Oct. 16, 1934. H. C. GRAVES, JR 1,976,781

CIRCUIT CONTROLLING DEVICE

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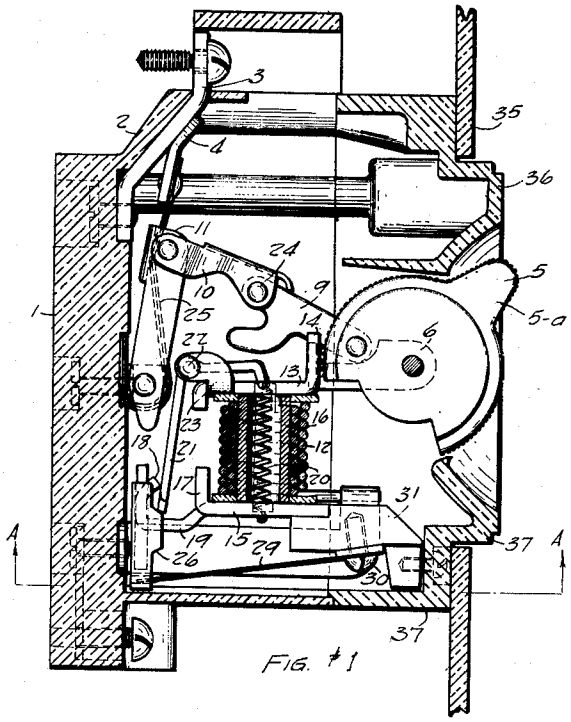


FIG. #1

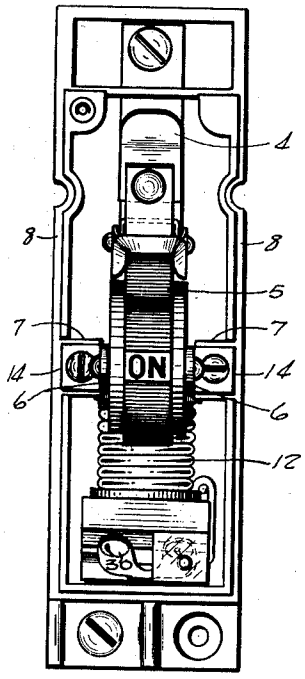


FIG. #2

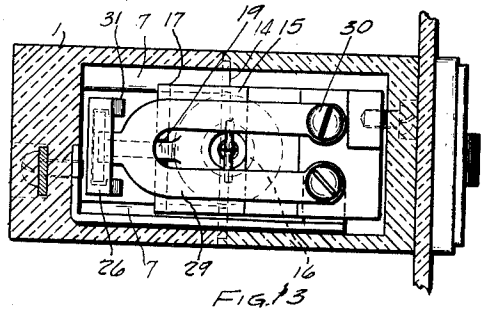


FIG. #3

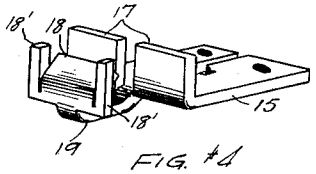


FIG. #4

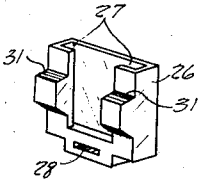


FIG. #5

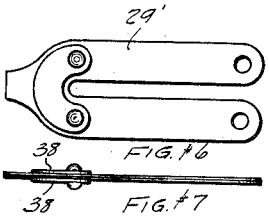


FIG. #6

FIG. #7

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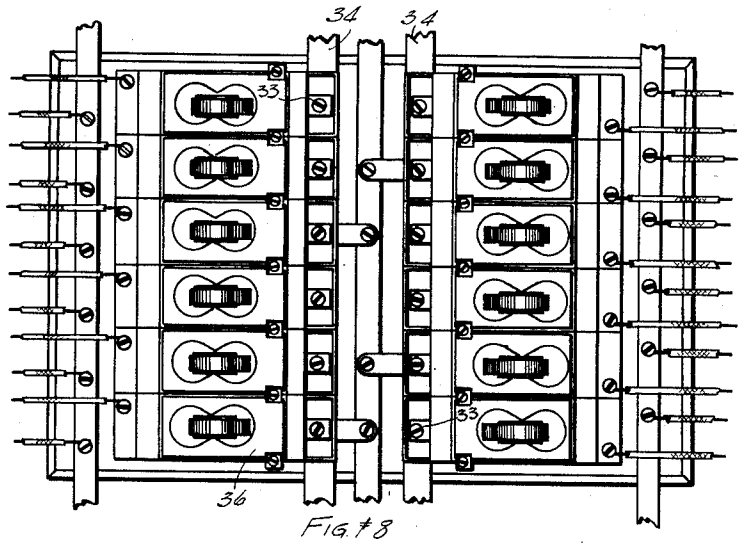


