May 19, 1953 G. M. EULER 2,638,737

THERMAL TYPE OVERLOAD CIRCUIT BREAKER

Filed Dec. 19, 1947

Fig. 1.

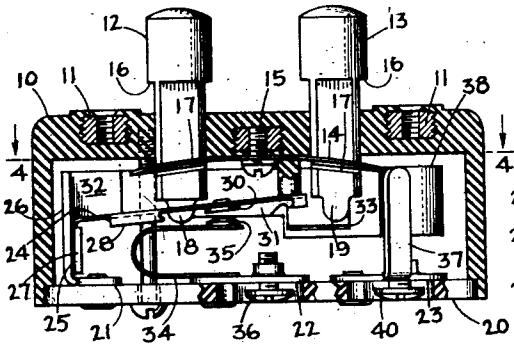


Fig. 2.

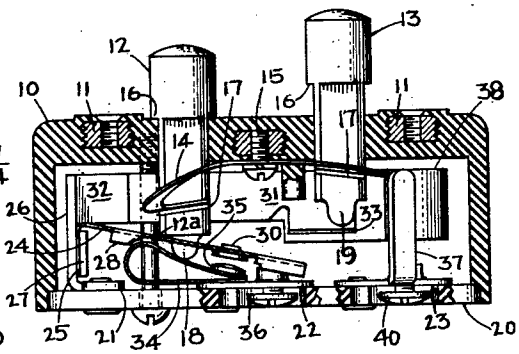


Fig. 4.

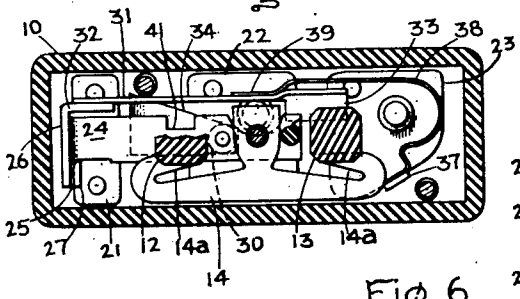


Fig. 3.

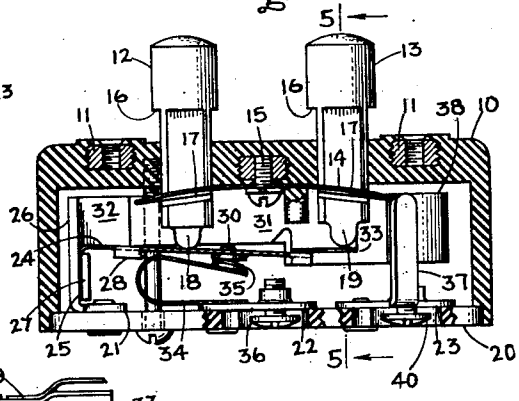


Fig. 6.

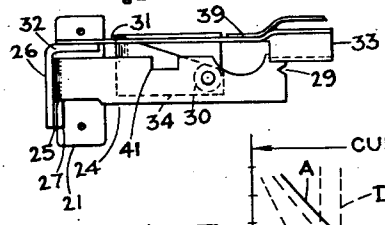


Fig. 5.

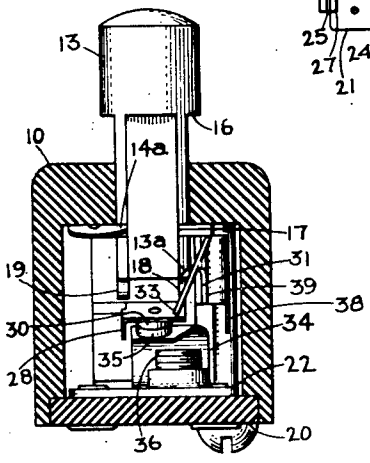
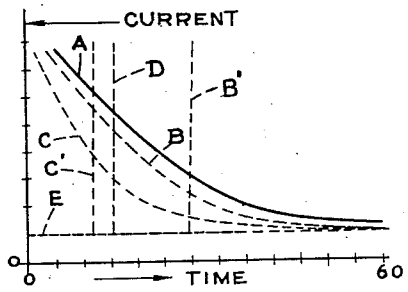


Fig. 7.



