Oct. 16, 1956 C. SCHINDLER 2,767,369

CONTROL MEANS AND SYSTEM OF CONTROL

Filed April 1, 1953

2 Sheets-Sheet 1

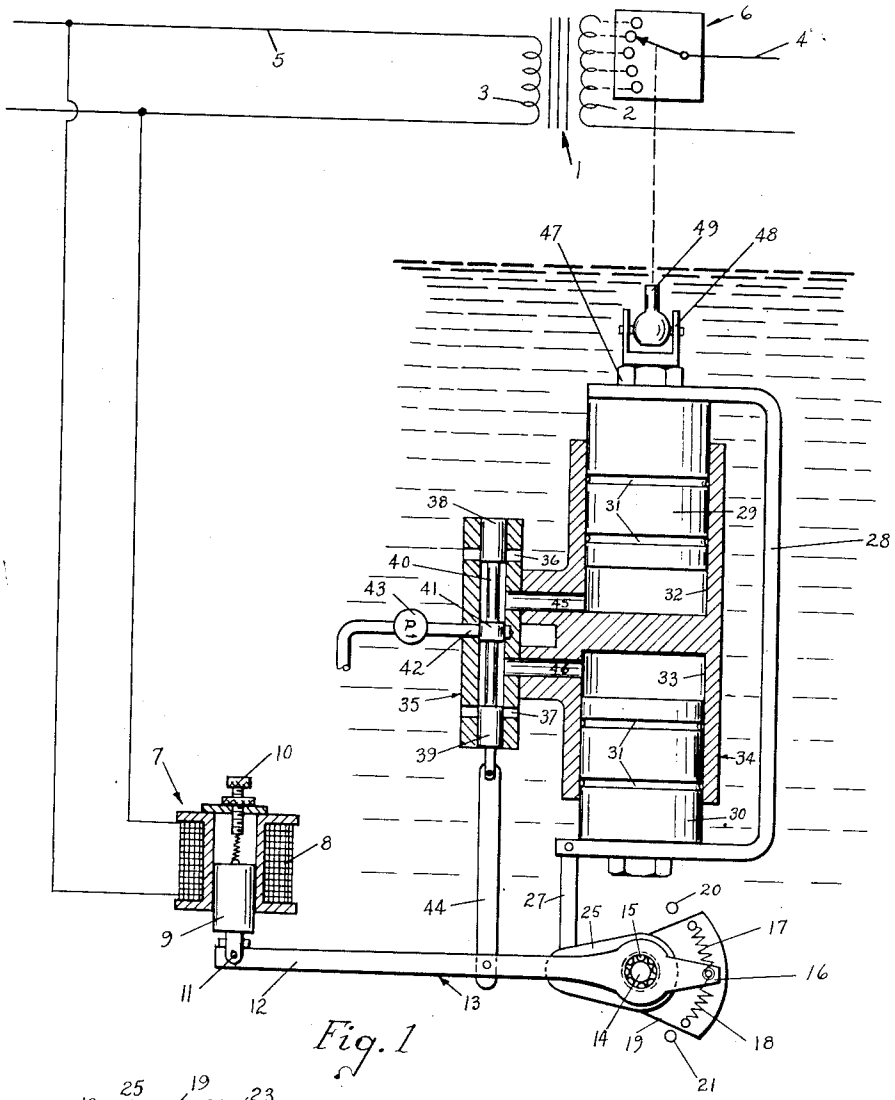

Fig. 1

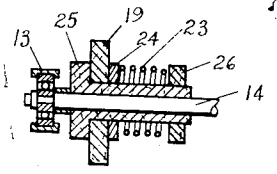

Fig. 2

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2 Sheets-Sheet 2

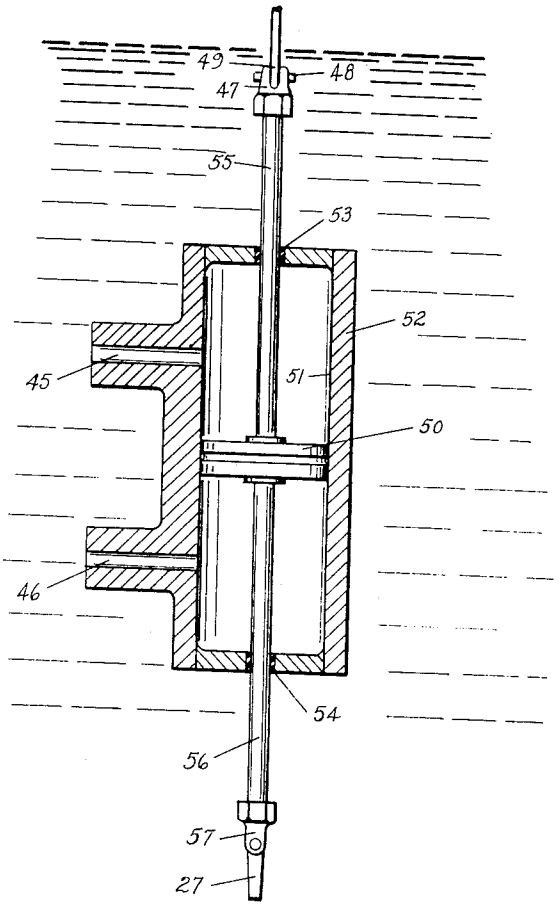

Fig. 3

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CONTROL MEANS AND SYSTEM OF CONTROL

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13 Claims. (Cl. 323—43.5)

This invention relates to control means and to a system of control and is particularly directed to a system of voltage control, though it is to be understood that in its broader aspect this invention can be followed in the control of different quantities.

It is an object of the present invention to provide a system of control responsive to voltage fluctuations, and which includes a hydraulically operated servo mechanism, which is self-compensating to permit the actuating mechanism to float at normal or neutral position with a minimum amount of hunting.

It is another object of this invention to provide a control means and system of control for use in voltage regulation, and which is readily adaptable for use in actuating a conventional transformer tap changer responsive to variations in voltage or some other electrical quantity such as current, reactive volt amperes, or power.

Specifically, it is an object of the present invention to provide an electrical servo mechanism which does not have contacts for the operating or driving mechanism, but which utilizes a work cylinder having dual hydraulic chambers, each having an independently operated piston connected with one another, and responsive to a selective valve connected to a pressurized hydraulic fluid supply, and which valve and pistons are jointly connected to a compensating mechanism which minimizes hunting, and which takes the form of balanced springs fastened to a frictionally actuated slip lever.

Further objects and advantages of the present invention will be apparent from the following description, considered in connection with the accompanying drawing, which forms part of this specification, and of which:

