May 4, 1965 R. R. JENNER 3,182,152

CIRCUIT BREAKER COMPENSATED FOR AMBIENT TEMPERATURE AND FOR THE ACTIVITY FACTOR OF THE CURRENT RESPONSIVE ELEMENT

Filed May 16, 1961 3 Sheets-Sheet 1

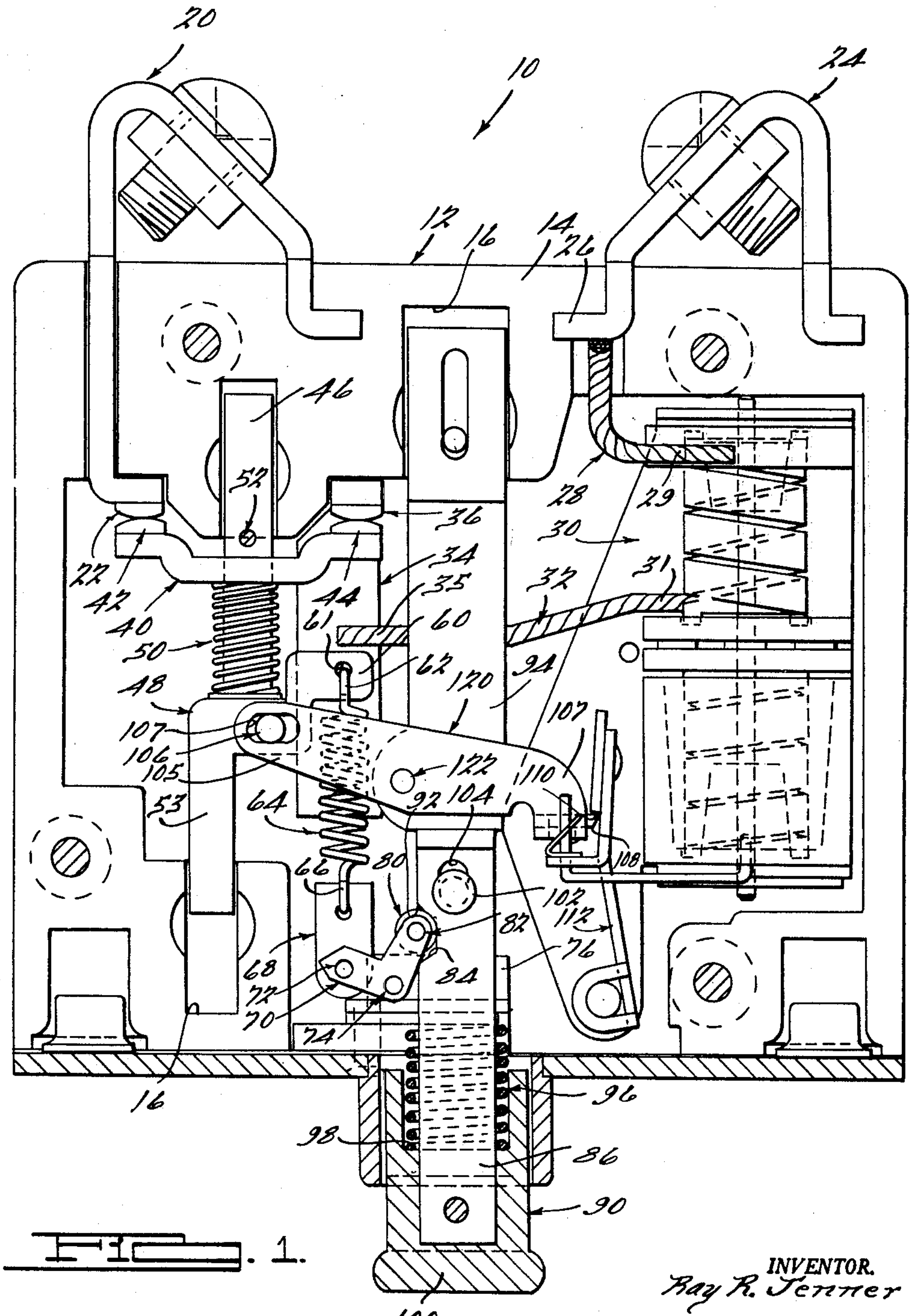

FIG. 1.

