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C. H. SMOOT

REGULATOR

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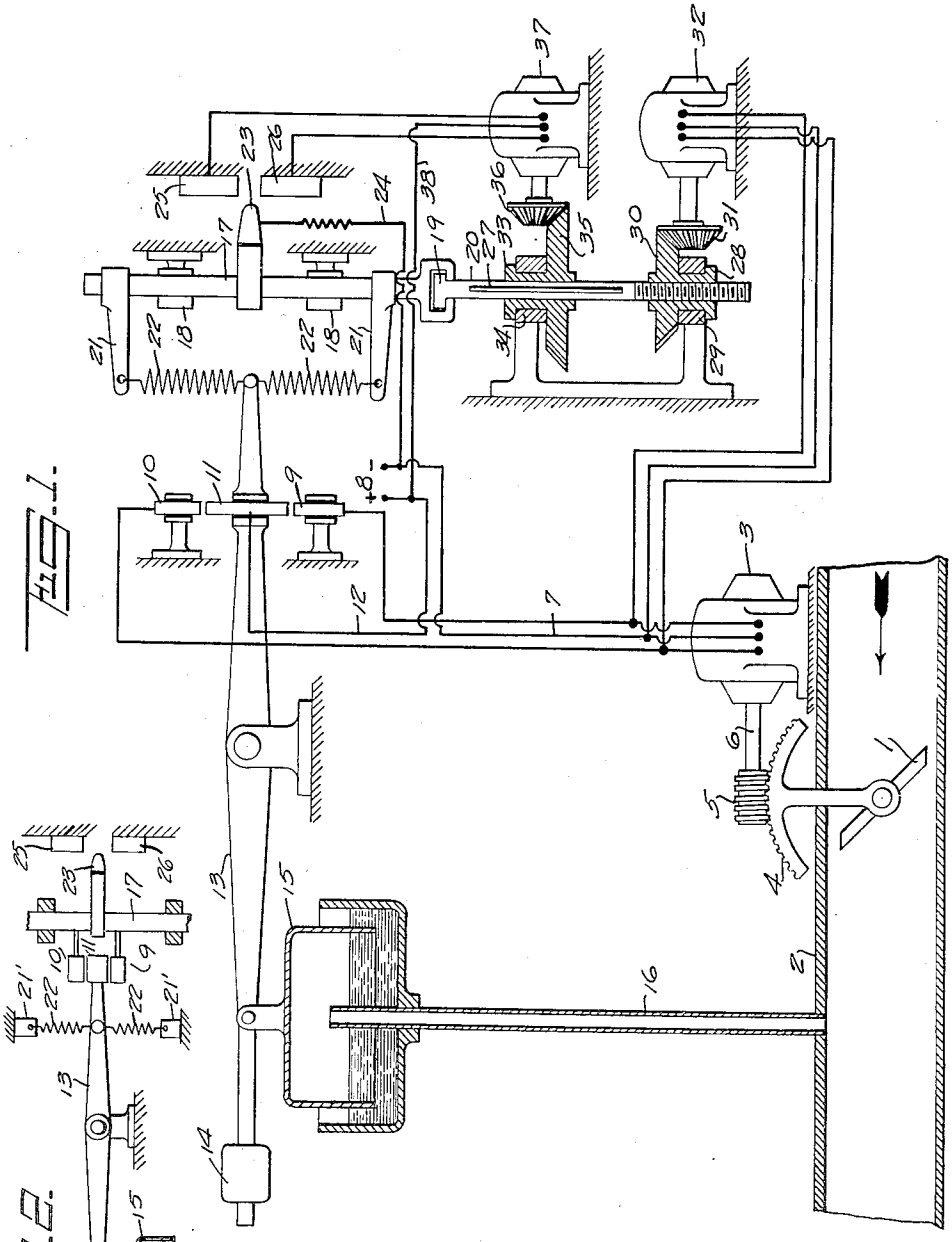


FIG. 1.

FIG. 2.

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REGULATOR.

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My invention is concerned with a novel regulator so constructed as to avoid hunting without loss of sensitiveness or power.

