

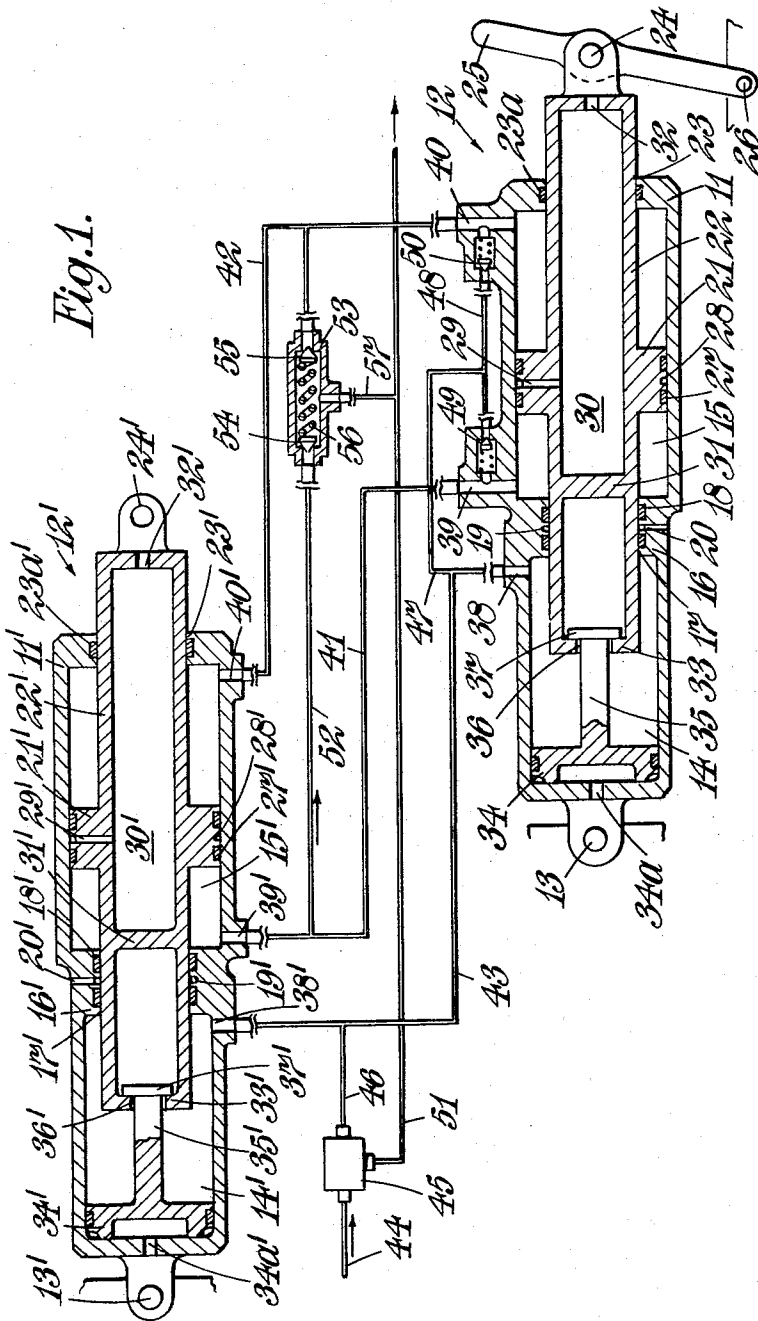
March 20, 1962

A. CAMERON-JOHNSON
HYDRAULIC ACTUATOR SYSTEMS

3,025,674

Filed June 20, 1960

3 Sheets-Sheet 1



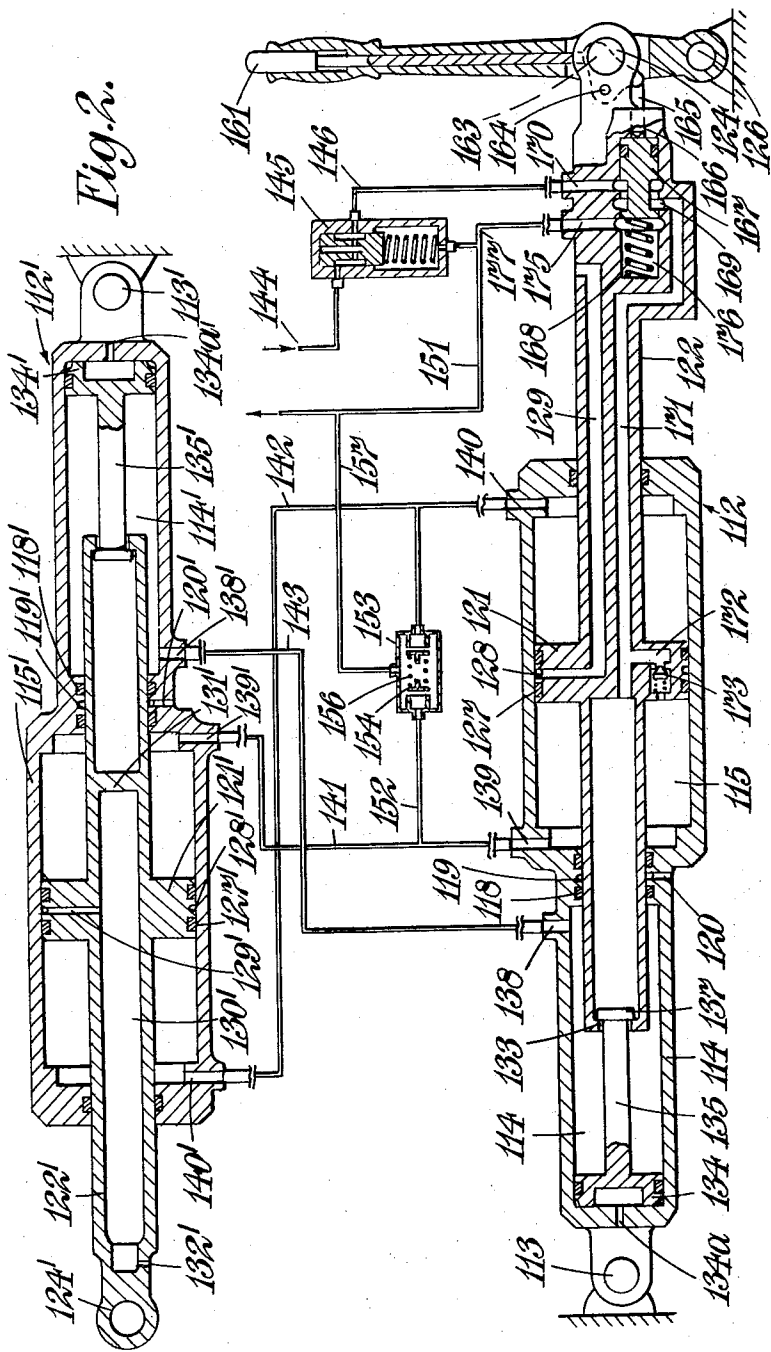
