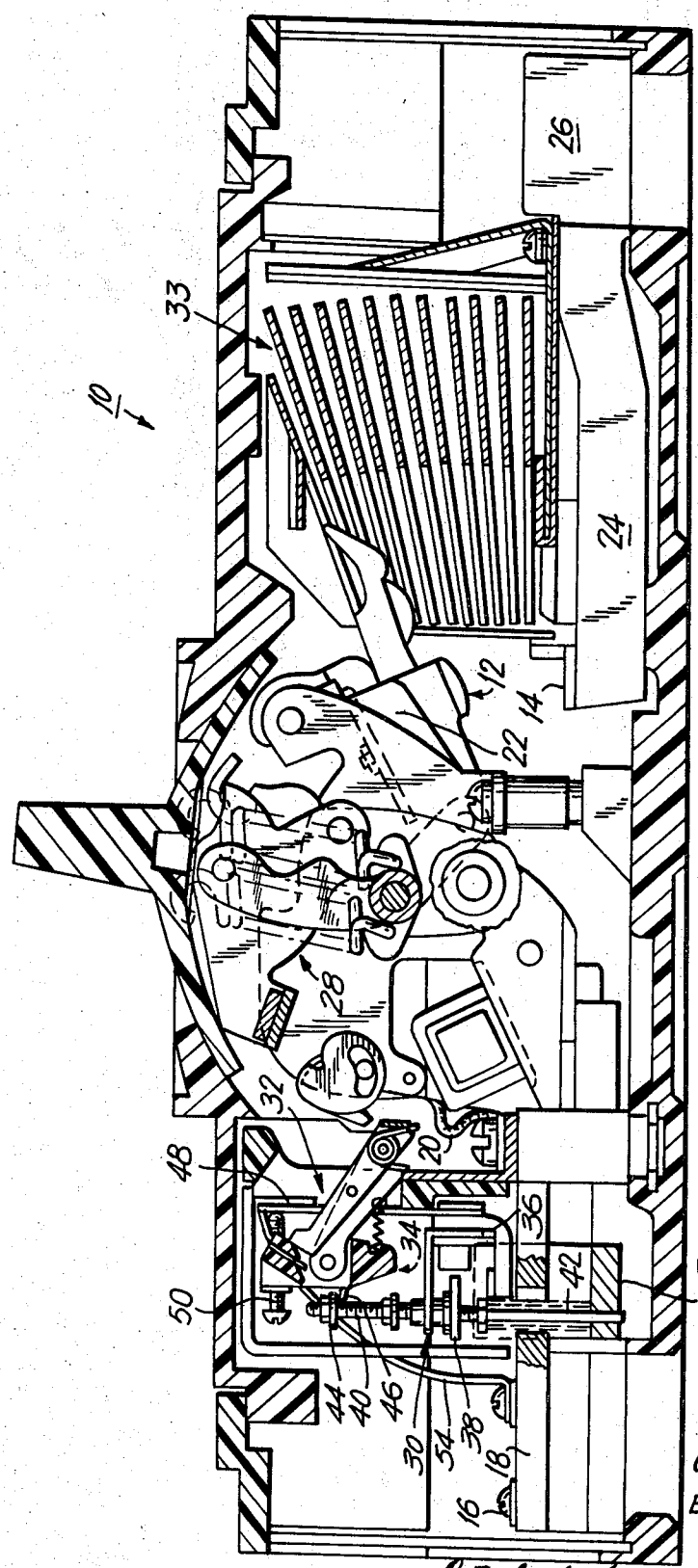
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COMBINED DIRECT AND INDIRECT THERMALLY CALIBRATED BIMETAL

