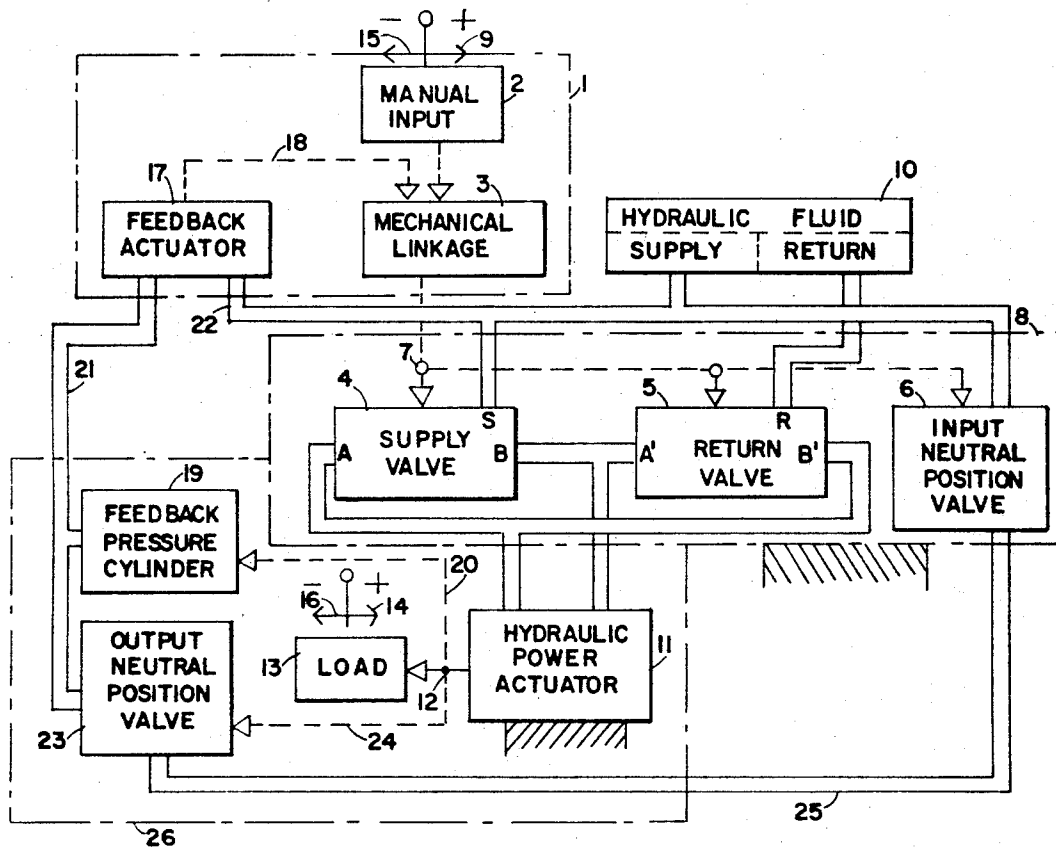


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HYDRAULIC FEEDBACK SYSTEM

Sheet 1 of 4



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March 18, 1969

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3,433,126

