

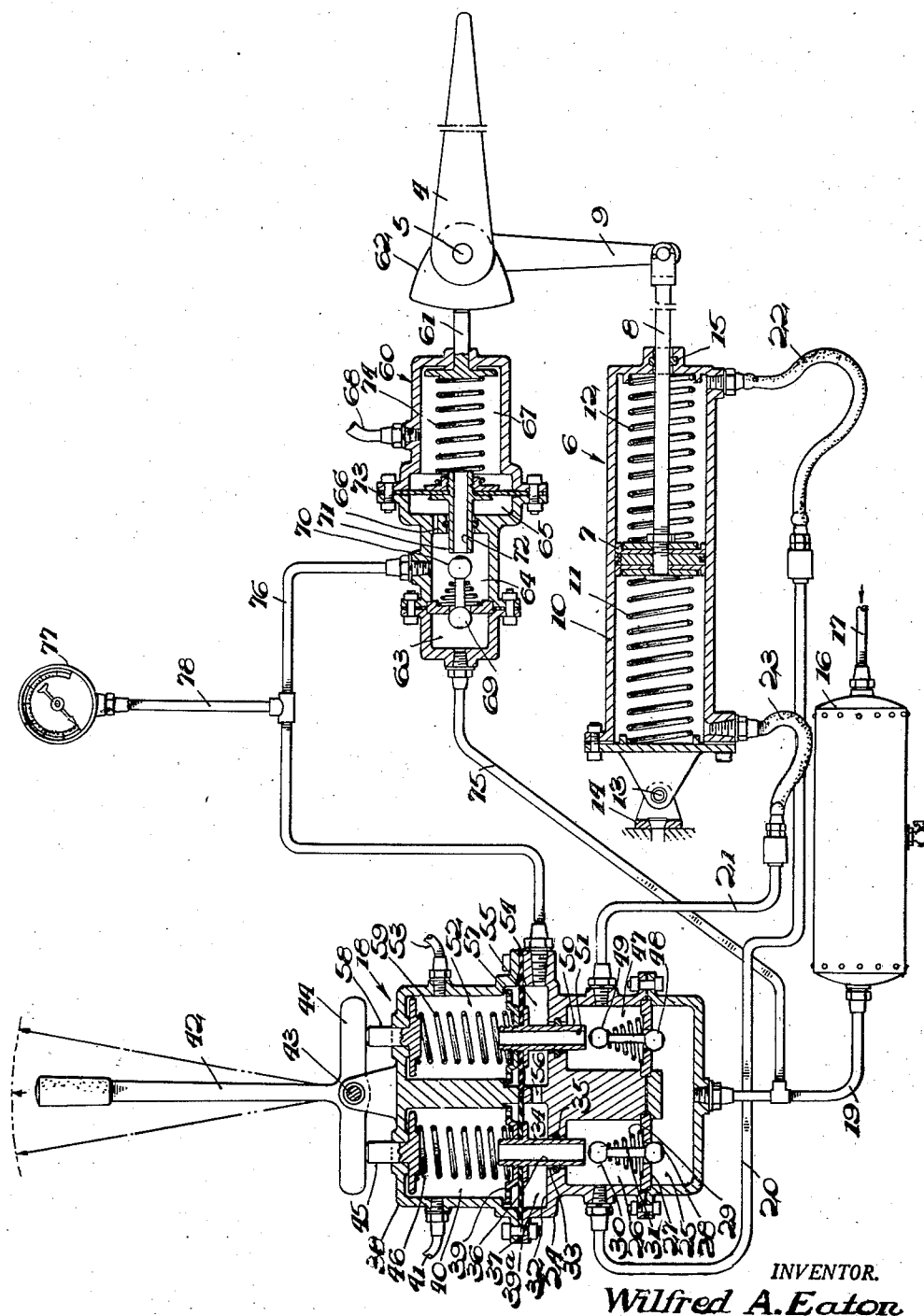
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FLUID PRESSURE CONTROL MECHANISM

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FLUID PRESSURE CONTROL MECHANISM

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This invention relates to fluid pressure control mechanism and more particularly to mechanism for effecting the control of a remotely positioned device such as an airplane or boat rudder without the use of mechanical connections between the device to be controlled and the operator's control station.

