Nov. 14, 1961 H. E. REICHERT ET AL 3,009,035

CIRCUIT INTERRUPTERS

Filed Aug. 17, 1956 4 Sheets-Sheet 1

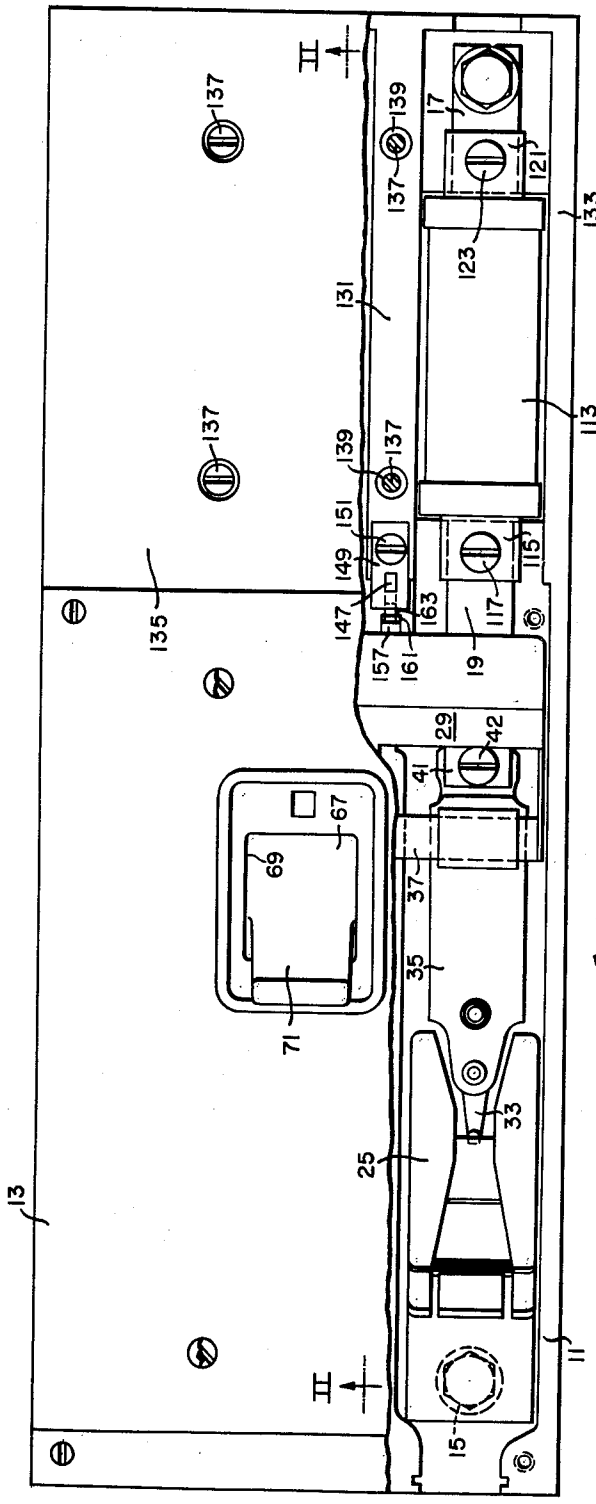


Fig. 1.

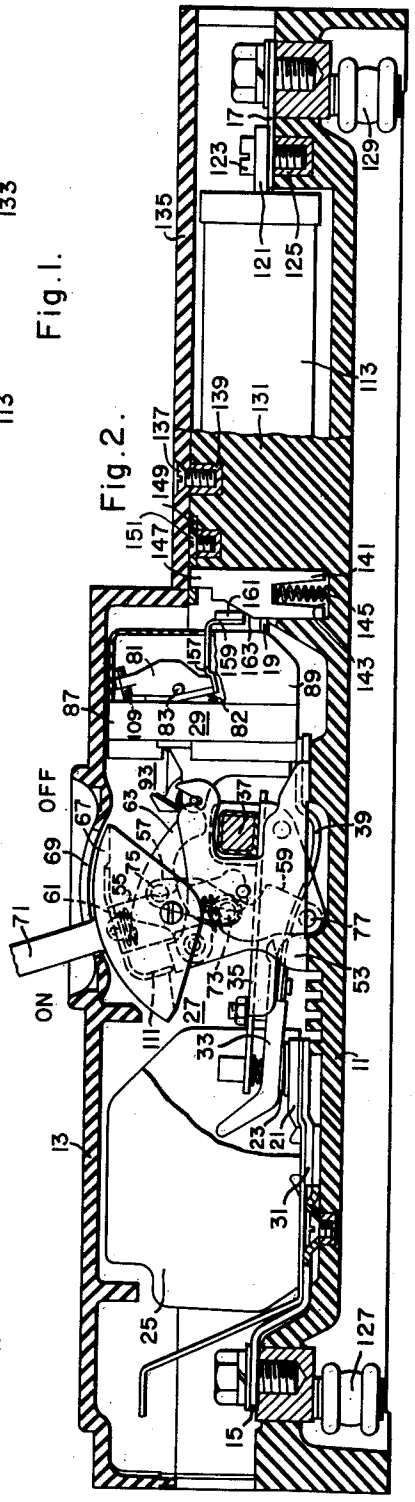


Fig. 2.

Nov. 14, 1961 H. E. REICHERT ET AL 3,009,035

CIRCUIT INTERRUPTERS

Filed Aug. 17, 1956

4 Sheets-Sheet 2

Fig.3.

