May 28, 1946. T. LINDSTROM ET AL 2,401,005

CIRCUIT BREAKER

Filed March 5, 1942 2 Sheets-Sheet 1

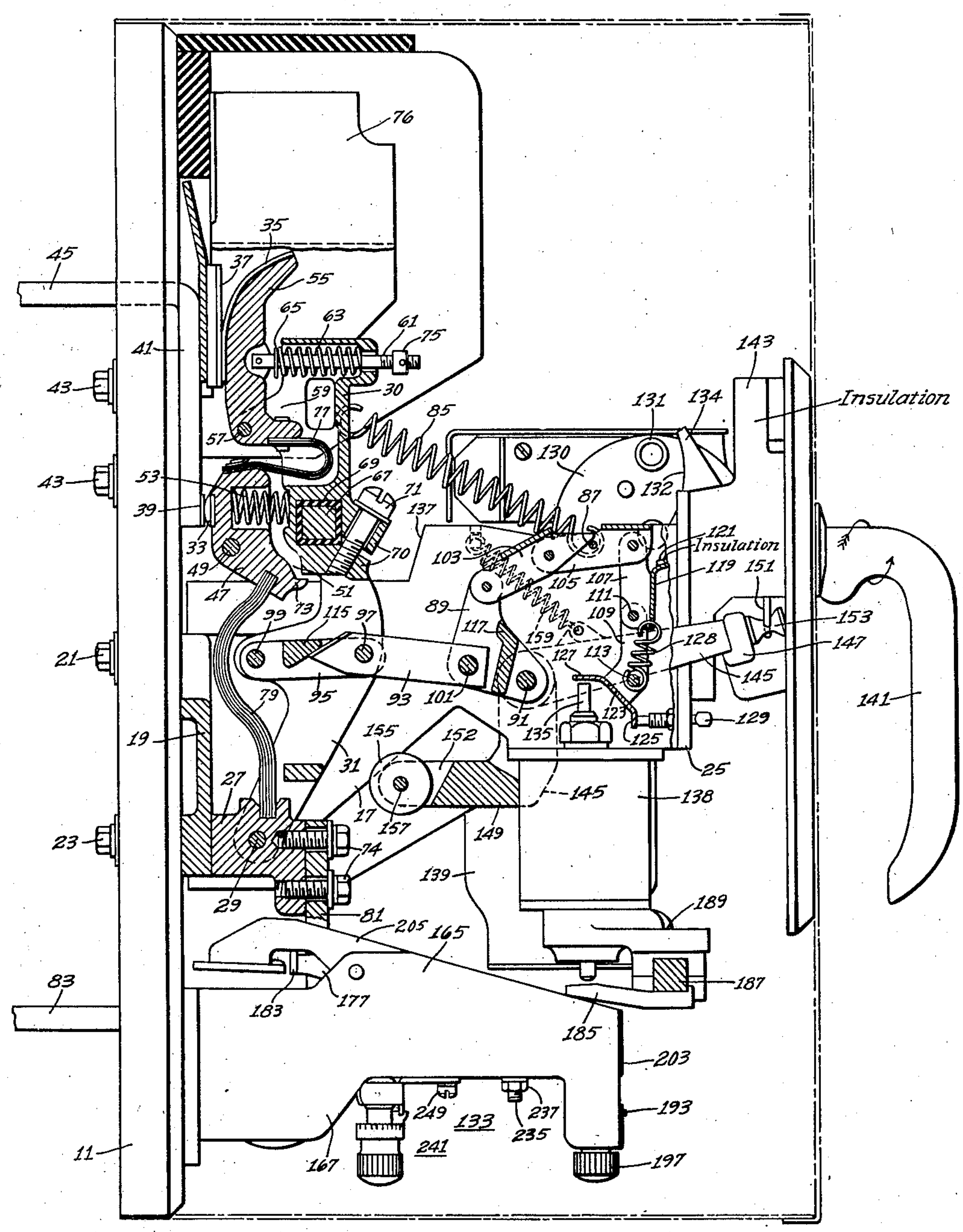

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Fig. 1.

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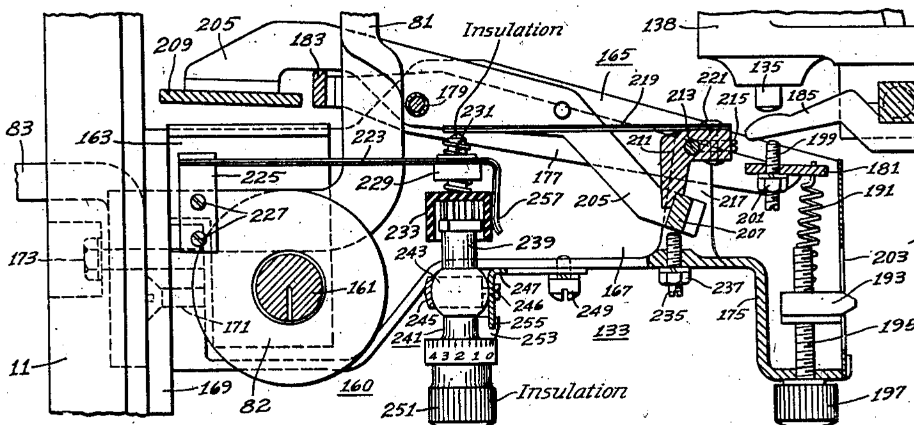

Fig 2.

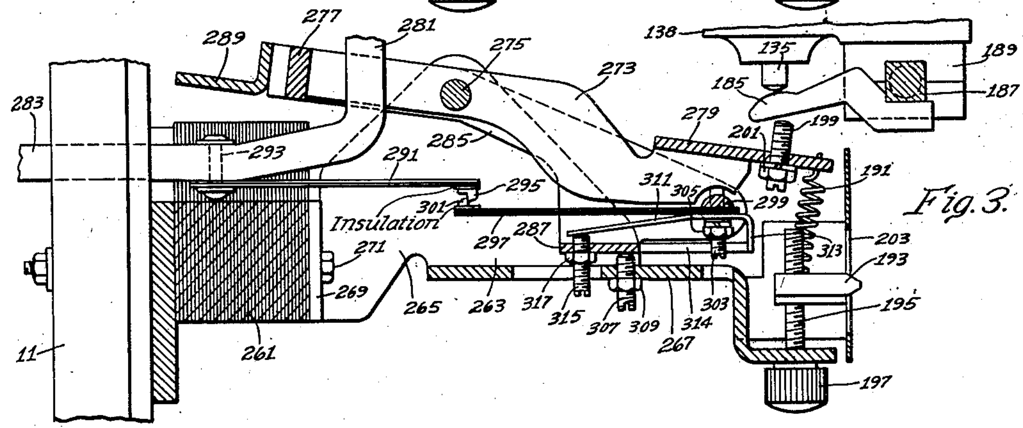

Fig. 3.

