

May 16, 1961

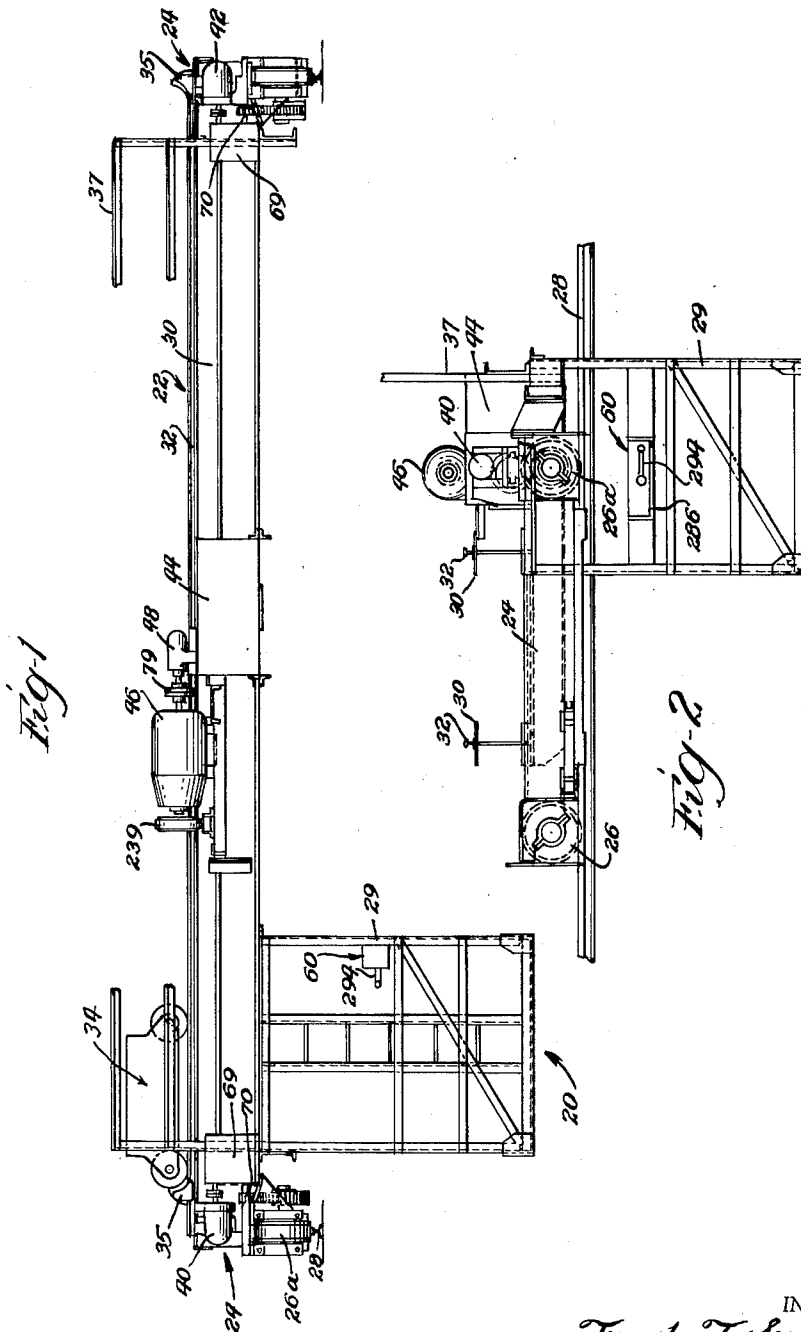
F. T. SMITH

2,984,191

HYDRAULICALLY OPERATED OVERHEAD CRANE

Filed Oct. 7, 1958

6 Sheets-Sheet 1



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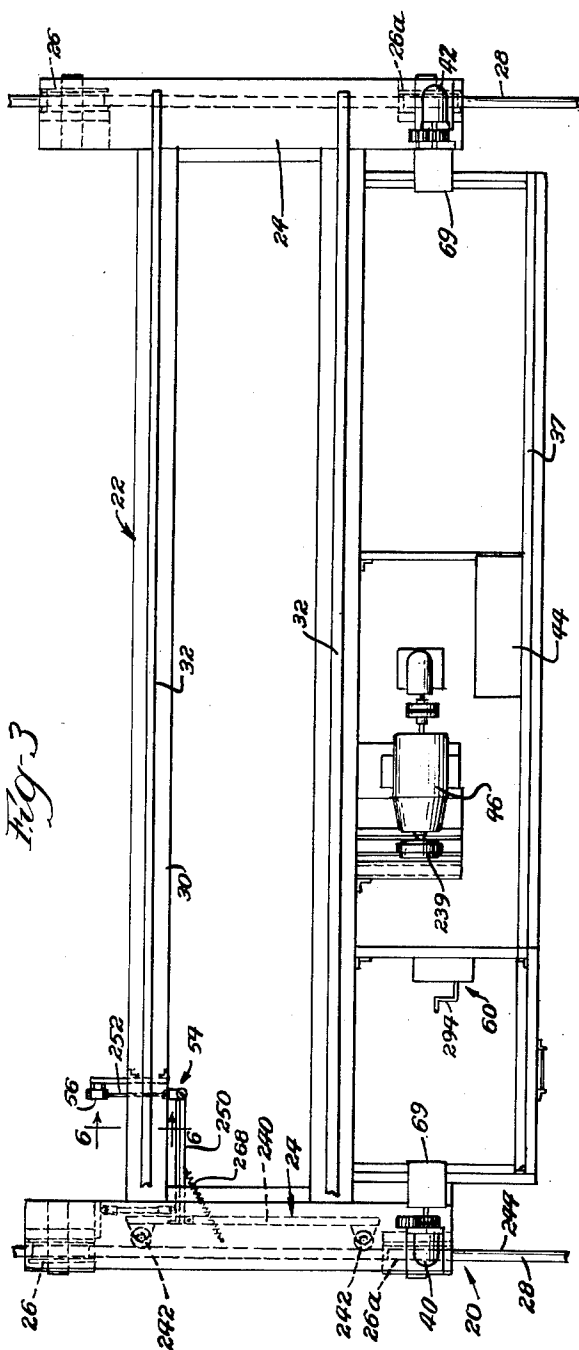
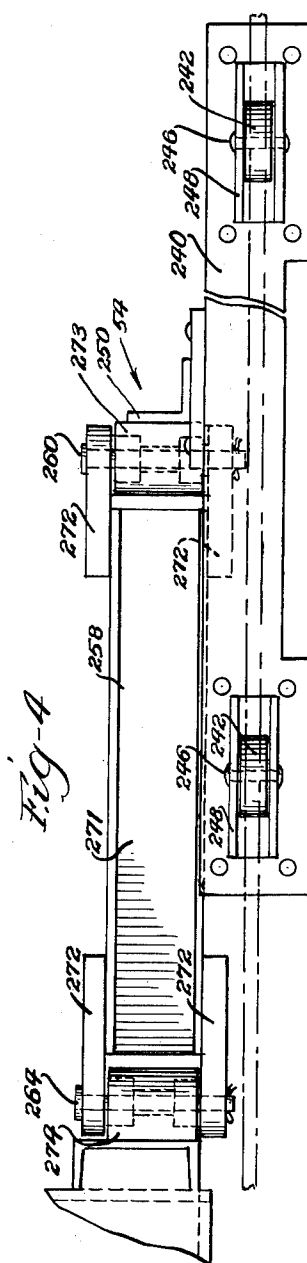
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HYDRAULICALLY OPERATED OVERHEAD CRANE

