Aug. 12, 1958 P. M. CHRISTENSEN 2,847,533

CIRCUIT BREAKERS

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Fig. 1.

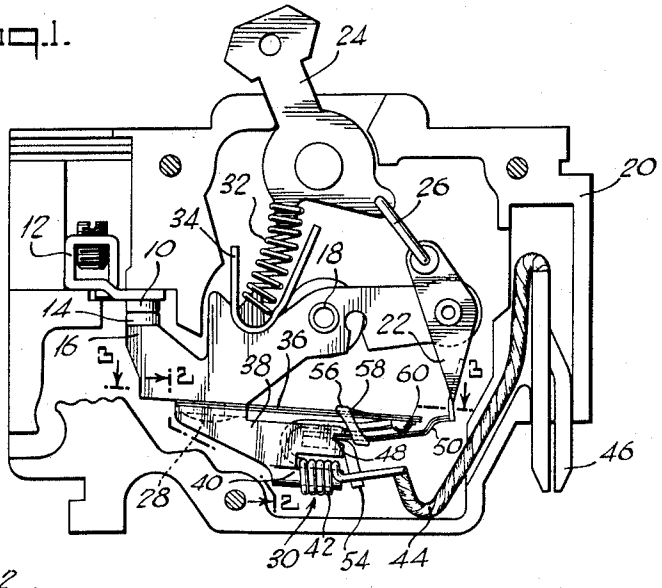


Fig. 2.

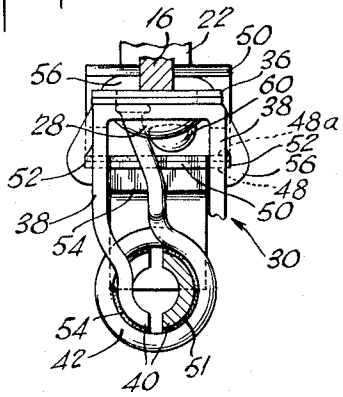


Fig. 3.

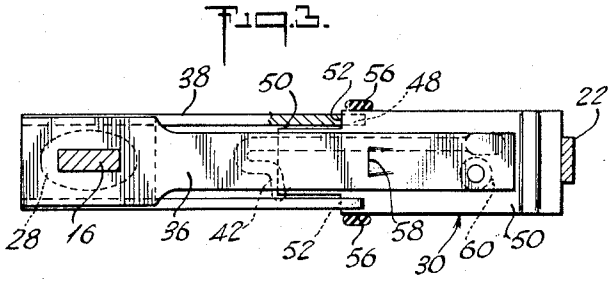
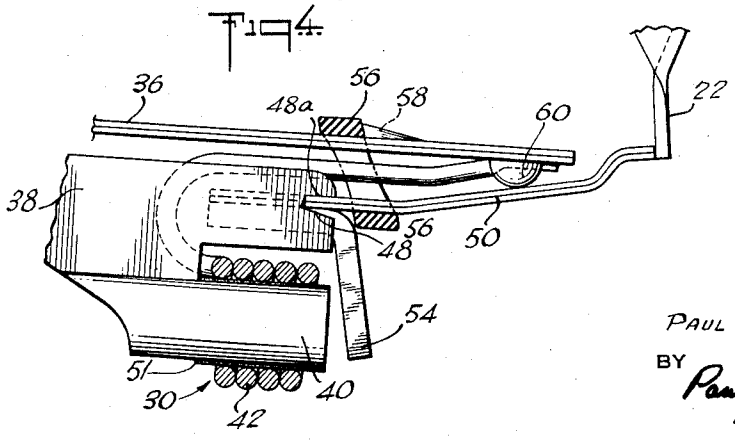


Fig. 4.



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CIRCUIT BREAKERS

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12 Claims. (Cl. 200—88)

The present invention relates to circuit breakers, and in particular it is concerned with combined thermal and magnetic tripping mechanisms for such breakers.

The present invention will be recognized as having wide application to various types of circuit breakers but, as will be seen, it has particular merit in connection with that type of circuit breaker wherein the trip assembly is mounted on the moving contact arm so as to be movable therewith. That type of mechanism has many signal advantages, not the least of which is the possibility of calibrating the trip mechanism as a subassembly prior to mounting thereof in an insulating housing.

An object of the present invention is to provide a novel trip assembly for circuit breakers enabling superior sensitivity both with respect to thermal and magnetic response to low currents.