It has been previously proposed to utilize fluid pressure operated mechanism for remotely controlling devices of the above character, but difficulty has been experienced in connection with some of these mechanisms in providing a properly graduated control similar to that provided by direct mechanical connections; and it is accordingly an object of the present invention to provide mechanism for overcoming these difficulties.

A further object of the invention is to provide remote control mechanism of the so-called telomotor type wherein the mechanism for controlling the energization of the actuator is responsive jointly to the operation of the operator's control member and the movement of the device to be actuated.

Yet another object of the invention is to provide, in connection with a system of the above type, simple and efficient means for indicating to the operator the degree of movement of the actuated device.

A still further object of the invention is to provide control mechanism of the above type wherein valve mechanism of the self-lapping type under the control of the operator is further controlled by self-lapping valve means operated by the movement of the actuated device.

Another object of the invention is to provide mechanism of the above type so constituted that movement of the operator's control member is opposed at all times by forces proportional both to the degree of movement of the actuated device and the degree of energization of the actuator.

These and other objects and novel features of the invention will appear more fully hereinafter from the following detailed description when taken in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is employed for the purpose of illustration only and is not designed as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

In the drawing, the single view illustrates diagrammatically and partially in section, a control mechanism for the elevator of an airplane constructed in accordance with the principles of the present invention.

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Referring to the drawing, the invention is illustrated in connection with an airplane elevator or rudder 4 pivotally mounted on the airplane, not shown, by means of a shaft 5, the elevator being actuated by means of a double acting fluid motor 6, having a piston 7 connected with the elevator through the medium of a piston rod 8 and a lever 9. The fluid actuator or motor 6 is provided with a cylinder 10 in which the piston is slidably mounted, the piston, and consequently the elevator, being normally maintained in the neutral position shown by means of opposed springs 11 and 12 interposed between the piston and the left and right ends of the cylinder, respectively. The left end of the cylinder is pivotally mounted by means of a pin 13 on a bracket 14 carried by the airplane, leakage around the piston rod at the right end of the cylinder being prevented by means of a suitable seal 15.

A source of fluid pressure such as a reservoir 16 is provided, fluid pressure being supplied to the reservoir by means of a compressor, not shown, through a conduit 17. The flow of fluid pressure from the reservoir to the motor 6 is controlled by means of an operator's duplex control valve mechanism 18, fluid pressure being supplied to the valve mechanism through a conduit 19, and being supplied from the valve mechanism to the right and left ends of the motor respectively, through conduits 20 and 21, the conduits being provided at their right ends with flexible hose portions 22 and 23 in order to provide for movement of the cylinder 10 about the pivot pin 13.

The valve mechanism 18 is provided with a casing 24 having an inlet chamber 25 connected with the conduit 19. The left hand portion of the valve mechanism is provided with an outlet chamber 26 separated from the inlet chamber by means of a ported partition 27, communication between the inlet and outlet chambers through the ported partition being ordinarily prevented by means of an inlet valve 28 normally maintained in the position shown by means of a spring 29 interposed between the upper face of the partition and the lower side of an exhaust valve 30 carried on the upper end of a stem 31 extending upwardly from the intake valve. The upper end of the outlet chamber 26 is closed by means of a partition 32 formed in the casing, this partition being provided with a vertical bore 33 arranged substantially in alignment with the inlet and exhaust valve assembly. A valve operating element 34 is slidably mounted in the bore, leakage from the upper end of the outlet chamber

