Oct. 30, 1962 A. J. KRALIK ETAL 3,061,697

THERMAL AND MAGNETIC TRIP DEVICE

Filed Dec. 22, 1958 2 Sheets-Sheet 1

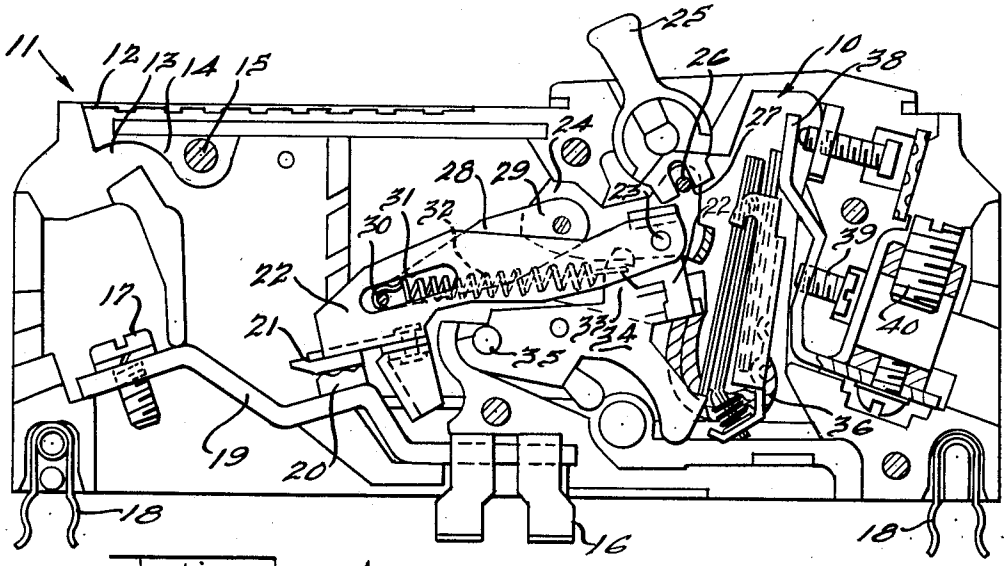


Fig. 1.

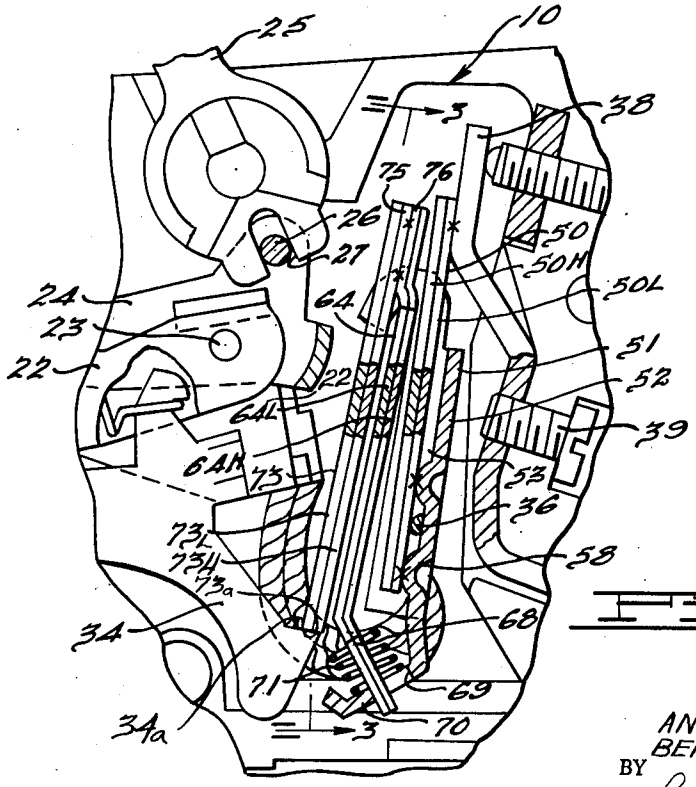


Fig. 2.

