Feb. 18, 1947. H. S. GANO ET AL 2,416,170

CIRCUIT BREAKER

Filed Sept. 15, 1942 2 Sheets-Sheet 1

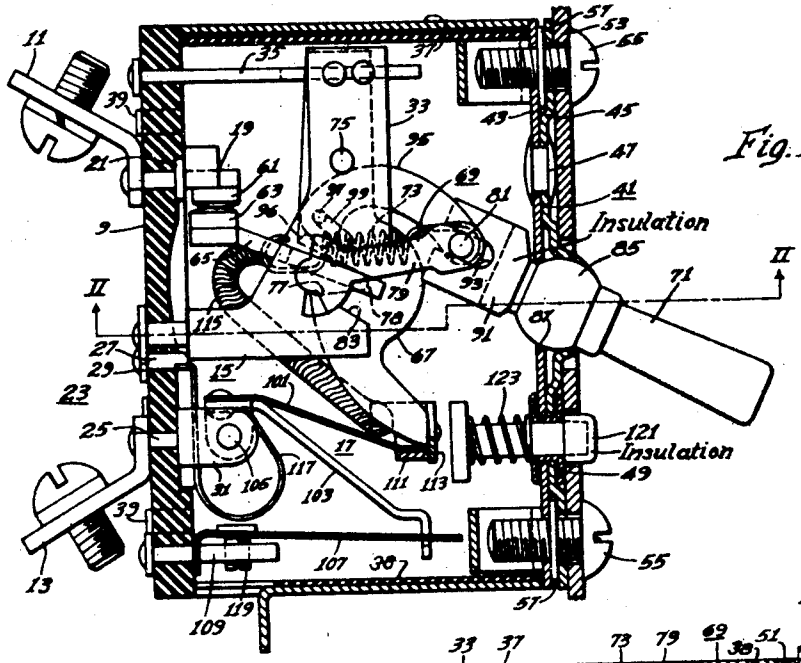

Fig. 1.

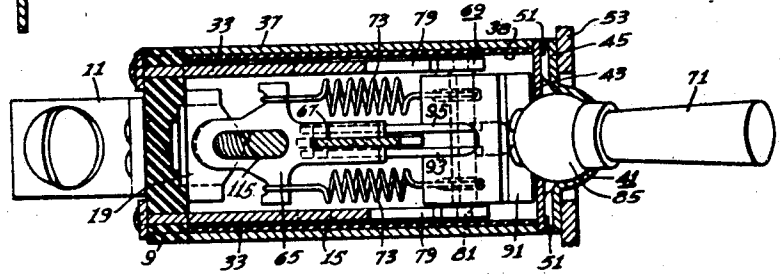

Fig. 2.

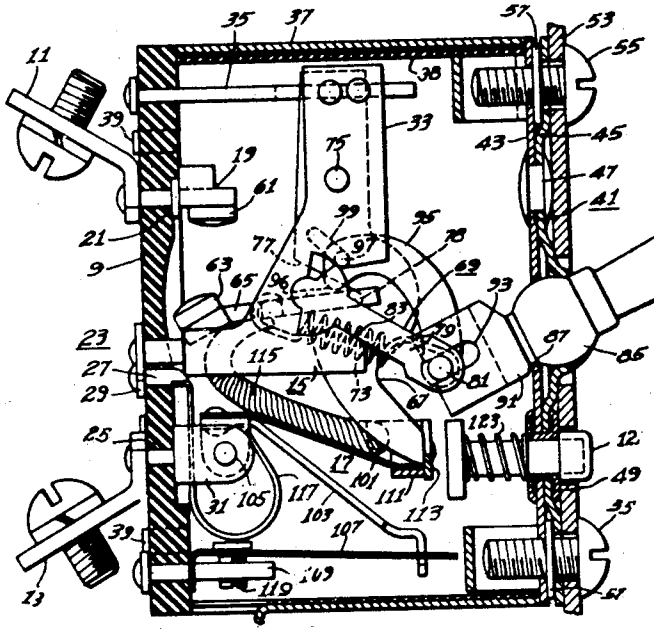

Fig. 3.

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CIRCUIT BREAKER

Filed Sept. 15, 1942 2 Sheets-Sheet 2

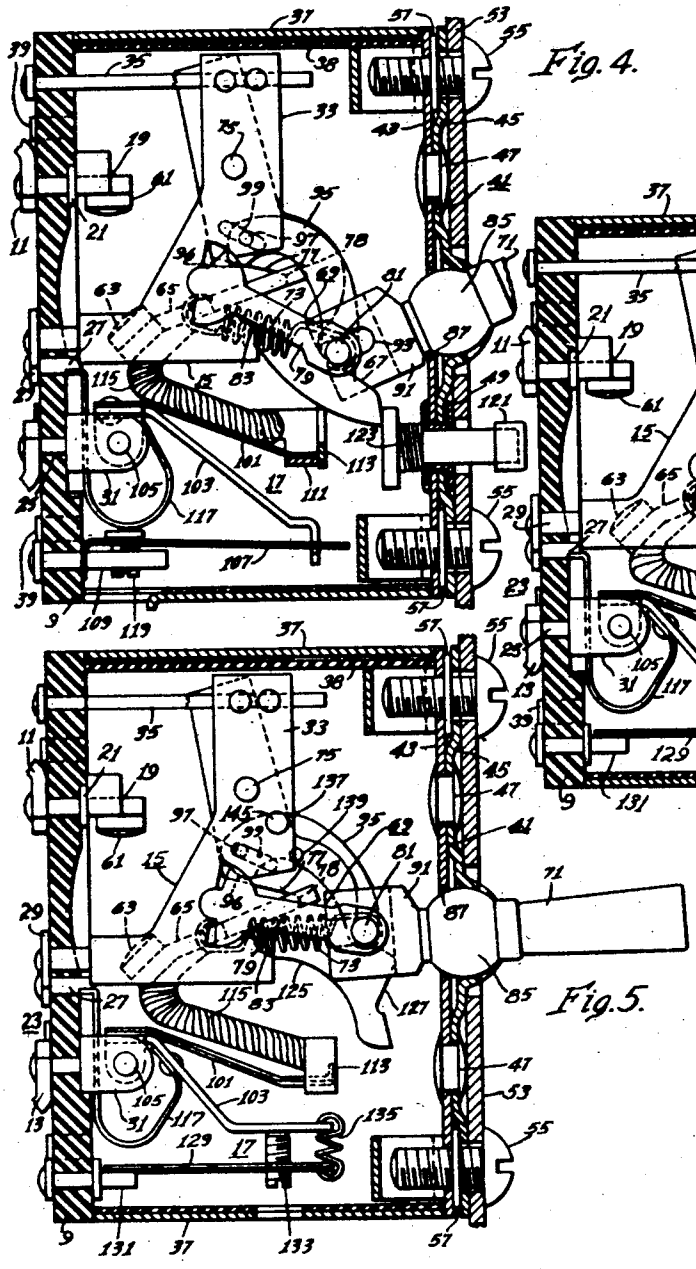

Fig. 4.