HYDRAULIC FEEDBACK SYSTEM

Filed Oct. 19, 1966

Sheet 2 of 4

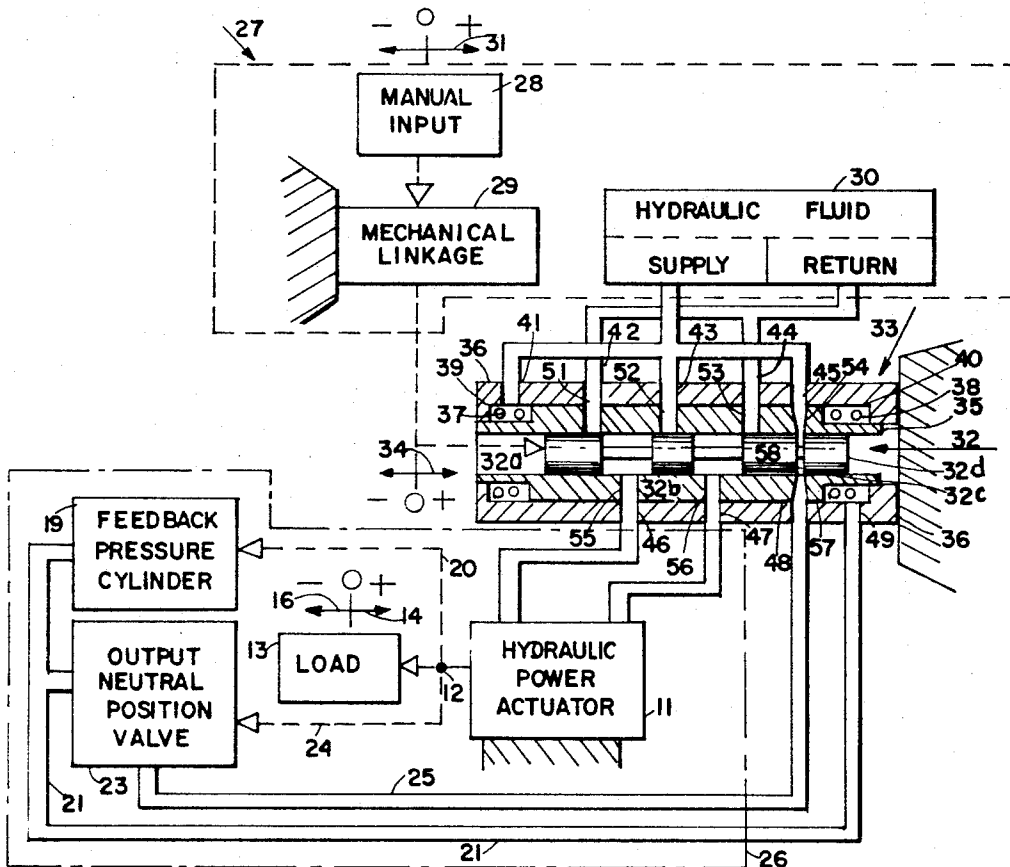


FIG. 2.

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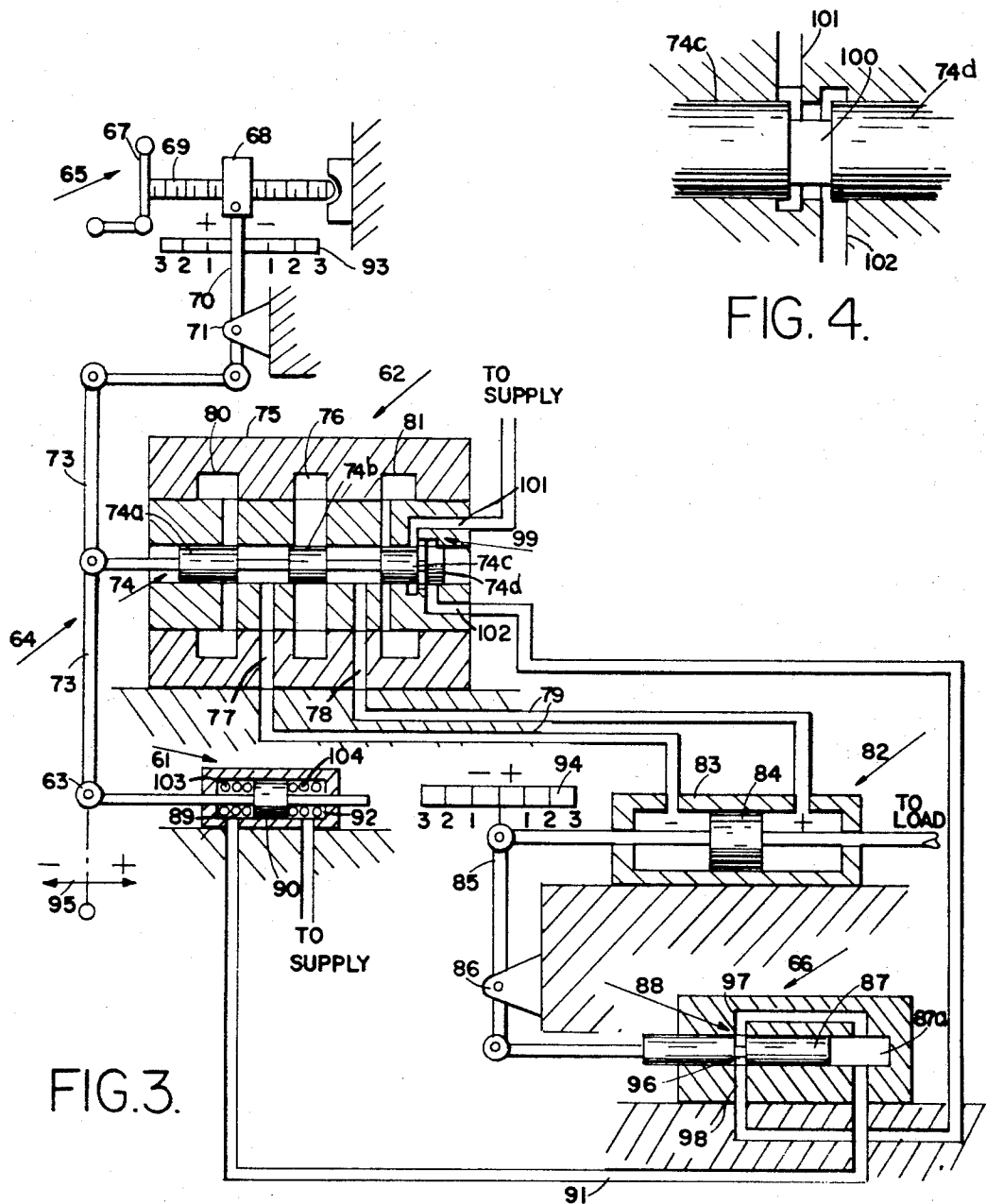
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Sheet 3 of 4



