June 10, 1930. H. E. WHITE 1,763,284

THERMAL RELAY

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Fig. 1.

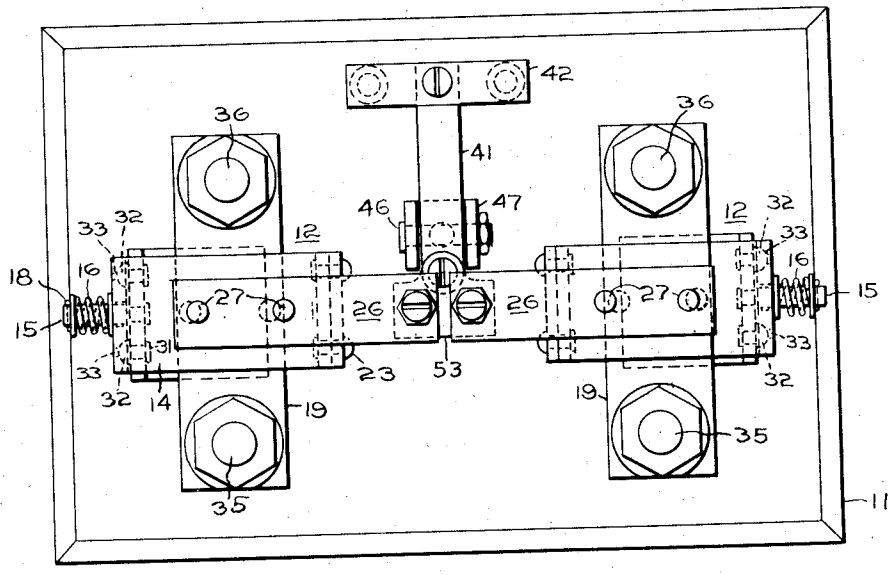


Fig. 2.

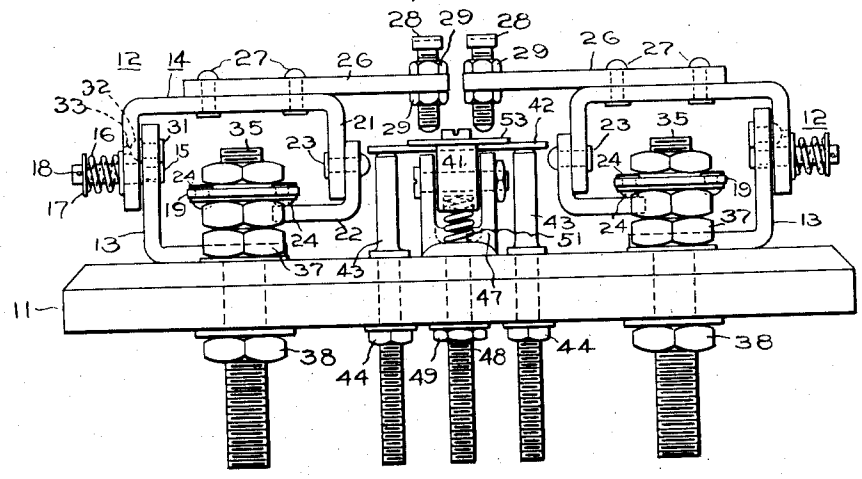
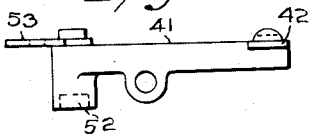


Fig. 3.



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Fig. 4.

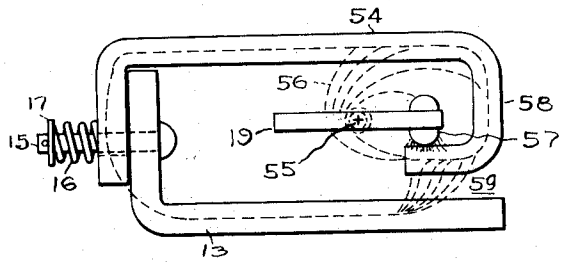


Fig. 5.

