Dec. 18, 1956 F. KESSELRING 2,774,920

ELECTROMAGNETIC SWITCH ARRANGEMENT

Filed Oct. 4, 1951 2 Sheets-Sheet 1

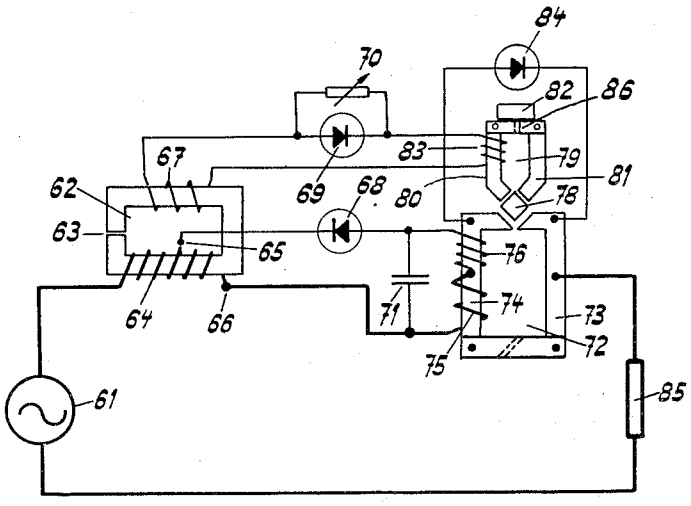

Fig. 1

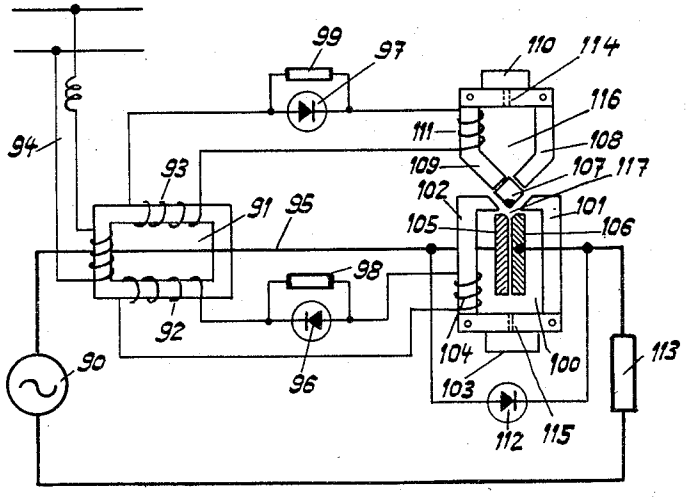

Fig. 2

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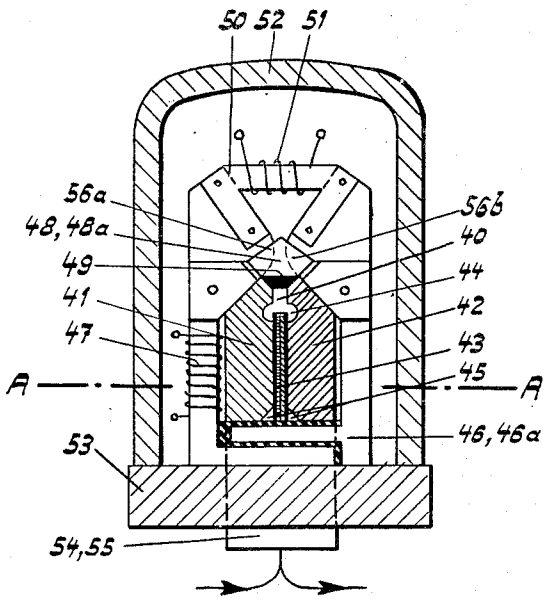