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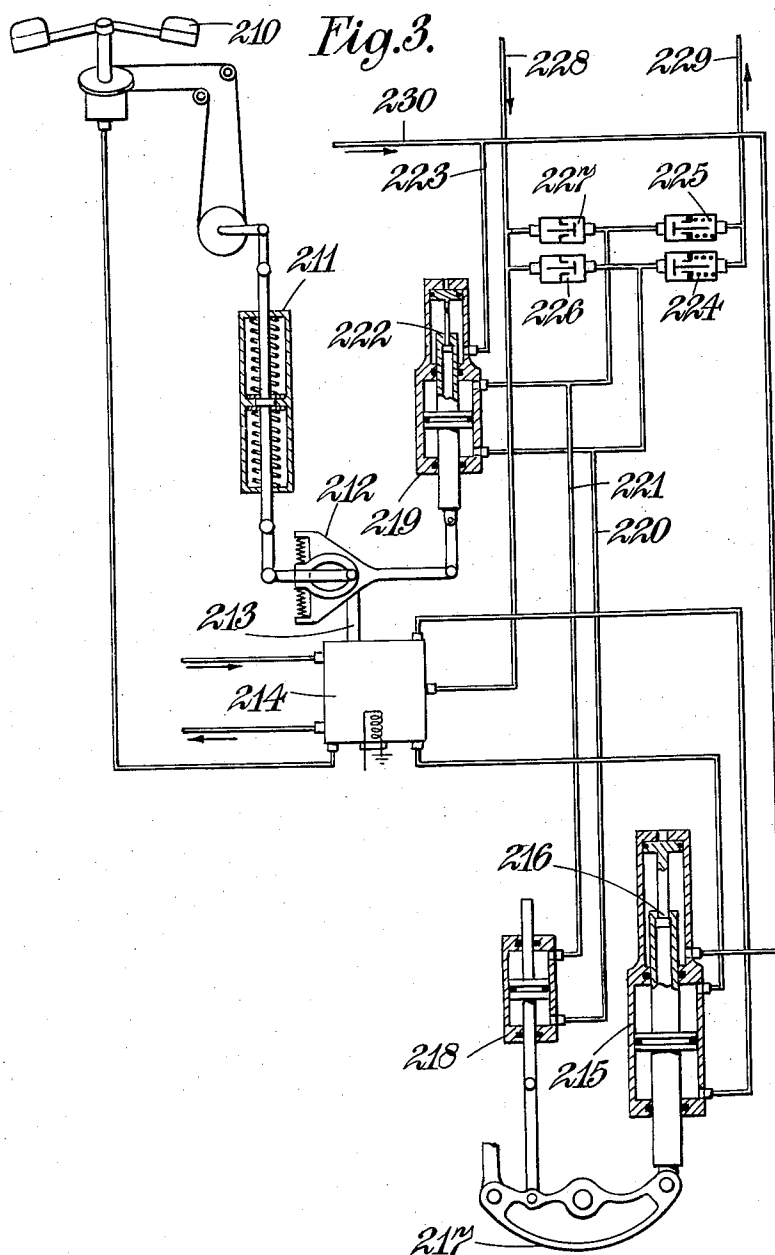
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HYDRAULIC ACTUATOR SYSTEMS

