

July 20, 1948.

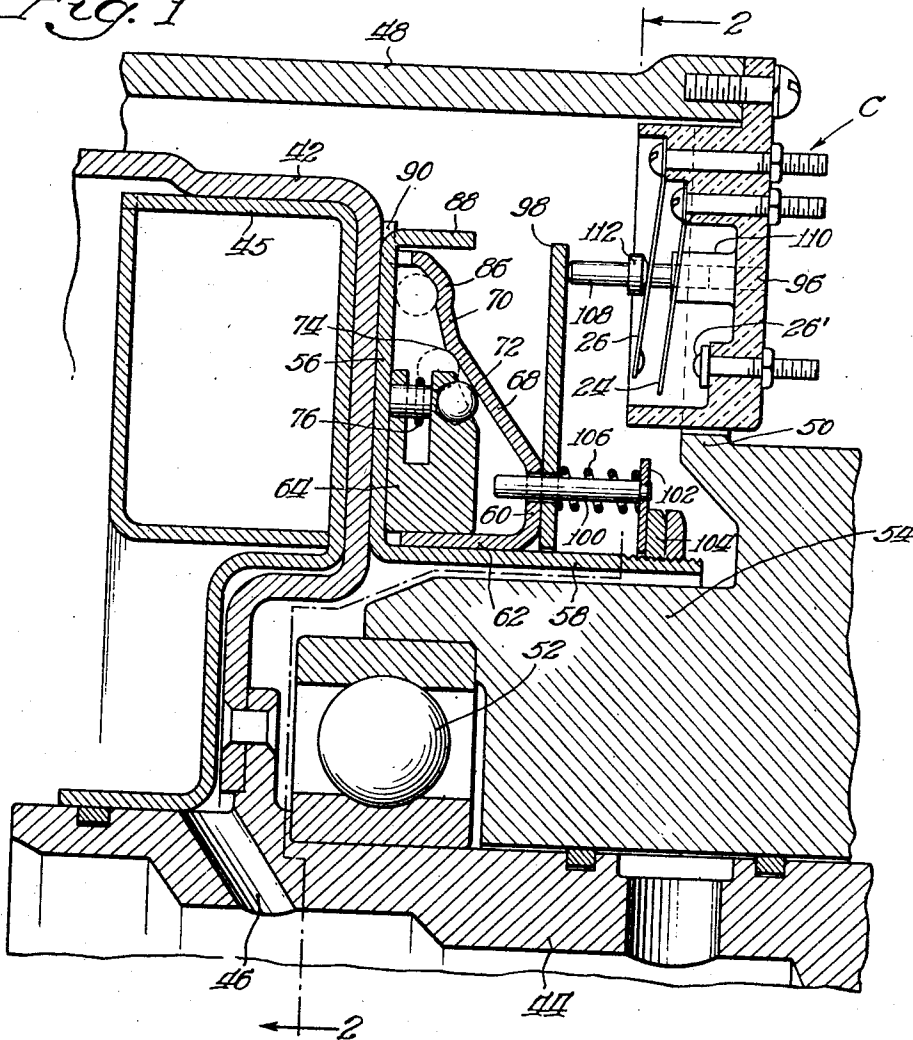
H. E. CARNAGUA
ELECTROMAGNETIC ACTUATOR

2,445,561

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Fig. 1