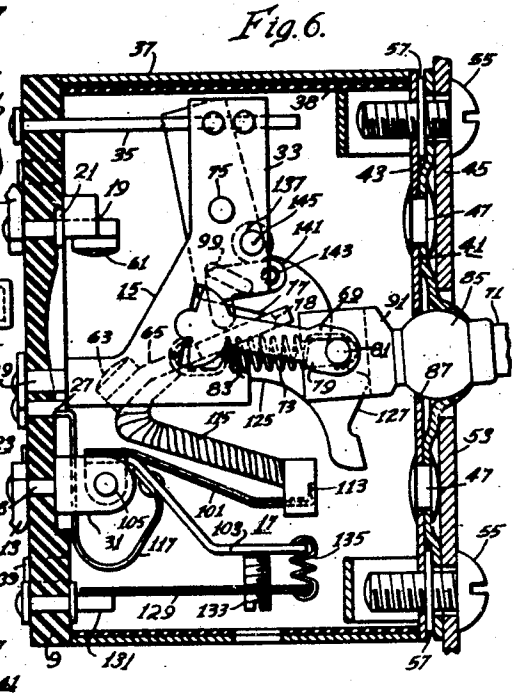

Fig. 6.

Fig. 5.

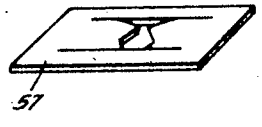

Fig. 7.

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2,416,170

CIRCUIT BREAKER

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Application September 15, 1942, Serial No. 458,390

26 Claims. (Cl. 200—116)

1

The invention relates to circuit interrupters and more particularly to circuit breakers for controlling lighting circuits and small to moderate power low voltage circuits.

An object of the invention is the provision of an improved circuit breaker of the class described that is very simple and compact, accurate and reliable in operation and economical to manufacture.

Another object of the invention is the provision of a circuit breaker embodying an improved snap-action operating mechanism that is manually operable to open and close the breaker and that is adapted to be tripped by a current responsive trip element in response to predetermined overload conditions to cause automatic opening of the contacts.

Another object of the invention is the provision of a circuit breaker with an improved operating mechanism as previously described wherein the breaker may be manually closed or held closed against an overload current condition in the circuit.

Another object of the invention is the provision of a circuit breaker with an improved operating mechanism having an operating lever that is manually operated to produce opening and closing of the breaker and a spring biased lever releasable to cause the mechanism to automatically open the breaker, and a link providing lost motion connection between the two levers whereby it is possible for the operator to close and hold the breaker closed against an overload in the circuit.

Another object of the invention is the provision of a circuit breaker with an improved operating mechanism as described in the preceding paragraph, wherein the breaker can be made trip free of the operating handle by eliminating one of the elements of the mechanism, namely, the aforementioned connecting link.

Another object of the invention is the provision of a circuit breaker with an improved operating mechanism wherein the mechanism after it is tripped can be reset to operative condition by moving the operating handle as far as it will go in an "off" direction, or the mechanism can be reset and the contacts closed at the same time by simply moving the handle to the "on" position.

Another object of the invention is the provision of a circuit breaker of improved construction wherein the cover of the casing is made up of two metal plates so formed and spaced as to provide a pivot and support for the external operating handle.

2

Another object of the invention is the provision of a circuit breaker embodying an improved operating mechanism having an internal operating lever that is separably engaged by an external handle lever mounted on the removable cover of the breaker housing.

Another object of the invention is the provision of a circuit breaker as previously described wherein a positive indication is given that the breaker has been tripped open.

Another object of the invention is the provision of a circuit breaker with an improved thermally responsive trip device operable to trip the circuit breaker in response to overload current conditions and which is fully compensated in a novel manner for changes in ambient temperature over a wide range.

Another object of the invention is the provision of a circuit breaker with an improved thermally responsive overload trip device that provides an improved automatic operating characteristic to afford a greater time delay action on overloads of low magnitude than many prior art thermal circuit breakers, and yet which also provides the desired quick response on heavy overloads and short circuits.

These and other objects and advantages of the invention, together with the detailed structure and mode of operation thereof, will be best understood from the following detailed description of several embodiments of the invention when read in conjunction with the accompanying drawings, in which:

Figure 1 is a vertical sectional view of a circuit breaker constructed in accordance with the invention, the breaker being shown in the closed circuit position;

Fig. 2 is a horizontal sectional view of the circuit breaker, the section being taken substantially along the line II—II of Fig. 1;

Fig. 3 is a sectional view similar to Fig. 1 but showing the breaker in the manually open or "off" position;

Fig. 4 is a sectional view similar to Fig. 1 but showing the breaker in the tripped open position;

Fig. 5 is a vertical sectional view of a modification of the circuit breaker wherein a modified shape or release lever has been substituted so that the operating handle will indicate tripping of the breaker; a slightly modified connection between the bimetal elements is also illustrated in this figure;

Fig. 6 is a vertical sectional view similar to Fig. 5 but showing a further modification of the breaker wherein the handle connecting link has

been eliminated to make the breaker trip free of the handle; this view and Fig. 5 both showing the breaker in tripped position; and

Fig. 7 is a perspective view of one of the lock nuts for the mounting screws which secure the breaker to a panel.

Referring to Figs. 1 to 4 of the drawings, the circuit breaker includes a rectangular base 9 of insulating material upon which is mounted a pair of terminal members 11 and 13, the circuit breaker mechanism frame 15, and an overload current responsive trip device 17.

The upper terminal member 11 is securely clamped to the back of the base 9 by a contact supporting bracket 19 of conducting material, which has an enlarged portion disposed on the front side of the base inside the circuit breaker casing, and a reduced portion that extends through openings provided therefor in the base 9 and terminal member 11. The shoulder provided by the enlarged portion of the bracket 19 bears against a metal washer 21, and the end of the reduced portion of the bracket is clenched or riveted over against the terminal member 11, thereby rigidly clamping the terminal member and the contact bracket in mounted position on the base 9. The lower terminal member 13 is secured to the back of the base 9 in a similar manner by a bracket 23 of conducting metal that has a flat portion bearing against the front of the base 9, and two rearwardly extending projections 25 and 27 that pass through openings in the base 9. The projection 25 also passes through an opening in the terminal member 13 and the end thereof is riveted over against the terminal member. The other projection 27 has its end riveted over against a metal washer 29. The bracket 23 has forwardly extending ears 31 which serve to pivotally support the current responsive trip element of the trip device 17 that will be described hereinafter.