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Sheet 4 of 4

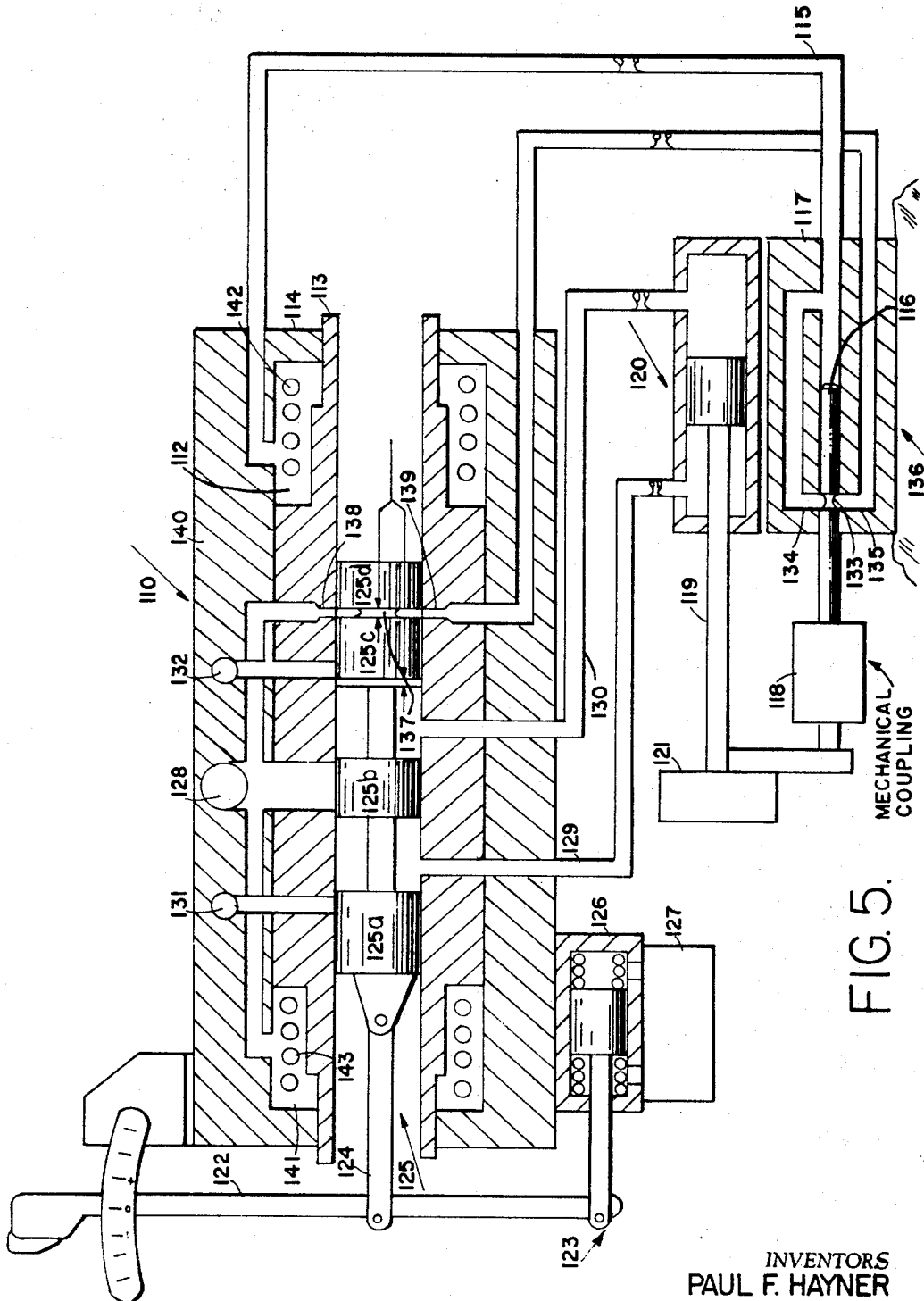


FIG. 5.

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HYDRAULIC FEEDBACK SYSTEM

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Filed Oct. 19, 1966, Ser. No. 661,151

U.S. Cl. 91-367

17 Claims

Int. Cl. F15b 13/16, 9/10

ABSTRACT OF THE DISCLOSURE

A hydraulically operated mechanism for positioning a remote load in accordance with the position of a local input member. Movement of the input member operates a control valve which transmits fluid pressure to an actuator which displaces the load and also actuates a mechanism which transmits feedback fluid pressure which repositions the control valve. Errors which accumulate due to leakage, fluid expansion due to temperature, etc. are corrected each time the system becomes static with both the input member and the load in their central or zero displacement positions.

This invention relates to hydraulic feedback systems and, more particularly, to hydraulic position feedback systems including means for eliminating and correcting position drift in the system.

Hydraulic position feedback systems generally include a mechanically actuated control valve by which hydraulic fluid is delivered from a supply source to an output actuator and through which return fluid from the actuator is delivered to the source. Such systems include position feedback means which also controls the valve but in an opposite sense to the manual control. Thus, the feedback is negative feedback. As often occurs in such systems, changes in the load, hydraulic leakage or changes in the volume of the hydraulic feedback system due to changes in temperature, result in an error in the position feedback.

It is one object of the present invention to provide a hydraulic position feedback system in which said errors are eliminated and/or corrected.

It is another object of the present invention to provide a hydraulic position feedback system including means whereby changes in the relationship between input control position and load position are eliminated and/or corrected.

It is another object of the present invention to provide an improved hydraulic position control system.

