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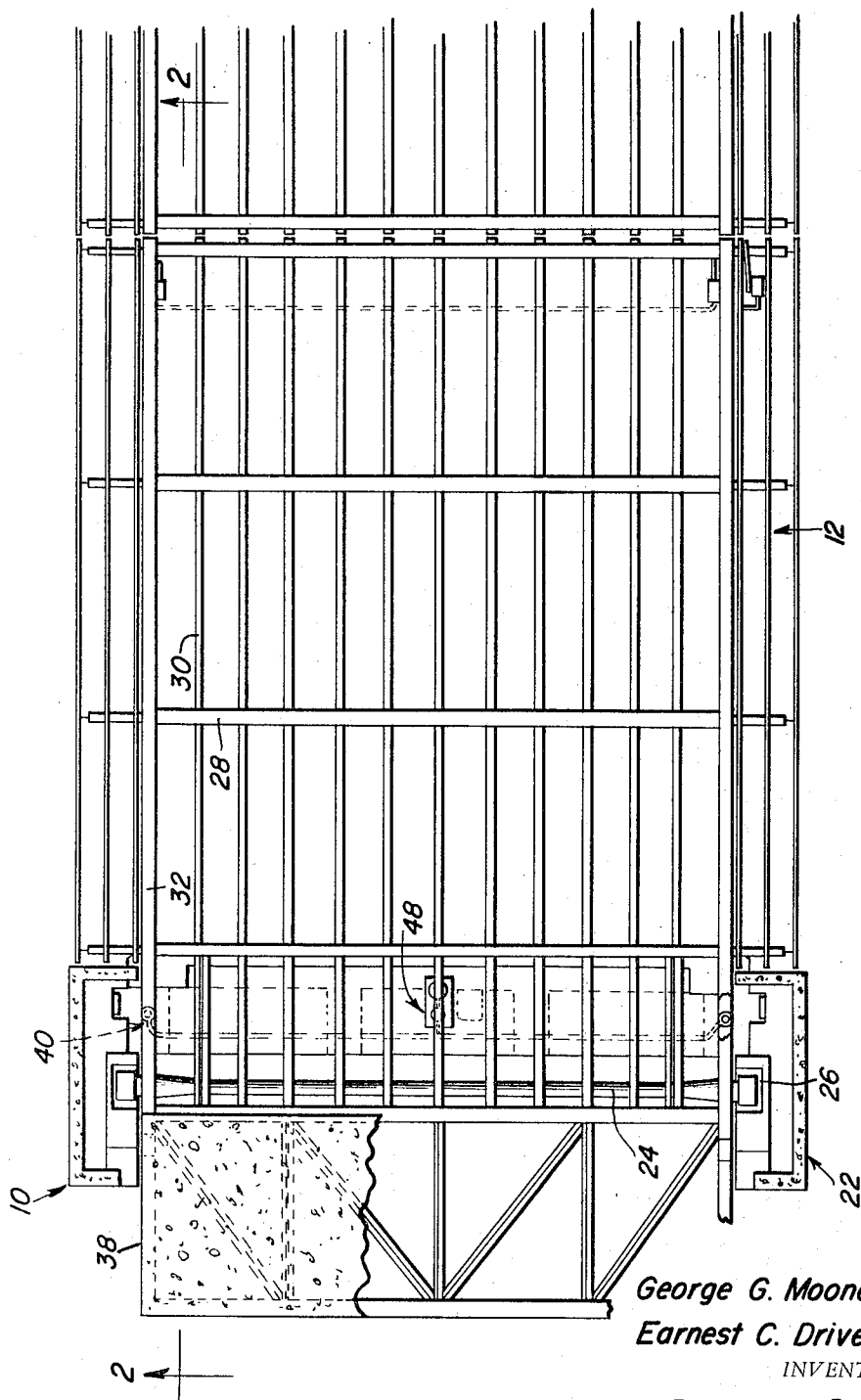
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HYDRAULIC OPERATING SYSTEM FOR OPENING BRIDGES