A widely employed form of circuit breaker employing thermal and magnetic tripping means utilizes a bimetal as the thermal current-responsive element; and this bimetal also serves to latch and release the circuit-breaker-opening mechanism. In such arrangement the bimetal is of necessity relied upon to resist the mechanical stress imposed by that mechanism which, upon thermal overload, causes the contact-opening mechanism to operate. It is desirable to reduce this mechanical load because of the corresponding reduction in the speed of opening of the contacts. Nevertheless, the practical limitations, such as the mechanical strength and thermal deflection characteristic of various bimetals are limitations on the minimum current ratings that may be made with practical success. In accordance with one feature of the present invention, the current-responsive bimetal is relied upon only to produce a lateral tripping force and is relieved of the mechanical compressive stress ordinarily imposed endwise on the bimetal by the contact-opening mechanism in the class of circuit breakers that use the bimetal in endwise compression. That is true of a very popular type of circuit breaker wherein the bimetal is movably carried by pivoted contact arm.

A further feature of the invention is to combine with a sensitive thermal tripping mechanism a correspondingly sensitive magnetic tripping.

The illustrative embodiment described in detail below will be seen to include an electromagnet having a core structure and an armature, with a winding about the core, wherein both the core and armature are supported separate and apart from the current-responsive bimetal. In this way, not only is the bimetal relieved of the endwise stress imposed in widely known forms of circuit breakers but in addition the bimetal is relieved of the mechanical load and inertia effects of such mechanical load that are of special significance where the tripping assembly is to shift abruptly during opening of the contacts. This abrupt shifting involves inertia effects of the tripping assembly when the tripping assembly is movably carried with the movable contact member.

The circuit breaker art in which the present invention represents a distinct improvement is very prominently

concerned with low cost without sacrifice of performance, because only through low cost can the advantages of such circuit breakers be made available for large scale use. Accordingly further features of the present invention involve unique features of construction promoting orderly and efficient assembling of the circuit breaker mechanism, and further minimizing variation in magnetic, tripping sensitivity of the novel circuit breakers without resorting to separate calibration of the magnetic tripping level.

Further features of the invention will be apparent from the following detailed description of an illustrative embodiment thereof which is shown in the accompanying drawings. In the drawings:

Fig. 1 is a side view of an assembled circuit breaker with one part of a two-part enclosure of insulation removed to reveal the internal construction;

Fig. 2 is a fragmentary end view of certain parts in Fig. 1 viewed from the line 2—2;

Fig. 3 is a fragmentary cross-section along the line 3—3 in Fig. 1; and

Fig. 4 is an enlarged portion of Fig. 1.

Referring now to the drawings there is shown in Fig. 1 a circuit breaker assembly including a fixed contact **10** carried by one terminal member **12** and a movable contact member **14** carried by movable contact arm **16**. Contact arm **16** is pivoted on a helical spring **18** whose axis extends perpendicular to the drawing and whose ends are received in recesses in the side walls of the two-part enclosure, only one part **20** being shown in the drawing. A metal actuator **22** has a metallic pivotal connection to the right-hand extremity of moving contact arm **16**. That a metal pivot rather than an insulated pivot may be employed at this point is significant because it facilitates the problem of holding close tolerance at this relatively critical part of the mechanism. A handle **24** of insulation is pivoted in the side walls of the insulated housing and is connected by a link **26** to operate actuator **22**. Member **26** is U-shaped with one leg (perpendicular to the drawing) received in a hole in handle **24** and the other leg of the U being received in a bearing in actuator **22**.

Moving contact arm **16** has a downward extension formed as a rivet **28** to unite latching assembly **30** to the moving contact arm, in position normally to obstruct and thereby to latch actuator **22**.

A spring **32** is held in compression between handle **24** and moving contact arm **16**. Contacts **10** and **14** are shown closed, and handle **24** is in the "closed" position. If handle **24** is operated clockwise from the position shown, the handle shifts link **26** so that the link and actuator **22** (which constitute a toggle) tend to swing actuator **22** counterclockwise and to allow spring **32** to drive moving contact arm **16** counterclockwise. When this occurs, assuming handle **24** is retarded, spring **32** is also effective to drive the handle clockwise all the way to its "off" position in readiness for renewed closing of the circuit breaker.

When handle **24** is operated in the counterclockwise direction (Fig. 1) from its "off" position, link **26** drives actuator **22** against the end of the latching assembly **30** to be arrested there. Further counterclockwise operation of the handle drives the moving contact arm **16** into contacts-closed position. Spring **18** allows the relatively rigid members **24**, **20**, **26** and **16** to complete their operation into "on" configuration even though moving contact **14** engages fixed contact **10** shortly before the handle completes its "on" stroke. V-shaped member **34** coacts with casing formations and with springs **18** and **32** to first arrest contact arm **16** and then release it for contact-closing with "snap" action.

