June 9, 1936. J. SANDIN 2,043,306

CIRCUIT INTERRUPTER

Filed Oct. 29, 1932 3 Sheets-Sheet 1

Fig. 1.

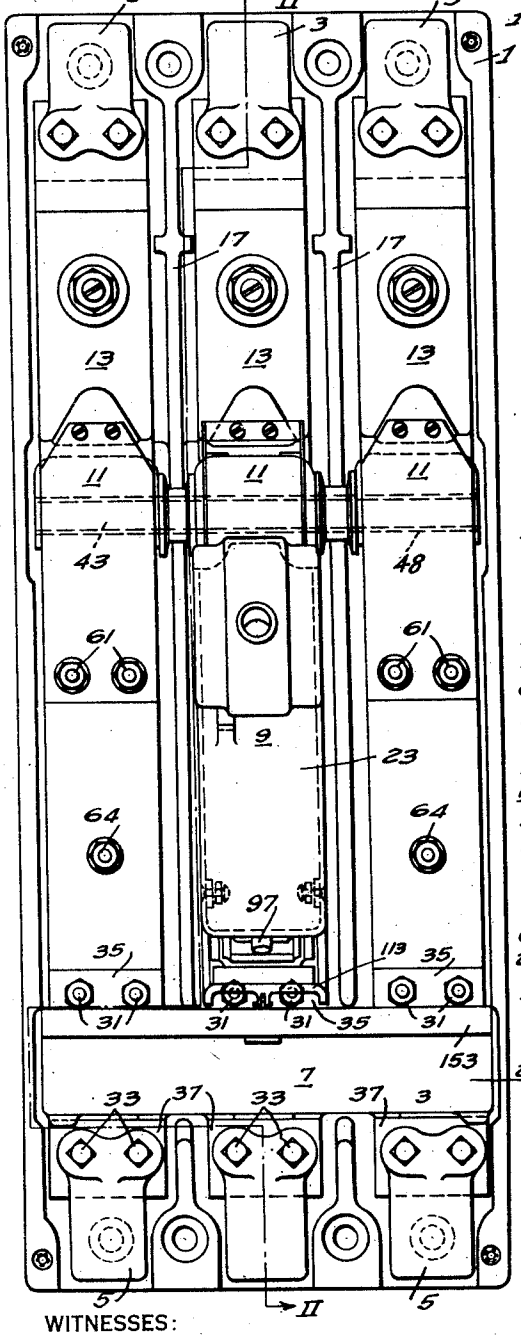
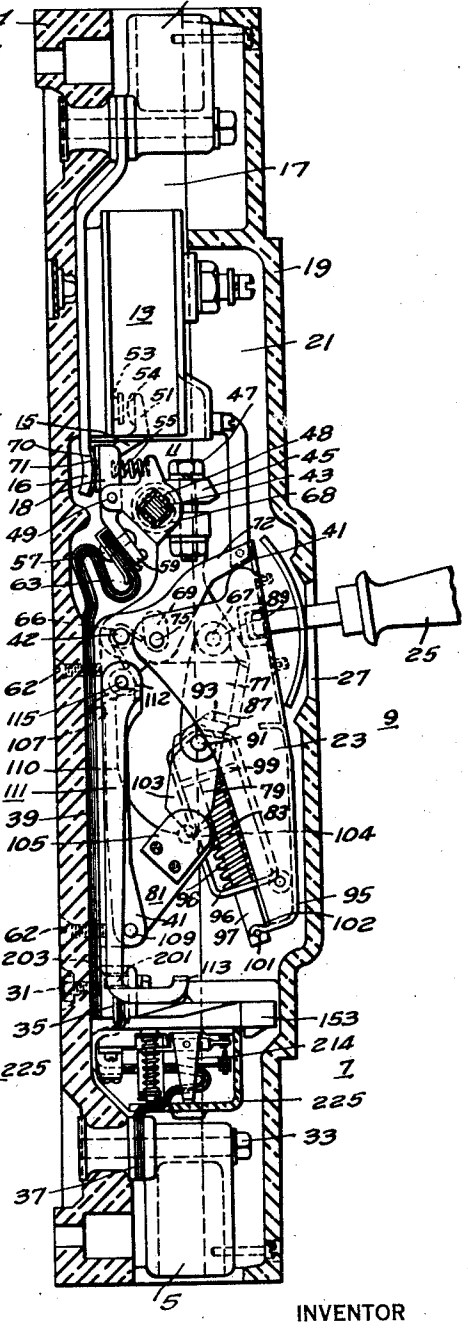


Fig. 2.



WITNESSES:

E. A. McCloskey.

Paul J. Sinister

INVENTOR

Jerome Sandin.

BY F. W. Lyle.

ATTORNEY

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CIRCUIT INTERRUPTER

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Fig. 3.

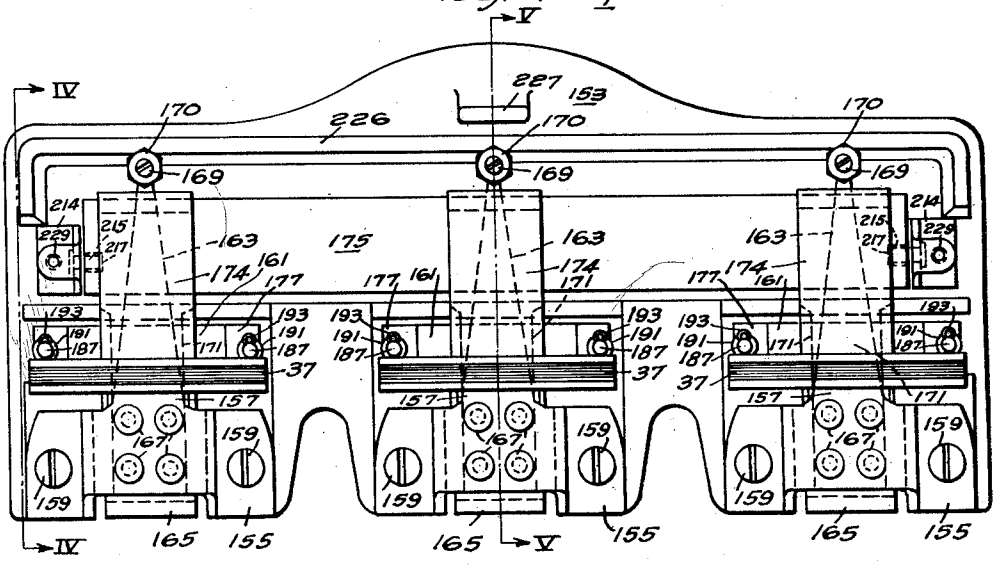
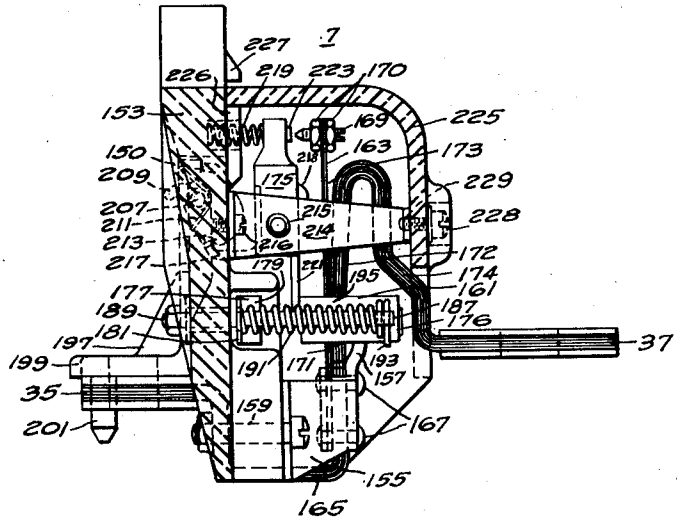


Fig. 4.