Fig. 3

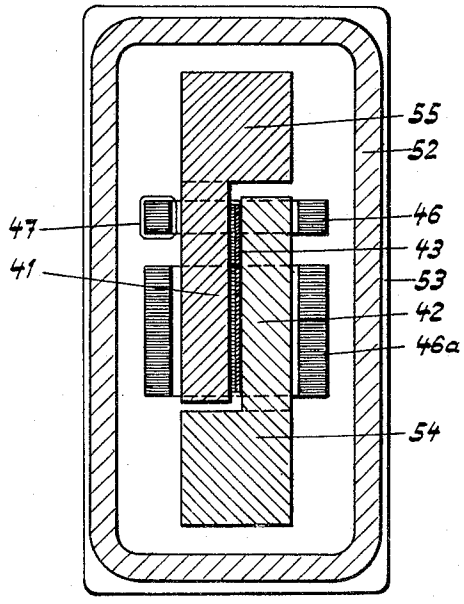

Fig. 4

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2,774,920

ELECTROMAGNETIC SWITCH ARRANGEMENT

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9 Claims. (Cl. 317—156)

My present invention relates to an electromagnetic switch arrangement with at least one electromagnetically actuated switching element actuation of which in closed position causes two stationary contacts to be connected and to complete the electric circuit to be switched, and two magnetic systems of which one serves for closing the said switching element, the second serving for opening said element, characterized by the fact that the switching element arranged between the pole pieces of the two magnetic systems is influenced, apart from the force of gravity, by magnetic forces only.

The accompanying drawings disclose three embodiments of this invention, Figs. 1 and 2 showing a switch arrangement in a transformer circuit, Figs. 3 and 4 showing a switch cartridge according to the invention.

Referring to Fig. 1, the numeral 61 designates the alternating current source, 62 a saturable reactor with an air gap 63, 64 is the main winding tapped at 65 and 66. The numeral 67 designates an auxiliary coil, 68 and 69 are valves, more particularly dry rectifiers. 70 is an adjustable shunt resistance, 71 a condenser. The magnetic closing system of the switch arrangement is generally indicated at 72, and it comprises the poles 73 and 74. The said magnetic closing system comprises the main winding 75 and the auxiliary closing coil 76. The magnetic opening system is designated by the reference numeral 79 and comprises the poles 80 and 81, an air gap 86 bridged by the permanent magnet 82, and the opening coil 83. In parallel relation to the point of interruption is arranged the valve 84, and 85 designates the load. Between the pole pieces of the two magnetic systems is arranged the switching element (armature) 78. It is evident that several such switching elements may be arranged serially. The pole faces of the poles 73, 74, 80 and 81 enclose spaces of square cross-section open at the corners, in which the armature or armatures are arranged. In addition, the poles 73 and 74 of the magnetic closing system 72 also constitute the stationary contacts.

This arrangement operates in the following manner: When a current begins to flow in the winding 64, a voltage pulse occurs between the taps 65 and 66 causing an impulse through the windings 75 and 76 and the valve means 68. Simultaneously, the condenser 71 is charged. The effect of this impulse attracts the armature 78 thereby bridging the poles 73 and 74. At the end of the voltage pulse, the condenser 71 discharges through the windings 75, 76 so that magnetization is extended beyond the duration of said pulse until the energization of the main winding 75 ensures sufficient holding power. When the main current approaches its zero value, the magnetization of the reactor 62 is again reversed. The voltage between the taps 65 and 66 is of opposite polarity. No current can flow through the closing windings 75, 76 by reason of the blocking winding of valve 68. However, a voltage pulse is created in the winding 67 and now energizes the opening coil 83 in such a manner that the latter assists the magnetizing effect of the permanent magnet 82. This causes the armature 78 to be attracted in the opening sense

and therefore in the proximity of the zero value, it rises clear of the poles 73 and 74. Owing to the effect of the permanent magnet 82, the armature 78 then remains in open position. When magnetization of the reactor 62 is reversed for closing, the cycle of the closing circuit described is repeated. In addition, however, a current flows from the winding 67 through the resistance 70 and the opening coil 83, in opposite direction, causing the attractive force of the permanent magnet 82 to be decreased to such a value that the armature 78 would drop even without the attraction of the magnetic system 72. It will be seen that the acceleration of the armature in the closing and opening directions only occurs by means of magnetic forces generated on the one hand by the energization of the closing winding 76, and, on the other hand, by the energization of the opening winding 83. The permanent magnet 82 only secures the open position of the switch in currentless condition. Its effect is compensated by counter-energization of the winding 83 in the closing process.

