

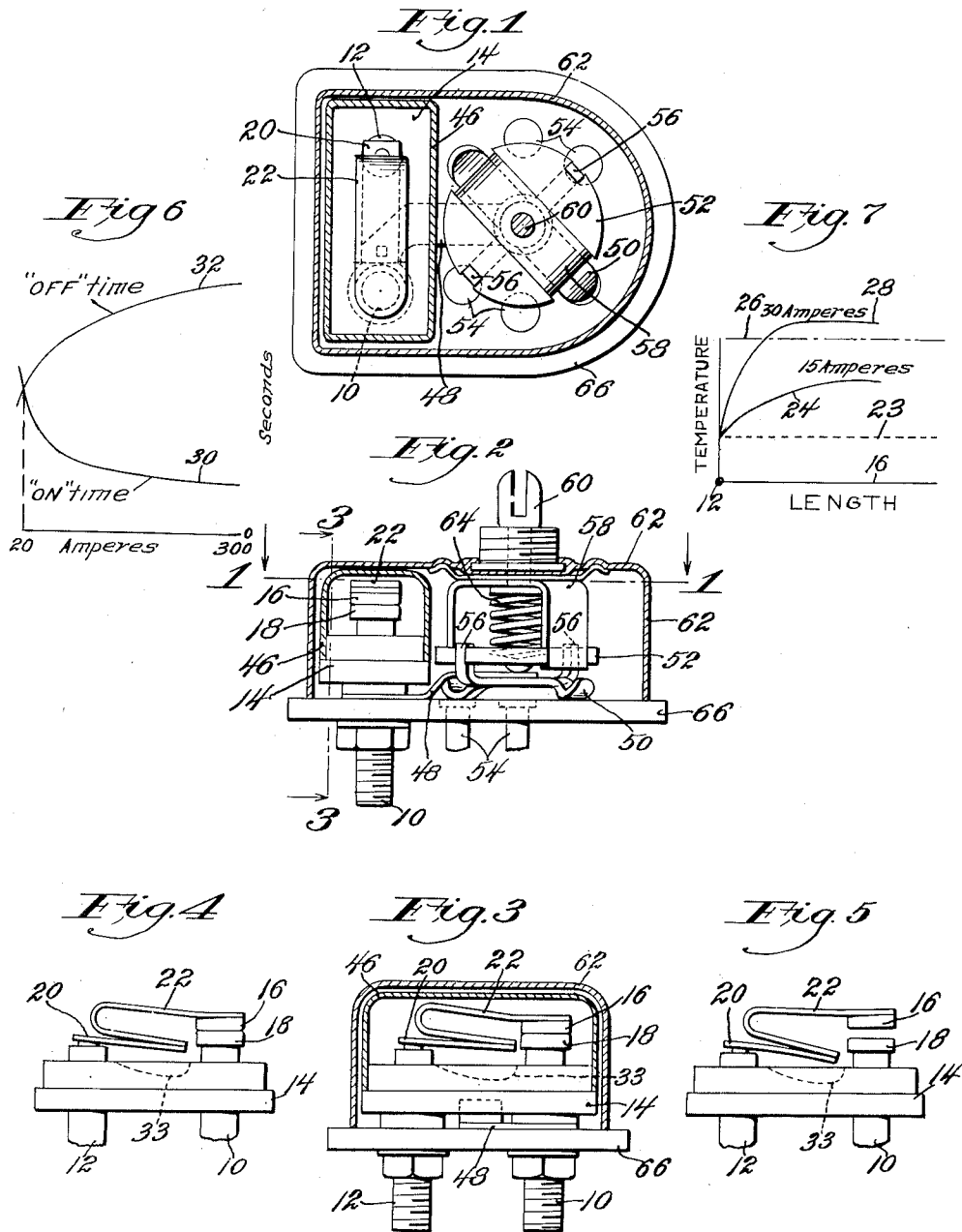
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ELECTRICAL CIRCUIT BREAKER

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ELECTRICAL CIRCUIT BREAKER

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The present invention relates to improvements in electrical overload circuit breakers of the type employing a bimetallic strip heated by current flow as the sole operating member.