INVENTOR.
Ray R. Jenner
BY
Harness, Dickey & Pierce
ATTORNEYS.

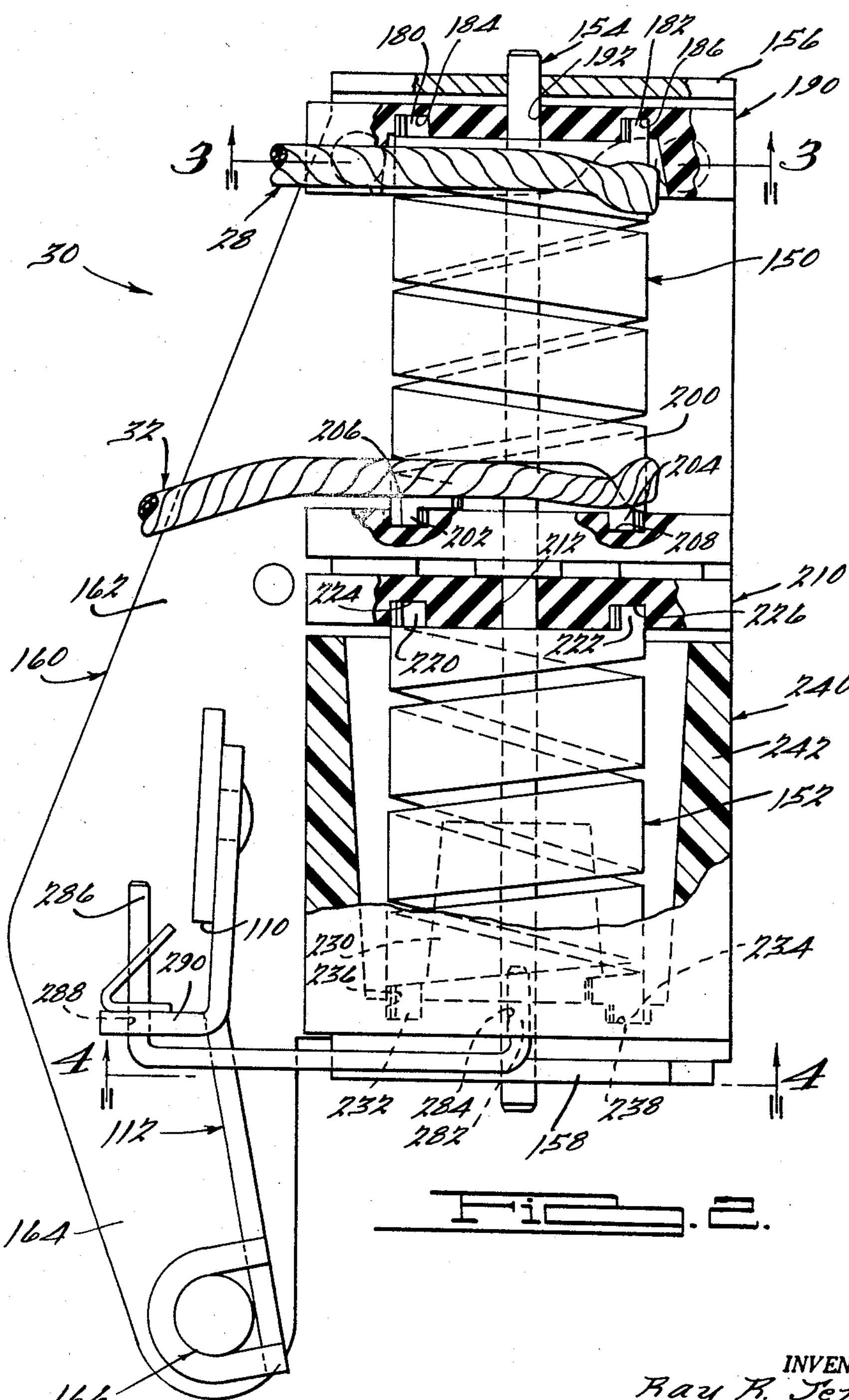

Fig. 2.