Fig. 2 shows an embodiment of the present invention specially employed for high current values. The numeral 90 designates the alternating current source, 91 the saturable reactor with windings 92 and 93, and the pre-energization system 94. The main energization of the saturable reactor 91 occurs through the current-carrying conductor 95, i. e. the reactor 91 is designed as a single-wire transformer. 96, 97 designate valves, 98, 99 resistances.

The magnetic closing system 100 comprises the poles 101 and 102 and an air gap 115. A permanent magnet 103 bridges the gap 115. The magnetic closing system is provided with an auxiliary closing coil 104. Main energization is effected by means of the current passage through the bars 105 and 106 which also serve as stationary contacts arranged below the gap 117 between the pole faces 101 and 102 of the magnetic closing system 100 and connected by the armature or armatures 107 in closed condition. The bars 105, 106 are insulated and adjacent, and represent a structure resembling a single-wire transformer in conjunction with the magnetic system 100. The magnetic opening system is designated by 116, its poles by 108 and 109. It also comprises an air gap 114 and a permanent magnet 110 bridging said gap, in addition also the opening coil 111. The valve bridging the stationary contacts 105, 106, is designated by the reference numeral 112, 113 being the load. Between the pole pieces of the two magnetic systems 100 and 116, the armature 107 is arranged as a circuit element, several such elements in serial arrangement being possible. The pole faces of the two magnetic systems 100 and 116 again define spaces of generally square cross section with open corners.

The operation of this arrangement corresponds in all essentials to the operation of the arrangement disclosed in Fig. 1. The arrangement of the permanent magnet 103 provides for the armature 107 to be held in closed position until the zero value is approached. On opening, the effect of the magnet 103 is compensated by the return current of the valve 96 flowing through the resistance 98, the operation being similar to that described for the closing magnet according to Fig. 1. In closed position the armature or armatures 107 cause the two bars 105, 106 to be connected. The armature or armatures are thus influenced apart from the force of gravity by magnetic forces only.

Fig. 3 shows a cross section and Fig. 4 a longitudinal section along the line A—A in Fig. 3 of a single-wire cartridge, in which the gap 40 is arranged in parallel relation to the two current bars 41, 42 forming the stationary contacts. Between the bars is arranged a plate-like current valve 43, e. g. a dry rectifier. The recesses

44 and 45 serve to increase the insulation distances. The magnetic closing system comprises two systems 46 and 46*a* and encloses the bars 41 and 42. The impulse winding 47 is connected only with the magnetic system 46 in order to reduce its inductance. Furthermore, a magnetic opening system 50 with the winding 51 is provided. The reference numerals 48 and 48*a* designate disc-shaped armatures carrying the conducting current bridges 49 at their lower ends and serially arranged in parallel relation between the pole pieces of the two magnetic systems 46 and 46*a* respectively. For the sake of clarity, the serially arranged armatures 48, 48*a* are not shown in Fig. 4. Finally, 52 designates the housing, 53 being the base-plate through which the elbows 54 and 55 of the bars 41 and 42 project downwardly. In order to secure the armatures 48 and 48*a* against dropping out, the closures 56*a* and 56*b* are provided. In these three embodiments the pole faces of the two magnetic systems define spaces of generally square cross-section with open corners, in which the armatures are disposed.

The operation of the arrangement is as follows: As soon as a forward current begins to flow through the valve 43, the impulse winding is energized and the effect of the opening winding 51 reduced, which causes the armatures 48 of the magnetic impulse system to be attracted and the bars 41, 42 to be connected. The increasing main current gradually increases the energization of the main magnetic system 46*a* and thus the associated armatures 48*a* are attracted. When the main current again approaches its zero value, only the armatures 48 are strongly attracted by the magnetic field generated by the impulse winding, while the armatures 48*a* only loosely rest on the bars 41 and 42. In the neighbourhood of the zero value, a counter-impulse is generated in a manner similar to that disclosed in Figs. 1 and 2, so that the current in the winding 47 practically drops to zero while the current of the opening winding 51 is substantially increased. This causes all armatures 48 and 48*a* to move into open position.

