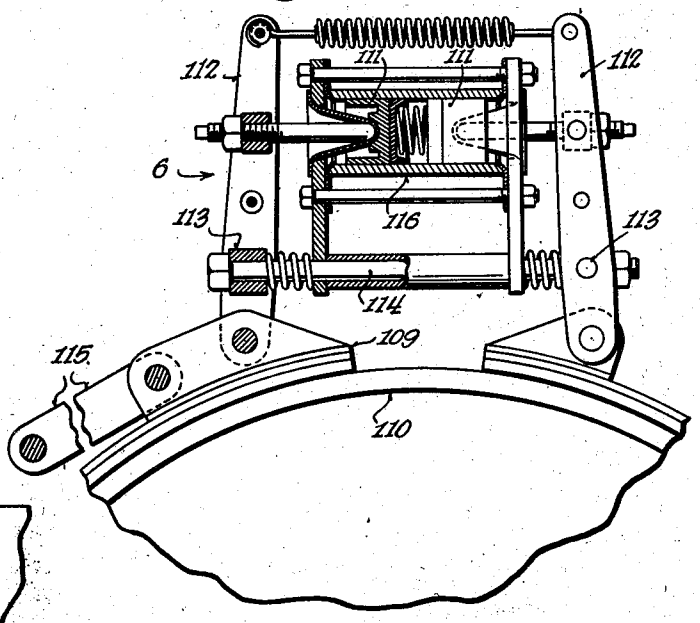
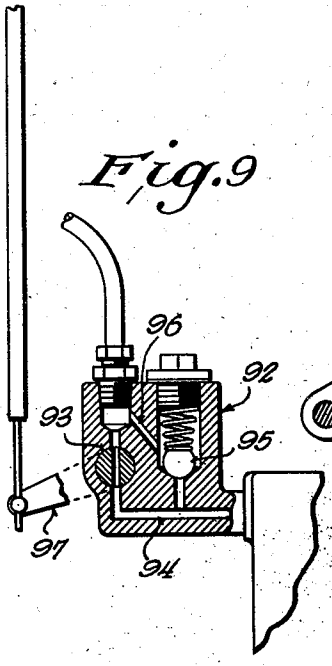


Fig. 9



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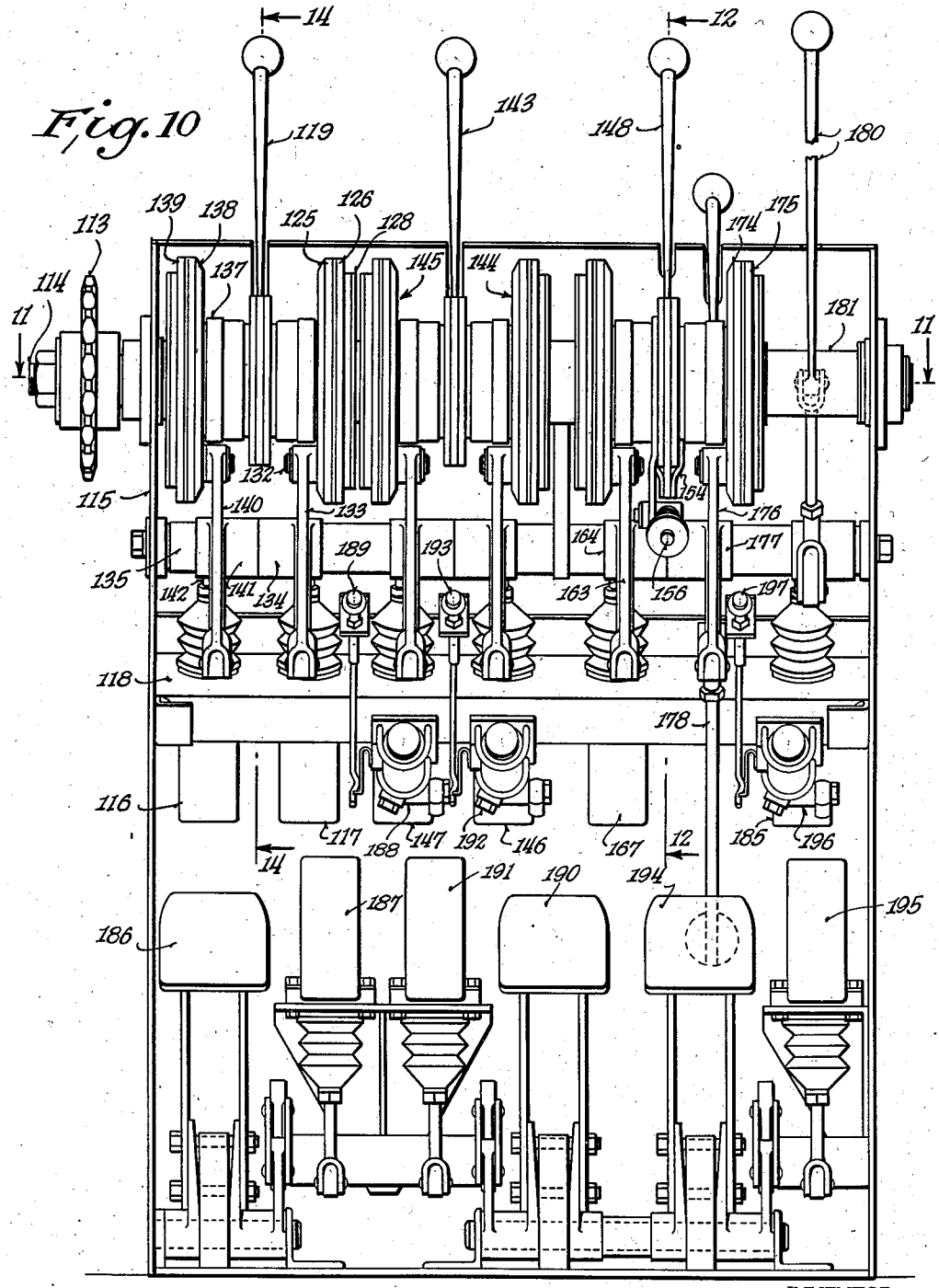
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HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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Fig. 10