past the outer surface of the element being prevented by means of a suitable seal 35. The valve operating element is provided with a centrally located bore 36, the lower end of the bore being normally in communication with the outlet chamber and being adapted to close on engagement with the upper surface of the exhaust valve 30 during downward movement of the valve operating element. A pressure responsive member or diaphragm 37 is clamped between the upper face of the casing 24 and a cover member 38, the diaphragm being attached at its center to the valve operating element by means of a suitable flanged nut 39, and forming in connection with the casing and the partition 32, a control chamber 39a for the diaphragm which is utilized for purposes to be more fully described hereinafter. The diaphragm forms in connection with the cover plate, an exhaust chamber 40 having an atmospheric conduit 41, and in view of the fact that the upper end of the bore 36 is connected at all times with chamber 40, it will be understood that with the valve mechanism in the position shown, the outlet chamber 26 will likewise be connected with atmosphere. In order that the valve operating element may be actuated by the operator to close the exhaust valve and open the intake valve to supply fluid pressure to the right end of the motor 6 through the conduit 20 and the hose 22, an operating lever 42 is pivotally mounted on the cover by means of a pivot pin 43, this lever being provided with a cross bar 44, the left end of which is adapted to engage the upper end of a valve operating plunger 45 slidably mounted in the upper end of the cover as shown. In order that the plunger 45 may serve to actuate the valve operating element in a downward direction to close the exhaust valve and open the intake valve, a resilient connection or spring 46 is interposed between the upper surface of the nut 39 and the lower end of the plunger 45, it thus being apparent that on movement of the lever 42 in a counterclockwise direction, the plunger 45 will be moved downward to increase the tension of the graduating spring 46, with a corresponding tendency for the valve operating element and diaphragm to be moved downward to close the exhaust valve and subsequently open the inlet valve to establish communication between the inlet chamber 25 and the outlet chamber 26. As heretofore stated the valve mechanism 18 is of the duplex type, and consequently the arrangement just described is substantially duplicated in the right hand portion of the valve, this portion being provided with an outlet chamber 47, inlet and exhaust valves 48 and 49, a valve operating element 50 provided with a bore 51 adapted with the element in the position shown to connect the outlet chamber with an exhaust chamber 52 connected with atmosphere through an exhaust conduit 53, together with a diaphragm 54 and a control chamber 55 formed in the casing below the diaphragm, this chamber being connected with the control chamber 39a by means of a port 56 as shown. The diaphragm is attached to the valve operating element by means of a nut 57 and the element is operated by means of the lever 42 and the bar 44 through the medium of a slidably mounted valve operating member 58 and a graduating spring 59 interposed between the lower end of the sliding member and the upper surface of the nut 57.

It will be readily understood from the foregoing description that on movement of the control lever in a counterclockwise direction, the plunger

45 will be moved downward to compress the graduating spring 46 with resultant downward movement of the diaphragm and valve operating element 34 to first close the exhaust valve and subsequently open the intake valve against the tension of the inlet valve spring 29, thus permitting substantially unrestricted communication between the reservoir 16 and the right end of the motor 6 through conduit 19, inlet chamber 25, ported partition 27, outlet chamber 26, conduit 20 and flexible hose 22, this application of fluid pressure to the right end of the motor tending to move the piston 7 to the left with consequent clockwise rotation of the elevator 4 about the pivot shaft 5. In the absence of any further mechanism, it is apparent that substantially full reservoir pressure would be supplied to the motor 6, and in order to control the operation of the valve mechanism 18 and to control the degree of movement of the elevator 4 in response to a given degree of movement of the mechanism 42, a self-lapping control valve mechanism 60, which may be of any well-known type, but is preferably constructed in accordance with the principles set forth in the patent to William J. Andres and Roy S. Sanford, No. 2,133,275, dated October 18, 1938, is provided with an operating plunger 61 adapted for actuation by means of a cam 62 carried by the elevator 4 and the shaft 5. The control valve mechanism 60 is provided with an inlet chamber 63, an outlet chamber 64, a diaphragm chamber 65 connected with the outlet chamber by means of a restricted passage 66, together with an exhaust chamber 67 connected with atmosphere by means of an atmospheric connection 68, communication between the inlet and outlet chambers being controlled by an inlet valve 69, and between the outlet chamber and the exhaust chamber by means of an exhaust valve 70 and a valve operating element 71 having a bore 72 serving to normally connect the outlet chamber with the exhaust chamber, the valve operating element being adapted for actuation in one direction by means of a diaphragm 73 subjected to the pressure in the diaphragm chamber, and in the other direction by means of a graduating spring 74 interposed between the right side of the diaphragm and the left end of the valve operating plunger 61. The inlet chamber 63 is connected with the reservoir through a conduit 75 connected with the conduit 19, the outlet chamber being connected with the control chamber 55 of the valve mechanism 18 by means of a conduit 76, it being noted that control chamber 55 is in turn connected with the control chamber 39a by means of the port 56 as heretofore described. In addition to the foregoing, the cam 62 is preferably so formed as to permit the operating parts of the valve 60 to remain substantially in the position shown when the elevator 4 is in neutral position, movement of the elevator, and consequently of the cam in either direction from that position, serving to cause the cam to move the valve operating plunger 61 to the left. On reference to the above named patent, it will be understood that with the valve parts in the position shown, communication will be prevented between conduits 75 and 76 and will be permitted between conduits 76 and 68, movement of the plunger 61 to the left serving to operate the valve operating element 71 in cooperation with the exhaust valve 70 to prevent communication between the outlet chamber 64 and the exhaust conduit 68, and on further movement to open the inlet valve 69 to