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FIG. 1




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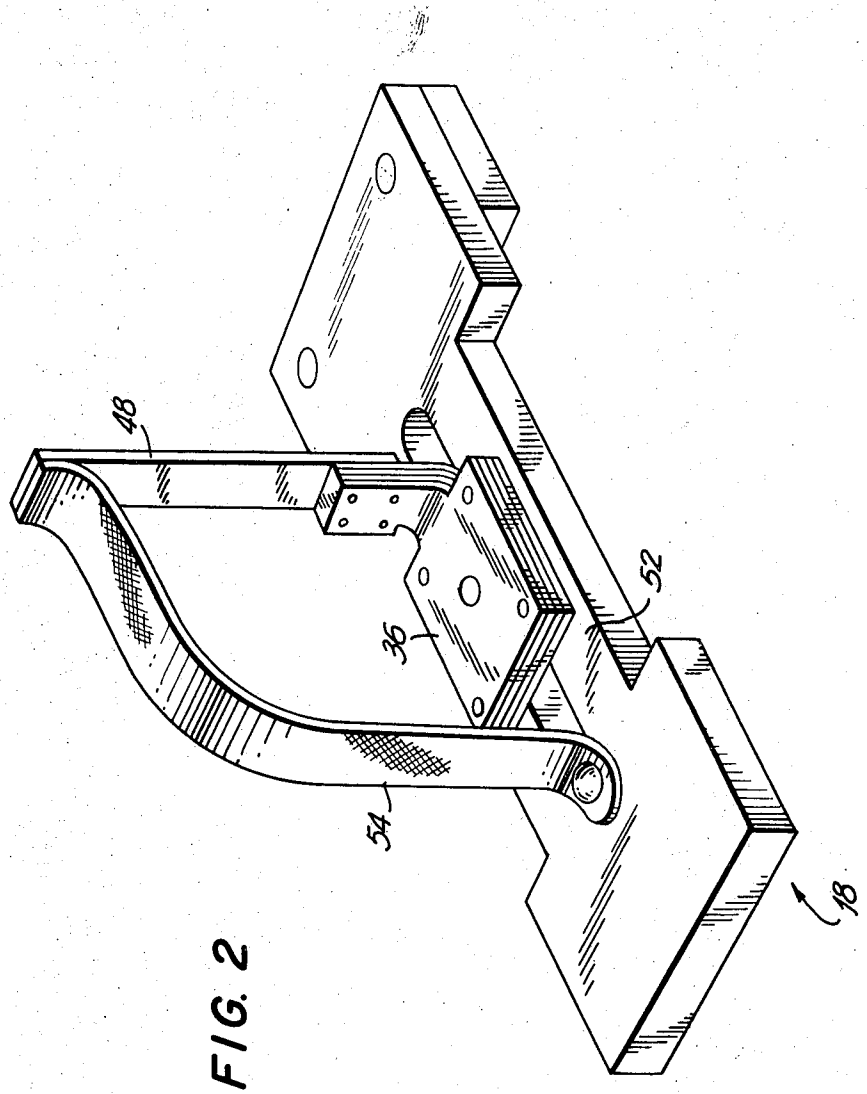



FIG. 2

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3,566,327

# COMBINED DIRECT AND INDIRECT THERMALLY CALIBRATED BIMETAL

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Int. Cl. H01h 61/013, 71/16, 73/50
U.S. Cl. 337—77 10 Claims

## ABSTRACT OF THE DISCLOSURE

An automatic circuit breaker in which the bimetal element of the thermally responsive tripping assembly is provided with both indirect and direct heating, responsive to the flow of current through the breaker. The bimetal is positioned adjacent a restricted cross-sectional area of a conductive member forming part of the circuit being protected so as to be indirectly heated by the flow of current through such conductive member, while at the same time a parallel electrical path is established across the conductive member which includes the bimetal itself in series. In this manner the bimetal is also heated directly by the flow of current through the parallel path.

This invention relates to the thermally responsive tripping assembly of an automatic circuit breaker, and more particularly relates to a structure by which the bimetal of such thermally responsive tripping assembly may be both indirectly and directly heated by the flow of current through the breaker.

Automatic circuit breakers conventionally include a pair of contacts automatically disengageable to interrupt the flow of current therethrough in response to predetermined conditions. Thus most automatic circuit breakers include an instantaneous tripping assembly, responsive to a severe overload condition. The terminology "instantaneous tripping" is utilized to connote an operation wherein the tripping assembly will be inoperative as the current flowing therethrough gradually rises above normal, but once the severe overload current is reached, such as during a short circuit, the breaker will be instantaneously tripped. An electromagnet, calibrated to attract its armature upon the occurrence of such predetermined fault current, is conventionally used to perform this function.

To provide tripping capabilities responsive to moderate overload currents (those overload currents not of sufficient magnitude to energize the instantaneous tripping mechanism), circuit breakers also include thermally responsive tripping mechanisms normally comprising a bimetal which deflects to trip the breaker upon the occurrence of predetermined overload currents persisting for predetermined lengths of time.