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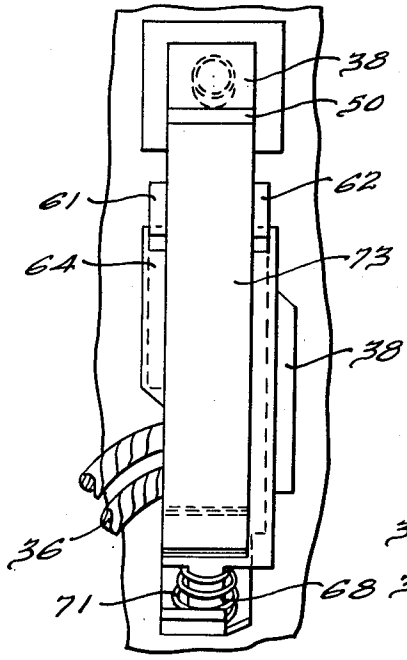


FIG. 3.

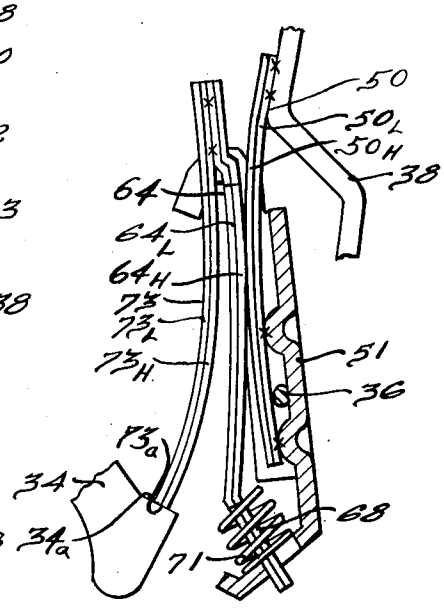


FIG. 5.

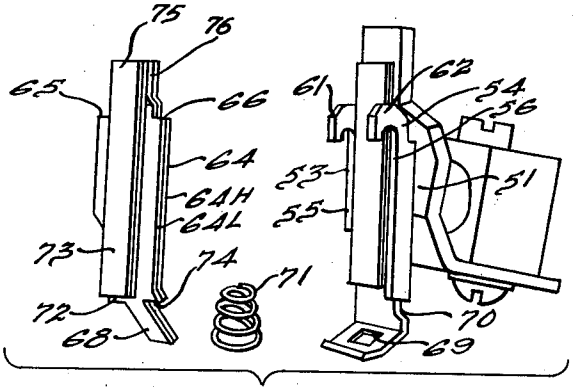


FIG. 4.

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THERMAL AND MAGNETIC TRIP DEVICE

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5 Claims. (Cl. 200—88)

This invention relates generally to electric circuit breakers and more particularly to a thermally and magnetically responsive trip device for controlling the automatic opening of an electric circuit breaker.

Automatic electric circuit breakers are often used to protect branch circuits having connected therein an electric motor or other electric translating device requiring a high initial or inrush current which greatly exceeds the normal continuous current rating of the circuit.

In many instances, such large inrush currents are permissible where they exist for relatively short periods of time and result from inherent characteristics of the device in the circuit. However, it has been found that when a circuit breaker of the types heretofore known in the art is used to protect such a circuit and is calibrated to provide proper continuous protection, the circuit breaker frequently trips, i.e., opens automatically, under normal inrush current conditions because the thermally responsive element heats too rapidly.

A trip device commonly used for causing automatic opening of such circuit breakers comprises a thermally responsive element in the form of an elongated bimetallic strip arranged to carry the current of the circuit to be protected and which, upon continuation of a moderate overload current for a predetermined time, heats sufficiently to flex and thereby to release the contact operating mechanism. It has been found that if such thermally responsive elements are designed to delay their tripping function until normal inrush currents subside, they cannot be calibrated to protect the circuit adequately against smaller overload currents after the inrush currents have subsided.