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Fig. 2

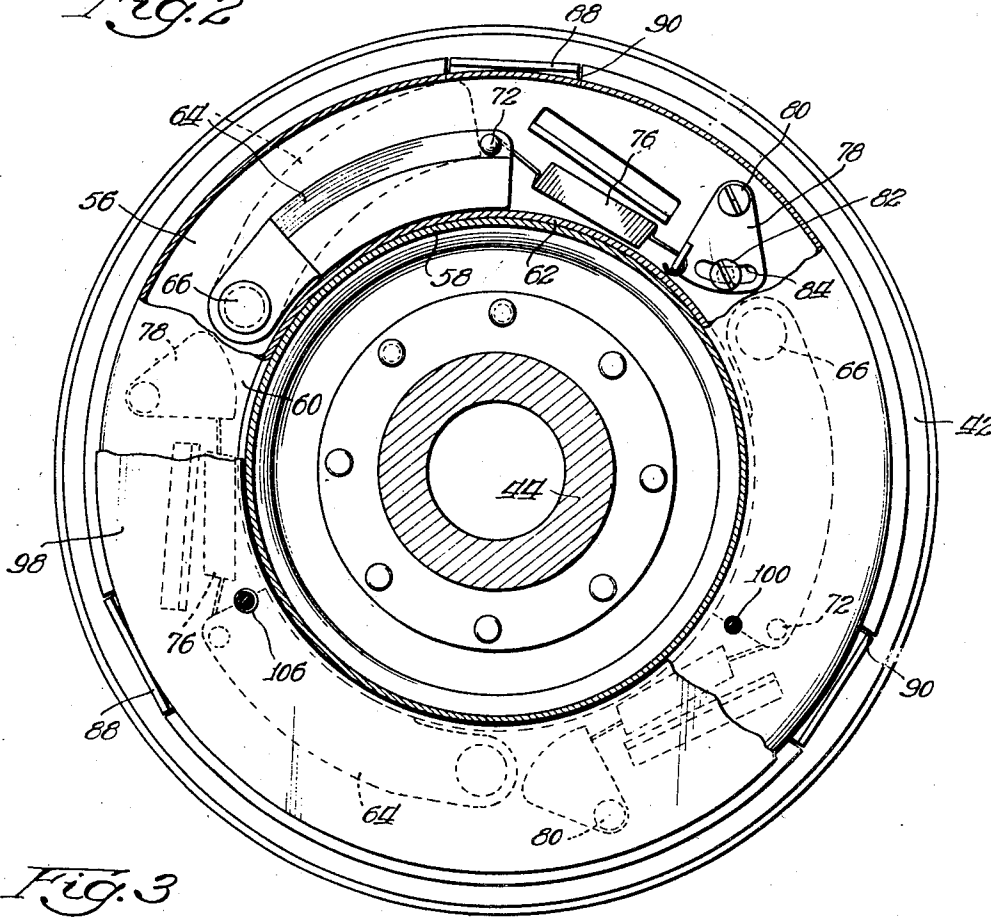
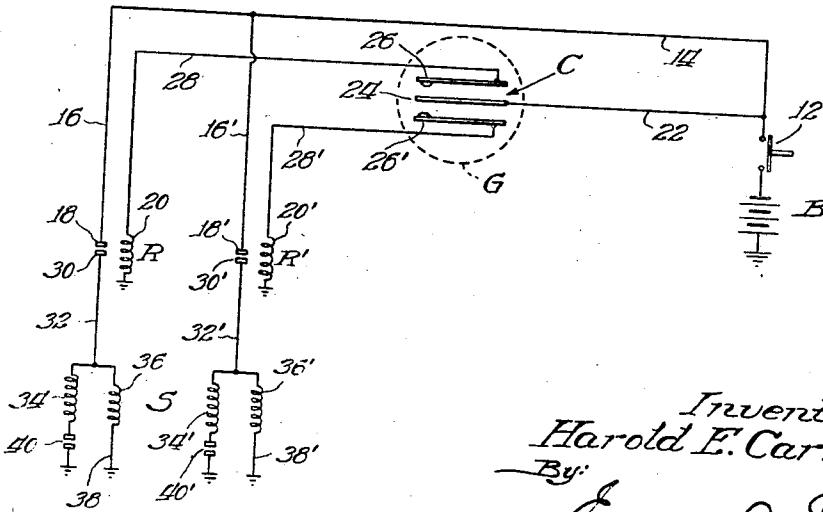