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permit communication between the inlet chamber and the outlet chamber, the valve mechanism thereafter serving to automatically maintain a pressure in the outlet chamber 64 and consequently in the conduit 76 which is substantially proportional to the degree of movement of the valve operating plunger 61 from the position shown. When the plunger 61 is operated by the cam 62, it will be understood that the surface of the cam in contact with the plunger can be so proportioned as to vary the pressure delivered by the valve in any desired ratio to the degree of movement of the elevator to either side of neutral position.

Assuming for example, that the operator desires to move the elevator 4 in a clockwise direction in order to raise the tail of the airplane and depress the nose, it is only necessary for him to move the control lever 42 in a counterclockwise direction about the pivot pin 43, whereupon the plunger 45 is depressed in accordance with the degree of movement of the lever, and the graduating spring 46 is accordingly compressed to a degree proportional to the degree of movement of the lever. When this action occurs, the lower end of the valve operating element 34 will contact the exhaust valve 30 to close off communication between the outlet chamber 26 and the exhaust conduit 41, subsequent movement of the element serving to open the inlet valve 28 to permit communication between the reservoir 16 and the right end of the fluid motor through the connections already described. Thereupon the piston 7 will be moved to the left, and in view of its connection with the elevator through piston rod 8 and lever 9, the elevator and the cam 62 will be rotated in a clockwise direction about the shaft 5. This rotation of the cam 62 will serve to depress the valve operating plunger 61 of the valve mechanism 60 in order to establish a pressure in the outlet chamber 64 and in the conduit 76 which is substantially proportional to the degree of movement of the plunger 61 and consequently to the degree of movement of the cam 62 and the elevator 4, and since fluid from the outlet chamber is supplied to the control chambers 39a and 55 through the conduit 76, as heretofore described, it will be understood that the elevator may eventually reach a position such that the pressure delivered by the valve mechanism 60 to the control chamber 39a will exert a sufficient upward force on the diaphragm 37 to overcome the force exerted by the spring 46 and to move the valve operating element 34 upward to permit closing of the inlet valve 28 under the action of the inlet valve spring 29. In the event the elevator continues its movement in the clockwise direction due to the inertia of the fluid or inertia of the moving parts, it will be clear that the pressure delivered by the valve mechanism 60 will still further increase, this increased pressure acting on the diaphragm 37 to move the valve operating element 34 upward sufficiently to permit opening of the exhaust valve and consequent escape of the excess fluid pressure from the right end of the motor 6 through the hose 22, the conduit 20, the outlet chamber 26, the bore 36, the chamber 40 and the exhaust conduit 41, the operation of the valves 28 and 30 thus being controlled in one direction by means of the graduating spring 46, and in the other direction by means of the diaphragm 37 in response to the pressure applied thereto by operation of the valve mechanism 60, this pressure in turn being responsive to the angular movement of the