In accordance with this invention, there is provided an improved trip device the thermally responsive means of which comprises a directly heated bimetallic element and a cooperating indirectly heated bimetallic element. Such a combination has been found to provide the necessary delayed tripping response under inrush conditions and yet to be capable of accurate calibration to give consistent and proper tripping response under all other conditions as well.

Accordingly, a principal object of the present invention is to provide an improved circuit breaker trip device having both a directly heated bimetallic element and an indirectly heated bimetallic element that cooperate to provide a relatively long time delay under inrush conditions, yet are operative to effect tripping of the circuit breaker properly under overloads or short circuit conditions.

In the preferred form of this invention, the indirectly heated bimetallic element is heated by heat transferred to it from the directly heated bimetallic element.

It is therefore a further object to provide an improved circuit breaker trip device having a pair of cooperating bimetallic elements, one of which is heated directly by current flowing therethrough and the other of which is heated by transfer of heat from the directly heated element.

Trip devices for circuit breakers to be used in branch circuits often include, in addition to a thermally responsive element, a magnetic assembly that becomes operative upon the occurrence of a severe overload or fault condition in the circuit to release the operating mechanism more quickly than can a thermally responsive element.

In the preferred form of the invention, the indirectly heated bimetallic element is magnetic and serves as the armature of the magnetic assembly.

Accordingly, it is a further object of this invention to provide a combined thermally and magnetically responsive trip device comprising a directly heated and an indirectly heated bimetallic element which cooperate to effect both thermal and magnetic operation of the trip device.

A trip device for a circuit breaker must operate properly under various ambient temperature conditions. Ambient temperature compensation is most often accomplished by the use of an ambient temperature compensating bimetallic element that neutralizes the effect of ambient temperature on the response of the current responsive bimetallic element. The ambient temperature compensating bimetallic element should be effective throughout the entire calibration range of the trip device and should insure proper operation throughout a wide range of ambient temperature.

Therefore, another object of the present invention is to provide a trip device having a directly heated bimetallic element, an indirectly heated bimetallic element, and an improved ambient temperature compensating bimetallic element operative to cause the response of the other bimetallic elements to be accurately related to current magnitude throughout a wide range of ambient temperatures.

A trip device in accordance with this invention for controlling the operation of a releasable means of a circuit breaker which means, upon release, causes operation of the circuit breaker comprises a magnetic core, means for producing a flux in the core directly related in amount to the magnitude of the current in an electric circuit associated with the circuit breaker, a bimetallic magnetic armature associated with the core and operative to move upon the amount of flux in the core exceeding a predetermined value, a bimetallic element, means for heating the armature relatively slowly and the bimetallic element relatively rapidly in direct relation to the magnitude of the current in the circuit, the bimetallic element and at least a portion of said armature flexing in response to heat produced therein, respectively, by the heating means, a latch means associated with the armature and the bimetallic element and normally restraining the releasable means, the latch means being operative to release said releasable means upon said movement of said armature, upon a predetermined degree of flexure of said bimetallic element, and also upon said flexing of both said bimetallic element and said armature when said bimetallic element has flexed to a lesser degree than said predetermined degree. Preferably, the latch is also a bimetallic strip that compensates for changes in ambient temperature.

Further objects and advantages of this invention will become apparent from the following description wherein reference is made to the drawings in which:

FIGURE 1 is a side elevation of the trip device of the present invention shown in operative association with a circuit breaker shown partially in section,

FIGURE 2 is a side elevation of the trip device of FIGURE 1 enlarged for increased clarity,

FIGURE 3 is a frontal view of the trip device taken as indicated by the line 3—3 of FIGURE 2,

FIGURE 4 is an exploded view of the trip device of FIGURE 1; and

FIGURE 5 is a side elevation of the trip device showing the flexure of the several bimetallic elements in exaggerated scale.