FIG. 8

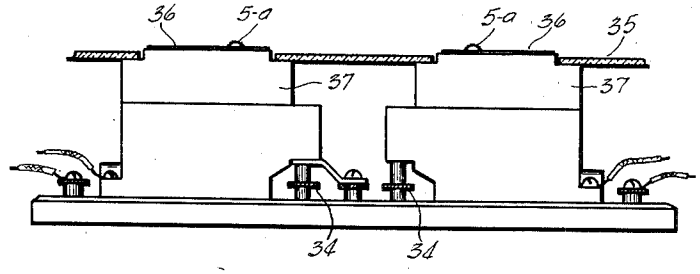


FIG. 9

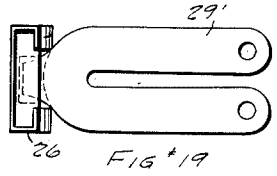


FIG. 19

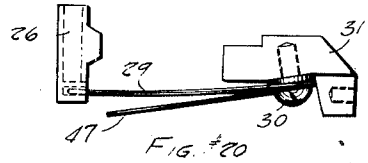


FIG. 20

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CIRCUIT CONTROLLING DEVICE

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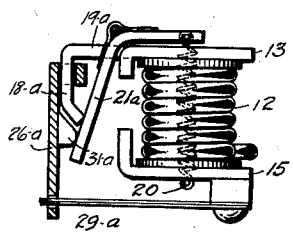


FIG. 10

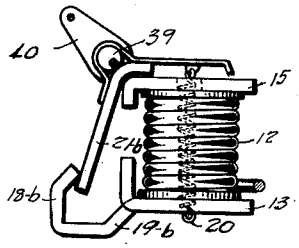


FIG. 11

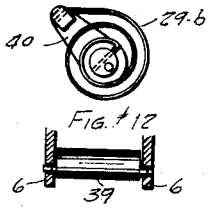


FIG. 13

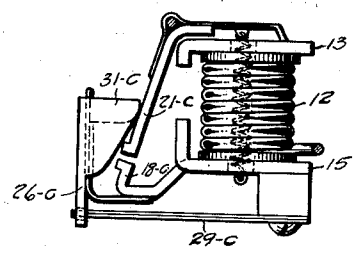


FIG. 14

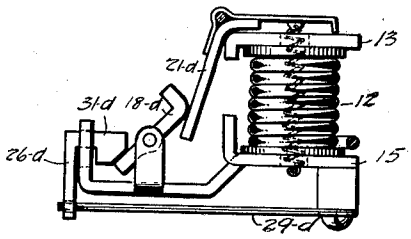


FIG. 15

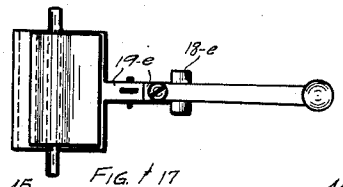


FIG. 17

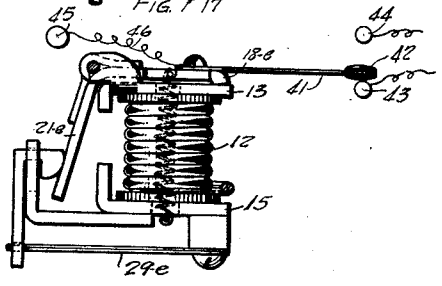


FIG. 16

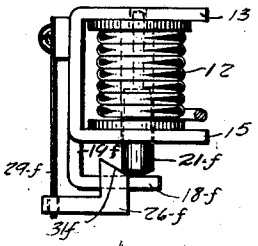


FIG. 18

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Patented Oct. 16, 1934 1,976,781

UNITED STATES PATENT OFFICE

1,976,781

CIRCUIT CONTROLLING DEVICE

Herbert C. Graves, Jr., Radnor, Pa., assignor to I-T-E Circuit Breaker Company, Philadelphia, Pa., a corporation of New Jersey

Application September 10, 1932, Serial No. 632,527

34 Claims. (Cl. 200—88)

My invention relates to circuit-interrupting devices, and particularly to circuit-breakers of the type which operate instantaneously upon occurrence of heavy overloads, and after a time for sustained overloads of lesser magnitude.

