Aug. 1, 1944. W. A. RAY 2,354,704

ELECTROMAGNETICALLY CONTROLLED OPERATOR

Filed Feb. 13, 1941

Fig. 1

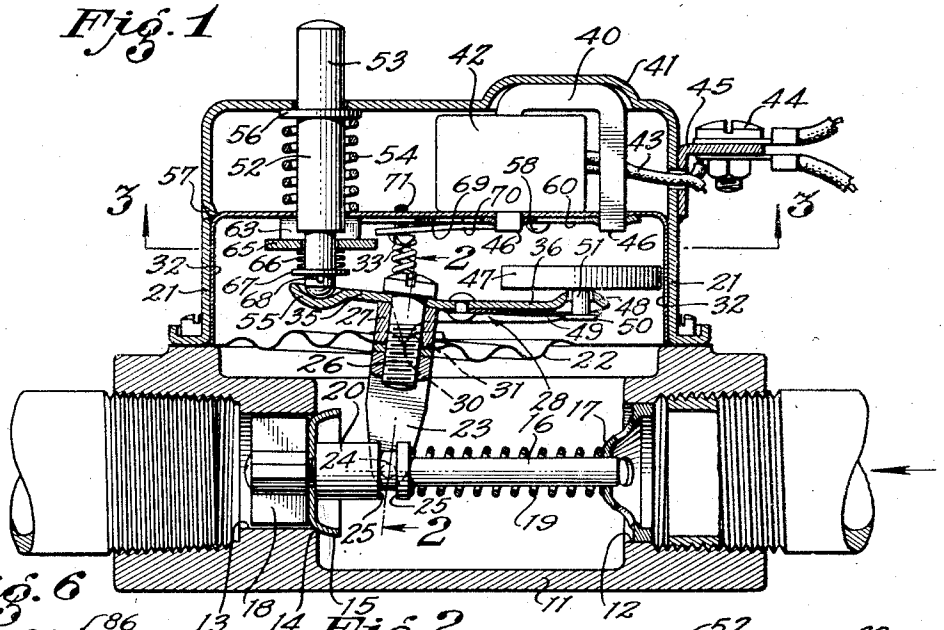


Fig. 6

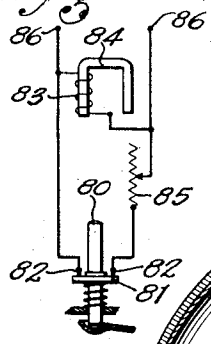


Fig. 2

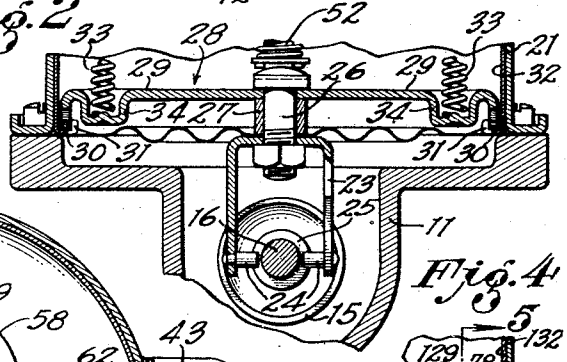


Fig. 3

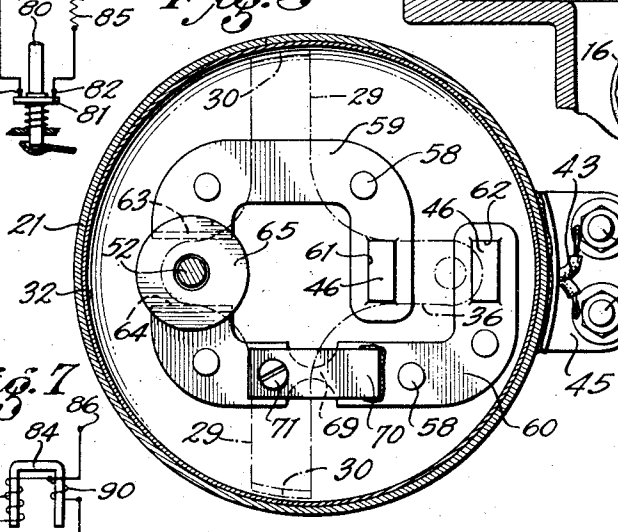


Fig. 4

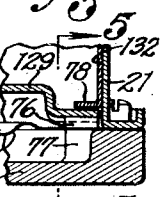


Fig. 5

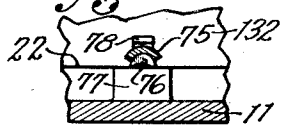
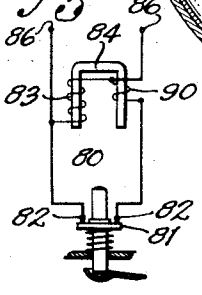


Fig. 7



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2,354,704

## ELECTROMAGNETICALLY CONTROLLED OPERATOR

William A. Ray, Glendale, Calif.

Application February 13, 1941, Serial No. 378,756

8 Claims. (Cl. 175—336)

My present invention relates to control apparatus, and more particularly to apparatus of the type wherein an electromagnet is employed for magnetically retaining an armature in engagement therewith only after they have first been brought together by mechanical means.

Such an electromagnet is adapted to be energized by a very small amount of electrical energy, such as that produced by a pilot-burner-heated thermoelectric device. A fluid control valve employing this principle is disclosed in my copending application Serial No. 237,029 filed October 26, 1938. A continuation of said application, Serial No. 379,980, was filed February 21, 1941, and matured into Patent No. 2,299,654 on October 20, 1942. It has been found that the amount of flux-producing electrical energy required to initially "hold-in" the armature is considerably greater than that required to maintain it in held position. In other words, the initial "hold-in" power is considerably greater than that of the "drop-out" power. The principal reason for this is the residual magnetism built up in the electromagnet core and the armature, even when the best available magnetic material is employed in the construction of these parts. It is obviously desirable that the armature should initially hold-in when the power in the system is less than that ultimately available (particularly when a pilot-burner-heated thermoelectric device is employed as a source of energy), with the result that upon increase of current the residual magnetism is so increased that, when the current in the electromagnet coil subsequently