The circuit breaker mechanism supporting frame 15 comprises a pair of angle shaped flat metal plates 33 which are mounted in spaced parallel relation on the front side of the base 9. Each side plate has a reduced portion that passes through an opening in the base 9 and the end of this reduced portion passes through a metal washer and is clinched or riveted over against the washer to securely clamp the plate in mounted position on the base 9. The frame also includes an end plate 35 located adjacent the upper end of the base 9 and securely clamped to the base in a similar manner by having a reduced portion projecting through the base and riveted over against a metal washer. The ends of the upwardly extending portions of the side plates 33 are riveted to the opposite side edges of the end plate 35 to thereby form a rigid frame structure.

A rectangular metal casing 37 is provided for enclosing the circuit breaker mechanism. This casing surrounds the circuit breaker mechanism and is secured to the insulating base 9 by a plurality of lugs 39 on the casing that are bent over the side edges of the base 9 to clamp the casing to the base. A cover 41 consisting of two preformed metal plates 43 and 45 that are riveted together by rivets 47 and 49, is mounted on the front of the casing to complete the enclosing housing of the breaker. The cover 41 is secured to casing 37 by a plurality of lugs 51 (Fig. 2) on the front edge of the casing, that are bent over the inner plate 43 of the cover. An insulating lining 38 is disposed around the entire inner surface of the casing 37 to insulate the metal casing from the mechanism.

The circuit breaker is adapted to be mounted on a panel 53 by means of a pair of screw bolts 55 which threadedly engage a pair of special lock nuts 57 that are disposed and retained in spaces provided therefor between the opposite ends of the cover plates 43 and 45. One of the special lock nuts is shown in Fig. 7.

The circuit breaker includes a stationary contact 61 mounted on the contact bracket 19, and a cooperating movable contact 63 secured to the end of a movable contact member or switch member 65 of conducting material adapted to be operated with a snap action to open and closed circuit positions by the circuit breaker operating mechanism, to open or close the circuit breaker contacts. The circuit breaker operating mechanism can be manually operated to effect opening or closing of the contacts and is also adapted to be operated automatically by the trip device to effect automatic opening of the contacts in response to predetermined overload current conditions in the circuit.

The operating mechanism comprises, in general, a pivotally mounted releasable supporting lever 67 on which the switch member 65 is pivotally mounted for oscillation, a pivoted operating lever 69, an external operating handle 71 operatively engaging the operating lever, and a pair of overcenter operating springs 73 operatively connecting the operating lever 69 to the movable switch member 65. The releasable supporting lever 67 is pivotally supported on the frame 15 between the sides thereof by a pivot pin 75, and this lever has a relatively deep V-shaped notch 77 therein for receiving the movable switch member 65. The outer end of the switch member 65 has a slot therein which pivotally engages the apex 78 of the V-shaped notch 77 to thereby pivotally mount the switch member on the releasable supporting lever 67. The supporting lever 67 is normally held latched in the fixed position shown in Figs. 1 and 3 by a latch of the trip device 17 which normally engages a latch surface on the lower free end of the lever 67 to hold the lever in this position.

The operating lever 69 consists of two legs or levers 79 (Fig. 2) which are rigidly secured together in spaced parallel relation by a cross pin 81 rigidly connecting the outer ends of the levers. The inner ends of the legs 79 are generally segmental in shape and are pivotally engaged in correspondingly shaped pivot bearing recesses provided therefor in the side plates of the frame 15, whereby the operating lever is pivotally mounted for oscillation on the frame. The legs of the operating lever are inserted in the bearing recesses in the frame by pushing them sideways into these recesses, lateral displacement of the operating lever being prevented by the sides of the casing after the casing 37 is assembled on the base 9. Notches 83 provided in the sides of the frame 15 limit opening and closing movement of the operating lever 69.

The two overcenter operating springs 73 are disposed on opposite sides of the releasable lever 67 and the switch member 65, the outer ends of these springs being connected to the operating lever 69 by engaging slots provided in the cross pin 81 of the operating lever. The inner ends of the springs 73 are connected to lateral projections formed on opposite sides of the switch member 65 as shown in Fig. 2.

The external operating handle 71 comprises

a metal lever having a generally spherical portion **85** by means of which it is pivotally mounted for oscillation on the cover **41** of the circuit breaker. The two plates **43** and **45** comprising the cover are formed to provide a pivot bearing for the spherical portion **85** of the operating handle. The inner plate **43** is provided with a cylindrical opening **87** against which the inner portion of the spherical portion of the handle bears, and the outer plate is slightly spaced from the inner plate opposite the circular opening **87**, and this portion of the plate **45** is provided with an oval-shaped opening bounded by edge portions which are spherically shaped to engage and conform to the shape of the spherical portion **85** of the external operating handle. The spherical portion of the handle is retained in mounted position between the two plates in the bearing provided therefor, and this handle is manually movable back and forth between "on" and "off" positions for operating the mechanism to cause closing and opening of the circuit breaker contacts. The portion of the handle **71** which projects inside of the casing has an insulating block **91** secured thereto as by a rivet, and this block is provided with a transverse slot **93** which is adapted to engage the cross pin **81** of the operating lever **69** whereby the operating handle **71** is operatively connected to the operating lever **69** when the casing and cover are assembled on the base **9**. Movement of the operating handle **71** upwardly to the "off" position moves the operating lever **69** downwardly to "off" or open position to effect opening of the circuit breaker contacts. Conversely, when the operating handle **71** is moved downwardly to the "on" position, it effects movement of the operating lever **69** upwardly to "on" or closed position to effect closing of the circuit breaker contacts.

A connecting link **95** is provided between the operating lever **69** and the releasable supporting lever **67**. This link is in the form of a double link which pivotally engages the cross pin **81** of the operating lever **69** at one end, and the other end of the link carries a pin **97** which engages and moves in an elongated slot **99** provided therefor in the releasable supporting lever **67**. During normal manual operation of the circuit breaker to opened and closed position, the slot **99** permits movement of the operating handle **71** and operating lever **69** to "on" and "off" positions while the releasable supporting lever **67** is restrained in the fixed position shown in Figs. 1 and 3. When the operating handle **71** is in the "on" position shown in Fig. 1, the pin **97** carried by the link **95** engages the inner end of the slot **99**, so that it is possible for an operator to hold the circuit breaker closed by holding the operating handle in the "on" position shown. When the handle is thus held in the "on" position, it acts through the link **95** to prevent tripping operation of the releasable supporting lever **67** even though the current responsive trip device may have released the lower end of the supporting lever **67**. Under these conditions, the link **95** acts to hold the releasable supporting lever **67** in the fixed position shown. The link **95** also provides a means whereby the circuit breaker mechanism may be reset and the contacts operated to the closed position simply by moving the operating handle to the "on" position following a tripping operation of the breaker.