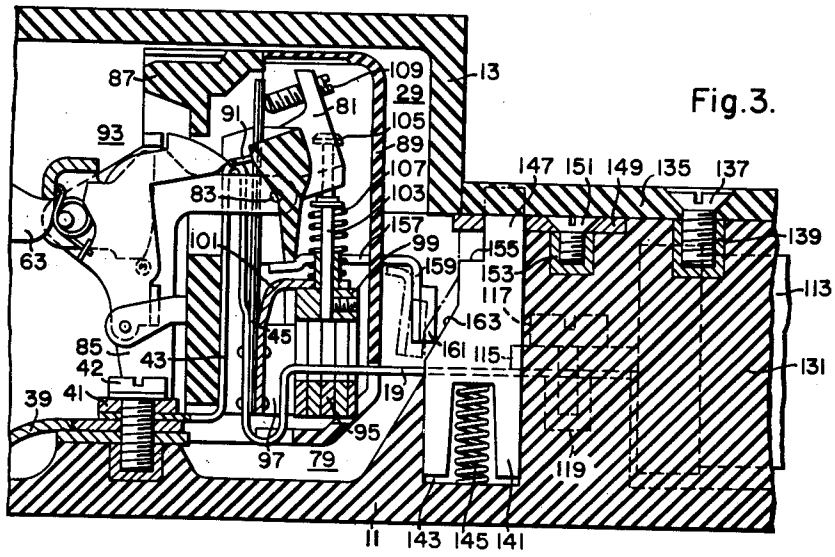
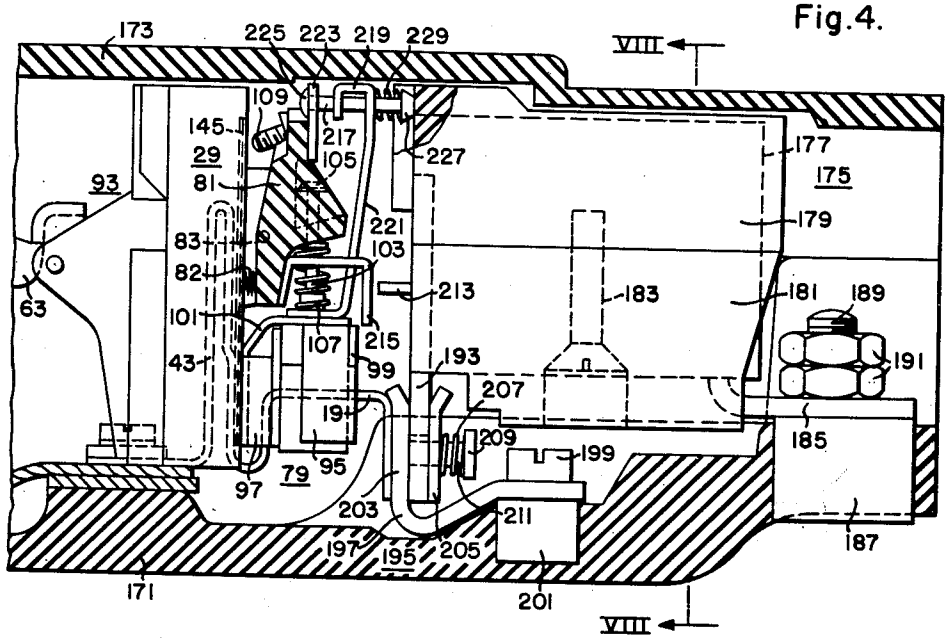


Fig.4.



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Nov. 14, 1961 H. E. REICHERT ET AL 3,009,035

CIRCUIT INTERRUPTERS

Filed Aug. 17, 1956 4 Sheets-Sheet 3

Fig.5.

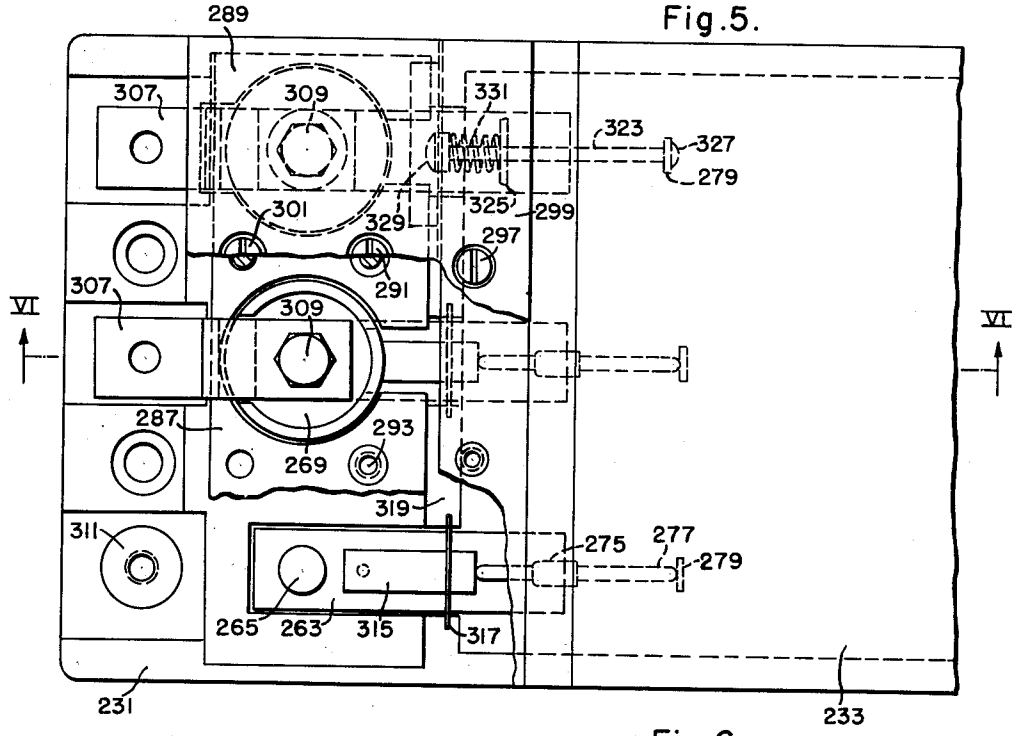
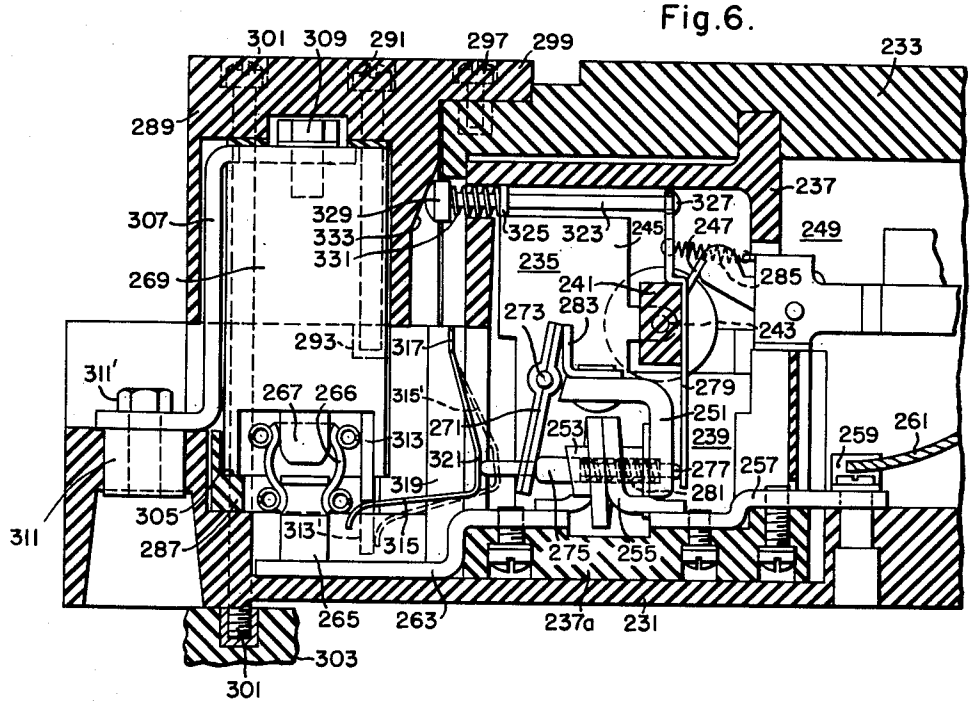