Conventionally, such bimetal is made responsive to current flow in the breaker by positioning the bimetal adjacent what is commonly designated the heater portion of the breaker. That is, a conductive member in series with the circuit being protected usually includes a restricted cross-sectional area portion which, therefore, generates substantially more heat than other portions of the conductive member as current flows therethrough. Thus a bimetal positioned adjacent to or mechanically connected to such restricted area portion of the conductive member will be indirectly heated, and will thereby deflect, in accordance with the magnitude of current flowing through the breaker. This indirect type of heating of the bimetal is to be distinguished from what is generally designated direct heating of the bimetal which is accomplished by actually including the bimetal in series with the circuit being protected.



Direct heating of the bimetal of a thermally responsive tripping mechanism is normally used in very small, low-rated circuit breakers of the household type wherein the magnitude of current flowing through the bimetal, even in a short circuit fault condition, will not damage such bimetal. However, in larger circuit breakers, rated for substantially higher currents, the direct method of heating the bimetal (that is, placing it in series with the line) cannot be used since the bimetal would be burned out or otherwise destroyed by the high magnitudes of current that such bimetal would be forced to carry when performing its protective function.

Thus it is conventional in higher rated circuit breakers to use only the indirect method of heating the bimetal. However, as will be explained below, the indirect method of heating the bimetal has serious drawbacks which the instant invention effectively overcomes.

Specifically, it will be appreciated that with low and moderate overload currents flowing through the breaker, the indirect method of heating the bimetal is more than satisfactory since the slower, indirect heating process is consistant with and fully complementary to the well-known time-delayed characteristics of a bimetal element. However, as the overload current increases in value to magnitudes which are substantially close to, but not yet equal to the predetermined instantaneous fault level, the slower, indirect method of heating the bimetal is totally inconsistent with the desired operation of instantaneously and immediately tripping the breaker when such magnitudes of overload current are flowing. In other words, since the instantaneous fault level has not been reached, the electromagnet of the instantaneous tripping mechanism will not be operative to trip the breaker such that tripping in the upper ranges of overload currents must be accomplished by deflection of the bimetal. With only indirect heating, the bimetal cannot possible deflect as fast as would be desired when such high magnitudes of current are flowing through the breaker.

Furthermore, the problem is not only one of desired speed of operation per se, but is more a question of the breaker being able to open quick enough to protect the circuit in which it is being used from the high ranges of overload currents which are just below what has been classified as an instantaneous fault, such as a short circuit, which would actuate the electromagnet of the instantaneous tripping mechanism.

As suggested above, one possibility of solving the problem described would be to place the bimetal in series with the line being protected such that it could respond slowly to low or moderate overloads while at the same time respond quickly to overloads approaching the instantaneous fault level. However, and as pointed out above, with higher rated breakers, the bimetal cannot withstand the magnitudes of current involved, and thus such a solution is impossible.

Accordingly, and in contradistinction to the prior art, the instant invention provides a system which is capable of indirectly heating the bimetal of a thermally responsive tripping mechanism at low or moderate overload currents, while at the same time provides a method for directly heating the bimetal, but without burning it or otherwise destroying it, at the higher band of overload currents which approach but do not quite reach the fault current level which has been preset for the instantaneous tripping. Thus, in the lower and moderate overload range or band, the indirect heating operationally complements the time delayed characteristics of the bimetal while in the higher band or range of overload currents, the direct heating of the bimetal, and consequent quick deflection,

more nearly simulates the instantaneous operation achieved with an instantaneous tripping assembly.

Specifically, in a preferred embodiment of the instant invention, the bimetal of the thermally responsive tripping mechanism is positioned so as to be heat-responsive, that is, indirectly heated by a conductive member which is in series with the circuit breaker contacts and thereby the line being protected. Thus the bimetal will be heated and deflect in accordance with the magnitude of current flowing through the breaker. However, in accordance with the instant invention, a secondary electrical path is established in parallel with the aforementioned conductive member with the bimetal being included in electrical series with such secondary parallel path.