In accordance with my invention, the armature of a circuit breaker is normally restrained from movement by a magnetic back-drag which for sustained light overloads is reduced by operation of a time-delay current responsive means, for example a thermal element, to allow the armature to be attracted to tripping position; more specifically, for heavy overloads the armature is instantaneously moved to tripping position.

Further in accordance with my invention, the thermal responsive element may be so disposed that it is influenced by the field of the tripping magnet; for example, the arrangement may be such that the magnetic effect is cumulative with temperature in effecting bending of the strip.

More particularly, the tripping magnet may have a hollow core in which is disposed a spring for biasing the armature, which may be pivoted adjacent one of its pole pieces, toward the magnetic stop.

Also in accordance with my invention, the armature may carry a non-magnetic plate so disposed that currents are induced therein which for heavy overloads provide a substantial repulsion force assisting tripping movement of the armature.

Further in accordance with my invention there is interposed a trip-free mechanism between the operating handle and the contact structure which can be reset immediately after tripping irrespective of the position of the temperature responsive element so long as the current is not abnormal at the time of resetting.

My invention further resides in circuit-interrupting apparatus having the features of combination, construction and arrangement hereinafter described and claimed.

For an understanding of my invention and for illustration of a preferred form thereof, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a side elevational view with parts in section of a circuit breaker utilizing the invention.

Fig. 2 is a front elevational view of Fig. 1 with cover structure removed.

Fig. 3 is a bottom plane view taken on line A—A of Fig. 1.

Figs. 4 and 5 are detailed views of parts shown in Fig. 1.

Figs. 6 and 7 are plan and side elevational views, respectively, of a modified form of thermal element.

Fig. 8 is a front view of a group of breakers arranged for a panel board.

Fig. 9 is a plan view showing the relation of the breakers with the panel in position.

Fig. 10 illustrates a modification of the thermal and magnetic armature-actuating system.

Fig. 11 shows a further modification.

Figs. 12 and 13 are detail views of parts shown in Fig. 11.

Figs. 14 to 16 illustrate further modifications.

Fig. 17 is a plan view of Fig. 16.

Fig. 18 illustrates the invention as applied to a plunger-type armature.

Figs. 19 and 20 are top plan and side elevational views of a modified thermal device.

Referring to Figs. 1 to 3, to the base 1 of the molded housing member 2 is secured a fixed contact 3 with which cooperates a movable contact member 4. The operating handle 5 is pivotally mounted upon the supports 6 which are secured to and extend from the ribs 7 integral with the sides 8 of the housing member. The links 9 and 10, pivotally mounted respectively upon the handle 5 and the supporting member 11 of the movable contact 4, form a toggle between the member 5 and the movable contact structure which is overtraveled when the contact 4 is in closed circuit position, as shown in Fig. 1.

When the device is used as a circuit breaker, the coil 12 is in series with the movable contact and is traversed by the load current. The coil is mounted by its upper pole piece 13 which is provided with lugs 14, 14 clamped between the handle support 6 and the outer surfaces of the ribs 7 of the housing 2. The lower pole structure 15 is secured to the upper pole structure by a hollow tubular member 16. As shown more clearly in Fig. 4, the lower pole structure is divided to form the main pole 17 and an auxiliary pole 18 or magnetic stop connected thereto by a portion 19 of reduced cross section.

The spring 20 which extends through the hollow core of winding 12 is secured at its upper end to an arm of the armature 21 for biasing the lower end of the armature into engagement with the auxiliary pole structure 18. As shown, the armature is pivotally mounted, as at 22, upon the lugs 23 extending from the upper pole structure 13.

Under normal circuit conditions, the armature 21 is held by the auxiliary pole piece 18 against the attraction of the main pole piece 17. However, for heavy overloads, the portion 19 of the

path including the auxiliary pole piece and the armature is magnetically saturated, and the reluctance of the path, including the main pole piece, is materially less, so that for heavy overloads the armature is instantly moved from the auxiliary pole piece. The arm 20 of the armature is therefore raised breaking the toggle by lifting the common pivot 24 of arms 9 and 10 above center, whereupon the spring 25 is effective to move the contact 4 to open circuit position.