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6 Sheets-Sheet 2



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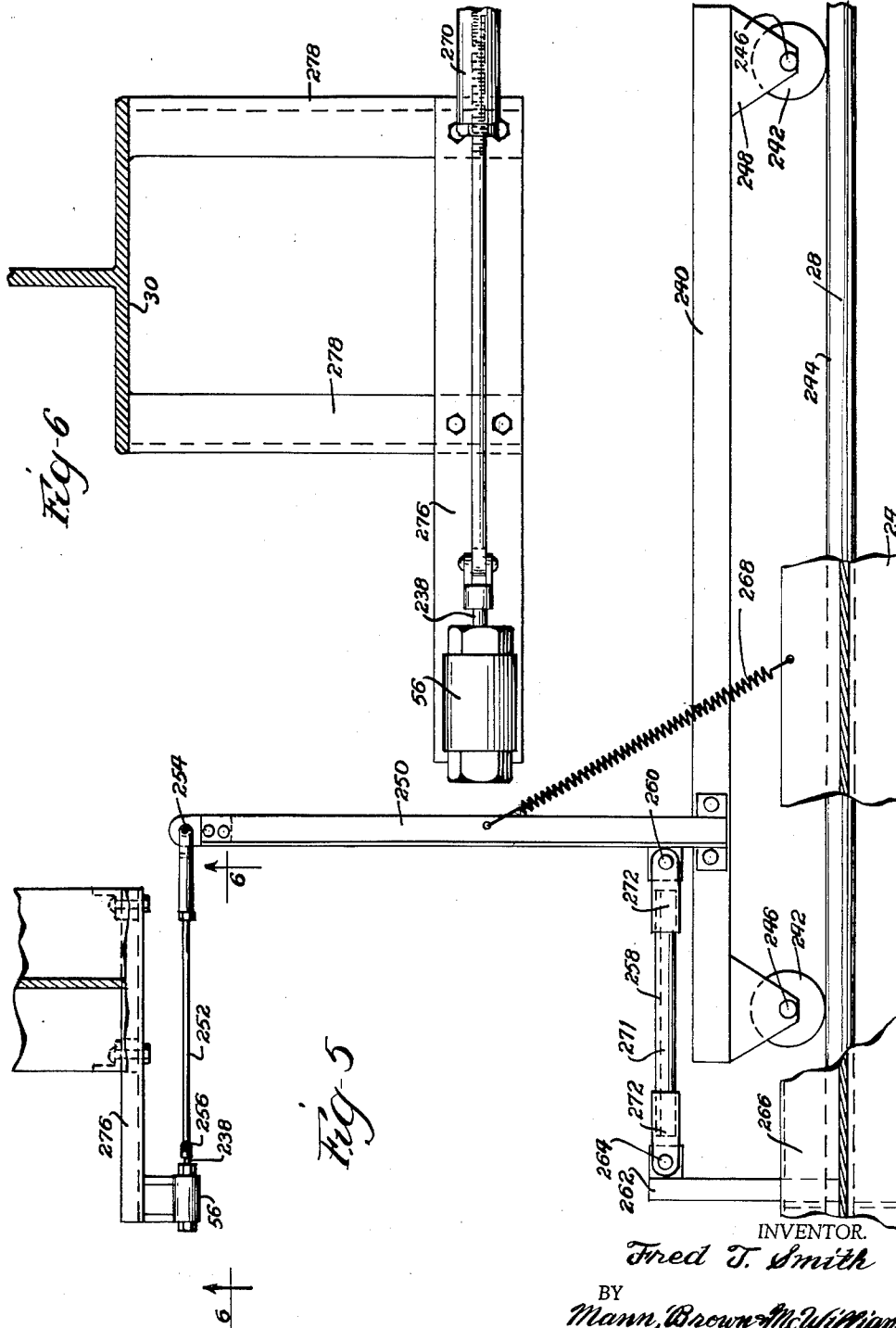
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HYDRAULICALLY OPERATED OVERHEAD CRANE

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6 Sheets-Sheet 3



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HYDRAULICALLY OPERATED OVERHEAD CRANE

