

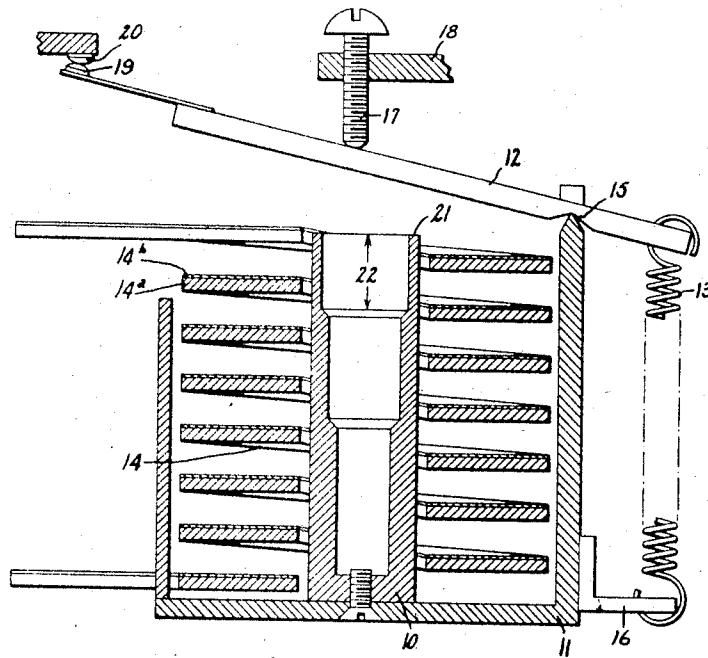
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ELECTRIC PROTECTIVE DEVICE

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## UNITED STATES PATENT OFFICE

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## ELECTRIC PROTECTIVE DEVICE

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7 Claims. (Cl. 200—87)

My invention relates to electric protective devices and particularly to thermally and magnetically responsive overload relays.

One object of my invention generally stated is to provide an overload relay operable upon both alternating current and direct current which shall be composed of a minimum number of parts and thus be inexpensive and easy to manufacture, and which shall be efficient in operation.

A further object of the invention is to provide an overload relay which shall be suitable for the protection of small motors and other electric energy translating devices against both moderate and extreme overload conditions.

It is a still further object of my invention to provide a new and improved overload relay having a thermal response with an inverse time-current characteristic upon the occurrence of a continued moderate overload below a predetermined value and having magnetic response with an instantaneous characteristic upon the occurrence of an extreme overload above said predetermined value.

Another object of the invention is to provide a relay of the above character which shall be adjustable over a wide range of current values, thereby to facilitate its application to various electrical devices having widely different normal current ratings.

According to the invention, a relay comprising a magnetic core and a magnetic armature normally spaced apart is provided with an energizing winding composed of a thermo-magnetic material arranged normally to shunt the major portion of the flux away from the armature. The thermo-magnetic material of which the energizing winding is formed has the property of showing a marked decrease in magnetic permeability upon an increase in its temperature due to the flow of excessive current therethrough. Upon an increase in the reluctance of the flux leakage path through the material of the energizing winding, the main portion of the flux is forced to pass through the relay armature, thereby to attract the armature to the core and actuate a pair of circuit controlling contacts. To facilitate instantaneous response upon the occurrence of an excessive overload above a predetermined value, a portion of the core is made of reduced cross section, as will be more fully described hereinafter.

My invention itself may be better understood and its object and advantages further appreciated by referring now to the following detailed specification taken in connection with the accompanying drawing, the single figure of which is a cross-sectional view of an overload relay embodying my invention.

In the drawing the relay is represented as comprising a hollow core 10 of magnetic material,

a magnetic frame 11, an armature 12 pivotally mounted upon the frame 11 and biased by a spring 13 to a normal position spaced from the core and an energizing coil 14 wound upon the core. The magnetic frame 11 provides a return path for the magnetic flux passing through the core 10, and to this end it comprises a base portion and two side portions extending in parallel spaced relation to the core 10. If desired, the side portion of the magnetic frame 11 may be made annular thereby completely to enclose the energizing coil 14. I wish to have it understood, however, that, while desirable, it is not essential to the practice of my invention that the side portions of the magnetic frame 11 form a closed annulus surrounding the coil.

The magnetic armature 12 is pivotally supported upon a fixed knife-edged bearing 15 which I have illustrated as forming an integral part of one side of the frame 11. The armature 12 is biased to a normal position spaced from the core 10 by means of a tension spring 13 connected between one end of the armature 12 and a fixed point such as a bracket 16 mounted upon the frame 11. In order to provide for control of the normal current rating of the relay, the armature 12 is provided with an adjustable stop screw 17 mounted in a fixed support 18 which may be connected to the frame 11. In order to control a protective circuit, the movable armature 12 carries one or more contacts 19 arranged for cooperation with one or more fixed contacts 20. For purposes of illustration I have shown the contacts 19 and 20 closed in the deenergized position of the relay, but it will be understood of course that, if desired, the fixed contact 20 may be arranged to engage the movable contact 19 when the armature 12 is in its attracted position.