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elevator, and a condition of balance will be eventually reached wherein the pressure delivered to the motor by the valve mechanism 18 is maintained at a value just sufficient to maintain the elevator in a position proportional to the degree of movement of the control lever 42, movement of the elevator in either direction from this position by the application of an outside force tending thus to control the valve mechanism 60 to increase or decrease the pressure in the motor 6 in order to compensate for the unbalanced condition set up by the application of the outside force. In like manner, movement of the lever 42 in the opposite direction from neutral position will serve to supply pressure to the left end of the motor in order to rotate the elevator in a counterclockwise direction, whereupon the valve mechanism 60 will again be under the control of the cam 62 to increase the pressure in the control chamber 55 in order to exert an upward force on the diaphragm which is sufficient to balance or overcome the downward force exerted by the graduating spring 59.

It has also been found desirable in connection with control mechanism of this general type, to provide means for advising the operator as to the actual position occupied by the elevator or other control surface, and simple and efficient means is provided in the present invention for accomplishing this desirable end. As will be understood by those skilled in the art, self-lapping control valves such as the valve mechanism 60 are adapted to deliver an output pressure proportional to the degree of movement of the operating plunger, and since the operating plunger of the valve 60 is actuated by a cam carried by the control surface, it will be apparent that the output pressure of the valve and the pressure in the conduit 76 will at all times be substantially proportional to the degree of movement of the control surface from neutral position, although it is to be understood that the surface of the cam may be varied in order to provide any desired proportion between the delivered pressure and the degree of movement of the control surface. The output pressure of the valve is accordingly a measure of the angular movement of the control surface, and a pressure gauge 77 is accordingly provided which is connected with the conduit 76 by means of a conduit 78 and is therefore responsive at all times to the pressure delivered by the valve mechanism 60. The dial of the indicator may be graduated to show the actual pressure delivered by the control valve, but is preferably graduated to indicate the angle of turn of the elevator from neutral position, it being understood that the intervals between the various graduating points on the gauge dial will vary in accordance with variations in the shape of the cam 62 which serves to operate the valve. Thus, on operation of the control lever 42 to effect movement of the control surface in either direction from neutral position, the pointer of the gauge 77 will indicate the angle of turn of the control surface, as well as any variation in the position of the control surface due to varying slip stream conditions adjacent thereto.

It has also been found desirable, in connection with control systems of the above type, to provide means for apprising the operator of the degree of energization of the fluid motor or actuator, and this desirable end is accomplished in the present invention by virtue of the fact that the areas of the valve operating elements 34 and 50 in the valve mechanism 18 are subjected at all

times to the pressure of fluid obtaining in the outlet chambers 26 and 47 respectively, and are consequently responsive to the pressures existing in the respective ends of the fluid motor. Thus, operation of the valve operating element 34, for example, to operate the valves 28 and 30, is opposed not only by the pressure supplied to the chamber 39a by the operation of the valve mechanism 60, but also by the pressure in the right end of the fluid motor and in the outlet chamber 26 acting on the lower end of the element. While the valve operating elements are illustrated as having relatively small areas, it will be understood that the areas of these elements may be so proportioned as to provide any desired degree of reaction on the operator's control member 42 in order to advise the operator of the degree of energization of the motor 6. Thus, each portion of the valve mechanism 18 is provided with a member responsive to the pressure in the fluid motor and a second member responsive to the pressure delivered by the valve mechanism 60, which in turn is proportional to the angle of turn of the elevator 4 from neutral position, the two pressure responsive members thus providing means for apprising the operator at all times not only of the angle of turn of the device being actuated but also of the degree of energization of the actuating motor.