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THERMAL TYPE OVERLOAD CIRCUIT BREAKER

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4 Claims. (Cl. 60—23)

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The present invention relates to circuit breakers, and more particularly to that type which combines electric motor starting and overload protective means. While particularly adapted for use in connection with motors, the device of the present invention is readily adapted to other electrical devices utilizing starting and overload protective means.

It is known in the art that a motor is designed to withstand a certain amount of overload for a limited period, and when this limit is reached it is necessary to open the circuit to avoid damage to the motor by overheating. However, it is equally important that means be provided which will allow the closing of the circuit, after the overload occurs, with a minimum loss of time. Equally important is the ability of such a device to permit the motor to reach its maximum operating capacity without tripping out or opening the circuit prematurely.

The present invention provides a new and improved device of the type referred to above capable of being manufactured economically and according to standard specifications and methods.

Another object is to provide a device, the tripping current of which never varies substantially over prolonged periods of time.

A further object is to provide, in a device of the type described, calibrating means which requires mechanical adjustment of a single component, thereby requiring an absolute minimum of skill.

Another object is to provide a device, the resetting time of which, after tripping, is very rapid.

Another object is to provide an improved device of the type described in which the response to overload conditions is based primarily on heat conduction to cause operation of the device.

Other and further objects and advantages of the present invention will become apparent and the foregoing will be understood in relation to the following exemplification thereof, reference being had to the drawing in which: Figs. 1, 2 and 3 are cross sectional side elevations of an electric overload switch embodying the improvements of the present invention, said views depicting several operating positions of the device; Fig. 4 is a top view taken in section on the plane of the line 4—4 of Fig. 1; Fig. 5 is an end view in cross-section on the plane of the line 5—5 of Fig. 3; Fig. 6 is a view of several elements of the device shown apart from the whole structure for purposes of more clearly pointing out certain salient features thereof; and Fig. 7 is a chart for graphically illustrating other features of the present invention.

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Referring now more particularly to the drawing, in which like reference numerals refer to like elements of the device, there is illustrated an enclosure or cover 10 for supporting thereon some of the elements of the present device. Preferably, this cover is composed of a suitable molded plastic insulating material. The cover has molded therein two metal punchings 11, the punchings being adapted to accommodate self-tapping screws. Other means for accomplishing the same arrangement can be used. The punchings are provided for the purpose of attaching to the device an escutcheon plate (not shown) or to provide means for supporting said device.

Two push buttons 12 and 13, which may be composed of the same material as the cover 10 are, preferably, of molded construction. These push buttons provide the means for actuating the switching assembly to be described. In this particular embodiment, the push button 12 is the "starting and reset" button and the push button 13 the "stop" button. The lower portions of the two push buttons are of slightly reduced cross section and are arranged to slip into a pair of apertures in the top of the cover 10. The motion of these push buttons in a downward direction is limited by a shoulder 16 on each of said push buttons. Both buttons 12 and 13 are provided, respectively, at those ends extending within the cover, with semi-circular extensions 18 and 19 integral with one side of said push buttons, as illustrated in Fig. 5. The function of these extensions will be explained below. The aforementioned extensions 18 and 19, as shown in Fig. 5, are so arranged within the cover 10 that, with respect to the observer, the extension 18 is at the right-hand side of the drawing, or with respect to the Figs. 1, 2 and 3 the extension 18 on the button 12 is toward the back of the cover 10 and the extension 19 on the button 13 toward the front.