decreases (as upon extinction of the pilot burner flame), the armature is held in its attracted position until the current has been reduced to an amount far less than that required for initial hold-in. This difference between the hold-in and drop-out value of the current, due to the hysteresis of the magnetic material, not only produces erratic operation, but may also cause dangerous delay, as when the means controlled by the electromagnet is arranged to shut off fuel supply to a burner upon extinction of the pilot burner flame. It is therefore a main object of my invention to provide simple and effective means for compensating for the effect of the hysteresis or residual magnetism so that the drop-out value of the current may be approximately equal to that of the hold-in.

Another object of my invention is to provide a control device embodying the features of the preceding object.

Another object is to provide a "manual reset" fluid control valve embodying the features of the main object.

Another object is the provision of a mechanically-operated magnetically-controlled valve wherein the electromagnet and armature are separated from the controlled fluid by a metallic diaphragm, the valve operating means sealingly extending through the diaphragm and being so arranged with respect thereto that substantially no fluid is displaced in the operation of the valve and variation of fluid pressure below the diaphragm is ineffective to affect operation of the valve operating means.

Other objects and advantages of my invention will be found in the description, the drawing and the appended claims.

For complete understanding of the invention, reference may be had to the following detailed description and accompanying drawing wherein:

Figure 1 is a sectional view of a valve embodying my invention;

Figure 2 is a fragmentary transverse section taken along the line 2—2 of Fig. 1;

Figure 3 is a horizontal section taken along the line 3—3 of Fig. 1;

Figure 4 is a fragmentary section illustrating a modified pivoting arrangement for the valve operating lever;

Figure 5 is a section taken along the line 5—5 of Fig. 4; and

Figures 6 and 7 are diagrams of modified means for reducing the armature-holding flux upon return of the reset button.