Latch assembly **30** includes a current-responsive bimetal **36** secured by integral rivet **28** to moving contact

arm 16 mechanically and electrically. This integral rivet also secures a magnetic core structure 38 fixedly to moving contact arm 16.

Member 38 has a connecting portion through which rivet 28 extends (Fig. 2) and a pair of side walls extending therefrom to incorporate a two-part curved core 40 about which a coil 42 as of copper wire is wound. One terminal of this coil is welded to the right-hand extremity of current-responsive bimetal 36 while the other terminal of the coil is joined to flexible copper braid 44 for connection to external terminal 46.

The side walls of magnetic structure 38 have notches 48 formed therein, opening toward actuator 22 pivotally or rockably supporting a latch member 50 by virtue of the shoulders 52 thereof. Armature 54 is united to the left-hand extremity of latch member 50. As shown in Fig. 4, this latch member has one arm which substantially occupies the space between the side walls of magnetic member 38 in the region of notches 48, this arm moving laterally along those magnetic side walls when coil 30 is appropriately energized. Armature 54 also has an arm extending downward and opposite the end of core 40. It is evident that a highly efficient magnetic circuit is formed of core 40 and the side walls of magnetic structure 38 which embrace the first-mentioned arm of armature 54. Consequently the current that flows through the circuit breaker energizes coil 40 and exerts a comparatively strong attraction for armature 54, and this in turn produces a tripping force exerted clockwise to swing latch member 50 out of the path of actuator 22 when the predetermined level of magnetic-tripping current flows.

Members 50 and 54 which are secured together as a combined latch-and-armature unit, are biased to the left and counterclockwise in Fig. 4 by a band 56 that is of insulation and acts as a spring. In concept, a metallic leaf or coil spring joined to an appropriate part of core structure 38 or arm 16 might be used, but the insulating elastic band is eminently more practical. A lance 58 projects upward from bimetal 36 to prevent the upper part of band 56 from sliding to the right (Fig. 1) on the bimetal. Armature 54 is a corresponding formation on latch-and-armature unit 50—54 that prevents the lower part of band 56 from shifting to the left (Fig. 1). In this way band 56 retains assembly 50—54 into its supporting notches 48, and band 56 also biases latch 50 in the reset or latching direction, that is, in the direction for operative engagement with bimetal 36.

In the extreme counterclockwise position of member 50 as illustrated, it bears against a button 60 of insulation carried by current-responsive bimetal 36. Core 40 is coated with insulation 51, and, as noted, band 56 is of insulation. Thus, the coil 42 and the movable end of bimetal 36 are insulated from core structure 38 that is united electrically to the contact arm 16 and is therefore at the same potential as the fixed end of bimetal 36.

The operation of the above tripping mechanism may now be described. Current flowing from one terminal 46 and braid 44 through coil 42 travels along current-responsive bimetal 36, to moving contact arm 16, through contacts 14 and 10, to opposite terminal 12. For small levels of current, the current-responsive bimetal 36 deflects downward only slightly, and the magnetic field produced by coil 42 and core 40 is inadequate to cause tripping. Before tripping can occur, latch 50 must be pressed down through a sufficient distance to clear actuator 22. Bimetal 36 is required to overcome the latch friction of latch 50 wiping across the latching end of actuator 22, this deflecting force requiring a much lower order of strength or stiffness than would be required of it if it were also to resist the endwise force applied by actuator 22 against the end of latch 50. Because only a low order of deflecting force is needed bimetal 36 can be made of relatively slender proportions so that its resistance can be relatively high and consequently tripping heat can be developed in response to low values of rated tripping current. In other words high thermal sensitivity can be realized.

When the current rises to a sufficient level, and for a sufficient period of time for the bimetal temperature to rise and cause sufficient deflection, thermal tripping takes place. Button 60 of insulation pushes latch 50 down out of the path of actuator 22. The latter swings clockwise quickly and spring 32 is then enabled to drive contact arm counterclockwise. If handle 24 is not held, it is also returned to "off" position at this time by spring 32. The linkage 26, 22 is then in condition for renewed closing of the circuit breaker. If handle 24 is later released, spring 32 effects resetting of the circuit breaker in condition for reclosing.