INVENTOR.
Ray R. Jenner
BY
Harness, Dickey & Pierce
ATTORNEYS

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Filed May 16, 1961 3 Sheets-Sheet 3

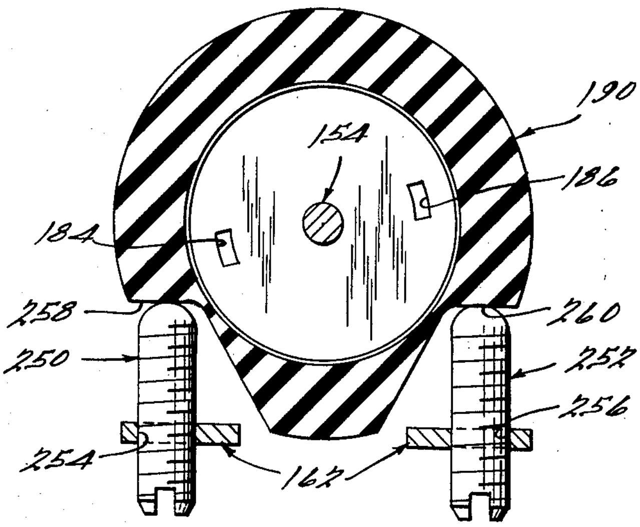

FIG. 3.

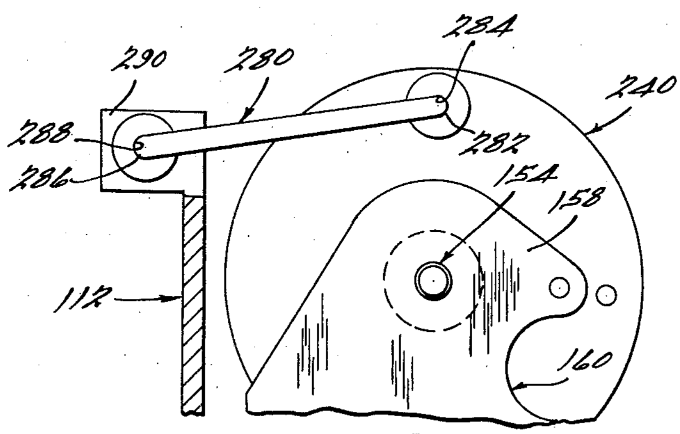

FIG. 4.

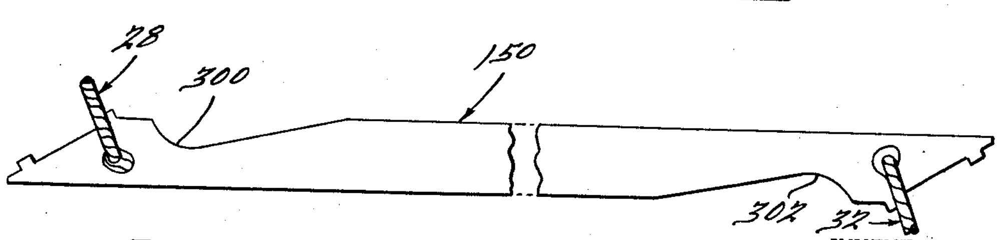

FIG. 5.

INVENTOR.
Ray R. Jenner
BY
Harness, Dickey & Pierce
ATTORNEYS.