Fig.6.



Nov. 14, 1961 H. E. REICHERT ET AL 3,009,035

CIRCUIT INTERRUPTERS

Filed Aug. 17, 1956 4 Sheets-Sheet 4

Fig.7.

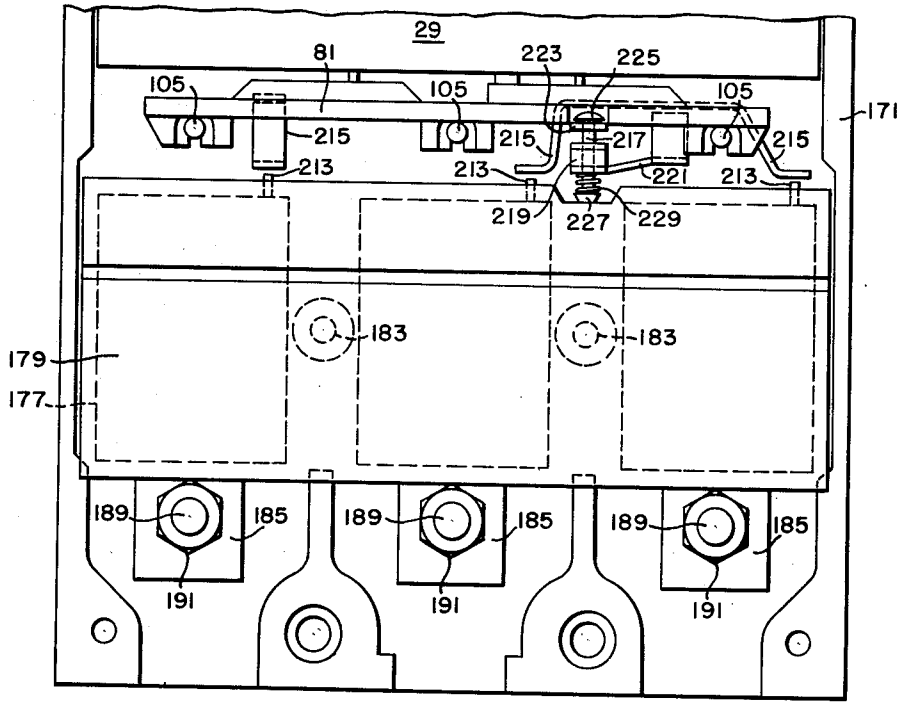
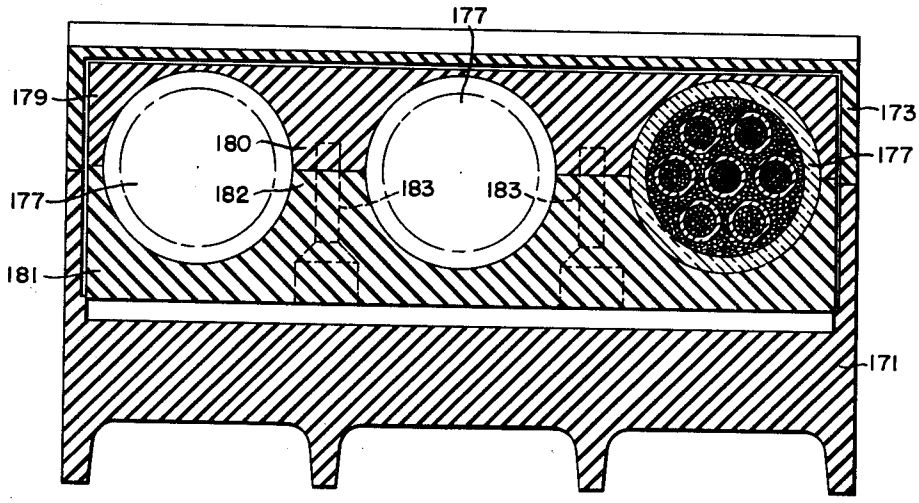


Fig.8.



United States Patent Office 3,009,035 Patented Nov. 14, 1961

3,009,035

CIRCUIT INTERRUPTERS

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Filed Aug. 17, 1956, Ser. No. 604,697
14 Claims. (Cl. 200—114)

This invention relates to circuit interrupters and, more particularly, to a circuit interrupter comprising a circuit breaker having fusible means electrically connected in series relation therewith.

Low-voltage circuit breakers, as applied to electric power distribution systems, are designed to continuously carry the current for which they are normally rated, and to interrupt fault currents up to their interrupting capacity. Many such distribution systems, however, are capable of full amplitude fault current far exceeding the interrupting capacity of low-cost circuit breakers. To safely interrupt a full amplitude short-circuit current of, for instance, 100,000 amperes by means of the commercially available circuit breakers today, would require the use of such a circuit breaker having its major parts designed for a device capable of carrying a continuous load of 4,000 amperes, in order to obtain one having an interrupting capacity of 100,000 amperes.