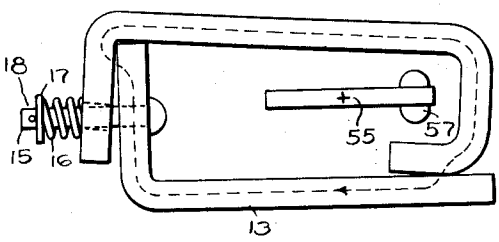


Fig. 6.

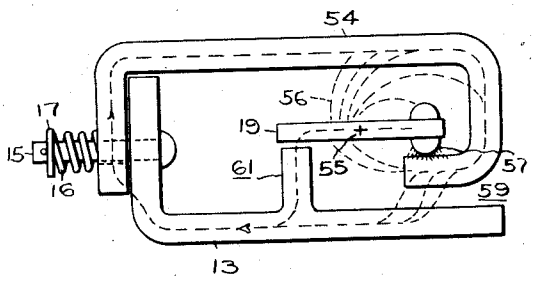
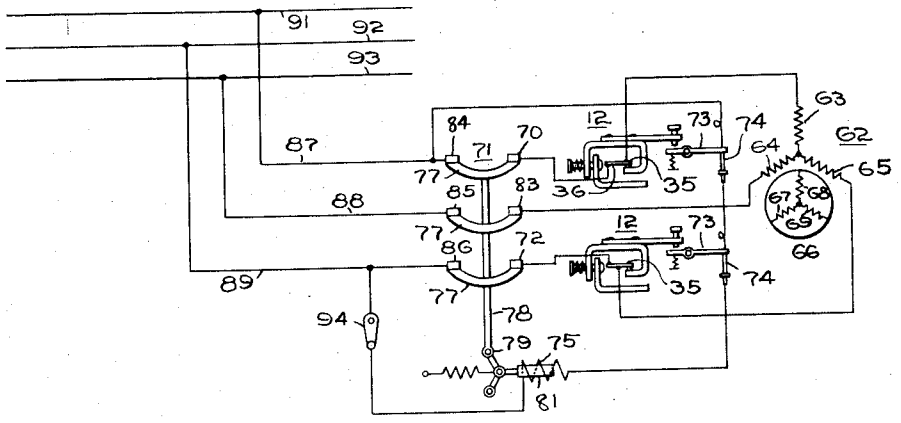


Fig. 7.



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UNITED STATES PATENT OFFICE

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THERMAL RELAY

Application filed September 9, 1927. Serial No. 218,385.

My invention relates to protective devices and particularly to thermally-responsive, electromagnetic relays.

An object of my invention is to provide a relay for protecting motors and similar devices from overloads, that shall be simple in construction, easily manufactured and positive in its operation.

Another object of my invention is to provide a relay that shall be capable of operating directly in a heavy-current circuit.

A further object of my invention is to provide a thermally-responsive electro-magnetic relay that shall be operable in response to the electro-magnetic field produced by a conductor carrying current and by a change in permeability of the conductor, and

A still further object of my invention is to provide an overload-responsive element that shall be capable of causing a portion thereof to be magnetically saturated in response to current flowing therethrough.

For a fuller understanding of my invention, reference may be had to the following description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a top plan view of an overload protecting device for multi-phase dynamo-electric machines embodying my invention.

Fig. 2 is a view, in side elevation, of the same device.

Fig. 3 is a detail view of a contact arm embodied in the device of Figs. 1 and 2.

Fig. 4 is an end view of an electro-magnetic thermally-responsive device embodied in the device of Figs. 1 and 2, illustrating the magnetic-field distribution therein.

Fig. 5 is a view of the same device after the thermal element thereof has responded to a current of a predetermined value.

Fig. 6 is a view illustrating a modification of the device shown in Figs. 4 and 5, and

Fig. 7 is a schematic illustration of circuits and apparatus embodying my invention.