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HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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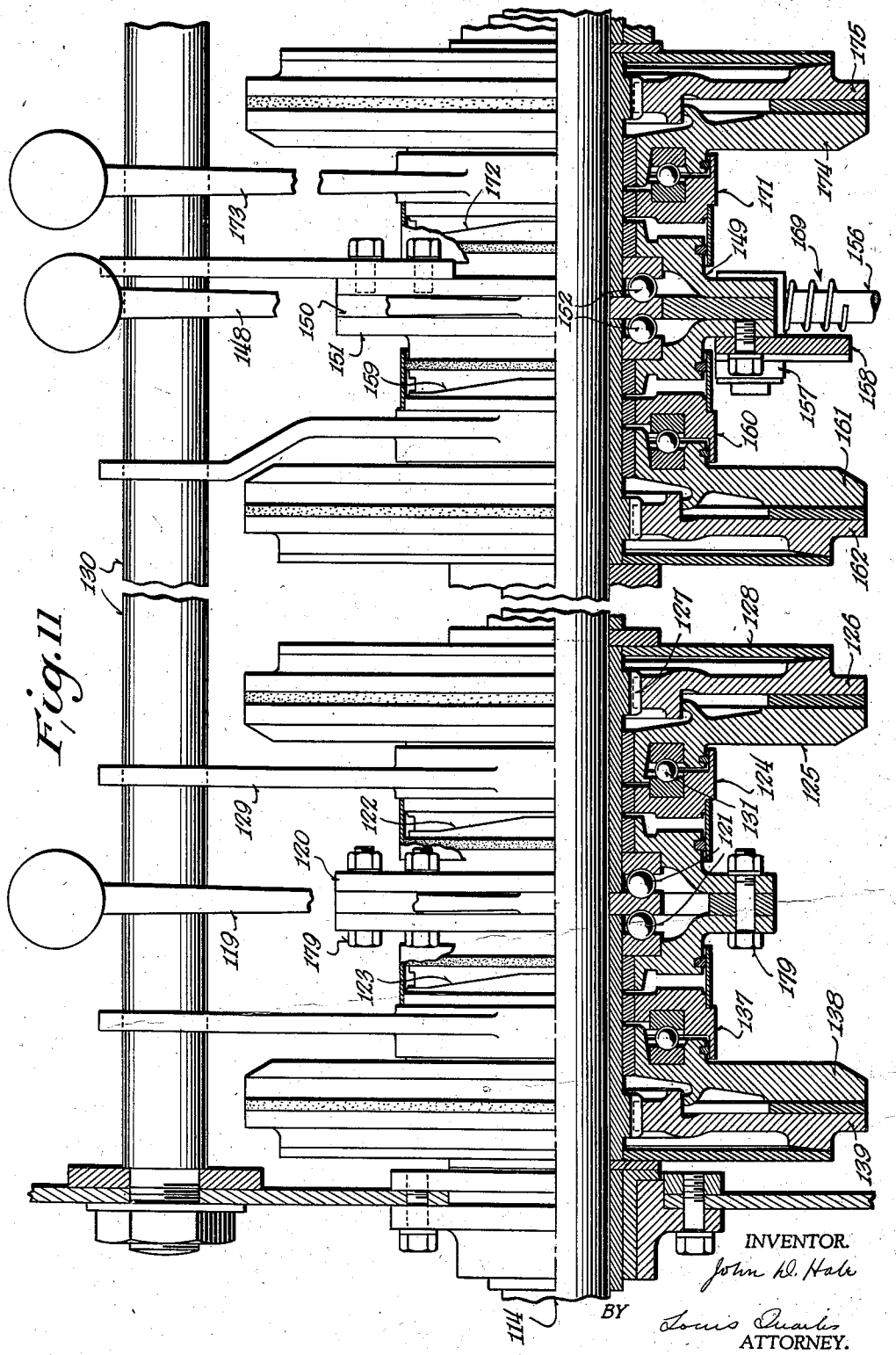


Fig. 11

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HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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Fig. 14