There are available current-limiting fuses having a rated interrupting capacity of 100,000 amperes. While such fuses do not actually interrupt a current of 100,000 amperes, they have the property of limiting the rise of current and of interrupting the current quickly, in less than a half cycle, before the instantaneous value of the current has risen to a peak value more than a small fraction of the available short-circuit current of the circuit. Thus, when a current-limiting fuse is rated as having an interrupting capacity of 100,000 amperes, it means that the fuse will safely interrupt a circuit in which 100,000 amperes would flow when subjected to a short circuit, if the fuse and its current-limiting function were not present. The peak value of the instantaneous current actually interrupted by such a fuse may be only about 10,000 to 25,000 amperes even though the available short-circuit current of the circuit without the fuse is 100,000 amperes.

This current-limiting action is very desirable in that it protects the circuit, and the apparatus connected therein, from the destructive effects of the maximum available short-circuit current. On the other hand, the use of current-limiting fuses has a number of disadvantages as compared with the use of circuit breakers. For one thing, the current-limiting fuse is a relatively expensive type of fuse and if the circuit is one which is subject to frequent small overloads or to relatively high-resistance short circuits, the cost of repeatedly replacing the fuses becomes a large item.

Another disadvantage in the use of fuses is that a fault on a single conductor of a three-phase circuit may blow only one fuse with the result that single-phase power is supplied over the other conductors. This can result in the burning out of motors or other equipment which may continue to operate on single-phase, though designed for three-phase operation.

Circuit breakers have the advantage over the use of fuses since anyone may quickly and safely restore service by manipulation of the insulated handle of the breaker.

It is an object of this invention to provide a circuit interrupter which largely retains the advantages set forth above of circuit breakers over fuses and at the same time embodies the desirable current-limiting function of current-limiting fuses when there is a heavy short circuit,

without requiring the use of an expensive circuit breaker of high interrupting capacity.

In a circuit interrupter for controlling a three-phase circuit equipped with a three-pole circuit breaker and a current-limiting fuse connected in series relation in the circuit through each of the poles, the occurrence of a fault current of sufficient magnitude to blow one of the fuses would usually energize the magnetic tripping means and trip the breaker to open all of its poles. In this situation, it is then possible to relatch and reclose the circuit breaker. This would result in supplying single-phase power with the dangers set forth above. There is also the possibility that the fuse would interrupt the current before the magnetic trip is energized sufficiently to trip the breaker open, in which case the circuit would also be single-phase.

Another object of the invention is to provide a unitary circuit interrupter comprising a circuit breaker having a trip device and fuse means connected in series in the circuit through the breaker embodying means operated by blowing of any one of the fuse means to operate the trip device to tripping position and hold the trip device in tripped position thus preventing closing the circuit breaker until the blown fuse is removed.

Another object of the invention is to simplify the construction of a multipole fused circuit breaker by using only a single trip bar extending across all of the poles and which is moved both by any one of the current-responsive elements and by a plunger projected from any one of the fuses. The construction is further simplified because no trip bar is removed upon removal of the fuse mounting or cover.

Failure of the circuit breaker to trip open when one of the fuses blows presents a hazard to a person attempting to remove the blown fuse since contact may be made with live parts of the interrupter which could result in serious injury or possible death to the person working on the fuse.

Another object of the invention is to provide a unitary circuit interrupter having an insulating housing comprising a base and cover for housing a circuit breaker in which the base is extended to receive and support current-limiting fuse means and having a separate cover or mounting member for the fuse means and biased means for tripping the circuit breaker open when the fuse cover or mounting member is removed.

Another object of the invention is to provide a unitary circuit interrupter having an insulating housing comprising a base and cover for housing a circuit breaker in which the base is extended to receive and support current-limiting fuse means with a separate cover for the fuse means and interlocking means for tripping the circuit breaker open when the fuse cover is removed and for preventing closing the circuit until the fuse cover is replaced.

Another object of the invention is to provide a circuit interrupter comprising a circuit breaker and fuse means according to the preceding paragraphs wherein cover means is provided which may be sealed to protect at least the trip unit of the circuit breaker from being tampered with, but which sealed cover need not be removed to replace the fuses and having a separate cover removable to give access to the fuse means, and interlocking means for actuating the trip unit to trip the circuit breaker open upon removal of said fuse cover.

A further object of the invention is to provide a unitary circuit interrupter comprising a circuit breaker and current-limiting fuse means having one insulating enclosing housing for housing the circuit breaker and a housing for the current-limiting fuse means removably secured to the circuit breaker housing, in which interlocking means is provided for effecting opening of the circuit breaker when the fuse housing is removed.

Another object of the invention is to provide a unitary circuit interrupter comprising a circuit breaker and current-limiting fuse means having an insulating enclosing housing for the circuit breaker and a fuse housing for the current-limiting fuse means removably secured to the circuit breaker housing, and embodying interlocking means for effecting opening of the circuit breaker when the fuse housing is removed and for preventing closing the circuit breaker until the fuse housing is replaced.

Another object of the invention is to provide a circuit interrupter comprising a circuit breaker and fuse means having an enclosing housing or cover for the fuse means removable to replace said fuse means and which is provided with means for tripping the circuit breaker open when any one of said fuse means blows and which is also provided with interlocking means for tripping the breaker and preventing it from being reclosed when said separate fuse housing or cover is removed.

Another object of the invention is to provide a multipole circuit interrupter comprising a circuit breaker and a current limiting fuse electrically connected in series relation with each pole of the circuit breaker having an enclosing housing for the circuit breaker and a separate housing for all of said current limiting fuses removable to replace said fuses, each of said fuses having means operable when the fuse blows to actuate the trip means of the circuit breaker to tripping position and hold said tripping means in tripping position until the blown fuse is removed, said circuit interrupter also having means for tripping said circuit breaker open when said fuse housing is removed and for preventing closing said circuit breaker until said fuse housing is replaced.

Another object of the invention is to shorten the length of a fused breaker by mounting the fuses endwise at right angles to the bottom of the breaker base. In addition, the fuses may be readily removed and replaced by an endwise plug-in movement.

The invention, both as to structure and operation, together with additional objects and advantages thereof, will be best understood from the following detailed description thereof when read in conjunction with the accompanying drawings.

In said drawings:

FIGURE 1 is a top plan view, with the cover partly broken away, of a circuit interrupter embodying the principles of the invention.

FIG. 2 is a vertical sectional view taken substantially on line II—II of FIG. 1 and looking in the direction indicated by the arrows.

FIG. 3 is an enlarged vertical sectional view of a portion of the circuit interrupter showing the trip device of the circuit breaker and the fuse cover interlock.