In Figs. 1 and 2 of the drawings, a base 11 is illustrated on which is mounted a pair of electro-magnetic thermal relays 12. The relays 12 being similar in construction, like parts will be designated by the same reference characters. Each of the relays 12 consists of a magnetic-loop device comprising a stator 13 of substantially L-shape, an armature 14 yieldingly mounted thereon by means of a bolt 15, a spring 16, a washer 17 and a cotter pin 18, and a self-magnetizable reversibly magnetic member 19 that passes through the loop device constituted by the armature 14 and the stator 13.

The armature 14 consists of a member 21 of substantially U-shape to which a member 22 of substantially L-shape is secured by rivets 23. The member 22 normally engages a rivet 24 of magnetic material that is attached to the reversibly magnetic member 19.

The member 21 of the armature 14 may be provided with a switch-actuating arm 26 that is secured thereto by rivets 27. The free end of the arm 26 may be provided with an adjustable screw 28 which may be locked in any desired position by nuts 29.

In order to prevent the armature 14 from turning on the bolt 15, rivets 31 are provided in the stator 13, the heads 32 of which register with a socket or recess 33 in the portion 21 of the armature.

The reversibly magnetic member 19, as hereinbefore stated, extends through the loop, constituted by the armature 14 and the stator 13, and is supported by, and secured to, terminal bolts 35 and 36 that extend through the base 11, the bolts being held securely in place on the base by means of co-operating nuts 37 and 38.

The member 19 consists of a strip of magnetic material which is substantially rectangular in shape, that is, the strip is relatively wide as compared with its thickness.

The alloy of which the member 19 is made has the characteristic that, when normally cool, it is magnetic but, when heated to a temperature of a predetermined value, it becomes non-magnetic and, when cooled to a temperature slightly below this value, it again becomes magnetic. Because of this characteristic, the member 19 may be designated as a reversibly magnetic member.

For my present purpose, the member 19 preferably consists of an alloy of nickel and iron in the proportions of substantially 65% iron and 35% nickel, with minor proportions

of other materials, is so desired. An alloy of 65% iron and 35% nickel has the characteristic that, when cool, it is magnetic, but, when heated to a temperature of substantially 150° C., it becomes non-magnetic, the magnetic properties being regained when cooled to a temperature slightly below this value.

When a current traverses the member 19, a magnetic field is produced thereabout which causes the armature and the stator 13 to become magnetized by induction. So long as the member 19 is magnetic, there will be sufficient magnetic attraction between the rivet 24 and the member 22 of the armature to hold the armature in substantially the position shown in Fig. 2 of the drawings. If, however, the temperature of the member 19 has exceeded that temperature, at which it becomes non-magnetic, if the current is of the proper value, there will be a magnetic attraction between the stator 13 and the portion 22 of the armature strong enough to cause the portion 22 to engage the stator 13. By the attraction of the armature to the stator the switch arm 26 is caused to be actuated downwardly by the armature.

In order that an electric circuit may be controlled when the member 19 has been rendered non-mognetic and the air gap between the portion 22 and the stator 13 has been substantially closed, the movement of the switch-actuating arm 26 may be utilized for actuating a bridging contact- supporting member 41. The member 41 may be provided with a contact-bridging member 42 at one end thereof for normally bridging a pair of stationary switch contacts 43 that extend through the base 11 and which may be secured thereto by nuts 44.

The member 41 is pivotally supported on a bolt 46 that extends through a bracket 47 of substantially U-shape, the member 41 being located between the legs of the bracket. The bracket 47 may be supported on the base in any suitable manner. In the present instance, it is secured thereto by a bolt 48 and a cooperating nut 49.

In order that the arm 41 may be biased toward such a position that the contact-bridging member 42 normally engages the stationary contacts 43 a spring 51 is provided, one end of which is disposed in a recess 52 in the member 41.