WITNESSES:

E. A. McCluskey.

Paul J. Blaisdell

INVENTOR

Jerome Sandin.

BY F. W. Lyle.

ATTORNEY

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CIRCUIT INTERRUPTER

Filed Oct. 29, 1932 3 Sheets-Sheet 3

Fig. 5.

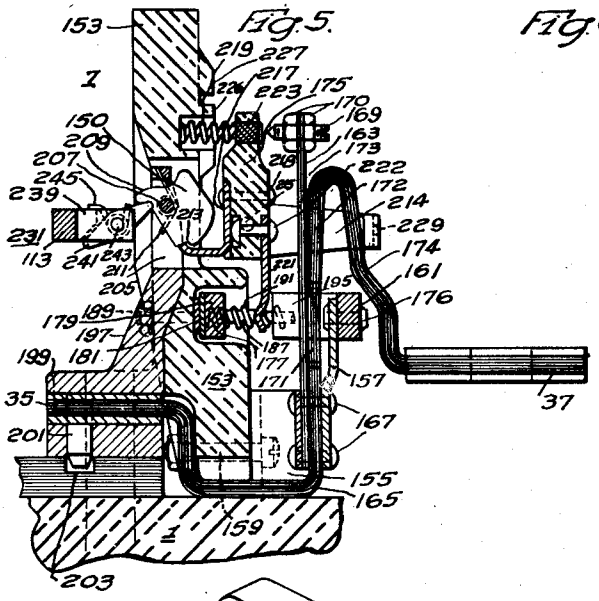


Fig. 6.

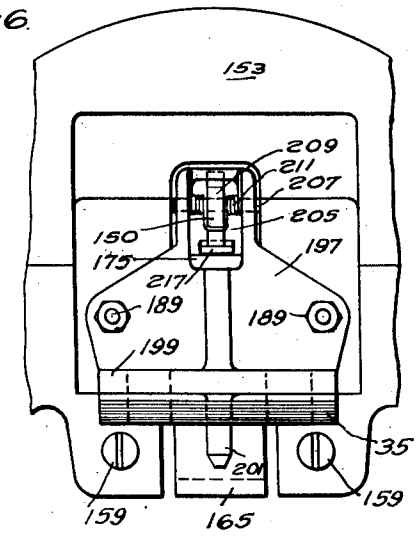


Fig. 7.

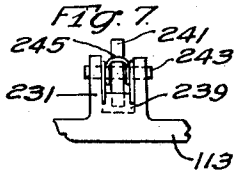


Fig. 8.

Fig. 9.

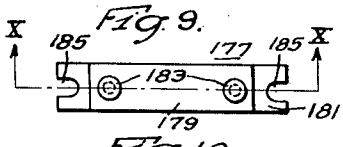
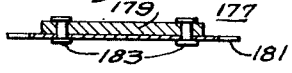


Fig. 10.



WITNESSES:

E. A. McCluskey.

Paul J. Sinister

INVENTOR

Jerome Sandin.

BY F. W. Lyle

ATTORNEY

Patented June 9, 1936

2,043,306

UNITED STATES PATENT OFFICE

2,043,306

CIRCUIT INTERRUPTER

Jerome Sandin, Forest Hills, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application October 29, 1932, Serial No. 640,214

30 Claims. (Cl. 200—88)

My invention relates to circuit breakers for use in controlling lighting and distribution systems, and is particularly concerned with electro-responsive trip devices for use with such circuit breakers. These breakers are usually manually operable to open or close the circuit, trip-free of the operating handle, and completely re-settable to the operative position either automatically or by means associated with the operating handle.

Trip devices for this type of service are subjected to very severe and very exacting operating conditions due to the large amounts of power available in most systems and the necessity of rendering uninterrupted service to the consumer. They must be capable of opening the controlled circuit practically instantaneously upon the occurrence of short circuits or dangerously large overloads, and yet must act upon the occurrence of moderate overloads only after a predetermined time delay in order to avoid undesirable discontinuities in the service. A magnetically responsive trip element, and a thermally responsive trip element, each capable of actuating the trip mechanism independently of the other, are provided to accomplish this selective opening of the circuit breaker. In addition, the device must be easily and quickly re-settable following each tripping operation.

It is an object of my invention, therefore, to provide an improved electro-responsive trip device, suitable for use with this type of circuit breaker, that shall be more satisfactory and more reliable in operation, and that shall be more economical to manufacture, than previous devices of this character.

Another object of my invention is to provide an improved thermally responsive element for circuit breaker trip devices, the operation of which shall not be affected by the magnetic forces set up within or around the heater.

A further object of my invention is to provide an improved heater for the thermally responsive element of removable, interchangeable trip devices, my improved heater to be of flexible construction in order that the mechanical stresses set up by the fastenings which connect the heater into the electrical circuit shall not affect the calibration of the thermally responsive element.

A further object of my invention is to provide an improved supporting means for removable, interchangeable electro-responsive trip devices that shall accurately position the trip lever with respect to the circuit breaker operating mechanism.

A further object of my invention is to provide a substantially shock-proof trip device for circuit breakers.

A further object of my invention is to provide a simplified and improved means for slidably mounting the armature of a magnetically responsive trip element.

A further object of my invention is to provide an improved armature for magnetically responsive trip elements that shall be simple in construction and that shall be incapable of sticking to its attracting core during operation.

A further object of my invention is to provide a new and improved arrangement for the parts of a combined thermally responsive and magnetically responsive trip element, my improved arrangement to result in better operation of the device and to reduce manufacturing cost.

A still further object of my invention is to provide an improved latch engaging structure for circuit breaker operating mechanisms that shall permit the use of interchangeable, completely automatically resettable trip devices.

Since, as mentioned above, the principal field for immediate application of my invention is in connection with multi-pole circuit breakers for controlling lighting and distribution feeder circuits, I shall hereinafter describe an embodiment of my invention as applied to such circuit breakers, without, in any way, intending to restrict the scope of my invention except as indicated in the appended claims.

In this embodiment of my invention, I provide a plurality of switch members and a plurality of cooperating stationary contact members for opening a plurality of poles. In addition, I provide a manually operable mechanism for opening and closing the circuit breaker contacts with a snap action, an insulating base upon which the structure is assembled, an arc extinguishing device for each pole, a spring for biasing each of the switch members to the open circuit position, a releasable restraining means for holding all of the switch members closed, and a removable, interchangeable, unitary trip device for releasing the restraining means in response to a predetermined electrical condition in any one pole, and thereby opening all of the poles of the breaker; the releasing means being operable to open the breaker regardless of the position of the operating handle.