Thermal tripping requires some short delay-time during which the current-responsive bimetal is heated by the current through the circuit breaker. Magnetic tripping involves no such delay, but magnetic tripping is commonly desired to operate at a level of 6 to 10 times the thermal tripping level in order that the circuit breaker shall not open in response to safe surge currents such as the in-rush current of a cold tungsten lamp load, which, when heated, draws a much lower operating current. In order to achieve magnetic tripping of 6 to 10 times the thermal trip rating, especially for small values of rated current, the present circuit breaker construction provides excellent sensitivity without an undue, massive number of turns in coil 42. Low mass is important for a minimum of inertia of parts carried by the moving contact arm, such inertia having a retarding effect on opening of the contacts after tripping occurs.

When the instantaneous current through the circuit breaker exceeds the magnetic tripping level, armature 54 swings clockwise and pulls latch 50 away from button 60 and out of latching engagement with actuator 22. Contact opening after magnetic tripping is the same as in connection with thermal tripping described above, but magnetic tripping involves no such delay as that occasioned by heating of the bimetal.

In the event of a short circuit being imposed on the circuit protected by the circuit breaker, a high instantaneous voltage develops between the wire of coil 42 and the metallic assembly 16—38—40. For this reason it is desirable to coat either or both of members 40 and 42 with insulation as, for example, an insulating enamel 51 on core 40. This insulation, and button 60 and band 56 of insulation prevent any portion of the normal circuit breaker current from by-passing bimetal 36 and the insulation also prevents occasionally heavy currents from flowing from the movable end of bimetal 36 to latch 50, to iron structure 38 joined to the fixed end of bimetal 36. Sparking or welding at the latch pivot might otherwise result in extreme conditions.

Member 50, described as a latch, is formed as a bimetal and arranged to curve in the reverse direction, compared to bimetal 36. The low-expansion sides of those bimetals face each other. Insulation button 60 bears against bimetal 50 between the ends thereof and, when bimetal 36 deflects downward, not in response to current but in response to an ambient temperature rise, bimetal 50 compensates by curving downward. In the embodiment illustrated, insulating button 60 engages bimetal latch 50 closer to the latching point than to latch pivot 52. This is of particular advantage in circuit breakers of low current ratings, where weak current bimetals may be expected. The force developed by bimetal 36 for tripping the breaker is required to overcome resistance to unlatching movement of the latch, developed at the point of engagement with actuator 22. This frictional resistance is developed at the end of the full length of lever 50, where the unlatching force developed by bimetal 36 is applied to lever 50 at a fraction of its length. This ratio of lever lengths is a disadvantage to circuit breakers that depend on weak current-responsive bimetals;

and the mechanical disadvantage in such breakers can be minimized by arranging effective coaction between the bimetals to be at a point of compromise between the ends of the compensating bimetal nearer to actuator **22** than to pivot **48—52**.

It has been noted that band **56** is an insulated tensioner between the bimetal **36** and the latch **50**. In the circuit breaker this tensioner is required to serve reliably for an indefinitely long period, and it is also subject to the elevated temperatures that may develop in current-responsive bimetal **36** due to overload. This band **56** is particularly effective when made of silicone rubber which has the properties of sustained resilience over long periods of time and of stable characteristics at normal and elevated temperatures, and is thus of special value in the organization described.

Tensioning band **56** is effective to bias the combined armature and latch unit **50—54** against the left-hand extremity the bottom, of notch **38**. It also biases member **50** against the top edge **48***a* of notch **48**, and against button **60** carried by bimetal **36**. Because of the few dimensional variables in the unity core structure **38** and in the latch-and-armature unit **50**, the orientation of latch member **50** is quite stable when once calibrated. This factor is of great importance in the routine production of circuit breakers which are to have and retain consistent characteristics. A further factor in this consistency is that, even with relatively strong bands **56** and firm, possibly variable tensions developed by the several bands **56** in many circuit breakers made in production, the magnetic tripping sensitivity is high and consistent. This tensioning band applies its force close to the pivot point of latch **50**, that is, close to shoulder **52**, and the distance between the band and that shoulder can readily be held to a consistent dimension, so that the counter-clockwise tensioning moment is small. Magnetic tripping force must overcome latch friction and little more. Consequently the magnetic tripping sensitivity as previously noted remains consistent from each breaker to the next in mass produced circuit breakers, and the sensitivity is high.