FIG. 4 is a vertical sectional view of a portion of a circuit breaker showing a modification of the invention and embodying means for tripping the circuit breaker when a fuse blows and for tripping the circuit breaker when the fuse housing is removed.

FIG. 5 is a top plan view of the trip portion of a circuit interrupter showing the invention applied to a circuit breaker having a somewhat different trip device.

FIG. 6 is a vertical sectional view taken on line VI—VI of FIG. 5 and looking in the direction indicated by the arrows.

FIG. 7 is a top view with the cover removed of the device shown in FIG. 4.

FIG. 8 is a vertical sectional view taken on line VIII—VIII of FIG. 4 and looking in the direction indicated by the arrows.

Referring to FIGS. 1 and 2 of the drawings, the circuit interrupter comprises a base 11 of molded insulating material on which the several elements of the circuit breaker mechanism and the current-limiting fuses are mounted. A cover 13 of molded insulating material, which may be fastened or sealed to the base 11, cooperates with the base 11 to form an enclosing housing for the circuit breaker.

The circuit interrupter is of the multiple type, each pole having line terminals 15 and load terminals 17, disposed at opposite ends of the base 11 and a terminal 19 (FIG. 1) disposed intermediate the ends of the base. The circuit breaker mechanism may be of the general type disclosed in Patent No. 2,508,178, issued May 16, 1950, to T. Lindstrom et al., the mechanism being shown and briefly described herein for purposes of illustration. The circuit breaker includes a stationary contact 21, a movable contact 23 and an arc extinguisher 25 for each pole of the breaker. A common operating mechanism indicated generally at 27 is provided for simultaneously actuating the three movable contacts to open and closed positions, and a removable trip device indicated generally at 29 serves to effect automatic opening of the breaker contacts in response to predetermined overload conditions in the circuit through any pole of the breaker.

The line terminal 15 forms the outer end of a conducting strip 31 which extends into the housing and rigidly supports the stationary contact 21. The movable contact 23 for each pole is rigidly mounted on a contact arm 33 supported on a switch arm 35 secured on a tie bar 37 which extends across all of the poles of the breaker and supports the switch arms for the several poles of the breaker for unitary movement to open and closed positions. The contact arm 33 is connected by a flexible conductor 39 to a terminal 41 (FIG. 3) secured to the base 11 by a screw 42 (FIG. 3) which also serves to secure one end or leg of a heater element 43 to the base. A bimetal element 45 forming a part of the trip device 29 is mounted on the other leg of the heater element 43 which is electrically integral with the intermediate terminal 19.

The operating mechanism 27 (FIG. 1) for the breaker is disposed in the center compartment of the housing and is supported by a pair of frame members 53 (only one being shown) secured to the base 11. The operating mechanism comprises a pivoted forked operating lever 55, a toggle comprising links 57—59, overcenter springs 61 and a pivoted releasable cradle 63 controlled by the trip device 29. An arcuate insulating shield 67 for substantially closing an opening 69 in the cover 13 is mounted on the end of the operating lever 55 and has an integral handle 71 extending out through the opening 69 to permit manual operation of the breaker mechanism.

The toggle links are pivotally connected together by a pivot pin 73. The toggle link 57 is pivotally connected by a pivot pin 75 to the cradle 63 and the toggle link 59 is pivotally connected to the switch arm 35 for the center pole by a pivot pin 77. The overcenter springs 61 are connected under tension between the knee pivot pin of the toggle 57—59 and the outer end of the operating lever 55.

The circuit breaker is operated to open position by a manipulation of the handle 71 (FIG. 1) in a clockwise direction to the "off" position actuating the overcenter springs 61 to cause collapse of the toggle 57—59 and opening movement of the switch arms 35 for all of the poles of the breaker in a well known manner.

The breaker is manually closed by reverse movement of the handle 71 from the "off" to the "on" position which causes the springs 61 to move overcenter and straighten the toggle thereby moving the switch arms 35 for all of the poles to the closed position.

In addition to the bimetal element 45 for each of the poles, the trip device also includes a series overload tripping magnet 79 (FIG. 3) for each pole and a trip bar 81 common to all of the poles and biased to latching position by a spring 82 (FIG. 2). The trip bar 81 is made of insulating material and is pivotally supported by means of pins 83 (only one being shown) supported in a bracket 85 secured to the base 11 by the screws 42. The bracket 85 also supports an insulating base 87 for the trip device. A sealed cover 89 of insulating material is provided to enclose the trip device. A latch 91 (FIG. 3) on the trip bar 81 normally engages a latch

mechanism 93 which, in turn, engages the cradle 63 to releasably restrain the operating mechanism in closed position.

The tripping magnet 79 comprises a U-shaped magnet yoke 95 (FIG. 3) supported on a bracket 97 which is rigidly supported on the base 87 for the trip device. A movable armature 99 is slidably supported in an extension 101 of the bracket 97 and has secured thereto a rod 103 which, at its outer end, has a head 105 for engaging and operating the trip bar 81 upon energization of the magnet. A spring 107 coiled about the rod 103 biases the rod and the armature 99 to the unattracted position. The tripping magnet 79 is energized by the terminal conductor 19 which extends between the legs of the U-shaped magnet yoke.

When a low overload current occurs the bimetal element 45 is heated by the heater element 43 and when heated a predetermined amount bends toward the right (FIG. 3) to engage an adjusting screw 109 on the trip bar 81 and actuate the latter to effect release of the cradle 63 and opening of the breaker contacts after a time delay.

The circuit breaker is tripped open instantaneously by operation of the tripping magnet 79. When the magnet is energized by overload currents of, for instance, 1000% or more of normal rated current, or by a short-circuit current, the armature 99 is attracted causing the head 105 to engage and actuate the trip bar 81 thereby effecting instantaneous release of the cradle 63. This effects automatic opening of the contacts of all three poles of the breaker.

It is necessary to reset and relatch the mechanism before the breaker contacts can be closed following an automatic opening operation. Resetting and relatching is effected by moving the handle clockwise as far as it will go. During this movement a projection 111 on the operating lever 55 engages a shoulder on the cradle 63 and moves the latter in a clockwise direction. Near the end of the clockwise movement of the cradle 63 the latching end thereof is reengaged with the latch mechanism 93 in a well known manner. The breaker contacts are then closed in the previously described manner by movement of the handle to the "on" position.