Fig. 1 is a view, partly in diagram and partly in section, showing a system of regulation in which a tap changer is operated from the control means.

Fig. 2 is a fragmentary sectional view showing the relation of certain parts and their manner of cooperating with one another to provide balanced compensation of the control means.

Fig. 3 is a sectional view of another embodiment of the working cylinder member of the control means.

Referring to Fig. 1, a transformer has been indicated generally by the reference character **1**. It is provided with a primary **2** and a secondary **3** connected, respectively, to the power line **4** and the load line **5**. A tap changer indicated generally by the reference character **6** is provided on the primary side of the transformer. This tap changer **6** is preferably of the multiple point, snap action type very commonly and widely used.

A voltage sensitive device in the form of an electromagnetic solenoid coil is electrically connected across the load or secondary line **5**, and is generally denoted by the reference character **7**. It will be apparent from the hereinafter description that the sensitive device may take any of various forms, such as current transformers, D'Arsonval instruments, and the like (not shown), which may be made responsive to current, reactive volt amperes, or power. As presently described, the device takes the form

of a voltage coil **8** arranged to receive a magnetic plunger or armature **9**, fastened at its upper end to a zero adjustment screw **10**, and at its lower end to a pivot pin **11**.

The armature **9** may be made of a temperature sensitive magnetic alloy, commonly used for devices of this nature where ambient temperatures might affect the delicate response of the voltage sensitive device. Temperature compensator alloys are generaly of iron-nickel alloys and have their magnetic permeability proportional to change in temperature.

The pivot pin **11** is attached to the operating end **12** of an actuating member or cantilever **13** which is rotatably mounted on a supporting shaft **14**. In order to keep the response to voltage fluctuation at a maximum sensitivity, the cantilever **13** is preferably mounted on ball or roller bearings **15** on the shaft **14**.