The features of my invention which I believe to be new, are particularly pointed out in the appended claims. For a fuller understanding of the principles of the invention reference may be had to the accompanying drawings in which:

Figure 1 is a plan view of a three-pole circuit breaker embodying the principal elements of my invention. The cover has been removed to more completely show the various parts of the breaker structure.

Fig. 2 is a sectional view taken on the line II—II of Fig. 1.

Fig. 3 is an enlarged elevational view of the unitary trip structure shown as a part of the circuit breaker illustrated in Figs. 1 and 2. The cover has been removed to more completely show the various parts of the trip device.

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 3. This view shows the trip device cover in position.

Fig. 5 is a sectional view taken on the line V—V of Fig. 3. This view also shows a part of the circuit breaker base and the engaging portion of the circuit breaker operating mechanism in the latched position.

Fig. 6 is a fragmentary elevational view showing the trip latch and the bracket which supports and positions the trip device.

Fig. 7 is a fragmentary plan view of the portion of the operating mechanism which engages the trip device.

Fig. 8 is a perspective view of the unitary trip device; part of the central heater has been cut away to show the disposition of the various structural elements.

Fig. 9 is a plan view of the armature used in each of the magnetically responsive trip devices, and

Fig. 10 is a sectional view taken on the line X—X of Fig. 9.

Referring to the drawings, the base 1 is of molded insulating material and has mounted thereon terminal contacts 3 and 5, the removable unitary trip device 7, the circuit breaker operating mechanism 9 which has associated therewith the assemblage of the switch members 11, the arc extinguishers 13, and the stationary contact assemblage 15 of the switch members. The assemblage of the switch members 11 and the stationary contact assemblages 15 combine to form a plurality of poles. Each of the poles is insulated from the adjacent pole by means of insulating barriers 17 (Figs. 1 and 2) which are molded into the base 1. These insulating barriers 17 aline with similarly shaped barriers 21 (Fig. 2) molded in the cover 19 which is likewise of insulating material. The operating member 23 has a removable handle 25 and is rigidly pivoted to the frame 41 of the operating mechanism 9. An opening 27 (Fig. 2) is provided in the cover 19 to accommodate the operating handle. The unitary trip device 7 is retained in position by the screw fastenings 31 and 33 which also serve to electrically connect the terminals 35 and 37 of the trip device with the laminated shunts 39 and the terminal contacts 5, respectively.

The electrical circuit for each of the poles is substantially the same. Beginning with the terminal contact 3, the current passes successively along the arc extinguishing structure 13, thence through the main stationary contact 16, the cooperating main moving contact 18 and the flexible shunt 39 which is associated with each of the switch members, the terminal 35 of the trip structure 7, and finally through the trip structure to the other terminal contact 5.

Since my invention is particularly concerned with the electro-responsive trip device, and since the circuit breaker wherein my invention has been embodied is completely described in the copending application of Harry J. Lingal, Serial No. 637,749, filed October 14, 1932, and assigned to the assignee of this invention, the description will be limited to a setting forth of the various elements. It will be noted that the reference numerals for this case coincide with the reference numerals for Serial No. 637,749, this has been done to facilitate a comparison therebetween.

The assemblage of the switch members 11 is pivoted to the frame 41 of the operating mechanism 9 by means of a pin 42. The steel tie bar 43 serves to rigidly interconnect the three switch members 11, there being only one pivot point. Each of the switch members 11 includes a clamp member 45 for engaging the tie bar 43, the bolts 47 being provided as a fastening means. A square tube 48 of insulating material is positioned between the tie bar 43 and the clamp members 45 to prevent the short circuiting of the several poles. The main moving contacts 18 are pivoted to the clamp members 45 through the agency of the pins 49; a projecting auxiliary contact member 51 is provided for engaging the stationary arcing contact 53. Springs 55 are provided for biasing each of the main moving contact members 18 toward the cooperating main stationary contact members 16 with a predetermined normal force.

The end of each of the shunts 39 adjacent the switch members 11 is affixed to the pivotally mounted main contact members 18 through the agency of rivets 57. Each of the main moving contact members 18 has a rearwardly extending portion 59 for engaging the end of the shunt 39 and for defining the limit of movement of each of the contact members 18 under the biasing action of the contact spring 55. The shunts 39 for the two outer poles are rigidly affixed to the base 1 by means of the screw fastenings 61 and 64, which pass through suitable openings in the shunts. The shunt 39 for the central pole is held in place by four screws 62 which engage threaded openings in the base 41 of the operating mechanism 9. The shunts 39 are of laminated construction, being built up of a plurality of thin sheets of copper and are, therefore, longitudinally flexible. A reverse or S-shape loop 63 has been placed in each of the shunts 39 between the rigidly fastened portion—the limits of which are defined by the screw fastenings 61 and 64—and the end 59 of the pivotally mounted contact members 18.

The clamp member 45 of the central switch member 11 has openings 66 for engaging the contact assemblage pivot pin 42, openings 67 for engaging the breaker operating mechanism, and slotted openings 69 for clearing the pivot pin 75 of the operating member 23. The limit of upward motion of the assemblage of the switch members 11 is defined by the engagement of the portion 68 of the central clamping member 45 with the portions 72 of the frame 41 (see Fig. 2).

The main stationary contact members 16 and the main moving contact members 18 have engaging faces 70 and 71, respectively, which are composed of silver in order to improve the current carrying qualities. The auxiliary stationary contact 53 and the engaging portion 54 of the auxiliary contact member 51 are composed of an arc resisting alloy of tungsten and silver, the proportions being 60% of the former and 40% of the latter. I prefer to use arc resisting material for

these contact surfaces in order to reduce to a minimum the injurious effects of the arc which is established therebetween during the operation of the breaker.

The arc extinguishers 13 which I prefer to use with my invention are of the spaced plate type in which the single arc formed incident to the opening of the circuit is divided into a plurality of short arcs by the spaced plates, the short arcs then being caused to move in the spaces between the plates in a rotary path until extinguished. Patent application Serial No. 592,236 of Mr. M. W. Brainard, filed February 16, 1932, and assigned to the assignee of this invention, fully discloses the structural features, and fully describes the operation, of an arc extinguisher of this type. Each of the arc extinguishers 13 is separated from the adjacent arc extinguisher by the insulating barriers 17 and 21; this construction gives an increased margin of safety while interrupting heavy current arcs by reducing the possibility of flashover between the adjacent poles.

The operating mechanism 9 comprises, in general, a base or frame 41, a pair of toggle links 77 and 79 having one end connected to the assemblage of switch members 11 through the central clamp member 45, a carrier lever 81 for releasably restraining the other end of the toggle links 77 and 79 in operative position, an operating member 23, an over-center spring unit 83 for connecting the operating member 23 to the knee of the toggle links, and the operating handle 25.

The base 41 is positioned above the conducting shunt 39 of the central pole and is rigidly affixed to the base 1 by means of the screws 62. As previously pointed out, the assemblage of the switch members 11 is pivoted to the base 41 by means of the pivot pin 42, and the operating member 23 is pivoted to the base 41 by means of the pivot pin 75. One end of the toggle link 77 operatively engages the openings 67 in the central clamping member 45 through the agency of the pin 89. The other end of the toggle link 77 is pivoted to one end of the toggle link 79 by means of the knee pivot pin 91. The toggle links 77 and 79 are provided with portions 87 and 93, respectively, which engage when the breaker is in the closed position to define the limit of upward movement of the knee of the toggle.