The initial calibration of the circuit breaker is achieved as in a widely used circuit breaker of this type by driving a wedge in the calibrating notch in arm **16** between pivot **18** and actuator **22** when the bimetal **36** has been heated by carrying rated current for a rated time interval. The wedge is then driven into the notch sufficiently to cause latch **50** to move relatively down and out of obstructing position at the end of latch **22**, and the calibrating wedge is removed.

In this circuit breaker, actuator applies an endwise, compressional force on latch **50** toward the latch pivot, being the principal force holding the latch in its separable pivot or hinge seat **48—52** when the circuit breaker is closed. Viewed otherwise, the latching end of actuator **22** moves in the direction along which latch **50** extends, at the instant of release of the actuator. When the circuit breaker is open, band **56** holds latch **50** in its seat.

It will be appreciated that the illustrative embodiment employs various features of the invention in exemplary fashion, but that certain features may well be applied to other types of circuit breakers than that illustrated; and consequently this invention should be broadly construed in accordance with its spirit and scope.

I claim:

1. A thermal and magnetically tripped circuit breaker having a pair of separable contacts, a manually operable mechanism to open and close the contacts and a metallic actuator effective when released to cause automatic opening of the contacts, a movable arm carrying one of said contacts and having a metallic pivot to said actuator, and a latching assembly movably carried by said contact arm and effective under normal current conditions to arrest said actuator, and to release said actuator in response to overload currents, said latching assembly including a current-responsive bimetal connected electrically in series with said contacts and joined at one end thereof to the contact arm and having a free end that shifts laterally in response to thermal changes in the bimetal, a magnetic pole structure united to the contact arm at the same point where said current-responsive bimetal is united thereto, said core structure embodying a core and having a recessed formation that opens toward said actuator, a latch-and-armature unit having a portion rockably received in said recessed formation as a readily separable hinge, said latch-and-armature unit including an elongated latch disposed substantially lengthwise in the path of said actuator during normal current conditions and having a two-armed armature, one arm of the armature extending opposite said pole and the other arm of the armature being movable laterally along a portion of said magnetic core structure, an insulating element at the movable end of said current-responsive bimetal, biasing means normally holding said latch-and-armature unit both in rockable assembly with said core structure and laterally in engagement with the insulating element on said current-responsive bimetal, and a coil on said core and connected in series with said current-responsive bimetal.

2. A thermally and magnetically tripped circuit breaker having a pair of separable contacts, a manually operable mechanism to open and close the contacts and an actuator effective when released to cause automatic opening of the contacts, one of said contacts being movably carried by a movable contact arm, and a latching assembly, said circuit breaker being of the type having the latching assembly movably carried by said contact arm and effective under normal current conditions to arrest said actuator, and to release the actuator in response to overload currents, said latching assembly including a current-responsive bimetal, connected electrically in series with said contacts and joined at one end thereof to said contact arm and having a free end that shifts laterally in response to thermal changes in the bimetal, a magnetic pole structure united to the contact arm at the same point where said current-responsive bimetal is united thereto, said core structure embodying a core, a latch-and-armature unit pivoted to said core structure and having a latch disposed in the path of said actuator during normal current conditions, said unit having a two-armed armature, one arm of the armature extending across said pole and the other arm of the armature being movable laterally along a portion of said magnetic core structure, biasing means normally holding said latch-and-armature unit toward the pivot thereof and laterally into operative engagement with the free end of said current-responsive bimetal, and a coil on said core and connected in series with said current-responsive bimetal.

3. A circuit breaker having separable contacts one of which is carried by a movable contact arm, manually operable mechanism to open and close said contacts, and overload responsive means carried by said movable contact arm for causing automatic separation of the contacts in response to fault currents, said overload responsive means including a current-responsive bimetal and a magnetic core structure united to said contact arm at a common point to be carried as unit therewith, a combined latch-and-structure unit pivoted to said core structure and having an elongated latch disposed in the path of deflection of said bimetal to be operated thereby for automatic release of the circuit breaker in response to thermal overload currents and a coil on said core structure effective to operate said latch in the tripping direction and away from said current-responsive bimetal in response to magnetic overload currents.

4. A circuit breaker in accordance with claim 3 wherein said latch is an ambient temperature responsive bimetal, arranged to be operatively engaged between its pivot end and its latch end by said current-responsive

bimetal, said bimetals being arranged to curve oppositely in response to heat.