A simple bimetallic strip of the usual construction flexes upon heating and requires a rapid change in temperature to insure quick positive movement. To insure positive movement with small changes of temperature and to avoid irregular action, it is common to connect a bimetallic strip with a snap mechanism, but such mechanism introduces difficulty in calibration, irregularity of friction and uncertain lost motion. For a circuit controller of low current carrying capacity an operating member of bimetal without snap mechanism has been found practical where it is desired to operate the strip upon changes of ambient temperature only. To reduce arcing at the contacts of such controller the strip is arranged in some instances with a short auxiliary portion acting in a direction opposed to the main operating portion of the strip, the opposed portion being heated by current flowing through the contacts. The opposed portion of the strip when heated tends to hold the contacts closed until the force of the main operating portion overcomes that of the opposed portion and the contacts start to separate. The flow of current is then reduced and the opposed strip portion is allowed to cool. Cooling the opposed portion opens the contacts still further and reduces arcing or chattering.

An arrangement of a bimetallic strip type circuit controller with an oppositely acting strip portion, being ordinarily subject to almost imperceptible heating from current flow alone, does not present serious problems in heat dissipation. In fact, it is desirable to concentrate the heating from current flow on the opposed portion of such strip. To do this the movable contact is mounted directly on the opposed portion of the strip to enable the heat from the contact to be conducted to the opposed portion. The opposed strip portion is in turn supported by the main operating portion of the strip and the main portion is anchored to a terminal post.

The requirements of a reliable overload circuit breaker are more difficult to meet than those of a low current controller, a circuit breaker being subject to intense heating well above ambient temperatures. If an attempt is made to employ a circuit controller having a bimetal operator of prior construction and arrangement, uniform circuit openings with varying intensities of overloads do not occur. If a bimetallic strip is

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arranged with an oppositely acting portion in the usual manner, the opposed portion will be subjected to injurious or disruptive temperatures before circuit opening can take place on overloads of great magnitude. For instance, in an overload breaker intended to protect a six to twelve volt circuit, opening must occur reliably within a range of from 15 to 600 amperes current flow without injury to the breaker. The intensity of heating produced in the bimetallic strip of such breaker reaches the annealing or melting point of the strip and contacts within a small fraction of a second, particularly if the heat is concentrated locally so that there is an irregular temperature gradient along the length of the strip, rising sharply at the contact carrying end of the strip.

The objects of the present invention are to provide an overload circuit breaker operated solely from a bimetallic strip heated normally above ambient temperatures by current flowing in the circuit to be protected, which breaker is of extremely simple and inexpensive construction and yet capable of withstanding the heating effects of repeated short circuits under all operating conditions without failure or loss of sensitivity to overloads of small magnitude. A further object of the invention is to provide such circuit breaker of compact and efficient form, requiring no more space than a fusible link type of circuit protector without sacrificing reliability of operation. To these ends the overload circuit breaker of the present invention has fixed and movable contacts operated solely by direct action of a single bimetallic strip without benefit of snap mechanism; a short higher resistance portion of the strip being arranged in opposed relation to the main operating portion of the strip in such manner that a sharply rising temperature gradient along the strip is avoided, while the portions of the strip are heated differently and both substantially above the ambient temperature by normal currents in the circuit with the contacts. In this way the full length of the main operating portion of the strip is quickly rendered responsive at all times for circuit opening action and the circuit is always opened before disruptive heating occurs. Also, local concentration of heat in the strip is prevented. An important advantage of the invention which contributes to its effectiveness is obtained in the proportioning of the bimetallic strip along its length to produce a temperature gradient which approaches a uniform value or which may even droop to a slightly lower

temperature towards the contact carrying end of the strip.

This feature of the invention is embodied in a bimetallic strip circuit breaker having a main strip portion of lower electrical resistance per unit of length but of predominating deflection and an oppositely acting auxiliary portion of higher resistance per unit of length but of shorter deflection connected thereto, the main portion being bent into a U shape with one arm carrying the movable contact at its inner side. Preferably, the opposed portion of the strip is relatively straight and supports one arm of the main operating portion in close parallel relation and is in turn mounted upon a terminal post which produces rapid cooling action by conduction of heat from the reverse portion.

These and other features of the invention include a novel and improved controller containing the circuit breaker embodying the principle feature of the invention, as well as certain novel constructions, combinations and arrangements of parts hereinafter described and claimed, the advantages of which will be apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a view in sectional plan view of a controller embodying the features of the present invention as seen along the line 1—1 of Fig. 2.

