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CIRCUIT BREAKERS

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Fig. 1.

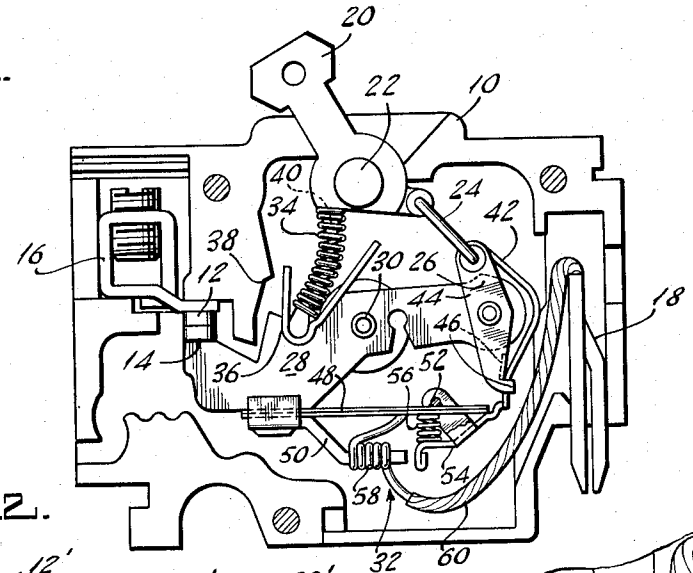


Fig. 2.

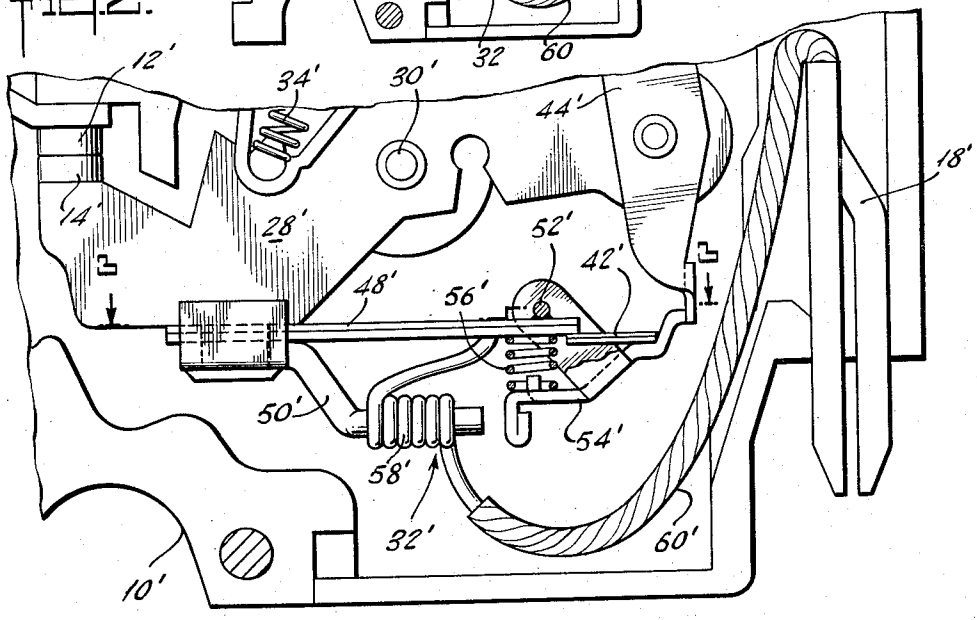
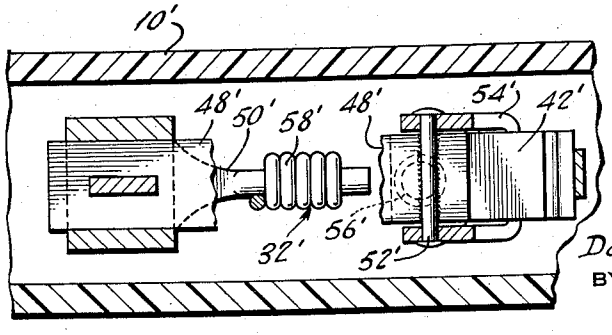


Fig. 3.