To reset the breaker, the handle 5 is moved upwardly to the position shown in Fig. 1. If the overload still exists, the toggle is again broken by armature 21, and the contact 4 moves to open position even though the handle is manually held in the position shown in Fig. 1. When the handle is released, it is moved to the lower dotted line position, as by gravity or a biasing spring not shown.

The armature releasing member 26, most clearly shown in Fig. 5, is provided with a groove 27 which receives the edges 18' of the auxiliary pole piece 18 which guides it for rectilinear movement. The lower end of member 26 is provided with a slot 28 which receives the end of a U-shaped bi-metallic member 29, fastened as by screws 30 to a block 31 disposed beneath the trip winding 12. The strip is connected in series with the coil 12 and is traversed by the current.

The continuance of overloads which are too light to effect tripping of the breaker as above described, produces an upward bending movement of strip 29 raising the slidable member 26, preferably of insulating material, so that the inclined surfaces or wedges 31 of the slide force the armature 21 out of contact with the auxiliary pole 18 and toward the main pole 17. This movement of the armature by bending of the strip continues until the armature reaches a position at which the field of the coil is sufficiently strong under the over current conditions to move the armature to unlatching or toggle breaking position; the heavier the overload, the shorter the distance that the armature need be moved by the thermostat and vice versa.

The parts are so constructed and arranged that the thermostatic element cannot move the armature to a position at which the toggle is broken and the thermostat is therefore never subjected to the strain of actually breaking the toggle. In fact throughout its movement it meets with no rigid obstruction or stop which would impose excessive strain.

Preferably, and as shown, the armature is not parallel to the auxiliary pole piece when in contact therewith. By varying this angle, as by bending the pole piece 18, the rate at which the attraction between the armature and the stop falls off as the latter is moved by wedge 31 can be adjusted. The lower tripping point of the breaker is thus predetermined, for the coil current required to move the armature toward the main pole piece varies with the distance that the wedges 31 move the armature; for example, the parts may be so disposed that when the wedge has moved the armature as far as it is able, the armature will trip the breaker at a current approximately 10% in excess of normal load.

The upper tripping point of the breaker may be changed by bending the reduced section 19 up or down to change the air gap between the end of the armature and this section; increase of air gap raising the tripping point and vice versa.

The angle of inclination of the wedge or cam surfaces 31 of the slide 26 determines the vertical and horizontal components of the force exerted thereon by the armature 21 and also the sensitivity of response; that is, the amount of movement imparted to the armature 21 for a given deflection of the thermal strip 29. By a proper choice of this angle, the vertical component, producing motion of the slide 26 and reacting upon the thermal strip 29, may be maintained within any desired limits.

Because of this same feature of construction the armature does not tend to chatter when displaced from the auxiliary pole piece, for when the current passes through zero neither pole piece attracts the armature and the armature is held against the cam surface by biasing spring 20, and when current is flowing the attraction of the auxiliary pole holds the armature against the rigid stop provided by the cam surface. Neither is there any chattering, when the armature is not displaced by the slide, for generally the same reasons, the auxiliary pole itself forming a non-resilient back stop. At no time is the armature against a yielding stop structure or system whose resilience might cooperate with the pulsating flux to cause vibration or chattering of the armature. In brief, the cams 31 afford a one-way, or unilateral, motion transmission means between the slide 26 or thermal element 29 and the armature.

It is of importance that the slide 26 can be freely moved by the thermal element and yet is not movable by the armature even though the latter, for alternating current use, is subjected to a varying flux. The arrangement in fact is particularly suited for alternating current uses, for the slide 26 may move when the magnetic attraction between the auxiliary pole and the armature passes through zero, at which time the only mechanical load imposed on the thermal element is due to the friction caused by the armature biasing spring which is negligible.

If desired, the direction of current through the strip may be such that there is a magnetic attraction between the strip and the coil which is cumulative with increase of current through the breaker for effecting upward movement of the slide 26.

It was found that when the breaker was used with alternating currents, the thermal element, under short-circuit conditions, would become unexpectedly hot at the bend of the U and even burn at that point. This was discovered to be due to the unequal distribution of current in the strip because of the inductive effect of the iron of the thermal element and/or the stray field of coil 12, which crowded the current toward the bend of the slot.