Furthermore, as will be appreciated from basic network analysis, the degree to which the total current applied to the conductive member will divide itself between the conductive member and the secondary parallel electrical path will be dependent upon the relative resistances of these two parallel circuits. Thus, and in further accordance with the instant invention, the conductive member and the parallel electrical path including the bimetal are so designed and constructed relative to one another that a major portion of the current applied to the conductive member does in fact flow through this conductive member while only a small portion of the total current applied will flow through the parallel path including the bimetal. Thus it may be appreciated that even in the upper ranges of overload currents which approach the instantaneous fault level, only a small portion of this otherwise harmful current will flow through the bimetal. However, this small portion of current when passing through a bimetal which is calibrated to be sensitive to such magnitudes, provides the quick-acting deflection which can only be achieved by direct heating and which most nearly simulates an instantaneous mode of operation.

Accordingly, it is an object of the instant invention to provide a thermally responsive tripping mechanism for a circuit breaker which includes means for heating the bimetal thereof indirectly while at the same time provides other means for directly heating the bimetal by the flow of current therethrough such that as greater magnitudes of current flow through the thermally responsive tripping mechanism of the circuit breaker, the bimetal will be more influenced by the direct method of heating than the indirect.

Another object of the instant invention is to provide such a thermally responsive tripping mechanism for a circuit breaker which includes a bimetal operatively positioned to be indirectly heated by a conductive member which forms a part of the circuit being protected, which bimetal is also included in electrical circuit path which is in parallel with such conductive member.

Still another object of the instant invention is to provide such a thermally responsive tripping mechanism which is so designed that only a small portion of the total current flowing through the circuit breaker will pass directly through the bimetal.

Yet another object of the instant invention is to provide such a thermally responsive tripping mechanism wherein the bimetal will be calibrated to respond to such small portion of current which may be flowing therethrough.

Other objects and a fuller understanding of the instant invention may be had by referring to the following description and drawings, in which:

FIG. 1 is a side view, partially in section, of a circuit breaker which incorporates the inventive concept herein presented; and

FIG. 2 is an enlarged perspective view of that portion of the circuit breaker of FIG. 1 which illustrates the instant invention.

Turning to FIG. 1 there is illustrated one phase of a multi-phase circuit breaker in which the instant invention may find application. It is to be understood that the instant invention can be practiced in a single phase or, alternatively, can be provided in each phase of a multiphase breaker, suitably interconnected to provide simultaneous operation in each phase. Furthermore, although a specific circuit breaker will be described in FIG. 1, it is to be understood that the instant invention may find application in any circuit breaker which includes a thermally responsive tripping mechanism having a bimetal as a portion thereof, and that the following description is for the sake of illustration only.

Futhermore, it should be pointed out that the illustrative circuit breaker of FIG. 1 is described in greater detail in United States patent application Ser. No. 690,878 filed Dec. 15, 1967, and assigned to the assignee of the instant invention. The description of the breaker of the aforementioned application is incorporated herein by specific reference thereto.

For purposes of understanding the operation of the instant invention it is sufficient to note that the circuit breaker **10** includes a pair of contacts **12** and **14** which are normally engaged so as to present a series circuit from terminal **16** through conductor **18**, conductive braid **20**, movable contact arm **22**, movable contact **12**, stationary contact **14**, and conductive member **24** to terminal **26**. Terminals **16** and **26** are connected in series with the circuit to be protected by the breaker **10**.

As well known in the art, such circuit breakers generally include some type of spring-charged overcenter mechanism, generally designated **28** in FIG. 1, which, when discharged, causes the rapid disengagement of contacts **12** and **14** to interrupt the flow of current therebetween. For a detailed description of such a spring-operated overcenter mechanism, reference is made to the aforementioned United States patent application Ser. No. 690,878 filed Dec. 15, 1967. Sufficient to note that in response to predetermined conditions sensed by an instantaneous tripping mechanism, generally designated **30**, and/or a thermally responsive tripping mechanism, generally designated **32**, a tripper bar **34** is rotated to release or discharge the contact arm **22** to disengage the contacts **12** and **14**. An arc chute **33** may be provided to help extinguish any arc drawn between the contacts **12** and **14**. For a detailed description of the manner in which rotation of the tripper bar **34** initiates discharge of the operating mechanism **28**, reference is made to the aforementioned application.