Alan Cameron-Johnson, Gloucester, England, assignor to Dowty Rotol Limited, Gloucester, England, a British company

Filed June 20, 1960, Ser. No. 37,458

Claims priority, application Great Britain June 29, 1959

3 Claims. (Cl. 60—54.5)

This invention relates to hydraulic actuator systems.

According to the invention there is provided an hydraulic actuator system comprising a hydraulic master actuator, a hydraulic slave actuator, conduit means connecting said actuators so that movement of the master actuator causes related movement of the slave actuator, and biasing means for biasing said actuators toward predetermined and related positions. Preferably the system comprises, inlet valve means arranged to connect said conduit means to a pressure supply conduit when the fluid pressure in the conduit means falls below a pressure which is a predetermined amount less than the pressure in said pressure-supply conduit. Preferably the system also comprises relief valve means adapted to connect said conduit means to drain when the fluid pressure in the conduit means rises above drain pressure by a predetermined amount.

With this arrangement should there be any undesirable expansion of fluid within the actuators the conduits will be connected to drain to relieve the fluid pressure; if there should be fluid loss fluid under pressure will be admitted to the system to compensate for this loss; and the biasing means will tend to maintain the actuators in related positions so that fluid added or relieved does not alter the relative positions of the actuators. Preferably the master and slave actuators are of the piston and cylinder type and the biasing means comprises a pair of biasing pistons acting in opposite directions and connected to the piston of at least one of the actuators, one of said biasing pistons being connected to the actuator piston with limited lost motion. One of the biasing pistons is preferably larger than the other and a stop is provided to limit motion of the larger biasing piston in the direction in which it moves under the influence of hydraulic pressure.