My regulator is of the type wherein an unbalance between a regulating force or forces and a force varying with a function of the element controlled effects the regulation of an element through an intermediate power means. My invention comprises electrical power means actuated upon an unbalance of regulating and regulated forces for effecting the control of the element and for preventing hunting of the regulator.

For an understanding of my invention, reference should be had to the accompanying drawings of which

Fig. 1 illustrates one embodiment of my regulator as applied to the control of a fluid pressure, and

Fig. 2 illustrates an alternative arrangement of a part of the apparatus shown in Fig. 1.

Referring now to Fig. 1, a damper 1 effects the control of the flow of fluid through a conduit 2. The damper is operated to maintain a constant fluid pressure at some point in the flow and is adjusted to the position corresponding to the desired pressure by a reversible electric motor 3 which turns the damper in either direction by means of rack 4 and worm gear 5 mounted on the shaft 6 of the motor. One terminal of the motor 3 is connected by means of a lead wire 7 with a power circuit at 8. The other terminals of the motor lead to contacts 9 and 10 arranged on either side of a contact 11 carried by a pivoted lever 13 and connected through lead wire 12 to the other side of the power circuit at 8. The lever 13 carries an adjustable weight 14 tending to turn the lever in a counter clockwise direction. Opposed to the turning moment offered by the weight 14 to the lever 13 is a moment due to the pressure of the fluid in the conduit 2 acting through a pressure bell 15 attached to the lever 13 and partially submerged in liquid, the space enclosed between the bell and the liquid being in communication with the conduit 2 through pipe 16.

The apparatus so far described would operate to regulate the fluid in the conduit 2 for constant pressure, but only with continual hunting of the damper. If the pressure of the fluid rises to a value greater than that for which the regulator is adjusted, the pressure within the bell 15 overpowers the effect of the weight 14 and tips the lever, thereby closing contacts 9 and 11 and energizing the motor 3 to close the damper 1. As long as the pressure within the bell is greater than that desired the motor 3 will continue to close the damper. By the time the reduction in pressure caused by the closing of the damper is felt at the lever the damper has been still further closed. This results in a too low value of the pressure in the bell and an energizing of the motor 3 by contacts 10 and 11 driving the motor in the reverse direction and to a position too far open.

The apparatus now to be described prevents this oscillation of the damper. A rod 17 is slidably mounted in fixed bearings 18 and is provided with a socket in its lower end in which the head 19 of a second rod 20 is free to turn. The rod 17 carries projections 21 to which are attached springs 22. The springs 22 are fastened to the end of the lever 13, the arrangement being such that with the normal position of the rod 17 and neutral position of the lever 13 the springs 22 exert no force upon the lever 13. The rod 17 carries a contact arm 23 connected through lead wire 24 with the power circuit at 8 and arranged to travel over fixed contacts 25 and 26 with upward and downward movement respectively of the rod 17. The rod 20 is threaded throughout its lower half and provided with longitudinal slots 27 along its upper half. A member 28 is screwed over the threaded portion of the rod 20 and is supported in a fixed bearing 29 in which it is free to turn but not to travel vertically. A gear 30 forming a part of the member 28 meshes with a gear 31 on the shaft of a reversible electric motor 32, which motor is connected in parallel with the motor 3 and is therefore actuated whenever the motor 3 is actuated. The upper half of the rod 20 passes through a member 33 to which it is keyed by means of longitudinal ridges on the inner side of the member which fit into the slots 27. The member 33 is mounted in fixed bearings 34 in which it is free to turn but not to move vertically. A gear 35 forms a part of the member 33 and meshes with a gear 36 driven by a third reversible electric motor 37, one terminal

of which is connected through lead wire 38 with the power circuit at 8 and the other terminals of which are connected to the stationary contacts 25 and 26.

The arrangement of the motors 32 and 37 with the rod 20 is such that either motor can raise or lower the rods, and if both motors are operating at the same time the travel of the rod will be either the sum or difference of the travels that would be caused by either motor alone, depending upon whether the motors are aiding or opposing each other. As shown, the gear 30 has a smaller diameter than the gear 35 and correspondingly fewer teeth with the result that with equal speeds of the motors, the rod will travel more rapidly with the motor 32 than with the motor 37.