Fig. 3



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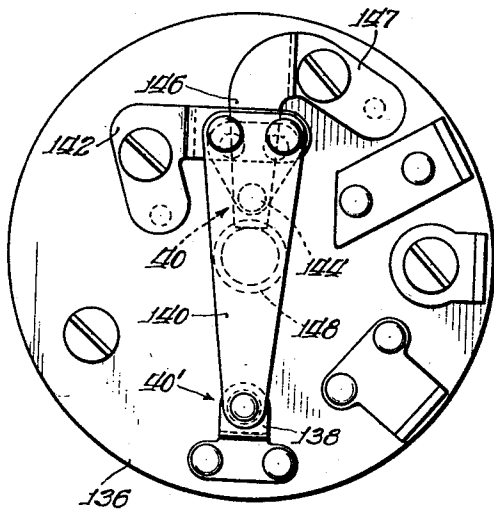
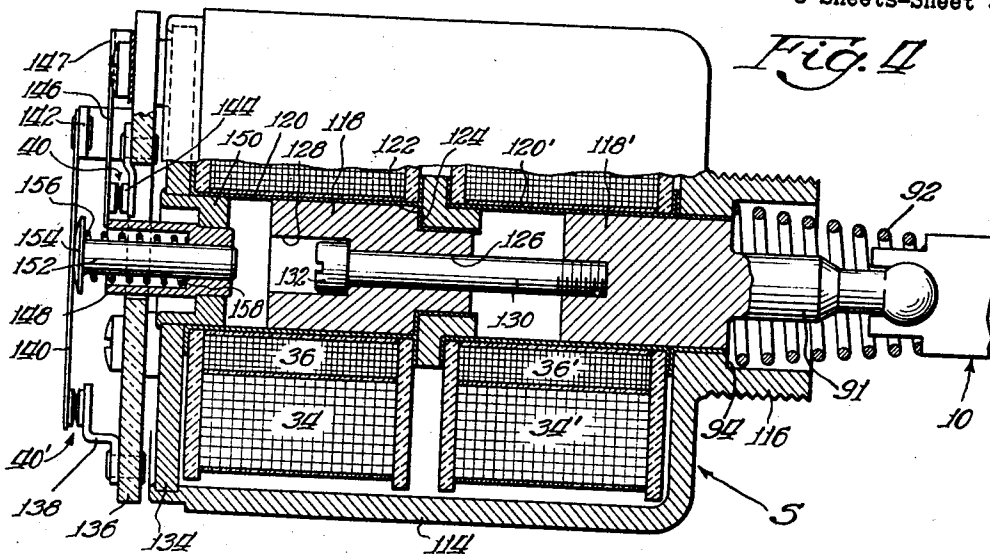
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,445,561

ELECTROMAGNETIC ACTUATOR

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Application October 7, 1942, Serial No. 461,169

5 Claims. (Cl. 175—335)

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This invention relates to control mechanisms and has as its general object to provide an improved arrangement for imparting a two-stage movement to a shiftable control element in response to variations in speed of a rotating body. The invention is applicable to any mechanism in which a control element having two or more positions (in addition to a neutral or starting position) is controlled in accordance with the speed of rotation of a member of the mechanism, and is particularly useful in an automatic or semi-automatic transmission, such as that shown in the pending application of John M. Simpson and Harold E. Carnagua, Serial No. 426,122, filed January 9, 1942, wherein a valve having two active control positions is moved from a neutral position to each of these control positions under the control of a governor.

One of the objects of the invention is to provide a relatively simple control arrangement for thus shifting a multiple position control element. To this end, the invention provides an arrangement in which the control valve or ultimate control element is linked to the governor through the medium of a novel multiple stage solenoid and a multiple stage switch, the switch being operated by the governor and in turn controlling the energization of the solenoid.

A further object of the invention is to provide an improved control mechanism embodying a novel multiple stage solenoid adapted to impart successive stages of movement to a common axially moving element.

A more specific object of the invention is to provide an improved control mechanism embodying a plurality of coils adapted to be energized successively and a plurality of armatures adapted to be energized by the respective coils, together with means for connecting both armatures to a common axially moving element in such a manner that the latter element is moved to one position by energized movement of one armature and to a second position by energized movement of another armature.

A further object of the invention is to provide, in an arrangement such as that last referred to, a solenoid having two sets of coils each comprising a moving coil and a holding coil, wherein the respective sets of coils are adapted to be successively energized and wherein means is provided for deenergizing the moving coil of a respective set of coils as soon as the corresponding armature has completed its energized movement.

Another object of the invention is to provide an improved control mechanism embodying a

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novel governor having a multiple stage action for closing in succession a plurality of sets of contacts of a multiple stage switch.