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3,182,152

CIRCUIT BREAKER COMPENSATED FOR AMBIENT TEMPERATURE AND FOR THE ACTIVITY FACTOR OF THE CURRENT RESPONSIVE ELEMENT

Ray R. Jenner, Jackson, Mich., assignor, by mesne assignments, to Mechanical Products, Inc., Jackson, Mich., a corporation of Delaware

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1 Claim. (Cl. 200—122)

This invention relates generally to electrical circuit breakers and more particularly to an improved trip device for an electrical circuit breaker.

Electrical circuit breakers are used to interrupt an electrical circuit upon the occurrence of a predetermined overload or short circuit condition therein. Such circuit breakers generally comprise one or more pairs of separable contacts, a releasable operating mechanism that effects separation of the contacts, and a current responsive trip device that responds to a predetermined electrical condition in the circuit to effect release of the operating mechanism.

Many diverse requirements must be considered in the development of a current responsive trip device suitable for use in such circuit breakers. One requirement is that the current responsive element have sufficient energy to effect unlatching of the releasable operating mechanism. This energy should be developed through a relatively long movement so that a sufficiently large latching surface can be provided to preclude release of the operating mechanism due to vibration.

Another requirement is that there be provision for ambient temperature compensation so that the circuit breaker effects interruption of the electrical circuit due to a desired electrical condition in the circuit irrespective of the ambient temperature.

In trip devices utilizing a bimetal as the current responsive element, ambient temperature compensation is complicated by the fact that such thermally responsive bimetals have different activity factors at different ambient temperatures. Therefore, it is desirable that variations in the activity factor of the bimetal, which relates to the amount of movement effected by an incremental change in temperature within a certain temperature range, be compensated to enable the trip device to be calibrated through a relatively wide temperature range. Thus, proper ambient temperature compensation includes compensation for the activity factor of the bimetal as well as for changes in ambient temperatures.

In addition, the ambient temperature compensating means must be well insulated from heat generated in the current responsive bimetal due to I^2R losses therein so as to preclude spurious over-compensation. On the other hand, the ambient temperature compensator must be adequately exposed to the environment externally of the circuit breaker so as to readily respond to changes in ambient temperature occurring, for example, in an aircraft traveling from a temperature of 150° F. on the surface of a desert to a minus 65° F. in the upper atmosphere in a period of two minutes. The high ambient temperature may be increased to 250° F. when, for example, jet engines are operated while an aircraft is on or near the ground. This means the circuit breaker is required to operate throughout a temperature range of −65° F. to +250° F.

A trip device, in accordance with the present invention, comprises what is essentially a thermal motor, the net rotation of which reflects the condition of an electrical circuit containing the circuit breaker. The trip device is compensated for ambient temperature and for the activity factor of the current responsive bimetallic element.

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The thermal motor generates a relatively high torque which is developed through a relatively large angle of rotation thereby to effect movement of an articulating link and a latch mechanism for the operating mechanism of the circuit breaker.

The current responsive bimetal of the thermal motor has a novel construction at opposite terminal ends thereof that limits the affect of variations in bimetal activity factor on the thermal motor.

Accordingly, one object of the present invention is an improved electrical circuit breaker.

Another object is an improved trip device for an electrical circuit breaker.

Another object is a thermal motor for the trip device of an electrical circuit breaker.

Another object is an improved bimetal configuration for the trip device of an electrical circuit breaker.

Another object is a trip device for an electrical circuit breaker that is compensated for variations in bimetal activity factor and ambient temperature.

Another object is a temperature compensated thermal motor usable as a prime mover, actuator, or current sensitive control.

Other objects and advantages of the present invention will be apparent from the following detailed description, claim and drawings, wherein:

FIGURE 1 is a side elevational view of a circuit breaker in accordance with the present invention with the cover thereof removed;

FIG. 2 is an enlarged view of the trip device of the circuit breaker of FIGURE 1 partially broken away for clarity;

FIG. 3 is a cross sectional view taken substantially on the line 3—3 of FIG. 2;

FIG. 4 is a cross sectional view taken substantially along the line 4—4 of FIG. 2; and

FIG. 5 shows the thermal responsive bimetal in the unwound condition.