The operation of the entire apparatus disclosed in Fig. 1 is as follows: With a steady flow through the conduit 2 and a pressure in the bell 15 just sufficient to maintain the lever in the neutral position, the motors 3, 32 and 37 will not be operating because the contact 11 will not be touching either of the contacts 9 or 10 and the contact 23 will not be touching either of the contacts 25 or 26. Assume now that the pressure in the conduit 2 and therefore in the bell 15 rises. This causes the contacts 11 and 9 to close and the motors 3 and 32 to operate simultaneously, the one to close the damper, the other to raise the rods 20 and 17. The raising of the rods 20 and 17 applies a resilient force to the lever 13 through the compression of the lower spring 22 and the tension of the upper spring 22 tending to open the contacts 11 and 9. If the increase in pressure in bell 15 was very great the motor 32 may have to raise the rods 17 and 20 very considerably before exerting enough force upon the lever to break the contacts and so to stop both motors 3 and 32. As soon as the rod 17 has been raised sufficiently to close the contacts 23 and 25 the motor 37 starts to turn the member 33 in a direction to lower the rods 20 and 17. While both the motors operate at once the motor 37 acts to slow up the travel of the rods, but as soon as the force exerted by the springs 22 is sufficient to break the electrical circuit through the lever, the rod begins to be slowly lowered by the motor 37 which thus gradually releases the force upon the lever due to the springs 22. The speeds of the motors or the size of the gears are preferably so chosen that the time taken for a change in the setting of the damper 1 to be felt as a pressure change in the bell 15 will correspond to that taken by the motor 37 to release the tension of the springs upon the lever 13.

With a decrease in pressure within the bell 15 the operation is of course just the reverse of that described above. The contacts 10 and 11 close energizing motors 3 and 32, causing them to operate in the reverse direction to that when contacts 9 and 11 are closed and resulting in an opening of the damper and a lowering of the rods. The tension of the springs upon the lever is thus increased until it becomes sufficient to open the contacts and to stop the motors. The motor 37 actuated when the rod was lowered gradually returns the apparatus to the neutral position.

If the damper has not been moved far enough by the time the motors 3 and 32 are stopped, then these motors will again be energized as soon as the tension of the spring 22 has been sufficiently reduced.

Fig. 2 illustrates a slightly different arrangement of lever, springs and contacts. In this arrangement the springs 22 are not carried by the rod 17 but are fixed at their ends to stationary members 21', and the contacts 9 and 10 are carried by the rod 17 instead of being fixed.

The operation of each arrangement is the same in that a closing of the contacts 11 and 9 or 11 and 10 results in a movement of the rod tending to open the contacts and to increase the tension of the springs upon the lever. In the embodiment of Fig. 1 this is accomplished by an upward movement of the rod when the contacts 9 and 11 are closed and by a downward movement of the rod when the contacts 10 and 11 are closed. In Fig. 2 this is accomplished by just the reverse movement of the rod 17, that is, a downward movement when the contacts 9 and 11 close and an upward movement when the contacts 10 and 11 close. In each arrangement the closing of the contacts 23 and 25 or 23 and 26 results in a movement of the rod 17 in a direction to return it to the position from which it has been moved.

I have now illustrated one embodiment of my invention and an alternative arrangement of a part thereof. For convenience I have shown my new regulator arranged to maintain constant the pressure of a fluid by the control of a damper. Obviously my invention is not concerned with the particular element controlled nor with the controlling force or forces which in the particular case illustrated was a constant, being the value introduced by the position of the weight 14 upon the lever. Obviously this weight can be replaced with any desired fixed or varying force or forces without affecting my invention. The particular means herein shown for acting on the lever with a force varying as a function of the element controlled is of course immaterial, as any desired means may be used.

Although I have shown the damper 1 and member 23 driven by separate motors, it obviously would not change the operation of my regulator if both of these elements were

driven by the same motor. Two motors, however, are more convenient in the case where the damper is at some distance from the rest of the apparatus.