Other objects, the advantages and uses of the invention will become more apparent after reading the following specification and claims, and after consideration of the drawings forming a part of the specification, wherein:

Fig. 1 is an axial sectional view of the governor and switch portion of a control mechanism embodying my invention;

Fig. 2 is a transverse sectional view of the governor taken as indicated by the line 2—2 of Fig. 1;

Fig. 3 is a skeletonized circuit diagram of a control mechanism embodying my invention;

Fig. 4 is a side elevation, partially in axial section, of the two-stage solenoid portion of the mechanism embodying my invention; and

Fig. 5 is an end elevation of the solenoid mechanism.

As an example of one form in which my invention may be embodied, I have shown in Fig. 3 a skeletonized circuit diagram of a control mechanism wherein a two-stage solenoid, indicated diagrammatically at S and shown in detail in Fig. 4, is adapted to impart two stages of movement to a control element 10 (Fig. 4) when energized in successive stages of energization by a source of electric current B, under the control of a two stage switch, indicated generally at C, which in turn is controlled by a two stage governor, indicated generally at G. Current from the source B passes first through a manual control switch 12, then through a common conductor 14 and parallel conductors 16, 16' to the contacts 18, 18' of a pair of relays indicated generally as R and R' respectively. Coils 20, 20' of the relays R, R' are energized through a common conductor 22 extending from the manual switch 12 to the common contact 24 of the switch C, then through the contacts 26, 26' and conductors 28, 28'. From the contacts 30, 30' of the relays R, R', conductors 32, 32' lead to the moving coils 34, 34' and also the holding coils 36, 36', respectively of the solenoid S. The holding coils 36, 36' are grounded directly as at 38, 38', while the moving coils 34, 34' are grounded through cutout switches 40, 40' by means of which the respective moving coils may be deenergized as soon as their corresponding armatures have completed their respective energized movements.

The control element 10 may be a valve having two active control positions, in which it is adapted to direct hydraulic fluid, under pressure, through different paths for effecting different or modified

control function such as the application of a hydraulic torque converter lockup clutch on the one hand and the engagement of a planetary gear set lockup clutch on the other hand, in a transmission such as that shown in the above identified application Serial No. 426,122.

The hydraulic actuating unit of the planetary gear set lockup clutch is shown in Fig. 1, and includes a cylinder 42 secured to the driven shaft 44 of the transmission and a piston 45 operating in the cylinder 42 and adapted, when fluid is admitted to the cylinder through the port 46, to move forwardly for engaging the clutch. The overall casing of the transmission is shown at 48, being provided with an end wall 50 having a boss 54 carrying a bearing 52 in which the shaft 44 is journaled.

The governor is designed to occupy an annular space surrounding the boss 54 between the end of the cylinder 42 and the end wall 50. This space would otherwise be wasted. The governor comprises an axially fixed disc 56 mounted on the rear of the cylinder 42 and having a rearwardly extending sleeve 58, and an axially movable disc 60 including a hub portion 62 slidably mounted on the sleeve 58. The discs 56 and 60 enclose between them a plurality of centrifugal weights 64 which are pivoted upon the disc 56 as indicated at 66 in Fig. 2 and which are adapted, under the effect of centrifugal force, to swing outwardly, acting in successive stages upon two conical portions 68 and 70, respectively, of the disc 60 so as to move the disc 60 rearwardly in successive stages of movement. A ball 72, socketed in the end region of each weight, provides the contact with the conical disc portions 68 and 70. The conical portion 68 is separated from the portion 70 by an annular ridge 74 of greater inclination from a radial plane than that of the conical portion 68, so as to cause the weights to dwell at the end of the first stage of movement until an appreciably higher rate of rotation has been attained before commencing the second stage of movement. The conical portion 70 has a lesser inclination from the radial than the conical portion 68, in order that the second stage of movement may not be unduly prolonged. In this connection it may be noted that the outward extension of the weights is opposed by coil springs 76 each having one end attached to a free end of a respective weight and its other end attached to an adjustable anchor 78, pivoted at 80 to the disc 56 and secured in adjusted position by a screw 82 extending through an arcuate slot 84 therein and threaded into the disc 56. The pull of this spring increases with the increased outward movement of the weight, and the lower inclination of the conical portion 70 compensates for this increased pull, as well as cutting down the amount of increase in speed necessary to effect the second stage of movement as compared to that necessary to effect the first stage of movement, if desired. Outwardly of the conical portion 70, the disc 60 is provided with a dwell portion 86, in which the ball 72 may dwell during decrease in speed so that the first stage of return movement of the weight is commenced at a substantially lower speed than that at which the final stage of extension was completed. The same effect is produced in the transition from the first to the second stage of return movement, owing to the difference in inclination between the conical portions 70 and 68.