The trip device **17** of the circuit breaker comprises a current responsive bimetal trip element **101** formed of a flat strip of bimetallic material

which is secured at its inner end to the shank portion of a metal connecting lever **103**. The shank portion of the metal connecting lever **103** is pivotally mounted by a pivot pin **105** on the ears **31** of the bracket **23**. The outer free end of the connecting lever **103** is bent and provided with a slot through which it engages the free end of an ambient temperature compensating bimetal element **107**. The inner end of the ambient temperature compensating bimetal strip **107** is bent angularly and is clamped against the base **9** of the circuit breaker by means of a bracket **109**. The bracket **109** has a reduced portion which extends through an opening provided therefor in the angularly bent foot of the bimetal strip **107** and passes through an opening in the base **7**. The end of the reduced portion of the bracket **109** is riveted over against a metal washer on the rear side of the base **9**, thereby securely clamping the ambient temperature responsive bimetal element in mounted position on the base **9**. The outer free end of the current responsive bimetal trip element **101** has a U-shaped element **111** rigidly secured thereto and a latch **113** is, in turn, rigidly secured to this U-shaped element on the free end of the bimetal element **101**. During normal conditions, the latch **113** is adapted to engage the free end of the supporting lever **67** to hold this lever in the fixed position shown in Figs. 1 and 3. The bimetal trip element is adapted to be heated in response to overload current in the circuit controlled by the breaker and when heated a predetermined amount, it deflects in a downward direction to cause the latch **113** to disengage and reelase the supporting lever **67** to thereby cause the mechanism to effect automatic opening of the circuit breaker contacts.

A flexible shunt conductor **115** electrically connects the switch member **65** and movable contact **63** to the outer free end of the bimetal trip element **101**. The inner end of this trip element is electrically connected by a resilient copper strip **117** to the lower terminal bracket **23** and hence to the lower terminal member **13**. The circuit through the breaker extends from the upper terminal member **11** through the contacts **61** and **63**, switch member **65**, flexible shunt conductor **115**, connecting element **111**, current responsive bimetal trip element **101**, conducting strip **117** and bracket **23** to the lower terminal member **13**.

The ambient temperature compensating bimetal element **107** is disposed to deflect in an opposite direction to that of the current responsive bimetal element **101** when the elements are heated by ambient temperature, so as to compensate the breaker for changes in ambient temperature. When the ambient temperature increases, the bimetal element **107** deflcts in an upward direction to compensate for the corresponding downward deflection of the trip element **101** produced by ambient temperature. Conversely, when the ambient temperature decreases, the ambient temperature responsive bimetal element **107** deflects downwardly to compensate for the corresponding upward deflection produced in the bimetal trip element **101** by the change in ambient temperature. Consequently, the trip device is made responsive only to overload currents and is unaffected by changes in ambient temperature. Adjustment of the minimum overload current trip setting at which the trip device will operate to trip the breaker is effected by means of an adjusting screw **119**. The adjusting screw has a head which engages the upper side of the ambient temperature responsive bimetal element

107 and the body of the screw is threadedly engaged in an opening provided in the mounting bracket 109. The lower end of the screw is provided with a slot which is disposed opposite an opening in the lower end wall of the casing to permit adjustment of the trip characteristic from outside of the circuit breaker casing. Turning the screw in a counter-clockwise direction will effect clockwise rotation of the current responsive bimetal element 101 about the pivot 105 and will decrease the minimum amount of overload current necessary to ultimately effect operation of the trip device. Turning the screw in a clockwise direction effects movement of the bimetal trip element 101 in a counter-clockwise direction and will increase the minimum overload current necessary to effect operation of the trip device. Due to the fact that the connecting lever 103 is of metallic material, a small amount of the heat produced in the bimetal trip element 101 by relatively low magnitude overload currents will be transmitted to the ambient temperature responsive bimetal element 107, and will thereby cause a greater time delay before the breaker is tripped in response to relatively low overload magnitude currents than would be the case if the two bimetal elements were completely heat insulated from one another. However, on moderate overloads and heavy overloads, little or none of the heat produced in the bimetal element 101 is transmitted to the ambient temperature responsive bimetal element 107 since there is insufficient time for a transfer of heat to take place through the metal connecting lever 103. Consequently, the bimetal trip element 101 has substantially the same operating characteristic for moderate overloads and high overloads as an uncompensated bimetal element of the same composition. This is a desirable feature of the construction since it provides a greater time delay action on the relatively low magnitude overloads before the breaker is tripped. These low magnitude overloads are not necessarily harmful and may be allowed to persist for a longer time without producing any damage in the control circuit.

A trip indicating button 121 of insulating material is provided for indicating when the breaker has been tripped in response to an overload current condition. The trip indicating button 121 is slidably mounted in the cover 41 of the circuit breaker casing by means of the rivet 49 which is of hollow or eyelet construction. The trip indicating button 121 is biased by a spring 123 to a non-indicating position. The spring is disposed upon the shank of the indicating button between the enlarged inner end thereof and the rivet 49. When the circuit breaker is tripped in response to operation of the trip device 17, the supporting lever 67 is released and moved outwardly, that is, in a counter-clockwise direction about its pivot 75 to a tripped position. The lower free end of the lever when so moved engages the trip indicating button 121 and moves the same outwardly to a trip indicating position as shown in Fig. 4.

The operation of this embodiment of the circuit breaker is briefly as follows. To open the circuit breaker, the operating handle 71 is moved upwardly to the "off" position shown in Fig. 3. This movement of the operating handle moves the operating lever 69 downwardly in a clockwise direction about its pivot axis to the open position shown in Fig. 3. During this movement, the line of action of the overcenter springs is shifted downwardly below the pivot axis 78, of the switch member, and as soon as it crosses below the pivot axis 78 the springs actuate the switch member 65 to the open circuit position shown in Fig. 3 with a snap action. In this position, the line of action of the springs is also below the pivot axis of the operating lever 69 so that the springs act to maintain the operating lever and the operating handle in the "off" position.