The energizing winding 14 is designed to carry the load current of an electric circuit to be protected, and is preferably formed of a strip of thermo-magnetic material edgewound upon the core 10. The radial dimension of the winding 14 is preferably such that the winding fills substantially the entire space between the core 10 and the magnetic frame 11, thereby to provide a flux leakage path radially through the turns of the coil from the core to the frame. Preferably also a thin strip of insulating material (not shown) is provided to separate the winding 14 from the core 10 and the frame 11.

The winding 14 may be composed of any alloy having a substantial degree of magnetic permeability and a high degree of sensitivity of permeability to change of temperature within a relatively narrow band of temperature. Such materials are known as "Curie" metals, and demonstrate as their essential characteristic a marked change in magnetic permeability within a relatively narrow band of temperature lying

within the normal operating range of electrical apparatus. I prefer to use a metal which has a substantial degree of permeability at normal operating temperatures but becomes substantially non-magnetic when heated to approximately 100 or 150° centigrade, depending upon the particular alloy used. It is material of this character to which I refer as "thermo-magnetic material."

In order to adapt my relay to high current ratings relative to the overall size of the device, I prefer to wind the energizing coil 14 of a bimetal strip comprising a portion 14a of the thermo-magnetic material and a portion 14b of low resistance electrically conducting material such as copper. Preferably the bimetal coil is formed by copper plating a coil of thermo-magnetic material. By this method the overall resistance may be easily controlled.

In operation, current passing through the energizing winding 14 sets up a flux in the magnetic core 10. In a simple relay this flux would ordinarily take a return path through the magnetic armature 12 and the magnetic frame 11. In my relay, however, the permeability of the edgewound coil 14 of thermo-magnetic material is such that at ordinary temperatures the coil provides a flux leakage path radially through the turns of the coil from the core 10 to the frame 11. Upon the occurrence of a moderate continued overload, the winding 14 becomes heated by the current passing through it and ultimately reaches a temperature at which the thermo-magnetic material becomes substantially non-magnetic and no longer provides a flux leakage path. In this condition the main portion of the flux passes from the core 10 through the armature 12 and the frame 11. The flux now passing from the armature 12 to the pole face 21 of the core 10 sets up a magnetic attraction which causes the armature to move to its attracted position against the bias spring 13. It will be readily understood by those skilled in the art that under continuous moderate overload conditions the relay will operate with a time delay which is dependent upon the value of the current in the energizing winding 14. Relatively large overload currents will require less time to heat the thermo-magnetic winding 14 to its demagnetizing temperature than will smaller overload currents.

Upon the occurrence of a sudden excessive overload of a predetermined value, for example 300 to 500% normal current, the leakage path radially through the winding 14 becomes saturated and sufficient flux is forced through the armature 12 to pick up the armature even before the thermo-magnetic winding 14 is heated. The relay thus loses its thermal inverse time-current characteristic upon the occurrence of such predetermined excessive overload and operates substantially simultaneously due to the fact that saturation of the flux leakage path makes unnecessary the attainment of the demagnetizing temperature. It will be understood that a relay having predetermined dimensions will become instantaneous in its operation at such a value of overload current as is sufficient to force a flux of operating value through the armature 12 without first heating the winding 14. The value of this predetermined overload current is controlled by the size and saturability of the winding 14, the saturability of the core 10, and the air gap between core and armature. The value of the instantaneous trip current is not, however, affected by the resistance of the wind-

ing 14, so that the addition of copper plating to the coil will have no effect in this respect.

It has been found that with a solid magnetic core it is difficult to set the current value for instantaneous trip higher than approximately 250 to 300% normal rating. In order to adapt the relay for thermal inverse time-current operation up to as high as 500% of its normal current rating, the cross-sectional area of the core 10 may be markedly reduced in a region 22 near the pole face 21 of the core. As shown, the core 10 is centrally bored in the region 22. Such reduction of the cross-sectional area of the core makes the core saturable in the region of the pole face 21, and this in turn reduces the relative effect of approaching saturation of the thermo-magnetic material of the energizing winding. For example, if, upon the occurrence of a 300% overload with a solid core relay, the leakage path through the edgewound coil 14 would saturate to such a point that sufficient flux would pass through the armature 12 to attract the armature, concurrent saturation of a hollow core upon the same overload would simultaneously tend to restrict the amount of flux passing through the armature 12 and force more of the flux through the partially saturated leakage path. Thus the current value for instantaneous trip is raised by making the core tip saturable.

The copper portion 14b of the energizing winding 14 permits higher normal current ratings by decreasing the overall resistance of a coil of a predetermined size. It will also be found that the tripping time at high overloads will be slightly increased by the use of a bimetallic coil due to the time delay introduced by the conduction of heat from the copper portion of the coil to the thermo-magnetic portion. The copper portion of the coil acts substantially as a shunt heater for the thermo-magnetic portion.

The device disclosed in the drawing is an automatically resetting type of relay since the armature 12 will assume its deenergized position upon decrease of current and temperature in the winding 14 to their normal values. The value of the resetting current may be adjustably predetermined by providing an adjustable stop on either the core 10 or the armature 12 arranged to control the air gap between the armature and the pole face 21 when the armature is in its attracted position.