An axially shiftable driving connection between the discs 56 and 60 is effected by a tongue 88 formed on the periphery of the disc 56 and ex-

tending through a notch 90 in the periphery of the disc 60.

The multiple stage switch C may embody any approved contact mechanism, preferably of a snap action type, but for the sake of simplicity in illustration, it has been shown as comprising simply a pair of contacts 26 and 24 adapted to be closed in the first stage of governor action and a pair of contacts 24 and 26' adapted to be closed in the second stage of governor action, the respective contacts being mounted in a base 96 of suitable insulating material secured in transmission housing 48.

Movement is transmitted from the governor to the switch contact 26 by means of an annular plate 98 encircling the sleeve 58 and mounted upon pins 100 which are mounted in a washer 102 likewise encircling the sleeve 58 and abutted against a nut 104 threaded on to the end of the sleeve. Coil springs 106, encircling the pins 100, yieldingly resist the centrifugal weight energized movement of the disc 60 which is communicated to the plate 98. The movement of the plate 98 under centrifugal action is communicated to a pin 108 axially slidable in a boss 110 in the switch base 96 and having a shoulder 112 in engagement with the switch contact 26. In the first stage of governor action, the contact 26 will be moved into engagement with the contact 24, thus energizing the relay R which in turn establishes a circuit to the coils 34 and 36 of the solenoid. In the second stage of governor action, the contact 24 is moved into engagement with the contact 26', energizing the relay R' which in turn energizes the coils 34' and 36' of the solenoid.

The solenoid S comprises a casing 114 having an exteriorly threaded neck 116 by means of which it may be mounted on a support, and the pairs of coils 34, 36 and 34', 36', which are mounted in coaxial end-to-end relationship in the casing 114, and the armatures 118, 118' which are slidably mounted in the liners 120, 120' of the respective pairs of coils. The liner 120 has an offset portion 122 and the armature 118 has a corresponding shoulder 124 adapted to engage the offset 122 to limit the movement of the armature 118 away from its energized position. The armature 118' is connected to the control element 10 by a stem 91 which extends through the neck 116. Movement of the armature 118' under energized solenoid action is yieldingly resisted by a spring 92 encircling the stem 91, one end of the spring 92 being engaged against the control element 10 and the other end of the spring 92 being engaged against a shoulder 94 in the neck 116. The armature 118 has a bore 126 one end of which is enlarged as at 128. A draft link 130 in the form of a bolt is extended through the bore 126, has a head 132 received in the enlarged portion 128 of the bore, and is threaded at its other end into the armature 118'. The link 130 forms a lost motion draft connection between the armatures 118 and 118' by means of which energized movement of the armature 118 is transmitted to the armature 118' to produce the first stage of movement of the control element 10, and permitting the armature 118' to move further in the same direction to produce the second stage of movement of the control element 10, while the armature 118 remains stationary. During this second stage of movement the draft link 130 slides in the bore 126.

Opposite the neck 116, the casing 114 is closed by an end wall 134 on which is mounted an annular switch base 136 of suitable insulating material. The switch 40' comprises a fixed contact carried

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by a bracket 138 mounted on the base 136 and a movable contact carried by a spring arm 140 mounted on a bracket 142 on the base 136 and biased toward the closed position of the contacts. The switch 40 comprises a fixed contact 144 secured against the base 136 and a movable contact carried by a spring arm 146 having a bracket portion 147 secured to the base 136. The free end of the spring arm 146 extends beyond the contact which it carries, and is adapted to be engaged by a sleeve 148 slidably mounted in a bushing 150 which in turn is mounted in the center of the solenoid casing end wall 134. Slidably mounted within the sleeve 148 is a push pin 152 having a head 154 engaging the arm 140 of the switch 40'. A light coil spring 156, received in an enlargement of the bore of the sleeve 148, has one end engaged against the shoulder 158 defining the end of such enlargement and its other end engaged against the head 154 so as to yieldingly maintain the push pin 152 in engagement with the arm 140.