The arc extinguisher 25 may be of any suitable type, the one shown consisting of a plurality of slotted plates of magnetic material, into which the arc is drawn and quickly extinguished.

The circuit breaker illustrated, by way of example, may have a continuous current-carrying rating of 100 amperes and an actual interrupting capacity of 15,000 amperes at 600 volts alternating current, and will safely interrupt fault currents up to its interrupting capacity. Buildings, such as factories, hospitals, apartment buildings, etc. have branch and feeder circuits for lighting and power circuits. Such circuits are, at times, connected to power sources that are capable of full amplitude instantaneous fault currents in the neighborhood of 100,000 or more amperes which far exceeds the interrupting capacity of the circuit breakers. Inserting current-limiting fuses having a higher interrupting capacity than that of the circuit breaker in series with the circuits through the several poles of the breaker permits the circuit breaker to function normally to interrupt fault currents up to values less than its interrupting capacity, but should a fault current of greater magnitude than the interrupting capacity of the circuit breaker occur, the current-limiting fuses become effective to interrupt the current.

Such a circuit interrupter structure, of which the instant application is an improvement, is disclosed in application Serial No. 457,135, filed September 20, 1954, by Lloyd W. Dyer, and assigned to the assignee of this application.

In the application just referred to, the current-limiting fuses are disposed in open compartments outside the breaker cover and at the line end of the breaker. It is possible to close the circuit breaker before a blown fuse is replaced. This fact, together with the easy accessibility of the fuses presents a hazard to a person attempting to replace one or more of the fuses.

An important advantage of the present invention is the provision of a removable cover for the fuses and interlocking means for tripping the circuit breaker when the fuse cover is removed and for holding the breaker in tripped condition until the fuse cover is replaced. It is thus impossible to gain access to any of the fuses while the circuit breaker is in the closed position.

Each pole of the circuit interrupter is provided with a current-limiting fuse 113, one blade 115 of which is connected directly to the intermediate terminal 19 by means of a screw 117 which threadedly engages a metal insert 119 molded in the base 11. The other blade 121 of the fuse 113 is similarly connected to the load terminal 17 by a screw 123 threaded into a metal insert 125 molded in the base 11. The line terminals 15 and the load terminals 17 at opposite ends of the base 11 are provided respectively with suitable connectors 127 and 129 for connecting the circuit interrupter in an electrical circuit. Such connectors are not provided for the intermediate terminals since all of the current flows through both the breaker and the fuses.

The portion of the base 11 in which the fuses 113 are mounted is divided into separate compartments by inner barriers 131 and the side walls 133 molded integral with the base 11. The barriers 131 terminate adjacent the trip device 29 and a fuse cover 135 is secured by means of screws 137 to the top of the barriers 131, the screws being threaded into metal inserts 139 molded in the barriers 131. The fuse cover 135 (FIGS. 1 and 2) covers all of the fuse compartments from the main portion of the break cover 13 to the end of the base 11.

In order to trip the breaker when the fuse cover 135 is removed to replace a blown fuse, there is provided a trip actuator 141 disposed in an opening 143 (FIGS. 2 and 3) in one of the barriers 131 and biased by means of a spring 145 in a direction to effect actuation of the trip bar 81 in tripping direction. The upper end of the trip actuator 141 is reduced and the reduced portion 147 engages a guide opening in a guide plate 149 which is disposed in a recess in the barrier 131 and secured thereto by a screw 151 threaded into a metal insert 153 molded in the barrier. When the fuse cover 135 is removed the spring 145 moves the trip actuator 141 upwardly until a shoulder 155 thereon engages the guide plate 149 which limits the upward movement of the trip actuator.

A bracket 157 (FIGS. 2 and 3) is rigidly secured to the bottom of the trip bar 81 and extends outside of the trip unit cover 89 and has a downwardly extending portion 159 on which is mounted a member 161 cooperating with a cam surface 163 on the trip actuator 141.

When the fuse cover 135 is removed for inspection or to replace a blown fuse, the stored energy in spring 145 moves the trip actuator 141 upwardly until it is arrested by engagement with the guide plate 149. During this movement of the trip actuator the cam surface 163 thereon engages the member 161 and moves the bracket 157 and the trip bar 81 in clockwise or tripping direction about the pivot point 83 of the trip bar. This movement disengages the latch 91 from the latch mechanism 93 to effect release of the cradle and opening of the breaker contacts in the manner previously described.

The trip bar 81 will remain in the tripped position until the fuse cover 135 is replaced thus preventing relatching the mechanism and closing the contacts until the fuse cover is replaced. When the fuse cover 135 is replaced in its position on the base 11 the cover engages the upper end of trip actuator 141 and moves it downwardly to the position shown by full lines in FIG. 3. This permits the trip bar 81 to return to its latching

position so that the mechanism can be relatched and the contacts closed.

The current-limiting fuses 113 are mounted in the base 11 of the breaker at the load end thereof so that, when the circuit breaker is open a fuse or fuses may be replaced without danger of electrical shock or from arcing to the person replacing the fuse. Since access to the fuses cannot be had until the fuse cover is removed, and removal of the fuse cover effects automatic opening of the breaker, the safety of the person inspecting or replacing the fuses is assured.

In the modification illustrated in FIGS. 4, 7 and 8, the current-limiting fuses for the three poles of the interrupter are all mounted in a separate housing that is removably mounted on the base of the interrupter and is enclosed by the interrupter housing. In the FIG. 4 modification, means is provided for tripping the circuit breaker open when the separate fuse housing is removed and for preventing closing the breaker until the fuse housing is replaced. Means is also provided in the FIG. 4 modification for tripping the circuit breaker open when one or more of the fuses blow.

Referring to FIG. 4 of the drawings, the housing for the interrupter comprises a base 171 and a cover 173 of molded insulating material. The base 171 and cover 173 as shown in FIG. 4 are shaped somewhat differently from those shown in FIG. 3 in order to receive a separate fuse housing indicated generally at 175 (FIG. 4) in which the three current-limiting fuses 177 are rigidly supported. The trip device of the FIG. 4 modification is essentially the same as that shown in FIG. 3 and like parts have been given the same references.