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6 Sheets-Sheet 4

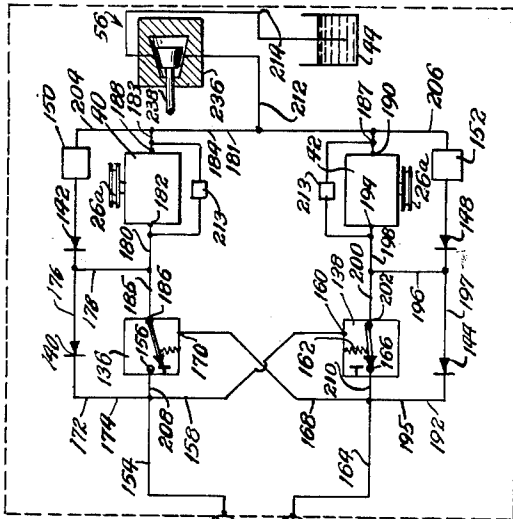


Fig. 7

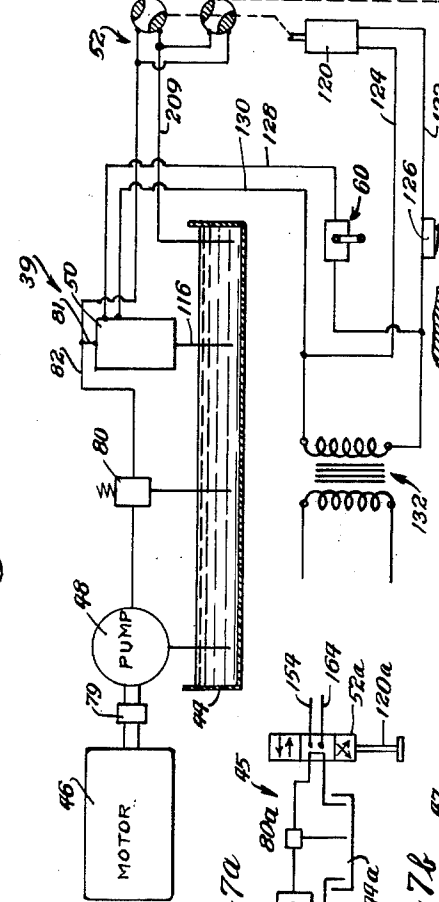


Fig. 7a



Fig. 7b

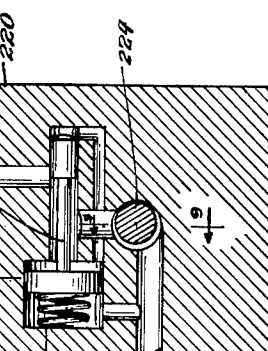


Fig. 8

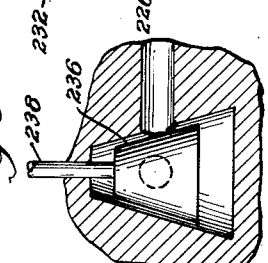


Fig. 9

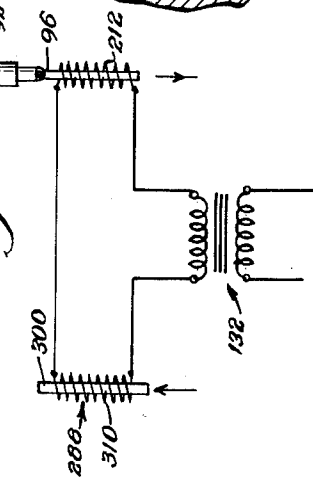


Fig. 10

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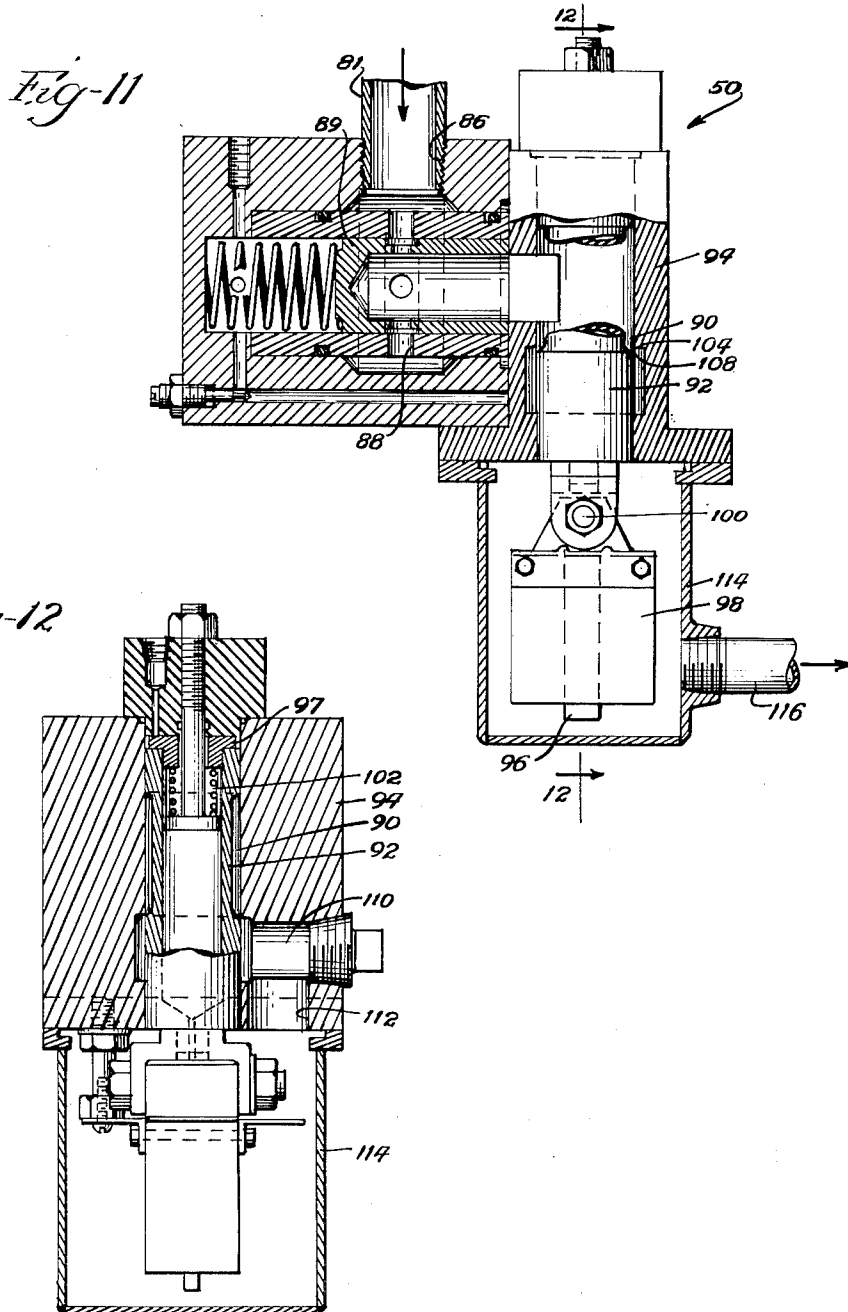
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HYDRAULICALLY OPERATED OVERHEAD CRANE

Filed Oct. 7, 1958

6 Sheets-Sheet 5



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2,984,191

HYDRAULICALLY OPERATED OVERHEAD CRANE

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Fig-13

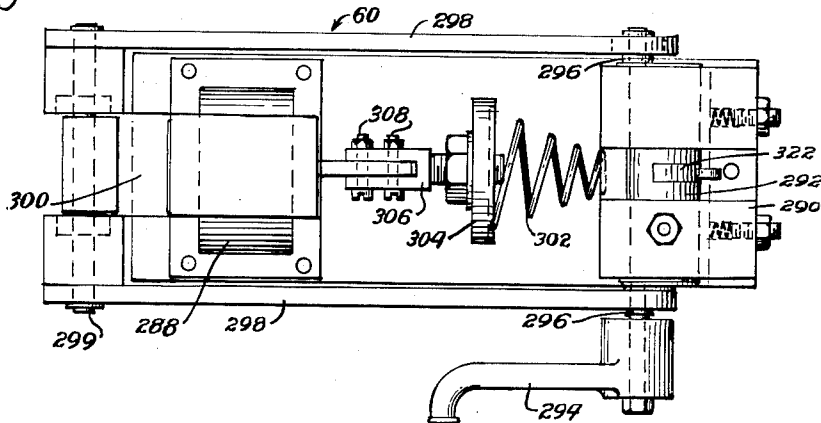


Fig-14

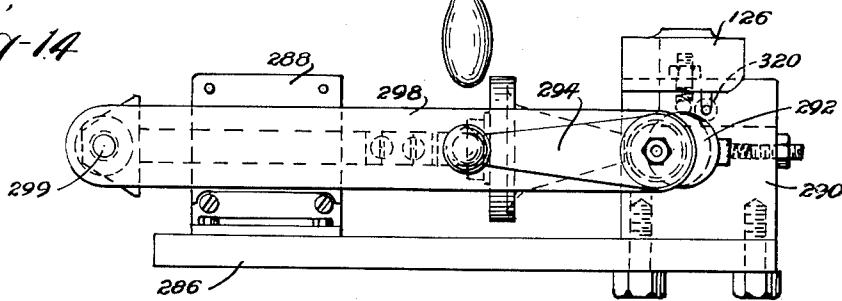
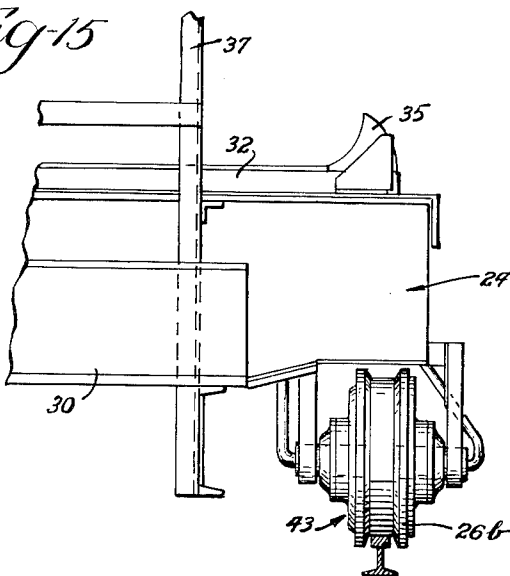


Fig-15



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2,984,191

HYDRAULICALLY OPERATED OVERHEAD
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Filed Oct. 7, 1958, Ser. No. 765,847

4 Claims. (Cl. 105—163)

My invention relates to a hydraulically operated overhead crane, and more particularly, to hydraulic apparatus and systems for effectively controlling the movement of the crane bridge along its runway.

Overhead cranes conventionally include a bridge that includes girders extending between trucks which ride on spaced runway rails mounted above the area that the crane is to move over. The bridge in turn carries track rails that extend longitudinally of the bridge and transversely of the runway, on which the trolley operates that carries the crane hoist.

The apparatus for moving the bridge of a conventional overhead crane along its runway conventionally includes and requires a squaring shaft that extends between the crane trucks and solidly connects like wheels of the trucks so that the crane bridge will not skew as it moves down the runway. The bridge is motivated by employing a variable speed electric motor coupled to the shaft by a gear train, couplings, and the like. As the shaft must be 70 feet in length on the average, and the numerous gears, bearings, couplings and the like must be carefully assembled, manufacturing costs are unduly high due to the expensive materials and large amount of assembly time required.

A principal object of my invention is to provide hydraulic apparatus for moving the bridge of overhead cranes which eliminates the squaring shaft together with its gear train, bearings, and the variable speed electric motor, while at the same time provides perfect control over the movement of the bridge and insures that the bridge remains square with its runway.

Yet a further principal object of my invention is to provide a hydraulic liquid synchronizing motor control circuit for synchronizing the operation of hydraulic motors employed to actuate the trucks at each end of the crane.

A further principal object of my invention is to provide an overhead crane in which the movement of the bridge is at all times subject to stepless speed control, regardless of whether the bridge is to be accelerated to full speed or braked to a full stop.