The outer end **16** of the cantilever is arranged to receive one end of compensating springs **17** and **18**, which are fastened at their opposite ends to a compensating lever **19** rotatably supported on the supporting shaft **14**, and engageable with stops **20** and **21**. This may be clearly shown in Fig. 2, wherein the compensating lever **19** is biased in an axial direction relative to the shaft **14** by means of a compression spring **23** engaging a slidable friction plate **24**, which abuts the lever **19**, forcing it towards frictional engagement with a crank **25**. The crank **25** is also rotatably mounted on the shaft **14** and is provided with a flange **26** which acts as a stop for the spring **23**. The crank is pivotally connected to a link **27** which, in turn, is pivotally attached to a yoke **28** having opposed pistons **29** and **30** secured thereto. The pistons are provided with pressure-equalizing and dirt collecting annular grooves **31**, and are adapted to be received by the bores **32** and **33**, respectively, of the working cylinder member **34**. The bores are each closed at one end and communicate only through a slide valve, which is denoted generally by the reference character **35**.

The slide valve includes outlet ports **36** and **37** communicating with upper and lower gate members indicated by the reference characters **38** and **39**, respectively. The gate members **38** and **39** form an integral part of a slide member **40**, which includes a gate portion **41** intermediate its ends. The gate portion **41** is adapted to alternatively open and close the inlet port **42**, communicating with a pump **43** arranged to supply oil or other hydraulic fluid under pressure. The slide member **40** is operatively associated with the operating end **12** of the cantilever member **13** by means of a pivoted link member **44**.

It is to be understood that the entire mechanism may be immersed in oil, if so desired, and that the same oil may be used as the hydraulic media. When so immersed, the unit will not have the tendency to become airbound. The pump is shown here diagrammatically, but it is to be understood that it may take any of various forms, and if so desired, the prime mover with which it is associated (not shown) may be electrically connected at the load side of the transformer without affecting circuit regulation or the operation of the control means. The slide valve **35** communicates with working cylinder member **34** through the ports **45** and, **46**, respectively. The yoke **28** is connected at its upper end to a contact actuator, which may take the form of a U-shaped trunnion **47** supporting a pivot pin **48**, which is rotatably connected to an actuating linkage **49**. The actuating linkage **49** is operatively connected to the snap action tap changer **6**, so that if the yoke **28** is shifted in position in the manner hereinafter described, the tap changer will select the appropriate tap preferably with a snap action.

With the arrangement as shown, it will be apparent that when the voltage (or other electrical quantity) in the load line decreases below an established norm, the sensitive device **7** will permit the plunger or armature **9**

to drop downwardly with respect to the solenoid, as shown in Fig. 1. It will be noted that the plunger **9** is resiliently supported at its top by means of a zero adjustment screw **10**. This downward movement of the plunger will cause the cantilever **13** to rock in a counterclockwise direction about the shaft **14**, and will simultaneously cause the link member **44** to move downwardly. The counterclockwise movement of the cantilever will draw the compensating spring **18** in tension against an equalizing compressive action on the compensating spring **17**. The compensating lever **19** will, accordingly, be biased towards counterclockwise motion about the shaft **14**.

The simultaneous downward motion of the link member **44** will actuate the slide member **40** of the slide valve **35** towards a downward direction, as viewed in Fig. 1. The downward motion of the slide member **40** will open the outlet port **37** by the sliding action of the gate member **39** and also open the inlet port **42** by the sliding action of the integral gate portion **41**. It will be noted that there is a free passageway above the lower piston **31** through the port **46** and out the inlet port **37**, permitting unimpeded movement of the lower piston **30** in either direction.

The hydraulic fluid, which is under pressure transmitted by the pump **43**, will be forced through the port **45** into the bore **32** of the working cylinder member **34**. This pressure will be imparted to the upper piston **29**, causing a simultaneous upward movement of the yoke **28** and the actuating linkage **49** through the trunnion **47**. It will be apparent that such upward motion will cause the tap changer **6** to raise the voltage on the load line or secondary line **5** responsive to the position of the contacts connected to the primary **2** of the transformer **1**.

Referring again to the upward motion of the yoke **28**, this movement, which occurs simultaneously with the change of taps, will be imparted to the link **27** pivotally attached to the crank **25**. The upward motion of the link **27** will tend to cause the crank **25** to rotate about the shaft **14** in a clockwise direction. Attention is drawn to the fact that the crank frictionally engages the compensating lever **19**, which lever has been previously biased towards a counterclockwise direction about the shaft **14** by means of the action of the compensator springs **17** and **18** responsive to the motion of the outer end **16** of the cantilever **13**. The compensating lever **19** is prevented from excess rotational movement by means of the stops **20** and **21** engageable therewith.