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2,876,309

CIRCUIT BREAKERS

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17 Claims. (Cl. 200—88)

The present invention relates to circuit breakers of the type combining fast magnetic tripping and thermal delay tripping characteristics. The invention has special application to circuit breakers wherein the tripping mechanism is carried as part of a moving contact assembly, but its broader aspects are generally useful in many types of circuit breakers.

Circuit breakers combining magnetic and thermal tripping characteristics have the desirable properties of tripping almost instantly upon occurrence of a severe overload, due to the magnetic tripping arrangement, and of tripping only after a brief delay in response to currents that moderately exceed the normal trip rating. It is desirable for the fast magnetic trip to occur at a sufficiently high level so that tripping will not result when a safe load is being connected to the protected circuit, where that load may momentarily draw a high but safe surge current.

In one aspect this invention has as an object the provision of an improved circuit breaker having a novel magnetic trip associated with a thermal trip. More specifically, a further object is to provide an improved thermal and magnetic trip assembly in a circuit breaker of the type having both latch and trip devices movable with the moving contact.

A class of circuit breakers to which this invention is especially applicable is required to withstand peak current on short circuit that could be many hundreds of times the normal tripping current for which the breaker is rated. The current of the circuit breaker all passes through the current-responsive bimetal, as a practical matter; and unless protection is provided, such severe peak currents would tend to deform the bimetal permanently. Accordingly a further object of this invention resides in the provision of a more sensitive magnetic trip associated with a current-responsive bimetal that is fast acting, so that the bimetal is protected from damage from extremely high current peaks.

A specific feature of considerable advantage in the illustrative embodiments of the invention detailed below includes a combined thermal and magnetic trip, with a magnetic armature carried by the bimetal in such relation to its operating electromagnet that the air gap is not increased as a result of thermal deflection of the bimetal, whereby desired high sensitivity of the magnetic trip is maintained. In these illustrative embodiments, the magnetic trip is a single element that incorporates an armature and latch. The latch is operated in the tripping direction not only by the electromagnet, but also by the bimetal. The magnetic trip is not restrained or retarded by the bimetal. The arrangement involves a supporting pivot on the bimetal for the combined latch and armature. The electromagnet has its own support independent of the bimetal. As the bimetal deflects, it moves the armature across the electromagnet, rather than toward and away from the electromagnet. In structural terms, this means that the armature extends generally

perpendicular to the bimetal. During thermal deflection the combined armature and latch element moves as a unit with the bimetal across the end of the electromagnet. The air gap remains essentially constant, and consequently the magnetic tripping sensitivity is constant.

The arrangement described has general application; but it is of particular advantage in circuit breakers of the type having the trip mechanism mounted for movement with the moving contact. Such breakers open abruptly and, in better types, such breakers close abruptly. Abrupt contact motion enforces corresponding abrupt motion of the bimetal. The bimetal carries only the added mass of the armature-and-trip element, and not the electromagnet. This means that the inertia effects of the magnetic-trip masses on the bimetal are minimized. Heavy masses carried by the bimetal in this type of circuit breakers tend to produce bending stresses on the bimetal (especially damaging when the latter is hot) when the bimetal moves abruptly during snap opening and closing of the circuit breaker.

A further feature of this novel trip mechanism, as will be seen, is that it is adaptable to compensation for ambient temperature variations. Further features of novelty will be noted, and the invention will be better appreciated, from the following detailed disclosure of two illustrative embodiments shown in the annexed drawings which form part of this disclosure. In the drawings:

Fig. 1 is a somewhat enlarged side elevation of a circuit breaker embodying features of the present invention, the front half of the casing being removed to reveal the internal mechanism;

Fig. 2 is a fragmentary view similar to Fig. 1 of a modification of the embodiment in Fig. 1, drawn to a larger scale; and

Fig. 3 is a fragmentary cross-section of the latter embodiment, along the line of 3—3 of Fig. 2.