The over-center spring unit 83 operatively connects the end 95 of the operating member 23 with the knee pivot pin 91 of the toggle links and exerts a tension force therebetween. The over-center spring unit 83 comprises a frame 96, one end of which is adapted to engage the knee pivot pin 91 and the other end of which has a circular opening to admit the plunger member 97. The over-center spring 98 which is, itself, in compression is positioned between the end of the frame 96 having the opening therein and the enlarged portion 99 of the plunger 97. The other end of the plunger 97 pivotally engages the end 95 of the opening member 23 by means of a pin 101 which fits into a suitable recess 102.

The end 103 of the toggle link 79 is provided with a circular bearing portion 104. The circular bearing portion 104 engages a suitable recess in the end of the bell crank carrier lever 81, and two retaining plates 105 are disposed on the outer sides of the carrier lever 81 to prevent the bearing portion 104 from moving sideways and disengaging the recess.

The bell crank carrier lever 81 has a projecting portion 107 (Fig. 2), for engaging the latching lever 111 and is pivoted to the base 41 at its apex by means of a pin 109. The portion 110 of the carrier lever 81 extends along the base 41 to form which might be termed a "tail" portion. The perpendicular distance from the center of the carrier pivot pin 109 to the line of action of the toggle lever 79 is considerably less than the distance from the center point of the carrier pivot pin 109 to the portion 107, which projects from the tail portion 110. This gives the carrier lever 81 a very appreciable mechanical advantage over the toggle.

The over-center spring unit 83, at all times, exerts a force on the carrier lever 81 biasing the lever in a clockwise direction (Fig. 2), and it is to restain the carrier lever in the operative position that the latching lever 111 is provided.

The latching lever 111 includes a projecting portion 112 for engaging the section 107 of the carrier lever 81 and a portion 113 for engaging the trip latch 150. One end of the latching lever 111 is pivoted to the base 41 by the pivot pin 115, adjacent the point of engagement with the tail piece 110 of the carrier member 81. The projecting portion 112 of the latching lever 111 normally overhangs the portion 107 which projects from the tail member 110 of the carrier lever 81 and thus holds the carrier lever 81 in an operative position by preventing it from moving upward. The free end of the latching lever 111 is releasably restrained in the position shown in Fig. 2 through the engagement of the portion 113 with the trip latch 150 which forms a part of the trip device 7.

It should be noted at this point that the mechanical advantage of the latching lever 111 is very great with respect to the carrier lever 81; the distance from the center of the latching lever pivot pin 115 to the point of engagement of the projecting portions 112 and 107—that is, the point of engagement of the latching lever 111 and the carrier lever 81—is very small as compared with the distance from the center of the pin 115 to the point of engagement of the latch of the trip device 7 and the latching lever 111. This makes possible the use of a very sensitive trip device, because the large forces exerted by the spring 83 may be controlled by a very small balancing force.

As previously pointed out, the trip structure 7 is a unitary device entirely assembled upon its own base 153 of molded insulating material and completely removable from the breaker, the screw fastenings 31 and 33 being utilized to mount the trip structure on the base 1 and to make the necessary electrical connections. The trip device 7 includes a thermally responsive element and a magnetically responsive element for each of the three poles, and the mechanism of the device is so arranged that a moderate over-load in the circuit controlled by any one of the poles will actuate the trip mechanism after a predetermined time delay, and a heavy overload in the circuit controlled by any one of the poles will actuate the trip mechanism instantaneously, to open all three poles of the breaker.

Being removable, the trip device 7 is interchangeable with other devices having the same physical dimensions but having different current ratings. It is thus possible to market an entire line of breakers by manufacturing only a single type of operating mechanism and contact assemblages, the different breaker sizes being secured by the supplying of a suitable trip device having the particular current rating desired. Although the contact and shunt assemblages must,

of necessity, be of sufficient size to handle the largest current value, and thus be wasteful of material when utilized for lower current applications, the advantages resulting from the standardization of parts and the elimination of a multiplicity of tools much more than balance the slightly greater cost of material.

One difficulty has arisen in the application of completely interchangeable trip devices to the type of circuit breaker disclosed herein, due to the necessity of securing good electrical contact between the terminals of the trip device and the cooperating conducting members associated with the circuit breaker and, at the same time, securing an accurate positioning of the trip latch with respect to the path of movement of the engaging member of the circuit breaker operating mechanism. This difficulty has been particularly objectionable in the higher current units because it has been the general practice to position and support the trip device by means of the screw fastenings which engage the trip device terminals. These terminals are mechanically as well as electrically connected to a conducting strip having the double function of serving as a heater for the thermally responsive element and of acting as an energizing means for the magnetically responsive element. For best operation, the heater must be fastened directly to a portion of the thermally responsive member—usually a bimetal strip—and in the larger current ratings the physical dimensions of this strip become so large that the fastening down of the terminals sets up sufficient mechanical stress in the heater strip to move the thermally responsive member from its normal position, thus destroying the calibration of the trip device. This difficulty may be overcome by very accurate machining of the terminals and of the cooperating members in the circuit breaker, but this solution is not a practical one from an economic viewpoint.

In this embodiment of my invention, I have provided a laminated heater which is longitudinally flexible and which permits the interchanging of the trip device without any objectionable alternation in the calibration of the thermally responsive element. As shown in Figs. 4, 5, and 8, the trip elements for each of the three poles are mounted on the trip base 153 through the agency of a metallic frame 155. The frame 155 is substantially U-shaped and has an up-standing portion 157 which is used to support the core 161 of the magnetically responsive element. Two screw fastenings 159 extend through suitable openings in the base 153 and serve to support each of the frames 155. The thermally responsive element 163 comprises a tapered bimetallic strip which is rigidly affixed at one end to the conducting heater 165 and the frame 155 by means of four rivets 167. The other end of the bimetallic element 163 is free to move and has an adjustable set-screw 169 positioned therein for engaging the trip bar 175. The set-screw 169 passes through a suitable opening in the free end of the bimetallic member 163 and is provided with two locking nuts 170 for maintaining the calibration of the device.

The heater 165 is of laminated construction and comprises a plurality of thin sheets of conducting material, preferably copper, having enlarged end portions which form the terminals 35 and 37 of the trip device, and having a central portion 171 of reduced area—or which is the same thing, increased resistance—which forms the heater portion. As previously pointed out, each of the heaters 165 and its associated bimetal element 163 are supported by one of the frames 155. Besides being thermally conductively joined to the bimetallic member 163, the heater 165 has a portion 172 which extends along a considerable part of the bimetallic member, but is separated therefrom by a tapered gap 173, (Figs. 4 and 5). This gap 173 prevents the bimetallic member 163 from sticking to the portion 172 of the heater 165 due to the attractive magnetic forces set up by the current flowing through the heater. This attraction is particularly noticeable when one portion of the bimetallic element is of magnetic material, and unless some means such as the gap 173 is provided for overcoming this attraction, or for rendering it ineffective, it is very difficult to secure reliable operation of the trip device. The gap is a particularly effective means of accomplishing the desired result because it reduces the magnetic effect most at the portion of the bimetallic element where the attraction would be most effective in disturbing the calibration, that is, at the free end.