Preferably a pair of biasing pistons is provided for each actuator and the smaller biasing piston of each pair is fixed relative to its actuator piston. Conveniently the conduit means and the fixed biasing pistons are relatively so arranged that movement of one actuator piston due to the action of its fixed biasing piston is in the opposite direction to the movement of that actuator piston caused by fluid transmission through the conduit means on movement of the other actuator piston under the influence of its fixed biasing piston.

Conveniently the system further comprises isolating means for rendering said biasing means inoperative.

The system of the invention can be used with advantage in the feed-back circuit of a hydraulic piston and cylinder motor, in which case the master actuator may be connected by a linkage for movement by the motor piston and the biasing means acts on the master actuator through the motor piston.

Three embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic cross-sectional drawings, of which,

FIGURE 1 shows an actuator system according to the invention having simple biasing or centring means,

FIGURE 2 shows an alternative actuator system having manually controlled biasing or centring means, and,

FIGURE 3 shows an aircraft noswheel steering sys-

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tem in which an actuator system according to the invention is provided in the feedback circuit.

Referring to FIGURE 1, the cylinder 11 of a master actuator 12 is pivotally connected at 13 to a fixed part and is provided with two cylindrical chambers 14 and 15 divided by a partition 16. The bore 17 in this partition houses a pair of sealing rings 18 having a leakage groove 19 between them, this opening through channel 20 to atmosphere. The piston 21 of the master actuator works in the chamber 15 and the tubular piston rod 22 extends through the bore 17. The piston rod 22 extends also in the opposite direction through a circular aperture 23 having a sealing ring 23a and at its extremity is pivotally connected at 24 to an operating member 25, in turn pivotally mounted upon a fixed part at 26.

The piston 21 is provided with a pair of sealing rings 27 having a leakage groove 28 between them, this opening through a radial channel 29 in the piston to a chamber 30 which is formed within the tubular piston rod 22 and is closed at its inner end by a partition 31. An aperture 32 in the outer end wall of the rod 22 places the chamber 30 in communication with atmosphere.

The inner end of the tubular piston rod 22 is provided with an inwardly directed radial flange 33. A biasing or centring piston 34 is housed within the cylindrical chamber 14 and a piston rod 35 integral therewith extends towards the piston rod 22, passing through the circular aperture 36 bounded by the flange 33. At its extremity the rod 35 is stepped up to a flanged part 37 the diameter of which is larger than that of the aperture 36, and in the position as drawn, that is the centred position of the piston 21, the part 37 engages the underside of the flange 33. An aperture 34a connects the space in cylindrical chamber 14 on the side of piston 34 remote from rod 35 to atmosphere.

A port 38 in the wall of the cylinder 11 communicates with the chamber 14. Two ports 39 and 40 are also provided in the wall of the cylinder 11, these communicating with the chamber 15, respectively, one at either end thereof.

A slave actuator 12' is provided in suitable relationship with the master actuator 12, its cylinder 11' being pivotally connected at 13' to a fixed part and its piston rod 22' being pivotally connected at 24' to a device (not shown) to be controlled. Otherwise the slave actuator is similar to the master actuator and like, but superscribed, numerals are used in FIGURE 1 for equivalent parts.

The ports 39 and 39' are connected by a fluid transmission conduit 41, the ports 40 and 40' are connected by a fluid transmission conduit 42 and the ports 38 and 38' are connected by a pressure supply conduit 43.