The push buttons 12 and 13 are molded in the same form but, as can be readily observed, it is simply a matter of disposing these buttons in their proper relative positions to the other elements, thereby eliminating the necessity of molding two separate types of push buttons. Preferably, the starting-reset button is a red color and the stop button black. In the lower portion of each of the above-mentioned push buttons there is provided a pair of slots 17 disposed, on opposite sides, in a transverse position and at a slight angle with respect to the length of said push buttons, these slots 17 being arranged to seat a spring member 14.

The above-mentioned spring member, in turn, is supported on the inner side of the top portion

of said cover and held in place by a screw 15. As illustrated in Fig. 4, the configuration of the spring member 14 is made similar to a pair of arms in bent position, the ends 14A of said arms being seated in the slots 17. The spring member preferably is made of spring steel or like material.

A base 20 is provided for supporting the main elements to be described. Preferably, this base is made of laminated insulating material and serves to insulate the various elements from each other. A plurality of metal brackets or supports 21, 22 and 23, electrically insulated from each other, are riveted to the base 20.

The bracket 21 is so fabricated that a portion 26 extends upwardly from the base 20, and a second portion 32 is bent to form a right angle to the portion 26. A flat substantially L-shaped spring member 24, preferably composed of beryllium copper, is fastened to the portion 26 and held rigidly in place by a flat rectangular metal member 27. This is done by having the shorter portion 25 of the spring member 24 disposed between the last-mentioned members 26 and 27 and then welding the entire assembly together. Rigidity is given the longer portion of the spring member 24 by having substantially all of one edge 28 thereof bent at right angles to the main body of said longer portion. This turned edge extends, from the free end of the spring member, for substantially the entire length of said longer portion of the spring except for a short portion thereof adjacent the bend in said spring. This short portion provides the resilience necessary for movement of the spring 24.

Attached to the spring 24, as by riveting, at a point spaced from the end of said spring member, is a contact 30. Preferably, this contact is composed of silver. At the free end of the spring member 24, and along the shorter edge thereof, a notch 29 (see Fig. 6) is provided for purposes of calibration as will be explained further along. The spring 24 is provided with a rectangular notch 41 cut out of the edge opposite the edge 28. This rectangular notch is so disposed as to be in register with the semi-circular extension 18. This relationship between the notch 41 and the extended portion 18 is arranged to provide a particular operating sequence that will be explained below.

Circuit opening means, in the event of an overload condition, is provided by a bimetallic member 31 supported on the portion 32 of the bracket 21. The bimetallic member 31 extends from the portion 32 in a direction parallel to the spring member and is slightly longer than the spring member 24. The length is determined by design considerations. As supported, the bimetallic member 31 has its main plane surface at a right angle to the main plane surface of the spring member 24. The unattached end of the bimetallic member is bent at a slight angle as illustrated in Figs. 5 and 6 to form a so-called latch or detent 33. In the close circuit position (see Fig. 6) the detent sits astride the free end of the spring member 24.

The aforementioned spring member 24 is plated with a metal, the surface of which when oxidized provides a relatively low electrically conductive path to the flow of current. Aluminum is one such metal and chromium is another. Preferably, the metal chromium is used in the present embodiment of this invention. The oxidation usually takes place after the chromium plating has been applied to the spring member 24. As long as the voltage drop at the point of contact is of a low order, for example, of the order of forty millivolts, the insulating effect of the oxide coating will remain substantially constant.

The use of chromium plating also provides a hard surface which substantially eliminates wear in the portion of the spring 24 which is in contact with bimetallic member 31 at that end thereof which forms the detent 33.

Another feature which results from the use of chromium plating on the spring member 24 is the substantial elimination of the current shunting effect of the spring member when in the latched position above mentioned. This effect is substantially reduced because of the oxidized layer on the chromium plating. In practice the current shunting effect is reduced to substantially zero.