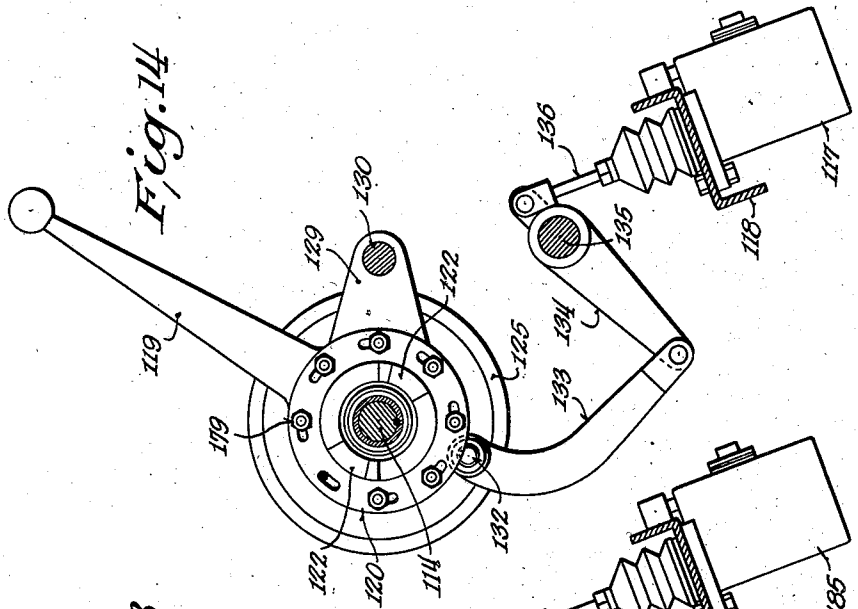


Fig. 13

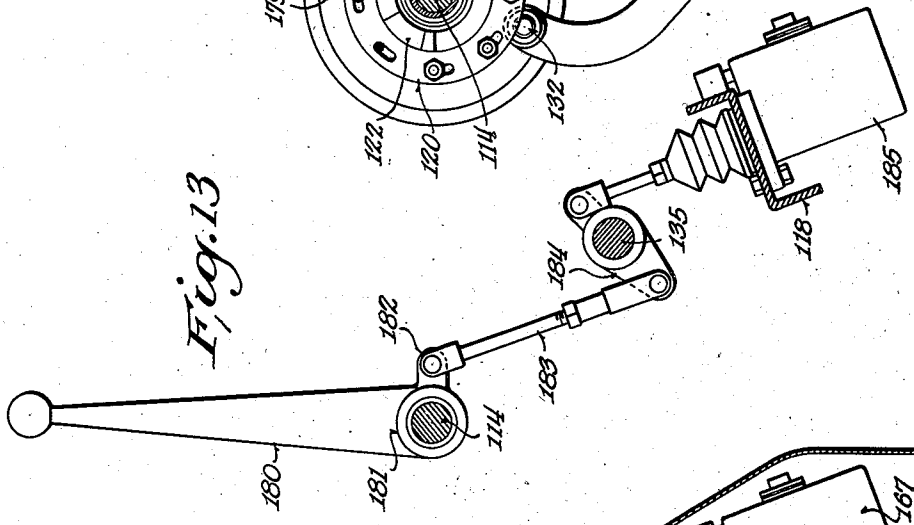
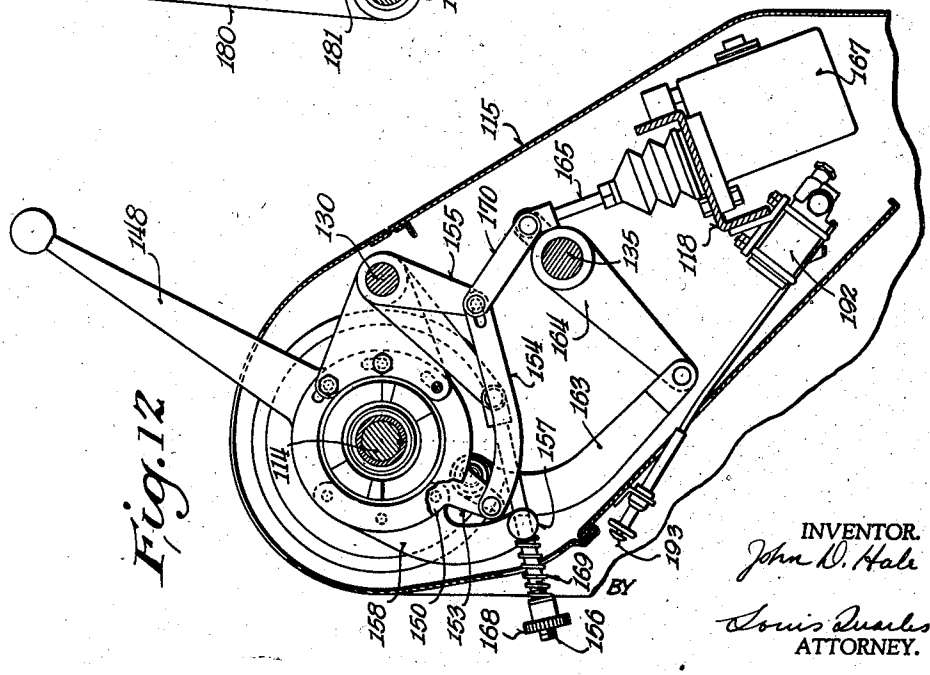


Fig. 12



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UNITED STATES PATENT OFFICE

2,356,517

HYDRAULIC CONTROL SYSTEM FOR EXCAVATING CRANES

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Application February 5, 1940, Serial No. 317,335

3 Claims. (Cl. 60—54.6)

This invention relates to systems for control of friction-driven excavating cranes and resides in an arrangement of friction members which are subject to control by hydraulic pressure-generating means located at the control position occupied by the operator, the said invention specifically residing in a plurality of manually-actuatable pressure-generating units so grouped and located with reference to one another and with reference to the crane body that the operator may, with normal, natural, and easily executed movements, and with moderate effort, cause the engagement and disengagement of the several clutches and brakes which cause the excavating crane to execute the usual excavating movements.

Heretofore in the art in excavating cranes, efforts have been made to overcome certain unsatisfactory properties of the mechanical control linkages heretofore employed, by substituting therefor means for transmitting control impulses from the operator to the particular clutch or brake to be controlled, by means of hydraulic systems of varying forms. In all such hydraulic control systems heretofore employed, hydraulic pressure for actuating the same has been derived from a common reservoir or prime mover and control impulses have been transmitted by operator-controlled valving of pressure fluid. In the case of such systems an unduly complex arrangement of piping has been required, including circulating piping, supply and return piping, and the like. Furthermore, the valving arrangements employed with such systems are not well adapted to compactness and convenient location and have not been adapted to grouping in such manner that the controls may be located for normal and natural manipulation by the operator. Furthermore, such control systems so completely deprive the operator of the feel of the load that it is impossible to operate a machine equipped therewith without experiencing dangerous shock effects and a certain amount of wildness and lack of precision in spotting.