In the drawing, the numeral 11 indicates a valve casing having axially aligned inlet and outlet openings 12 and 13, respectively. Cooperable with a seat 14 formed at the inner end of the outlet opening is a closure member 15 mounted on a rod 16, which rod is guided at its right-hand end in an apertured cup-shaped washer 17 pressed in the inlet opening 12. The left-hand end of rod 16 is guided by a vaned member 18 secured thereto and freely slidable in the outlet opening 13. A spring 19, compressed between an enlarged portion 20 of the rod and the washer 17, urges the closure member toward its seat. Covering an opening in the upper wall of the casing and secured thereto is a housing 21. Interposed at its margin between the flanged lower portion of this housing and the surface of the casing surrounding the opening is a corrugated metallic diaphragm 22. Extending from the underside of the diaphragm is a U-shaped closure-operating member 23, in the lower portions of the

side arms of which are pins 24, freely received in an annular recess 25 formed in the enlarged portion 20 of the rod 16. The member 23 is secured to the diaphragm by a bolt 26 which extends through an opening concentric of the corrugated portion thereof. Also secured to the diaphragm by the bolt 26, with a bushing 27 therebetween, is a cross-shaped lever 28, the general contour of which is shown in dot-and-dash lines in Fig. 3. The arms 29 of this lever are provided at their downwardly-turned outer ends with knife-edged portions 30 which bear in V-shaped notches cut in upwardly-turned lug portions 31 formed on the lower end of a sub-housing 32, which sub-housing fits snugly within the main housing 21. The lever 28 is thus pivoted substantially in a plane of the diaphragm 22, and is held in that position by the force of a pair of springs 33, compressed between the arms 29 and the upper wall of the sub-housing 32. The pivots of the lever also being on a line which intersects the axis of member 23 at the diaphragm, no appreciable amount of fluid is displaced in the flexing of the diaphragm as the lever is rocked, and for the same reason, variation of fluid pressure below the diaphragm has no tendency to rock the lever. So that the springs 33 will not produce a "toggle action" when the lever is rocked, the arms 29 are provided with depressed portions 34 for receiving the springs so that their lower ends are substantially in the axis of rotation of the lever. The lever 28 has an additional pair of arms 35 and 36 which extend at right angles to the arms 29.

Mounted in the upper part of the housing 21 is an electromagnet comprising a U-shaped core 40, the upper end of which is received in a recess 41 formed in the top wall of the housing. Surrounding one of the side arms of the U-shaped core is a coil 42, the leads 43 of which extend through an opening in the side wall of the housing and are connected to terminals 44, insulatingly mounted in a bracket 45 secured to the housing. The side arms of the core extend through openings in the top wall of the sub-housing and the electromagnet is maintained in position by its coil. Cooperable with the pole faces 46 of the core is an armature 47 which is rockably mounted on an up-set end portion 48 of the arm 36, the armature being resiliently held to the arm by a leaf spring 49 compressed against the inner surface of the head 50 of a pin 51 secured to the armature. This rockable mounting of the armature permits accurate alignment of its upper surface with the pole faces 46 when the parts are brought together.

Reciprocable in aligned openings formed in the top walls of housing 21 and sub-housing 32 is a rod 52, the outer end portion 53 of which forms a manually operable push-button. Compressed between a shoulder 56 formed on rod 52 and the upper wall of the sub-housing 32 is a spring 54 which urges the rod upward, its movement in this direction being limited by the shoulder 56. The rounded lower end of rod 52 engages a cupped portion 55 of lever arm 35, downward movement of push-button 53 serving to rock the lever about its pivots so that the closure member 15 is moved into open position and armature 47 is simultaneously brought into engagement with the pole faces 46 of the core. If, when this occurs, the core 40 is sufficiently energized by passage of current through coil 42, upon release of push-button 53, the armature being magnetically held in engagement with the pole faces, the closure member is retained in open position against the bias of spring 19. If the current through coil 42 is interrupted or substantially weakened, the armature is released by the core and the valve closes.