Referring now to Fig. 1 a circuit breaker is shown having a casing **10**, fixed contact **12** joined to screw terminal **16**, and movable contact **14**. A circuit extends from terminal **16** through the circuit breaker mechanism to "stab" terminal **18**. Contact **14** may be brought into engagement with contact **12** by a manually operated linkage. This linkage includes: handle **20** of insulating material having a pivot **22** in bearings in the casing, link **24** pivoted at one end to handle **20**, and actuator **26** pivoted to the other end of link **24** and to moving contact arm **28** that carries contact **14**. This moving contact arm **28** has a pivot **30** in the form of a coil spring whose axis extends perpendicular to the view and has end bearings in the casing, to yieldably support contact arm **28**. When handle **20** is shifted from the extreme right-hand position to the left-hand position shown, the linkage including handle **20**, link **24** and actuator **26** operates moving contact arm **28** so as to swing arm **28** clockwise about pivot **30** and force contact **14** against fixed contact **12**. The linkage that operates contact arm **28** is all rigid or substantially so, but yielding pressure of contact **14** against contact **12** is achieved by virtue of the spring pivot **30**.

The closing operation of the circuit breaker mechanism thus far described depends on the latching of actuator **26** in the position shown by the combined thermal and magnetic latching assembly generally designated by the arrow and numeral **32** detailed below.

A V-shaped member **36** is rockably carried by arm **28**. When the handle is operated to close the breaker, member **36** coacts with cam **38** formed on the casing wall, to cause closing of the contacts with a snap, even if the handle should be moved gradually. During the closing operation, moving contact arm **28** gradually raises the left-hand arm of element **36** so that that arm travels

along cam surface 38 until it is arrested by the shouldered part of the cam. At this stage, the moving contact is spaced a substantial distance away from the fixed contact 12. As the closing operation of handle 20 continues, and toggle 20—24 straightens, contact arm 28 is shifted to the right, spring pivot 30 yielding in the course of this operation. In this way, element 36 is shifted to the right and out of contact with the shoulder portion of cam 38. This frees moving contact arm 28 to move with snap action upward and to the left, into firm wiping contact with fixed contact 12. Portion 40 of handle 20 also insures the removal of element 36 from the shoulder portion of cam 38 by engaging the right-hand arm of element 36. To open the circuit breaker manually, handle 20 is shifted to the right from the position shown in the drawing. This reverses toggle 20—22 to release actuator 26 and contact arm 28 for abrupt opening motion, spring 34 acting to drive the moving contact 14 away from fixed contact 12. V-shaped element 36 also promotes this opening operation. The arm of handle 20 to which link 24 is pivoted strikes the right-hand arm of element 36, tending to drive moving contact arm 28 positively in the opening direction despite the possibility of a superficial weld having been formed between the contacts.

Actuator 26 is a composite structure including ambient temperature compensating bimetal 42 which is held in place at one end, being looped about the pivot of link 24. At its other end, bimetal 42 moves in slide bearings 46 in the formed sheet-metal part 44, and the two ends of the bimetal are interconnected by a bowed length of bimetal. When the ambient temperature changes, the lower end of the bimetal 42 slides in and out, to compensate for deflection of bimetal 48 due to changes in ambient temperature. An insulating bearing is interposed between metal part 44 and moving contact arm 28, to avoid a shunt electrical path being formed that would by-pass part of the current intended for the thermal and magnetic tripping devices.

The current-responsive bimetal 48 is rigidly joined at its left-hand end to moving contact arm 28. A magnetic core 50 is also joined to contact arm 28 at this point, by a rivet extending integrally from the contact arm. The cross-section of the rivet is rectangular and the holes in the bimetal and the magnetic core 50 are also rectangular so that they do not tend to twist out of position. A coil of insulated wire 58 wound about core 50 has one end welded to bimetal 48 as far from the supporting rivet as practicable and the other end of coil 58 is connected by a flexible copper braid 60 to "stab" terminal 18.

A pivot 52 is welded to the bimetal 48 near the right-hand free end of the bimetal. This pivot carries a combined latch and magnetic armature 54 which is biased by spring 56 counterclockwise into a normal position limited by the free end of bimetal 48. The armature portion of member 54 is formed of sheet iron that is doubled back on itself as shown, to give extra thickness of magnetic material. This armature extends across the end of electromagnet 50, 58. In operation closing of the circuit breaker completes a circuit from "stab" terminal 18, through coil 58 and bimetal 48, through the contacts 12, 14 and to external terminal 16. Gradual heating of bimetal 48 due to the current which traverses the bimetal causes it to curve downward. When the peak steady-state rating of the breaker has been exceeded, bimetal 48 carries the latch member 54 out of its position obstructing actuator 26, thereby allowing the contact to snap open.