The member 41 is provided also with a strip 53 for cooperating with the bolt 28 when the switch-actuating arm 26 is moved downwardly by the armature 14. When the switch-actuating arm 26 has been moved downwardly by the armature, the bolt 28 is caused to strike against the strip 53 to thereby cause the member 41 to turn on its pivot 46 to effect disengagement between the contact-bridging member 42 and the stationary contacts 43. Thus, an electric circuit may be broken therebetween to effect control of an electro-responsive device.

In Fig. 4 of the drawings, the armature of the magnetic-loop device consists of an integral member 54 of substantially C-shape. The member 54 may be yieldingly supported on the stator 13 in substantially the manner shown in Figs. 1 and 2. The spring 16 tends to bias the armature 54 towards the position shown in the drawings.

When the current traversing the member 19 is above a predetermined value and the direction of current flow is in the direction of the tail of the arrow 55, the magnetic lines incident to the flow of current are substantially in the direction indicated by broken lines 56. Since the conductor 19 is relatively thin and wide, the central portion of the conductor tends to become saturated magnetically; therefore, the excess lines of magnetism or leakage flux, will tend to traverse the armature 54 and the stator 13.

As the member 19 is provided with the rivet 24 for engaging the armature, there will be flux concentration at 57, the point of contact between the armature and the rivet. Thus, it is seen that there will be a plurality of magnetic circuits set up about the member 19, one of which is through the end portion 58 of the armature 54 and the conductor 19 and the other of which is from the armature 58 through the air gap 59, to the stator 13. When the member 19 is magnetic, it acts as a shunt, whereby magnetic flux may be diverted away from the air gap 59. If the member 19 is heated to the temperature at which it becomes non-magnetic, the flux about the member 19, as indicated by the broken lines 56, substantially disappears but there remains the magnetic flux traversing the armature 54, the air gap 59 and the stator 13. Stated in another way, it may be said that the reluctance of the path traversed by the flux indicated by the broken lines 56 is increased, thereby rendering the flux passing through the air gap 59 sufficient, at the desired current values, to cause the armature and the stator to be actuated to the position shown in Fig. 5 of the drawings, wherein the armature and stator form a substantially closed magnetic loop about the member 19.

In Fig. 6 of the drawings, a magnetic lug 61 is secured to the stator 13 for diverting a portion of the magnetic flux surrounding the member 19 through the armature 54 and the stator. The lug may be integral with the stator, if desired. Thus, there will be more flux traversing the rivet 24 than in the case illustrated in Fig. 4 during the time when the member 19 is magnetic. But, if the member 19 becomes non-magnetic by reason of current traversing the same, a larger amount of flux will be available through the air gap 59 for causing positive engagement between the armature and the stator.

The flux distribution through the armature and stator and the distribution about the conductor 19 in Fig. 6 is approximately that indicated by the broken lines and the arrows attached thereto indicate the direction of the flux, it being assumed that the current is flowing in a direction into the member 19 as viewed from the front.

An application of the relays 12 to a polyphase motor 62 is shown in Fig. 7. The motor 62 comprises a stator having windings 63 to 65, inclusive, and a wound rotor 66 having windings 67 to 69, inclusive. The winding 63 of the stator may be connected to the terminal 35 of the relay 12, and the terminal 36 may be connected to a stationary switch contact 70 of a circuit breaker 71. The winding 65 of the stator may be connected to the terminal 35 of another relay 12, and the terminal 36 to a stationary switch contact 72 of the circuit breaker. The winding 64 of the motor is connected to a stationary contact 83. In the schematic illustration of Fig. 7, each of the relays 12 is provided with a pivotally mounted contact 73 for cooperating with a stationary contact 74 for controlling the circuit of a solenoid 75. The solenoid 75 is utilized for operating a plurality of movable switch contacts 77 of the circuit breaker 71 carried by a switch-actuating arm 78 by means of a toggle mechanism 79 and a core 81 attached thereto.