Secured to the underside of the top wall of the housing, as by rivets 58, is a pair of generally U-shaped straps 59 and 60 of high-permeability ferrous material. The right hand end portions of the straps 59 and 60 are provided with rectangular openings 61 and 62, respectively, which conform to the cross sectional shape of and tightly fit the core arms, so that the straps form branches of the magnetic circuit of the core. The left hand end portions of the straps are downwardly bent to provide spaced portions 63 and 64 which, when the push-button 53 is in its normal retracted position, are bridged by an iron disk 65 carried on the reduced lower end portion of rod 52. A spring 66, compressed between a washer 67 (abutting a pin 68 pressed in the lower end of the reduced end portion of rod 52) and the washer 65, urges the same upward into engagement with the edges of portions 63 and 64 when the push-button is in its normal or retracted position. When the button is depressed, the washer 65 is moved out of bridging engagement by the enlarged upper portion of rod 52. The disk 65 has a loose fit on the rod so that its upper surface can accurately conform to the edges of portions 63 and 64. It will be understood that the sub-housing 32 and the housing 21 are each of non-magnetic material. When, in the operation of the valve, the armature is magnetically held in engagement with the pole faces of the core, upon release of the push-button 53 the magnetic circuit of the core is shunted by the magnetic circuit comprising straps 59 and 60 and disk 65, with the result that the magnetic force acting to hold the armature is reduced. This reduction in armature-holding flux tends to equalize the hold-in and drop-out values of the electromagnet current, the advantage of which was pointed out in the statement of invention.

So that the reluctance of the shunt magnetic circuit may be adjusted, a portion 69 of strap 60 is reduced in size and a magnetic strip 70, welded at its right hand end to strap 60, is arranged to variably bridge this reduced portion. A screw 71, passing through an opening in the other end of the strip and threaded in the top wall of the sub-housing 32, permits variation of the surface contact of the strip.

In Figs. 4 and 5, the numeral 129 indicates a modified form of the arm 29 shown in Figs. 1–3. The end portion of arm 129 is downwardly bent and provided with a horizontal concave portion 75 which rides on a semi-cylindrical member 76, secured as by solder to the upper surface of diaphragm 22 adjacent its margin and above an extended lug portion 77 of the casing 11. A lower end portion 78 of the sub-housing 132 (corresponding to sub-housing 32 in Figs. 1–3) is bent up to form an abutment for the arm 129 which prevents raising of the same from its pivots by excessive fluid pressure below the center of the diaphragm. By the arrangement shown in Figs. 4 and 5, it will be seen that the arm 129 may be pivoted in the theoretical plane of the diaphragm.

In the diagram of the Fig. 6, wherein is shown a modified arrangement for reducing the armature-holding flux upon return of the manual operating means, the numeral 80 indicates a reset button to which is secured a contact disk 81 cooperable with fixed contacts 82. In series with these contacts is the energizing coil 83 for a core

84 (corresponding to the core 40 in the structural drawing) and a variable resistor 85. When the push-button 80 is depressed to reset the valve, full current can flow to the electromagnet coil from a source to which terminals 86 are assumed to be connected. When the push button is released, part of the current through coil 83 is shunted through resistor 85, thereby weakening the magnetic flux acting on the armature. In the modified circuit of Fig. 7, an additional winding 90 is provided around another portion of the core. This winding is in electrically opposed relation to the main coil 83 so that when contacts 82 are bridged by contact disk 81 and the winding is thus energized, the magnetic flux in core 84 is reduced.

It will be understood that the reduction in armature holding flux may be accomplished either by reducing the effective current in the electromagnet coil, as by introducing resistance in series or in shunt with the coil; or by increasing the reluctance of the magnetic circuit, as by magnetically shunting it, or by providing an air gap in the main magnetic circuit which is opened upon release of the push-button.

In my copending application Serial No. 237,029, referred to hereinbefore, I have shown mechanical means for accomplishing substantially the same result as is produced in my present invention by the electro-magnetic means. This mechanical means comprises a spring normally urging the armature away from the core, the spring being so arranged that its force is substantially zero when the armature is mechanically brought into engagement with the core, the force being gradually increased as the reset button is then retracted.

While I have herein shown and described specific embodiments of my invention, I wish it to be understood that modifications may be made without departing from the spirit of the invention, and that I intend therefore to be limited only by the scope of the appended claims.