In the event of sudden currents which far exceed the rated tripping current level (as by a factor of ten) coil 58 causes pivoting of latch member 54 almost instantaneously, even before bimetal 48 has been heated enough for tripping, and latch 54 is magnetically tripped to open the breaker. This magnetic tripping occurs fast enough to prevent this bimetal being damaged by excessive heating. Potentially, the current that the breaker may be required to withstand may be several hundred times the rated current. Sensitive magnetic tripping promotes response to short-circuit and hence it provides superior protection for the current-responsive bimetal. This sensitive magnetic tripping also affords protection for the circuit immediately when clearly abnormal circuit conditions are demonstrated by currents greatly exceeding the rated current, by over ten times for example, without, however, tripping in response to safe surge currents of perhaps five times the steady-state rating of the circuit breaker. Such surges may occur when a large incandescent lamp load is switched on in the protected circuit.

The circuit protected by the circuit breaker may be carrying a steady-state load current at a time when an added load is switched on. Prior to that time, the current bimetal 48 was curved downward, but not enough for tripping. The armature part of element 54 was carried downward by the bimetal 48, but its spacing from electromagnet 50, 58 remains unaffected by the curvature. The magnetic trip will respond to the added load essentially in the same way that it would respond when there was no initial load in the protected circuit, because in both cases the magnetic air gap is the same.

The load current may rise to a point short of tripping, with latch 54 moving down along latch 26; and thereafter the current might fall off. Pivot 52 would then be raised with the cooling bimetal 48. Spring 56 advantageously is strong enough to overcome latch friction so as to keep the latch in engagement with the end of the current-responsive bimetal; but it should be weak compared to the leaf-spring stiffness of bimetal 48, in order to realize the full benefit of the pivoted sensitive magnetic trip. The spring can be made still weaker, if there is no objection to a moderate decrease in the air gap (increase in sensitivity) with fluctuations of current in the protected circuit.

In the novel arrangement described, the magnetic trip and the thermal trip are integrated into a common tripping latch 54, yet each is virtually independent of the other. The magnetic armature is so supported that it moves in its own plane as bimetal 48 curves up and down, the armature moving across the pole of the electromagnet. The current bimetal and the electromagnet (which are electrically connected in series) are disposed generally parallel to each other. The low mass carried by this current bimetal renders the circuit breaker virtually immune to mechanical shock, and avoids imposing heavy deforming stresses on that bimetal when the trip and the bimetal move with the moving contact arm during snap-opening of the circuit breaker. Slight deformation seriously disturbs calibration. Further, quite apart from this curved configuration of the current bimetal caused by varying loads and changing ambient temperature, the magnetic trip retains high sensitivity.

A modification of the invention as shown in Fig. 1 is illustrated in Fig. 2. In this figure, primed numerals are used to designate corresponding elements in Fig. 1. In this instance, however, compensating bimetal 42 is omitted from actuator 26 and instead is suitably joined to the free end of current-responsive bimetal 48'. Bimetal 42' curves upward in response to rising ambient temperature just as bimetal 48' curves downward. Magnetic latch 54' is carried bodily downward as bimetal 48' heats in response to current levels approaching tripping level. During this deflection the armature portion of latch 54' merely moves in its own plane transverse of the core 50' without appreciably changing the magnetic gap. The magnetic trip is thus maintained at high sensitivity despite deflection caused by current heating of bimetal 48'. The effect of ambient temperature changes on bimetal 48' has only a second-order effect on the air gap.

Members 54 and 54' have been illustrated as having two arms provided at the ends of the wire welded to the current-responsive bimetal. An advantageous modification of this arangement involves a combined armature and latch carried by a single arm, pivoted in the position

shown, where that one arm is received snugly in a longitudinal guiding slot centered widthwise in bimetal 48 or 48' near the free end thereof.