To manually close the circuit breaker, the operating handle 71 is moved downwardly to the "on" position shown in Fig. 1. This movement is transmitted to the operating lever 69 moving the same upwardly to the "on" position. The line of action of the overcenter spring 73 is shifted above the pivot axis 78 of the switch member 65. As soon as the line of action of the springs moves above the pivot axis 78, the springs operate the switch member 65 to closed circuit position with a snap action. In this position, the line of action of springs is also disposed above the pivot axis of the operating lever 69 so that the springs maintain the operating lever and operating handle in the "on" position. The springs also maintain a predetermined high contact pressure between the contacts 61 and 63. The springs always act to bias the releasable supporting lever 67 in a counter-clockwise direction about its pivot 75. However, this member is normally restrained against tripping movement by the latch of the trip device 17.

When an overload current above the minimum trip setting of the breaker occurs in the circuit controlled thereby, the current responsive bimetal trip element 101 is heated by the overload current and after it has been heated a predetermined amount, this element deflects downwardly, causing the latch 113 to release the supporting lever 67, whereupon the operating springs 73 actuate the supporting lever 67 in a counter-clockwise direction about its pivot 75 to the tripped position shown in Fig. 4. During the initial portion of the movement of the supporting lever 67, the upper edge of the V-shaped notch engages the switch member 65 and moves the switch member 65 along with the supporting lever 67 to open position. The tripping movement of the supporting lever 67 also acts through the connecting link 95 to move the operating handle and operating lever 69 toward "off" position. At a predetermined point during the movement of the supporting lever 67 toward its tripped position, the line of action of the overcenter spring 73 is shifted below the pivot 78 of the switch member, thereby causing the switch member 65 to be moved to the open position shown in Fig. 4 with a snap action. The line of action of the springs is also shifted below the pivot axis of the operating lever 69 so that the springs act to move the operating lever 69 and the operating handle 71 quickly to the "off" position as shown in Fig. 4.

To reset the circuit breaker mechanism and reclose the contacts of the breaker after an overload tripping operation, the operating handle 71 is moved from the "off" position shown in Fig. 4 back to the "on" position shown in Fig. 1. This movement of the operating handle acts through the link 95 to reset the supporting lever 67 back to its latched position where it is reengaged by the latch 113 of the trip device. This movement of the operating handle also and at the same time moves the operating lever 79 upwardly to the "on" position, thereby causing the operating springs 73 to move overcenter and close the contacts with a snap action. By reason of the link 95, it is possible for an operator to close the cir-

cuit breaker contacts and hold the contacts closed against an overload condition in the circuit controlled by the breaker. This may be desirable under certain conditions, such as when it is necessary to prevent interruption of the circuit even though an abnormal current may be present when the circuit is closed. It will be noted that the link **95** has a projection **96** on the inner end thereof. The purpose of this projection is to positively initiate opening movement of the movable contacts **63** and switch member **65** during both manual and automatic operation of the circuit breaker in order to insure that the mechanism will carry out the opening operation of the contacts even though the contacts may tend to stick or adhere together. Any sticking or slight welding of the contacts is broken by the positive prying action of the projection **96** on the inner end of the connecting link **95**.

If it is desired to make the circuit breaker trip free of the operating handle, all that is necessary to be done is to omit the connecting link **95** and provide a resetting projection on the supporting lever **67**, similar to the resetting projection shown in the Fig. 6 modification, which will be described hereinafter.

A modification of the invention is shown in Fig. 5. The main elements of the circuit breaker structure shown in Fig. 5 are essentially the same as those of the original embodiment of the invention except that the releasable supporting lever for the contact arm is made of a different shape so as to cause the operating handle to assume an intermediate indicating position when the breaker has been tripped, thereby eliminating the necessity of a trip indicating button such as disclosed in Fig. 1. The modified shape of the releasable supporting lever also permits this lever to be reset to the latched position by moving the breaker operating handle to the "off" position after a tripping operation. A slightly modified form of trip device is also shown in Fig. 5. Those elements and parts of the circuit breaker structure shown in Fig. 5 that are identical to the corresponding elements shown in the original embodiment are indicated by the same reference characters.

Referring to Fig. 5, the releasable supporting lever **125** in this embodiment is generally similar to the releasable supporting lever **67** of the original embodiment except that the lever **125** is provided with a cam-shaped projection **127** which cooperates with the cross-pin **81** of the operating lever **69**. The releasable lever **125** is pivoted on the frame **15** by means of the pivot pin **75**, and has a V-shaped notch for receiving and pivotally supporting the switch member **65** in the same manner as in the original embodiment previously described. The operating handle **71** is movable to "off" and "on" positions to cause the mechanism to effect opening and closing of the circuit breaker contacts with a snap action in the same manner as in the original embodiment previously described. The operating handle **71** is movable to "off" and "on" positions to cause the mechanism to effect opening and closing of the circuit breaker contacts with a snap action in the same manner as in the case of the original embodiment. When an overload current above the minimum trip setting of the breaker occurs in the circuit controlled thereby and persists for a sufficient length of time to heat the bimetal trip element **101** a predetermined amount, this bimetal element deflects downwardly, causing the latch **113** to disengage the lower free end of the supporting lever **125**, thereby releasing the supporting lever. Upon release of the supporting lever **125**, the operating springs **73** move this lever in a counter-clockwise direction about its pivot **75** to the tripped position shown in Fig. 5. During the initial tripping movement of the releasable supporting lever **125**, the upper edge of the V-shaped notch thereof picks up the contact member **65** and moves it along with the lever and at the same time the projection **96** on the lever **95** also engages and initiates opening movement of the switch member toward open position. At a predetermined point in the movement of the lever **125**, the line of action of the operating springs **73** is shifted below the pivot axis **78** of the switch member **65**, whereupon the springs move the switch member to open position with a snap action. The link **95** also moves the operating handle **71** toward the "off" position, this movement being continued by the operating springs as soon as the line of action of the springs shifts below the pivot axis of the operating lever **69**. In this embodiment, however, the projection **127** of the releasable lever moves into the path of the cross-pin **81** of the operating lever **69** and arrests the opening movement of the operating lever and operating handle **71** in an intermediate position as shown in Fig. 5 whereby the operating handle **71** indicates that the breaker has been tripped by an overload.

After the breaker has been tripped in response to an overload, the breaker may be reclosed and the mechanism reset by moving the operating handle **71** from the position shown in Fig. 5 downwardly back to the "on" position. This movement of the handle to the "on" position acts through the connecting link **95** to reset the supporting lever **125** back to its latching position where it is reengaged by the latch **113** of the trip device. At the same time, this movement of the lever to the "on" position shifts the line of action of the operating springs above the pivot axis **78** of the switch member **65**, causing movement of the switch member to closed position with a snap action. The mechanism may be reset after tripping without closing the contacts by moving the operating handle **71** upwardly to the "off" position. This movement of the operating handle moves the operating lever **69** downwardly to the "off" position and during this movement, the cross-pin **81** rides on the surface of the cam projection **127** of the supporting lever, forcing that lever back to its latched position where it is reengaged by the latch **113** of the trip device. In this instance, however, the circuit breaker contacts remain in open position, and after resetting in this manner the circuit breaker may be closed by moving the operating handle back to the "on" position in the same manner as for normal manual closing operation of the breaker.