Fig. 2 is a side sectional view of the controller illustrated in Fig. 1;

Fig. 3 is a sectional view taken along the line 3—3 of Figure 2;

Fig. 4 is a side detail view of the breaker illustrated in Fig. 3 with cover removed showing the position of the parts in an intermediate position of increased pressure on the contacts during normal current flow;

Fig. 5 is a similar view of the breaker taken at the moment of opening a circuit;

Fig. 6 is a diagrammatic view illustrating the manner in which the opening action of the breaker accelerates with greater magnitudes of overload current flow; and

Fig. 7 is a diagrammatic view illustrating the temperature gradients along the strip under different conditions.

The circuit breaker illustrated in the drawings is constructed with a single unitary non-snap bimetallic operator to provide overload protection for low voltage circuits such as are employed in automotive or similar usage. Upon the occurrence of an overload, the circuit is held closed for an instant of time, the length of which is shorter the greater the overload, and then the circuit is opened quickly. The breaker has the usual terminal posts 10 and 12 fast in an insulating base 14. The bimetallic operator is in the form of an integral strip formed with layers of metal having different coefficients of expansion at its opposite sides and mounted at one end on the post 12. At the other end the strip is provided with a movable contact 16. The movable contact is secured by welding to the high expansion side of the strip so that the current passing through the contacts affects the entire length of the strip. Cooperating with the movable contact is a contact 18 fixed by welding to the terminal post 10. The strip is made with such a cross-sectional area and with such initial shape and tension that it will be heated throughout its length by normal current flow within its intended rating substantially above the ambient temperature before the contacts are opened.

In the construction of a bimetallic strip oper-

ated circuit controller intended for response to ambient temperature changes having in its bimetallic strip a main operating and an opposed portion for avoiding sluggishness and excessive arcing at the contacts, the opposed portion is secured in heat and electrical conducting relation to the main operating portion with sides of similar coefficient of expansion together and is formed with a reduced cross-section to provide a relatively high resistance, the main operating portion acting to close the contacts against the contact opening action of the auxiliary portion. The current in the circuit controlled by such device is small and in order to obtain as much benefit as possible from the opposed portion of the strip the movable contact is mounted upon it. In this way the opposed portion of the strip is heated more when any arcing occurs at the contacts and is flexed thereby to press the contacts together until positive opening occurs. Upon cessation of current flow a maximum flexure of the strip toward circuit opening position takes place.

If an attempt is made to employ a circuit breaker construction similar to that used for ambient temperature control reliable protection cannot be ensured. With a high resistance highly heated portion at the free contact carrying end of the bimetallic strip there will be a local concentration of heat at the contact carrying end, causing a steep temperature rise at the movable contact. With a dead short circuit the temperature at the movable contact will quickly reach a destructive or injurious value. Furthermore, a circuit protected by a breaker constructed according to prior practices is not maintained open indefinitely but only long enough to cool the main portion of the bimetallic operating strip. Thereafter the circuit is reclosed. A circuit breaker in which the bimetallic operator is subject to a local concentration of high temperature will not remain in open position long enough to cool the high temperature portion but will reclose as soon as the main operating portion is cooled. Continued opening and closing will therefore quickly build up the temperature of the locally heated portion above a destructive value. Thus, the operation of a circuit breaker having a bimetallic operator according to prior ambient temperature controller designs is ineffective for the present purposes.

To ensure uniformly reliable protection in a self-reclosing overload circuit breaker having an auxiliary circuit closing strip portion secured in direct electrical and heat conducting relation to the main portion, and to avoid destructive heating in its bimetallic strip and contacts, according to the present invention, the strip is arranged to be heated substantially above the ambient temperature throughout the main operating portion of its length by normal current flow and the main and auxiliary portions are reversed from their usual positions. The auxiliary portion of the illustrated strip is indicated at 20 and acts to increase the pressure on and maintain the contacts closed briefly upon heating above the ambient temperature. The auxiliary portion is secured in heat and electrical conducting relation to the terminal post 12 and is narrower than the main portion (see Fig. 1) and is of relatively high resistance per unit of its length as compared with the main operating portion of the strip and accordingly the auxiliary portion has a tendency to heat more rapidly than the main operating portion of the strip, indicated at 22. For this reason also the reverse portion is heated well above the ambient temperature. However,

the auxiliary strip portion is shorter than the main operating portion 22 and consequently conducts the heat more rapidly to adjacent parts. It does not cool the main operating portion 22 but rather conducts heat to it so that the full length of the main portion 22 is effective for circuit opening action when heated above the opening temperature. Thus, both portions along the entire length of the strip being of different cross-sectional area are kept heated substantially above ambient temperatures so that there is an active flow of heat away from the strip at all times with normal currents within the rating of the breaker. In this way the strip is kept in a quickly responsive condition the instant the temperature of the main operating portion 22 rises above the predetermined operating point.