Referring to FIGURE 1, a trip device **10** in accordance with this invention is shown in association with a circuit

breaker 11 which may be of any suitable type. As shown, the circuit breaker 11 comprises an insulating base 12 provided with suitable recesses 13 and barriers 14 for supporting the operating components of the circuit breaker and maintaining them in operative position. A cover portion (not shown) complementary to the base 12 substantially encloses the components of the circuit breaker to form an enclosure and is preferably held in position by a plurality of rivets 15. For use in conjunction with a plug-in panelboard, the circuit breaker 11 may be connected to one side of an external source of electrical energy by a pair of centrally disposed spring jaw clips 16. A solderless connector or terminal 17 is provided for use when a flexible conductor (not shown) is used to make a connection to one side of the power source. The circuit breaker 11 is arranged to be mechanically supported and held within a panelboard by a pair of spaced spring jaw clips 18.

The spring jaw clips 16 and the solderless connector 17 are electrically connected to a source terminal strip 19. Mechanically and electrically secured to the terminal strip 19, as by welding, is a fixed or stationary contact 20 which cooperates with a movable contact 21 supported on a movable contact carrier 22. The contacts 20 and 21 are shown in closed position. The movable contact carrier 22 is pivoted on an operating pin 23 suitably supported in the base 12. An operating member 24 is also pivoted on the pin 23 and is operatively coupled to an operating handle 25 by the engagement of a transverse pin 26, carried by the operating member, with the side walls of a groove 27 formed in the lower end portion of the handle 25. A U-shaped connecting link 28 has the free end portions 29 of its legs pivotally connected to the operating member 24 and its bight portion 30 received within a slot 31 formed in the contact carrier 22. A helical operating spring 32 has one end secured to the bight portion 30 of the connecting link 28 and has its other end secured to an upstanding hook-like portion 33 of a releasable member 34. The releasable member 34 is pivotally supported on a transverse pivot pin 35 which is suitably supported within the base 12. The releasable member 34 is latched in the closed position shown by engagement with the trip device 10 as will be explained. A flexible conductor 36 is electrically secured to and extends between the contact carrier 22 and the trip device 10.

Referring now to FIGURES 1 through 5, the trip device 10 is electrically and mechanically connected to a load terminal strip 38 which is secured within the insulating base 12 as by a screw 39. To facilitate connection of the circuit breaker 11 to an external load, a solderless connecter or load terminal 40 is electrically and mechanically connected to the load terminal strip 38 at the outer end thereof.

In accordance with the present invention, the trip device 10 comprises an elongated bimetallic strip 50 which is electrically and mechanically connected at its upper end portion, as seen in the drawings, to the upper end portion of the terminal strip 38, as by welding. The strip 50 has a high expansion portion 50H and a low expansion portion 50L. A yoke or core 51 of magnetic material has a generally U-shaped cross-section defined by a bight portion 52 and leg portions 53 and 54 (see FIGURE 4) and is attached to the lower end portion of the bimetallic strip 50, as by welding. The magnetic yoke 51 extends upwardly generally parallel to the bimetallic strip 50 with its bight portion 52 facing and next adjacent to the low expansion portion 50L of the strip 50 and with the leg portions 53 and 54 disposed on opposite sides of the strip 50 and extending inwardly of the circuit breaker beyond the high expansion portion 50H of the strip 50. A pair of outer edge faces 55 and 56 on the leg portions 53 and 54, respectively, function as pole faces of the magnetic yoke 51. An end portion of the flexible conductor 36 is interposed between the bight portion 52 of the magnetic yoke 51 and the bimetallic strip 50 and is mechanically and electrically secured to the strip 50, as by welding. The strip 50 thus carries the current of a circuit associated with the circuit breaker and, since the strip 50 is disposed between the legs 53 and 54, the current in the strip causes a flux to be created in the yoke 51 which is related in amount to the magnitude of the current in the circuit. The central portion of the bimetallic strip 50 is spaced from the bight portion 52 of the magnetic yoke 51 by a pair of protrusions 58 formed in the magnetic yoke which serve as welding areas.