In the process of fabricating the spring member 24, the plating on said member is applied first and thereafter an aperture is punched in the spring member 24 to accommodate the contact 30. This procedure is necessary in order that the conductivity between said spring member 24 and the contact 30 remain unimpaired with respect to the flow of current therebetween. It can be readily appreciated that if the chromium plating were applied to the spring member after the aperture was provided, that said plating would adhere within the aperture and result in insulating the spring from the contact 30.

Also a feature of the use of chromium plating when combined with the notched arrangement 29 is to provide, by these means, a simple calibrating procedure with respect to the tripping current of the device of the present invention. In the practice of this particular art prior to the conception of the present improvement thereto, calibration of the tripping time of such a device was performed, by passing through same, a current whose magnitude was the desired maximum for causing the device to trip or break the circuit for which it was intended to be used. This procedure was necessarily slow and relatively expensive. The present device is so designed as to provide a novel method for performing the necessary calibration by means entirely mechanical and extremely simple.

The notch 29 is disposed a predetermined distance from the edge of the spring adjacent the detent 33, as illustrated in Figs. 5 and 6. This distance is a function of the movement of the bimetallic strip 31 when it is subjected to self-heat and the conducted heat of a member 39 at a predetermined temperature induced by circuit overload conditions. That is to say, the length of lateral movement (induced by the last-mentioned condition) of the bimetallic member 31 across the spring member 24 determines the position of the notch 29. Once this is established, the calibration of the device resolves itself into merely positioning the edge of the detent so as to align same with the far side (with respect to the observer) of the notch 29. This is done by altering the position of the portion 32 by bending same in the proper direction.

A second of the supporting members 22 is riveted to the base 20 and serves to support a substantially flat U-shaped spring member 34. Preferably, this spring member is composed of beryllium copper or Phosphor bronze. Attached to the free end of said member 34 is a contact 35 composed of the same material as the contact 30 and so disposed on the spring member 34 as to be adjacent the contact 30. The supporting member 22 is provided with a threaded aperture to accommodate a screw 36 which functions as one terminal for connection in a current-carrying circuit.

A third supporting member 23 is riveted to the base 20 near the free end of the bimetallic blade 31

and is so designed as to provide an arm 37 integral therewith and extending at right angles from the plane surface of said support. Attached to the arm 37 is the heater element 38. The member 38 is composed of current resistance material, such as Nichrome, and preferably has a resistance several times that of the thermally deformable member 31. The opposite end of said heater element is attached to the free end of the bimetallic member 31 at a point 39 thereon, as shown in Fig. 4, and the body portion of the heater 38 is curved loosely between the supporting arm 37 and the member 31 and thus positioned with its body portion remote from the body portion of the bimetal blade. In the preferred embodiment, the ratio of stiffness of the heater element 38 with respect to the bimetallic member 31 is of the order of 1:120. For example, the heater element 38 may be composed of a material having a thickness of the order of 5 mils and the bimetallic strip 31 will have a thickness of the order of 25 mils.

The above arrangement permits the bimetallic strip to move freely in response to the heat conducted by the heater element 38 attached thereto. In addition, the remote position of the bimetallic member 31 and the heater element 38 with their ends connected in electric and thermal conducting relation is such that an absolute minimum of heat is transferred to the bimetallic member by convection or radiation currents, but rather substantially all of the heat generated in the heater element 38 is conducted through the point of connection 39 (as illustrated in Figs. 4 and 6) to the bimetallic member 31. As a result, due to this particular improvement, the recovery or cooling-off time of the bimetallic member is reduced to the order of fifteen seconds or less. This is so because the bimetallic member is required to dissipate, primarily, the conducted heat from the heating member 38 and appreciably little radiated or convected heat, the converse of which is usually met with in devices of this type as manufactured in accordance with the practice of the prior art.

In practicing the present invention, the heating element 38 is so constructed as to have a ratio of area to volume which will provide an appreciably rapid rate of heat dissipation. Preferably, the member 38 should have a ratio of area to volume of the order of 400:1 or greater. This ratio enables faster resetting of the contact members 30 and 35. This is so because an appreciable portion of the heat in the member 38 is dissipated to the walls of the cover 10 and only that portion of the heat necessary to actuate the bimetallic member 31 is conducted thereto.