The immediate effect of the compensating mechanism is to reduce overtravel of the piston **29** to cause the tap changer to move beyond the desired degree of regulation. Obviously, this will reduce wear and tear on the regulator and switch taps in addition to reducing unnecessary voltage fluctuation and flickering of electric lamps on the regulated circuit. The compensating device also permits the mechanism to float between taps as long as the normal voltage exists. The compensating lever **19** is nothing more than a slip lever frictionally contacting the crank **25**, permitting the floating action no matter which tap might be engaged by the tap changer switch blade. The frictionally driven lever and the compensating spring connection will tend to slip past the crank after a period of time has expired when the tap change has been completed, to permit the mechanism to float at the new position and supply normal secondary voltage. It will be apparent that the positions of compensation may be determined by the size and force exerted by the compensating springs **17** and **18**.

When normal secondary voltage has been restored, this voltage will be immediately reflected in the voltage sensitive device **7**, causing the zero adjusted plunger **9** to seek its normal operating position. The normal operating position will be immediately reflected in the slide member **40** to close the inlet port **42** and the outlet ports **36** and **37**. This action will permit an equilibrium condition to exist between the pistons **29** and **30** responsive to the compensation provided by means of the lever **19** and the crank **25**.

It will be apparent that the device will operate in substantially the same manner as above described when an overvoltage condition exists. The existence of an overvoltage will be reflected in the voltage sensitive device **7** to cause the plunger **9** to move in an upward direction with a consequent opening of the inlet port **42** to permit the pressurized hydraulic fluid to enter the port **46** to the bore **33** of the working cylinder member **34**, which will force the piston **30** in a downward direction and concurrently operating the tap changer to move to a lower voltage tap position. The port **45** will permit any trapped fluid to escape out through the opened outlet port **36** for unimpeded motion of the upper piston **29**. The same compensating effect will take place between the lever **19** in the crank **25**, but in an opposite direction about the shaft **14** than as described in connection with undervoltage conditions in the load or secondary **5**. The device will then float at the new tap with a minimum of hunting between taps as compensated for between the members **19** and **25**.

The preferred embodiment of the control means has been described in connection with a dual-chamber cylinder supplying pressure to two independently operable piston members each joined to a linking yoke. However, the device may conveniently take the form illustrated by Fig. 3 without departing from the scope of invention.

Like parts relating to both embodiments bear the same reference character in each of the figures of the drawings. The embodiment of Fig. 3 is illustrative of a single piston **50** having dual working faces, and which is axially slidable in the bore **51** of the working cylinder member **52**. The working cylinder member is closed at both ends except for an opening in each end sealed by means of gaskets **53** and **54**, respectively. The gaskets **53** and **54** are arranged to receive piston rods **55** and **56**, respectively. The rods **55** and **56** extend from either face of the piston member **50** and are joined at their outer ends to pivot trunnions **47** and **57**, respectively. Ports **45** and **46** provide an entrance and an exit means for the pressurized hydraulic fluid, which is alternatively admitted and expelled in substantially the same manner as described in connection with the preferred embodiment. The compensating means, which has hereinabove been fully described, is adapted to operate in the same manner with the present embodiment through the link **27** and the piston rods **55** and **56** integrally positioned on the piston **50**.

It will be apparent that a novel form of an electrical quantity regulation control means and system has been provided by this invention, which includes a compensating means immediately responsive to quantity variations, simultaneous to the reaction of an acutator member, which substantially eliminates objectionable hunting common to many regulating servo mechanisms.

I claim:

1. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including dual pressure chambers each having a piston slidable therein, condition responsive means responsive to variations in said electrical quantity and including a solenoid coil and magnetic plunger, said plunger comprising a temperature sensitive magnetic alloy having its magnetic permeability proportional to change in ambient temperature, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to alternatively admit said fluid to said dual chambers, a cantilever actuator jointly operatively associated with said plunger and with said valve, said actuator being rotatively positioned on a shaft member and having a portion extending radially from said shaft member, a crank rotatable on said shaft member

and operatively associated with said piston members, and a compensating member rotatable relative to said shaft member and frictionally engaged radially relative to said crank, opposed spring members each conjointly engaging said compensating member and the radially extending portion of said actuator, whereby movement of said magnetic plunger will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said opposed spring members to permit balanced movement of said pistons in a preselected direction alternatively responsive to variations in said electrical quantity.

2. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including a piston arranged for actuation of said control means, condition responsive means responsive to variations in said electrical quantity, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, an actuator jointly operatively associated with said condition responsive means and with said valve, and compensating means for providing balanced movement of said piston and comprising a pair of frictionally engaged relatively movable members, one of said movable members being connected to said piston, and force balancing means interconnecting the other of said relatively movable members and said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said other of said relatively movable members through the medium of said actuator and said force balancing means to permit balanced movement of said piston in a preselected direction alternatively responsive to variations in said electrical quantity.

3. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including a piston arranged for actuation of said control means, condition responsive means responsive to variations in said electrical quantity, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, an actuator jointly operatively associated with said condition responsive means and with said valve, and compensating means for providing balanced movement of said piston and comprising a shaft member, a crank rotatable upon said shaft member and operatively connected to said piston, a compensating member positioned on and rotatable relative to said shaft member, said compensating member and said crank being frictionally engaged radially relative to one another, and force balancing means interconnecting said compensating member and said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said force balancing means to permit balanced movement of said piston in a preselected direction alternatively responsive to variations in said electrical quantity.

4. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including a piston arranged for actuation of said control means, condition responsive means responsive to variations in said electrical quantity, selective valve means jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, an actuator jointly operatively associated with said condition responsive means and with said valve means, and compensating means for providing balanced movement of said piston and comprising a shaft member, a crank rotatable upon said shaft member and operatively connected to said piston, a compensating member positioned on and rotatable relative to said shaft member, said compensating member and said crank being frictionally engaged radially relative to one another, and force balancing means interconnecting said compensating member and said actuator, whereby movement of said condition responsive means will simultaneously actuate said valve means and said compensating member through the medium of said actuator and said force balancing means to permit balanced movement of said piston in a preselected direction alternatively responsive to variations in said electrical quantity.

5. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including a piston arranged for actuation of said control means, condition responsive means responsive to variations in said electrical quantity, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, an actuator jointly operatively associated with said condition responsive means and with said valve, and compensating means for providing balanced movement of said piston and comprising a shaft member, a crank rotatable upon said shaft member and operatively connected to said piston, a compensating member positioned on and rotatable relative to said shaft member, said compensating member and said crank being frictionally engaged radially relative to one another, and balanced resilient means interconnecting said compensating member and said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said balanced resilient means to permit balanced movement of said piston in a preselected direction alternatively responsive to variations in said electrical quantity.

6. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including dual pressure chambers, each having a piston slidable therein and each piston arranged for alternative actuation of said control means, condition responsive means responsive to variations in said electrical quantity, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to alternatively admit said fluid to said dual chambers, a cantilever actuator jointly operatively associated with said condition responsive means and with said valve, said actuator being rotatively positioned on a shaft member and having a portion extending radially from said shaft member, a crank rotatable on said shaft member and operatively associated with said piston members, and a compensating member rotatable relative to said shaft member and frictionally engaged radially relative to said crank, balanced resilient means conjointly engaging said compensating member and the radially extending portion of said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said resilient means to permit balanced movement of said pistons in a preselected direction alternatively responsive to variations in said electrical quantity.

7. In an alternating current electrical system having adjustable control means to control the magnitude of an electrical quantity of said system; a hydraulic work cylinder including dual pressure chambers, each having a piston slidable therein and each piston arranged for alternative actuation of said control means, condition responsive means responsive to variations in said electrical quantity and including a solenoid coil and magnetic plunger, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic

fluid under pressure to alternatively admit said fluid to said dual chambers, a cantilever actuator jointly operatively associated with said plunger and with said valve, said actuator being rotatively positioned on a shaft member and having a portion extending radially from said shaft member, a crank rotatable on said shaft member and operatively associated with said piston members, and a compensating member rotatable relative to said shaft member and frictionally engaged radially relative to said crank, opposed spring members each conjointly engaging said compensating member and the radially extending portion of said actuator, whereby movement of said magnetic plunger will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said opposed spring members to permit balanced movement of said pistons in a preselected direction alternatively responsive to variations in said electrical quantity.