The advantage of the switch arrangement resides mainly in the fact that mechanical supports for the switching element are dispensed with so that no additional energy need be expended in order to counteract the effect of an opening spring when the arrangement is switched in, and that the omission of all supporting means simplifies the manufacture, assembly and setting of the arrangement. The magnetic opening arrangement provides the additional advantage that the switching elements are magnetically held in their final positions, and that all backward rocking, which would entail a reduction of dielectric strength, is practically impossible.

What I claim is:

1. An electromagnetic switch arrangement for the control of current flow from an alternating current source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, and an electronic device, said circuit closing magnetic system comprising a first and second pole piece electrically insulated from each other and having an air gap therebetween, said switching element electrically bridging said air gap when said switching element is moved to circuit closed position, a main closing winding wound on at least one pole piece of said closing magnetic system and electrically connected to one pole piece for magnetically energizing said closing magnetic system when said main closing winding is electrically energized, a main winding on said saturable reactor, an electrical circuit for connecting said electronic device to said pole pieces, an electrical circuit for connecting the load to the other of said pole pieces, said main winding and said main closing winding being electrically connected in series with said alternating current source and load through said pole pieces and electronic means, said switching element short circuiting said electronic means when moved to bridge said one air gap of said poles of said closing magnetic system, a secondary winding on said saturable reactor, an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized, first means to prevent full energization of said opening winding when said main and auxiliary closing winding are energized during one-half of the alternating current cycle to attract said switching element to closed position and second means during the other half of the alternating current cycle to prevent full energization of said auxiliary and main closing windings when said opening winding is fully energized from said secondary winding of said saturable reactor to move said switching element to open position.

2. An electromagnetic switch arrangement for the control of current flow from an alternating current source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, and an electronic device, said circuit closing magnetic system comprising a first and second pole piece electrically insulated from each other and having an air gap therebetween, said switching element electrically bridging said air gap when said switching element is moved to circuit closed position, a main closing winding wound on at least one pole piece of said closing magnetic system and electrically connected to one pole piece for magnetically energizing said closing magnetic system when said main closing winding is electrically energized, a main winding on said saturable reactor, an electrical circuit for connecting said electronic device to said pole pieces, an electrical circuit for connecting the load to the other of said pole pieces, said main winding and said main closing winding being electrically connected in series with said alternating current source and load through said pole pieces and electronic means, said switching element short circuiting said electronic means when moved to bridge said one air gap of said poles of said closing magnetic system, a secondary winding on said saturable reactor, an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized, first means to prevent full energization of said opening winding when said main and auxiliary closing winding are energized during one-half of the alternating current cycle to attract said switching element to closed position and second means during the other half of the alternating current cycle to prevent full energization of said auxiliary and main closing windings when said opening winding is fully energized from said secondary winding of said saturable reactor to move said switching element to open position and a third means connected in said opening magnetic system, said third means being effective to maintain said switching element in disengaged position when said switch element is moved to disengaged position by energization of said opening winding.

3. An electromagnetic switch arrangement for the control of current flow from an alternating current source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, and an electronic device, said circuit closing magnetic system comprising a first and second pole piece electrically insulated from each other and having an air gap therebetween, said switching element electrically bridging said air gap when said switching element is moved to circuit closed position, a main closing winding wound on at least one pole piece of said closing magnetic system and electrically connected to one pole piece for magnetically energizing said closing magnetic system when said main closing winding is electrically energized, a main winding on said saturable reactor, an electrical

circuit for connecting said electronic device to said pole pieces, an electrical circuit for connecting the load to the other of said pole pieces, said main winding and said main closing winding being electrically connected in series with said alternating current source and load through said pole pieces and electronic means, said switching element short circuiting said electronic means when moved to bridge said one air gap of said poles of said closing magnetic system, a secondary winding on said saturable reactor, an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized, first means to prevent full energization of said opening winding when said main and auxiliary closing winding are energized during one-half of the alternating current cycle to attract said switching element to closed position and second means during the other half of the alternating current cycle to prevent full energization of said auxiliary and main closing windings when said opening winding is fully energized from said secondary winding of said saturable reactor to move said switching element to open position and electronic means controlled from said source of alternating current for rendering said opening magnetic system ineffective during the energization of said closing magnetic system.