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Fig. 1



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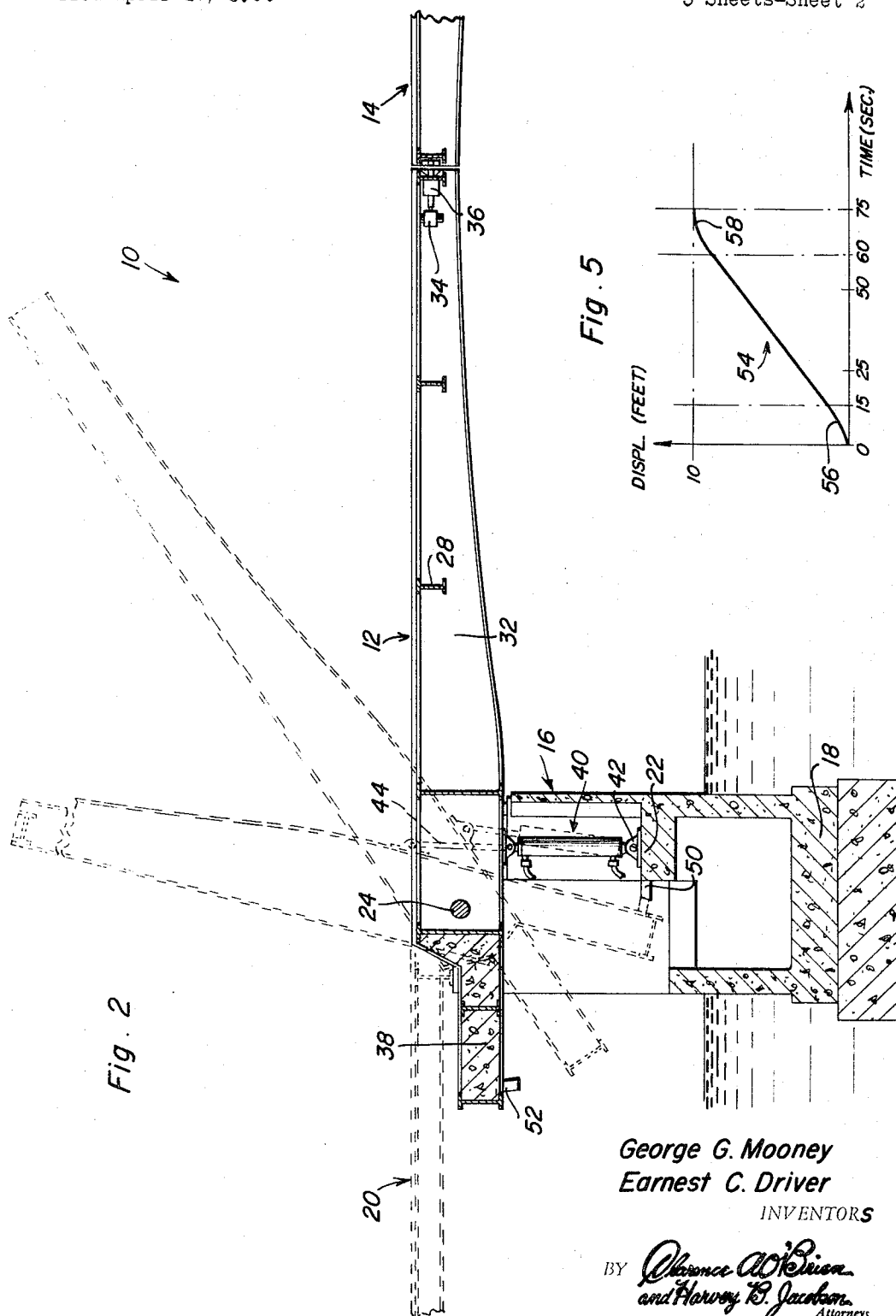
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Fig. 3