Still a further object of the invention is to provide an overhead crane in which the bridge may be actuated by hydraulic motors that are operationally controlled to prevent skewing of the bridge with respect to its running.

Another important object of the invention is to provide a remote control for the bridge of an overhead crane that eliminates the need for the sliding or wearing surfaces or contacts that are commonly required in the friction brakes and electrical controls now employed in conventional overhead crane control mechanisms, with consequent savings in initial investment and maintenance costs.

Yet a further object of the invention is to provide a control system for overhead cranes which insures complete control over the movement of the crane regardless of the load carried by it or the skill of the operator.

Other objects, uses and advantages will be obvious or

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become apparent from a consideration of the following detailed description and the application drawings.

In the drawings:

Figure 1 is a side elevational view of an overhead crane arranged in accordance with my invention, the trolley being shown in phantom;

Figure 2 is an end elevational view of the crane shown in Figure 1, the trolley being omitted and the view being taken from the left hand side of Figure 1;

Figure 3 is a plan view of the crane shown in Figures 1 and 2, the trolley being omitted;

Figure 4 is a fragmental elevational view of the squaring control employed in the crane of Figures 1 and 3, the device being viewed is seen in Figure 2 but on an enlarged scale;

Figure 5 is a plan view of the squaring control shown in Figure 4 illustrating portions of the adjacent crane structure to which it is connected;

Figure 6 is a view along line 6—6 of Figures 3 and 5;

Figure 7 is a diagrammatic view schematically illustrating a synchronizing hydraulic motor control circuit (shown within the area enclosed by the dashed lines), together with an appropriate directional and speed control hydraulic circuit for actuating the synchronizing circuit, for controlling the movements of the bridge of Figures 1—6;

Figures 7a and 7b illustrate simplified direction and speed control circuits that may be substituted for that shown in Figure 7;

Figure 8 is a diagrammatic cross-sectional view illustrating a flow control valve that may be employed as part of the hydraulic circuit of Figure 7;

Figure 9 is a diagrammatic fragmental cross-sectional view along line 9—9 of Figure 8;

Figure 10 is a diagrammatic plan view illustrating the principal components of the remote control device that I have provided for controlling the movement of the crane bridge;

Figure 11 is a sectional view through a specific form of valve employed in the hydraulic circuit of Figure 7, which is controlled by the circuit of Figure 10;

Figure 12 is a diagrammatic cross-sectional view along line 12—12 of Figure 11;

Figure 13 is a plan view of a hand control forming a part of the remote control device diagrammatically illustrated in Figure 10;

Figure 14 is a front elevational view of the device shown in Figure 13; and

Figure 15 is a fragmental side elevational view illustrating a modified overhead crane bridge structure including a special hydraulic motor for operating same.

General description

Reference numeral 20 of Figures 1—3 generally indicates an overhead crane in which the principles of my invention have been embodied. Crane 20 includes the familiar bridge 22 secured between trucks 24 that employ flanged wheels 26 which ride on spaced rails 28. The rails 28 are supported in any suitable manner along the area over which the crane 20 is to operate.

The bridge 22 includes the usual girders 30 that carry the operator's cage 29 and on which rails 32 are mounted that form the runway for trolley 34 that is shown in phantom in Figure 1. Trolley stops 35 are conventionally provided at the ends of rail 32 to limit the movement of the trolley longitudinally of the bridge, and the bridge conventionally carries hand rail 37.

As mentioned previously, cranes of the type shown in Figures 1—3 ordinarily include a squaring shaft that extends between and fixedly unites two of the wheels 26, these wheels being designated 26a in the illustrated embodiment (see Figure 3). The squaring shaft acts in a

manner similar to the solid axle employed in railroad car wheels and forms a solid torque connection between the two trucks so that the bridge will stay perpendicular with respect to the rails 28 as the bridge moves down its runway. Conventional overhead crane bridges are actuated by turning the squaring shaft through a gear train that is in turn powered by a variable speed electric motor. Braking is achieved in cab operated cranes by employing a foot operated friction brake closely resembling the automatic type, while in floor controlled cranes, friction type brakes are electrically controlled from the floor, which precludes the desired sensitivity of control.

In accordance with my invention, the squaring shaft is eliminated and the thus disjunctively related spaced wheels 26a are driven by separate hydraulic motors 40 and 42 with no other connection between them. The hydraulic motors 40 and 42 are incorporated in the synchronizing hydraulic motor control circuit 41 shown in Figure 7 which is designed to synchronize the operations of motors 40 and 42 and thereby prevents any tendency of the bridge to skew even though the conventional squaring shaft has been eliminated. A suitable direction and speed control circuit 39 may be employed to operate circuit 41, and such circuit 39 may include a tank 44 (see Figures 1 and 3) forming a reservoir for the hydraulic liquid, a constant speed, continuous duty A.C. squirrel cage type electric motor 46 that actuates constant volume supply pump 48 (through a suitable coupling) which supplies the hydraulic liquid under pressure to the motors, a hydraulic liquid ejection or dump valve 50 (see Figure 7) which controls the volume of hydraulic liquid reaching the hydraulic motors, and a four-way hydraulic liquid flow orienting valve 52, which controls the direction of flow of the hydraulic liquid to the synchronizing control circuit 41 and thus the direction of rotation of the motors. The synchronizing circuit 41 includes a flow control valve 56 of a squaring control device 54 (see Figure 3) which varies the hydraulic liquid supply to one of the motors 40 or 42 as required to keep the bridge from skewing as it moves down its runway.

In the arrangement of Figure 7, the operation of motors 40 and 42 is controlled by hand control 60 of directional and speed control circuit 39 (see Figure 13), which is electrically associated with valves 50 and 52 as diagrammatically illustrated in Figures 7 and 10 to provide finger tip control over movement of the crane bridge.

As a practical matter, however, more simplified directional and speed control circuits may be employed to operate synchronizing circuit 41, such as, for instance, the directional and speed control circuits 45 and 47 of Figures 7a and 7b, respectively. Thus, fixed volume pump 48a supplies hydraulic liquid to hand operated four-way control valve 52a through relief valve 80a in the embodiment of Figure 7a, while in the embodiment of Figure 7b, the variable volume reversible pump 48b, which is actuated by any suitable type motor 46b, supplies hydraulic liquid directly to circuit 41.

In operation, the crane operator starts up operation of the motor 46 and the pump 48 or pumps 48a at the beginning of the work day, and they continuously operate during the period that the overhead crane is in use. In the arrangement of Figure 7, the valve 50 is positioned to continuously return the hydraulic liquid supplied by pump 48 to reservoir 44. When it is desired to move the crane bridge 22, the operator actuates hand control 60 to set the valve 50 so that hydraulic liquid is fed to the motors 40 and 42, and to effect the proper positioning of four-way control valve 52 in accordance with the desired direction of movement. By gradually moving the valve 50 from zero hydraulic liquid feed position to maximum feed position, the hydraulic motors 40 and 42 smoothly accelerate the bridge 22 up to maximum speed (if this speed is desired) and in the direction desired; to slow the bridge down to a full halt, the hand control is gradually moved in the opposite direction to channel the

hydraulic liquid back to the tank 44 through the valve 50.

In the circuit of Figure 7a, hand control valve 52a is manually positioned to achieve the speed and direction desired, relief valve 80a returning unneeded hydraulic liquid to reservoir 44a, while in the circuit of Figure 7b, pump 48b and its motor 46b are operated at the speed and direction desired to achieve directional and speed control of motors 40 and 42, additional hydraulic liquid being supplied to this circuit through check valves 49 when the pressure on the suction side of the pump 48b reaches a predetermined minimum.

Regardless of the specific directional and speed control circuiting employed, the control of valve 56 of the synchronizing circuit 41 by the squaring control device 54 insures that any tendency of the bridge 22 to skew during its movement along the runway is overcome by so varying the hydraulic feed to motors 40 and 42 that the skewing action is fully compensated for.