The leg portions 53 and 54 of the magnetic yoke 51 are provided, near their upper ends, with hook-like armature supports 61 and 62, respectively, which pivotally support a magnetic armature 64 in operative relation with the pole faces 55 and 56. The armature 64, near its upper end, has a pair of spaced and oppositely directed shoulders 65 and 66 which engage and pivot on the armature supports 61 and 62, respectively. The magnetic armature 64 comprises a bimetallic strip, having a high expansion portion 64H facing and next adjacent the high expansion face 50H of the strip 50 and a low expansion portion 64L facing inwardly of the circuit breaker. The bimetallic armature 64 is indirectly heated by radiant, conductive, and convective transfer of heat produced by current flowing through the current responsive bimetallic strip 50. An offset lower end portion or finger 68 on the armature 64 extends through a cutout portion 69 in a spring retainer cup 70 formed by turning the end portion of an extension of the bight portion 52 of the magnetic yoke 51 inwardly of the circuit breaker. A helical compression spring 71 is disposed about the finger 68 and operates between the spring retainer cup 70 and a pair of spaced shoulders 72 and 74 on the bimetallic armature 64. Normally, the spring 71 biases the armature 64 clockwise about the pivotal shoulders 65 and 66 so as to provide an air gap between the armature 64 and the pole faces 55 and 56 of the magnetic yoke 51. When the amount of flux in the core 51 exceeds a predetermined value, magnetic attraction on the armature 64 overcomes the bias of the spring 71 and causes the armature to swing counter-clockwise about the supports 61 and 62.

An upper end portion 75 of an ambient temperature compensating bimetallic strip 73 is attached, as by welding, to an inwardly offset upper end portion 76 of the bimetallic armature 64 and extends downwardly substantially parallel to the armature 64 from its point of attachment to engage the releasable member 34.

The high expansion portion 73H of the ambient bimetal 73 is next adjacent to and faces the low expansion side 64L of the magnetic armature 64. A lower edge face 73A of the bimetallic strip 73 serves as a latch for the releasable member 34 and normally engages an upwardly directed surface 34A at the outer end of the releasable member 34 to hold the member 34 in its closed position.

The path of current through the trip device 10 is from the terminal strip 38, through the bimetallic strip 50 and the flexible conductor 36, to the contact carrier 22, to the movable contact 21 and fixed contact 20 to the conductive terminal strip 19 and to the spring jaw clips 16 or solderless connector 17.

Upon the occurrence of an overload in a branch circuit protected by the circuit breaker 11 the flow in the current responsive bimetallic strip 50 causes the strip to deflect in a counter-clockwise direction (see FIG. 5) about its point of attachment to the terminal strip 38. When the overload is moderate and of relatively short duration, as due to an inrush current, the current responsive bimetal 50 flexes slightly but, due to the short duration of the overload, the bimetallic armature 64 is not heated sufficiently by radiation, conduction or convection, to flex and supplement flexure of the current responsive bimetal 50 and the latching face 73A of the ambient

temperature bimetal **73** is not retracted from engagement with the releasable member **34**.

Upon the occurrence of a sustained moderate overload, heat produced as a result of the flow of current through the bimetallic strip **50** indirectly heats the bimetallic armature **64** and causes it to flex thereby to move the offset upper portion **76** thereof in a counter-clockwise direction about the shoulders **65** and **66**. This causes the lower edge face **73A** of the ambient temperature bimetallic strip **73** to move away from the surface **34A** to release the releasable member **34**. Thus it is seen that release of the releasable member **34** due to a moderate overload requires flexure of both the current responsive bimetal **50** and the magnetic armature **64** and is thereby a function of time as well as the magnitude of the overload current.

Upon the occurrence of a severe overload flexure of the current responsive bimetal **50** is sufficient to retract the latching face **73A** of the ambient temperature bimetal **73** from engagement with the latching surface of **34A** of the releasable member **34** before heat transfer to the bimetal armature **64** is sufficient to cause flexure thereof to effect tripping in the manner described hereinbefore.