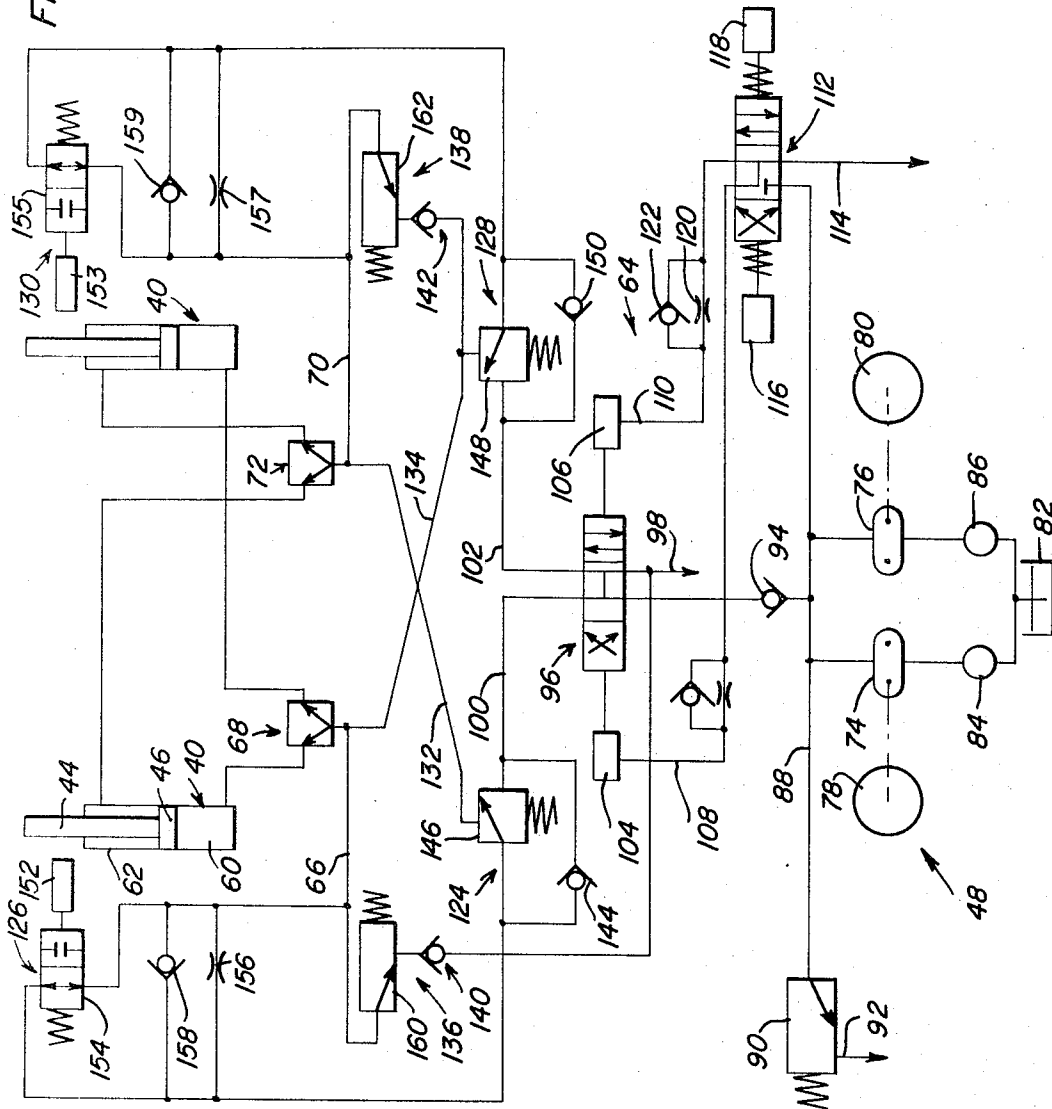


Fig. 4A

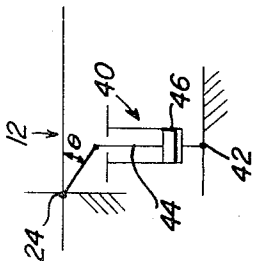
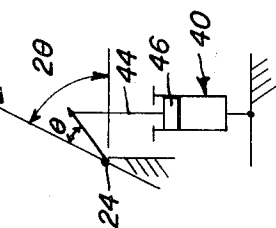


Fig. 4B



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HYDRAULIC OPERATING SYSTEM FOR OPENING BRIDGES

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9 Claims. (Cl. 14—36)

This invention relates to the control of bridges having pivotally mounted spans adapted to be raised to provide a passageway between the mounting piers.