In an application of the present invention, a hydraulic feedback system is provided for administering a control action to the main hydraulic control valve which controls the flow of hydraulic fluid to and from an output actuator in such a manner that the actuator positions a load to positions corresponding to the position of the main valve control mechanism. The sense of the feedback control applied to the valve is such that the valve feeds hydraulic fluid to the actuator which positions the load until the load reaches a position corresponding to the position of the control mechanism. As this corresponding position is reached, the feedback system administers a control action to the valve which cuts off the flow of the hydraulic fluid through the valve to the actuator. In the present invention, means are provided to eliminate the feedback action each time the valve control mechanism is positioned at the neutral or zero position. In applications where the feedback is a hydraulic pressure, feedback is eliminated at the zero position by connecting the feedback pressure to a reference pressure source selected to represent zero feedback. This is accomplished employing

one or more neutral position valves in series which connect the feedback pressure to the reference pressure and is operated by the output actuator.

For example, if the requirement for system gain is sufficiently low, a single neutral position valve operated by the output actuator may be employed to open the feedback pressure line to the reference pressure each time the actuator is positioned at neutral. On the other hand, if the system gain requirement is relatively high, the phase lag between input and output at increasing response rates may best be solved by two neutral position valves in series. In this case, the first neutral position valve is operated by the main valve control mechanism and opens when the mechanism is positioned at the neutral position, and the second neutral position valve is actuated by the output actuator and opens when the load is positioned at the neutral position. These two valves are connected in series and open the hydraulic feedback line to the reference pressure so that the feedback system is neutralized and provides neither positive nor negative feedback to the main control valve.

In the various embodiments of the invention described herein, the feedback system includes a spring loaded piston. Hydraulic fluid at constant pressure (reference pressure) is provided to one side of the piston and hydraulic fluid at variable pressure is provided to the other side of the piston. The variable pressure fluid is obtained from a feedback pressure piston which is mechanically actuated by the output actuator so as to provide greater and greater hydraulic fluid pressure to the second side of the feedback system as the output actuator moves in the given direction. The unbalanced pressure across the feedback piston causes the piston to move until the unbalanced pressure is opposed and balanced by the spring forces, and this movement is applied to the main control valve as the feedback thereto. In the present invention, when the input control mechanism and the load are positioned at their neutral positions, equal pressures are applied to both sides of the feedback piston and so the feedback piston provides no feedback to the main control valve.

Hydraulic position control systems, such as described above, in normal use are operated through the neutral position many times during each hour of operation. Employing the present invention, each time the system is operated through the neutral position, feedback errors which arise for reasons already stated are eliminated. For example, the steering and diving controls on a submarine will go through the neutral position on the average about once a minute, and since the temperature change of the hydraulic fluid in one minute is comparatively small and leakage is also small, the one minute interval between corrections is adequate.

Other objects and features of the present invention will be apparent from the following specific description taken in conjunction with the figures in which:

FIG. 1 is a block diagram of a hydraulic position control system incorporating features of the present invention;

FIG. 2 is a block diagram of a hydraulic position control system incorporating features of the present invention and includes a sectional view of one form of the main control valve;

FIG. 3 is a sectional view of one arrangement of parts of the hydraulic system illustrated in FIG. 1 and illustrates a main control valve and feedback system slightly different from that illustrated in FIG. 2;

FIG. 4 is an enlarged sectional view of a portion of FIG. 3; and

FIG. 5 is a sectional view of a control system similar to that illustrated in FIG. 2.

Turning first to FIG. 1 there is shown a block diagram which illustrates a typical hydraulic control system which is manually controlled and which positions a load. This system is equipped with position feedback and includes means for eliminating the position feedback when in the neutral position. The input mechanism 1 of the system is controlled by manipulation of the manual input 2 which actuates a mechanical linkage 3. Mechanical linkage 3 simultaneously actuates the supply valve 4, a return valve 5 and the input neutral position valve 6. These valves 4, 5 and 6 are effectively ganged and operated together by, for example, a single actuating mechanism 7 from the mechanical linkage 3. The ganged valves are referred to by the reference number 8.

The ganged valves 8 are controlled by the mechanism 7 so that a manual control in the positive direction 9 of the manual input 2 causes the supply valve 4 to feed hydraulic fluid from the supply portion of the hydraulic fluid source 10 from port S to port A of the supply valve 4. At the same time, the return valve 5 is actuated to feed return hydraulic fluid from port A' to port R which returns the fluid to the return portion of the source 10.

Port A of the supply valve 4 feeds hydraulic fluid to one side of the hydraulic power actuator 11 which includes a ram piston connected by the mechanism 12 to load 13 causing the load to move in the positive direction denoted by arrow 14.

On the other hand when the manual input 2 is moved in the negative direction indicated by arrow 15, the mechanism 7 causes the supply valve 4, ports S and B to connect and causes the return valve 5, ports R and B' to connect. Thus, hydraulic fluid from the supply is delivered to the opposite side of the hydraulic powered actuator ram causing the load 13 to move in the negative direction indicated by the arrow 16.

Position feedback in the system described so far can be accomplished in a variety of ways. One way of accomplishing position feedback is illustrated in the figure. For example, a feedback actuator 17 which is mechanically part of the input mechanism 1 can be employed. The actuator 17 is hydraulically powered and applies a mechanical action 18 which combines with the output from the manual input 2 to control the mechanical linkage 3. The feedback actuator 17 responds to movement of the load in such a manner that a movement of the load in the positive direction in response to a manual input in the positive direction causes the feedback actuator 17 to provide a mechanical input to the mechanical linkage which tends to oppose the manual input to the mechanical linkage, or tends to reduce the effect of the mechanical input from the manual input 2 to the mechanical linkage 3. Thus, the feedback is negative. The feedback effectively turns off the supply and return valves 4 and 5 so that there is no flow of hydraulic fluid between the actuator 11 and the source 10 even through the manual input remains stationary at a positive position or a negative position.