A circuit breaker **10**, in accordance with an exemplary embodiment of the present invention, comprises a housing **12** having suitable ribs **14** and recesses **16** for the acceptance and support of the operating components thereof. A first terminal **20** is adapted to be connected to one side of an electrical circuit and supports a fixed contact **22** at an inner end thereof. A second terminal **24** is adapted to be connected to the other side of an external electrical circuit and has an inner end portion **26** for electrical connection to a flexible conductor or pigtail **28**.

An end portion **29** of the pigtail **28** is electrically connected to a trip device, generally designated by the numeral **30**, in a manner to be more particularly described hereinafter. An end portion **31** of a second pigtail **32** is electrically connected to the trip device **30** and to an electrically conductive fixed contact support member **34** at an opposite end **35** thereof.

The fixed contact support **34** supports a fixed contact **36** in alignment with a contact bridge **40** that supports a pair of movable contacts **42** and **44**. The contacts **42** and **44** are engageable with the fixed contacts **22** and **36**, respectively, to make and break an electrical circuit through the circuit breaker **10** as will be described. The contact bridge **40** is guided for movement toward and away from the fixed contacts **22** and **36** by an upstanding end portion **46** of a reciprocable contact bridge carrier **48**. The contact bridge **40** is normally biased upwardly, as seen in FIGURE 1 of the drawings, with respect to the carrier **48** as by a helical compression spring **50**. A pin **52** extends transversely of the upper end portion **46** of the carrier **48** to limit upward movement of the bridge **40** under the bias of the spring **50** and to effect downward movement of the bridge **40** upon downward movement of the bridge 48. The carrier 48 has a lower end portion 53 that is acceptable in a complementary recess 16 in the housing 12, thereby to guide the carrier 48 for vertical translation with respect to the housing 12.

The carrier 48 has a horizontal arm portion 60 with an aperture 61 therein for the acceptance of one end portion 62 of a tensioned coil spring 64. An opposite end 66 of the coil spring 64 engages a link 68 that is pivotally connected to a bellcrank 70 as by a pin 72. The spring 64 normally biases the carrier 48 downwardly with respect to the housing 12 and biases the bellcrank 70 clockwise about a pin 74. The pin 74 is fixedly mounted with respect to the housing 12 by an upstanding bracket 76 that is fixedly secured to the housing 12. A roller 80 is pivotally supported on an opposite end of the bellcrank 70 as by a pin 82. The roller 80 is engageable in a complementary notch 84 in a lower portion 86 of a manual operator 90, and in a notch 92 in an upper end portion 94 of the manual operator 90.

The lower end portion 86 of the manual operator 90 is normally biased outwardly or downwardly with respect to the housing 12 by a helical compression spring 96 that extends between the bracket 76 and a complementary recess 98 in a handle 100 on the manual operator 90. A lost motion connection between the upper and lower end portions 94 and 86, respectively, of the manual operator 90 is effected by a pin 102 in the upper portion 94 that extends through a complementary slot 104 in the lower portion 86. Therefore, movement of the lower portion 86 of the manual operator outwardly of the housing 12 under the bias of the spring 96 is transmitted to the upper portion 94 through the pin 102.