While the invention has been illustrated and described as utilized in connection with the operation of one of the movable control surfaces of an airplane, it will be understood that the invention may be utilized for the control of other types of devices requiring graduated remote actuation under the control of the operator. While there has been shown and described one form of the invention, it is to be expressly understood that same is not limited thereto but may be embodied in various forms. Various changes in the size and shape, as well as in the arrangement of the various parts, may likewise be made without departing from the spirit of the invention. Reference will, therefore, be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The combination with a device to be actuated and a fluid motor for operating the device, of means for controlling the energization of said motor including valve mechanism having a valve operating element movable in one direction to supply fluid pressure to the motor and in another direction to release fluid pressure from the motor, manually operable means having a resilient connection with the element for moving the latter in said one direction, a pressure responsive member associated with the element for moving the latter in said another direction, and means for supplying fluid pressure to said member for moving the element in said another direction including a control valve and means controlled by movement of said device for operating said control valve for correspondingly varying the pressure of fluid supplied to the member by said control valve.

2. The combination with a device to be actuated and a power actuator for operating said device, of means for controlling the energization of said actuator including power controlling mechanism having an element movable in one direction to supply power to the actuator and in another direction to release power from the actuator, a movable control member for operating said element in one direction, a resilient operating

connection between said control member and element, power operated means associated with said element for moving the latter in said another direction, and means for supplying power to said power operated means for moving said element in said another direction including power control means and means controlled by movement of said device for operating the power control means for correspondingly varying the power supplied to said power operated means by the power control means.

3. The combination with a device to be actuated and a fluid motor for operating said device, of means for controlling the energization of said motor including valve mechanism having valves operable in one position to supply fluid pressure to the motor and in another position to release fluid pressure therefrom, a valve operating element for moving said valves, means for moving the element to move the valves to said one position including a manually operable member and a resilient connection between said member and element, a pressure responsive member associated with the element for moving the latter to move the valves to the other position, means including a self-lapping valve for supplying fluid pressure to said pressure responsive member, and means for effecting an operating connection between said self-lapping valve and device whereby said valve is operated by movement of the device to vary the pressure of fluid supplied to said pressure responsive member in accordance with said movement.

4. The combination with a device to be actuated, a fluid motor for operating the device, and a control member for controlling the operation of the device, of means for controlling the degree of energization of said motor in accordance with the degree of movement of said member and device including valve mechanism having inlet and exhaust valves for supplying fluid pressure to the motor and releasing fluid pressure therefrom, a valve operating element movable in one direction to close the exhaust valve and open the inlet valve and operable in another direction to permit closing of the inlet valve and to open the exhaust valve, a spring for connecting the control member and element for operating the latter in said one direction, a spring for closing the inlet valve, a pressure responsive member connected with the valve operating element, and means for supplying fluid pressure to said pressure responsive member to move the element in said another direction including a control valve operable by movement of the device for varying the pressure of fluid supplied to said pressure responsive member in accordance with said movement.

5. The combination with a device to be actuated, means for normally maintaining said device in a neutral position, a double acting fluid motor for operating said device in either direction from neutral position, and a control member having a neutral position and operable in either direction to control the operation of the device in either direction from neutral position, of means for controlling the degree of energization of said motor in accordance with the degree and direction of movement of said member and device from neutral position including valve mechanism having inlet and exhaust valves for supplying fluid pressure to the motor to operate the device in either direction, a pair of valve operating elements selectively movable in one direction to operate the valves to control the supply of fluid pressure to the motor to operate the device in one

or the other of said directions, a resilient operating connection between each element and the control member for operating the elements in one said direction, a separate pressure responsive member for moving each element in the other direction, and means for supplying fluid pressure to said pressure responsive members to move the corresponding elements in said other direction including a control valve and means associated with said control valve and device for operating the valve to increase the pressure of fluid supplied to said pressure responsive members whenever the device is moved from neutral position in either direction.