For the purpose of controlling the feedback actuator 17, a feedback pressure cylinder 19 is provided. The piston in the pressure cylinder 19 is mechanically connected by mechanism 20 to the ram in the actuator 11 so that motion of the ram, in for example, the positive direction, causes the piston in the cylinder 19 to increase the pressure in the hydraulic feedback line 21 connected to the feedback actuator 17.

The hydraulic feedback pressure in line 21 opposes the supply (reference) pressure fed to feedback actuator 17 via line 22 and, depending upon which pressure is greater, causes the feedback actuator to move one way or another against a spring load. This movement continues until the spring load counter balances the unbalanced pressure. The action of the feedback cylinder is response to movement of the output ram, the design of the feedback actuator and its spring loading, the design of the supply and return valves and the mechanical linkage thereto are

all such that the position of the load in the plus direction and minus direction on each side of the zero position corresponds to the position of the manual input in the plus and minus directions on each side of its zero position. The feedback is such that once the load is positioned to a position which corresponds with the manual input position, all flow of hydraulic fluid between the actuator 11 and the source 10 stops, effectively locking the actuator 11 in position.

As can be seen, from the above description of the system, changes in the magnitude of the load 13, changes in the relative temperature between the fluid in lines 21, 22 and 25 and internal or external leakage of fluid from lines 21, 22 and 25 will all introduce an error in the system so that the magnitude of feedback will drift. In accordance with the present invention, this situation is remedied by valving means which connect the line 25 to the supply. This effectively neutralizes the feedback actuator each time the system is positioned at the neutral or zero position. For this purpose, there is provided the input neutral position valve 6 controlled by the mechanism 7 and the output neutral position valve 23 which is controlled by mechanical connection 24 to the ram in the power actuator 11. Thus, valve 6 is controlled by the input to the system and valve 23 is controlled by the output from the system. The feedback line 21 is opened to the supply portion of the source 10 (reference pressure) via valve 6, line 25 and valve 23 each time the manual input 2 and the load 13 simultaneously move through their zero or neutral positions, thereby correcting the feedback errors introduced to the system for reasons already stated. For convenience, the actuator 11, load 13, feedback cylinder 19 and output neutral position valve 23 are preferably at the same location and constitute the output mechanism 26.

The system described above includes two neutral position valves 6 and 23 and is preferred when the requirements for system gain is relatively high. If system gain is relatively low, the input neutral position valve may be eliminated (bypassed) so that only a single valve, 23, connects the feedback line 21 with the supply of source 10. The inherently greater stability of the low gain system permits use of the single neutral position valve controlled by the output actuator 11 to open each time the actuator is positioned at neutral.

FIG. 2 illustrates a similar embodiment of the invention in which the supply valve, the return valve and the input neutral position valve are formed in an integral unit shown in cross section and referred to herein as the main control valve. As shown in FIG. 2, the output mechanism 26 at one location is the same as in FIG. 1. This includes the hydraulic power actuator 11 driving the load 13 and the feedback pressure cylinder 19 and output neutral position valve 23 which are operated by mechanical connection to the ram of the actuator 11 just as already described with reference to FIG. 1. The input mechanism 27 including the manual input 28, mechanical linkage 29 and hydraulic fluid source 30 may also be similar to correspondingly named parts in FIG. 1.

In operation, the manual input 28 is positioned to, for example, a plus position by movement in the direction of arrow 31 and this movement is transmitted via the mechanical linkage 29 to the main spool 32 in the valve 33. A positive motion of the manual input in the direction of arrow 31 causes the main spool 32 to move in a positive direction indicated by arrow 34. The spool 32 moves within a cylindrical sleeve 35 which is slideably mounted within the valve block 36. The sleeve is positioned within the valve block by springs 37 and 38 at each end of the sleeve which bear against both the sleeve and the valve block. The springs 37 and 38 are enclosed within cavities 39 and 40, respectively, to which hydraulic fluid is fed which also tends to position the sleeve within the block, the final position of the sleeve within the block being determined

by the spring tensions and the magnitude of the fluid pressures in the cavities 39 and 40.

Hydraulic fluid ports 41 to 49 are provided in the block. Port 41 feeds hydraulic fluid (reference pressure) from the supply of the source 30 to the cavity 39 and port 49 feeds fluid from feedback line 21, which is pressurized by the feedback pressure piston 19, to the cavity 40. Thus, the differential pressure acting upon the sleeve within the valve block is a function of the displacement of the load from the zero or neutral position. This function may be a linear function such that the differential is zero when the load is at the zero position and increases linearly as the load is displaced in the positive direction indicated by arrow 14. Correspondingly, as the load is displaced in the negative direction indicated by arrow 16, the direction of the differential is reversed and also changes proportional to the magnitude of the displacement from the zero position. Thus, negative position feedback is provided.