In the operation of the solenoid, the first stage of action is effected by energization of the coils 34 and 36, drawing the armature 118 to the left as viewed in Fig. 4. At the conclusion of this movement, the armature 118 contacts the end of the sleeve 148 which normally projects slightly beyond the bushing 150, and moves the sleeve 148 to the left so as to open the switch 40, thus deenergizing the moving coil 34 while the holding coil 36 remains energized. The armature 118 is stopped by its contact with the bushing 150. This first stage of armature movement is transmitted from the armature 118 through the draft link 130 to the armature 118' and thence to the control element 10 through the stem 92.

In the second stage of solenoid action, the coils 34' and 36' are energized, drawing the armature 118' further to the left while the draft link 130 moves axially through the bore 126 of the armature 118, into contact with the push pin 152, moving the latter to the left and opening the switch 40'. This deenergizes the moving coil 34', leaving the holding coil 36' energized. This second stage of movement is transmitted directly from the armature 118' to the control element 10, moving the latter to its second active control position.

These two stages of solenoid action are produced by the closing of the switch contacts 26, 24 and the subsequent closing of the contacts 24, 26', in response to the two stages of governor action. As long as the governor weights remain in their fully extended positions, the control element 10 will be maintained in its second active control position by the solenoid. When the weights drop back to their intermediate positions, the springs 106 will move the plate 98 to the left as viewed in Fig. 1, permitting the contacts 24 and 26' to open and deenergizing the coils 34' and 36' of the solenoid. The spring 92 will then move the control element 10 back to its intermediate or first active control position, causing the controlled mechanism, if it be a transmission such as that described in the above identified application Serial No. 426,122, to be shifted down to the gear ratio controlled by said intermediate position. When the governor weights recede from their intermediate positions, the plate 98 will be moved further to the left by the springs 106, permitting the contacts 24 and 26 to open, completely deenergizing the solenoid and permitting the spring 92 to move the control element 10 back to its starting position.

I claim:

1. A solenoid including a housing and a plu-

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rality of pairs of coils in said housing, said pairs of coils having their axes on a common line and each pair including a moving coil and a holding coil, a tubular armature positioned within one of said pairs of coils, a second armature positioned within another of said pairs of coils, a pull rod connected with said second armature and extending through said tubular armature and having a head adapted to coact with the tubular armature to form a lost motion connection for mechanically transmitting movement of said tubular armature to said second armature, said tubular armature being adapted to be moved to its attracted position and to transmit such movement to said second armature through said pull rod when the moving coil corresponding to said tubular armature is energized, and said second armature being adapted to be moved farther in the direction of the aforesaid movement to its attracted position when its corresponding moving coil is energized, said latter movement being permitted by the movement of said pull rod through said tubular armature, a first self-closing switch carried by said housing for completing the circuit through the moving coil of one of said pairs of coils, a second self-closing switch carried by said housing for completing the circuit through the moving coil of the other of said pairs of coils, a thrust member supported by said housing adjacent said first switch and in the path of movement of said tubular armature and adapted to open said first switch following energized movement of said tubular armature to its attracted position, and a second thrust member supported by said first thrust member adjacent the second switch and in the path of movement of said pull rod and adapted to open said second switch following energized movement of said second armature and the pull rod connected therewith.

2. A solenoid including a housing and a plurality of pairs of coils in said housing, said pairs of coils having their axes on a common line and each pair including a moving coil and a holding coil, a tubular armature positioned within one of said pairs of coils, a second armature positioned within another of said pairs of coils, a pull rod connected with said second armature and extending through said tubular armature and having a head adapted to coact with the tubular armature to form a lost motion connection for mechanically transmitting movement of said tubular armature to said second armature, said tubular armature being adapted to be moved to its attracted position and to transmit such movement to said second armature through said pull rod when the moving coil corresponding to said tubular armature is energized, and said second armature being adapted to be moved farther in the direction of the aforesaid movement to its attracted position when its corresponding moving coil is energized, said latter movement being permitted by the movement of said pull rod through said tubular armature, a first self-closing switch carried by said housing for completing the circuit through the moving coil of one of said pairs of coils, a second self-closing switch carried by said housing for completing the circuit through the moving coil of the other of said pairs of coils, a thrust member supported by said housing adjacent said first switch and in the path of movement of said tubular armature and adapted to open said first switch following energized movement of said tubular armature to its attracted position, a second thrust member supported by said first thrust member adjacent the second switch and in

the path of movement of said pull rod and adapted to open said second switch following energized movement of said second armature and the pull rod connected therewith, and a spring interposed between said thrust members for maintaining said second thrust member in contact with said second switch.