Upon the occurrence of a fault current the magnetic bimetallic armature **64** is attracted to the pole faces **55** and **56** of the magnetic core **51** thereby disengaging the latching face **73A** of the ambient temperature bimetal **73** from the latching surface **34A** of the releasable member **34**, before the current responsive bimetal **50** flexes in response to the fault.

Thus a novel trip device is provided wherein release of the releasable member **34** due to an overload is a function of time as well as the magnitude of the current and wherein release due to a fault current is substantially instantaneous.

Upon release, the releasable member **34** rotates counter-clockwise about the pin **35** to carry the operating spring **32** across a line between the point of engagement of the bight portion **30** of the link **28** in the slot **31** of the contact carrier **22** and the pivot point of the link **28** on the operating member **24**.

When the trip device **10** is subjected to a high ambient temperature condition, the ambient temperature bimetal **73** flexes clockwise about its point of attachment to the bimetallic armature **64**, as shown in exaggerated scale in FIGURE 5. This movement of the ambient temperature bimetal neutralizes the effect that a high ambient temperature has upon the current responsive bimetal **50** and the bimetallic armature **64**. Under high ambient temperatures, the lower edge face **73A** of the ambient temperature compensating bimetallic strip **73** maintains contact with the surface **34A** on the releasable member **34** even though the current responsive bimetallic strip **50** flexes to a position that, under lower ambient temperature conditions, would effect release of the releasable member **34**.

Upon manual movement of the operating handle **25** in the clockwise direction, the operating member **24** rotates about the pin **23** through engagement of the pin **26** in the slot **27** of the operating handle. The operating member **24** moves the pivotal connection thereof with the link **28** across the line of action of the spring **32** thereby biasing the link **28** clockwise with a snap action. Upon movement of the link **28**, the bight portion **31** of the link **28** biases the contact carrier **22** clockwise about the pin **23** to separate the contacts **20** and **21**.

Upon manual movement of the operating handle **25** in the counter-clockwise direction, the operating member **24** rotates about the pin **23** under bias of the slot **27** in the handle **25** with the pin **26**. The operating member moves the pivotal connection thereof with the link **28** across the line of action of the spring **32** thereby biasing the link **28** counter-clockwise with a snap action. Upon movement of the link **28**, the bight portion **31** thereof biases the contact carrier **22** counter-clockwise about the pin **23** to close the contacts **20** and **21**.

What is claimed is:

1. A trip device for controlling the release of a releasable means of an electric switch which means, upon release, causes operation of the switch, said trip device comprising a magnetic core, means for producing a flux in said core directly related in amount to the magnitude of the current in an electric circuit associated with the switch, a bimetallic magnetic armature associated with said core and operative to move upon the amount of flux in said core exceeding a predetermined value, a bimetallic element, means for heating said armature relatively slowly and said bimetallic element relatively rapidly in direct relation to the magnitude of the current in said circuit, said bimetallic element and at least a portion of said armature flexing in response to heat produced therein, respectively, by said heating means, and a latch means associated with said armature and said bimetallic element and normally restraining said releasable means, said latch means being formed of bimetal, being rendered operative to release said releasable means upon movement to a predetermined position with respect to said releasable means, being responsive to ambient temperature to predetermine the amount of movement required to reach said predetermined position, and being moved to said predetermined position upon any of three occurrences, namely, upon said movement of said armature, upon a predetermined degree of flexure of said bimetallic element, and also upon said flexing of both said bimetallic element and said armature when said bimetallic element has flexed to a lesser degree than said predetermined degree.