The fuse housing 175 comprises an upper portion 179 and a lower portion 181 of molded insulating material. Both portions of the fuse housing have barrier portions 180 and 182 (FIG. 8) molded therein which divide the fuse housing into three separate compartments. The upper and lower portions of the fuse housing are rigidly secured together by means of screws 183 extending upwardly through the barriers 182 in the lower housing portion and threaded into the corresponding barriers 180 in the upper housing portion.

Each of the current-limiting fuses 177 is provided at its outer end with a blade 185 which is rigidly but removably mounted on a metal connector or load terminal insert 187 molded in the base 171 adjacent the end of the base. The blade 185 is secured to the insert 187 by a bolt 189 and nuts 191 which also serve to connect the interrupter in an electrical load circuit.

The inner end of each current-limiting fuse 177 is provided with a downwardly extending blade 193 that is slotted at its lower end so that it can be plugged into a clamp device plug-in receptacle indicated generally at 195. The plug-in receptacle or terminal 195 comprises an angular conducting member 197 having one end rigidly secured by means of a screw 199 to a metal insert 201 molded in the base 171. The conducting member has a finger 203 extending upwardly in contact with the blade 193 and to which the intermediate terminal conductor 19 is rigidly mechanically secured to form a good electrical connection. A contact plate 205 is disposed on the other side of the blade 193 from the finger 203 and is biased against the blade 193 by means of a spring 207 compressed between the contact plate 205 and the head 209 of a screw 211 which is threaded into the finger 203.

Means is provided to mechanically trip the breaker open when a fuse blows and for holding the circuit breaker in tripped condition to prevent closing the circuit breaker until the blown fuse is removed. This means comprises a spring-loaded trip-operating plunger 213 (FIGS. 4 and 7) for each of the fuses that is actuated when the fuse blows. This plunger and the spring means for operating it when the fuse blows can be of the types illustrated in Rawlins Patent No. 2,435,844, issued February 10, 1948, or other means can be used.

When the fuse for any pole of the interrupter blows, the plunger 213 associated therewith is actuated outwardly from the end of the fuse and engages a bracket or trip operator 215 secured to the trip bar 81, there being a bracket or trip operator 215 on a portion on the trip bar at a different point along its length for each pole of the breaker to be engaged by the plunger of each fuse to actuate the trip bar and effect tripping of the breaker. The plunger 213 of any one fuse then holds the trip bar 81 in tripping position until the blown fuse is removed thus preventing relatching the breaker mechanism and closing the contacts, and also preventing a single-phase condition. Thus, only a single trip bar 81 is needed to extend across the breaker to trip all poles of the breaker upon actuation of any one of the three thermal elements 145, upon attraction of any one of the three armatures 99, or upon blowing of any one of the three fuses 177. This trip bar is the regular trip bar which is part of the breaker and its trip unit and no additional trip bar to be actuated by the blowing of the fuses is needed.

In order to remove the blown fuse or fuses the separate fuse housing 175 together with all of the fuses must be removed. Before this can be done it is necessary to remove the cover 173 of the interrupter housing. When the cover 173 has been removed the fuse housing is accessible but the individual fuses are not since the screws 183 which hold the fuse housing parts 179—181 together are inserted from the bottom of the fuse housing. After the cover 173 is removed the fuse housing 175 is removed by first removing the nuts 191 and then lifting the fuse housing upward to disengage the blades 193 from the plug-in device 195. The blown fuse or fuses are then removed and replaced by removing the screws 183 to permit separation of the fuse housing parts 179—181 and access to the fuses. After the blown fuse has been replaced in the fuse housing and the parts of the fuse housing secured together by insertion of the screws 183, the fuse housing together with the fuses is replaced in the interrupter by inserting the blades 193 of the fuses in their corresponding plug-in device 195 and then replacing the nuts 191. The interrupter cover 173 is then replaced and secured to the base 171.

When the fuse housing 175 together with the blown fuse is removed the plunger 213 which actuated the trip bar 81 upon blowing of the fuse is also removed and no longer holds the trip bar in tripped position. Consequently, with the fuses removed the circuit breaker could be relatched and closed. While the circuit is open between the bolt 189 and the plug-in connector 195 when the fuse housing is removed, a dangerous situation could arise if an attempt were made to replace the fuses in position with the circuit breaker closed. Means is therefore provided to trip the breaker open when the fuse housing 175 is removed and hold it in tripped condition until the fuse housing is replaced.

The means for tripping the breaker open upon removal of the fuse housing comprises a rod or plunger 217 (FIGS. 4 and 7) slidably mounted in the formed over upper end 219 of a bracket 221 which is rigidly mounted on the extension 101 of the bracket 97. The rod 217 extends through an opening in a plate 223 rigidly attached to the upper portion of the trip bar 81 and has a head 225 thereon for engaging the plate 223. The right-hand end of the rod 217 is provided with a head 227 which is normally biased toward the right against the upper portion 179 of the fuse housing 175 by a coil spring 229 compressed between the bracket 221 and the head 227.

When the fuse housing 175 is removed the spring 229 moves the trip actuating rod 217 toward the right and, through the plate 223 actuates the trip bar 81 to the tripping position and holds it in tripping position until the fuse housing is replaced in its position in the interrupter. With the trip bar 81 held in the tripped position the cir-

cuit breaker mechanism cannot be relatched or the breaker contacts closed until the fuse housing is replaced.

When the fuse housing is replaced and the blades **193** are in alignment with the plug-in connector **195** the inner end of the housing engages the head **227** and thrusts the rod **217** toward the left freeing the trip bar **81** which is then restored to its normal latching position by the spring **82**.

It will be seen that the modification of the invention shown in FIG. 4 trips the circuit breaker open when any one of the fuses blows and holds the breaker in tripped condition until the blown fuse together with the fuse housing is removed from the breaker. Means is also provided to trip the breaker upon removal of the fuse housing and to hold the breaker in tripped condition until the fuse housing is replaced in the breaker.

FIGS. 5 and 6 illustrate the invention as applied to a circuit breaker having a somewhat different form of trip device. Referring to FIG. 6, a base **231** and cover **233** both of molded insulating material are provided for the circuit breaker, only the trip device of which is shown. The trip device is shown generally at **235** supported in its own insulating housing comprising cover **237** and base **237***a* which is rigidly mounted in the breaker housing adjacent the load end thereof. The trip device comprises a series overload magnet **239** for each pole of the breaker and a trip bar **241** common to all of the poles. The trip bar **241** is made of insulating material and is pivotally mounted at its ends by pins **243**, only one of which is shown molded into the ends of the trip bar and supported in end brackets **245** (only one being shown) rigidly mounted on the base **237***a* of the trip device housing. A latch **247** on the trip bar **241** normally engages a latch mechanism **249** which, in turn, engages and releasably restrains the breaker operating mechanism in operative position.