8. In a pressure fluid operated controlling device including a hydraulic work cylinder having a piston for actuating a member to be controlled, condition responsive means, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, the combination therewith of an actuator jointly operatively associated with said condition responsive means and with said valve, and compensating means for providing balanced movement of said piston and comprising a pair of frictionally engaged relatively movable members, one of said movable members being connected to said piston, and force balancing means interconnecting the other of said relatively movable members and said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said other of said relatively movable members through the medium of said actuator and said force balancing means to permit balanced movement of said piston in a preselected direction alternatively responsive to conditions affecting said condition responsive means.

9. In a pressure fluid operated controlling device including a hydraulic work cylinder having a piston for actuating a member to be controlled, condition responsive means, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, the combination therewith of an actuator jointly operatively associated with said condition responsive means and with said valve, and compensating means for providing balanced movement of said piston and comprising a shaft member, a crank rotatable upon said shaft member and operatively connected to said piston, a compensating member positioned on and rotatable relative to said shaft member, said compensating member and said crank being frictionally engaged radially relative to one another, and force balancing means interconnecting said compensating member and said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said force balancing means to permit balanced movement of said piston in a preselected direction alternatively responsive to conditions affecting said condition responsive means.

10. In a pressure fluid operated controlling device including a hydraulic work cylinder having a piston for actuating a member to be controlled, condition responsive means, selective valve means jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, the combination therewith of an actuator jointly operatively associated with said condition responsive means and with said valve means, and compensating means for providing balanced movement of said piston and comprising a shaft member, a crank rotatable upon said shaft member and operatively connected to said piston, a compensating member positioned on and rotatable relative to said shaft member, said compensating member and said crank being frictionally engaged radially relative to one another, and force balancing means interconnecting said compensating member and said actuator, whereby movement of said condition responsive means will simultaneously actuate said valve means and said compensating member through the medium of said actuator and said force balancing means to permit balanced movement of said piston in a preselected direction alternatively responsive to conditions affecting said condition responsive means.

11. In a pressure fluid operated controlling device including a hydraulic work cylinder having a piston for actuating a member to be controlled, condition responsive means, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to selectively admit said fluid to said cylinder, the combination therewith of an actuator jointly operatively associated with said condition responsive means and with said valve, and compensating means for providing balanced movement of said piston and comprising a shaft member, a crank rotatable upon said shaft member and operatively connected to said piston, a compensating member being frictionally engaged radially relative to one another, and balanced resilient means interconnecting said compensating member and said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said other of said compensating member through the medium of said actuator and said balanced resilient means to permit balanced movement of said piston in a preselected direction alternatively responsive to conditions affecting said condition responsive means.

12. In a pressure fluid operated controlling device including a hydraulic work cylinder having dual pressure chambers, each having a piston slidable therein and each piston arranged for alternatively actuating a member to be controlled, condition responsive means, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to alternatively admit said fluid to said dual chambers, the combination therewith of a cantilever actuator jointly operatively associated with said condition responsive means and with said valve, said actuator being rotatively positioned on a shaft member and having a portion extending radially from said shaft member, a crank rotatable on said shaft member and operatively associated with said piston members, and a compensating member rotatable relative to said shaft member and frictionally engaged radially relative to said crank, balanced resilient means conjointly engaging said compensating member and the radially extending portion of said actuator, whereby movement of said condition responsive means will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said balanced resilient means to permit balanced movement of said pistons in a preselected direction alternatively responsive to conditions affecting said condition responsive means.

13. In a pressure fluid operated controlling device including a hydraulic work cylinder having dual pressure chambers, each having a piston slidable therein and each piston arranged for alternatively actuating a member to be controlled, condition responsive means including a solenoid coil and magnetic plunger, a selective slide valve jointly associated with said working cylinder and with a source of hydraulic fluid under pressure to alternatively admit said fluid to said dual chambers, the combination therewith of a cantilever actuator jointly operatively associated with said plunger and with said valve, said actuator being rotatively positioned on a shaft member and having a portion extending radially from said shaft member, a crank rotatable on said shaft member and operatively associated with said piston members, and a com-

pensating member rotatable relative to said shaft member and frictionally engaged radially relative to said crank, opposed spring members each conjointly engaging said compensating member and the radially extending portion of said actuator, whereby movement of said plunger will simultaneously actuate said slide valve and said compensating member through the medium of said actuator and said opposed spring members to permit balanced movement of said pistons in a preselected direction alternatively responsive to conditions affecting said condition responsive means.

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