3. In combination, a source of electrical energy, a solenoid having a housing and a plurality of stages of action and including a plurality of pairs of coaxial coils, said pairs of coils each including a moving coil and a holding coil, means connectible between said source of energy and the pairs of coils of said solenoid for supplying energy to them successively, a tubular armature movable within one of said pairs of coils, a second armature movable within another of said pairs of coils, a pull rod secured in said second armature and extending through said tubular armature and having a head adapted to coact with the tubular armature to form a lost motion connection therewith, a first stage of solenoid action, said first stage of action being effected by energization of said one pair of coils whereupon said tubular armature is moved to its attracted position and transmits said movement through said pull rod to said second armature, a second stage of solenoid action, said second stage of action being effected by energization of said other pair of coils resulting in further movement of said second armature in the direction of the aforesaid movement, which further movement is permitted by the movement of said pull rod within said tubular armature, a first self-closing switch carried by said housing for completing the circuit through the moving coil of one of said pairs of coils, a second self-closing switch carried by said housing for completing the circuit through the moving coil of another of said pairs of coils, a thrust sleeve supported by said housing adjacent said first switch and in the path of movement of said tubular armature and adapted to open said first switch following energized movement of said tubular armature, a movable pin supported by said thrust sleeve adjacent the second self-closing switch and in the path of movement of said pull rod and adapted to open said second self-closing switch following energized movement of said second armature, and a spring interposed between said movable pin and said thrust sleeve for maintaining said pin in contact with said second switch.

4. A solenoid including a pair of coils having their axes on a common line, a tubular armature positioned within one of said coils, a second armature positioned within the other of said coils, a rod connected with said second armature extending through said tubular armature and having a lost-motion connection with the tubular armature for mechanically transmitting movement of the tubular armature to said second armature, said tubular armature being adapted to be moved to its attracted position and to transmit such movement to said second armature through said rod when the coil corresponding to the tubular armature is energized, and said second armature being adapted to be moved farther in the direction of the aforesaid movement to its attracted position when its corresponding coil is energized, said latter movement being permitted by the movement of said rod through said tubular armature, a first switch connected with said coil for said tubular armature for completing a circuit through said coil for said tubular armature, a second switch connected with the other of said coils for

completing a circuit through the other of said coils, a thrust member in the path of movement of said tubular armature, means actuated by said thrust member for effecting opening of said first switch following energized movement of said tubular armature to its attracted position, and a second thrust member supported by said first thrust member and in the path of movement of said second armature, means actuated by said second thrust member for effecting opening of said second switch following energized movement of said second armature and said rod connected therewith.

5. A solenoid including a plurality of pairs of coils having their axes on a common line and each pair including a moving coil and a holding coil, a tubular armature positioned within one of said pairs of coils, a second armature positioned within another of said pairs of coils, a rod connected with said second armature and extending through said tubular armature and having a lost-motion connection with said tubular armature for mechanically transmitting movement of said tubular armature to said second armature, said tubular armature being adapted to be moved to its attracted position and to transmit such movement to said second armature through said rod when the moving coil corresponding to said tubular armature is energized, and said second armature being adapted to be moved farther in the direction of the aforesaid movement to its attracted position when its corresponding moving coil is energized, said latter movement being permitted by the movement of said rod through said tubular armature, a first switch connected with said moving coil for said tubular armature for completing a circuit through the moving coil for said tubular armature, a second switch connected with the moving coil for said second armature for completing a circuit through the moving coil for the second armature, a thrust member adjacent said first switch and in the path of movement of said tubular armature, means actuated by said thrust member for effecting opening of said first switch following energized movement of said tubular armature to its attracted position, and a second thrust member supported by said first thrust member adjacent the second switch and in the path of movement of said rod, and means actuated by said second thrust member for effecting opening of said second switch following energized movement of said second armature and the rod connected therewith.

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