A releasable member 120 is pivotally supported for movement with and for rotation with respect to the upper portion 94 of the manual operator 90 by a pin 122. The releasable member 120 has a slot 107 at one end 105 thereof for the acceptance of a pin 106 that is fixedly supported by the carrier 48. An opposite end portion 107 of the releasable member 120 has a latch plate 108 thereon that is engageable under a complementary latching surface 110 of a trip lever 112. It is to be noted that the downward bias on the carrier 48 under the influence of the spring 64 is transmitted to the releasable member 120 by the pin 106, thereby effecting a counterclockwise bias on the releasable member 120 about the pin 122, tending to bias the latch plate 108 against the latch surface 110 on the trip lever 112. The normal counterclockwise bias of the releasable member 120 is thus restrained by engagement of the latch plate 108 with the latching surface 110 of the trip lever 112. Release of the releasable member upon movement of the trip lever 112, due to the occurrence of a predetermined electrical condition in a circuit containing the circuit breaker 10, as will be described, permits the releasable member 120 to rotate counterclockwise, thus freeing the carrier 48 for downward movement with respect to the housing under the bias of the spring 64 and carrying the bridge 40 and movable contacts 42 and 44 out of engagement with the fixed contacts 22 and 36, respectively. Downward movement of the carrier 48 reduces the bias of the spring 64 to reduce the clockwise bias of the roller 80 in the notches 84 and 92 in the lower portion 86 and upper portion 94, respectively, of the manual operator 90, whereupon the lower portion 86 of the manual operator 90 moves downwardly under the bias of the spring 96. Downward movement of the lower portion 86 carries the upper portion 94 downwardly due to engagement of the pin 102 thereof in the slot 104 of the lower portion 86. Thus, the releasable member 120 is carried downwardly to maintain the carrier 48 and contact bridge 40 in the contact's open condition.

Manual opening of the circuit breaker is accomplished by pulling downwardly on the handle 100 of the manual operator 90 thereby to forcibly rotate the bellcrank 70 counterclockwise out of the notches 84 and 92 in the lower and upper portions 86 and 94 of the manual operator 90. Downward movement of the lower portion 86 of the manual operator 90 is transmitted to the upper portion 94 thereof through the pin 102, which movement pulls the releasable member 120 downwardly.

Downward movement of the releasable member 120 effects downward movement of the carrier 48 due to engagement of the pin 106 thereof in the slot 104 in the releasable member 120 thereby separating the contacts 42 and 44 from the contacts 22 and 36, respectively.

Referring now to FIGS. 2, 3 and 4, the current responsive trip device 30 comprises a pair of oppositely and helically wound bimetals 150 and 152. The bimetals 150 and 152 are aligned coaxially with respect to a mounting shaft 154 that extends between opposite leg portions 156 and 158 of a generally U-shaped trip device frame 160. The frame 160 has a vertically extending bight portion 162 with a depending lower end portion 164 for the support of a trip lever pivot pin 166. The trip lever 112 is pivotally supported by the pin 166 for movement in response to operation of the trip device 30, as will be described.

The current responsive bimetal 150 has a pair of nibs 180 and 182 thereon that are engageable in complementary recesses 184 and 186, respectively, in an insulating calibration disk 190. The calibration disk 190 has a central bore 192 therein for the acceptance of the shaft 154 and is therefore pivotally supported for rotation with respect to the frame 160 about the shaft 154. An opposite end portion 200 of the current responsive bimetal 150 has a pair of downwardly extending nibs 202 and 204 that are engageable in complementary recesses 206 and 208 in an intermediate insulating member 210. The intermediate member 210 has a central aperture 212 for the acceptance of the shaft 154 so as to be pivotally supported thereby.

The ambient temperature compensating bimetal 152 has a pair of upwardly extending nibs 220 and 222 that are acceptable in complementary apertures 224 and 226, respectively, in the intermediate disk 210. Similarly, a lower end portion 230 of the ambient compensating bimetal 152 has a pair of nibs 232 and 234 that are accepted in complementary recesses 236 and 238, respectively, in an insulating cup 240. The insulating cup 240 has a side wall portion 242 that substantially encloses the ambient temperature compensating bimetal 152, thereby to protect the ambient temperature bimetal 152 from spurious movement due to heat transfer from the current responsive bimetal 150.