As shown in FIG. 1, the instantaneous tripping assembly **30** includes a magnet **35**, usually constructed of laminated sheets of metal. The magnet **35** is so arranged relative to the conductive member **18** as to form a loop thereabout such that magnetic flux is generated in the magnet as current flows through the conductive member **18**. A cooperating armature **38** is mounted on a shaft **40**, normally biased upwardly by spring **42**.

Upon the occurrence of a predetermined fault current flowing through the conductive member **18**, sufficient flux is generated through the magnet **35** to attract the armature **38** against the bias of spring **42** thereby causing the shaft **40** to be pulled down whereby an extending portion **44** thereof engages an extension **46** of the tripper bar **34** to begin the tripping process.

As mentioned earlier, an instantaneous tripping mechanism such as the one just described is generally utilized to initiate circuit interruption upon the occurrence of severe overloads such as short circuit faults. It will be appreciated that the operation of such a tripping mechanism is rapid and in fact very nearly instantaneous because of the nature of electromagnetic response. Thus upon the occurrence of short circuits and other extremely high fault conditions, the breaker will be immediately tripped to protect the circuit.

As is conventional in the art, the thermally responsive tripping mechanism **32** of the breaker **10** includes a bimetal **48** which is positioned relative to the conductive member **18** so as to be heated by the flow of current

through the conductive member **18**. In the illustrated embodiment of FIG. 2, the bimetal **48** is secured to a portion of a thermal conductor **36** (preferably of copper laminations) which, in turn, is fastened above a restricted cross-sectional area portion **52** of the conductive member **18**. Because of the restriction, the thermal conductor **36** and thereby the bimetal **48** is indirectly heated in response to current flow through the conductive member **18**.

As well known in the art, the bimetal **48** includes at least two materials having different coefficients of expansion such that the entire bimetal **48** will deflect in response to the heat to strike an adjusting screw **50**, which, in turn will cause rotation of the tripper bar **34** to initiate circuit interruption in the manner described in the aforementioned application.

As pointed out earlier, the relatively slow indirect method of heating the bimetal **48** (as by mechanically connecting it to the conductive member **18**) is conventionally used in large circuit breakers even though it would be desirable to have faster operating characteristics for the bimetal at higher magnitudes of overload currents (i.e., those overload currents approaching the magnitude of current necessary to energize the instantaneous magnetic tripping mechanism). Thus it would be desirable to place the bimetal in series with the circuit being protected such that it would be heated directly by the actual overload current flowing through the breaker. However, and as noted previously, this is only possible for very small, low-rated breakers. Thus the prior art has been forced to accept indirect heating in the higher rated circuit breakers.

The instant invention, on the other hand, provides means whereby the indirect method of heating the bimetal is utilized with low or moderate overload currents flowing through the breaker; while at the higher overloads approaching the instantaneous fault level, the direct method of heating the bimetal can be advantageously used. Thus, as shown in FIG. 2, the instant invention proposes to establish a parallel electrical path including the conductive braid **54**, the bimetal **48**, and thermal conductor **36** to establish the bimetal **48** in a parallel path with respect to the conductive member **18**.

Furthermore, the construction parameters of the conductive member **18** and the parallel electrical path, i.e., the width, material, configuration, etc., are so chosen that the resistance of the parallel electrical path is substantially greater than the resistance of the conductive member **18** whereby a substantially greater portion of the current which is applied to the conductive member **18** will flow through such conductive member **18** than through the parallel electrical path which includes the bimetal **48**. In the preferred embodiment of the instant invention, the design parameters are so designed such that 3–6% of the total current applied to the conductive member **18** will flow through the parallel path including the bimetal **48** whereas from 94–97% will actually flow through the conductive member **18**.

In operation, when the overload currents are relatively low or moderate, such that negligible amounts of current flow directly through the bimetal **48**, the bimetal **48** will be chiefly influenced by indirect heat generated by the restricted area **52**. The rather slow deflection of the bimetal resulting from this indirect method of heating is perfectly consistent and complementary with the time-delayed characteristics desired from bimetals with low and moderate overloads.

However, as the magnitude of the overload current reaches the upper ranges of overload and approach the level where instantaneous tripping would be imminent, the increased magnitude of current flowing directly through the parallel path and hence through the bimetal **48** is influential enough to cause a more rapid deflection of the bimetal. This action permits a quicker tripping operation, one which is consistent with the speed of operation which would be desired with faults of such magnitudes. It should be noted that even with overload currents approaching short circuit magnitudes, only 3–6% of such current is actually flowing through the bimetal, and hence it will not be burned or destroyed as would be the case if the bimetal were in series with the fault current alone. Furthermore, it will be appreciated that the bimetal **48** is calibrated to respond quickly to such magnitudes of current as would be flowing through the parallel path.