To prevent this burning, the thermal element may be made as shown in Fig. 3 with substantial separation between the legs of the U, or as shown in Figs. 6 and 7, the narrow slot may be retained and plates 38, of suitable conducting material as copper, fastened to the ends of the legs to divert current from the thermal element and to increase the conductivity at the critical region of the bend. An equivalent arrangement would be to connect two bi-metallic strips corresponding to the legs of the U by a bridge of copper, or other suitable conductor. Burning of the thermal element may also be prevented by securing to it in overlying relation, one or more laminations or punchings 47 (Figs. 19 and 20), of generally the same outline as the thermal element, of phosphor bronze, copper, or other metal. In general the added plates or laminations should have a higher thermal capacity and lower temperature coefficient of resistance than the thermal element.

It is particularly to be noted that as the maximum position of the slide 26 is short of the tripping position of the armature, that the breaker, after tripping, may be immediately reset to closed circuit position, for there is no tripping action by the member 26, even though its position is still substantially the same as that at which tripping occurred because of the time lag of the thermal element. The breaker will not trip despite the displaced position of member 26 unless the current flowing through the coil is above the breaker rating.

If desired, the arm 20 of the armature assembly may be of non-magnetic conductor, as brass. The disposition of the arm, perpendicular to the axis of the coil, is such that there are induced in it circulating currents which upon heavy overloads produce a repulsion force of substantial magnitude which tends to move the armature away from the auxiliary pole 18, and which is cumulative with the attraction of the main pole 17 in causing tripping movement of the armature.

As shown in Figs. 8 and 9, a plurality of circuit breakers as described may be arranged side by side for panel board use, the screws or bolts 33 which pass through the fixed contacts 3, engaging the bus bars 34, 34 to assist in supporting the units. The panel 35 is provided with openings through which project the central portions 36 of the cover members 37 of the breakers. The operating handles of the breakers are visible and operable from the front of the panel board; the position of the projection 5*a* or the indices On—Off indicating the circuit condition of the individual breaker.

In the modification shown in Fig. 10, the bi-metallic element 29*a* is reversed so that it bends downwardly or away from the coil upon increase of its temperature. To simplify the construction, the auxiliary pole 18*a* is made part of or extends from the upper pole structure instead of from the lower pole as in the previous modification. The principal advantage of the arrangement of Fig. 10 is that there is less frictional resistance offered to the cam 31*a* of the slide 26*a* by the armature. The operation is the same and need not be repeated.

Another form of the invention is shown in Figs. 11 to 13. In this modification, the armature 21*b* is pivotally mounted on an eccentric cam 39 to which is suitably secured an arm 40 connected to one end of the coiled bi-metallic element 29*b*. As the strip is subjected to increasing temperature, the arm 40 rotates and with it the eccentric cam whose movement moves the pivotal axis of the armature toward the magnet in a direction which is downward and to the right, Fig. 11. The motion of the armature is restricted by the non-magnetic stop lever resting on the upper pole piece so that the lower end is forced away from the auxiliary pole. In general, the operation is the same as that of the previous modifications.

The modification shown in Fig. 14 is similar to Fig. 10 in that the bi-metallic element bends away for increase of temperature from the coil. It differs therefrom in that the auxiliary pole 18*c* does not engage the armature but exerts an end-drag thereon tending to maintain the armature in the position shown. As the slide 26*c* is moved downwardly by the thermal element, the cam 31*c* forces the armature more or less out of alignment with the upper face of the auxiliary pole reducing the attractive force. The mode of operation is clear from the descrption of the operation of preceding modifications.

In the modification of Fig. 15, the back stop 18*d* is pivotally mounted, one end normally adjacent or engaging the armature 21*d* as shown. The other end is disposed in the path of cam 31*d* of the thermally controlled slide 26*d* so that upon continuance of light overloads, the pole or stop 18*d* is moved away from armature 21d. When the attraction of the main pole predominates, the armature is moved thereby to effect tripping. As in all modifications, for heavy overloads the armature is instantaneously attracted irrespective of its position.