2. A circuit breaker including separable contacts, means releasable to effect separation of said contacts, and a trip device operable to release said releasable means in response to predetermined electrical conditions in an electric circuit containing said circuit breaker, said trip device comprising a current responsive bimetallic element, means for connecting said current responsive bimetallic element in said electric circuit, said current responsive bimetallic element being heated and thereby caused to flex upon the occurrence of one of said predetermined electrical conditions, a magnetic core, said current responsive bimetallic element being operatively related with said magnetic core to produce a magnetic flux therein upon the occurrence of another of said predetermined electrical conditions, a bimetallic magnetic armature operatively related with said magnetic core so as to be attracted thereto upon the occurrence of said another predetermined electrical condition and disposed to be indirectly heated by said current responsive bimetallic element so as to flex upon the occurrence of said one predetermined electrical condition, and an ambient temperature compensating bimetallic element fixedly mounted on said magnetic armature, said compensating bimetallic element having a latching portion releasably engageable with said releasable means, said latching portion being movable by said armature upon said attraction thereof to effect release of said releasable means, flexure of said armature effecting relative movement of said latching portion with respect to said releasable means, and said latching portion being movable with respect to said magnetic armature upon a change in ambient temperature.

3. A circuit breaker including separable contacts, means releasable to effect separation of said contacts, and a trip device operable to release said releasable means in response to predetermined electrical conditions in an electric circuit containing said circuit breaker, said trip device comprising a current responsive bimetallic element, means for connecting said current responsive bimetallic element in said electric circuit, said current responsive bimetallic element being heated and thereby caused to flex upon the occurrence of one of said predetermined electrical conditions, a magnetic core, said current re-

sponsive bimetallic element being operatively related with said magnetic core to produce a magnetic flux therein upon the occurrence of another of said predetermined electrical conditions, a thermally deformable magnetic armature operatively related with said magnetic core so as to be attracted thereto upon the occurrence of said another predetermined electrical condition and movable by said current responsive bimetallic element upon the occurrence of said one predetermined electrical condition, and an ambient temperature compensating bimetallic element fixedly mounted on said thermally deformable magnetic armature, said compensating bimetallic element having a latching portion releasably engageable with said releasable means, said latching portion being movable by said armature upon said attraction thereof to effect release of said releasable means, and said latching portion being movable with respect to said thermally deformable magnetic armature upon a change in ambient temperature.

4. In an electrical circuit breaker having a pair of separable contacts and a releasable member operable to effect separation of said contacts, a tripping mechanism operable to release said releasable member, said tripping mechanism having three different modes of operation and comprising:

(*a*) a flexible bimetallic conductor forming a part of an electric circuit through said circuit breaker when said circuit breaker is installed and an electric circuit is completed therethrough, said bimetallic conductor undergoing changes in temperature and flexing in accordance with the magnitude of the current passing therethrough,

(*b*) a magnetic core operatively associated with said bimetallic conductor and adapted to have a magnetic flux induced therein by the current flowing in said bimetallic conductor,

(*c*) a flexible bimetallic magnetic armature operatively associated with both said magnetic core and said bimetallic conductor and adapted to undergo changes in temperature and flex in accordance with the amount of heat transferred thereto from said bimetallic conductor, said bimetallic armature being normally spaced from said magnetic core and being arranged to be attracted into engagement with said magnetic core by said magnetic flux upon an increase

in the current flowing in said bimetallic conductor to a predetermined value, and

(*d*) a latch operatively associated with said bimetallic armature, said latch being normally engaged with said releasable member to hold said releasable member in a latched position and being movable with respect to said releasable member in accordance with said three modes of operation of said tripping mechanism to permit operation of said releasable member and effect separation of said contacts, said three modes of operation of said tripping mechanism including

(1) attraction of said bimetallic armature into engagement with said magnetic core to move said latch and release said releasable member upon an increase in the current flowing in said bimetallic conductor to said predetermined value,

(2) flexing of said bimetallic conductor to move said latch and release said releasable member upon an increase in the current flowing in said bimetallic conductor to a second value less than said predetermined value, and

(3) flexing of both said bimetallic armature and said bimetallic conductor to move said latch and release said releasable member upon a sustained increase in the current flowing in said bimetallic conductor to a value less than said second value but still above a normal rated value.

5. A tripping mechanism as claimed in claim 4, wherein said latch is a flexible bimetallic member and compensates for changes in said bimetallic armature and said bimetallic conductor caused by changes in ambient temperature.

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