The friction-driven excavating crane as now manufactured is an apparatus of fairly well developed and crystallized design. Usually there is provided a rotating cab, capable of free rotation in both directions. Mounted upon this rotating cab two principal drums are usually provided, one designated the "hoisting" drum arranged to be driven in the forward direction by a friction clutch and also furnished with a friction brake for arresting and holding the same. The other principal drum is usually designated the "digging" drum and for purposes of versatility is usually arranged to be driven in the forward direction by one friction clutch and in the reverse direction by another friction clutch and, in addition, is usually provided with a friction brake for arresting and holding the same. Such an excavating crane may be adapted in the well-known manner for use either as an out-stroke shovel, as an in-stroke shovel, or as a dragline, by simple substitution of the necessary attachments therefor. As a result, the following primary digging controls are required: right swing, left swing, forward digging or crowd, rearward digging or retract, digging brake, hoist and hoist brake. By custom, both directions of swinging movement are usually arranged to be under control of a single lever manipulated by the left hand of the operator, driving of the hoisting drum being under control of a lever manipulated by the right hand of the operator, while both forward and reverse rotation of the digging drum is controlled by a single lever placed between the hoist control lever and the swing control lever, so that it may be manipulated by either hand of the operator. In addition, control of the hoisting brake is regulated by a foot-pedal accessible to the right foot of the operator, while control of the digging brake is regulated by a foot-pedal accessible to the left foot of the operator. Without departing from the customary arrangement of controls, the apparatus of this invention permits the grouping of the same with unusually close and convenient location with respect to the operator. In addition, because of the absence of a large part of lost motion exhibited by mechanical linkages heretofore in use, positive and effective control is secured by means of the apparatus of this invention with a materially reduced amount of travel. Furthermore, a reduction in the effort required for operation may be achieved with the control of this invention.

This invention is herein described with the aid of the accompanying drawings which form a part hereof and in which there is set forth by way of illustration and not of limitation specific forms of the embodiment of this invention.

In the drawings:

Fig. 1 is a rear elevation, with parts broken away, of one form of control cabinet of this invention containing the pressure-generating elements of the apparatus of this invention.

Fig. 2 is a side sectional view of the control cabinet shown in Fig. 1, viewed through the broken plane indicated by the section line 2—2;

Fig. 3 is a detailed view, in side elevation, of the pressure-generating elements of the hoist

control, showing the over-center hold-in linkages;

Fig. 4 is a detailed view, in side elevation, of the control lever and rocker arm for controlling the pressure-generating cylinders of the swing control elements of the apparatus of this invention;

Fig. 5 is a plan view of a representative crane excavator cab showing one form of installation of the apparatus of this invention;

Fig. 6 is a diagrammatic showing of the piping connections of a typical apparatus of this invention;

Fig. 7 is a side view of one form of excavating crane to which the apparatus of this invention is adapted, showing the several members subject to control thereby;

Fig. 8 is a detailed view, partly in section, of a suitable hydraulic actuator for the friction bands employed in the apparatus shown in Fig. 5;

Fig. 9 is a detailed view, in section, of a brake-holding valve which may be employed in conjunction with the apparatus of this invention;

Fig. 10 is a rear elevation of another form of control cabinet suitable for use in connection with the apparatus of this invention, the same being adapted for servo operation of the pressure-generating cylinders;

Fig. 11 is a plan view, partly in section, of fragments of the servo actuators for swing control and the hoist and dipper actuators contained in the control cabinet shown in Fig. 10;

Fig. 12 is a detailed view of the linkages employed in connection with the hoist control of the apparatus shown in Fig. 10;

Fig. 13 is a detailed view of the boom hoist control of the apparatus shown in Fig. 10; and

Fig. 14 is a detail of the swing control of the apparatus shown in Fig. 10.

In Fig. 5 of the drawings one suitable form of the apparatus of this invention is shown mounted upon and applied to the control of a typical excavating crane rotating base. Upon the base there is provided a hoisting drum 1, mounted to be driven by the hoist clutch 2 and controlled by the hoist brake 3. In addition there is provided a digging drum 4, arranged to be driven in one direction by crowd-clutch 5 and in the opposite direction by retract-clutch 6. A brake for arresting movement of the digging drum 4 is mounted as shown at 7. To provide the necessary power for rotation of the rotating base, right and left swing clutches 8 and 9 are provided, as shown.

Control impulses to be transmitted to the parts above named are generated in a control cabinet 10 positioned upon the rotating base in convenient location for access by the operator, as shown. Piping connections extending from the control cabinet 10 to the individual clutches and brakes are brought together and carried through a protecting sheath 11, as shown. Contained within the control cabinet 10 are right- and left-swing control handle 12 for controlling the clutches 8 and 9, crowd and retract control handle 13 for control of forward and reverse drive of drum 4, and hoist control handle 16 for controlling rotation of drum 1.

The machine shown in Fig. 7 is but one instance of an excavating crane such as may be employed in connection with the apparatus of this invention. The machine as shown diagrammatically is mounted upon a suitable traveling base 18, upon which there is mounted rotating cab 19, containing the various hoisting and control instrumentalities. Extending from the rotating base 19 is a boom 20, upon which there is mounted, in well-known manner, the shipper shaft 14 for producing crowding and retracting movement of the dipper stick 15 under influence of the sprockets and chains indicated by dotted lines which communicate, as shown in Fig. 5, with the digging drum 4 through the idler sprockets 21. Outward action of the dipper is produced by hoisting line 17, which is arranged to be wound upon hoist drum 1.