To further ensure against local heating of the strip the auxiliary portion 20, being mounted upon the terminal post 12 is cooled directly by rapid conduction while the main operating portion 22 is cooled only by heat dissipation to the air or through the contacts when the breaker is closed. The conduction of heat from the strip through the contacts is relatively small in comparison to that through the terminal post by reason of its direct heat conducting mounting on the terminal post. While the breaker is in open circuit position the temperature of the main operating portion of the strip therefore, quickly reaches a uniform value and even when the circuit is closed the temperature of the contact carrying end of the portion 22 is reduced only slightly by conduction through the contacts.

Referring to Fig. 7, the temperature gradient along the length of the bimetallic strip with normal currents for the circuit breaker is illustrated by the curve 24, running from the ordinate at the terminal post 12 to its upper end at the contact 16. The broken line 23 represents the ambient temperature of the air and the dot dash line 26 the temperature of the bimetallic strip at which circuit opening occurs. From this curve it is apparent that the main operating portion 22 of the strip is heated with a temperature gradient which approaches a constant value. As the temperature of the strip increases above the ambient value with increased current flow, the temperature gradient approaches a parallel relation to the opening temperature line 26. As soon as the line 26 is crossed, as in curve 28, practically the full length of the main operating portion 22 of the strip is acting to open the contacts. In this way all tendency to sluggish action from improper heat distribution in the strip is avoided. Even when the contacts close again the heat is conducted from the outer end of the strip at a relatively slow rate so that there is only a slight droop to a lower temperature at the end of the gradient.

By keeping the high resistance auxiliary portion 20 of the bimetallic strip cooler through conduction, than the lower resistance main operating portion of the strip, the full benefit of the arc reducing action of the auxiliary portion is obtained and local heating of the strip above the temperature of the main operating portion of the strip is definitely prevented. Since the main operating portion of the strip is heated with a temperature gradient approaching a parallel relation to the opening temperature line throughout the entire length of the main operating portion, the maximum temperature at any point on the main operating portion can never exceed greatly the opening temperature for the strip without

separating the contacts and allowing the strip to cool. This condition is distinguishable from that in previous circuit controllers of this type in which a high resistance portion is not kept cooler than the lower resistance portion and in which points of extremely high temperature are allowed to build up to a destructive value.

With reliable operation ensured by the manner of construction above described, the calibration and performance of the improved circuit breaker can be determined more exactly and with certainty. Referring to Fig. 6, it will be apparent that for a breaker designed for opening on currents above 20 amperes at 6 volts, the time during which the circuit remains closed after an overload current begins to flow is represented for all overload currents up to 300 by the curve 30 marked, "on time." After having opened the circuit for a given overload it will remain open at the time indicated by a point on the curve 32, marked "off time," directly above that selected on the "on time" curve. As indicated by these curves, the time measured vertically at which an overload current is permitted to flow varies from less than a second to more than three seconds. The times at which the circuit remains open varies from three seconds to more than twenty, the ordinates being measured logarithmically. The "off time" periods increase in length at a rapidly progressing rate with higher overload magnitudes so that adequate cooling of the heated parts is ensured during the "off times." It is for this reason that the breaker of the present invention is able to continue in operation successfully where prior breakers of the bimetallic type have failed.

It will be noted in connection with the "on time" curve 30 that there is much less drop in this characteristic than there is in rise in the "off time" curve 32, bearing in mind that both curves are plotted on a logarithmic scale which has large units at its lower end and units of progressively decreasing height at its upper end, so that for the same vertical distance the curve 30 indicates a smaller time interval than the curve 32. By proportioning the bimetallic strip 20, 22 in this way the "on time" interval with overloads caused by a few frayed and grounded strands broken from a multiple wire cable, such as is common to automotive use, will be allowed to continue long enough to burn the frayed strands free from their ground without damage to the remaining strands of the cable. The present circuit breaker enables reliable "burn free" action of this type because of its uniformity in opening a short circuit before destructive temperatures are reached within the breaker itself. This advantage is not obtainable with the use of prior circuit protecting devices of the fusible link or snap mechanism type since the "burn free" action is a new function not found possible or intended with prior protecting devices.