Controllable operating mechanism have heretofore been associated with bridges of the type to which the present invention relates, such bridges being referred to as Bascule bridges. Operating systems for pivotally elevating and lowering the span sections of such bridges, have been of the mechanical gear driven type. In accordance with the present invention however, the mechanical gear driven systems are to be replaced by a hydraulic system and reversible hydraulic motors. The disposition of the hydraulic motors and the control thereof exercised by the fluid control system, makes the referred to replacement both practicable and desirable.

It is therefore a primary object of the present invention to provide a completely fluid or hydraulic system for controlling the opening and closing of span sections of the type of bridges with which the present invention is concerned.

An additional object of the present invention is to provide a fluid control system for reversible piston-type of fluid motors capable of coping with variable and differential loads imposed on the fluid motors.

A still further object of the present invention is to provide a hydraulic control system for a pair of laterally spaced, two-way piston motors which are extensible for raising a pivotally mounted load such as the span section of a bridge as well as to controllably lower the span section by retraction of the pistons.

Another object of the invention is to provide in a fluid control system, means for regulating acceleration and deceleration of fluid driven pistons and also to vary the rate of movement thereof in accordance with variations in the loading imposed thereon. The fluid control system of the present invention is therefore able to cope with extreme variations in wind forces imposed on the span sections of the bridges which load the piston motors.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a top plan view of a portion of a typical bridge with which the hydraulic control system of the present invention is associated.

FIGURE 2 is a side sectional view taken substantially through a plane indicated by section line 2—2 in FIGURE 1.

FIGURE 3 is a hydraulic circuit diagram of the fluid control system of the present invention.

FIGURES 4A and 4B are simplified kinematic diagrams associated with the control system of the present invention.

FIGURE 5 is a graphical illustration of the piston movement effected by the fluid control system of the present invention.

Referring now to the drawings in detail it will be observed from FIGURES 1 and 2, that the hydraulic con-

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trol system of the present invention is associated with a type of bridge generally referred to by reference numeral 10 which includes a pair of span sections or bridge leaves 12 and 14 which are aligned with each other in a lowered, substantially horizontal position so as to form a span between a pair of concrete piers 16 supported by concrete foundations 18 below water level. The span sections may be supported adjacent to fixed spans 20. Each span section is similar in construction and is pivotally mounted between piers 16 on the platforms 22 by means of a trunnion 24. The trunnion is received at opposite ends within the trunnion bearings 26 supported on the piers 16 so as to establish a fixed horizontal pivotal axis about which the span section is moved from its substantially horizontal position shown by solid line in FIGURE 2, to a substantially vertical position as shown by dotted line in FIGURE 2. The span sections are constructed in the usual manner including transversely extending floor beams 28 to which the roadway stringers 30 are secured between main girders 32. At the remote forward end of the span section 12 below the roadway, is a lock actuating cylinder device 34 connected to a lock device 36 by means of which the adjacent ends of the span sections may be interconnected. A counterweight mass 38 is mounted on the rear side of the trunnion 24 opposite the hydraulic lock so as to balance the load of the span section above a pair of hydraulic cylinder devices 40.

The hydraulic cylinder devices 40 are mounted by pivot anchors 42 on the concrete platforms 22 just forwardly of the trunnion 24. Piston rods 44 which extend upwardly from the cylinder devices, are pivotally connected to the main girders 32 adjacent the lateral sides of the span section to which the floor beams 28 are connected. The piston rods 44 of the cylinder devices are pivotally connected to the span section in a vertical position at a point below the fixed axis extending through the trunnion 24 to form an angle with the horizontal through the axis, of thirty-eight and one-half degrees, as depicted by angle in FIGURE 4A. When the piston rods 44 of the cylinder devices are fully extended by the pistons 46 so as to elevate the span sections to the elevated position illustrated in FIGURE 4B, the cylinder devices will resume a vertical position so as to better sustain the load thereon because of the reduced moment arm about the anchor point 42. Accordingly, the span section will have been angularly displaced from the horizontal by seventy-seven degrees or twice the angle θ as depicted in FIGURE 4B.

The size and stroke of the hydraulic piston motors 40 are selected so as to effect the aforementioned pivotal movement of the span sections. Fluid distributing conduits are therefore interconnected with the motor devices 40 below each span section, and conduits being connected with a fluid pressure generating apparatus 48 located on the platform between the girders 32. Also provided on the platform at the base of the piston motor devices 40, is a resilient abutment 50 adapted to be engaged by a wooden bumper block 52 mounted on the lower side of the counterweight portion 38 of the span section. The pair of hydraulic motor devices 40 associated with each of the span sections is therefore operative to impart controlled movement to the span sections by selective control exercised at any suitable location for the operator controls as usually provided for bridges of this type.