In Figs. 16 and 17, the magnetic back drag is provided by forming the upper arm of the armature of magnetizable material with a section 19*e* of reduced cross-section between tip 18*e* and the rest of the armature. Under normal conditions, the attraction upon the upper arm which is biased into engagement with the upper pole structure predominates. Upon occurrence of heavy overloads, the reluctance of the path, including the depending part of the armature and pole 15, is less than the reluctance of the path including the upper arm because of the saturation of reduced section 19*e*. The armature is therefore instantaneously moved to tripping position In all modifications, the magnetic circuit of the back drag includes iron of reduced cross section so that during heavy current flow, the back drag is weak compared to the attraction of the main pole. For lighter sustained overloads, the back drag is reduced by moving the armature to separate tip 18*e* from the upper pole face, as by any of the thermal arrangements previously described.

This device, as well as any of the others shown, may be utilized to trip latch or toggle mechanism of a switch or circuit breaker, or as indicated in Fig. 16 it may directly actuate switch contacts. For example, a resilient contact arm 41, carrying contact 42, may be carried by the armature for engagement with either of fixed contacts 43 or 44. Contact arm 41 is connected to terminal 45 by a flexible conductor 46. The device may control the circuit of the tripping coil of a circuit breaker or any other apparatus desired.

Fig. 18 illustrates application of the invention to a plunger type armature 21*f*. Normally, the upwardly acting force of the coil is overcome by the attraction between the lower end of the plunger and the auxiliary pole or stop 18*f*. For heavy overloads, the attractive force of the coil is sufficiently great to overcome the back-drag of the auxiliary pole and immediately moves the armature to tripping position. For lighter sustained overloads, the plunger is moved away from the back stop by the thermal strip 29*f* through the intermediary of slide 26*f* whose cam face 31*f* lifts the plunger more and more as the strip bends further to the right, Fig. 18. However, the core is lifted to a position short of its tripping position to which it is moved by the attraction of coil 12. Instead of providing a portion 19*f* of reduced cross-section for the auxiliary pole, the lower part of the plunger may be suitably reduced in cross-section to provide a holding or restraining path which is saturated for high current values; an arrangement generally similar to Fig. 16 except for the type of armature.

Though for purposes of explaining my invention, I have illustrated and described a particular form of construction, it is to be understood that the invention is not limited thereto

but is co-extensive in scope with the appended claims.

What I claim is:

1. A circuit breaker comprising a magnet winding, a tripping armature coacting therewith, means for providing a magnetic back drag normally restraining movement of said armature by the field of said winding, structure movable to vary the effective magnitude of said magnetic back drag as a function of the movement thereof, and thermal means for effecting movement of said structure to permit the attraction of said field to effect movement of said armature to tripping position.

2. A circuit-interrupting device comprising a winding, a movable armature attracted by the field thereof for movement to circuit-interrupting position, pole structure magnetized by said winding for restraining said armature against movement by said attraction except for field strengths in excess of a predetermined magnitude, and means for moving the armature from said pole structure to permit field strengths below said magnitude to effect circuit-interrupting movement of the armature.

3. A circuit-interrupting device comprising an armature movable to circuit-interrupting position, a thermal device for moving said armature to a position short of said circuit-interrupting position, a winding for attracting said armature to circuit-interrupting position, and a magnetic means magnetized by said winding for holding said armature against the attraction of said winding except for high magnitude of current through said winding.

4. A circuit breaker comprising a tripping armature, a magnet winding, magnetic stop structure magnetized by said winding and engaging said armature for restraining movement thereof by the field of said winding so long as the current therethrough is less than a predetermined magnitude, and means for moving said armature from said stop structure to permit said winding to effect tripping movement thereof for lesser magnitudes of current comprising means responsive to continued flow of current at said lesser magnitude.

5. A circuit breaker comprising contact structure, a toggle for holding said structure in closed circuit position, an armature, a magnet winding for effecting instantaneous movement of said armature to toggle-breaking position upon occurrence of heavy overloads, magnetic means restraining movement of said armature for lesser overloads, structure movable to vary the effective magnitude of said magnetic back drag as a function of the movement thereof, and means responsive to continuance of lighter overloads for moving said structure accordingly to allow said winding to effect movement of said armature to break said toggle at said lighter overloads.