A threaded aperture for engagement of a screw 40 is provided to enable the present device to be connected in series with one side of a current-carrying circuit (not shown).

The Figs. 1 through 3 illustrate the various operating positions of the present device, Fig. 1 depicting the tripped or open circuit position. In Fig. 2, the push button 12 is depressed so that the extension 18, being clear of the spring member 24, as provided by the opening 41, presses on the spring member 34, while the bottom portion 12A presses on the first spring member 24. When the push button 12 is depressed so as to cause the shoulder 16 thereof to rest on the top of the cover 10, the contacts 30 and 35 are still in the open circuit position. This is a feature of this type of circuit breaker and will be presently explained. The position of the contacts 30 and 35, as illustrated in Fig. 3, depict the closed circuit position after the push button 12 has been released.

It will be observed that the detent 33 is now astride the end portion of the spring 24 adjacent the notch 29. This is more clearly brought out in Figs. 5 and 6.

If now an overload occurs in the circuit in which this device be connected, the temperature of the bimetal member 31 and the heater element 38 will be appreciably increased. The added heat thus generated is conducted to the bimetallic strip 31, causing the same to move away from the observer with respect to Fig. 6, and consequently disengage the contacts 30 and 35. Should the push button 12 be depressed while the overload condition persists, no harm can be done, since the contacts will remain in open circuit position because of the pressure by extension 18 on the spring member 34. The contacts 30 and 35 can only be reset to the closed circuit position upon the expiration of the recovery time of the bimetallic member 31. However, if the overload condition persists, the contacts 30 and 35 will not remain in the reset or closed circuit position.

Depressing the push button 13 causes the edge 13A thereof to force the detent 33 away from the spring member 24. As shown in Fig. 5, this movement would be to the right with respect to the observer and serves to break the circuit.

The improved arrangement of the circuit terminals 36 and 40 provides means for connecting the present device in one side of a current-carrying circuit so as to avoid any misalignment of the tripping assembly supported on the base 20 when the terminals 36 and 40 are subjected to strain induced by the conductors (not shown) attached to them. By avoiding any external connection to the member 21 which supports the bimetallic tripping member 31, any possible misalignment between the last-mentioned member and the spring member 24 is obviated.

Referring now to Fig. 7, there is illustrated a chart which graphically discloses the advantages of the device of the present invention over those of the prior art. A curve A designates the limiting characteristic of a device which is to be thermally protected, for example, a motor. The curve A is plotted to show, relatively, the range of current flowing through said device versus the time required in a given ambient for the device to reach a maximum safe temperature. Currents ranging up to the curve E are those which can be tolerated indefinitely.

A pair of curves B and C are time-current curves for two extremes of overload relay design, B being the slow relay curve and C the fast relay curve. However, in order to suitably protect the motor, the curves B and C must be in the region below the curve A. The ideal condition of course is for the curve B to have exactly the same characteristics as the curve A. Since this is impractical from a standpoint of economy of manufacture and the physical size involved in the design of a device to meet such requirements, a compromise such as designated by the curve B is utilized. It is, of course, desirable that the curve B should be as close to the curve A in characteristics as possible but should never exceed it in order that the motor be used to its full capacity.

The curve C is typical of a so-called fast relay. Such a relay overprotects the device for which it is utilized and, if carried too far, is so fast that the inrush current-time characteristic of the motor trips the relay before the motor can reach its proper operating level E. A relay having these characteristics employs a great deal of self

heat in the bimetal or operating element so that this element is the main one to cool off.