In order to better describe the apparatus by which control impulses are created and the manner in which the same is arranged for ready access by the operator, reference is had to Figs. 1, 2, 3, and 4 of the drawings. As shown in these figures, a horizontal shaft 21 extends transversely across the interior of the upper part of control cabinet 10. Pivotally mounted upon the left end of shaft 21 is a rocker assembly 22 having oppositely extending rocker arms 23 and 24, as shown more clearly in Fig. 4. Formed as a portion of the rocker assembly 22 is an upwardly-extending boss 25 to which there is secured the swing-control lever 26, which terminates in handle 12, as shown, for easy grasping by the operator. Mounted vertically above the extremity of the rocker levers 23 and 24, upon the shelf 27, are a pair of pressure-generating cylinders of well-known form, such as are employed in automotive hydraulic brake systems. One of these cylinders is designated by the numeral 28, the other by the numeral 31 in Fig. 6, said cylinder being hidden in the other views in the drawings but being of exactly similar form. Impulse-transmitting tubes 29 and 30 emerge respectively from the cylinders 28 and 31, the same being shown partially broken away for clarity in the showing. Extending upwardly from the ends of the rocker arms 23 and 24 are a pair of pivotally-connected pushrods 32 and 33, which are secured to and extend through flexible boots, one of which is shown at 34, into the interior of their respective operating cylinders into engagement with a piston contained therein in a manner to be more fully described in connection with similar cylinders employed elsewhere in the apparatus.

The digging drum control is effected through lever 35, which engages a boss 36, which forms part of a rocker assembly 37 pivoted to turn upon shaft 21, as shown more in detail in Fig. 2. The rocker assembly 37 includes laterally-extending rocker arm 38 and depending rocker arm 39 and carries upon the side opposite the rocker arm 38 a pivotal idler link mounting 40. The lower end of depending rocker 39 makes pivotal connection, as shown, with thruster link 41, which in turn engages the juncture between toggle links 42 and 43. The upper end of toggle link 42 is connected to and guided by an idler link 44, which is carried upon the idler link mounting 40, previously referred to. The lower end of toggle link 43 is provided with a lost-motion slot, as shown, which engages a pin held by bracket 45, which is securely bolted to the back plate of cabinet 10, as shown.

Mounted above the rocker assembly 37 on the horizontal shelf 27 is a pair of pressure-generating cylinders 46 and 47, being in form exactly similar to cylinders 28 and 31, previously referred to. Pivotally connected to and extending upwardly from the upper extremity of toggle link 42 is a pushrod 48 which is secured to and passes upwardly through a flexible boot 49 in the interior of cylinder 47, where it engages a pressure-generat-

ing piston. In like manner, pivotally connected to and extending upwardly from the extremity of rocker arm 38 is a pushrod 50, which is secured to and extends upwardly through a flexible boot 51 into engagement with a downwardly facing socket in piston 52, which is arranged to slide in cylinder barrel 53.

The pushrod 50 fits loosely in the socket in piston 52 so that when the lever 35 is moved in the direction designated "Retract" in Fig. 2, the piston 52 is raised in the cylinder barrel 53, causing a rise in fluid-pressure therein, while, on the other hand, if the lever 35 be moved in the direction designated by the legend "Crowd," the end of pushrod 50 simply separates from its seat in the socket in piston 52, while the piston 52 remains stationary in its lowermost position, as shown in Fig. 2, and while a corresponding extension in boot 51 takes place. Communicating with the cylinder barrel 53, as shown, is a reservoir 54, adapted to hold fluid and to compensate for leaks and losses which may occur. A compression spring 55 within the cylinder barrel 53 assists in the return of the piston 52 and aids in retaining cup-washer 56.

The foregoing described structural detail of cylinder 46 is characteristic of the structural detail of cylinders 28, 31, and 47, which have already been referred to, as well as cylinders 57, 58, and 59, which will be hereinafter mentioned.

Upon movement of control lever 35 in the direction designated "Crowd," toggle links 42 and 43 are caused to move toward a position of alignment, thus forcing pushrod 48 into cylinder 47 until the over-center position is reached. By moving the toggle links 42 and 43 slightly beyond the over-center position, the lever 35 becomes self-retaining, in which position it will remain until the operator desires to release it by a slight push toward rest position. Emerging from the pressure cylinders 46 and 47 are pressure-transmitting tubes 60 and 61, respectively, which are broken away for clarity in the showing and which emerge from the cabinet 10 through the grommet plate 62, as shown clearly in Fig. 2.

To provide control for the driving of the hoisting drum 1 a lever 63 extends downwardly into engagement with a boss 64 which forms a part of rocker assembly 65 mounted to turn upon the shaft 21, in the manner shown in detail in Fig. 3. The rocker assembly 65 is provided with a depending rocker arm 66, which pivotally engages a thrust link 67, which in turn pivotally joins with the mid point of the pair of toggle links 68 and 69. The upper end of toggle link 68 is guided by a pivotal idler link 70, which makes pivotal connection with the rocker assembly 65, as shown. Pivotally connected to and extending upwardly from the upper extremity of toggle link 68 is a vertical pushrod 71, which is secured to and passes through a flexible boot 72 into the interior of pressure-generating cylinder 57. Movement of the lever 63 in the direction designated by the legend "Hoist" in Fig. 3 eventually brings the toggle links 68 and 69 to and beyond an over-center position, as shown by the dotted line in Fig. 3. The hoist control is thus self-retaining in the position of extreme applied pressure, but may be released by a slight manual pressure in the return direction. A tube for transmitting control impulses generated in the cylinder 57 emerges therefrom and is designated by the numeral 73, this tube being shown partially broken away, as in the case of tubes emerging from the other cylinders.