The hydraulic motors for bridge

Hydraulic motors 40 and 42 in the embodiment of Figures 1-14 are of any conventional type suitable for the purpose, while in the embodiment of Figure 15, the motor 43 is of the type shown in Figure 10 of my co-pending application Serial No. 710,452, filed January 22, 1958, the disclosure of which is hereby incorporated by reference. Motors 40 and 42 are mounted in any suitable manner on the respective trucks 24 and drive wheels 26a through appropriate gear reducers 69 and chains 70 trained about appropriate sprockets that are respectively keyed to the respective gear reducers and flange wheels 26a.

In the embodiment of Figure 15, the motor 43 is built into the flange wheel 26b in the manner described in said application Serial No. 710,452, thus eliminating the need for gear reducers and the chain and sprocket drive.

In the hydraulic motor synchronizing control circuit of Figure 7, the same results are obtained when motors 43 are substituted for the respective motors 40 and 42.

The motor 43 is of special significance as it provides a uniform torque output over its cycle of operation, and furthermore, is capable of providing high torque at low speed regardless of whether the motor operates in a forward or a reverse direction. Consequently, this motor serves as a drive unit having stepless speed control and is capable of moving heavy loads at low speeds without pulsation.

The disclosure of said application Serial No. 710,452 may be referred to for a specific description of motor 43. No further description of conventional motors 40 and 42 shall be made as any suitable hydraulic motor structure will be satisfactory for the purposes of my invention with regard to the synchronizing control provided by circuiting 41 of Figure 7.

The hydraulic circuiting

Referring now to Figure 7, the continuously operating pump 48 (of directional and speed control circuit 39), which may be of any conventional type, is driven by motor 46 through appropriate coupling 79 (in the illustrated embodiment, see Figure 1) and supplies hydraulic liquid under pressure to four-way control valve 52 through conduit 82 in which a conventional type of pressure relief valve 80 may be interposed, and with which valve 50 is connected by appropriate conduit 81.

A specific form of valve 50 is shown in Figures 11 and 12 and it will be noted that the valve 50 is actually arranged to tap supply conduit 82 to return the hydraulic liquid to reservoir 44 when it is not desired to actuate the hydraulic motors at full speed. As shown in Figure 11, the hydraulic liquid enters valve 50 through port 86 that leads to distributing passages 88 through which the hydraulic liquid passes into hollow spool 89 that is in communication with space 90 defined by valve spool 92 and the valve housing 94. The spool 92 is mounted for

sliding movement longitudinally of its axis and is connected to core member 96 of solenoid 98, as by an appropriate bolt 100. Compression spring 102 (see Figure 12) acting on nut 97 carried by spool 92 biases the spool 92 upwardly of Figures 11 and 12 to close off the space 90 at the internal shoulder 104 (the position of Figure 12). When the coil of solenoid 98 is energized, the core member 96 is moved downwardly against the action of spring 102 to form the annular orifice 108 (the position of Figure 11) that permits hydraulic liquid flow through passages 110 and 112 (see Figure 12) into the sealed solenoid housing 114 and thence through conduit 116 back to tank 44.

Figures 11 and 12 have been provided for illustrative purposes only as any suitable valving arrangement conforming to the principles of my invention will be satisfactory.

The four-way control valve 52 of circuit 39 may be of any suitable type, though in the embodiment of Figure 7 it is shown as including a solenoid 120 (see Figure 7) that is energized through appropriate leads 122 and 124 when microswitch 126 is closed. For purposes of this description, it will be assumed that when the solenoid is not energized, the valve 52 will be positioned for hydraulic liquid feed in the manner shown in Figure 7, whereas when the solenoid 120 is energized, the valve will be positioned for hydraulic liquid feed in the opposite direction.

In the showing of Figure 7, the leads 122 and 124 of solenoid 120 are connected in parallel with leads 128 and 130 that are provided to supply electrical energy to the solenoid 98 of valve 50. The leads 122, 124, 128 and 130 are energized by means of an appropriate transformer 132 or in any other suitable manner.

The hydraulic system downstream of the four-way control valve 52 forms the hydraulic synchronizing motor control circuit 41, which includes counterbalancing valves 136 and 138, check valves 140, 142, 144 and 148, fixed orifice flow control valves 150 and 152, valve 56, and motors 40 and 42 (or a pair of motors 43), motors 40 and 42 in the showing of Figure 7 being coupled directly to the respective wheels 26a for simplicity of illustration. Conduit 154 extends between one port of four-way control valve 52 and a port 156 of counterbalance valve 136, conduit 158 extending between conduit 154 and port 160 of counterbalance valve 138 for the purpose of holding counterbalance valve 138 open against the action of an appropriate biasing spring 162, when four-way control valve 52 is positioned as shown in Figure 7 to admit hydraulic liquid under pressure to conduit 154. A similar conduit 164 communicates with counterbalance valve 138 at port 166, conduit 168 extending between conduit 164 and port 170 of counterbalance valve 136 for the purposes of holding counterbalance valve 136 open when the direction of hydraulic liquid flow is reversed.

A conduit 172 including the segments 174, 176, 178 and 180 extend between conduit 154 and the port 182 of motor 40, check valve 140 being interposed in conduit 172 between conduit 154 and conduit segment 178. Conduit 185 connects the conduit section 180 and port 186 of counterbalance valve 136.

A conduit 181 including segments 183, 184 and 187, extends between port 188 of motor 40 and port 190 of motor 42.

The other side of the hydraulic system includes conduiting similar to that already described, a conduit 192 extending between the conduit 164 and port 194 of motor 42, the conduit 192 including segments 195, 196, 197 and 198 and having interposed therein check valve 144 between conduit 164 and conduit segment 196. Conduit 200 extends between conduit segment 198 and port 202 of counterbalance valve 138.

A bypass conduit 204 in effect extends across the ports 182 and 188 of motor 40, and as illustrated, the conduit 204 has check valve 142 and flow control valve 150 in-

terposed therein. Motor 42 has a similar bypass conduit 206 connected thereabout and conduit 206 has check valve 148 and flow control valve 152 interposed therein. As illustrated, bypass conduit 204 extends between conduit segments 176 and 184, while bypass conduit 206 extends between conduit segments 184 and 197.

A conduit 208 extends between port 156 of counterbalance valve 156 and conduit 154 while conduit 210 extends between port 166 of counterbalance valve 138 and conduit 164. Conduit 209 extends between four-way control valve 52 and reservoir 44.

Conduit 181 thus connects motors 40 and 42 in series, a conduit 212 extending between conduit 181 and variable orifice flow control valve 56, which returns hydraulic liquid to tank 44 through an appropriate conduit 214.

The check valves 140, 142, 144 and 148 may be of any conventional type that will block hydraulic liquid flow in the direction indicated by the arrowheads, that is hydraulic liquid flow is permitted in the direction opposite to that indicated by the arrow heads. The counterbalance valves 136 and 138 may be of any suitable type, their functions being well known in the art. Pressure relief valves 213 of any appropriate type may be connected across the inlet and outlet ports of motors 40 and 42 as a safety factor against excessive pressures in the adjacent circuiting during braking of the bridge, when these motors may tend to act as pumps.

Flow control valves 150, 152 and 56, may be of the type shown diagrammatically in Figures 8 and 9, and may include a valve body 220 formed with an inlet 222 which leads to a flow control valve head 224 and thence to a flow outlet 226. The volume flow passing from outlet 226 is rendered constant by a hydrostatic compensating device generally indicated at 228 which includes a double headed piston 230 biased toward the right hand side of Figure 8 by a spring 232.

The function of the various structural elements illustrated in Figure 8 is well known in the art, so no further specific showing is believed necessary, though it may be mentioned that the primary function of these valves is to provide accurate volume control in hydraulic circuits regardless of any variations in the imposed liquid pressure. In the illustrated embodiment, the flow control member 224 comprises a tapered element 236 which in the case of valves 150 and 152 is secured in place to permit a fixed amount of liquid flow to pass the respective valves, while in the case of valve 56, the member 236 is mounted to permit variation of the liquid flow past the valve.