If it is desired to enforce manual resetting of the relay after the occurrence of an overload, latch means may be provided for engaging the armature 12 in its attracted position and holding it until manually released.

While I have described only one preferred embodiment of my invention by way of illustration, many modifications will occur to those skilled in the art and I therefore wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A thermally responsive overload relay comprising a magnetizable core, a magnetizable armature positioned in attractive relationship to said core, means providing a substantially closed flux path including said core and said armature, and an energizing coil of thermo-magnetic material arranged normally to provide a flux leakage path in shunt relation to said armature.

2. An overload relay comprising a magnetizable

core, a magnetizable armature biased to a normal position in spaced attractive relationship to said core, a magnetizable frame arranged in spaced relation to said core to provide a return path for magnetic flux passing through said core and armature, and means for normally shunting the main portion of said magnetic flux away from said armature comprising a current carrying winding of thermo-magnetic material encircling said core and extending radially between said core and said frame.

3. An overload relay comprising cooperating circuit controlling contacts, a magnetizable core, a movable armature of magnetizable material arranged to control one of said contacts, means for biasing said armature to a normal position in spaced attractive relationship to said core, said core being formed to provide saturable section adjacent said armature, a magnetizable frame having an end portion and a side portion providing a return path for magnetic flux passing through said core and armature, and means for normally shunting the main portion of said magnetic flux away from said armature through a leakage path between said core and said frame comprising an energizing winding for said relay composed of a thermo-magnetic alloy arranged to encircle said core and to fill substantially the entire space between said core and said frame, whereby continuous overloads below a predetermined value will heat said thermo-magnetic material to a predetermined demagnetizing temperature thereby to disable said leakage path and actuate said relay with an inverse time-current characteristic and a sudden overload above said predetermined value will actuate said relay instantaneously.

4. An overload relay comprising cooperating circuit controlling contacts, a magnetizable core having an end portion defining a pole face, said core being of substantially diminished cross-sectional area in the region of said pole face, a movable magnetizable armature operatively associated with one of said contacts, spring means for biasing said armature to a normal position spaced from said pole face, a magnetizable frame having a side portion magnetically linked with one end of said armature and spaced from said core and an end portion magnetically linked with said core thereby to provide a return path for magnetic flux passing through said core and armature, and means for normally shunting the main portion of said magnetic flux away from said armature comprising an energizing winding formed of thermo-magnetic alloy, said energizing winding being arranged to encircle said core and to substantially fill the space between said core and said frame.

5. An overload relay comprising cooperating circuit controlling contacts, a magnetizable core member, a magnetizable armature operatively associated with one of said contacts and biased to a normal position in spaced attractive relationship to said core member, a magnetizable frame magnetically linked with said armature and core to provide a return path for magnetic flux passing through said core and armature, said frame having a side portion positioned in substantially parallel spaced relation to said core, and a bimetallic energizing winding for said relay com-

prising a strip of thermo-magnetic material encircling said core and extending radially from said core to said side portion of said frame thereby to provide a low reluctance leakage path between said core and said frame at normal operating temperatures, said winding also including a strip of relatively low resistance electrically conducting material formed integrally with said thermo-magnetic material thereby to decrease the overall resistance of said winding.

6. An overload relay comprising cooperating circuit controlling contacts, a magnetizable core member, a movable magnetizable armature operatively associated with one of said contacts and biased to a normal position in spaced attractive relationship to said core member, a magnetizable frame providing a return path for magnetic flux passing through said core and armature, said frame member including an end portion magnetically linked to said core and an annular side portion magnetically linked to said armature and arranged in parallel spaced relation to said core, and a bimetallic energizing winding for said relay encircling said core and extending radially to fill substantially the entire annular space between said core and said annular side portion of said frame, said bimetallic winding comprising a strip of thermo-magnetic material providing a low reluctance leakage path between said core and said frame at normal operating temperature and an integrally formed strip of low resistance electrically conducting material for decreasing the overall resistance of said winding.

7. An overload relay comprising cooperating circuit controlling contacts, a central magnetizable core member having an end portion defining a pole face, said core member being centrally bored in the region of said pole face to provide a saturable section of a relatively small cross-sectional area, a magnetizable frame having an annular side portion in concentric relation to said core and an end portion magnetically linked to said core thereby to provide a return path for magnetic flux passing through said core, a magnetizable armature pivotally mounted upon said side portion of said frame and operatively associated with one of said contacts, spring means connected between said armature and said frame to bias said armature to a normal deenergized position in spaced attractive relationship to said pole face, an adjustable stop for determining the deenergized position of said armature with respect to said pole face, and a bimetallic energizing winding for said relay encircling said core and extending radially to fill substantially the entire annular space between said core and said annular side portion of said frame, said winding comprising an edgewound strip of thermo-magnetic material providing a low reluctance leakage path between said core and said frame at normal operating temperatures and an integrally formed portion of low resistance electrically conducting material for decreasing the overall resistance of said winding, said leakage path being saturable upon the occurrence of a sudden overload in excess of a predetermined value thereby to provide instantaneous actuation of said armature.

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