For the purpose of controlling the brake which may be applied to the hoist drum 1, a cylinder 58, in form similar to the cylinders previously described, is mounted upon a bracket secured to the lower rear wall of the cabinet 10. A piston-actuating pushrod 74 emerges from cylinder 58 and its flexible boot 75, the pushrod 74 being pivotally connected at its lower end to a rocker arm 76, which forms a part of bell-crank assembly 77, which in turn is mounted upon a supporting shaft 78, secured to the rear wall of cabinet 10. An upwardly extending rocker arm 79, which forms a part of the bell-crank assembly 77, makes pivotal connection near its upper end with adjustable connecting link 80. The opposite end of link 80 is pivotally connected with a vertical rocker arm 81 which forms an integral part of a treadle rocker assembly 82, the latter being mounted to turn upon supporting shaft 83. The treadle rocker assembly 82 is provided with upwardly-extending arms 84 to which the foot-plate 85 is secured. Return movement of the foot-plate 85 is assisted by spring 86, as shown.

Secured to the outlet of cylinder 58 in hydraulic communication therewith is a check-valve and by-pass unit 87 which provides an unrestricted hydraulic passage from the cylinder 58 to the impulse-transmitting tube 88 when in the position shown in Figs. 1 and 2 of the drawings. Check-valve and by-pass unit 87, however, is provided with an operating lever 89, which may be moved by drawing upon the knob 90 which is connected thereto by flexible operating wire 91. When the control lever 89 is thus raised, check-valve and by-pass unit 87 provides a hydraulic passage for the fluid from cylinder 58 to transmitting tube 88 only in the outward direction. The hoist brake may thus be rendered self-retaining by drawing knob 90, and said self-retaining characteristics may be released by returning the knob 90 to the position shown.

The construction of check-valve and by-pass unit 87 is like that of the unit 92, shown in detail in Fig. 9, where the unit is shown as comprising by-pass plug valve 93, which controls by-pass 94 and ball-check-valve 95, which controls the check-valve passage 96. Plug valve 93 is controlled by control lever 97, the position of which may be regulated by the knob 98 acting through flexible control wire 99. Unit 92 is employed in connection with cylinder 59 which is mounted in a manner similar to the mounting of cylinder 58 and is controlled through push-rod 101, rocker assembly 102, adjustable link 103, treadle rocker 104, and treadle pad 105, as shown. Control pressures created in cylinder 59 and transmitted through unit 92 are transmitted into the communicating tubing 106, as shown.

To provide for a supply of hydraulic fluid to make up such losses as may occur and to maintain a slight hydrostatic pressure throughout the system to prevent entrance of air, a central supply reservoir 107, shown in Fig. 6, is provided. The supply reservoir 107 is positioned slightly above the highest point of elevation of any of the parts of the hydraulic system and is connected to the individual reservoir of cylinders 57, 46, 47, 28, 31, 59 and 58, by means of a manifold tube 108, as shown.

The control impulses created in the several pressure-generating cylinders may be converted into control action by any suitable means. One of such means, adapted for the controlling of the band clutches and brakes shown in Fig. 5, is shown in detail in Fig. 8. The actuator shown in Fig. 8 is adapted to cause contraction of a

band 109 about the periphery of a drum 110. Hydraulic fluid fed into the center of cylinder barrel 116 between a pair of opposed, outwardly acting pistons 111 causes the upper ends of rocker arm 112 to move away from one another while pivoting about the fulcrum blocks 113, which are held by the fulcrum bolt 114, thus causing the open ends of the band 109 to move toward one another. The band 109 is preferably restrained from tangential movement by a radially-displaceable anchoring link 115. If desired, however, pressure cylinders of conventional form acting upon the thruster forks of other forms of clutches or brakes, such as clutches 8 and 9 employed to control swinging movement, may be employed as diagrammatically indicated in Fig. 6.

From the foregoing it will be noted that means are provided by the apparatus of this invention through which the various operating functions of an excavating crane may be controlled without the use of the complicated system of mechanical linkages heretofore employed and without the complexities and difficulties of power-driven hydraulic control systems heretofore proposed. All controlling members are conveniently located and accessible to the operator and may be compactly ararnged and positioned at the forward end of the operating cab without causing obstruction or inconvenience.

In the case of heavy machinery, where the effort of the operator alone is not adequate to perform the control work required, the apparatus of this invention may be adapted for servo-operation, as shown in Figs. 10, 11, 12, 13 and 14. Such apparatus may be in all respects similar to that which has been described above with the exception that effort applied to the control members is derived through continuously sliding friction clutches arranged to be manipulated by the operator. Power for the operation of the sliding clutches may be derived through a single continuously turning shaft 114 mounted in cabinet 115 and driven by sprocket 113, as shown in Fig. 10.