6. A circuit-interrupting device comprising a magnet winding, divided pole structure therefor forming a main pole and an auxiliary pole of similar polarity, an armature biased into engagement with said auxiliary pole to prevent movement thereof by said main pole to circuit-interrupting position except for currents through said winding in excess of a predetermined value, and thermal means for moving the armature from said auxiliary pole through a range short of its circuit-interrupting position.

7. The combination with a magnet winding, of a pivoted armature having a magnetizable portion attracted by said winding and a non-magnetic portion repulsed by said winding, and magnetic pole structure normally engaging said armature to prevent its movement by the combined attraction and repulsion effects of said winding.

8. The combination with a magnet winding traversed by alternating current, of an armature therefor, and magnetic pole structure magnetized by said winding and restraining movement of said armature from a predetermined position by the field of said winding, and means for biasing said armature to said predetermined position, thereby preventing chattering of the armature by the fluctuations in field strength.

9. The combination with a magnet winding, of an armature therefor, and a bi-metallic element for effecting movement of the armature in response to changes so disposed in the field of said winding that the temperature and the magnetic reaction of the element and said winding are cumulative in their effect upon said element.

10. A circuit-controlling device comprising a magnet winding having a hollow core, an armature pivoted adjacent said winding, biasing means for said armature disposed within said hollow core, and contact structure controlled by said armature.

11. The combination with a magnet winding having a hollow core, of an armature pivoted adjacent said core, pole structure normally engaging said armature and restraining it from movement by said winding, and spring means within said core biasing said armature toward engagement with said pole structure.

12. A circuit interrupting device comprising contact structure, means holding said contact structure in closed circuit position, a magnet winding, an armature therefor for releasing said holding means, a magnetic stop magnetized from said winding and restraining said armature, a thermal element for moving said armature from said stop to a position short of its releasing position, said magnet winding being effective to move said armature from said stop to releasing position upon occurrence of heavy overloads and to said releasing position for lighter overloads after said thermal element has moved the armature from the stop.

13. The combination with a magnet winding, main pole structure therefor, auxiliary pole structure spaced from said main pole structure, a pivoted armature biased toward said auxiliary pole structure, a reciprocable member having an inclined surface for moving said armature from said auxiliary pole structure toward said main pole structure, and time-delay current-responsive means for effecting movement of said reciprocable member.

14. The combination with a magnet winding, of main pole structure therefor, auxiliary pole structure therefor connected thereto by a section of reduced cross-section, an armature biased toward said auxiliary pole structure which normally restrains it from movement by attraction of said main pole structure, and time-delay current-responsive means for moving said armature away from said auxiliary pole structure and toward said main pole structure.

15. A circuit breaker having a magnet winding, a U-shaped element traversed by load current and disposed in the field of said winding, whose legs at least are bimetallic, and conductive plate structure overlying the bottom of the U to prevent burning under abnormal current conditions.

16. A circuit breaker having a magnet winding, a U-shaped bi-metallic strip traversed by load

current disposed in the field of said winding, and having substantial separation between the legs thereof to prevent burning at the bend of the U under abnormal circuit conditions.

17. A circuit breaker having a magnet winding, a U-shaped bi-metallic strip traversed by load current and disposed in the field of said winding, and conductive plate structure fastened to said strip to overlie the bottom of the U to prevent burning under abnormal circuit conditions.

18. A circuit breaker comprising a winding, main pole structure therefor, an armature attracted by said main pole structure, and an auxiliary pole structure normally restraining said armature, having its surface at an angle to armature, and structure movable to move said armature from said auxiliary pole structure toward said main pole structure, said auxiliary pole structure being bendable to change said angle thereby to vary the current required in said coil to move the armature from its maximum position by the attraction of said main pole structure.

19. A circuit breaker comprising a winding, main pole structure therefor, an armature attracted thereby, and auxiliary pole structure normally restraining said armature having a surface disposed beyond the end of said armature and a surface engaging said armature and extending at an angle therefrom, said auxiliary pole structure being movable to change the air gap between the end of said armature and said first surface.

20. A circuit breaker comprising a winding, a main pole therefor, an armature attracted thereby, an auxiliary pole structure normally restraining said armature, structure movable to move said armature from said auxiliary pole structure, and time-delay current-responsive means for actuating said movable structure, said auxiliary pole structure comprising a portion engaging said armature and extending therefrom at an angle variable to change the sustained light overload tripping point of the breaker, and another portion spaced from the end of the armature at a distance variable to change the tripping point of the breaker for heavy overloads.