Varied changes in detail of the above embodiments of the invention will occur to those skilled in the art, and the broader aspects of the invention extend to other forms of the circuit breakers than that in the illustrative embodiments; and consequently the invention should be broadly construed in accordance with its true spirit and scope.

What is claimed is:

1. A circuit breaker including a pair of separable contacts, mechanism to operate one of said contacts to open and closed positions, and an automatic load responsive trip mechanism for said operated contact, said trip mechanism including a current-responsive bimetal, a pivoted latch operable by said bimetal to trip said breaker upon predetermined thermal deflection, an electromagnet having a pole supported adjacent said bimetal and having a coil electrically connected in series with said bimetal, and an armature extending from said latch and having a face opposite said pole and extending along the path of thermal deflection of said bimetal, the pivotal axis of said pivoted latch being oriented in relation to said pole to provide for magnetic operation of said armature toward said pole and across said path of thermal deflection.

2. A circuit breaker including a pair of separable contacts, mechanism to operate one of said contacts to open and closed positions, and an automatic load responsive trip mechanism for said operated contact, said trip mechanism including a current-responsive bimetal, a latch pivoted to said bimetal and movable thereby to trip said breaker upon predetermined thermal deflection of said bimetal, an electromagnet adjacent said bimetal and connected in series with said bimetal, said electromagnet extending generally parallel to said bimetal, and an armature extending from said latch to a position opposite a pole of said electromagnet, said armature being movable with said bimetal across the electromagnetic pole during thermal deflection of said bimetal and the pivotal axis of said pivoted latch being oriented in relation to said pole to provide for magnetic operation of said armature toward said pole and across its path of movement resulting from the thermal deflection of the bimetal.

3. A circuit breaker including a pair of separable contacts, operating mechanism for moving one of said contacts manually to open and close the circuit breaker, and a trip mechanism effective to release said circuit breaker automatically in response to an overload, said trip mechanism including a current-responsive bimetal, a pivoted latch carried by said bimetal for movement as a unit therewith during thermal deflection, an armature extending from said latch generally perpendicular to said bimetal, and an electromagnet electrically connected to said bimetal and disposed adjacent said armature for movement of the armature across a pole of the electromagnet during thermal deflection of the bimetal and the pivotal axis of the latch being oriented in relation to said pole to provide for magnetic operation of the armature toward the pole and across the thermal-deflection path of movement of the armature for tripping of the latch independently of bimetal deflection.

4. A circuit breaker including fixed and movable contacts, manual operating means for said movable contact to open and close the circuit breaker, and a trip mechanism carried by said movable contact member including a current-responsive bimetal joined at one end to said movable contact member, a pivoted latch joined to said bimetal near the free end thereof, said latch having a magnetic armature, and an electromagnet connected in series with said bimetal and disposed adjacent said armature for releasing said pivoted latch independent of bimetal deflection.

5. A circuit breaker including fixed and movable contacts, manual operating means for said movable contact to open and close the circuit breaker, and a trip mechanism carried by said movable contact member including a current-responsive bimetal joined at one end to said movable contact member, a pivoted latch joined to said bimetal near the free end thereof, said latch having a magnetic armature, and an electromagnet connected in series with said bimetal adjacent said armature and supported directly by said movable contact member so as to be movable therewith for releasing said pivoted latch independent of bimetal deflection.

6. A circuit breaker including fixed and movable contacts, manual operating means for said movable contact to open and close the circuit breaker, and a trip mechanism carried by said movable contact member including a current-responsive bimetal joined at one end to said movable contact member, a pivoted latch joined to said bimetal near the free end thereof, said latch having a magnetic armature, and an electromagnet connected in series with said bimetal adjacent said armature for releasing said pivoted latch independent of bimetal deflection, said armature extending perpendicular to said bimetal and across a pole of said electromagnet.

7. A circuit breaker including fixed and movable contacts, manual operating means for said movable contact to open and close the circuit breaker, and a trip mechanism carried by said movable contact member including a current-responsive bimetal joined at one end to said movable contact member, a pivoted latch joined to said bimetal near the free end thereof, said latch having a magnetic armature, and an electromagnet connected in series with said bimetal adjacent said armature and supported directly by said movable contact member so as to be movable therewith for releasing said pivoted latch independent of bimetal deflection, said armature extending perpendicular to said bimetal and across a pole of said electromagnet.