Contained within the control cabinet 15 is a pair of pressure-generating cylinders 116 and 117, which are mounted upon and held rigidly in place by channel member 118. These cylinders are arranged to be connected by means not shown with the right- and left-swing clutches of the crane, respectively, through tubes 29 and 30 shown in Fig. 6. The transmission of actuating forces to the cylinders 116 and 117 is controlled by the operator through the swing-control handle 119. The swing-control handle 119, as shown in Figs. 11 and 14, makes rigid connection with a thruster-hub 120, which in turn is carried upon a double row thrust-bearing 121, which locks the thruster-hub 120 against endwise movement along shaft 114, but which permits hub 120 to remain stationary, or turn, independently of the turning movement of shaft 114. To the right of hub 120 is a pair of inclined cam faces 122, which become operative upon movement of the swing-control lever 119 away from the operator to cause the non-turning intermediate thrust member 124 to act toward the right, thus causing driven clutch disk 125 to be engaged and rotated by spring-backed driving clutch disk 126, which is being continuously driven by means of the splined connection 127, which is carried around by the continuously rotating shaft 114. A plate-spring 128 furnishes desired resiliency to the driving clutch disk 126, as shown.

Intermediate thrust member 124 is provided with a laterally extending arm 129, the outer end of which is bored to slidingly receive the reaction rod 130, shown clearly in Figs. 11, 12, and 14. To eliminate any undue friction between the intermediate non-turning thrust member 124 and the driven clutch disk 125, bearing 131 is provided.

Driven clutch disk 125 carries a crank-pin 132 which makes connection, as shown in Fig. 14, with connecting-link 133, which in turn pivotally connects with the rocker 134, which rocker is mounted to turn upon the rock-shaft 135. The opposite end of rocker arm 134 is pivotally connected, as shown in Fig. 14, with a pushrod 136, which enters cylinder 117 to actuate a piston therein in the manner which has been previously described in connection with other pressure-generating cylinders of the apparatus of this invention.

It will be observed, therefore, with the continuously running shaft 114 turning in a clockwise direction, as viewed from the right hand end, that engagement of driven clutch disk 125, caused by movement of the swing-control lever 119, as described above, will cause the pushrod 136 to be forced into the cylinder 117, thus generating a hydraulic impulse. It will be understood that the driven clutch disk 125 is a continuously-sliding member and that the same is capable of a limited amount of rotation only by reason of the linkages connected thereto and, further, it will be readily understood that the intensity of hydraulic impulse created thereby will be regulated by the intensity of the pressure of engagement between driving disk 126 and driven disk 125, a factor which is entirely under the control of the operator through manipulation of swing-control lever 119. In exactly similar manner, upon movement of the swing-control lever 119 toward the operator, inclined cam faces 123 cause intermediate thrust member 137 to move toward the left, thus causing engagement of driven clutch disk 138 with driving clutch disk 139, thus causing connecting link 140 to act upon rocker 141, causing the pushrod 142, which enters cylinder 116, to act to generate a hydraulic impulse.

In like manner the "crowd" and "retract" control handle 143 is mounted upon continuously-turning shaft 114 in proper relationship to control the "crowd" and "retract" clutches designated generally by the numerals 144 and 145, respectively, which clutches, acting through linkages similar to those above described, produce hydraulic impulses in "crowd" and "retract" cylinders 146 and 147, respectively.

Fluid - impulse - transmitting conduits, not shown, such as conduits 60 and 61, shown in Fig. 6, may connect the cylinders 146 and 147 with "crowd" and "retract" clutches.

To provide a control for the hoisting drum and to render said control self-retaining in the extreme applied position, hoist-control handle 148 is mounted upon a free-turning center disk 150 and associated with the remaining parts in a manner quite different than that which has been previously described. Disk 150 is capable of free turning movement independently of stationary side-thrust hub 149 and displaceable side-thrust hub 151, although all of these parts derive support from and perform their functions independently of the turning of shaft 114 by reason of double-row thrust bearing 152. As shown more clearly in Fig. 12, disk 150 is provided with a downwardly-projecting lug 153, which pivotally

engages a pushrod 154, which in turn is arranged to act upon the bell-crank 155, which is mounted to turn upon the reaction rod 130, as shown. The longer of the two unequal arms of the bell-crank 155 makes pivotal engagement with a clevis which is secured to the end of adjustable connecting bolt 156, which bolt passes through a trunnion block 157, which is in cooperative engagement with the curved lug 158, which in turn is secured to the independently movable thruster-hub 151, as shown in Figs. 11 and 12. When the lever 148 is moved counter-clockwise the link 154 straightens the toggle links 155 and 170. This tends to cause the piston rod 165 to enter the cylinder 167 however, at the same time the longer end of the toggle 155 pulls upon the rod 156 and thus rotates the clutch thruster 158 causing the friction disks 161 and 162 to come into engagement. Thereupon, the connecting rod 163 pulls on the lever 164 and thus contributes its force to cause the piston rod 165 to enter the cylinder 167. It will be apparent, therefore, that upon movement of the hoist-control lever 148 toward the operator, thruster-hub 151 will rotate so as to cause inclined cam faces 159 to act against non-turning intermediate thrust member 160, thus causing engagement of driven clutch disk 161 with driving clutch disk 162. When this occurs, connecting link 163, as shown in Fig. 12, will move so as to cause rocker 164 to turn, thus forcing pushrod 165 into cylinder 167. The resulting intensity of hydraulic impulse created in cylinder 167 as compared with the effort applied to the lever 148 may be regulated through adjustment of adjustable nut 168 acting against adjusting spring 169 and thus the degree to which the load is "felt" by the operator is subject to regulation at the pleasure of the operator. The engaging force between the disks 161 and 162 is transmitted through the compression spring 169. Therefore if initial compression is set up in spring 169 by turning down the nut 168 a stronger force may be transmitted through it and if such is done the clutch disks 161 and 162 engage with greater intensity and contribute in larger measure to the force required to drive the piston rod 165 into the cylinder 167. The part of the force contributed for this purpose by the effort of the operator applied to the straightening of the toggle links 155 and 170 therefore is diminished and the higher the initial compression in spring 169, the less the operator has a feel of the load. It will be noted that at all times the operator has a sense of the extent to which the piston rod 165 has entered the cylinder because of the direct linkage connection between the lever 148 and the piston rod 165. Thus the operator can not only feel how hard a load is involved, but he may also sense to what extent movement under load has taken place.