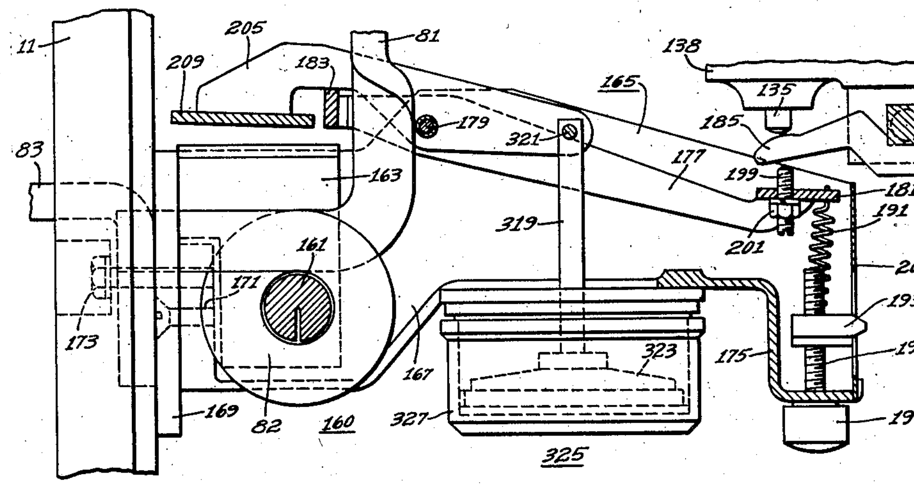

Fig. 4.

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UNITED STATES PATENT OFFICE

2,401,005

CIRCUIT BREAKER

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Application March 5, 1942, Serial No. 433,473

13 Claims. (Cl. 200—88)

This invention relates to circuit breakers and, more particularly, to circuit breakers of the type that are tripped instantaneously on overloads above a predetermined value and after a time delay on lesser overloads.

An object of the invention is the provision of a circuit breaker with an improved trip device comprising an electromagnet having an armature which is operable to effect tripping of the breaker and which is controlled by a current responsive bimetal element to provide inverse time delay operation on overloads up to a predetermined magnitude.

Another object of the invention is the provision of a circuit breaker with an improved trip device comprising an electromagnet having an armature operable to effect tripping of the breaker, the armature being normally latched in unattracted position and released in response to the operation of a current responsive bimetal element.

Another object of the invention is the provision of a circuit breaker with an improved trip device comprising an electromagnet having two armatures one of which is operable to instantaneously effect tripping of the breaker upon the occurrence of overloads above a predetermined value and the other of which is controlled to provide inverse time delay tripping on overloads below the instantaneous tripping current.

Another object of the invention is the provision of a circuit breaker with an improved trip device comprising an electromagnet having two armatures one of which is operable to instantaneously effect tripping of the breaker upon the occurrence of overloads in excess of a predetermined magnitude and the other of which is normally held latched in unattracted position and is released by the operation of a current responsive bimetal element to cause tripping of the breaker in response to overloads below said predetermined magnitude.

Another object of the invention is the provision of a circuit breaker as previously described wherein release of the inverse time delay armature is effected by the differential movement of a current responsive bimetal element and an ambient temperature compensating bimetal element.

Another object of the invention is to provide a circuit breaker having an improved trip mechanism comprising an electromagnet having two armatures or trip members which are operated at times simultaneously after a time delay to trip the breaker, and at other times, one of the trip members is operated instantaneously independently to trip the breaker.

Another object of the invention is to provide an improved circuit breaker in which a plurality of trip members are operated by a single electromagnet one of the trip members being normally latched against operation and being releasable after a time delay under certain conditions to effect tripping of the breaker.

Another object of the invention is to provide a circuit breaker having an improved trip mechanism in which a plurality of trip members are provided, one trip member being operated at times independently of a second trip member, and at other times the one trip member is operated by the second trip member to trip the breaker.

Another object of the invention is to provide a circuit breaker having an improved trip mechanism wherein a current responsive bimetal acting through an ambient compensating bimetal operates a latch to release a trip member and cause tripping of the breaker.

Another object of the invention is to provide a circuit breaker with an improved trip device having an electromagnetic means which is operable to trip the breaker, a trip member operable by the electromagnet to trip the breaker, and normally latched member operable by the electromagnet when released to operate the trip member.

Another object of the invention in accordance with a modification thereof is the provision of a circuit breaker having an improved trip device in which a pair of bimetal elements are normally latched one to the other to restrain operation of a trip member, one of the bimetals being heated in response to the current of the circuit and operable to unlatch the trip member to effect tripping of the breaker under certain conditions, the other bimetal element being arranged to compensate the device for changes in ambient temperature.

Another object of the invention is the provision of a circuit breaker with an improved trip device which is simple, accurate and reliable in operation and inexpensive to manufacture.

The novel features that are considered characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to structure and operation together with additional objects and advantages thereof will be best understood from the following detailed description of several embodiments thereof when read in conjunction with the accompanying drawings in which:

Figure 1 is a vertical sectional view through the center pole of a multiple circuit breaker embodying a trip device constructed in accordance with the invention;

Fig. 2 is an enlarged fragmentary sectional view of the trip device;

Fig. 3 is an enlarged fragmentary view, partly in section, showing a modified form of the trip device; and

Fig. 4 is an enlarged fragmentary view, partly in section, showing a further modification of the invention.

Referring to Figure 1 of the drawings, the circuit breaker is provided with an operating mechanism common to all of the poles which is mounted in a U-shaped main frame **17** having sides which are rigidly connected by a cross member **19**. The frame **17** is mounted on the central portion of a base **11** of insulating material and is secured thereto by means of bolts **21** and **23**. The outer ends of the sides of the frame are rigidly connected by a cross member **25**.