8. A circuit breaker including fixed and movable contacts, manual operating means for said movable contact to open and close the circuit breaker, and a trip mechanism carried by said movable contact member including a current-responsive bimetal joined at one end to said movable contact, a pivoted latch joined to said bimetal near the free end thereof and an electromagnet connected in series with said bimetal and directly supported by said movable contact member for releasing said pivoted latch independent of bimetal deflection, said latch having an armature extending perpendicular to said bimetal and across a pole of said electromagnet, and an ambient temperature bimetal for adjusting the latch as the current-responsive bimetal deflects with ambient temperature changes.

9. A circuit breaker including a pair of separable contacts, operating mechanism for moving one of said contacts manually to open and close the circuit breaker and a trip mechanism effective to release said circuit breaker automatically in response to an overload, said trip mechanism including a current-responsive bimetal, a latch pivotally carried by said bimetal and biased by a weak spring into operative engagement with the bimetal for movement as a unit therewith during thermal deflection, an armature extending from said latch generally perpendicular to said bimetal, and an electromagnet connected to said bimetal and disposed adjacent said armature for movement of the armature across a pole of the electromagnet during thermal deflection of the bimetal and the pivotal axis of the latch being oriented in relation to said pole to provide for magnetic operation of the armature toward the pole and across the thermal deflection path of movement of the armature for tripping of the latch independently of thermal bimetal deflection.

10. A circuit breaker including separable contacts, normal operating means for opening and closing said contacts, and a load-responsive trip mechanism for automatic opening of the contacts, said trip mechanism including a current-responsive bimetal, a two-armed latch pivoted to a thermally deflected part of said bimetal, one of said

latch arms having a latching edge, the line between said latching edge and the latch pivot normally being directed along said bimetal, an armature on the other arm of said two-armed latch, said armature having a face extending crosswise of said bimetal, and an electromagnet having a fixed support presenting a pole thereof at a point normally spaced from said face of said armature so that the bimetal, when heated, carries the armature face across the pole rather than toward or away from the pole, and the armature being magnetically operable toward the pole along a path crossing its movement resulting from bimetal deflection.

11. A circuit breaker including separable contacts, manual operating means for opening and closing the contacts, and a load-responsive trip mechanism for automatic opening of the contacts, said trip mechanism including a current-responsive bimetal supported at one end thereof, a two-armed latch pivoted to a thermally deflected part of said bimetal, one of the latch arms having a latching edge, the line between said latching edge and the latch pivot being directed substantially towards the supported end of the bimetal, an armature on the second latch arm extending crosswise of said bimetal, and an electromagnet supported separately from the thermally movable part of said bimetal and having a pole disposed laterally opposite said armature, so that when the bimetal is deflected by a temperature increase the armature shifts across the pole rather than toward or away from the pole and the armature being magnetically movable toward the pole along a path crossing its path resulting from bimetal deflection.

12. A circuit breaker including separable contacts, manual operaitng means for opening and closing the contacts, a rigid conductor forming part of the electrical path through the circuit breaker, and a load-responsive trip mechanism for automatic opening of the contacts, said trip mechanism including a substantially flat current-responsive bimetal having one face at one end thereof held against and joined to said rigid conductor, an electromagnet having a ferrous core mechanically held against the opposite face of said bimetal where said bimetal is joined to said conductor, and a two-armed latch pivoted to a thermally deflected part of said bimetal, one of the arms of said latch having a latching edge and the other of said arms having an armature, a face of said armature being disposed opposite an end of said core, said face being disposed crosswise of said bimetal whereby deflection of the bimetal carrying the latch therewith moves the armature face across the end of the core rather than toward and away from the end of the core, and the armature being magnetically operable toward said end of said core along a path crossing the armature movement resulting from bimetal deflection.