From the aforementioned description, it should be apparent that expansion and contraction of the current responsive bimetal 150 results in relative rotation between the calibration disk 190 and the intermediate disk 210. Movement of the intermediate disk 210 is transmitted directly to one end of the compensating bimetal 152. Similarly, expansion and contraction of the ambient temperature compensating bimetal 152 results in relative rotation between the intermediate disk 210 and the insulating cup 240. However, because the current responsive bimetal 150 is wound oppositely from the ambient compensating bimetal 152, angular rotation of the insulating cup 240 with respect to the calibration disk 190 reflects the condition of the electrical circuit as sensed by the current responsive bimetal 150 and as compensated for ambient temperature by the bimetal 152. Thus, the bimetals 150 and 152 constitute what, in effect, is a thermal motor having a net rotation that is indicative of the condition of an electrical circuit as compensated for ambient temperature.

As best seen in FIG. 3 of the drawings, the calibration disk 190 is adjustable to an index position by advancement and retraction of a pair of adjustment screws 250 and 252 that extend through complementary threaded apertures 254 and 256 in the bight portion 162 of the frame 160. The screws 250 and 252 are engageable with suitable shoulders 258 and 260 on the calibration disk 190 to positively locate the disk 190 at a desired rotative position with respect to the trip device frame 160, thereby to index the insulating cup 240 to a desired rotational position with respect to the frame 160 at a desired calibration current rating and ambient temperature condition.

Rotation of the insulating cup 240 is transmitted to the trip lever 112 by a link 280 having an end portion 282 extending into a complementary aperture 284 in the cup 240 and an opposite end portion 286 extending through a complementary aperture 288 in a flange 290 on the trip lever 112. Rotation of the insulating cup 240 is thus transmitted to the trip lever 112 through the link 280 which causes rotation of the trip lever 112 about its supporting shaft 166.

In accordance with one feature of the present invention, the trip device 30 is compensated for variation in activity factor of the current responsive bimetal 150 as well as for variation in ambient temperature. It has been found that the end portions 29 and 31 of the pigtails 28 and 32 function as heat sinks for opposite end portions of the bimetal 150, thereby tending to cool the opposite end portions thereof and reduce the activity thereof. Also, it has been found that the terminal end portions of the bimetal 150, outwardly of the electrical connections of the pigtails 28 and 32 thereto, remain relatively cool in that there is no flow of current therethrough with its attendant I^2R losses. The net effect of these conditions is that the terminal end portions of the bimetal 150 are relatively inactive as compared to the center portion thereof, which condition, coupled with the inherent variation in activity factor of the bimetal 150 at high temperatures and current ratings, has a deleterious effect on the energy and movement of the trip device 30.

To alleviate this condition, the bimetal 150 is provided with a pair of notches 300 and 302 adjacent to and between the pigtails 28 and 32, as shown in FIG. 5. The notches 300 and 302 function to narrow the cross section of the bimetal 150 adjacent the pigtails 28 and 32, thereby to increase the current density in the adjacent region and increase heating of the bimetal at these points sufficiently to increase the activity of the opposite end portions of the bimetal 150 to compensate for any reduction in activity factor and the aforementionad physical conditions. However, these notches 300 and 302 decrease the activity factor of the bimetal 150 when rated current is applied to the bimetal 150. During a 200% run, the notched portions 300 and 302 generate heat fast enough to render the bimetal 150 active right up to the pigtails 28 and 32. This allows the calibration disc 190 to be moved counterclockwise as viewed in FIG. 3 to cause a physical wind-up in the bimetals 150 and 152 which causes a compression of the drive link 280. Thus, the additional wind-up requires more activity and consequently more degrees of rotation to be generated by bimetal 150 in order to disengage the latch surface 110 from latch plate 108. As a result of this additional requirement for activity, the breaker will not trip when normal current is applied through bimetal 150.