In the case of valves 150 and 152, the member 236 may be locked in place by suitable lock nuts engaging stem 238, and the member 236 is preferably positioned so that the valves 150 and 152 will pass a liquid flow that is equivalent to the leakage through the respective motors 40 and 42.

In the case of valve 56, the stem 138 is actuated by the squaring control 54 to open and close the valve 56 as is necessary to maintain the crane bridge square with its runway. Motor 46, pump 48 and tank or reservoir 44 may be mounted in any suitable manner on bridge 22, for instance, in the manner indicated in Figures 1-3. The conduiting indicated in Figure 7 is omitted from the showing of Figures 1-3, but can be arranged about the bridge as seems most expedient to the designer. Motor 46 may be provided with a suitable brake where indicated at 239 in Figure 3.

Circuits 45 and 47 have been previously described, and the components diagrammatically illustrated may be of any conventional type that will perform the functions desired. The respective components can be arranged about the bridge as seems most expedient to the designer.

Squaring control device

The squaring control device 54 (see Figures 3, 5 and 6) comprises a trackway follower in the form of a truing

or control arm 240 positioned adjacent one of the runway track rails 28 and including a pair of spaced rollers 242 engaging the side 244 of the head of the rail. Rollers 242 are rotatably secured to the member 240 by pins 246 that are fixed between the spaced flanges 248 at each end of the member 240. The pins 246 are spaced equal distances from the center line of member 240 so that when the rollers are in engagement with the rail 28, the member 240 extends parallel to the rail 28.

The truing or control arm 240 fixedly carries an arm or link 250 (see Figure 5) which is positioned at right angles with respect to the member 240. The arm or link 250 pivotally carries a connecting rod 252 which is connected to the stem 238 of valve 56. The rod 252 is pivoted to arm or link 250 as at 254, and is pivotally secured to the stem 238 as at 256.

A squaring control link 258 is pivotally secured between the arm or link 250 as at 260 and an arm 262, as at 264, which is fixed to the member 266 of the adjacent truck 24. A tension spring 268 is preferably secured between the truck from member 266 and the arm or link 250, as best seen in Figure 5, for purposes of biasing the rollers 242 of control or truing arm 240 against the head of rail 28.

Connecting rod 252 preferably is made adjustable in length as by employing a suitable screw threaded fitting as at 270 (see Figure 6). Control link 258 comprises a bar 271 carrying spaced lugs 272 at each end thereof (see Figure 4) which are formed to receive pins 260 and 264 that pivotally connect link 258 to pivot blocks 273 and 274 carried by arms 250 and 262, respectively.

The valve 56 is placed in operative relation with the squaring control 54 by being secured in any suitable manner to supporting bar or member 276 that is fixed to suitable supports 278 welded or otherwise secured to the adjacent girder 30.

As a practical matter, squaring control 54 may be positioned in association with either girder 30 at either end of each girder, or may be associated with a special framework carried between or on either side of the girders, as will now be obvious to those skilled in the art, so long as the hydraulic circuit valve 56 is mounted for operation in a manner that is consistent with the objects of the invention.

During movement of the crane bridge along its runway, control arm or member 240 is maintained in true alignment with the rail, and since link 250 is fixed with respect to truing or control arm 240, it is positioned always transversely of the runway. The connecting rods 252 and 258 form a parallel linkage between the squaring control arm 250 and the bridge, and if the bridge tends to skew in either direction with respect to its runway, stem 238 of valve 56 is moved to vary the hydraulic liquid feed to the hydraulic motors so as to counteract and effectively prevent the tendency to skew.

Control for hydraulic circuiting

As mentioned hereinbefore regarding directional and speed control circuit 39, the motor 46 and pump 48 continuously operate to supply hydraulic liquid under pressure to the hydraulic system, ejection or dump valve 50 being provided to control the amount of hydraulic liquid that reaches four-way control valve 52, which in turn controls the speed of motors 40 and 42 (or 43).

The circuit 39 may be so arranged that the amount of hydraulic fluid that is ejected or returned to tank 44 by valve 50 is remotely controlled by hand control 60 (see Figures 15 and 14) that may be mounted, for instance, in the cage 29 of the crane. As diagrammatically illustrated in Figures 13 and 14, the hand control 60 may comprise a suitable support 286 on which is mounted a solenoid 288 and a shaft support 290 for a shaft 292 that is actuated by crank arm 294 of the hand control. The shaft 292 at each of its ends is provided with eccen-

trically positioned studs 296 (see Figure 13), the handle 294 being keyed to one of these studs. The studs 296 each pivotally receive one end of a link 298, the other ends of which are pivotally secured as by pin 299, to core member 300 of solenoid 288. In the illustrated embodiment of Figure 13, a compression spring 302 is interposed between shaft support 290 and abutment 304 of a yoke member 306 that is secured to core member 300 by appropriate bolts 308.

As diagrammatically illustrated in Figure 10, the coil 310 of solenoid 288 is connected in series with the coil 212 of solenoid 98 of valve 50, spring 102 being shown as acting in tension, though in the specific embodiment of Figure 11, it acts in compression. Spring 102 is preferably of sufficient strength to hold the core member 96 above a central position within coil 212 (in the illustrated arrangement), even against the maximum magnetic effect exerted by coil 212, though it should be sufficiently flexible to flex under the magnetic action of the coil when energized. In the showing of Figure 7, the solenoids of hand control 60 and valve 50 are connected in series with the transformer 132.

The maximum speed position of the hand control is achieved when core member 300 is centered within coil 310, which provides maximum inductance in the simple circuit in which coils 212 and 310 are incorporated with a consequent minimum current. This permits the spring 102 of valve 250 to close off its orifice 108, which insures that all the hydraulic liquid supplied by pump 48 and passed by pressure relief valve 80 will be fed to four-way control valve 52.

If the crank 294 is turned to move core member 300 away from its central position within coil 310 (in the direction of the arrow of Figure 10), the inductance of the simple circuit in which coils 212 and 310 are incorporated is substantially reduced, which effects a substantial increase in the current passing through this circuit; this in turn effects a sufficient increase of the magnetic action of coil 212 to draw the spool member 92 downwardly, as viewed in Figure 11, to open orifice 108, thereby permitting the return or short-circuiting of hydraulic liquid back to tank 44.

The "neutral" position of the hand control is achieved when coil 212 is provided with sufficient current to fully open orifice 108 of valve 50 so that all hydraulic liquid supplied by pump 48 is ejected back to tank 44. In this position, the core member 300 will be displaced a maximum amount from the center of coil 310, and spring 302 is provided in the hand control 60 to bias the core member to this position for safety purposes.

For purposes of this description, it will be assumed that when the crank 294 is positioned as shown in Figure 14 with respect to the links 298, the neutral position is provided.

When the crank 294 is turned upwardly or downwardly 90 degrees, the core member 300 is moved to its central position within coil 310, which reduces the magnetic effect of coil 212 to its minimum and permits spring 102 to close orifice 108 of valve 50.

The hand control 60, in accordance with my invention, is also employed to effect the changes in the positioning of four-way control valve 52. As already mentioned, the solenoid 120 of this valve is energized by closing micro-switch 126. As best seen in Figure 14, the roller 320 of switch 126 preferably operates in a groove 322 formed in hand control shaft 292. Switch 126 is mounted adjacent shaft support 290 in any suitable manner.

The shaft groove 322 is proportioned so that when the crank 294 is in its neutral position, a slight movement either upwardly or downwardly will close or open switch 126 as required to effect the change in rotation of motors 40 and 42. For purposes of this description, it will be assumed that when crank 294 is moved downwardly, switch 126 will be closed to change four-way control

valve 52 from the position shown in Figure 7 to its opposite position.

With regard to directional and speed control circuits 45 and 47, the four-way control valve 52a or the controls for variable volume pump 48b may be mounted in cage 29 for operation by the crane operator.