In order that the hoist control may exhibit self-retaining properties in the extreme applied position, a link 170, shown in Fig. 12, is interposed between and pivotally connected to the rocker 155 and the rocker 164, thus forming a toggle linkage which will hold the control in applied position once said toggle linkage has been carried beyond the over-center position. The cylinder 167 may be connected by tubing, not shown, to the hoisting clutch as by the tube 73 shown in Fig. 6.

To provide a servo-actuated dipper trip, an intermediate thrust member 171 may be mounted so as to act against non-turning thrust-hub 149, through inclined cam faces 172, as shown in Fig. 11. The intermediate thrust member 171 may be provided with an operating handle 173, upon the movement of which handle toward the operator driven clutch disk 174 comes into engagement with driving clutch disk 175, as shown. A connecting link 176, which engages a crank-pin mounted on the driven clutch disk 174 is arranged to operate a rocker 177, to the end of which rocker any appropriate means may be secured, such as transmission rod 178, which extends to the dipper trip or other instrumentality which it is desired to operate, but which is not shown.

To provide for precise positioning of inclined cam faces so as to insure consistent engagement of the sliding clutch disk, said cam faces, as shown, for example, in Fig. 14, may be mounted upon members having elongated tangential means about their periphery for accommodation of the assembly bolts 179, which pass therethrough. At any time it is possible to loosen the bolts 179 and reset the inclined cam faces in proper position, thus compensating for wear and similar effects.

If desired, manual control, not assisted by any servo-action may be combined with the servo-control above described, as, for example, shown in the case of boom-hoist control lever 180, which is simply mounted to pivot about shaft 114 upon the hub 181, as shown. Projecting from the hub 181 is a lug 182 which engages connecting-rod 183, which acts through rocker 184 mounted on rockshaft 135 to cause manual actuation of cylinder 185, which cylinder, by appropriate piping connection, not shown, may be connected to a boom-hoist clutch.

In like manner and also without benefit of servo-action, there may be included within the cabinet 115, foot-operated control, as shown. For example, a "crowd" and "retract" foot-brake 186, arranged to act upon the cylinder 187, in the manner described in connection with cabinet 10, may be provided and connected by appropriate tubing, such as tube 106, shown in Fig. 6, with the brake controlling the "crowd" and "retract" or digging drum. If desired, a check-valve and by-pass unit 188, controlled by the knob 189, may be interposed in such transmission tubing. In like manner, a hoist-drum brake 190, pressure cylinder 191, by-pass and check valve unit 192 and control knob 193 may be provided and connected as shown in Fig. 6 with tubing 83 to provide brake control for the hoisting drum. If desired, there may also be provided a brake pedal 194, pressure-cylinder 195, by-pass and check valve unit 196, and control knob 197, for control of the boom hoist 198, shown in Fig 7, through appropriate tubing connections not shown.

From the foregoing it will be observed that through this invention there is provided hydraulic control for machines of the type of the excavating crane, which control may be either manually or power operated and which control eliminates the deficiencies of hydraulic control systems heretofore employed on excavating cranes wherein valving of fluid supply is involved. This is accomplished by providing separate pressure-generating means for each control function required and by locating said pressure-generating means in close proximity to the member which is manipulated by the operator to cause energization thereof. By so doing mechanical linkages extending over great distances are avoided and all the advantages of ease of instal-

lation of hydraulic transmission tubing are attained, while at the same time retaining a close correspondence between the control effort exerted by the operator and the resulting control forces produced thereby.

While there has been disclosed herein specific instances of the embodiment of this invention, it is desired that it be understood that the same are set forth by way of illustration and not of limitation, since it is intended that the protection of Letters Patent to be granted hereon extend to the limits of the inventive advance disclosed herein as set forth in the claims hereto appended.

That which I wish to claim as my invention is:

1. In a hydraulic control, the combination comprising a pivoted control lever movable to and from a rest position, a hydraulic cylinder having a piston, continuously sliding controllable friction-driven means for causing said piston to enter said cylinder, a source of power for driving the same, a pair of toggle links movable toward and slightly beyond a position of alignment connected to said control lever for movement thereby, means actuated by movement of said toggle links for causing and controlling engagement of said continuously sliding friction-driven means with said source of power, and means engaging one of said toggle links and said piston whereby said control lever is rendered self-retaining in extreme applied position and the extent of movement of said piston into said cylinder may be sensed by one operating said control lever.

2. In a hydraulic control the combination comprising a pivoted control lever movable to and from a rest position, a hydraulic cylinder having a piston, continuously sliding controllable friction-driven means for causing said piston to enter said cylinder, a source of power for driving the same, an over center means movable toward and slightly beyond a self-retaining over center position connected to said control lever for movement thereby, means actuated by movement of said over center means for causing and controlling engagement of said continuously sliding friction-driven means with said source of power, and a connection between said control lever and said piston whereby the extent of movement of said piston into said cylinder may be sensed by one operating said control lever.

3. In a hydraulic control the combination comprising a movable control member, hydraulic displacement means, continuously sliding controllable friction-driven means adapted to act upon said hydraulic displacement means, a source of power for driving said friction-driven means, means connecting said control member to said hydraulic displacement means, and resilient adjustable means associated with said connecting means and adapted to cause and control engagement of said continuously sliding friction-driven means with said source of power.

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