The portion of the heater 174 which connects the portion 172 with the terminal 37 is bent backward (Figs. 4, 5 and 6) to form a U-shaped loop about the U-shaped core 161 of the magnetically responsive element. Thus, the current flowing in the heater 165 also energizes the magnetically responsive element. The U-shaped core 161 is affixed to the up-standing portion 157 of the frame 155 by means of a pair of rivets 176 and is thereby positioned between the leg portions 172 and 174 of the heater 165.

The core 161 and the looped heater 155 of each of the magnetically responsive elements provide the attracting means for the movable armatures 177. Each of the armatures 177 comprises a rectangular strip of magnetic material 179 which is affixed to a guide member 181 by means of two rivets 183 of non-magnetic material. The guide member 181 has a cutout portion 185 for engaging the cylindrical guide rods 187 which are affixed to the base 153 of the trip device by means of the screw fastenings 189. A biasing spring 191 is positioned about each of the guide rods 187 and provides a means for biasing the movable armature 177 away from the core 161 of the magnetically responsive element. The biasing springs 191 are retained in position on the guide members 187 by means of cotter pins 193.

One method of supporting the movable armature of a magnetically responsive trip element that has been used to some extent in the past consists in supporting the armature by a single pin which extended through a suitable opening in a frame member and then providing a spring for biasing the pin (and with it the armature) in the desired direction. This scheme is more or less satisfactory for low current ratings, but when an attempt is made to apply this method to circuit breakers adapted to handle considerable amounts of power, two difficulties arise. First, it is difficult to secure enough biasing force from a single spring without unduly lengthening the spring. Second, due to the large forces resulting from the heavier short circuit currents, it is not uncommon for the armature to begin to move at an angle—there being only one support and guide means—and to stick before it actuates the trip mechanism. By supplying two guides as has been done in this embodiment of my invention, I am able to overcome these difficulties, and, as a result, I have secured a magnetically responsive trip

device which may be equipped with sufficiently powerful biasing springs to adapt it for the use in heavy current applications, which, at the same time, occupies a minimum of space, and which is much more dependable in operation than the previously known devices.

The particular armature construction which I use is also of great value in securing reliable and accurate operation of the trip device. By making the guide member 181 of relatively thin material, I prevent the armature from sticking in the guides as a result of uneven or irregular forward movement of the two ends of the armature proper. In addition to this, the rivets 183 which fasten the magnetic portion of the armature 177 to the guide portion 181 are made of non-magnetic material and are adapted to aline with the engaging poles 195 of the core member 161. This engagement prevents any freezing of the armature due to residual flux which might be set up in the magnetic circuit and adds much to the reliability of operation of the trip device.

Although the laminated heaters 165 are of great value in securing accuracy of operation, and at the same time preserving the interchangeable feature of the trip device, they are of little value as a support and positioning means of the trip device itself. Furthermore, it is imperative for accurate operation that the trip device be positioned very accurately with respect to the path of movement of the latching lever 111. In order to accomplish this accurate positioning, I have provided a metallic bracket 197 which is rigidly affixed to the central portion of the trip base 153 by means of the central screw fastenings 189 (Figs. 5 and 6). The bracket 197 has a base portion 199 which is of substantially the same outline as the central terminal 35 and is thus adapted to be fastened to the base 1 of the circuit breaker proper by means of the screw fastenings 31 of the central pole. The central fastenings 31 would probably be sufficient to accurately position the trip base with respect to the operating mechanism 9, but in order to be sure that the positioning is correct, I have provided an additional positioning means which consists of a projecting male member 201 which extends downwardly (Figs. 5 and 6) through a suitable opening in the central terminal 35 and is adapted to engage a cooperating female portion 203 in the central shunt 39, this shunt being securely fastened to the base 1 and accurately positioned with respect to the operating mechanism 9 by means of the screws 62.

The bracket 197 has an opening 205 in the upper portion, the trip lever 150 being pivotally mounted therein through the agency of the pin 207. The positioning of the trip lever 150 is thus made independent of the positioning of the terminals of the trip device.

The trip lever 150 is preferably constructed of metal and has a projecting portion 209 for engaging the latch engaging means associated with the latching lever 111. A spring 211 is provided for biasing the latching lever to the latched position and a notch 213 is provided for engaging the trip bar 175.

The trip bar 175 is of molded insulating material and extends across all three poles of the breaker. It is pivotally supported at either end through the engagement of the pivot pins 215 with suitable openings 217 in the trip bar itself (see Fig. 3). The pivot pins 215 are, in turn, supported by brackets 214 which are fastened to the trip base 153 by screws 216. By positioning the openings 217 substantially at the intersection of the horizontal and vertical axes of movements of the trip bar, an accurate balance of that member is attained for all positions of the breaker. This balance is of great value in reducing the possibility of the trip bar 175 moving to open the breaker as a result of a shock.

The trip bar 175 engages the trip lever 150 through the agency of a bracket 217 (Figs. 4 and 5), one end of which engages the notch 213 and the other end of which is rigidly affixed to the trip bar by a pair of rivets 218. The spring 219 biases the trip bar clockwise (Fig. 5) about its pivot point, or what is more important, biases it into its latched position. Three downwardly extending members 221 each affixed to the trip bar by means of a rivet 222 (Fig. 5) are provided for engaging the armature 177 of each of the magnetically responsive elements of the trip device. The thermally responsive elements 163 engage the trip bar directly through the agency of the set-screws 169 which are adapted to abut against cooperating portions 223. A cover 225 of molded insulating material is provided for the trip device 7. This cover is positioned on the trip base 153 by means of two molded projections 226 and 227, and is secured in place by two screws 228 (Fig. 4) which engage suitable threaded openings 229 in the brackets 214.

The portion 113 of the latching lever 111 includes a bifurcated projection 231 which pivotally supports the latch engaging lever 241 through the agency of the pivoted pin 243 (see Figs. 5 and 7). The latch engaging lever 241 is biased into the engaged position by a spring 245, and its movement in a clockwise direction (Fig. 5) is limited by the base portion 239 of the bifurcated member 231. The exact details of operation of the circuit breaker mechanism 9 are set forth in the previously mentioned application of Harry J. Lingal, and the disposition of the various parts of the mechanism in the open, the closed, and the tripped positions are shown in the drawings accompanying that application. Generally, however, the operation is as follows:

To manually move the contacts from the closed position shown in Fig. 2 to the open position, the handle 25 is moved downwardly. This downward movement causes the toggle links 77 and 79 to collapse toward the base 1 under the influence of the operating spring unit 83. The collapse of the toggle causes the entire assemblage of the switch members 11 to pivot about the pin 42 and move to the open position with a snap action. To close the contacts manually, the operation is reversed, the handle is moved upwardly and the toggle is restored to the position shown in Fig. 2 by the force exerted through the over-center spring unit 83. The contacts close as well as open with a snap action due to the progressive acceleration given by the toggle.