The bolt **23** extends through the base and the cross member **19** and serves to rigidly secure a connector **27** of conducting material to the cross member and to the base **11**. A shaft **29** extending through an opening in the connector **27** and through openings in the sides of the frame **17** pivotally supports a pair of arms **31** having their free ends integral with a contact arm **30** for the center pole. The contact arms **30** (Fig. 1) for the outer poles (not shown) are identical with the arm **30** for the center pole but are not provided with arms **31**. The contact arms for the outer poles are rigidly secured to a tie bar **67** which extends across all of the poles and which is clamped to the center pole contact arm **30** by means of a split clamp **70** and a screw **71**. The three contact arms **30** are thus mechanically connected for movement together. Rectangular tubes **69** of insulating material between the tie bar **67** and contact arms **30** for the several poles serve to insulate the three movable contact arms and their associated contacts from the tie bar **67**.

The movable contact structures and the stationary contacts for the several poles are all alike and hence only the contacts for the center pole have been shown. The contact arm **30** pivotally carries a main movable contact member **47** and a movable arcing contact member **55**. The main contact member **47** is pivoted on a pivot pin **49** supported in projections **51** of the contact arm **30**, and the movable arcing contact member **55** is pivoted on a pivot pin **57** supported in projections **59** of the arm **30**. The main movable contact member **47** carries a contact **33**, and a contact **35** is secured to the arcing contact member **55**. These contacts **33** and **35** are adapted to engage respectively fixed contacts **39** and **37** secured on a conductor **41** which is in turn secured to the base **11** by means of bolts **43**. The conductor **41** extends upwardly and is bent at right angles, the bent portion extending through an opening in the base **11** to form a terminal connector **45**.

A spring **53** compressed between a spring seat on the contact arm **30** and a spring seat on the main contact member **47** provides contact pressure for the main contacts **33—39** when the contact arm is in the closed position. Contact pressure for the arcing contacts **35—37** is provided by a spring **63** surrounding a rod **61** pivotally connected to the arcing contact member **55** and slidable through an opening in a spring seat on the contact arm **30**. The spring **63** is compressed between a washer **65**, seated on a shoulder on the rod **61**, and the spring seat on the contact arm **30**. The rod **61** has a nut **75** on the outer end thereof which acts to limit counterclockwise rotation of the arcing contact member **55** about its pivot when the contact arm **30** is moved to open the contacts. Counterclockwise movement of the main contact member **47** is limited by a projection **73** thereon striking the body of the contact arm **30**. The adjustment of the nut **75** on the rod **61** is such that the arcing contacts **35—37** open after the main contacts **33—39** open during an opening operation of the circuit breaker, and close before the main contacts close during a closing operation.

When the contact arm **30** is operated to open the contacts, the arc across the arcing contacts **35—37** resulting from the rupture of the current is drawn into an arc extinguisher indicated generally at **76** where it is cooled and extinguished. Any suitable arc extinguisher may be employed, the one illustrated comprising, generally, a stack of slotted plates (not shown) of magnetic material disposed adjacent the paths of travel of each of the arcing contacts **35**. The plates serve to draw the arc towards the ends of the slots where it is broken up into a plurality of short arcs which are quickly cooled and extinguished.

The movable arcing contact member **55** is connected by a flexible shunt conductor **77** to the main contact member **47** and another flexible shunt conductor **79** connects the main contact member **47** to the connector **27**. The connector **27** for the center pole is secured to the cross member **19** of the frame **17** by the bolts **23**, and the connectors **27** for the outer poles are bolted to the base **11** with a spacer (not shown) between the base and each of these connectors in order to align the members **27** of the outer poles with the corresponding member **27** for the center pole. A conductor **81**, secured to the connector **27** by means of bolts **74** extends downwardly therefrom and is electrically connected to a terminal connector **83** which, together with the terminal connector **45**, serves to connect the breaker in an electrical circuit.

The electrical circuits for each of the several poles of the breaker are essentially the same. The circuit for the center pole extends from the terminal connector **45** through the conductor **41**, the main contacts **33—39**, the main contact member **47**, the flexible shunt conductor **79**, the connector **27**, the conductor **81** to the terminal connector **83**. The circuit for the arcing contacts **37—35** extends from the terminal connector **45**, through the conductor **41**, the arcing contacts **37—35**, contact member **55**, the flexible shunt conductor **77**, the main contact members **47**, and through the previously described circuit to the terminal connector **83**.

The contact arms **30** are biased in a clockwise or opening direction by means of a pair of springs **85** (only one being shown). These springs are tensioned between the center pole contact arm **30** and a fixed pivot **87** supported in the main frame 17. In the closed position of the breaker, the center pole contact arm 30 and consequently all of the contact arms are releasably restrained in closed contact position (Fig. 1) by means of a toggle and linkage mechanism which is collapsible to cause opening of the contacts. The toggle and linkage forms a part of the common operating mechanism.

This collapsible linkage includes a lever 89 pivotally mounted on a fixed pivot 91 supported on the main frame 17. The lever 89 comprises a pair of levers rigidly connected by an integral cross bar 117, and is operatively connected to the support arms 31 of the center pole contact arm 30 by a main operating toggle comprising toggle links 93 and 95. The toggle link 93 has one end pivoted on a pin 101 supported on the lever 89 and the link 95 is pivoted on a pivot pin 99 on the arms 31. The links 93 and 95 are pivotally connected by a knee pivot pin 97. The toggle link 95 comprises a pair of links rigidly connected by means of an integral cross bar 115.

The free end of the lever 89 is pivotally connected by means of a link 103 to one arm of a lever 105 pivoted on the fixed pivot 87. The other arm of the lever 105 is pivotally connected to a toggle link 107 of a tripping toggle comprising the link 107 and a toggle link 109. The link 109 is pivoted on a fixed pivot 113 supported on the frame 17 and comprises a pair of links joined near the pivot 113 by an integral yoke 123 provided with projections 125 and 127. The toggle link 107 comprises a pair of links connected by an integral yoke 119 having a bent portion to which is secured an extension 121 of insulating material. The toggle links 107 and 109 are pivotally connected by a knee pivot pin 111. The purpose of the extension 121 is to cooperate with a part connected to a manually operable handle 141 to manually trip the breaker in a manner to be more fully described later. The lever 105 and the link 103 each comprise a pair of members rigidly connected by yokes substantially as illustrated.