4. An electromagnetic switch arrangement for the control of current flow from an alternating current source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, and an electronic device, said circuit closing magnetic system comprising a first and second pole piece electrically insulated from each other and having an air gap therebetween, said switching element electrically bridging said air gap when said switching element is moved to circuit closed position, a main closing winding wound on at least one pole piece of said closing magnetic system and electrically connected to one pole piece for magnetically energizing said closing magnetic system when said main closing winding is electrically energized, a main winding on said saturable reactor, an electrical circuit for connecting said electronic device to said pole pieces, an electrical circuit for connecting the load to the other of said pole pieces, said main winding and said main closing winding being electrically connected in series with said alternating current source and load through said pole pieces and electronic means, said switching element short circuiting said electronic means when moved to bridge said one air gap of said poles of said closing magnetic system, a secondary winding on said saturable reactor, an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized, first means to prevent full energization of said opening winding when said main and auxiliary closing winding are energized during one-half of the alternating current cycle to attract said switching element to closed position and second means during the other half of the alternating current cycle to prevent full energization of said auxiliary and main closing windings when said opening winding is fully energized from said secondary winding of said saturable reactor to move said switching element to open position, a permanent magnet for energizing said open magnetic system, said permanent magnet being effective to maintain said switching element in open position when said switching element is moved to open position by said opening winding and while said main closing winding is de-energized.

5. An electromagnetic switch arrangement for the control of current flow from an alternating current source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, and an electronic device, said circuit closing magnetic system comprising a first and second pole piece electrically insulated from each other and having an air gap therebetween, said switching element electrically bridging said air gap when said switching element is moved to circuit closed position, a main closing winding wound on at least one pole piece of said closing magnetic system and electrically connected to one pole piece for magnetically energizing said closing magnetic system when said main closing winding is electrically energized, a main winding on said saturable reactor, an electrical circuit for connecting said electronic device to said pole pieces, an electrical circuit for connecting the load to the other of said pole pieces, said main winding and said main closing winding being electrically connected in series with said alternating current source and load through said pole pieces and electronic means, said switching element short circuiting said electronic means when moved to bridge said one air gap of said poles of said closing magnetic system, a secondary winding on said saturable reactor, an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized, first means to prevent full energization of said opening winding when said main and auxiliary closing windings are energized during one-half of the alternating current cycle to attract said switching element to closed position and second means during the other half of the alternating current cycle to prevent full energization of said auxiliary and main closing windings when said opening winding is fully energized from said secondary winding of said saturable reactor to move said switching element to open position, and additional means for controlling the magnetization of said opening magnetic system to maintain said switching element in open position when said switching element is moved to open position by said opening winding and while said main closing winding is de-energized.

6. An electromagnetic switch arrangement for the control of current flow from an A.-C. source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, a first and second stationary contact and an electronic device; said circuit closing magnetic system comprising a first and second pole piece having an air gap therebetween, said switching element being movable into and out of bridging relationship with respect to said air gap; said stationary contacts being positioned to be engaged by said switching element when said switching element is moved into bridging relationship with respect to said air gap; said saturable reactor comprising a main winding and a first and second secondary winding; said A.-C. source, said saturable reactor main winding, said pair of stationary contacts, and said load being connected in series; said saturable reactor first secondary winding being connected to energize said electromagnetic switch operating winding responsive to a predetermined condition of unsaturation of said saturable reactor to thereby magnetically energize said closing magnetic system; an electrical circuit for connecting said electronic device across said stationary contacts, said switching element short circuiting said electronic means when moved to engage said stationary contacts; an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized; said saturable reactor second secondary winding being connected to energize said opening winding responsive to a predetermined condition of unsaturation of said saturable reactor, a first means to prevent full energization of said opening winding when said closing winding is energized to attract said switching element to a closed position and a second means to prevent full energization of said closing winding when said opening winding is energized to move said switching element out of engagement with said stationary contacts.