When the circuit breaker is in the closed circuit position (Fig. 2), and an overload of sufficient magnitude and of sufficient duration to actuate the trip device occurs in the circuit controlled by any one of the poles of the breaker, the latching lever 150 moves to release the unpivoted end of the latching lever 111. The latching lever 111 is biased counter-clockwise (Fig. 2) about its pivot pin 115 by the spring and by the transmitted force of the operating spring unit 83, and as soon as it is released, it moves so that the portion 112 uncovers the cooperating portion 107 forming a part of the tail member 110 of the

carrier lever 81. The entire mechanism is now free to move under the biasing action of the contact springs 55; these springs cause the assemblage of the switch members 11 to move clockwise about the pivot pin 42 and at the same time cause the toggle link 77 to be moved toward the base of the circuit breaker. The combined result of these movements is to cause a clockwise movement of the carrier lever 81 and a collapse of the toggle toward the base 1 due to the bringing of the center line of the operating spring unit 83 below the center line of the toggle link 79. The circuit breaker operating mechanism is completely resettable by means associated with the operating member 23, the important feature in regard to this application being that the latching lever 111 is moved toward the base 1 in a substantially fixed path about the pivot pin 115.

The operation of the trip device is substantially as follows:

Upon the occurrence of an overload in the circuit controlled by any one of the poles of the breaker, the free end of the thermally responsive bimetallic element 163 in the pole is caused to move toward the trip bar 175. If the overload persists for a sufficient period of time the setscrew 169 engages the cooperating portion 223 of the trip bar 175 and moves the bar counterclockwise (Figs. 4 and 5) against the biasing action of the spring 219. The bracket 217 is moved to disengage the notch 213 in the latch lever 150, thus permitting the latch engaging lever 241 affixed to the un-pivoted end of the latching lever 111 to disengage the projection 209 on the latch 150. The free end of the latching lever 111 is biased away from the base 1 by the spring and by the operating mechanism itself, and it, therefore, immediately moves to the tripped position thereby causing the contacts of the breaker to open. As soon as the latch engaging lever 241 has disengaged the projection 209 on the latch 150, the biasing spring 211 restores the latch to the latched position shown in Fig. 5. The opening of the circuit breaker removes the heating effect which caused the bimetallic element 163 to engage the trip bar, and that member immediately begins to move to the normal position. The bracket 217 on the trip bar 175 then re-engages the notch 213 in the latching lever 150 due to the biasing action of the spring 219, whereupon the device is completely reset and again ready for operation.

Upon the occurrence of a short circuit or heavy overload in the circuit controlled by any one of the poles of the breaker the energization of the core 161 reaches a sufficient magnitude to overcome the biasing action of the springs 191 and to attract the movable armature 177 theretoward. The movement of the armature 177 toward the core 161 is impeded by the projection 221 which extends downardly from the trip bar 175, and before the armature 177 can complete its movement it must move the trip bar 175 clockwise a sufficient amount to cause the bracket 217 to disengage the notch 213 in the latch lever 150. This disengagement of the notch 213 acts, as in the delayed operation of the thermally responsive device, to permit the latching lever 111 to move so as to cause the breaker contacts to open. The resetting operation, following the opening of the breaker contacts by any one of the magnetically responsive devices, is completely automatic and takes place practically instantaneously, the moving armature being immediately restored to the normal position (Fig. 5) by the springs 191, the latch being restored by the spring 211 and the trip bar being restored by the spring 219.

As previously mentioned, the trip bar 175 is mounted so as to be substantially shock proof. The shock proof construction has been extended to include the movable armatures 177—the only other large mass parts of the device that might cause trouble—by making those members free to move only in a path substantially parallel to the plane of the circuit breaker base 1. This effectively accomplishes the desired result, for practically all applications, because circuit breakers of this type are designed for mounting upon supporting members which extend in planes parallel to the base plane, and any transmitted shock of sufficient magnitude to move the armatures 177 will have its line of action substantially normal to the base plane—or what is more important in a path incapable of causing the tripping of the breaker.

It should be noted that it is necessary in this particular embodiment of my invention to have some type of latch engaging means intermediate the latching lever 111 and the latch 150. This results from the fact that both members move in a substantially fixed path, and from the fact that the trip device is automatically resettable. Thus, if the latch engaging means were not provided it would be impossible to re-engage the free end of the latching lever 111 with a trip device. It is also essential, if the operation of this device is to be at all dependable, that the latch be positioned very accurately with respect to the path of movement of the latching lever and its associated latching engaging means.

One important feature of my invention which has not been specifically pointed out is the method I use for changing the rating of the trip device. With my improved type of heater it is necessary only to vary the number of laminations used in order to vary the rating of the heater. Furthermore, in order to vary the rating of the magnetic responsive elements, it is necessary only to change the springs 191. Thus, it is possible to manufacture a complete line of trip devices having a wide range of current values from a standard set of parts. The entire trip device may be assembled except for the heaters and the biasing springs 191 for the magnetically responsive elements. Then, when it is necessary to supply a trip device of any particular rating, the heaters may be built up to suit, it being necessary to insert but four rivets to completely assemble that part of the device. The springs 191 may likewise be supplied to suit the particular requirement.

It will thus be seen that I have disclosed a new, interchangeable, electro-responsive trip device particularly suitable for use with multi-pole circuit breakers. My improved trip device is substantially shock proof, and it includes a thermally responsive and a magnetically responsive element for each of the several poles; the calibration of the thermally responsive element is not affected during the removal and interchanging of the trip device, nor is it affected by the magnetic forces set up in the current carrying heater associated therewith. In addition, I have provided an improved type of flexible heater suitable for use in thermally responsive devices, which may be readily constructed from standard parts for any desired rating, and which may be used without the necessity of having very accurately machined parts.

Furthermore, I have provided an improved

method for mounting removable interchangeable trip devices and for accurately positioning those devices with respect to the operating mechanism of the circuit breaker. I have provided an improved armature for magnetically responsive trip devices and an improved method for supporting that armature. I have disclosed how the parts of a combined thermally responsive, magnetically responsive element may be assembled to more effectively use the available space, and I have disclosed an improved means for engaging the latch of a trip device thereby permitting the trip device to be completely automatically resettable. These new features all combine to make a circuit breaker trip device which is much more reliable in operation and which is much more economical to manufacture than the previously known devices of this type.

While in accordance with the patent statutes I have given the foregoing details of a practical embodiment of my invention, it is to be understood that many of these are merely illustrative and that variations of their precise form will be desirable in some applications. I desire, therefore, that the language of the accompanying claims be accorded the broadest reasonable construction and that my invention be limited only by what is shown in the prior art, and by the appended claims.

I claim as my invention:

1. In electrical apparatus, a thermally responsive strip of bimetallic material having a length several times its breadth, and a conducting heater member thermally conductively joined to said thermally responsive strip adjacent one end thereof, the other end of said thermally responsive strip being movable, said heater member having a portion extending longitudinally along a considerable part of said thermally responsive strip, said portion being separated from said thermally responsive strip by a tapered gap.

2. In electrical apparatus, a thermally responsive element, and a laminated heater means disposed adjacent thereto, said heater means including a plurality of thin, superposed sheets of conducting material, said sheets having similarly disposed portions of reduced area which determine the heating effect of said means.

3. In electrical apparatus, a thermally responsive element, and a laminated heater therefor, said heater comprising a stack of thin sheets of conducting material, each of said sheets having an enlarged terminal portion at either end and a centrally disposed portion of increased resistance, said heater having a portion thermally conductively joined to a portioin of said thermally responsive element and having a portion extending along and positioned a short distance away from a considerable portion of said thermally responsive element.