I claim as my invention:

1. In combination: an electromagnet comprising an armature member, a core member and an energizing coil, said core member forming with said armature member a magnetic circuit; said core member being adapted when energized to retain said armature member in engagement therewith only when the members are first mechanically brought together, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature member through space; mechanical means operable to move one of said members into engagement with the other; and means responsive to the return of said mechanical means toward its unoperated position for reducing the magnetic flux acting to hold the armature, and comprising means for reducing the electrical energy in the electromagnet acting to produce said armature-holding flux.

2. In combination: an electromagnet comprising an armature member and a core member including an energizing coil therefore, means biasing said members apart, said core member being adapted when energized to retain said armature in engagement therewith against the force of said bias only when the members are first mechanically brought together, mechanical means effective in its movement in one direction to move one of said members into engagement with the other, said mechanical means being movable in another direction away from said one of said members, means biasing said mechanical means in said other direction, and means actuated by the movement of said mechanical means in said other direction for weakening the magnetic flux acting to hold said armature, said last-named means including switching means in circuit with said coil.

3. In combination: an electromagnet comprising an armature member, a core member and an energizing coil, said core member forming with said armature member a magnetic circuit; said core member being adapted when energized to retain said armature member in engagement therewith only when the members are first mechanically brought together, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature member through space; mechanical means operable to move one of said members into engagement with the other; and means responsive to the return of said mechanical means toward its unoperated position for reducing the magnetic flux then acting to hold the armature.

4. In combination: an electromagnet comprising an armature member, a core member and an energizing coil, said core member forming with said armature member a magnetic circuit; said core member being adapted when energized to retain said armature member in engagement therewith only when the members are first mechanically brought together, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature member through space; mechanical means operable to move one of said members into engagement with the other; and means responsive to the return of said mechanical means toward its unoperated position for reducing the magnetic flux then acting to hold the armature, and comprising a magnetic shunt circuit for the electromagnet.

5. In combination: an electromagnet comprising an armature member, a core member and an energizing coil, said core member forming with said armature member a magnetic circuit; said core member being adapted when energized to retain said armature member in engagement therewith only when the members are first mechanically brought together, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature member through space; mechanical means effective in its movement in one direction to move one of said members into engagement with the other, said mechanical means being movable in another direction away from said one of said members; and means actuated by the movement of said mechanical means in said other direction for weakening the magnetic flux then acting to hold said armature member.

6. In combination: an electromagnet comprising an armature member, a core member and an energizing coil, said core member forming with said armature member a magnetic circuit; means biasing said members apart; said core member being adapted when energized to retain said armature in engagement therewith against the force of said bias only when the members are first mechanically brought together, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature member through space; mechanical means effective in its movement in one direction to move one of said

members into engagement with the other, said mechanical means being movable in another direction away from said one of said members; means biasing said mechanical means in said other direction; and means actuated by the movement of said mechanical means in said other direction for weakening the magnetic flux then acting to hold said armature member.

7. In combination: an electromagnet comprising an armature member, a core member and an energizing coil, said core member forming with said armature member a magnetic circuit; means biasing said members apart; said core member being adapted when energized to retain said armature in engagement therewith against the force of said bias only when the members are first mechanically brought together, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature member through space; mechanical means effective in its movement in one direction to move one of said members into engagement with the other, said mechanical means being movable in another direction away from said one of said members; means biasing said mechanical means in said other direction; and means actuated by the movement of said mechanical means in said other direction for weakening the magnetic flux then acting to hold said armature member, said last-named means comprising means for shunting the magnetic circuit of said electromagnet.

8. In combination: an electromagnet comprising a core and an energizing coil therefore, an armature movable toward and away from said core and biased in the latter direction, said core forming with said armature a magnetic circuit, said electromagnet when energized being effective to magnetically hold the armature in engagement with the core against the force of said bias only when it is first mechanically moved to that position, the energizing coil and magnetic circuit of said electromagnet being so designed that the electromagnet is incapable of attracting said armature through space, mechanical means independent of the armature for moving the same in one direction into engagement with the core and biased in an opposite direction, and means actuated by the movement of said mechanical means in said opposite direction for reducing the magnetic flux then acting to hold the armature.

WILLIAM A. RAY.