A slightly modified form of ambient temperature compensating arrangement is shown in the Fig. 5 embodiment of the invention. The ambient temperature compensating bimetal element **129** of this embodiment of the invention is secured at its inner end to a supporting bracket **131** which is, in turn, secured to the insulating base **9**. An adjusting screw **133** threaded through the ambient temperature bimetal element adjacent the outer end thereof engages the connecting lever **103** and serves to provide for adjusting the minimum overload trip setting of the breaker. A relatively stiff spring **135** connects the free end of the ambient temperature responsive bimetal element **129** to the free end

of the connecting lever 103 and serves to maintain the lever 103 in contact with the adjusting screw 133. An opening is provided in the lower end wall of the casing to permit adjustment of the screw 133 from outside of the casing. Turning the screw in a clockwise direction moves the current bimetal trip element 101 upwardly about its pivot 105 and increases the minimum overload trip current to which the breaker will respond. Conversely turning the screw 133 in a counterclockwise direction causes the current bimetal trip element 103 to be moved downwardly about its pivot and thereby decreases the minimum overload current to which the breaker will respond. In the case of relatively low magnitude overload currents, some of the heat produced in the current bimetal trip element 101 is transmitted to the ambient temperature responsive bimetal element 129 and thereby causes greater time delay action in the case of such relatively low magnitude overload currents than in the case of an uncompensated bimetal trip device. In the case of moderate overload currents and heavy overload currents or short circuits, substantially no heat is transferred to the ambient temperature responsive bimetal element 129 so that the current bimetal element under these conditions operates just as quickly, that is to say, with the same time characteristic as an uncompensated current responsive bimetal element of the same composition. This is mainly due to the fact that there is insufficient time for any substantial transfer of heat from the current bimetal to the ambient bimetal element.

It will be noted that the side plate of the frame 15 is provided with a circular opening 137 and the releasable supporting lever is also provided with an opening 139. The purpose of these openings will be explained in the description of the structure shown in Fig. 6.

Due to the presence of the connecting link 95, the circuit breaker structure shown in Fig. 5 is non-trip-free of the operating handle, that is to say, the circuit breaker may be closed and held closed against an overload current condition in the circuit by the handle 71 the same as in the case of the original embodiment of the invention.

If it is desired to make the circuit breaker trip-free of the operating handle 71, the circuit breaker structure is modified as shown in Fig. 6 by omitting the connecting link 95, and an additional angle-shaped lever 141 is provided which is pivotally mounted on a pivot pin 143 supported in the pivot opening 139 of the releasable supporting lever. This angle-shaped lever engages a fixed stud 145 that is secured in the opening 137 in the side plate of the frame 15. The remaining structure of the breaker as shown in Fig. 6 is exactly the same as the circuit breaker structure shown in Fig. 5, and the corresponding parts have been given the same reference character. The circuit breaker shown in Fig. 6 is manually operated to open and closed position in the same manner as the previously described embodiments of the invention by moving the operating handle to "off" or "on" position. When an overload of sufficient magnitude and duration occurs in the circuit controlled by the breaker, the bimetal trip element 101 deflects downwardly, effecting release of the supporting lever 125, whereupon the springs 73 actuate the supporting lever to the tripped position shown and cause movement of the switch member to open position. During the initial portion of the tripping movement of the lever 125, the angle-shaped lever 141 is caused to be moved downwardly by reason of its engagement with the fixed stud 145, and this downward movement of the angle-shaped lever positively initiates opening movement of the switch member 65 and assists in moving the switch member downwardly until the line of action of the overcenter springs has been shifted below the pivot axis of the switch member, and also below the pivot axis of the operating lever 69. As the line of action of the springs is shifted below the pivot axis of the operating lever 69, the springs act to move the operating lever downwardly to the "off" position and the handle 71 upwardly toward the "off" position. The movement of these elements is arrested in an intermediate position by the cam projection 127 striking the cross-pin 81 of the operating lever. Due to the omission of the link 95, the contacts and switch member are trip-free of the operating handle, that is to say, opening of the contacts will take place even though an operator were to hold the operating handle in the "on" position when the breaker trips. This trip-free action results from the fact that upon tripping of the breaker, the line of action of the operating springs is shifted below the pivot axis 78 of the switch member 65 even though the handle is held in the "on" position. Before the breaker can be closed after a tripping operation, it is necessary to reset the releasable supporting lever back to its latched position. This is accomplished in the Fig. 6 construction by moving the operating handle 71 from the intermediate indicating position shown, upwardly back to its "off" position. This movement of the operating handle causes the operating lever 69 to be moved downwardly to "off" position, and during this movement the pin 81 rides on the cam projection 127 and thereby forces the supporting lever back to its latched position where it is reengaged and held by the latch of the trip device 17. After the breaker has been reset, it may be reclosed by moving the operating handle downwardly to the "on" position.

While the invention has been disclosed in accordance with the provisions of the patent statutes, it is to be understood that various changes in the structural details, arrangement of parts and combination of elements may be made without departing from some of the essential features of the invention. It is desired, therefore, that the language of the appended claims be given the broadest reasonable interpretation permissible in the light of the prior art.

We claim as our invention:

1. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising an operating member movable to an "on" position to effect closing of said contacts, a spring biasing said contacts together when in said "on" position, a normally restrained member biased by said spring to be operable when released to cause opening of said contacts, a trip device normally restraining said releasable member and operable in response to predetermined abnormal conditions to release said spring-biased member, said operating member having means engageable with said spring biased member to prevent operation of said spring biased member when said operating member is held in the "on" position.

2. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising an operating member movable to "off" and "on" positions to open and close said contacts, a spring operatively connecting the operating member and the movable contact for actuating

the movable contact, a trip member biased by said spring and normally restrained in a fixed position, said trip member when released being actuated by said spring to cause automatic opening of said contacts, a trip device normally restraining said trip member and operable in response to predetermined abnormal conditions to release said trip member, said trip member remaining restrained in fixed position during normal opening and closing of said contacts, said operating member having means engageable with said trip member to prevent circuit opening operation of said trip member when said operating member is held in a predetermined position.

3. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising an oscillatable operating member movable to the "off" and the "on" positions for effecting opening and closing of said contacts, a spring biased member normally restrained in a fixed position and operable when released to cause automatic opening of said contacts, a trip device normally restraining said spring biased member and operable in response to predetermined overload conditions to release said member, said spring biased member remaining restrained in fixed position during normal opening and closing of said contacts, and a link connecting said operating member and said spring biased member, said link having a lost motion connection to one of said members to permit movement of said operating member to the "on" and the "off" positions while said spring biased member is restrained in fixed position and said link acting to maintain said spring biased member in fixed position when said operating member is held in the "on" position.

4. A circuit breaker comprising a contact member movable to open and closed positions, a support for supporting the said contact member, said support being movable when released to cause movement of the contact member to an open position, a trip device normally restraining the support in fixed position and operable in response to predetermined abnormal conditions to release the support, an operating member movable to open and closed positions for operating the contact member to open and closed positions, and an operating spring connecting the operating member to the contact member, said operating member having means engageable with the support effective to restrain the support in fixed position when the operating member is held in closed position.

5. A circuit breaker comprising a contact member movable to open and closed positions, a normally restrained support for the contact member that is movable when released to cause movement of the contact member to an open position, a trip device normally restraining said support in fixed position and operable in response to predetermined overload conditions to release said support, an oscillatable operating member movable to "off" and "on" positions for effecting operation of said contact member to open and closed positions, an overcenter operating spring connecting said operating member to said contact member for actuating said contact member and for actuating said support when the support is released, and a link providing a lost motion connection between said operating member and said support.

6. A circuit breaker having a switch member movable to open and closed circuit position, operating mechanism therefor comprising an operating member movable to "on" and "off" positions for operating said switch member to open and closed circuit positions, an overcenter operating spring operatively connecting said operating member and said switch member for actuating said switch member, a normally restrained releasable member operatively related to said switch member and operable by said spring when said member is released to cause movement of said switch member to an open circuit position, a trip device normally restraining said releasable member in fixed position and operable in response to predetermined overload conditions to release said releasable member, and a link connecting said operating member and said releasable member effective to prevent tripping operation of said releasable member when said operating member is held in a predetermined position, said link having a pin and slot connection to one of said last-mentioned members to permit movement of said operating member to the "on" and "off" positions while said releasable member is restrained in fixed position by the trip device.

7. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising a pivotally mounted operating member movable to the "off" and the "on" positions for effecting opening and closing of said contacts, a releasabe member normally held in fixed position and operable when released to cause automatic opening of said contacts, means normally holding said releasable member in fixed position, said means being operable to release said member, and a connecting link pivotally connected to one of said members and having a lost motion connection with the other of said members, said operating member when moved to the "on" position following automatic opening operation of said contacts effecting resetting of said releasable member to its fixed position and closing of said contacts.

8. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising an operating member movable to the "off" and the "on" positions to effect opening and closing of said contacts, a normally restrained spring biased member automatically operable upon the occurrence of predetermined abnormal conditions to cause opening of said contacts, a lever pivotally connected to said spring biased member, and means for moving said lever relative to said spring biased member for positively initiating opening of said contacts.

9. A circuit breaker having a switch member movable to open and to closed circuit positions, operating mechanism therefor comprising an operating member manually operable to the "off" and the "on" positions for effecting operation of said switch member to open and closed position, a normally restrained spring biased member automatically operable upon the occurrence of predetermined abnormal conditions to cause movement of said switch member to an open circuit position, and a lever pivotally connected to said spring biased member for positively initiating opening movement of said switch member both on manual and automatic opening operations of said breaker.

10. A circuit breaker having a switch member movable to open and to closed circuit positions, operating mechanism therefor comprising an operating member manually operable to the "off" and the "on" positions for effecting operation of said switch member to open and closed position, an operating spring operatively connecting said operating member and said switch member, a

normally restrained spring biased member automatically operable upon the occurrence of predetermined abnormal conditions in the circuit to cause movement of said switch member to an open circuit position irrespective of the position of said operating member, and a lever pivotally connected to said spring biased member for positively initiating movement of said switch member to open position upon operation of said spring biased member.

11. A circuit breaker having a switch member movable to open and closed circuit positions, operating mechanism therefor comprising an operating lever manually operable to the "off" and the "on" positions for effecting operation of said switch member to open and closed positions, an overcenter operating spring operatively connected to bias said operating member and said switch member, a spring biased member normally restrained in one position and automatically operable upon the occurrence of predetermined abnormal conditions in the circuit to cause movement of said switch member to an open circuit position, and a lever connecting said operating member and said spring biased member and having a pin and slot connection with one of said members, said lever having a projection engageable with said switch member for positively initiating opening movement of said switch member.

12. A circuit breaker having relatively movable contact members, operating mechanism therefore comprising an oscillatable operating lever manually operable to "off" and the "on" positions to effect opening and closing of said contact members, an operating spring operatively connected to bias said operating lever and the movable contact member, a normally restrained releasable member operatively related to the movable contact member and operable when released to cause automatic opening of said contact members and movement of said operating lever to an intermediate position, and a trip device operable to release said releasable member, said operating lever when moved to the "on" position after an automatic opening operation of the breaker effecting resetting of said releasable member to its restrained position and closing of said contact members.

13. A circuit breaker having a switch member movable to open and to closed circuit positions, operating mechanism therefor comprising an oscillatable operating member movable to "off" and the "on" positions to effect operation of said switch member to open and to closed position, an overcenter operating spring operatively connecting said operating member and said switch member, a pivotally mounted support member upon which said switch member is pivotally supported, a trip device having means normally restraining said support member in fixed position and operable in response to predetermined overload conditions to release said member, said support member when released causing automatic opening of said switch member and movement of said operating member to an intermediate position, said operating member when moved to the "on" position following automatic opening operation of the breaker effecting both resetting of said support member and operation of said switch member to closed position.

14. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising an oscillatable operating member movable to "off" and the "on" positions to effect opening and closing of said contacts, a normally restrained releasable member operable when released to cause said mechanism to automatically open said contacts and move said operating member to an intermediate position, a trip device normally restraining said releasable member and operable in response to predetermined overload conditions to release said member, said operating member when moved from said intermediate position to said "off" position being operative to reset said releasable member to its restrained position and being operable when moved from said intermediate position to said "on" position to effect both resetting of said releasable member and closing of said contacts.