Operation

When the operator puts the crane in operation, assuming directional and speed control circuit 39 is employed, he starts up motor 46 and does not shut it off until the workday of the crane is completed. Motor 46 continuously operates the pump of the specific directional and speed control circuit it serves, which supplies hydraulic liquid under pressure to synchronizing circuit 41 as required to effect movement of the bridge. In the directional and speed control circuit of Figure 7, the hydraulic liquid being supplied is entirely returned to tank 44 when the hand control 60 is in its neutral position. When the circuit 45 of Figure 7a is employed, motor 46 operates as described above and the hydraulic liquid supplied is entirely returned to tank 44a when the hand operated valve 52a is positioned as shown (its neutral position). In the circuit 47 of Figure 7b, the controls of pump 48b are merely set so that no hydraulic liquid is pumped.

Assuming that directional and speed control circuit 39 is employed, when the operator desires to move the crane bridge to the left of Figure 7 (which is to the right of Figure 2 and downwardly of Figure 3), the operator turns hand control crank 294 upwardly, which provides the four-way control valve positioning shown in Figure 7. If the hand control crank 294 is moved the full 90 degrees, the bridge moves at maximum speed to the left of Figure 7 along its runway, while reverse movement of crank 294 effects a slowing of the bridge, and if desired, a positive braking action.

If the crank 294 of hand control 260 is moved downwardly from its neutral position, the solenoid 120 of four-way control valve is energized to reverse the position of the valve and change the direction of hydraulic liquid flow in the hydraulic system downstream of the four-way control valve which turns the motors 40 and 42 in the opposite direction, thus providing a movement of the crane bridge in the opposite direction. Movement of the hand control downwardly through its full range 90 degrees brings the speed of movement of the crane bridge up to its maximum and the return of the crank 294 to its neutral position may be employed to effect a braking action on the bridge and bring it to a complete halt.

Where directional and speed control circuit 45 is employed, the valve 52a is changed to provide the hydraulic flow desired by gripping handle 120a and moving the valve to one of the settings indicated. Relief valve 80a returns excess hydraulic liquid to tank 44a between the full open and closed positions of valve 52a.

With regard to circuit 47, appropriate adjustment of the direction of rotation and volume delivery of pump 48b effects the changes in direction of movement and speed desired.

The squaring control over the crane bridge provided by synchronizing circuit 41 is effective both for acceleration and deceleration of the crane bridge in either direction of its movement, regardless of the directional and speed control circuit employed, the squaring control device 54 together with valve 56 of the hydraulic circuit 41 effecting changes in the speed of operation of the motors to overcome any tendency of the bridge to skew, even during braking of the bridge, thus keeping operation of the motors (40 and 42 or 43) in substantial synchronism during operation of the crane.

For instance, assuming that the four-way control valve 52 of directional and speed control circuit 39 is positioned as shown in Figure 7 so that the bridge of the crane will move to the left of Figure 7 and the bridge is accelerating or moving at uniform speed, hydraulic liquid passing

through four-way control valve 52 will enter conduit 154 and pass thence to conduit 172 and through its check valve 140 as well as its segments 174, 176, 178 and 180 to port 182 of motor 40. The spring of counterbalance valve 136 maintains this valve closed while the pressure of the hydraulic liquid in conduit 158 holds counterbalance valve 138 open against the action of its spring 162, as shown in Figure 7.

The hydraulic liquid is forced through motor 40 to operate same and passes thence to conduit 181 and its segments 183, 184 and 187 to port 190 of motor 42. The hydraulic liquid is forced through motor 42 to operate same and then leaves its port 194 through conduit segments 198 and 200 to port 202 of counterbalance valve 138 and through counterbalance valve 138 and conduit 210 to conduit 164 and thence back through four-way control valve 52 to reservoir 44.

At the same time, the fixed orifice flow control valve 150 permits a volume flow through bypass conduit 204 equivalent to the volume of hydraulic liquid leaking by motor 40. This bypass quantity of hydraulic liquid may be considered a compensating quantum as it is employed to speed up the operation of motor 42 where this is necessary; its actual amount should be as little as possible since it represents power lost from the system, but it may be larger in amount than the volume of hydraulic liquid leaking by the motor.

The neutral setting of valve 56 is such that it returns to tank 44 a fluid flow equivalent to that being passed by fixed orifice flow control valve 150. The valve 56 is at this setting as long as the crane bridge remains square with its runway, the links being proportioned and adjusted so that arm 250 of squaring control 54 is parallel with the bridge girders when valve 56 is in its neutral setting.

If, when the crane bridge is moving to the left of Figure 7 and the bridge is accelerating or moving at uniform velocity, the end of the bridge on which motor 40 is mounted tends to run ahead of motor 42, the squaring control 54 and valve 56 effect a sufficient speeding up of motor 42 to offset the tendency of the bridge to skew. In the illustrated embodiment, the squaring control 54 effects a pull on stem 238 of valve 56 as bridge 32 tends to move out of alignment with link 250 of the squaring control, to reduce the amount of hydraulic liquid passing through valve 56, and thereby effects a larger volume of flow of liquid through conduit 181 to motor 42. This speeds up motor 42 a corresponding amount so that the tendency of the bridge to skew is overcome and the action of motors 40 and 42 on the bridge remains synchronized.

If the end of the bridge on which motor 40 is mounted tends to lag as the bridge is moving to the left of Figure 7, the squaring control 54 effects a push on stem 238 of valve 56 to further open this valve so that it will pass a larger volume of flow of hydraulic liquid to tank 44. This means that a less volume flow of hydraulic liquid reaches motor 42 with the result that motor 42 tends to slow down whereby the tendency of the bridge to skew is overcome, and the action of the motors 40 and 42 on the bridge remains synchronized.

Manifestly, the proportioning of the elements of squaring control 54 and the movement of stem 238 of valve 56, as well as the liquid flow provided by this valve must be such that the adjustment made by the squaring control 54 on valve 56 in response to a tendency to skew effects the desired reduction in or increase flow of the hydraulic liquid to motor 42.

The same hydraulic action described immediately above obtains when the volume flow of hydraulic liquid supplied to circuit 41 is reduced gradually enough to effect a slowing of the motors without the inertia of the load on the motors causing them to act as pumps. However, the hydraulic liquid supply flow may be, and frequently is,

reduced at a greater rate to effect a braking action on the bridge and its load.

When this braking action takes place, the inertia of the load tends to keep the bridge moving in spite of a reduced volume flow feed; the traction of the wheels 26a on the rails 28 keeps the wheels turning, and causes motors 40 and 42 to act as pumps, which temporarily reverses the flow of hydraulic liquid in circuit 41. Thus, motor 42 pumps hydraulic liquid into conduit 181 and motor 40 pumps hydraulic liquid into conduit 180, pressure relief valve 213 being set to return hydraulic liquid to, for instance, the port 183 side of motor 40 when the pressure in conduit 180 side exceeds a safe maximum.

Where the valve 56 is positioned to reduce the volume of hydraulic liquid returned to tank (under the skewing conditions first assumed above), the motor 40 when acting as a pump will operate under a somewhat greater pressure than motor 42, which effects a drag on the motor 40 that corresponds to the speeding up effect achieved on motor 42 when motors 40 and 42 act as motors. When the valve 56 is positioned to increase the rate of return of hydraulic liquid to tank due to the lag of the end of the bridge on which motor 40 is mounted, motor 42 under braking conditions will operate under a greater back pressure than motor 40, which means that motor 40 will operate as a pump at a greater rate than motor 42, this differential corresponding to the reduction of speed of motor 42 when motors 40 and 42 act as motors.

Thus, the synchronizing action of circuit 41 keeps the effective output of motors 40 and 42 in synchronism on braking of the bridge, although the compensating action is applied to the opposite end of the bridge. The changes in direction of hydraulic liquid flow in circuit 41 are entirely automatic and since the circuit is so arranged that the necessary compensating action is achieved regardless of the speed of operation of the bridge, skewing is effectively prevented.