The linkage just described serves to releasably hold the contact assemblage including the movable contacts for all of the poles of the breaker in closed contact position. In the closed position, the main operating toggle 93—95 is overcenter above a line through the center of the pins 99—101, and a second toggle, one link of which comprises the overcenter links 93—95 and the other link of which comprises the lever 89, is overcenter above a line through the center of the pins 99 and 91. The overcenter movement of the main operating toggle 93—95 is limited by the projecting end of the link 93 engaging the cross bar 115 of the link 95.

With the main operating toggle 93—95 and the toggle comprising the links 93—95 and the lever 89 in the overcenter position, as shown in Fig. 1, the springs 85 bias the lever 89 in a clockwise direction. Clockwise movement of the lever 89, however, is normally prevented by the tripping toggle 107—109 which is overcenter to the left of a line through the center of the fixed pivot 113 and the point of connection of the toggle link 107 with the lever 105. The toggle 107—109 is biased to its overcenter position by a spring 128 tensioned between the yoke 119 and the fixed pivot 113. The overcenter position of the tripping toggle 107—109 is adjustably determined by the projection 125 of the yoke 123 engaging an adjusting screw 129 in the cross member 25 of the frame. The tripping toggle 107—109 in its overcenter position, acting through the lever 105 and the link 103, prevents clockwise movement of the lever 89 and consequently holds the movable contact assemblage in the closed contact position against the biasing influence of the springs 85.

The tripping toggle 107—109 is adapted to be moved overcenter outwardly in a direction to cause its collapse to effect opening of the contacts by means of a trip device indicated generally at 133 (Fig. 1). The trip device is operable in response to overload currents in the circuits of the breaker to actuate a trip rod 135 and cause collapse of the tripping toggle 107—109. The trip rod 135 is slidable vertically through a shunt trip coil (not shown) enclosed in a casing 138 attached to the main frame 17. The shunt trip coil forms an additional tripping means for tripping the breaker. The shunt coil is adapted to be energized from a suitable source and in a manner well known in the art, to operate the trip rod and trip the breaker from a remote point.

When operated either by the shunt coil or by the overload trip device 133, the trip rod 135 is thrust upwardly and strikes the projection 127 of the yoke 123 and rocks the toggle link 109 clockwise about the fixed pivot 113. This movement of the link 109 causes collapse of the tripping toggle 107—109 permitting clockwise movement of the lever 89 which permits the springs 85 to rock the movable contact assemblage clockwise to open the contacts.

The main operating toggle 93—95 does not immediately collapse but the force of the springs 85 applied through the contact arm 30—31 and the main operating toggle causes collapse of the toggle comprising the links 93—95 and the lever 89 which results in a clockwise movement of the lever 89. This movement is transmitted through the link 103 and the lever 105 to complete the collapse of the tripping toggle 107—109.

The clockwise or opening movement of the contact arm 30 is arrested by projections (not shown) thereon striking portions 137 of the frame 17. At this time the rebound of the inertia of the main operating toggle 93—95 and the parts of the linkage 89, 103, and 105 starts the main operating toggle 93—95 overcenter in a direction to cause its collapse. By the time the knee pin 95 of the toggle has passed overcenter below the line 99—101 the weight of the parts act to complete the collapse of the toggle 93—95 and causes the linkage 89, 103, 105 and the tripping toggle 107—109 to be automatically reset to their normal position. The main operating toggle 93—95 remains in collapsed condition until the contacts are closed.

The contacts are closed manually by operation of the previously mentioned handle 141. The handle is rotatably mounted in a bracket 143 of insulating material secured to the outer end of the main frame 17. Operatively connected to the mechanism (not shown) operated by the handle is a link 151. The lower end of the link 151 is recessed and straddles a pulley-shaped projection 153 rigidly secured on a cross member 147 rigidly connecting the outer ends of a pair of spaced contact closing levers 145. These levers are disposed on the outside of the frame 17 and are pivotally supported on the ends of the fixed pivot 91 which project beyond the sides of the frame 17. The inner ends of the levers 145 are rigidly connected by a cross member 149. Spaced projections 152 extending from the center portion of the cross member 149 support a pivot pin 157 upon which is rotatably mounted a roller 155.

The contacts are closed manually by clockwise rotation of the handle 141. This movement of the handle, through connections (not shown) thrusts the link 151 downwardly and due to its engagement with the projection 153, rotates the closing lever 145 in a clockwise direction. During this movement of the lever 145, the roller 155 engages the link 93 of the now collapsed main operating toggle 93—95 and moves this toggle to its overcenter position. Since at this time the tripping toggle 107—109 has been restored to its overcenter holding position, rotation of the lever 89 is prevented and consequently the force applied by the roller 155 to straighten the toggle 93—95 rotates the contact arm 30 counterclockwise to close the contacts and to tension the springs 85. The clockwise movement of the closing lever 145 moves the toggle 93—95 overcenter above the line 99—101 so that the contacts are held in the closed position until the breaker is again tripped.

Upon release of the handle 141 following a contact closing operation, a spring 159 tensioned between the closing lever 145 and the frame 17 restores the lever 145 in a counterclockwise direction. This movement of the lever 145 and the projection 153 thrusts the link 151 upwardly to restore the handle 141 to its neutral position.

The closing lever 145 may be operated to automatically close the contacts through the agency of a motor 139 (Fig. 1) mounted on a plate attached to the side of the frame 17. The motor 139 may be energized from any suitable source. When energized, the motor is adapted, through a suitable driving connection, to rotate a crank disc 130. This disc carries an anti-friction roller 131 which is adapted to engage a cam face 132 on an arm 134 secured to one side of the closing lever 145 and rotate the arm and the closing lever 145 clockwise to effect closing of the contacts in the previously described manner. As soon as the roller 131 passes out of engagement with the arm 134, the spring 159 acts to restore the lever 145 to its normal position. The motor 139 is deenergized by a suitable limit switch (not shown).