The ports 42 to 48 are at least in partial registry at all times with the ports 51 to 57, respectively, in the sleeve 35. Ports 42 and 44 connect to the return of the hydraulic fluid source 30 and ports 41, 43 and 45 connect to the supply of the hydraulic fluid source. The purpose of the sections 32a to 32d of the spool 32 sliding within the sleeve 35 is to gate the flow of hydraulic fluid between the source 30 and the actuator 11 and between the source and feedback line 21 via the output neutral position valve 23. Thus, the functions of supply valve 4, return valve 5 and input neutral position valve 6 in FIG. 1 are all performed by the main control valve 33 and position feedback is applied to this valve via line 21 as a hydraulic fluid pressure rather than a mechanical actuation as in FIG. 1.

If system gain is sufficiently low, or the system is inherently exceedingly stable, the input neutral position valve may be eliminated and so valve 23 may be connected directly to the supply of the source 30 (reference pressure). Thus, in such a low gain system, the valve 33 may be substantially simplified and the feedback system requires only one hydraulic line between the output mechanism 26 and the valve 33.

In operation, when the spool 32 is moved in the positive direction denoted by arrow 34, port 51 is blocked, port 52 is opened feeding supply fluid through port 55 to the actuator 11, and port 53 is opened feeding hydraulic fluid from the actuator 11 through ports 56 and 53 to the return of the source 30. This causes the ram of the actuator 11 to move and displace the load 13 in the positive direction denoted by arrow 14. At the same time, the ram moves the piston in the feedback cylinder 19 decreasing the pressure of fluid in line 21 which changes the unbalance of pressure on the sleeve within the block causing the sleeve to move relative to the block in the direction of arrow 34. Thus, the motion of the spool to uncover ports and permit hydraulic fluid to flow to the actuator causing the actuator to move is compensated for as the feedback causes the sleeve to move in the same direction as the spool. When the actuator 11 is at a position corresponding to the concurrent position of the manual input 28, the compensation is complete and the supply and return of the source 30 are blocked from the actuator 11.

The ports 54 and 57 in the sleeve 35 are positioned so that when there is no unbalanced hydraulic pressure on the sleeve within the block 36 and when the spool 32 is at the zero or neutral position of the manual input, these ports align with the narrow annular groove 58 between the spool sections 32c and 32d so that supply fluid pressure is applied to the output neutral position valve 23. The groove 58 and ports 54 and 57 combine to define the input neutral position valve which performs the same function as valve 6 in FIG. 1.

Valve 23 opens when the load is at the zero or neutral position and causes hydraulic fluid supply pressure to be applied to line 21. This effectively connects the cavities 39 and 40 which drive the sleeve in the block to the same supply pressure and so the sleeve is positioned only by the springs 37 and 38. Thus, it is seen that each time the system

moves through the zero or neutral position the effect of feedback is made zero thereby eliminating the feedback errors due to the previously mentioned time changing variables.

FIGS. 3 and 4 illustrate still another embodiment of the invention including parts which correspond substantially to the various parts in the block diagram of FIG. 1. In this embodiment, the feedback is both hydraulic and mechanical, just as in FIG. 1, and is applied from the feedback actuator 61 to the main control valve 62 by moving the floating fulcrum 63 of the mechanical linkage 64 which connects the manual input 65 to the valve. The main control valve 62 provides the functions of the supply valve 4, return valve 5 and the input neutral position valve 6 of FIG. 1. Also, the feedback pressure actuator 66 performs the functions of the feedback pressure cylinder 19 and output neutral position valve 23 in FIG. 1.

In operation, the manual input 65 is operated by rotating the handle 67 which translates a nut 68 along a screw 69 and the screw moves a lever 70 about the input fulcrum 71. This in turn moves the main valve lever 73 about the floating fulcrum 63 and positions the spool 74 within the valve housing 75. The spool 74 includes four sections 74a and 74d. Section 74b meters hydraulic fluid from the supply cavity 76 to one or the other of ports 77 or 78 which connect with the lines 79 feeding the load actuator 82. The spool sections 74a and 74c meter flow between the ports 77 and 78 and the return cavities 80 and 81.

The actuator 82 includes a cylinder 83 and ram or piston 84 which drives the lever 85 about the output fulcrum 86 so as to position the positive acting piston 87 and neutral position valve 88 in the position actuator 66. The piston 87 pressurizes hydraulic fluid in the cavity 87a which connects to one side 89 of the feedback piston 90 in the feedback actuator 61 via feedback line 91. The other side 92 of the feedback piston is fed directly from the hydraulic fluid supply.

In operation, when the manual input 65 is operated so that the nut 68 travels along the input scale 93 in the positive direction or to a positive position, lever 73 is moved so that the main spool piston 74b opens port 77 to fluid supply pressure. At the same time, piston 74c opens port 78 to the return 81. This causes the output ram to move in the positive direction as indicated on the output scale 94 and move the piston 87 so as to decrease the pressure on side 89 of the feedback piston 90 which moves in the negative direction indicated by arrow 95 and displaces the floating fulcrum 63 in the negative direction. This shift of the fulcrum 63 in the negative direction, indicated by arrow 95, effectively cancels the manual control action on the spool 74 so that the flow of hydraulic fluid between the output actuator 82 and the supply and return cavities of valve 62 is stopped. This locks the output ram in position. Thus, it is seen, the hydro-mechanical position feedback is negative feedback and causes the output scale reading to follow the input scale reading.