13. A circuit breaker including separable contacts, manual operating means for opening and closing said contacts, and a load-responsive tripping mechanism for automatically opening the contacts, said tripping mechanism including a current-responsive bimetal having a secured end and having a free end which deflects in response to thermal changes, a latch movable with said free end of said bimetal upon deflection thereof, an electromagnet having a core fixed relative to said secured end of said bimetal, and an armature operably connected to said latch and movable therewith, said armature having a face extending in line with its path of movement caused by thermal deflection of said bimetal and said armature being supported for magnetic operation thereof along a path extending crosswise of said line of thermal-deflection movement, and said core having a pole disposed opposite said face of said armature and laterally of said thermal-deflection path of movement thereof and being effective, when energized, to attract and operate said face of said armature toward said pole for operating said latch to release the circuit breaker.

14. A circuit breaker including separable contacts,

manual operating means for opening and closing said contacts, and a load-responsive tripping mechanism for automatically opening the contacts, said tripping mechanism including an elongated current-responsive bimetal having a secured end and a free end which deflects in response to thermal changes, a latch pivotally carried by said bimetal adjacent said free end and bodily operable thereby, the pivotal axis of the latch being transverse of the bimetal and to the deflection path thereof, an electromagnet having a core fixed relative to said secured end of said bimetal, and an armature on said pivot latch, said armature having a face extending in line with its path of movement upon thermal deflection of said bimetal and said core having a pole disposed opposite said armature face and lateral of said thermal-deflection path of movement thereof.

15. A circuit breaker including separable contacts, manually operable means for opening and closing said contacts, a releasable element, and a load-responsive tripping mechanism controlling said releasable element for automatic opening of the contacts, said tripping mechanism including an electromagnet having a core, a current-responsive bimetal having a secured end and having a free end movable by thermal deflection relative to said core, a latch movable with said free end of said bimetal for tripping said releasable member by deflection of said bimetal, and an armature operably connected to said latch and movable therewith and having a face extending in line with its own path of movement with said bimetal and said armature being supported for magnetic operation along a path extending crosswise of its said path of movement with the bimetal, said core having a pole disposed opposite said face of said armature and lateral of said path of movement thereof with said bimetal, said latch being mounted movable relative to said bimetal and said core being effective to shift said armature face toward said pole and thereby to shift said latch relative to said bimetal for magnetically tripping said releasable element.

16. A circuit breaker including separable contacts, manually operable means for opening and closing said contacts, and a load-responsive tripping mechanism for automatic opening of the contacts, said trip mechanism including a releasable element, an electromagnet having a core, a current-responsive bimetal having a secured end and having a free end movable by thermal deflection relative to said core, a pivoted latch movable with the free end of said bimetal upon deflection thereof, said latch being arranged to restrain said releasable element normally and to be shifted for releasing said releasable element upon sufficient thermal deflection of said bimetal, an armature on said latch having a face extending in line with its own path of movement upon deflection of said bimetal and the pivotal axis of said latch being oriented relative to said core to provide for magnetic operation of said armature crosswise of said path of movement of the armature, said core having a pole disposed opposite said face of said armature and lateral of said path of movement thereof and effective to operate said latch for pivotal movement for releasing said releasable element in response to a tripping level of magnetization of said core.

17. A circuit breaker including separable contacts, manually operable means for opening and closing said contacts, a releasable element and a load-responsive tripping mechanism controlling said releasable element for automatic opening of the contacts, said tripping mechanism including an electromagnet having a core, a current-responsive bimetal having a secured end and having a free end that deflects relative to said core in response to thermal changes, a latch pivoted to said bimetal adjacent said free end and bodily movable therewith for restraining said releasable element through a normal range of bimetal deflection and to release the releasable element when tripping deflection occurs, the

pivotal axis being transverse of said bimetal and of the direction of deflection thereof, and an armature on said latch having a face extending in line with its own path of bodily movement caused by thermal deflection of said bimetal, said core having a pole disposed opposite said face of said armature and lateral of said path of bodily movement thereof, said pivotal axis being spaced from said armature substantially along said path of bodily movement to provide for pivotal magnetic operation of said armature along an arc crosswise of its path of bodily movement and said core being effective when sufficiently magnetized to shift said armature face toward said pole and thereby to operate said latch for pivotal movement to release said releasable member.

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