Thus there has been described a thermally responsive tripping mechanism for a circuit breaker in which the bimetal thereof is heated both indirectly and directly in a manner which will complement the time-delayed characteristics desired with low and moderate overloads and at the same time complement the rapid interruption desired as overload currents approach excessive short circuit fault conditions. It is to be understood that the instant invention is applicable in virtually any circuit breaker which includes a thermally responsive tripping mechanism and that it may also be practiced in a circuit breaker which does not include an instantaneous tripping mechanism of the type described in this specification. Further, it should be apparent that one skilled in the art can practice the instant invention in different rated breakers. If the breaker were relatively low-rated, then a greater percentage of the current may be permitted to flow directly through the bimetal. On the other hand, with higher-rated breakers, less current should be allowed through the bimetal. These variables can be changed simply by changing the resistance ratios of the two circuit paths. The basic concept involved is that of placing a normally indirectly heated bimetal in a parallel electrical path with respect to the line being protected such that small magnitudes of current flow in series through the bimetal.

Although there has been described a preferred embodiment of this novel invention, many other variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appended claims.

I claim:

**1** A circuit breaker including a housing; conductive means disposed within said housing for carrying current through said circuit breaker having terminal means engageable from outside said housing for connecting said circuit breaker in a circuit to be protected; said conductive means including a pair of cooperating contacts and a conductive section connected in series with said contacts; operating means for moving said contacts into and out of engagement; trip means which upon actuation thereof, due to the occurrence of predetermined fault current conditions, controls said operating means to automatically disengage said contacts; said trip means including a bimetal which upon predetermined deflection thereof actuates said trip means; said conductive section including a heater portion; said bimetal positioned for indirect heating thereof from heat generated in said heater portion by current flowing through said conductive section; conductive path means connecting said bimetal in circuit with said conductive section and bypassing a portion of the current through said circuit breaker to flow through said bimetal for direct heating thereof by current flowing therethrough; with fault currents in a first current range flowing through said circuit breaker actuation of said trip means being affected by said bimetal principally as a result of indirect heating thereof; with fault currents in a second current range, greater than said first current range, flowing through said circuit breaker, actuation of said trip means being affected by said bimetal principally as a result of direct heating thereof; actuation of said trip means being faster under conditions in said second current range than under conditions in said first current range; said bimetal and said conductive section having relative impedances such that substantially more current flows through said conductive member than through said bemetal.

**2.** A circuit breaker as set forth in claim **1**, also in-

cluding an instantaneous means for actuating said trip means upon the occurrence of fault currents in a third current range greater than said second current range.

3. A circuit breaker as set forth in claim 1, in which the heater portion is located remote from said terminal means.

4. A circuit breaker as set forth in claim 1, in which an increase in current flow through the circuit breaker results in direct heating of the bimetal having a greater influence on deflection of the bimetal in relation to the influence of indirect heating.

5. A circuit breaker as set forth in claim 4, in which said bimetal is connected in parallel with said heater portion; said circuit breaker also including an instantaneous means for actuating said trip means upon the occurrence of fault currents in a third current range greater than said second current range.

6. A circuit breaker as set forth in claim 1 wherein said conductive section, said conductive path means, and said bimetal are constructed utilizing predetermined parameters of construction relative to one another to establish predetermined ratios of current flow through said heater portion and said bimetal relative to the total current which may be applied to said circuit breaker.

7. A circuit breaker as set forth in claim 6 wherein the predetermined ratio of current flow through said bimetal relative to the total current applied to said circuit breaker is between 2 and 7 percent.



8. A circuit breaker as set forth in claim 1, in which said bimetal is connected in parallel with said heater portion.

9. A circuit breaker as set forth in claim 8, in which a reduced cross-sectional part of said conductive section located intermediate the ends thereof constitutes said heater portion.

10. A circuit breaker as set forth in claim 9, also including an instantaneous means for actuating said trip means upon the occurrence of fault currents in a third current range greater than said second current range.

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