The neutral or zero position correction to the feedback system is accomplished by connecting the cavity 87a (which controls the position of the feedback piston) to the supply or reference pressure. The cavity 87a is connected to supply pressure when the neutral position valve 88 opens. This valve opens when the annular groove 96 in the feedback pressure piston 87 is in registry with the ports 97 and 98 which connect the cavity 87a to supply pressure via the input neutral position valve 99, shown enlarged in FIG. 4. The input neutral position valve 99 is formed between spool sections 74c and 74d or by an opening 100 between these sections which provides passage between the underlapped piston ports 101 and 102. Thus, whenever the output ram 84 moves through the neutral or zero position as indicated on the output scale 94, and at the same time the main spool of valve 62 is manually positioned at or very near the input neutral position as indicated on scale 93, the left side 89 of the piston 90 is connected to supply pressure thereby reducing

the pressure differential across the feedback piston 90 to zero so that the feedback piston is positioned by the springs 103 and 104 loaded therein. This places the fulcrum 63 at the zero or neutral position. By placing the fulcrum at the zero position each time the system goes through neutral, the drift in the feedback caused, for example, by changes in the load driven by the actuator 82 or leakage of fluid from the pressure actuator 66 or the feedback actuator 61 is eliminated.

If the requirement for system gain is sufficiently low or the system is inherently very stable, the function of the input neutral position valve 99 may be eliminated. In this case, port 98 of the position actuator 66 would connect directly to supply pressure so that valve 99 is bypassed. This would reduce the total number of hydraulic lines running between the actuators 82 and 66 and the main control valve 62 to a minimum of three.

The underlapped piston ports 101 and 102 of the input neutral position valve 99 and the annular opening 100 between the piston sections 74c and 74d of the main spool are dimensioned to provide a zero position deadband region of this valve equal to the deadband region of the valve 88 formed in the feedback pressure actuator 66. A reasonable requirement for this deadband region is 0.5% of the overall positioning range. This is a reasonable requirement, for example, for the hydraulic steering and diving control of a submarine. The dwell time of such a hydraulic positioning system at any particular position is at least 0.1 second. Accordingly, in the submarine steering and diving control systems, the dimensions of the input neutral position valve 99 and the output neutral position valve 88 as well as the fluid lines between these valves and the feedback actuator 61 are sufficient so that the correction to the floating ground position may be accomplished within the 0.1 second dwell time.

FIG. 5 illustrates in sectional view an embodiment incorporating structural features shown in FIGS. 2 and 3. In this embodiment, the main control valve 110 is substantially identical to valve 33 and the position feedback to this valve is all hydraulic just as in FIG. 2. Feedback pressure is applied to the cavity 112 at one end of sleeve 113 mounted slideably within the valve block 114. The feedback fluid in line 115 is pressurized by the feedback piston 116 driven within the feedback piston cylinder 117 by a mechanical coupling 118 which connects the piston to the output ram 119 of the output actuator 120. Thus, the movement of the piston 116 is proportional to the movement of the load 121 by the output ram 119 and is in such a direction as to provide negative feedback.

The valve 110 is operated manually by positioning the lever 122 about a spring centered fulcrum 123 so that an arm 124 connecting the lever to the valve spool 125 positions the spool within the sleeve 113. The fulcrum 123 is centered by the spring operated actuator 126 which may be controlled by a mechanism 127 for imposing a bias on the system. The mechanism 127 may be electrically, mechanically, hydraulically, or pneumatically operated and preferably imposes a predetermined schedule of operation on the system which may be overridden at any time by operation of the manual input lever 122. For example, if the system is used to control the diving or steering control surfaces of a submarine, the mechanism may be automatically controlled in response to submarine depth or heading as detected by appropriate transducers. Thus, in this manner, the system would operate as an automatic pilot subject at any time to being overridden by the human operator.

A bias mechanism such as 127 may also be employed in the system shown in FIG. 3 to add a third control action to the mechanical linkage 64 which positions the spool 74 to control the hydraulic flow to and from the load actuator 82. In this case, the mechanical linkage is not a simple lever as shown, but preferably takes the form of the so called tripod input lever described in co-pending application entitled, "Multi-Arm Lever Mecha-

nism," by Paul F. Hayner and Lawrence W. Sharpe, Ser. No. 587,893, filed on even date herewith and assigned to the same assignee as is the instant application.

The tripod input lever feeds three mechanical actuations to the spool of the main control valve; these are the manual input from a device such as 65, a feedback actuation from a feedback actuator such as 61 and a bias actuation from a bias actuator such as 126 which is controlled by a bias mechanism such as 127. All three actuations are instrumental, via the tripod input lever, to position the spool in the main control valve.

The tripod input lever is so constructed that the manual input can override both the feedback and the bias. Since the bias can represent a predetermined schedule of operation, the system can operate as an automatic pilot subject to being overridden by the human operator.

Referring again to FIG 5, the spool section 125b meters supply fluid from the supply cavity 128, which connects the hydraulic fluid source, to the ports 129 and 130, which connect to one side or the other of the output actuator 120. At the same time, one of the return fluid cavities 131 or 132 is blocked and so fluid is returned from the other side of the actuator 120 to the source. This causes the ram 119 to move the load 121 and to actuate the mechanical coupling 118 which in turn moves the feedback piston 116 in such a direction as to change the pressure in line 115 and cavity 112 in such a sense that the sleeve 113 moves in the same direction that the spool has just moved which in sequence blocks the supply cavity 128 and return cavities 131 and 132 within the main valve block.