The circuit breaker may be tripped manually by rotation of the handle 141 through a small angle in a counterclockwise direction from its neutral position. When the handle is rotated in tripping direction, a projection (not shown) on the link 151 engages the extension 121 on the yoke 119 of the toggle link 107 and rocks the link counterclockwise about its point of connection with the lever 105. This moves the tripping toggle 107—109 overcenter in a direction to cause its collapse and effects opening of the contacts in the previously described manner.

As previously stated, the trip rod 135 is operated to effect tripping of the breaker by means of a current responsive trip device 133. There is a trip device 133 provided for each of at least two of the poles of the breaker but since the trip devices are alike only the one for the center pole is shown and will be described.

Referring to Fig. 2, the trip device includes an electromagnet indicated generally at 160 including a magnet core 161 having upwardly extending end pieces 163 (only one being shown) secured thereto, both the core 161 and the end pieces 163 being constructed of magnetic material. The end pieces 163 are securely mounted on a U-shaped frame 165 of non-magnetic material comprising parallel side members 167. A spacer 169 is secured to the frame 165 by means of screws 171 (only one being shown), and the frame and the spacer are secured to the base 11 by bolts 173 (only one being shown). The outer ends of the side members 167 are rigidly connected by a cross member 175 formed integral therewith. An energizing coil 82 electrically connected to, or formed integral with, the conductor 81, makes one complete turn about the core 161 and forms the energizing winding for the magnet structure 160. The other end of the conductor 81 is electrically connected to the terminal 83. A trip lever 177 comprising a pair of parallel levers of non-magnetic material is pivotally supported on the frame 165 by a pivot pin 179. The levers 177 are rigidly connected at their outer ends by means of a yoke 181 and are joined at their opposite ends by a relatively small armature 183. The trip lever 177 is biased against operation by the magnet 160, by means of a pair of springs 191 (only one being shown) having one end hooked to the yoke 181 and the other end anchored to a vertically movable plate 193. The plate 193 cooperates with an adjusting screw 195 which is provided with a knurled head 197 bearing against the bottom side of the cross member 175. Rotation of the screw 195 moves the plate 193 and thereby adjusts the tension of the springs 191 to vary the minimum overload tripping point of the breaker. A scale plate 203 supported on the outer ends of the cross member 175, bears indicia which indicates the trip setting of the breaker.

A trip bar 187 is rotatably supported in a bracket 189 secured to the casing 138 (Fig. 1) for the shunt trip coil. The trip bar 187 extends across all the poles of the breaker and is provided with an arm 185 for each pole (only one being shown), the center one of the arms being in alignment with the lower end of the trip rod 135. An adjusting screw 199 is mounted in each of the yokes 181 in alignment with the corresponding arm 185 and is locked in adjusted position by means of a lock nut 201.

Normal rated current flowing through the circuit of the breaker, including the energizing winding 82, causes slight energization of the magnet 160, but not sufficient to overcome the tension of the spring 191. Upon the occurrence of an overload current above a predetermined value, for example, above 10 to 12 times rated current in the circuit of any pole, the flow of current through the corresponding coil 82 causes energization of the magnet 160 sufficient to overcome the tension of the springs 191 and attract the armature 183 rocking the trip lever 177 counterclockwise. At this movement of the trip lever 177, the screw 199 engages the corresponding arm 185 of the trip bar and rocks the trip bar 187 in a clockwise direction thereby thrusting the trip rod 135 upwardly to trip the breaker in the previously described manner.

Means are also provided to effect tripping of the breaker after a time delay in response to persistent overload currents below the predetermined value. This means includes a trip lever 205 comprising a pair of parallel levers of non-magnetic material pivotally mounted on the pivot 179 and disposed between the sides of the previously described lever 177. The trip levers 205 are rigidly connected at their outer ends by means of a cross bar 207, and a relatively large armature **209** is secured to their opposite ends in juxtaposition with the end pieces **163** of the magnet core. The trip lever **205** is normally latched against operation by the magnet **160**, by a latch member **211** which normally engages the cross bar **207**. The latch member **211** is secured to a pivot rod **213** by a set-screw **215**, and the rod **213** is pivotally supported by projections **217** (only one being shown) formed integral with the frame **165** and extending upwardly from the cross member **175**.

An ambient compensating bimetal element **219**, secured to the latch member **211** by means of rivets **221**, extends substantially horizontally from the latch member toward the base **11**. A low temperature thermally responsive bimetal element **223** is supported by a metal bracket **225** to which it is rigidly secured by welding or in any suitable manner. The low temperature responsive bimetal may comprise any bimetal element in which one side has a relatively high coefficient of expansion and the other side has a relatively low coefficient of expansion and which will deflect in response to a relatively small change in temperature. The bracket **225** is secured by means of screws **227** to the conductor **81** at the left of the coil **82** of the magnet, the bimetal element **223** extending outwardly and toward the right above the coil and having its free end disposed just below the free end of the compensating bimetal **219**. The free end of the bimetal **223** has a nut **229** rigidly secured thereto in which is threaded an adjusting screw **231** of insulating material. The screw **231** has an enlarged lower end **233** also of insulating material formed integral therewith, the purpose of which will be described later.

The bimetal element **219** is disposed to deflect upwardly in response to an increase in ambient temperature, and the bimetal element **223** is disposed to deflect upwardly in response to an increase in ambient temperature or in temperature generated by an overload current flowing through the conductor **81** and the coil **82**. When the bimetal element **223** deflects upwardly a predetermined amount in response to an increase in temperature of the conductor **81** resulting from the flow of overload current, the screw **231** engages the free end of the compensating bimetal **219** and rotates the latter and the latch member **211** clockwise to disengage the latch member from the cross bar **207**. The increased energization of the magnet **160** occasioned by the overload current is sufficient to attract the large armature **209** and rotate the trip lever **205** counterclockwise. As previously stated, overload currents below a predetermined value do not energize the magnet **160** sufficiently to overcome the tension of the springs **191** and operate the trip lever **177** due to the smaller size of the armature **183**. The larger armature **209**, however, provides for an increased flow of magnetic flux and, therefore, a greater magnetic pull so that when the latch member is operated to release the trip lever **205**, the magnet immediately attracts the armature and rotates the trip lever **205** counterclockwise. Due to the engagement of the trip lever **205** with the armature **183**, this movement of the trip lever **205** rotates the trip lever **177** therewith to effect tripping of the breaker, as previously described.