15. A circuit breaker having a switch member movable to open and to closed circuit positions, operating mechanism therefor comprising an oscillatable operating member movable to "off" and the "on" positions to effect operation of said switch member to open and to closed position, an overcenter operating spring operatively relating said operating member to said switch member, a normally restrained releasable member operatively related to said switch member and operable when released to cause said mechanism to effect automatic circuit opening operation of said switch member and movement of said operating member to an intermediate position, a trip device having means normally restraining said releasable member and operable in response to predetermined abnormal current conditions to release said member, said operating member having means engageable with said releasable member whereby movement of said operating member from said intermediate position to said "off" position resets said releasable member to its restrained position and movement of said operating member from said intermediate position to said "on" position also resets said releasable member in addition to operating said switch member to the closed position.

16. A circuit breaker comprising a base of insulating material, contact means including a movable contact member mounted on said base, operating mechanism therefor mounted on said base comprising a pivoted operating lever, an overcenter operating spring operative to bias said operating lever and said contact member, a normally restrained releasable member operable when released to cause automatic opening operation of said contact means, a cover removably mounted on said base, an operating handle oscillatably mounted on the front of said cover and having a bifurcated portion engaging said operating lever to provide a separable operative connection between the handle and lever.

17. A circuit breaker having a switch member movable to open and closed circuit positions, operating mechanism therefor comprising an oscillatable operating member having a handle movable to "off" and "on" positions for effecting operation of said switch member to open and to closed circuit positions, an overcenter operating spring operatively relating said operating member to said switch member, a normally restrained releasable member operatively related to said switch member and operable to a tripped position when released to cause said mechanism to automatically move said switch member to an open circuit position and move said operating member to the "off" position, a casing for enclosing said parts except the handle portion of said operating member which projects through an opening in the front wall of said casing, and

a trip indicating element mounted in the front wall of said casing and engaged and moved to an indicating position by said releasable member upon release thereof.

18. In a circuit breaker having relatively movable contacts and operating mechanism therefor, a trip device comprising a pivotally mounted bimetal trip element heated in response to the current of the circuit and deflectable when heated a predetermined amount by overload current to effect tripping of said circuit breaker operating mechanism, an ambient temperature responsive bimetal element for compensating said current responsive bimetal element for changes in ambient temperature, said ambient temperature responsive bimetal element being mounted on a fixed support at one end, and a metal lever connecting the pivot end of the current responsive bimetal element to the free end portion of said ambient temperature responsive bimetal element.

19. In a circuit breaker having relatively movable contacts and operating mechanism therefor, a trip device comprising a pivotally mounted bimetal trip element heated in response to the current of the circuit and deflectable when heated a predetermined amount by overload current to effect tripping of said circuit breaker operating mechanism, an ambient temperature responsive bimetal element for compensating said current responsive bimetal element for changes in ambient temperature, said ambient temperature responsive bimetal element being mounted on a fixed support at one end, a metal lever connecting the pivot end of the current responsive bimetal element to the free end portion of said ambient temperature responsive bimetal element, and an adjusting screw engaging said ambient temperature responsive bimetal element for adjusting the minimum trip current setting of said trip device.

20. In a circuit breaker having relatively movable contacts and operating mechanism therefor, a trip device comprising a pivotally mounted bimetal trip element heated in response to the current of the circuit and deflectable when heated a predetermined amount by overload current to effect tripping of said circuit breaker operating mechanism, an ambient temperature responsive bimetal element for compensating said current responsive bimetal element for changes in ambient temperature, said ambient temperature responsive bimetal element being mounted on a fixed support at one end, a lever connecting the pivot end of the current responsive bimetal element to the free end portion of said ambient temperature responsive bimetal element, and an adjusting screw engaging said ambient temperature responsive bimetal element adjacent the fixedly supported end for moving said ambient responsive bimetal element to adjust the trip characteristic of said trip device.

21. In a circuit breaker having relatively movable contacts and operating mechanism therefor, a trip device comprising a pivotally mounted bimetal trip element heated in response to the current of the circuit and deflectable when heated a predetermined amount by overload current to effect tripping of said circuit breaker operating mechanism, an ambient temperature responsive bimetal element for compensating said current responsive bimetal element for changes in ambient temperature, said ambient temperature responsive bimetal element being mounted on a fixed support at one end, and a metal lever connecting the pivot end of the current responsive bimetal element to the free end portion of said ambient temperature responsive bimetal element, said connecting lever having a bent portion provided with a slot engaging the free end portion of said ambient temperature responsive element.

22. In a circuit breaker having relatively movable contacts and operating mechanism therefor, a trip device comprising a pivotally mounted bimetal trip element heated in response to the current of the circuit and deflectable when heated a predetermined amount by overload current to effect tripping of said circuit breaker operating mechanism, an ambient temperature responsive bimetal element for compensating said current responsive bimetal element for changes in ambient temperature, said ambient temperature responsive bimetal element being mounted on a fixed support at one end, and a metal lever connecting the pivot end of the current responsive bimetal element to the free end portion of said ambient temperature responsive bimetal element, said lever engaging an adjusting screw threadedly supported in the ambient temperature responsive bimetal adjacent the free end thereof.

23. A circuit breaker having relatively movable contacts, operating mechanism therefor comprising an operating member movable to the "off" and the "on" positions to effect opening and closing of said contacts, a normally restrained spring biased member automatically operable upon the occurrence of predetermined abnormal conditions to cause opening of said contacts, and a lever operatively connected between said normally restrained spring biased member and a fixed point so that movement of said spring biased member upon the occurrence of said predetermined abnormal conditions causes movement of said lever relative thereto for positively prying said contacts open.

24. A circuit breaker having a switch member movable to open and to closed circuit positions, operating mechanism therefor comprising an operating member manually operable to the "off" and the "on" positions for effecting operation of said switch member to open and closed position, an operating spring operatively connecting said operating member and said switch member, a normally restrained spring biased member automatically operable upon the occurrence of predetermined abnormal conditions in the circuit to cause movement of said switch member to an open circuit position irrespective of the position of said operating member, and a lever having a slidable engagement with said normally restrained spring biased member for prying said switch member and positively initiating movement thereof to open position upon operation of said spring biased member.

25. An electric switch having a manually operated member movable between positions corresponding to switch open and switch closed positions, mechanism operated thereby including a spring for permitting opening and closing of the switch, electro-responsive means for effecting opening of the switch, and means selective at will to permit the opening of said switch by the spring in response to said electro-responsive means with and also without associated movement of said manual operating member.

26. An electric switch having switch operating mechanism including an operating handle movable between positions corresponding to switch open and switch closed positions for moving said

mechanism manually into and out of said positions, electro-responsive means for permitting operation of said mechanism into switch open position, and means selective at will to condition said handle for movement with said mechanism in response to the operation of said electro-responsive means and also to permit switch opening movement of said mechanism in response to operation of said electro-responsive means independently of movement of said handle into switch open position.

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