The particular embodiment of the present invention illustrated in Figs. 1 to 5 is a circuit breaker of extremely compact construction for use where it is desirable to maintain a minimum spacing between the terminal posts 10 and 12. The auxiliary portion 20 of the bimetallic strip is welded directly to the high resistance main portion 22 with sides of dissimilar coefficient of expansion together at the welding point and comprises a relatively straight strip piece. The main operating portion 22 of the strip is bent into a U shape with one arm of the U longer than the

other. The longer arm of the U carries the movable contact 16 at its inner side so that when the end of the shorter arm is integrally connected to the auxiliary portion 20 of the strip it will be close and approximately parallel to it. Care must be taken in securing the two portions of the strip together not to permit them to touch except at the point of securement. Otherwise a substantial length of the operating portion will be electrically short-circuited. Although the two strip portions preferably are secured together by welding, riveting also produces effective results.

With a straight auxiliary strip portion 20 and a U-shaped main operating portion 22 connected together in electrical and heat conducting relation in the manner indicated, the movement of the two portions under normal and overload currents is illustrated in Figs. 4 and 5. When the strip is cold and at ambient temperature, a position is assumed similar to that of Fig. 3. When a normal current flows through the breaker below an overload value, the auxiliary strip portion 20 bends downwardly, pressing the contacts more firmly together as in Fig. 4. Upon heating by an overload current flow, the movements of the main operating portion of the strip predominate, having been heated above an opening temperature. Eventually, a slight separation of the contacts occurs, producing a sudden concentration of heat in the contact end of the main strip portion 22. A quick movement of contact separation is then produced, interruption of current flow causing a continued separating movement of the contacts toward fully open position as the auxiliary portion cools (Fig. 5).

It may be desirable to provide a well 33 in the base 14 to prevent engagement of the strip with the base. The arrangement of the U-shaped main and straight auxiliary portions of the strip reduces to a minimum the tendency of the movable contact to slide on the fixed contact. In this way a firm contact engagement is ensured at all times with the movement of the movable contact restricted when opening the circuit to that perpendicular to the engaging surface of the fixed contact.

In applying a self reclosing circuit breaker of the type described above to a unitary automotive lighting circuit controller as an example, the breaker is covered with a drawn housing 46 locked to the rabbeted edge of the base 14. To connect the breaker with a two-way manually operated lighting switch, a thin flat flexible conductor 48 is fastened to the terminal post 10. The conductor 48 extends at right angles to the length of the breaker base and is yieldingly clamped between a movable contact 50 in the switch and an insulating contact actuating member 52 pressed against the flat conductor which in turn presses the movable contact 50 against a fixed contact 54. The flat conductor 48 thus is interposed between two parts pressed yieldingly together and may be inserted or removed in assembling or disassembling the controller without special manipulations.

For ensuring proper operation of the controller, the movable contact 50 is formed in the shape of a cross with two bent up ears 56 engaging diametrically opposed recesses in the insulating disk 52. To operate the controller, the disk is notched outside its points of engagement with the movable contact to receive the extremities of a manually operated yoke 58 having fixed to its central portion an operating spindle 60 rotatable in an outer housing 62. At its end outside the housing, the

spindle is slotted for connecting a knob or similar manual operator. Between the yoke and the disk 52 is compressed a coil spring 64 for applying the yielding force to clamp the conductor 48 and press the movable contact against the fixed contacts. To provide a firm connection the movable contact is dented upwardly or the disk dented downwardly at their centers of rotary movement so that the points of engagement between the movable contact and the conductor 48 will not change while operating the switch.

By arranging the parts in this way the controller is readily assembled and dissembled merely by bringing the parts into proper operating relationship. The entire controller comprising the manual switch and the overload circuit breaker thus forms a complete assemblage. For maintaining the parts together in this way they are mounted upon a single insulating base 66 perforated and otherwise shaped to accommodate them.