When the bridge is moved to the right instead of to the left, the action of the squaring control and valve 56 effects a similar control over the crane bridge, though the flow of hydraulic liquid is reversed to achieve reverse operation of motors 40 and 42 as motors. Thus, when the crank 294 of hand control 60 is moved downwardly from its neutral position, solenoid 120 of four-way control valve 52 is energized to change the liquid flow through this valve. The conduit 164 would then be the pressure side of the system, and under other than braking operating conditions, the hydraulic liquid under pressure would enter conduit 164 and pass thence through conduit 192, its check valve 144, and its segments 195, 196, 197 and 198 to port 194 of motor 42. Counterbalance valve 138 would be held closed by its spring 162, the pressure of the hydraulic liquid in conduit 168 holding counterbalance valve 136 open.

The hydraulic liquid is then forced through motor 42 to operate same and leaves motor 42 through port 190, and conduit segments 187, 184 and 183 to port 183 of motor 40, through which it is forced to operate same and leaves through port 182 and thence through conduit segments 180, 185, counterbalance valve 136, conduit 208 and conduit 154 back to four-way control valve 52.

During operation of the crane bridge to the right of Figure 7, fixed orifice flow control valve 152 in bypass conduit 206 permits a bypass liquid hydraulic flow equivalent to the hydraulic liquid that leaks by motor 42.

If the end of the crane bridge at which motor 40 is secured runs ahead under other than braking operating conditions, the squaring control 54 effects a push on valve stem 238 to increase the volume flow passed by valve 56 to reduce the liquid flow reaching motor 40 which thereupon slows down sufficiently to overcome the tendency to skew; under braking conditions, motor 40 operates as a pump under greater back pressure than motor 42, which holds down the operation of motor 40 (with respect to motor 42) to achieve the same result.

If the end of the bridge at which motor 40 is secured tends to lag the other end of the bridge, the squaring control 54 effects a pull on stem 238 to close valve 56 a corresponding amount, which effects a speeding up of motor 40 sufficiently to overcome the tendency to skew; under braking conditions, motor 40 operates as a pump under proportionately less back pressure than motor 42, which maintains the increased speed (with respect to motor 42) to achieve the same result. The pressure relief valve 213 across motor 42 acts in the same manner as that across motor 40.

When motors 43 of Figure 15 are employed on the crane bridge, they are incorporated in the synchronizing circuit of Figure 7 and the results obtained are the same when the crane bridge is operated as described above. In addition, however, motors 43 provide the advantages described in my said copending application.

Advantages of invention

It will thus be seen that my invention provides a number of important advantages, some of which have already been brought out.

Perhaps the most important advantage is the elimination of the large squaring shaft required on conventional overhead cranes to prevent the skewing of the bridge with respect to its runway. The substitution of the hydraulic motors for operating the driven wheels of the bridge also eliminate the need for the conventional gear train and its associated structures. The variable speed electric motor is also eliminated in favor of a suitable constant speed continuous duty motor in the case of the embodiments of Figures 7 and 7a, which operates continuously during the period that the crane is in service.

The hydraulic motors of my said copending application when employed to drive the crane bridge, provide high torque at low speed without pulsation and thereby provide stepless speed control from exceedingly low to relatively high speeds regardless of the load carried by the crane. They also permit stepless speed control from relatively high speeds to a complete halt under the same conditions. Thus, the hydraulic motors permit the bridge to be braked gradually without employing friction surfaces.

The hand control arrangement of the directional and speed control circuit 39 provides the operator with finger tip control over the movement of the bridge, which is achieved by merely appropriately moving the single control crank 294. The element of chance is thus entirely eliminated from the operation of the bridge together with the corresponding opportunities for error and accident. The crane bridge operation is so simplified by such a directional and speed control circuit that even the most unskilled operator may perform his duties with facility.

The crane 20 usually operates on a straight runway, but the squaring control 54 and valve 56 of synchronizing circuit 41 may be readily adapted for negotiating a curved trackway by properly proportioning the path of travel of valve head 236 of valve 56 so that the necessary speeding up or slowing down of the respective hydraulic motors is achieved. Moreover, my invention is applicable to any wheeled vehicle (including those not employing flanged wheels running on rails) for maintaining the operation of the vehicle in alignment with a predetermined path of movement.

The term "uniform angular torque output type hydraulic motor" as employed in the appended claims means the motors described in my said copending application as well as their equivalents.

The term "synchronizing" as employed with reference to the hydraulic circuiting for controlling the operation of the illustrated crane truck motors is intended in the appended claims to mean equivalent hydraulic circuits for operating vehicles on curved runways, or runways that include curves,

The terms "upstream" and "downstream" as used in the appended claims refer to the direction corresponding to the direction of hydraulic liquid flow through the hydraulic components referred to.

The foregoing description and the drawings are given merely to explain and illustrate my invention and the invention is not to be limited thereto except insofar as the appended claims are so limited, since those skilled in the art who have my disclosure before them will be able to make modifications and variations therein without departing from the scope of the invention.

I claim:

1. In an overhead crane including a bridge secured between trucks that include wheels running on supporting rails, the improvement wherein hydraulic means is employed for driving at least one of the wheels of each truck, said hydraulic means comprising a hydraulic motor coupled to said one wheel of each truck, and a hydraulic system carried by said bridge including a hydraulic liquid reservoir, a flow orienting valve, supply and return conduit means extending between said reservoir and said flow orienting valve, further supply and return conduit means extending between said motors and said flow orienting valve, pump means interposed in the first mentioned supply conduit means for supplying hydraulic liquid under pressure to said valve from said reservoir, hydraulic liquid ejection valve means interposed in said conduit means between said pump means and said flow orienting valve, said ejection valve means comprising a valve body in communication with said conduit means and including variable orifice means controlled by movement of a valve stem member, said variable orifice means controlling communication between said first mentioned supply conduit means and return conduit means extending between said ejection valve means and said reservoir, resilient means biasing said variable orifice means to closed position whereby said variable orifice means shuts off communication between said first mentioned supply conduit means and the last mentioned return conduit means, solenoid means associated with said stem member, said solenoid means including a coil and a core member positioned within said coil, said core member being secured to said stem member, and said resilient means biasing said core member away from its central position within said coil, a hand control for said variable orifice means including a solenoid comprising a coil and a core member positioned therewithin, said coils being connected in series to a source of electrical energy, said hand control including means for varying the position of the last mentioned core member within its coil, whereby a deflection of the first core member within its coil is effective to actuate said stem member to vary the volume flow of hydraulic pressure fluid to said motors, whereby stepless speed control of said motors is obtained.

2. The improvement set forth in claim 1 wherein said flow orienting valve is of the solenoid operated type, the solenoid of said flow orienting valve being electrically connected to switch means actuated by said hand control.

3. In an overhead crane including a bridge secured between trucks that include wheels running on supporting rails, the improvement wherein hydraulic means is employed for driving at least one of the wheels of each truck, said hydraulic means comprising a uniform angular torque output type hydraulic motor coupled to said one wheel of each truck, and a hydraulic system carried by said bridge for supplying hydraulic pressure liquid to said motors.

4. In valve means employing a valve body and including variable orifice means controlled by movement of a valve member, and resilient means biasing said valve member to close said orifice means, a remote control device therefor comprising solenoid means associated with said valve member, said solenoid means including a coil and a core member positioned within said coil, said core member being secured to said valve member and said resilient means biasing said core member away from its central position within said coil, a hand control for said variable orifice means including a solenoid comprising a coil and a core member positioned therewithin, said coils being connected in series to a source of electrical energy, said hand control including means for varying the position of the last mentioned core members within its coil, whereby a deflection of the last mentioned core member from a central position within its coil is effective to cause the first mentioned coil to actuate said valve member to open said variable orifice means against the action of said resilient means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,984,191

May 16, 1961

Fred T. Smith

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 27, for "direction" read -- directional --;
column 14, line 29, for "members" read -- member --.

Signed and sealed this 5th day of December 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

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Commissioner of Patents

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