The fluid control system is operative to impart movement to the pistons 46 of the fluid motor devices 40 as depicted by the curve 54 in FIGURE 5. It will therefore be noted, that the curve 54 includes an acceleration portion 56 of fifteen seconds duration followed by a normal

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running period of forty-five seconds, with a final deceleration period depicted by the curve portion 58 during a final fifteen seconds of a normal seventy-five second opening period during which the pistons undergo a stroke of ten feet. It will of course be appreciated, that variations in load imposed on the pistons because of wind force and other factors, will cause deviations in movement from the normal movement depicted by curve 54. In such case, the fluid control system will automatically react in a corrective manner. Accordingly, the operator need not make any adjustments because of overload or overrun conditions.

Referring now to FIGURE 3, the fluid control system associated with each span section, is depicted by the circuit diagram showing a pair of piston motor devices 40 each of which is provided with a lift chamber 60 on one side of the piston 46 and a retract chamber 62 on the other side of the piston opposing the lift chamber 60. Fluid under pressure generated by the fluid pressure generating apparatus 48 is therefore supplied under control of the directional control assembly 64 to either the lift chambers 60 of both fluid motor cylinder devices 40 in order to elevate the span section associated therewith or to the retract chambers 62 in order to controllably lower the span sections. Accordingly, both of the lift chambers 60 are interconnected with a pressure supply or exhaust line 66 through a flow divider 68 while both of the retract chambers 62 are interconnected with a second pressure supply or exhaust line 70 by means of the flow divider 72. The flow dividers are therefore operative to synchronize the cylinder devices 40 despite any differential loading of the cylinder devices. It will therefore be apparent, that the cylinder devices will impart movement to the span section without any lateral displacement thereof.

The pressure generating apparatus 48 includes a pair of fluid displacement pumps 74 and 76 respectively driven by electric motors 78 and 80. The pumps when driven by the motors draw fluid such as oil from a fluid reservoir or sump 82 through filters 84 and 86 so as to pressurize a discharge pressure line 88. The maximum pressure developed in the discharge pressure line is limited by a safety relief valve device 90. The safety relief valve device is therefore operative upon development of excessive pressure in the discharge line 88, to vent excess fluid through vent port 92 connected to sump 82. The discharge pressure in line 88 is supplied to the directional control assembly 64 from which the fluid under pressure is routed to the cylinder devices 40 as aforementioned.

Fluid under pressure from the discharge line 88 is supplied through a one-way relief check valve 94 to a main distributor valve 96 biased toward a neutral position in which the single inlet port and two outlet ports are connected to the vent line 98 connected to sump. Accordingly, when the distributor valve is shifted in one or the other direction from its neutral position, fluid under line pressure from the one-way relief check valve 94 will be supplied to either line 100 or 102 respectively connected to the outlet ports of the distributor valve. The distributor valve is shifted in one direction or the other by signal pressure actuated devices 104 and 106 respectively receiving pressure signals through signal lines 108 and 110. The signal lines are therefore connected to the outlet ports of a directional control valve 112 similar in construction to the distributor valve 96 and accordingly also having an inlet port directly connected to the pump discharge line 88 and a vent port connected to sump by the vent line 114. A pair of selectively controlled solenoid devices 116 and 118 are therefore associated with the control valve 112 for shifting thereof in one or the other direction from the neutral position wherein the outlet ports are connected to the vent line 114. Accordingly, shifting of the control valve will supply signal pressure to one of the signal lines so as to correspondingly shift the distributor valve 96. Connected in each of the

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signal lines, is a flow restrictor 120 disposed in parallel relation to a one-way check valve 122 by means of which a pressure signal is rapidly dispatched in one direction from the control valve to one of the signal pressure actuators 104 or 106. Release of signal pressure on the other hand, is retarded because of the closing of the check valve 122. Accordingly, shifting of the distributor valve 96 is regulated in order to permit the system to controllably accelerate and decelerate the pistons through a complete operational stroke in response to selective control by the operator.