Fluid under pressure is supplied from a pump or accumulator (not shown) through a conduit 44 to a reducing valve 45. The reduced pressure supply is taken then through a conduit 46 to connect with the conduit 43. A further conduit 47 is branched from conduit 43 and taken to a conduit 48. Conduit 48 connects with the port 39 through a non-return valve 49 and with the port 40 through a non-return valve 50.

A drain conduit 51 is taken from the reducing valve 45 to tank (not shown). Disposed in a conduit 52 which connects the fluid transmission conduits 41 and 42 is a double non-return valve unit 53. The two valve elements 54 and 55 of this unit are urged on to their seatings by a common coil spring 56. A conduit 57 places the chamber on the underside of these elements in communication with the drain conduit 51.

With the system in operation, the system is hydraulically full. Fluid pressure is always applied in the chambers 14 and 14' biasing the pistons 34, 34' to the left in the drawing and a corresponding smaller force is

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applied to the rods 22, 22', such that the difference of the two forces is a force tending to hold rods 22, 22' in the predetermined position, that is to the centring position for the pistons 21, 21'.

Assuming the operator moves the member 25 in a clockwise direction about the pivot 26 and from the centred position, then the biasing force prevailing in chamber 14 is overcome and the piston 34 is displaced to the right with the piston 21 and the piston rod 22. As this occurs, the piston 21' and piston rod 22' move to the left in the drawing, the piston 34' remaining in the position as drawn, at the end of the cylindrical chamber 14'.

If actuator pressure builds up above a predetermined value, for example, due to temperature variations, either one or both of the elements 54, 55 of the non-return valve unit 53 open to relieve this to tank. If leakage of fluid occurs, then it is desirable in the interests of positive action and correct phase relationship in the system, to make up the loss. This is not necessarily achieved immediately upon loss, but the build up of pressure in chambers 14, 14' is sufficient to make up the loss through conduits 47 and 48 and one of the non-return valve elements 54 or 55, to whichever is the lower pressure side of pistons 21, 21'. Make up of fluid on the other, high pressure, sides of the pistons 21, 21' would only occur when the operating member 25 is released and the actuator at rest in its centred position. Then the centring pressure is sufficiently higher than the actuator pressure to open the appropriate non-return valve element 54 or 55. The build up of pressure in chamber 14, 14' is vented to tank through reducing valve 45, which also acts as a relief valve.

Release of the control 25 following movement in a clock-wise direction results in the actuators returning to a predetermined (centred) position of the pistons 21, 21' under the pressure acting on the pistons 34, 34' and upon the inner end of rods 22, 22' respectively.

If the operating member 25 is moved in the anti-clockwise direction about the pivot 26, the reverse procedure occurs, piston 21 moving to the left in the drawing and piston 21' moving to the right.

In practice it may not always be desirable to have the hydraulic centring loads continuously applied, and FIGURE 2 shows a self-compensating actuator system which, in principle and operation, is similar to that of FIGURE 1, but includes means interposed to isolate the centring units from system pressure when the actuator system is in operation.

The master actuator 112 and the slave actuator 112' are very similar to the master and slave actuators of FIGURE 1 and like parts are identified in FIGURE 2 by similar reference numerals prefixed by the numeral 1.

The actuators are however disposed in the opposite sense, the piston rod 122' of the slave actuator extending to the left in the drawing to connect with the controlled device (not shown). Hence the fluid transmission's conduits 141 and 142 cross over one another, fluid transmission conduit 141 connecting ports 139 and 139' and fluid transmission conduit 142 connecting ports 140 and 140'.

Thus, if the operating member 125 is moved in an anti-clockwise direction about the pivot 126 then the piston rod 122' will move to the left in the drawing, and vice versa.