When the circuit is interrupted at the main contacts (Fig. 1), the magnet **160** is deenergized and the springs **191** (Fig. 2) restore the trip lever **177** to normal position and, by means of the armature **183**, restore the trip lever **205** to its normal position. As the bimetal element **223** cools and resumes its normal position, it permits the bimetal element **219** to rotate counterclockwise, thus restoring the latch member to latching engagement with the cross bar **207**. The clockwise or restoring movement of the trip lever **205** is limited by an adjusting screw **235** which is locked in position by a lock nut **237**. Due to the engagement of the lever **205** with the armature **183**, the screw **235** also limits the clockwise movement of the trip lever **177**.

The previously mentioned, enlarged end **233** of the screw **231** forms a part of a device for varying the amount of time delay provided by the bimetal element **223**, that is, the amount of deflection of the bimetal that is required to release the latch. This result is obtained by rotating the insulating screw **231** to thereby adjust the distance of the end of the screw from the bimetal **219**.

The squared upper end **239** of an adjusting member **241** of insulating material fits relatively loosely within serrations formed on the inside of the enlarged end **233** of the screw **231** forming a slidable connection between the member **241** and the screw **231**. The member **241** is provided with a portion **243** substantially spherical in shape which is supported for universal movement in a U-shaped convex metal band **245** passing around the portion **243** and having its ends secured by means of screws **246** (only one being shown) to a bracket **247** which, in turn, is secured by means of a screw **249** to the underside of the frame **165**. The lower end of the member **241** is formed in the shape of a knurled head **251** and is provided with a lug **253** which is adapted to engage a projection **255** of the bracket **247** to limit the rotation of the member **241**.

The end **257** of the bimetal **223** which projects to the right of the nut **229** is bent downwardly and is tensioned against the periphery of **233** which is provided with a plurality of flat surfaces in order to retain the screw member **233** and the screw **231** in adjusted position.

Since the end **233** of the screw **231** is movable axially relative to the member **241**, rotation of this member does not move the bimetal **223** but merely moves the end of the screw **231** toward and away from the bimetal **219** and in this manner varies the time delay provided by the bimetal element **223**.

When the bimetal **223** deflects upwardly in response to overload currents, it moves the axis of the screw **231** and the enlarged end **233** thereof upwardly and slightly in a counterclockwise direction out of the normal position, moving the member **233** slightly toward the right. This movement, through the slidable connection **233—239**, rotates the adjusting member **241** slightly clockwise, the spherical portion acting as the pivot. Since the member **241** is freely movable in its support bracket or band **245**, it imposes no restraint on the deflecting movement of the bimetal **223**.

The enlarged end portion **233** with its serrated inner surface, and the square portion **239** of the member **241** also serve as a means for calibrating the bimetal element to correspond to the trip setting of the adjusting screw **195**. When the minimum trip setting of the device is adjusted by the screw **195**, it is necessary to recalibrate the bimetal **223** accordingly and this is done by removing the adjusting member **241** and turning the screw **231** to obtain the proper distance of the screw end from the free end of the bimetal **219** corresponding to the new trip setting of the screw 195, and then reassembling the member 241.

Since the bimetal element 223 is a low temperature bimetal, that is, one which will deflect when its temperature is increased a relatively small amount, it can be heated by conduction directly from the conductor 82 without any resistance heating means and without any current flow through the bimetal. By this construction overload currents cannot damage the bimetal element or alter its calibration, and there is no heater which might be burned up as in the case of some prior art devices.

The bimetal elements 219 and 223 have the same characteristics and deflect upwardly the same extent in response to an increase in ambient temperature. It can be seen, therefore, that the additional deflection of the bimetal 223, in order to trip the breaker in response to an overload of given magnitude and duration, will remain the same for any ambient temperature within the limits of the device.

Fig. 3 illustrates a modification of the invention in which an ambient compensating bimetal carried by a trip member is latched directly to a thermally responsive bimetal element to control tripping of the breaker on overloads below the predetermined value. In the modification shown in Figs. 3 and 4, like parts have been given the same reference characters. This trip device includes a U-shaped magnet core 261 and a frame 263 of non-magnetic material comprising parallel side members 265 rigidly connected by a cross member 267. Each of the side members 265 is provided with an angularly bent foot 269 abutting against the magnet core 261, and the frame and the magnet core are secured to the base 11 by means of bolts 271 (only one being shown). A trip lever comprising a pair of arms 273 is pivotally mounted on a rod 275 supported in the frame 263. At their inner ends the arms carry an armature 277 and the outer ends of the arms 273 are rigidly connected by a yoke 279. The trip lever 273 is biased against operation by the magnet 261, by means of a pair of springs 191 having one end secured to the yoke 279 and the other end attached to the vertically movable plate 193. A conductor 281 secured to the connector 27 (Fig. 1) in place of the conductor 81 and coil 82 of the previously described trip device, extends downwardly and between the legs of the magnet core and thereby forms a single turn energizing coil for the magnet core. The end of the conductor 281 extends substantially horizontally through an opening in the base 11 and forms a terminal connector 283.

The conductor 281 serves to energize the magnet 261; however, on low overloads below a predetermined value, this energization is insufficient to overcome the tension of the springs 191 and effect tripping of the breaker. On overloads above a predetermined value, for example above 10 to 12 times rated current, the pull of the magnet is sufficient to overcome the springs 191, attract the armature 277, and operate the trip lever 273 to trip the breaker in the previously described manner.