4. In a circuit interrupter, a base member, relatively movable contacts for opening and closing the circuit, actuating means for said contacts including a member movable in a substantially fixed path to cause said relatively movable contacts to open, and a removable electro-responsive trip device having a latch means for engaging said movable member, said latch means being mounted on a bracket and accurately positioned with respect to the path of movement of said movable member thereby, said bracket member supporting and positioning said trip device and being itself supported by said base.

5. In a circuit interrupter, a main base member, relatively movable contacts for opening and closing the circuit, actuating means for said contacts including a member movable in a substantially fixed path to cause said relatively movable contacts to open, and a removable, electro-responsive trip device mounted on an auxiliary base member and having a latch means for engaging said movable member, said auxiliary base being supported substantially at right angles to said main base by a bracket member which also directly supports and positions said latch with respect to the path of movement of said movable member.

6. In a circuit interrupter, relatively movable contact members for opening and closing the circuit, actuating means for said contacts including a member movable in a substantially fixed path to cause said relatively movable contacts to open, and a removable trip device having means for engaging said movable member, said trip device including an electro-responsive element having terminals for connecting said element in circuit with said contact members, and means, in addition to said terminals, for accurately positioning said engaging means with respect to the path of movement of said movable member.

7. In a circuit interrupter a base member, a contact member, a switch member cooperating therewith to open and close the circuit, actuating means for said switch member including a releasable member movable in a substantially fixed path to cause said switch member to move to the open position, and a removable electro-responsive trip device having terminals, means for releasably engaging said movable member, and a bracket member for supporting said trip device and accurately positioning said engaging means with respect to the path of movement of said movable member independently of the position of said terminals, said bracket member and said base member having cooperating male and female portions.

8. In a circuit interrupter, a pair of terminals, a contact member, a switch member cooperating therewith to open and close the circuit, a releasable member for holding said switch member closed, and a removable, interchangeable trip device for engaging said releasable member, said trip device having a thermally responsive element and a heater means of conducting material therefor, a portion of said thermally responsive element being thermally conductively joined to a portion of said heater means, said heater means being electrically connected in circuit with said switch member and having a portion of flexible construction to prevent any change in the calibration of said thermally responsive element during the removal and interchanging of said trip device.

9. In a circuit interrupter, a base member, a pair of terminals, a contact member, a switch member cooperating therewith to open and close the circuit, a releasable member for holding said switch member closed, and a removable, interchangeable trip device for engaging and releasably restraining said releasable member, said trip device including a thermally responsive element, a heater means of conducting material having a portion thermally conductively joined to said thermally responsive element, and a base member, said heater means electrically connecting one of said terminals with said switch member and having a portion of flexible construction to prevent any change in the calibration of said thermally responsive element during the removal

and interchanging of said trip device, said base member for said trip device having means for accurately positioning said device with respect to said releasable member.

10. In a circuit interrupter, a pair of terminals, a contact member, a switch member cooperating therewith to open and close the circuit, a releasable member for holding said switch member closed, and a removable, interchangeable trip device for engaging and releasably restraining said releasable member, said trip device including a thermally responsive element and a heater means of conducting material having a portion thermally conductively joined to said thermally responsive element, said heater means electrically connecting one of said terminals with said switch member and comprising a stack of thin laminations having a portion of reduced area to determine the heating effect thereof, said laminations rendering said heater flexible and thereby preventing any change in the calibration of said trip device during the removal and interchanging of said trip device.

11. In a circuit breaker, a base member, separable contacts, actuating means for said contacts, and a trip device including a balanced trip bar for causing said device to be unaffected by mechanical shocks and an electro-responsive means for actuating said trip bar, the movable portions of said electro-responsive means having appreciable mass being restrained from movement except in a plane substantially parallel to the plane of said base member.

12. In electrical apparatus, an electro-responsive element including a U-shaped heater, a thermally responsive member having a portion thermally conductively joined to said heater and having a portion extending along a portion of one leg of said heater, and a core member disposed between the legs of said U and energized by the current flow therethrough.

13. In a circuit interrupter, relatively movable contact members for opening and closing the circuit, actuating means for said contacts including a movable operating handle, a member movable, independently of said operating handle, in a substantially fixed path to cause said contact members to open, and an electro-responsive trip device having a latch movable in a substantially fixed path and biased to the latched position for engaging said movable member, said movable member having a latch engaging means associated therewith, said latch engaging means being biased to the engaged position and being movable to clear said latch and to permit re-engagement therewith during the resetting of said interrupter actuating means.

14. In a circuit interrupter relatively movable contact members for opening and closing the circuit, actuating means for said contacts including a member movable in a substantially fixed path from a normal inoperative position to an operative position to cause said contact means to open, and an electro-responsive trip device which includes a latch for releasably restraining said movable member in said inoperative position, means normally biasing said latch to the latched position in order that said trip device shall be automatically resettable following each operation thereof, and means operable upon the occurrence of predetermined conditions to cause said latch to release said movable member, said movable member having a latch engaging member pivotally supported thereon so as to be disposed intermediate said latch and said movable member when said interrupter is in the normal operative position, and including means for biasing said latch engaging member to the engaged position, said latch engaging member being movable relative to said movable member in order to permit that member to be moved from said operative to said inoperative position and re-latched in the latter position following each opening operation of said interrupter resulting from the operation of said trip device.

15. In a trip device for use with electrical apparatus; a single base member; a trip member supported on said base and movable to cause the actuation of said device; a plurality of electro-responsive elements mounted on said base member, each of said elements being individually capable of causing said trip member to move to cause the actuation of said device; and a single conducting means likewise supported on said base for energizing said plurality of electro-responsive elements; one of said electro-responsive elements comprising a thermally responsive element, and another of said elements comprising a magnetically responsive element which includes a movable armature of magnetic material, a pair of guide members supported on said base member for guiding the movement of said armature, and attracting means for said armature energized by said single conducting means, said armature having guide openings in either end for slidably engaging said pair of guide members.

16. In a trip device for use with electrical apparatus; a single base member; a trip member supported on said base and movable to cause the actuation of said device; a plurality of electro-responsive elements mounted on said base member, each of said elements being individually capable of causing said trip member to move to cause the actuation of said device; and a single conducting means likewise supported on said base for energizing said plurality of electro-responsive elements, one of said electro-responsive elements comprising a magnetically responsive element which includes a movable armature of magnetic material, a pair of guide members supported on said base member for guiding the movement of said armature, and attracting means for said armature including a U-shaped core member, said armature having guide openings in either end for slidably engaging said pair of guide members; another of said electro-responsive elements comprising a member of thermally responsive material; the said single conducting member which energizes said electro-responsive elements and the said member of thermally responsive material extending through the space between the opposed sides of said U-shaped core member.

17. In electrical apparatus, a thermally responsive strip of bimetallic material having a length several times its breadth, and a conducting heater means thermally conductively joined to said strip adjacent one end thereof, the other end of said strip being movable, said heater comprising a plurality of longitudinally flexible sheets of conducting material, superposed one upon the other and electrically connected in parallel, and at least a portion of said heater extending along said strip for at least a substantial portion of the total length thereof.