If the notches 300 and 302 are not used, heat generated by I^2R losses varies from a maximum halfway between leads 28 and 32 to a minimum at leads 28 and 32 because of the effective heat sink characteristic of these leads and to the extendable attachment portion which carries nibs 202, 204, 180 and 182.

In an exemplary constructed embodiment, the bimetal 150 is .035 inch thick, .100 inch wide and has an active length of 2.530 inches. The bimetal 150 is notched as at 300 and 302 to a depth of .030 inch, thereby reducing the width of the bimetal 150 to .070 inch at these points.

The compensating bimetal 152 has an active length of 2.190 inches, is .100 inch wide and .035 inch thick and is of the same material as the bimetal 150. Thus,

from the relationship of the active lengths of the bimetals 150 and 152, it should be apparent that the bimetal 152 does not fully compensate the bimetal 150 for variations in ambient temperature, which undercompensation, in combination with the notches 300 and 302, compensates for the reduced activity factor of the current responsive bimetal 150. In other words, bimetal 152 does not fully compensate bimetal 150 because if the entire breaker is subjected to ambient temperatures in the area of 250° and bimetal 150 is further heated electrically to an operating temperature of approximately 400° F., bimetal 150 will be operating at a low point on the activity factor curve and will need undercompensation to accomplish a trip more easily. Conversely, if the entire breaker is subjected to −65° F., both bimetals will be operating at a lower point on the activity factor curve than they do at a normal room ambient temperature. While the breaker is subjected to −65° F., the application of current will cause the temperature in bimetal 150 to rise to approximately normal room ambient so it will be operating at a relatively high point on the activity factor curve. Consequently, the need is for undercompensation.

The notches 300 and 302 control the distribution of heat so high activity is attained during 200% or high current runs and low activity is attained during 100 to 115%.

Therefore, the trip device 30 has a relatively uniform response characteristic at all ambient temperatures to which the circuit breaker 10 is exposed. The novel configuration and orientation of the bimetals 150 and 152 is complementary to the aforementioned notching of the current responsive bimetal 150 so that the net rotation of the trip device 30 directly reflects the actual condition of a circuit containing the circuit breaker 10.

It is also contemplated that the active bimetal 150 and the compensating bimetal 152 may be relocated so the compensating bimetal 152 would be anchored and its position controlled by screws 250 and 252. These screws would act on notches in the insulating cup 240. The active bimetal 150 would drive latch 112 through drive link 280. This means the anchored end of the active bimetal 150 would be positioned by the free end of the compensator bimetal and intermediate disc 240. Interchanging the bimetals speeds up the operation of the breaker under extremely high current interruption conditions because rotation of the active end of the bimetal 150 does not need to wind up to overcome the inertia effect of the compensating bimetal 152.

It is to be understood that the specific construction of the improved circuit breaker herein disclosed and described is presented for the purpose of explanation and illustration and is not intended to indicate limits of the invention, the scope of which is defined by the following claim.

What is claimed is:

In an electric circuit breaker comprising a pair of separable contacts and a releasable operating mechanism for effecting separation of the contacts, an improved trip device for effecting release of the operating mechanism upon the occurrence of a predetermined electrical condition in an electrical circuit containing the circuit breaker comprising a helically wound current responsive bimetal having a fixed end portion secured to a calibration disc and a movable end portion secured to a movable intermediate disc, a helically wound ambient temperature compensating bimetal coaxially aligned with said current responsive bimetal, said compensating bimetal having one end secured to the intermediate disc so as to be movable thereby in direct relation to movement of the free end of said current responsive bimetal and another end secured to a rotatable insulating cup, said insulating cup substantially enclosing said compensating bimetal and being rotatable about the central axis thereof to reflect the condition of the electric circuit as compensated for ambient temperature, means connected to said cup to effect release of the operating mechanism, and means for rotating said calibration disc to effect calibration of said trip device.

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BERNARD A. GILHEANY, *Primary Examiner.*