5. In a circuit breaker having a pair of separable contacts and a movable contact carrying arm for one of said contacts, an overload release assembly carried by said movable contact arm and including both a current-responsive bimetal and a magnetic core structure carried by said contact arm and united thereto at a common point, said current-responsive bimetal having a free end portion that deflects laterally in response to temperature variations, a combined latch-and-armature unit pivoted to said core structure and disposed in the high-temperature deflection path of said bimetal for operation thereby in response to thermal overload currents, and a coil carried by said core structure and connected in series with said bimetal for magnetizing said core structure and thereby operating said combined latch-and-armature unit in the circuit-breaker-releasing direction and out of operative connection to said bimetal in response to magnetic overload currents higher than said thermal overload currents.

6. In a circuit breaker having manual operating means for opening and closing the circuit breaker and having a movable contact arm carrying an actuator effective when released to cause opening of the circuit breaker, and said movable contact arm carrying a latching assembly normally arresting said actuator, said latching assembly including a current-responsive bimetal and a magnetic core structure united to said contact arm, and a combined latch-and-armature unit carried by said core structure and operable laterally by said bimetal for releasing said actuator in response to thermal overload currents, and a coil mounted on said core structure effective to operate said latch-and-armature unit in the release direction and away from said current-responsive bimetal in response to magnetic overload currents.

7. In a circuit breaker having manual operating means for opening and closing the circuit breaker and having a movable contact arm carrying an actuator effective when released to cause opening of the circuit breaker and said movable contact arm carrying a latching assembly normally arresting said actuator, said latching assembly including a current-responsive bimetal, a latch formed as an elongated ambient temperature bimetal extending along said current-responsive bimetal, a latch support carried by said contact arm alongside said current-responsive bimetal and forming a pivotal connection to the latch, and a tensioning spring biasing the latch into lateral coaction with said current-responsive bimetal for deflection thereby.

8. A circuit breaker having manual operating means for opening and closing the circuit breaker and having a movable contact arm carrying an actuator effective when released to cause opening of the circuit breaker and said movable contact arm carrying a latching assembly normally arresting said actuator, said latching assembly including a current-responsive bimetal and a member forming one part of a separable hinge fixed to said contact arm, an elongated latch separably and rockably engaging said fixed hinge member and operable laterally by said bimetal for releasing said actuator in response to thermal overload currents, and a spring biasing said latch both toward the seat and laterally toward said bimetal.

9. A circuit breaker of the type having manual operating means for opening and closing the circuit breaker, a moving-contact arm, an overload-release latching assembly carried on said arm and an actuator carried on said arm and normally arrested by said latching assembly but operative when released to cause contact-opening operation of the contact arm, said latching assembly including a combined latch-and-armature unit having an elongated latch member formed with a latching end in the path of said actuator during normal current conditions and extending from said latching end in the direction initially traveled by the arrested portion of said actuator upon release, a magnetic core structure carried by said contact arm and pivotally supporting said latch-and-armature unit, a coil carried by said magnetic core structure and arranged to operate said latch-and-armature unit in response to overload current, and a bimetal connected in series with said coil and arranged to engage said member between the pivot and the latching end and to deflect said latch-and-armature unit for release of said actuator in response to thermal overload current, said current-responsive bimetal being disposed with its low-expansion side facing said latch-and-armature unit, and said coil and armature being arranged to deflect said unit away from said bimetal in response to magnetic overload currents.

10. A circuit breaker in accordance with claim 9 wherein said latch member is a bimetal for compensating for ambient temperature variations having the low expansion side thereof facing the low expansion side of the current-responsive bimetal.

11. A circuit breaker having manual opening and closing means and automatic overload release means, said release means including a latching assembly having a current-responsive bimetal, a magnetic core structure disposed on the low-expansion side of the bimetal, a coil on the magnetic core structure and electrically connected in series with said bimetal, and a combined latch-and-armature unit arranged to be operated in the circuit-breaker-releasing direction both by said bimetal and by the magnetic field produced by said coil, said latch-and-armature unit having a latch element formed of an ambient temperature compensating bimetal pivoted to the core structure at one end and having a latching portion at its opposite end and said compensating bimetal being operatively engaged by said current-responsive bimetal between said ends.

12. A circuit breaker having manual opening and closing means and automatic overload release means, said overload release means including a latching assembly having a current-responsive bimetal, fixed at one end and having an operative portion, an elongated ambient temperature compensating bimetal disposed on the low-expansion side of the current-responsive bimetal, said compensating bimetal having its low-expansion side facing the low expansion side of the current-responsive bimetal, said compensating bimetal having a latching portion and a pivot remote from said latching portion and being operatively engaged by said operative portion of said current-responsive bimetal between and spaced substantially from both said latching portion and said pivot.

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