21. The combination with a magnet winding, of an armature attracted thereby, stop structure against which said armature is biased, and electro-responsive means for moving said stop structure to vary the position of said armature with respect to said winding, said stop structure being so constructed and disposed that it is at all times non-resilient in the direction of movement of said armature.

22. The combination with a magnet winding, of an armature, electro-responsive means, and means providing a one-way driving connection for transmission of motion from said electro-responsive means to said armature for movement toward said winding.

23. The combination with an armature, of a winding traversed by alternating current for producing flux paths, one of which attracts the armature for movement and another of which restrains the armature, and means for increasing the reluctance of said second path comprising retarded current responsive means and stop structure actuated thereby to transmit movement to said armature during zero flux.

24. A circuit-controlling device comprising a winding, an armature movable thereby to circuit controlling position, a magnetic stop magnetized by said winding to restrain said armature from movement by the attraction of said winding except for high magnitudes of current, and a system for moving said armature from said stop to a position short of said circuit-controlling position comprising a thermal element freely movable throughout its operating range.

25. In combination with a winding traversed by current, an armature pivoted adjacent one pole of said winding and biased from the other pole thereof, a stop against which said armature is biased and which is non-resilient in the direction of movement of the armature, and electro-responsive means for moving said stop to vary the distance between said armature and said other pole.

26. A circuit breaker comprising contact structure, means holding said contact structure in closed circuit position, a magnet winding, an armature therefor for releasing said holding means, magnetic means magnetized by said magnet winding for normally restraining movement of said armature, a time-delay electro-responsive device for reducing the restraint of said magnetic means, said magnet winding being effective to move said armature to releasing position instantaneously upon occurrence of heavy overloads, and after a time-delay for lighter overloads.

27. The combination with a magnet winding, of an armature, magnetic means for normally restraining movement of said armature, means for reducing the restraint of said magnetic means comprising a reciprocable member having an inclined surface for moving said armature, and a time-delay current-responsive means for effecting movement of said reciprocable member.

28. The combination with a magnet winding, of an armature, a magnetic stop magnetized by said winding, said stop having a surface engaging said armature and extending at an angle therefrom, means for biasing said armature against said stop, and time-delay current responsive means for separating said armature from said stop.

29. The combination with a magnet winding, of a pivoted armature having one arm normally held by one pole of said winding and an oppositely extending arm attracted by the other pole of said winding, said first arm being comprised in a path which is saturated at high magnitude of current through said winding to permit the attraction of said other pole to move the armature, and time-delay electro-responsive means for moving said armature to a position from which it is moved by the attraction of said other pole.

30. A circuit-breaker comprising a winding, pole structure therefor, an armature cooperating therewith to form two flux paths, one of which is normally substantially closed but saturated for high values of current through said winding to permit movement of the armature to shorten the other of said paths and trip the breaker, and thermal means for moving said armature under conditions of sustained light overloads to shorten the other of said paths to such extent that the armature is magnetically moved to tripping position.

31. An electro-responsive device comprising a magnet winding, an armature attracted thereby, structure magnetized by said winding and providing a magnetic back-drag on said armature which is high relative to the attraction of said winding for low magnitude of current and which is low relative to the attraction of said winding for high magnitude of current, and time-delay electro-responsive means for reducing the back-drag upon continuance of low magnitudes of current in excess of a predetermined low magnitude.

32. An electro-responsive device comprising a magnet winding, a substantially U-shaped bi-metallic strip, and conductive plate structure overlying said strip and electrically in parallel thereto having a higher thermal capacity and lower temperature coefficient of resistance than said strip.

33. A circuit-interrupter comprising contacts, means for effecting circuit-closing engagement of said contacts, means for holding said contacts in circuit-closed position, and means for tripping said holding means comprising a single winding, an armature therefor, and magnetic restraining means for said armature operative solely in response to energization of said single winding and effective during the initial current inrush upon circuit-closure.

34. A circuit breaker comprising a magnet winding, circuit controlling means including a movable armature coacting with said winding, means for providing a magnetic back drag normally restraining movement of said armature by the field of said winding, structure movable to vary the effective magnitude of said magnetic back drag as a function of the movement thereof, and means for effecting movement of said structure in accordance with predetermined circuit conditions to permit the attraction of said field to effect movement of said armature to operative position.

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