18. In electrical apparatus, a thermally responsive element which comprises a tapered strip of bimetallic material having a length several times its greatest width, and a current-carrying heater member thermally conductively joined to said

strip adjacent the wider end thereof, the other end of said strip being movable to actuate said apparatus, said heater member having a portion which extends longitudinally along a considerable portion of said strip, said portion being separated from said strip by a tapered gap.

19. In a multi-pole trip device, a plurality of electro-responsive elements, each of which includes means movable upon the occurrence of predetermined conditions, a single trip bar which is adapted to be directly engaged, and thereby moved to effect the actuation of said trip device, by any one of said plurality of movable means, and means for pivotally supporting said trip bar in such manner that it is substantially balanced about its axis of rotation.

20. In electrical apparatus, an electro-responsive element including a U shaped, current-carrying heater, a thermally responsive strip of bimetallic material having a length several times its breadth, one end of said strip being thermally conductively joined to said heater and the other end of said strip being movable to actuate said electro-responsive element, one of the sides of said U shaped heater extending along a considerable portion of said strip, a core member disposed between the legs of said U shaped heater and energized by the current flow therein, and a movable armature which is adapted to be attracted to said core member to actuate said electro-responsive element.

21. In electrical apparatus; an electro-responsive element including a U shaped, current-carrying heater which is formed from a stack of thin sheets of conducting material, each of which sheets has a terminal portion at either end and a centrally disposed portion of increased resistance; a thermally responsive strip of bimetallic material, having a length several times its breadth, one end of said strip being thermally conductively joined to said heater adjacent said portions of increased resistance and the other end of said strip being movable to actuate said electro-responsive element; one of the sides of said U shaped heater extending along a substantial portion of said strip; a core member disposed between the legs of said U-shaped heater and energized by the current flow therein; and a movable armature which is adapted to be attracted to said core member to actuate said electro-responsive element upon the occurrence of predetermined conditions.

22. In electrical apparatus; an electro-responsive element including a U shaped, current-carrying heater; a tapered strip of bimetallic material having a length at least several times its greatest breadth, the wider end of said strip being thermally conductively joined to said heater and the other end of said strip being movable to actuate said electro-responsive element; said heater having a portion extending longitudinally along a considerable portion of said bimetallic strip, and being separated from said strip by an air-gap of predetermined dimensions; a core member disposed between the legs of said U shaped heater and energized by the current flow therein; and a movable armature which is adapted to be attracted to said core member to actuate said electro-responsive element.

23. In electrical apparatus; an electro-responsive element including a U shaped current-carrying heater which comprises a stack of thin sheets of conducting material, electrically connected in parallel; a thermally responsive strip of bimetallic material having a length several times its breadth, one end of said strip being thermally conductively joined to said heater and the other end of said strip being movable to actuate said electro-responsive element; one of the sides of said heater extending along a considerable portion of said strip and being separated therefrom by a tapered gap; a core member disposed between the legs of said U shaped heater and energized by the current flow therein; and a movable armature which is adapted to be attracted to said core member to actuate said electro-responsive element upon the occurrence of predetermined conditions.

24. In a circuit interrupter, a main base member, separable contacts for opening and for closing the electrical circuit therethrough, actuating means for said contacts, and a removable electro-responsive trip device which is operable upon the occurrence of predetermined conditions to cause said actuating means to move said contacts to the open circuit position, said trip device including an auxiliary base upon which the various structural elements thereof are mounted, a bracket member rigidly affixed to said auxiliary base, and means supported on said bracket member for engaging said operating mechanism to cause the opening of said interrupter, said main base and said bracket member having cooperating male and female portions.

25. In a circuit interrupter, a main base member, separable contacts for opening and for closing the electrical circuit therethrough, actuating means for said contacts, including a member movable in a substantially fixed path to cause said contacts to move to the open circuit position, and a removable electro-responsive trip device which includes an auxiliary base upon which the various structural elements thereof are mounted, a bracket member rigidly affixed to said auxiliary base, and a latch means supported on said bracket member for engaging said movable member in order that said member shall be prevented from moving to cause the opening of said interrupter except in response to the operation of said trip device, said main base, and said bracket member having cooperating male and female portions for aiding in accurately positioning said removable trip device upon said main base.

26. In a circuit interrupter, a main base member, separable contacts for opening and for closing the electrical circuit therethrough, actuating means for said contacts including a member movable in a substantially fixed path to cause said contacts to move to the open circuit position and means biasing said member to cause said contacts to move to the open circuit position, and a removable electro-responsive trip device which includes an auxiliary base upon which the various structural elements thereof are mounted, a bracket member rigidly affixed to said auxiliary base, a latch means pivotally supported upon said bracket member for restraining said movable member against movement under the influence of said biasing means therefor, except in response to the operation of said trip device, and means biasing said latch toward a position where it engages and restrains said movable member, said bracket member and said main base having cooperating male and female portions for accurately positioning said latch with respect to the path of movement of said movable member.

27. In a circuit interrupter, a main base member, separable contacts for opening and for closing the electrical circuit therethrough, actuating means for said contacts including a member

movable in a substantially fixed path to cause said contacts to move to the open circuit position, means normally biasing said member to cause said contacts to open, and a removable electro-responsive trip device which includes an auxiliary base member, a bracket member rigidly affixed to said auxiliary base, and latch means supported on said bracket member for releasably engaging said movable member, said bracket member also serving to support said auxiliary base, said main base and said bracket member having cooperating male and female portions for accurately positioning said latch means with respect to the path of movement of said movable member.

28. In a circuit interrupter, a main base member, separable contacts for opening and for closing the electrical circuit therethrough, actuating means for said contacts including a member movable in a substantially fixed path to cause said relatively movable contacts to move to the open circuit position, and a removable electro-responsive trip device having a latch means for engaging said movable member, an auxiliary base, and a bracket rigidly affixed thereto, said latch means comprising a member which is pivotally supported between two opposed side portions forming a part of said bracket means and is biased toward the latched position by spring means, said bracket member and said main base member having cooperating male and female portions for aiding in accurately positioning said removable trip device upon said main base.

29. In a multipole circuit interrupter, a main base member, separable contacts for opening and for closing the electrical circuit therethrough, actuating means for said contacts, and a removable electro-responsive trip device operable upon the occurrence of predetermined conditions to cause said actuating means to move said contacts to the open circuit position, said trip device including a separate base, a plurality of terminals, and conducting means extending between said terminals for connecting said device into the electrical circuits controlled by a plurality of the poles of said interrupter, one of said terminals being fixedly secured to said base in order that said trip device may be accurately positioned on said main base and a plurality of said terminals being flexibly mounted on said auxiliary base.

30. In a multipole circuit interrupter, a main base member, a plurality of pairs of separable contacts for opening and for closing the electrical circuit through each of the several poles of said interrupter, actuating means for said contacts, and a removable, current-carrying, electro-responsive trip device which is operable upon the occurrence of predetermined conditions to cause said actuating means to remove said contacts to the open circuit position, said trip device including an auxiliary base upon which the various structural elements thereof are mounted, a plurality of terminals, and conducting means connected thereto for electrically connecting said trip device into the circuit controlled by at least some of the poles of the interrupter, one of said terminals being fixedly mounted on said auxiliary base in order that said trip device may be accurately positioned with respect to said operating mechanism, and the remainder of said terminals being flexibly mounted on said base in order to permit relative movement between those terminals and said auxiliary base.

JEROME SANDIN.