6. The combination with a device to be actuated and a double acting fluid motor for operating the device in either direction from a neutral position, of means for controlling the supply of fluid pressure to the motor including a pair of valve operating elements each operable to supply fluid pressure to the motor to operate the latter in one direction or the other and to release fluid pressure therefrom, means for selectively moving said elements to supply fluid pressure to the motor including a control member and resilient connecting means between the control member and elements, pressure responsive means for moving said elements to release fluid pressure from the motor, and means including a valve controlled by movement of said device for varying the pressure of fluid supplied to said pressure responsive means in accordance with the movement of said device in either direction from neutral position.

7. The combination with a device to be actuated and a fluid motor for actuating the device, of means for controlling the supply of fluid pressure to said motor including an element operable in one direction to supply fluid pressure to the motor and in the other direction to release fluid pressure from the motor, means including a movable control member and a resilient connection between the member and element for moving the latter in said one direction, means for subjecting the element to the pressure in the motor for moving the element in said other direction, a pressure responsive member for moving the element in said other direction, and means for varying the pressure of fluid supplied to said pressure responsive member in accordance with the movement of said device including a control valve operated by the device.

8. The combination with a device to be actuated and a fluid motor for actuating the device, of means including a control member for controlling the supply of fluid pressure to said motor, and means for opposing operation of said control member with a force varying substantially in accordance with the degree of movement of said device including a pressure responsive member, a resilient connection between the pressure responsive member and control member, and means controlled by the movement of the device for subjecting the pressure responsive member to a correspondingly varying pressure.

9. The combination with a device to be actuated and a fluid motor for actuating the device, of means including a control member for controlling the supply of fluid pressure to said motor, and means for opposing the operation of said control member with a force varying in accordance with variations of pressure in the motor and in accordance with variations in the position of said device including a control element responsive to the pressure of fluid in the motor, a resilient

connection between the element and control member, a pressure responsive member connected with the element, and means controlled by the movement of the device for subjecting the pressure responsive member to a correspondingly varying pressure.

10. The combination with a device to be actuated and a fluid motor for actuating the device, of means including a control member for controlling the supply of fluid pressure to said motor, means for opposing operation of said control member with a force varying substantially in accordance with the degree of movement of said device including a pressure responsive member, a resilient connection between the pressure responsive member and control member, and means controlled by movement of the device for subjecting the pressure responsive member to a correspondingly varying pressure, and means for advising the operator of the degree of movement of said device including an indicator responsive at all times to the pressure to which the pressure responsive member is subjected.

11. The combination with a device to be actuated, a power actuator for the device, and means including a power controlling element for controlling the supply of power to the actuator, of means for controlling the operation of said element including a control member having a resilient connection with the element for moving the latter to supply power to the actuator, a power responsive member for moving the element to release power from the actuator, and power supply means controlled by movement of said device for varying the power supplied to said power responsive member in accordance with the movement of said device.

12. The combination with a device to be actuated, a power actuator for the device, and means including a power control element for controlling the supply of power to the actuator, of means for controlling the operation of said element including a control member having a resilient connection with the element for moving the latter to supply power to the actuator, and means for moving the element to release power from the actuator including means for subjecting the element to the power supplied to the actuator, a pressure responsive member for moving the element, and power supply means controlled by movement of said device for varying the power supplied to said power responsive member in accordance with the movement of said device.

13. Control mechanism for a device of the type having a power actuator for actuating the device, means including a power controlling element for controlling the supply of power to the actuator, and means for controlling the operation of said element including a control member having a resilient connection with the element and a power responsive member connected with the element, said mechanism including power supply means for varying the supply of power to said power responsive member and an operative connection between said device and power supply means for operating the latter to vary the degree of power supplied to said power responsive member in accordance with the movement of said device.

14. Control mechanism for a device of the type having a power actuator for operating the device, said mechanism including a self-lapping valve having a power controlling element for controlling the supply of power to the actuator, means for controlling the operation of said element in-

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cluding a control member movable in one direction and having a resilient connection with the element and a power responsive member connected with the element, and means for controlling the supply of power to said power responsive member to move the latter and control member in the opposite direction including power sup-

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plying means having an operative connection with the device and operable to vary the degree of power supplied to the power responsive member in accordance with the movement of the device.

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