Disposed within the operating member 125 is a button 161 connected to a rod 162. The inner end of this rod engages a cam 163 pivotally mounted at 164 upon the member 125. The cam in turn engages a plunger 165 which enters a small bore 166 in the outer extremity of the piston rod 122. The inner end of this plunger 165 engages a slide valve spool 167 which is biased towards the plunger by a coil spring 168. In the position shown in the drawing, an annular groove 169 formed in the spool 167 places a pressure fluid inlet port 170 in the piston rod 122 in communication with a

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conduit 171 also formed in the piston rod. This conduit leads to an annular chamber 172 formed in the piston 121 of the master actuator 112. Annular chamber 172 is in communication through non-return valves similar to non-return valves 49 and 50 of FIGURE 1, with the chambers on the left and right hand sides respectively of the piston 121. These non-return valves are thus provided in the piston 121, and one is indicated on the drawing at 173. The drain channel 129 from the groove 128 between the seals 127 passes through the piston rod 122 to a point near its outer end and there opens to atmosphere.

Supply pressure fluid from the reducing valve 145 passes through conduit 146 to the port 170 and reaches the chamber 114 through suitable clearances between the flange 137 on the piston rod 135 and flange 133 on the hollow piston rod 122.

A port 175 places the chamber 176 containing the coil spring 168 in communication with a conduit 177 connecting with drain conduit 151.

In the position drawn the slide valve spool 167 effects centring of the actuator system and fluid losses from the system are made up in the manner described with reference to FIGURE 1, except that the non-return valves 173 are located in the piston 121, and not in the master actuator cylinder body.

To operate the system, the button 161 is depressed moving the slide valve spool 167 and opening the tank return line 151 to the centring means of both actuators and cutting off the pressure supply. The system can then operate without being loaded by the centring means.

The cam arrangement on the operating member 125 ensures that with the button 161 depressed, movement of the operating lever does not cause movement of the valve spool 167. Automatic selection of the valve spool 167 can be obtained in any other convenient manner, mechanical, electrical or hydraulic.

With the valve spool 167 in the position drawn for centring, the reducing valve operates as a relief valve in the event of excessive pressures being built up in the system.

FIGURE 3 shows an aircraft nosewheel steering system comprising a rudder bar 210 and spring-loaded transmission device 211 to a differential unit 212 controlling the input member 213 of a steering selector 214. This selector controls the displacement of a steering jack 215 having nosewheel-centring means 216 integral therewith. The output of the steering jack connects with a banana steering link 217 which in turn connects with the nose-wheel (not shown).

The feedback system from the link 217 to the differential unit 212 conveniently utilises an actuator system according to the invention. The actuator 218 constitutes the master actuator in the feedback system, but the centring means 216 associated with the steering jack 215 is arranged in series with this actuator. The actuator 218 is connected with a slave actuator 219 through fluid transmission conduits 220 and 221. The centring means 222 integrated with actuator 219 are connected through a fluid transmission conduit 223 with the centring means 216 of the steering jack 215. Apart from this difference, the feedback system is similar to the system shown in FIGURE 1, relief valves 224 and 225, and non-return valves 226 and 227 being included conveniently in circuit with the supply conduit 228 and return conduit 229. The relief valves 224 and 225 are of the type in which the annular valve seats are displaceable against the valve spring. When the end of the stem of the valve poppet contacts the right-hand end of the valve casing, continued movement to the right of the annular seat effects opening of the valve. Centring pressure is applied through conduit 230 as centring of the steered wheel is selected and each centring means 216, 222 will act to bias its associated actuator 218, 219 to its central position.

By virtue of the accuracy in phase operation of the

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two actuators 218 and 219, the feedback system provided ensures an extremely stable steering system, at the same time, utilising the centring device of the main steering jack.

Broadly, the invention therefore provides a simple means of ensuring accurate phase relationship in the operation of two linearly moving actuators.