My apparatus is in some respects like, and in other respects unlike, a step by step regulator. Its likeness consists in the fact that the regulation is automatically checked before the force on the balance returns to that to which it is regulated, but there the likeness ceases. My regulator attempts to make the correct change in one step but if this step is not sufficient it makes a further correction. The length of any step depends upon the actual magnitude of the change in the element and also upon duration of this change. A momentary increase or decrease in pressure, no matter how large, results in a very small movement of the damper and an immediate return to the original setting while a large permanent change results in a large movement of the damper before the motor is stopped.

Obviously many substitutions and rearrangements of parts may be made without departing from the scope of my invention and parts of my apparatus may be advantageously employed without the corresponding use of other parts.

I claim:

1. In a regulating apparatus of the type wherein an unbalance between a regulating force and a force varying as a function of the element controlled effects the control of an element through auxiliary electrical power means, the improvement consisting in electrical means actuated simultaneously with said power means, for creating a gradually increasing resilient force tending to stop both said power means and itself from functioning and additional electrical means actuated when said resilient force reaches a definite value tending to reduce said force.

2. In a regulator of the type wherein an unbalance between a regulated force and a force varying as a function of the element controlled effects the control of an element through auxiliary power means, the improvement consisting in electrical means actuated simultaneously with said power means for creating a gradually increasing resilient force tending to prevent the continued operation of both said power means and itself, and additional slower acting means tending to reduce and remove said resilient force.

3. In a regulator of the type in which a regulating force opposes a force which is a function of the regulated element, the combination comprising a reversing switch, the movable member of which is subjected to said opposing forces and is normally acted upon in open position by equal opposing resilient forces, electric means actuated by closure of said switch upon an unbalance of the forces acting upon said movable member, and operating to produce a regulating effect and to cause an unbalance of said resilient forces progressively increasing until sufficient to open said switch, and other electric means brought into operation at a given unbalance of the resilient forces and acting to restore the normal balance thereof.

4. In a regulating apparatus the combination of a controlling means, a movable member acted upon by a regulating force and by a force varying as a function of the element to be controlled, an electric motor for operating said controlling means, means for driving said motor in one direction with a displacement of said member in one direction and for reversing said motor with a displacement of said member in the other direction, springs tending to hold said member in a neutral position, means for increasing continuously the force exerted on said member by said springs during continued operation of said motor, other means operating to return the force of said springs to zero and started into operation when the force of said springs has reached a predetermined value.

5. In a regulator of the type wherein a regulating force opposes a force which is a function of the regulated element, the combination comprising a reversing switch, the movable member of which is subjected to said opposing forces and is maintained in open position by a balance thereof, a second movable member, electric means actuated by closure of said switch under an unbalance of said forces, and operating to effect the regulation and to move said second member, means for creating a force increasing with the displacement of said second member and tending to reopen the switch, and means, actuated upon a definite displacement of said second member tending to return it to its original position and tending likewise to reduce and remove said last mentioned force.

6. In a regulator of the type wherein an unbalance between a regulating force and a regulated force varying as a function of the element controlled effects the control of an element through intermediate power means, the improvement consisting in a longitudinally movable member and electric means including at least one reversible electric motor for moving said member and for effecting the regulation of the element, means for actuating said motor upon an unbalance of regulating and regulated forces, means carried by said member tending upon continued movement thereof to stop the operation of said electric means, another reversible electric motor for returning said member to its original position and means carried by said member for actuating said last named motor.

7. Apparatus as in claim 6 wherein said

longitudinally movable member consists of two parts, one carrying the means for actuating said second motor and being adapted to be moved vertically by the other part but not to be rotated thereby, and the other part being adapted to be moved vertically by a differential rotation given to it by said motors.

8. In a regulator of the type wherein a regulating force opposes a force which is a function of the regulated element, the combination comprising a reversible switch, means for subjecting the movable member of said switch to said forces to prevent closure of the switch except upon an unbalance of said opposing forces, electrical means actuated by the closure of said switch for effecting the regulation and for creating a force increasing with the duration of the closure of the switch and acting upon said member in a direction to open the switch, slower acting apparatus tending to relieve said member of said last mentioned force, means for bringing said apparatus into operation after said switch has been closed for a definite time, and for continuing it in operation until said member is relieved of said last mentioned force.

In testimony whereof, I have signed my name to this specification.

CHARLES H. SMOOT.