An annular groove 133 in the feedback piston 116 combines with ports 134 and 135 in the cylinder 117 to define the output neutral position valve 136 and the groove 137 between spool pistons 125c and 125d combines with ports 138 and 139 in the sleeve to define the input neutral position valve 140. Port 138 connects to the supply cavity 128 and port 139 connects to the output neutral position valve 136.

In operation, when both the input, 140, and output, 136, neutral position valves are open, cavity 112 is connected to the supply or reference pressure just as the cavity 141 and so the sleeve is returned to the neutral position by the centering springs 142 and 143. This operation is the same as in valve 38 in FIG. 2. The dimensions of the groove on the main spool piston sections 125c and 125d and the ports 138 and 139 and the dimensions of the output neutral position valve 136 are such that a significant calibration correction is made each time the system is at or near the neutral position. If, for example, the deadband portion is 1½% of maximum stroke and the output ram feedback has about six percent position error, the system must course through the zero or neutral position four times to make a complete calibration correction of the neutral position.

This completes descriptions of a number of embodiments of the present invention of a hydraulic position system including position feedback which may be administered to the input of the system hydro-mechanically or all hydraulically and in which means are provided for effectively cancelling the feedback so that the feedback is zero each time the system is positioned at a neutral position, thereby correcting feedback errors introduced by changes in the trapped hydraulic volume due to external or internal leakage across the system seals, changes in volume due to changes in the system load, or changes in the trapped volume due to rapid changes in temperature of the hydraulic fluid.

What is claimed is:

1. A hydraulically operated positioning system comprising:

- (A) a source of pressurized hydraulic fluid,
- (B) means for driving a load,
- (C) means for controlling the flow of said hydraulic fluid to said driving means,

- (D) feedback means coupling said driving means to said control means,
- (E) whereby said driving means and said control means function in synchronism moving together to related positions, and
- (F) means for inactivating said feedback means when said driving means is at a predetermined position.
2. A hydraulically operated positioning system comprising:
- (A) A source of pressurized hydraulic fluid,
- (B) means for driving a load,
- (C) means for controlling the flow of said hydraulic fluid to said driving means,
- (D) feedback means coupling said driving means to said control means,
- (E) whereby said driving means and said control means function in synchronism moving together to related positions, and
- (F) means for inactivating said feedback means when said driving means and said control means are each in a predetermined position.
3. A system as in claim 2 in which:
- (A) said predetermined positions of said driving means and said control means are their respective neutral positions.
4. A system as in claim 3 and in which:
- (A) said control means comprises mechanically controlled valve having a mechanical input thereto, and
- (B) said feedback means mechanically connects to said mechanical input.
5. A system as in claim 3 and in which:
- (A) said control means includes a hydraulically driven valve, and
- (B) said feedback means connects hydraulically to said valve.
6. A system as in claim 3 and in which:
- (A) said feedback means includes means for producing a feedback fluid pressure representative of the position of said driving means,
- (B) feedback actuator means responsive to said feedback pressure, and
- (C) means coupling said feedback actuator means to said control means.
7. A system as in claim 6 and in which:
- (A) said means for inactivating said feedback means includes means for substantially nullifying the effect of said feedback pressure on said feedback actuating means.
8. A system as in claim 7 and in which:
- (A) said means for nullifying includes a valve which connects said feedback pressure to a reference pressure to cause said nullification.
9. A system as in claim 7 and in which:
- (A) said means for nullifying includes two valves in series which connect said feedback pressure to a reference pressure to cause said nullification.
10. A system as in claim 8 and in which:

- (A) said means for nullifying includes at least two valves in series which open said feedback pressure to said source pressure to cause said nullification.
11. A system as in claim 7 and in which:
- (A) said feedback actuator means includes a spring centered feedback piston which mechanically connects to said control means, and
- (B) said feedback piston is driven against said springs by the hydraulic pressure differential between said feedback pressure and said source pressure.
12. A system as in claim 10 and in which:
- (A) the first of said two valves in series is controlled by said control means, and
- (B) the second is controlled by said driving means.
13. A system as in claim 10 and in which:
- (A) said driving means, said means for producing said feedback pressure and said second valve are formed in an integral unit.
14. A system as in claim 10 and in which:
- (A) said control means, said feedback actuator means and said first valve are formed in an integral unit and said driving means, said means for producing said feedback pressure and said second valve are formed in another integral unit.
15. A system as in claim 2 and further including:
- (A) manually operated means connected to said controlling means, and
- (B) biasing means connected to said controlling means and responsive to a preselected parameter,
- (C) whereby said manually operated means can be actuated by an operator to override said biasing means in the operation of said system.
16. A system as in claim 15 and in which:
- (A) said biasing means comprises a hydraulic bias signal, a hydraulic bias actuator responsive thereto and means connecting said bias actuator to said controlling means.
17. A system as in claim 15 and in which:
- (A) said biasing means comprises an electrical bias signal, a bias actuator responsive to said bias signal and means connecting said bias actuator to said controlling means.

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U.S. Cl. X.R.

91—374, 384, 388; 307—88