The distributor outlet line 100 is connected to the lift chambers 60 of the cylinder devices through holding valve means 124 operative to maintain the rate of movement of the pistons in accordance with variations in the load thereon, and through load limiting valve means 126 operative to decelerate movement of the pistons 46 as they approach the ends of their strokes in the retracting direction. Similarly, the outlet line 102 from the distributor valve 96, is connected to the retract chambers 62 of the cylinder devices 40 through holding valve means 128 in series with flow limiting valve means 130 to decelerate piston movement when approaching the ends of the stroke in the extension direction. The holding valve means 124 includes a by-pass check valve 144 through which fluid under pressure is supplied from line 100 when the piston rods are to be extended at a rate controlled by shift or distributor valve 96 to the left. Accordingly, fluid flow proceeds through one-way check valve 158 and line 66 to line 134 supplying a pressure signal to the holding valve means 128 for permitting return flow of fluid from chamber 62. Similarly, supply of fluid under pressure to line 102 proceeds through check valve 150, check valve 159 and line 70 to line 132 for supplying a pressure signal to holding valve means 124 in order to permit return flow from chambers 60. Accordingly, the holding valve means 124 and 128 will respond to pressure signals communicated therewith through the lines 132 and 134 in order to prevent uncontrolled overrun of cylinder devices 40. The pressure signals in these lines will therefore open the valves 146 and 148 of the holding valve means for return flow through distributor valve 96 to vent line 98. The valves 146 and 148 also act as static brakes for the cylinder devices.

When the distributor valve 96 is shifted in one direction by the signal pressure responsive device 106 for example to direct extension of the piston rods 44, acceleration thereof is controlled by the rate of shift of the distributor valve as aforementioned. Deceleration of the bridge span load is also controlled by the rate of shift to the neutral position of the distributor valve. Flow limiting valve means 130 is then operative as an overriding control when the pistons are approaching the ends of the stroke during the deceleration period 58 as shown in FIGURE 5. Similarly, the flow limiting valve means 126 is operative to provide an overriding deceleration control as the pistons approach the ends of the stroke in a retracting direction as aforementioned.

After the pistons move away from their end limit positions, the flow limiting valve means 126 and 130 move to their normally open positions. Accordingly, the flow limiting valve means include cam operators 152 and 153 actuated by the piston rods 44 as they approach the ends of the stroke so as to displace the cut-off valves 154 and 155 to the closed position. Closing of the cut-off valves will cause return flow of fluid from the chambers 60 or 62 to proceed through an adjustable restrictor 156 or 157 associated with each of the flow limiting valve means and connected in by-pass relation to the cut-off valves. The pistons 46 are thereby automatically decelerated as they approach the ends of their strokes.

The overload valve means 136 and 138 are operative to provide dynamic braking when deceleration of the pistons exceeds normal characteristics because of a combus-

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tion of wind and inertia forces. The overload valve means 136 therefore includes a relief valve 160 which will in response to development of excessive pressure within the lift chambers 60, reduce pressure therein by venting through the one-way check valve 140 connected to the vent line 98 and to the retract chambers 62 through line 102, and check valve 150. Since the volume of lift chambers 60 are larger than the retract chambers 62 because of the space occupied by pistons 44 extending through the retract chambers, excess fluid will flow to sump through the vent line 98. The overload valve means 138 also includes a relief valve 162 operative in response to development of excessive pressure in the retract chambers 62 to open and reduce such pressure by flow of fluid through check valve 142 and line 134 to chambers 60. Inasmuch as additional fluid volume is required to satisfy the larger volume lift chambers, fluid will also flow from line 100 of distributor valve 96 through check valve 144 to the lift chambers. Further, the overload relief valve means 136 and 138 will act as static slip brakes when wind forces exceed normal safe overload. The valves 160 and 162 will therefore be operative to provide overload protection because of wind forces for example, that may be considerably higher than the forces capable of being developed by the normal operating system pressures or because of extreme inertia decelerating forces. In the event the distributor valve 96 fails to decelerate the pistons properly, when being extended for example, development of excessive pressure in the chambers 62 as a result thereof, would effect transfer of pressure to the chambers 60 through the relief valve 162.