The movable switch contact members 77 are provided also with a plurality of stationary contacts 84 to 86, inclusive, which may be connected by conductors 87, 88 and 89, respectively, to supply conductors 91 to 93, inclusive.

The solenoid 75 may be energized from the supply conductors 87 and 89 by closing a switch 94 for establishing an electric circuit through the solenoid and the contacts 73 and 74 from the conductors 87 and 89.

When the solenoid 75 is energized and the switch contact 77 is actuated to engage their cooperating stationary contacts, the motor 62 will be energized from the supply conductors 91 to 93. If the current traversing the windings 63 to 65, inclusive, or any one of them individually exceeds a predetermined value, the member 19 will be heated to the temperature at which it becomes non-magnetic, and the armature 14 caused to be actuated to the position in which the disengagement between the contacts 73 and 74 and consequent deenergization of the solenoid 75 and the motor 62 are affected.

Various modifications may be made in the device embodying my invention without departing from the spirit and scope thereof. I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art and the appended claims.

I claim as my invention:

1. In combination, a single magnetic-loop device comprising armature and stator members, means for biasing said armature to provide an air gap in said loop, a current-conducting member extending through said loop and normally engaging said armature for providing a shunt path for said air gap and for magnetizing said loop, said current-conducting member being normally magnetic when cool and non-magnetic when heated to a temperature of predetermined value, whereby a reduction in said air gap and consequent movement of said armature are effected when said current-conducting member has been heated to said temperature.

2. In combination, a single magnetic-loop device comprising armature and stator members, means for biasing said armature to provide an air gap in said loop, a current-conducting member extending axially through said loop and normally engaging said armature for providing a shunt path for said air gap and for magnetizing said loop, said current-conducting member being normally magnetic when cool and non-magnetic when heated to a temperature of predetermined value, whereby a reduction in said air gap and consequent movement of said armature are effected when said current-conducting member has been heated to said temperature, and a contact device actuable by said armature for controlling an electric circuit.

3. In combination, a magnetic-loop structure comprising a plurality of members disposed for relative movement and constituting a single conductor for magnetic lines of force, a current-conducting magnetically-reversible member extending through said structure, for providing a plurality of magnetic circuits with respect to said magnetic structure, said magnetically-reversible member when heated to a temperature of a predetermined value, being effective to interrupt one of said magnetic circuits.

4. In combination, a single magnetic circuit structure comprising a plurality of members disposed for relative movement, and a current-conducting magnetizable member extending through said single magnetic circuit structure in such a manner that a plurality of magnetic lines of force are caused to permeate said magnetic structure when a magnetizing force is applied to the magnetizable member, said magnetizable member being operable, when heated to a temperature of a predetermined value, to so increase the reluctance of one of said magnetic circuits that relative movement of the magnetic-circuit structure members is effected.

5. In combination, a single magnetic-circuit device comprising a plurality of members disposed for relative movement, a normally magnetizable member extending through said single magnetic-circuit structure in such a manner that a plurality of magnetic circuits including said structure are pro-

vided when a magnetizing force is applied thereto, said normally magnetizable member being effective, when heated to a temperature of a predetermined value, to interrupt one of said circuits and thereby to render the other of said magnetic circuits effective to cause relative movement between the members of said magnetic-circuit structure.

6. An electromagnetic, thermo-responsive device comprising a plurality of magnetically permeable members disposed for relative movement and arranged to constitute a single loop, means for biasing said members to provide an air gap between adjacent ends thereof, a normally magnetic thermo-responsive member extending through said loop and positioned to engage one of the adjacent ends of said permeable members, said thermo-responsive member being disposed, when a magnetizing force is applied thereto, to cause a plurality of magnetic circuits to permeate said permeable members when its temperature is below a predetermined value and to increase the reluctance of one of said magnetic circuits when heated to a temperature of a predetermined value.

In testimony whereof, I have hereunto subscribed my name this 29th day of August, 1927.

HAROLD E. WHITE.