7. An electromagnetic switch arrangement for the con-

trol of current flow from an A.-C. source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, a first and second stationary contact and an electronic device; said circuit closing magnetic system comprising a first and second pole piece having an air gap therebetween, said switching element being movable into and out of bridging relationship with respect to said air gap; said stationary contacts being positioned to be engaged by said switching element when said switching element is moved into bridging relationship with respect to said air gap; said saturable reactor comprising a main winding and a first and second secondary winding; said A.-C. source, said saturable reactor main winding, said pair of staticnary contacts, and said load being connected in series; said saturable reactor first secondary winding being connected to energize said electromagnetic switch operating winding responsive to a predetermined condition of unsaturation of said saturable reactor to thereby magnetically energize said closing magnetic system; an electrical circuit for connecting said electronic device across said stationary contacts, said switching element short circuiting said electronic means when moved to engage said stationary contacts; an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized; said saturable reactor second secondary winding being connected to energize said opening winding responsive to a predetermined condition of unsaturation of said saturable reactor, a first means to prevent full energization of said opening winding when said closing winding is energized to attract said switching element to a closed position and a second means to prevent full energization of said closing winding when said opening winding is energized to move said switching element out of engagement with said stationary contacts; said first and second stationary contacts comprising a first and second bar arranged below said first air gap.

8. An electromagnetic switch arrangement for the control of current flow from an A.-C. source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, a first and second stationary contact and an electronic device; said circuit closing magnetic system comprising a first and second pole piece having an air gap therebetween, said switching element being movable into and out of bridging relationship with respect to said air gap; said stationary contacts being positioned to be engaged by said switching element when said switching element is moved into bridging relationship with respect to said air gap; said saturable reactor comprising a main winding and a first and second secondary winding; said A.-C. source, said saturable reactor main winding, said pair of stationary contacts, and said load being connected in series; said saturable reactor first secondary winding being connected to energize said electromagnetic switch operating winding responsive to a predetermined condition of unsaturation of said saturable reactor to thereby magnetically energize said closing magnetic system; an electrical circuit for connecting said electronic device across said stationary contacts, said switching element short circuiting said electronic means when moved to engage said stationary contacts; an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized; said saturable reactor second secondary winding being connected to energize said opening winding responsive to a predetermined condition of unsaturation of said saturable reactor, a first means to prevent full energization of said opening winding when said closing winding is energized to attract said switching element to a closed position and a second means to prevent full energization of said closing winding when said opening winding is energized to move said switching element out of engagement with said stationary contacts; said closing magnetic structure comprising a second air gap therein; a permanent magnet; said permanent magnet being positioned to bridge said second air gap.

9. An electromagnetic switch arrangement for the control of current flow from an A.-C. source to a load comprising an electrical circuit closing magnetic system, an electrical circuit opening magnetic system, a switching element, a saturable reactor, a first and second stationary contact and an electronic device; said circuit closing magnetic system comprising a first and second pole piece having an air gap therebetween, said switching element being movable into and out of bridging relationship with respect to said air gap; said stationary contacts being positioned to be engaged by said switching element when said switching element is moved into bridging relationship with respect to said air gap; said saturable reactor comprising a main winding and a first and second secondary winding; said A.-C. source, said saturable reactor main winding, said pair of stationary contacts, and said load being connected in series; said saturable reactor first secondary winding being connected to energize said electromagnetic switch operating winding responsive to a predetermined condition of unsaturation of said saturable reactor to thereby magnetically energize said closing magnetic system; an electrical circuit for connecting said electronic device across said stationary contacts, said switching element short circuiting said electronic means when moved to engage said stationary contacts; an opening winding on said opening magnetic system for magnetically energizing said opening magnetic system when said opening winding is electrically energized; said saturable reactor second secondary winding being connected to energize said opening winding responsive to a predetermined condition of unsaturation of said saturable reactor, a first means to prevent full energization of said opening winding when said closing winding is energized to attract said switching element to a closed position and a second means to prevent full energization of said closing winding when said opening winding is energized to move said switching element out of engagement with said stationary contacts; said opening and closing magnetic structures having an air gap therein for receiving a permanent magnet to thereby magnetically bias said magnetic structures.

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