From the foregoing description, the construction, operation and utility of the control system and associated apparatus will be apparent. It will therefore be appreciated, that reversible control of the piston motor devices 40 may be effected in order to produce the proper movement of the span sections, under normal design conditions. Without any necessity for adjustment by the operator, automatic reaction to overload or overrun conditions will correctively alter operation of the system, until normal conditions are restored. The operational characteristics of fluid control system together with the disposition of the fluid motor devices imparting movement to the bridge span sections enables the use of a complete hydraulically operated control mechanism with the advantages of the automatic reaction control and motion regulating features aforementioned.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. In combination with a bridge span pivotally mounted about a fixed axis, means for movement of the span between a lowered position and an elevated position comprising a pair of laterally spaced fluid motor devices having pistons connected to the span forwardly of the fixed axis and fluid operating means connected to said motor devices for extension and retraction of the pistons by equal amounts to elevate and lower said span, and means mounting the motor devices for pivotal displacement during said movement of the span from a substantially vertical position in both the lowered and elevated positions of the span, said fluid operating means including, fluid pressure supply means, directional control means operatively connecting the supply means to the fluid motor devices for extension or retraction of the pistons, stroke limiting means operatively connected to the motor devices for decelerating movement of the pistons as the span approaches the lowered or elevated positions thereof, and

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overload responsive means operatively connected to the motor devices for limiting pressure developed therein.

2. The combination of claim 1 including holding valve means interconnected between the directional control means and the motor devices for regulating the rate of movement of the span.

3. In a Bascule bridge control system, a fluid actuated device having opposed pressure chambers exerting a regulated force on a piston, fluid pressure generating means having a pressure discharge conduit, directional control means operatively connected to the discharge conduit of the pressure generating means for selectively supplying fluid under pressure at an operating value to one of said chambers and exhausting pressurized fluid from the other chamber, flow limiting valve means operatively connecting the directional control means to the opposed chambers for restricting exhaust flow of fluid from the other chamber in response to approach of the piston toward limits of travel to regulate deceleration thereof, holding valve means connected to the directional control means and responsive to supply of fluid under pressure to said one chamber for controlling said exhaust flow of fluid from the other chamber to prevent overrun and overload valve means responsive to development of pressures exceeding said operating value in either of said chambers for venting fluid therefrom.

4. The combination of claim 3 wherein said holding valve means includes a pressure actuated valve opened to conduct unrestricted exhaust of fluid from said other chamber, means connecting the valve to said one chamber for opening thereof by pressure of fluid supplied thereto, and unidirectional flow means connected in bypass relation to said valve for limiting flow of fluid to said one chamber in one direction.

5. The combination of claim 4 wherein said overload valve means comprises, a first relief valve, one-way vent means connected to said one chamber by the first relief valve, a second relief valve connected to the other chamber and one-way flow means connecting the second relief valve to said one chamber.

6. The combination of claim 5 wherein the directional control means comprises, a distributor valve connected to said chambers through the holding valve means and the flow limiting valve means, signal pressure operating means connected to said distributor valve for controlling rate of movement thereof, a selectively actuated control valve connected to the pressure generating means for developing pressure signals, and one-way restriction means for conducting the pressure signals to the signal pressure operating means.

7. The combination of claim 3 wherein the directional control means comprises, a distributor valve connected to said chambers through the holding valve means and the flow limiting valve means, signal pressure operating means connected to said distributor valve, a selectively actuated control valve connected to the pressure generating means for developing pressure signals, and one-way restriction means for conducting the pressure signals to the signal pressure operating means.

8. The combination of claim 3 wherein said overload valve means comprises, a first relief valve, one-way vent means connected to said one chamber by the first relief valve, a second relief valve connected to the other chamber and one-way flow means connecting the second relief valve to said one chamber.

9. In combination with a pivotally mounted bridge span section, reversible fluid motor means connected to said span section for elevation and lowering thereof, and fluid controlled operating means connected to said fluid motor means for controlling operation of the motor means in accordance with variable loading thereof by the span section including, static brake means operatively connected to the motor means for regulating movement of the span section, and dynamic brake means operatively

connected to the motor means and the static brake means
for maintaining said regulated movement of the span sec-
tion despite variations in loading imposed thereon.

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