A curve B' designates the usual reset time for a circuit breaker having the curve B characteristics and the reset time thereof is usually of the order of minutes. This is so because most circuit breakers in this class use a heating element which transmits heat to an operating element by all three means, namely, conduction, convection and radiation. Of these, the radiation factor is large; as is the thermal storage factor of the heating element and the operating element. This means, of course, that an appreciably longer time is required for the operating element to cool off sufficiently before the circuit breaker or switch can be reset and the motor started under full load. A reset time curve C', although shorter than the reset time curve D, is obviously immaterial in view of the extremely fast tripping time of a circuit breaker whose characteristics are such as shown by the curve C.

In accordance with the present invention, it is possible to arrive at a trip curve B and a reset curve such as D. The slow tripping characteristic is obtained by permitting heat generated in the element 38 to flow into the bimetal member 31 substantially only by conduction from the heater element 38. Such flow occurs providing the resistance of element 38 is considerably greater than the resistance of the thermally deformable member 31, as mentioned previously, so that considerably more, and preferably several times more, watts are generated in the heater element 38 than in the bimetal member 31. With this arrangement, considerable time is required to bring the bimetal member up to its operating temperature, such time being an appreciably longer time than is possible if a greater portion of self heat in the bimetal is used.

The fast recovery characteristic of the present invention is obtained because of the novel arrangement of the bimetal member 31 and heater element 38. This arrangement provides for the flow of energy from the heater to the bimetal by conduction, while substantially little radiation occurs from the heater to the bimetal. Consequently, after the device has tripped and because the thermal time constant of the heater is low (where ratio of surface area to mass is large) it can cool rapidly by radiation to the walls of the cover 10. After the heater 38 has cooled to the temperature of the bimetal member 31, it acts as additional means of radiation for the bimetal. If, for example, the bimetal and heater faced each other, cooling would be appreciably retarded. As a result of the above arrangement, the reset time as indicated by the curve D is of the order of fifteen seconds or less.

The embodiment of the present invention which has been illustrated and described is selected for the purpose of setting forth the principles involved. It will be obvious that the invention may be modified to meet various conditions for different specific uses and it is, therefore, intended to cover by the appended claims all such modifications which fall within the true spirit and scope of the present invention.

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

1. In an electric control device, an elongated bimetallic member fixedly mounted at one end with its other end free to move, and an elongated resistance heating element having one end connected directly to the free end of said member in electric and thermal conductive relation therewith, said heating element being positioned with its body portion remote from the body portion of said member and having an electric resistance large in relation to the electric resistance of said member, whereby said member is heated slowly by thermal conduction and is cooled rapidly and substantially independently of said element.

2. In an electric control device, a bimetallic blade fixedly mounted at one end with its other end free to move, and an elongated flexible strip of electric resistance material having one end connected directly to the free end of said bimetallic blade in thermal and electric conductive relation therewith, said flexible strip being loosely positioned adjacent said free end of said blade and remote from the body portion thereof and having an electric resistance of the general order of several times the resistance of said blade.

3. In an electric control device, a bimetallic blade fixedly mounted at one end with its other end free to move, an electric heating element comprising a flat thin elongated strip of electric resistance material more flexible than said blade and having one end connected directly to the free end of said blade in electric and thermal conductive relation, said strip having a resistance of the order of several times the resistance of said blade and being fixedly mounted at its other end and loosely disposed adjacent the free end of said blade remote from the body portion thereof, and electrical connections providing for the circulation of electric current serially through said plate and said heating element.

4. In an electric control device, a support provided with a first upright bracket, a flat bimetallic blade fixed at one end to said bracket with its other end free to move, a second upright bracket fixed to said support adjacent said free end of said blade, and an electric heating element comprising an elongated flat flexible strip of high electric resistance material fixed at one end to said second bracket and having its other end connected to said free end of said blade in electric and thermal conductive relation, said strip having a resistance of the order of several times the resistance of said blade and being loosely disposed between said second bracket and said free end of said blade with the body portions of said strip and blade relatively remote thereby to minimize radiant heat transfer therebetween.

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