The current responsive inverse time limit tripping means of the Fig. 3 modification includes a trip lever 285 of non-magnetic material comprising a pair of spaced arms pivotally mounted on the rod 275 and connected at their outer ends by means of a yoke 287. A relatively large armature 289 is secured to the inner ends of the arms of the lever 285 for cooperating with the magnet 261. A low temperature thermally responsive bimetal element 291, secured to the underside of the conductor 281 by means of two rivets 293 (only one being shown), has a latch member 295 secured to but insulated from its free end. An ambient compensating bimetal element 297 has one end rigidly secured to a flattened portion of a shaft 299 rotatably supported in the ends of the lever arms 285. A latch member 301 secured to but insulated from the free end of the ambient bimetal 297 cooperates with the latch member 295 to normally prevent operation of the trip lever 285 by the magnet 261. An adjusting screw 303 is threaded into an opening in the shaft 299 in alignment with one of the arms of the lever 273 and is locked in adjusted position by a lock nut 305. Another adjusting screw 307 in the cross member 267 of the frame 265 forms an adjustable stop for the trip lever 285 and is engageable by the yoke 287 of the lever. A lock nut 309 maintains the screw in adjusted position. The springs 191 bias the trip lever 273 in a clockwise direction against the screw 303 and by means of the screw and the shaft 299 biases the trip lever 285 also clockwise into contact with the screw 307. The screw 303 serves as an adjustable stop between the trip levers 285 and 273. The screw 307 serves as an adjustment to obtain proper clearance at the latch point. This screw 307 should preferably be adjusted for a maximum clearance of .005 of an inch at the latch point.

An adjustment is provided to adjust the overlap of the latch members 295 and 301. This adjustment includes a resilient spring strip 311 secured to the compensating bimetal element 297 at the point where the bimetal is secured to the shaft 299. The member 311 has a substantially horizontal portion adjacent the bimetal 297 and is bent downwardly as at 313 to the right thereof and engages the right-hand end of an extension 314 of the yoke 287. To the left of the shaft 299, the member 311 inclines downwardly and, at a point near its left-hand end, engages an adjusting screw 315. The screw 315 is held in position in the yoke 287 by a lock nut 317.

The member 311 is tensioned between the end of the screw 315 and the end of the extension 314. Rotation of the screw 315 in a direction to move it upwardly increases the tension of the member 311 and causes a slight clockwise rotation of the shaft 299 and the bimetal 297 to increase the latch overlap. Movement of the screw 315 in the opposite direction decreases the tension of the member 311 and effects a reduction in the latch overlap. The tension of the spring 191 is adjusted in the previously described manner and for the same purpose.

Upon the occurrence of an overload below the predetermined value, the pull of the magnet 261 increases, and the bimetal 291, when heated a predetermined amount deflects upwardly to disengage the latch member 295 from the latch 301. When this occurs, the magnet 261 attracts the large armature 289 and rocks the trip lever 285 counterclockwise, which movement through the agency of the shaft 299 and the screw 303, rocks the trip lever 273 in the same direction to effect tripping of the breaker in the manner previously described.

When the current is interrupted and the magnet 261 is deenergized, the spring 191 restores the trip lever 273 to its normal unattracted position as shown, and by means of the connection 299—303 restores the lever 285 to the position shown. As the bimetal 291 cools and resumes its normal position, the latch 295 reengages the latch 301.

The bimetal elements 291 and 297 have the same characteristic and deflect upwardly an equal extent in response to a rise in ambient temperature, thus providing a maximum correction for variations in ambient temperatures.

According to the modification shown in Fig. 4 of the drawings, the breaker is tripped after a time delay in response to overloads below the predetermined value under the control of an oil dashpot. On overload currents above the predetermined value, the breaker is tripped instantaneously independently of the dashpot.

The trip lever 177 shown in Fig. 4 is identical with the lever 177 shown in Fig. 2 and operates in the same manner to trip the breaker instantaneously on overloads above the predetermined value. The magnet 160, including the magnet core 161—163 and the energizing coil 82, is the same as that shown in Fig. 2, and the trip lever 205 is the same as the one shown in Fig. 2 with the exception that the cross bar 207 is omitted, the right-hand arms are shortened and are operatively connected by means of a rod 319 and pivot pin 321 to the piston 323 of a dashpot indicated generally at 325. The dashpot 325 may be of any suitable type, such, for instance, as is fully disclosed in the copending application of John W. May and William H. Stuellein, Serial No. 392,048, filed May 6, 1941, and assigned to the assignee of the instant invention, which application became Patent No. 2,340,973 on February 8, 1944. The dashpot is of the suction disk type and comprises a cup-shaped member or pot 327 secured to the bottom of the frame 165 and at least partially filled with oil. The piston 323 is provided with suction surfaces (not shown) on its lower face which cooperate with similar suction surfaces (also not shown) in the bottom of the cup 327. The cup is so mounted that it may be rotated to vary the effective suction area which provides a convenient means of determining the tripping time delay of the breaker on overloads below the predetermined value.

As previously mentioned, the magnet 160 is energized sufficiently to instantaneously trip the breaker when an overload above the predetermined value or a short circuit occurs, the trip lever 177 operating independently of the trip lever 205 and the dashpot.

Normal rated current flowing through the coil 82 does not energize the magnet 160 sufficiently to attract the armatures 183 and 209 and overcome the tension of the spring 191. When an overload current below the predetermined value occurs, the increased energization of the magnet 160 creates a pull on the armatures sufficient to overcome the spring 191 and applies a force on the rod 319 in an upward direction, which, after a time delay determined by the magnitude and duration of the overload, breaks the suction or oil seal between the suction surfaces of the piston 323 and the cup 327. The magnet 160 then attracts the armatures and operates the trip levers 177 and 205 to trip the breaker. When the overload current is interrupted, the springs 191 function to restore the lever 177, and by means of the armature 183, the lever 205 to normal position as shown in Fig. 4.

We claim as our invention:

1. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip mechanism comprising a trip member operable to cause opening of the contacts, an electromagnet operable in response to overload currents above a predetermined value to instantaneously operate the trip member, a second member operable by said magnet to operate the trip member, a latch normally restraining said second member against operation and operable to release said second member, a thermally responsive bimetallic element heated in response to the current of the circuit and operable when heated a predetermined amount in response to overload currents below said predetermined value for operating said latch, and an ambient responsive bimetallic element intermediate the thermally responsive bimetallic element and the latch for compensating the device for changes in ambient temperature.

2. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of said contacts, an electromagnet operable in response to overload currents above a predetermined value to operate said trip member, a second member operable to operate the trip member, a latch normally restraining said member against operation and operable to release said member, an ambient temperature responsive bimetallic element secured to said latch, and a thermally responsive bimetallic element heated in response to the current of the circuit and operable when heated a predetermined amount to engage said ambient temperature responsive bimetallic element and operate the latch, said ambient temperature responsive bimetal compensating the device for changes in ambient temperature.

3. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of the contacts, an electromagnet operable in response to overload circuits for operating said trip member, an armature operable by said electromagnet under certain conditions to operate the trip member, said trip member being operable under certain other conditions independently of said armature, a latch member normally latching said armature against operation and movable to an unlatching position to release the armature, an ambient temperature responsive bimetallic element operatively associated with said latch member, and a thermally responsive bimetallic element heated in response to the current of the circuit and operable when heated a predetermined amount to cause said armature to be released, said ambient responsive bimetallic element acting in response to changes in ambient temperature to compensate the device for changes in ambient temperature.

4. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of the contacts, an electromagnet operable in response to overload currents above a predetermined magnitude to instantaneously operate said trip member, a second member operable by said electromagnet in response to overload currents below said predetermined magnitude to operate said trip member, said trip member being operable instantaneously upon overloads above said predetermined magnitude independently of said second member, an ambient responsive bimetallic element operatively associated with said second member, and a thermally responsive bimetallic element cooperating with said ambient responsive bimetallic element to normally restrain the member against opera-

tion, said thermally responsive bimetallic element being heated in response to the current of the circuit and operable when heated a predetermined amount by overload currents to release said second member and permit said second member to operate the trip member.

5. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including an electromagnet, a trip member operable by said electromagnet under certain circuit conditions to cause instantaneous opening of the contacts, an auxiliary member operable by said electromagnet under certain other circuit conditions to operate the trip member, an ambient temperature compensating bimetal element operatively associated with said auxiliary member, and a thermally responsive bimetal element cooperating with said ambient compensating bimetal element to normally restrain the auxiliary member against operation, said thermally responsive bimetal element being operable when heated a predetermined amount in response to said certain other circuit conditions to release the auxiliary member and thereby cause the electromagnet to operate the trip member.

6. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of said contacts, an electromagnet operable in response to overload currents above a predetermined value to instantaneously operate the trip member, an auxiliary member operable by said magnet to operate the trip member, a latch member normally restraining said auxiliary member against operation, a pair of bimetallic elements disposed to deflect in the same direction when heated, one of said bimetallic elements being operatively associated with the latch member and responsive to changes in ambient temperature, and the other of said bimetallic elements being heated in response to the current of the circuit and operable when heated a predetermined amount in response to overload currents below the predetermined amount to effect unlatching of the auxiliary member.

7. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of said contacts, an electromagnet operable in response to overload currents above a predetermined value to instantaneously operate said trip member, an auxiliary member operable by said electromagnet to operate the trip member, a latch member for restraining said auxiliary member against operation, a pair of bimetallic elements disposed to deflect in the same direction when heated, one of said bimetallic elements being operatively associated with said latch member, and the other of said bimetallic elements being operable when heated a predetermined amount in response to overload currents below said predetermined value to cause operation of the latch member to release said auxiliary member, and adjusting means comprising an adjustable member rotatably mounted on the thermally responsive bimetallic element and movable therewith and a member mounted for universal movement in a fixed support for operating said adjustable member to determine the unlatching point of the latch member.

8. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of said contacts, a latch normally restraining said trip member against operation and operable to release said member, an ambient temperature responsive bimetallic element secured to said latch, and a thermally responsive bimetallic element heated in response to current of the circuit and operable when heated a predetermined amount to engage the ambient temperature responsive bimetallic element and operate the latch, said ambient temperature responsive bimetallic element compensating the device for changes in ambient temperature.

9. A circuit breaker comprising relatively movable contacts, operating mechanism therefor, a trip device including a trip member operable to cause opening of the contacts, a latch normally restraining said trip member against operation and operable to release said trip member, an ambient temperature responsive bimetallic element secured to said latch, a low temperature responsive bimetallic element disposed in heat conducting relationship to a current conductor of the breaker and operable when heated a predetermined amount to engage the ambient temperature responsive bimetallic element and operate the latch, said ambient temperature responsive bimetallic element compensating the device for changes in ambient temperature.

10. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of said contacts, a latch member for restraining said trip member against operation, a pair of bimetallic elements disposed to deflect in the same direction when heated, one of said bimetallic elements being operatively associated with the latch member, and the other of said bimetallic elements being operable when heated in response to overload currents to cause operation of the latch member to release the trip member, an electromagnet operable in response to overload currents to operate said trip member, and adjusting means comprising an adjustable member rotatably mounted on the thermally responsive bimetallic element and movable therewith and a member mounted for universal movement in a fixed support for operating said adjustable member.

11. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including a trip member operable to cause opening of the contacts, an electromagnet operable in response to overload current above a predetermined value to operate the trip member, a second member operable to operate the trip member, a latch member for normally restraining said second member against operation, said latch member being pivoted on a fixed pivot, an ambient temperature responsive bimetal element secured to said latch member, and a thermally responsive bimetal element heated in response to the current of the circuit and operable when heated a predetermined amount to move the ambient temperature responsive bimetal and operate the latch, said ambient temperature responsive bimetal compensating the trip device for changes in ambient temperature.

12. A circuit breaker comprising relatively movable contacts, operating mechanism for said contacts, a trip device including an electromagnet, a trip member operable by said electromagnet in response to overload currents above a predetermined value to cause instantaneous open-

ing of the contacts, an auxiliary member operable by said electromagnet to operate the trip member, an ambient temperature responsive bimetal element mounted on said auxiliary member for movement therewith, a thermally responsive bimetal element cooperating with said ambient temperature responsive bimetal to normally restrain said auxiliary member against operation, said thermally responsive bimetal element being operable when heated a predetermined amount in response to overload currents to release the auxiliary member and thereby cause the electromagnet to operate the trip member.

13. A circuit breaker comprising relatively movable contacts, operating mechanism therefor, a trip device including a trip member operable to cause opening of the contacts, an electromagnet operable in response to overload currents above a predetermined value to instantaneously operate said trip member, an auxiliary member operable by said electromagnet to operate the trip member, an ambient temperature responsive bimetal element mounted on and movable with said auxiliary member, a latch member on said bimetal element, a thermally responsive bimetal element, a latch on said thermally responsive bimetal element cooperating with said latch member to normally restrain the auxiliary member against operation, said thermally responsive bimetal deflecting when heated a predetermined amount in response to overload currents below said predetermined value to release said auxiliary member and thereby cause the magnet to operate the trip member.

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