Under extreme conditions not intended to be coped with by the illustrated circuit breaker, the construction hereinbefore described has the inherent advantage that the high resistance portion of the bimetallic strip will melt and act as a fuse before the low resistance portion is disrupted. The fuse action of the high resistance portion is desirable whether the contacts become welded together before fusing occurs or not. If the contacts are welded together when the high resistance portion 20 is fused the lower resistance portion 22 will tend to move away from the terminal post 12 as long as any current continues to flow, thus aiding in breaking the circuit. If the contacts are not welded together the portion 22 will drop off if the portion 20 is fused so that the circuit will be broken positively under any extreme overload.

The nature and scope of the invention having thus been indicated and an embodiment having been specifically described, what is claimed is:

1. An overload circuit breaker having fixed and movable contacts, and a pair of heat conducting terminal posts, one of which supports the fixed contact, in combination with an integral bimetallic strip having one end mounted on the other terminal post to open the contacts upon heating above a predetermined temperature by current flowing through the contacts, and an auxiliary movable contact actuating portion of the strip being disposed in oppositely acting relation to the remainder of the strip to cause an increase in the pressure on the contacts below the opening temperature, the remainder of the strip comprising a main contact opening portion bent into U shape with one arm carrying the movable contact and of lower electrical resistance per unit of length than the auxiliary portion of the strip.

2. An overload circuit breaker having fixed and movable contacts, and a pair of heat conducting terminal posts, one of which supports the fixed contact, in combination with an integral bimetallic strip, having one end mounted on the other terminal post to actuate the movable contact away from the fixed contact upon heating above a predetermined temperature by current flowing through the contacts and main and auxiliary portions, the auxiliary portion of the strip being disposed in oppositely acting relation to the main operating portion to cause an increase in pressure on the contacts when heated below the opening temperature, the main operating portion of the strip being bent into U shape with one arm carrying the movable contact and the auxiliary

portion of the strip being relatively straight and supporting the main operating portion with one arm of the U in close parallel relation.

3. An overload circuit breaker having fixed and movable contacts, and a pair of heat conducting terminal posts, one of which supports the fixed contact, in combination with an integral bimetallic strip having main operating and auxiliary portions of different electrical resistance per unit of length secured at its higher resistance end on the other terminal post to open the contacts upon heating above a predetermined temperature by current flowing in the contacts, the high resistance portion being disposed in oppositely acting relation to the low resistance portion to cause an increase in pressure on the contacts when heated below the opening temperature, the low resistance portion of the strip being bent into a U shape with one arm longer than the other carrying the movable contact and the auxiliary high resistance oppositely acting portion of the strip being relatively straight with one end of the auxiliary portion supporting the shorter arm of the lower resistance main portion in close parallel relation.

4. An overload circuit breaker having a movable contact, terminal posts and a contact fixed to one of the terminal posts, in combination with an integral bimetallic strip formed with a main contact opening portion and an auxiliary contact closing portion secured in heat and electrical conducting relation to the main portion and directly in heat and electrical conducting relation to the other of said terminal posts, the auxiliary portion having a substantially higher resistance per unit of length than the main portion.

5. An overload circuit breaker having a movable contact, terminal posts and a contact fixed to one of the terminal posts, in combination with an integral bimetallic strip formed with a main contact opening portion and an auxiliary contact closing portion secured in heat and electrical conducting relation to the main portion and directly in heat and electrical conducting relation to the other of said terminal posts, the auxiliary portion having a substantially higher resistance per unit of length than the main portion but being of shorter length than the main portion.

6. An overload circuit breaker having a mov-

able contact, terminal posts and a contact fixed to one of the terminal posts, in combination with an integral bimetallic strip formed with a main contact opening portion and an auxiliary contact closing portion secured in heat and electrical conducting relation to the main portion and directly in heat and electrical conducting relation to the other of said terminal posts, the auxiliary portion having a substantially higher resistance per unit of length than the main portion, the main contact opening portion of the strip being bent into a U-shape and having the movable contact secured to one arm of the U at the inner side thereof.

7. An overload circuit breaker having a movable contact, terminal posts and a contact fixed to one of the terminal posts, in combination with an integral bimetallic strip formed with a main contact opening portion and an auxiliary contact closing portion secured in heat and electrical conducting relation to the main portion and directly in heat and electrical conducting relation to the other of said terminal posts, the auxiliary portion having a substantially higher resistance per unit of length than the main portion, the main contact opening portion of the strip being bent into a U-shape with arms of unequal length and with the movable contact secured to the longer arm.

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