I claim:

1. A fluid operated actuator system comprising a master double-acting piston and cylinder actuator, a slave double-acting piston and cylinder actuator, two actuator conduits placing the master cylinder at the two sides of the master piston in communication with the slave cylinder at the two sides of the slave piston respectively; and means for biasing one of said pistons towards a position intermediate the ends of its travel, which biasing means comprises a piston and cylinder, a member coupled to the said one piston, which member extends slidably into the cylinder of the biasing means, a lost-motion connection coupling the piston of the biasing means and the said member together, and conduit means for supplying pressure fluid to the cylinder of the biasing means between the biasing piston and said member.

2. A fluid operated actuator system comprising a master double-acting piston and cylinder actuator, a slave double-acting piston and cylinder actuator, two actuator conduits placing the master cylinder at the two sides of the master piston in communication respectively with the slave cylinder at the two sides of the slave piston, a pressure fluid supply conduit, and inlet valve means in said pressure fluid supply conduit means, which inlet valve means, when open, places the conduit means in communication with said two actuator conduits and is adapted to open when the fluid pressure in the actuator conduit falls a predetermined amount below that in the supply conduit; and means for biasing one of said pistons towards a position intermediate the ends of its travel, which biasing means comprises a piston and cylinder, a member coupled to the said one piston, which member extends slidably into the cylinder of the biasing means, a lost-motion connection coupling the piston of the biasing means and the said member together, and conduit means for supplying pressure fluid to the cylinder of the biasing means between the biasing piston and said member.

3. A system as claimed in claim 2, further comprising relief valve means disposed in said two actuator conduits and adapted to connect said conduit means to drain when the fluid pressure in said conduits rises above drain pressure by a predetermined amount.

4. A system as claimed in claim 1, said member having a smaller effective area exposed to the pressure of said pressure fluid than the biasing piston.

5. A system as claimed in claim 4, wherein said member comprises a piston rod connected to said one piston.

6. A fluid operated actuator system comprising a master double-acting piston and cylinder actuator, a slave double-acting piston and cylinder actuator, two actuator conduits placing the master cylinder at the two sides of the master piston in communication with the slave cylinder

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at the two sides of the slave piston respectively; and means for biasing one of said pistons towards a position intermediate the ends of its travel, which biasing means comprises a piston and cylinder, a member coupled to the said one piston, which member extends slidably into the cylinder of the biasing means, a lost-motion connection coupling the piston of the biasing means and the said member together, conduit means for supplying pressure fluid to the cylinder of the biasing means between the biasing piston and said member, and an isolating valve in said conduit means operable selectively to connect the cylinder of the biasing means to drain.

7. In a hydraulic actuator mechanism comprising a double-acting piston and cylinder servo motor, conduit means for delivering pressure fluid to the motor to actuate it, and selectively operable servo valve means and associated follow-up valve means in said conduit for controlling the supply of pressure fluid to the motor, feed-back means comprising a master double-acting piston and cylinder actuator connected to the motor to be controlled by movement of the motor, a slave double-acting piston and cylinder actuator connected to the follow-up valve means to actuate it, two actuator conduits placing the master cylinder at the two sides of the master piston in communication respectively with the slave cylinder at the two sides of the slave piston; and means for biasing said slave piston towards a position intermediate the ends of its travel, which biasing means comprises a piston and cylinder, a member coupled to the said slave piston, which member extends slidably into the cylinder of the biasing means, a lost-motion connection coupling the piston of the biasing means and the said member together, and conduit means for supplying pressure fluid to the cylinder of the biasing means between the biasing piston and said member.

8. In a hydraulic actuator mechanism, feed-back means as claimed in claim 7, wherein the servo motor is provided with means for biasing the motor piston thereof towards a position intermediate the ends of its travel relative to the motor cylinder, which biasing means comprises a piston and cylinder mechanism, a plunger coupled to the servo motor piston which plunger extends slidably into the cylinder of the servo motor biasing means, a lost motion connection coupling the piston of the servo motor biasing means and the plunger together, and conduit means for supplying pressure fluid to the cylinder of the servo motor biasing means between the piston thereof and said plunger.

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