The tripping magnet **239** comprises an angular magnet yoke **251** supported in the bracket **245** and a companion bracket (not shown) there being a pair of brackets **245** for each pole of the breaker. One leg of the magnet yoke comprises a fixed core **253** which extends through one energizing coil **255** having one end secured to a conducting strip **257** secured to the base of the trip device housing. The other end of the conducting strip extends into the circuit breaker housing and has a terminal **259** mounted thereon which is connected to the moving contact structure by a flexible conductor **261**. The other end of the coil **255** is connected to a conducting strip **263** which extends outwardly into a fuse compartment and has a stud **265** mounted thereon and a plug-in type terminal or connector **266** is mounted on the stud for receiving the plug-in contact or terminal **267** forming part of a fuse **269**. The trip device for each of the poles is provided with an armature **271** pivoted on a pin **273** supported in the frames **245**. A trip rod **275** slidably mounted in an opening in the core **253** is adapted to be actuated by the armature **271** and operate the trip bar **241**. The reduced right-hand end **277** of the trip rod extends through an opening in the lower end of the magnet yoke **251** and engages the lower end of a bracket **279** secured to the trip bar **241**. The trip rod **275** is biased to the left by a spring **281** compressed between the magnet yoke **251** and a shoulder on the plunger. The spring **281** acting through the trip rod **275** also biases the armature **271** to its unattracted position as shown in FIG. 6 against an adjusting bracket **283** mounted on the horizontal leg of the magnet yoke **251**.

When the tripping magnet **239** for any pole of the breaker is energized in response to an overload current of sufficient magnitude, the armature **271** is attracted against the core **253** thrusting the trip rod **275** toward the right and, through the bracket **279** rotates the trip bar **241** counterclockwise or in tripping direction. This disengages the latch **247** from the latch mechanism **249** and effects opening of the circuit breaker in the manner previously described. A spring **285** restores the trip bar to its latching position when the breaker mechanism is reset.

The fuses **269**, of which there is one for each pole of the breaker, are mounted in a separate removable housing which is attached to the load end of the circuit breaker housing so that it can be removed without removing the circuit breaker cover. The fuse housing comprises a base **287** and a cover **289** secured together by means of screws **291** which extend downwardly through openings in the cover **289** and threadedly engage metal inserts **293** molded in barriers in the base **287** of the fuse housing. The fuse housing is secured in place on the breaker housing by means of screws **297** extending through openings in an overlapping portion **299** of the cover **289** and engage metal inserts molded into the breaker cover **233**. Mounting screws **301** which pass through openings in the fuse cover **289**, the fuse base **287** and the base **231** of the breaker housing engage metal inserts in a support member, a fragment of which is shown at **303** (FIG. 6), serve to hold the fuse housing on the breaker housing and to secure the breaker to the support member.

When the screws **291** and **301** are tightened the fuses **269** are rigidly clamped between the fuse cover **289** and a shoulder **305** on the fuse base **287**. When the fuse housing with the fuses mounted therein is in position on the circuit breaker the lower terminals or plug-in contacts **267** positively secured to the fuses are engaged in the plug-in terminals or connectors **266**. A conducting terminal strip **307** has one end secured by means of a bolt **309** to the upper terminal of the fuse, the other end of the conducting strip **307** being secured to a terminal **311** at the adjacent end of the base **231** of the breaker housing.

It is thus seen that the fuses **269** are positioned with their axes vertical, as shown in FIG. 6, or at right angles with the base or bottom **231** of the circuit breaker. This makes it possible to keep the length of the fused breaker as short as possible, and the fuses are plugged in by an endwise movement in the direction of the longitudinal axes of the fuses.

When overload current close to or above the interrupting capacity of the circuit breaker occurs, one or more of the fuses **269** (FIG. 6) will blow and interrupt the current quickly before it rises to its full magnitude. The tripping magnet **239** will also function to actuate the trip bar **241** and trip the breaker open even though the fuse will interrupt the current before the breaker contacts open. Means is provided to hold the trip bar in the tripped position, thus preventing relatching the breaker mechanism and closing the breaker, until the blown fuse is removed. This means comprises a spring loaded plunger **313** on each of the fuses that is actuated downwardly when the fuse blows, and an angular spring trip-operating member **315**. The upper end of the spring **315** is provided with laterally extending ears **317** which are seated in slots in a cross barrier **319** (FIG. 5) in the base **231** of the circuit breaker housing. The spring trip operator **315** has flat portion **321** disposed adjacent the left end of the trip rod **275**.

When the fuse for any one of the poles of the interrupter blows, the plunger **313** of that fuse is released and driven downwardly to the position indicated at **313'** forcing the trip-operating member **315** toward the right to the position indicated at **315'** thereby moving the magnet trip rod **275** toward the right to move and hold the trip bar **241** in its unlatching position. As long as the blown fuse remains in position in the interrupter the trip bar will be held in the tripped position and prevent resetting of the breaker and closing the breaker contacts until the blown fuse is removed. It will be noted that this modification of the invention also uses only a single common trip bar **241** extending across all poles of the breaker to be actuated at different points

along its length by movement of any one of the fuse plungers 313 in addition to being actuated by the current responsive means, and this single trip bar is part of the breaker and trip unit assembly rather than being part of the removable fuse assembly.

The fuse housing together with the fuses are removed by first removing the screws 297 and 301 and the terminal bolt 311' and then lifting the fuse housing vertically upward to separate the lower terminal 267 of the fuses from the plug-in connectors 266. As the fuses and their housing are removed the spring actuators 315 return to their normal positions and the springs 281 restore the trip rods 275 to their normal position as shown in FIG. 6. Also the spring 285 would restore the trip bar to its latching position making it possible to relatch the mechanism and close the breaker. However, means is provided to prevent returning the trip bar 241 to the latching position when the fuse housing is removed and to hold the trip bar in unlatching position until the fuse housing is again placed in position on the interrupter.

The means for holding the trip bar in the tripped position when the fuse housing is removed comprises a trip actuating rod 323 slidably mounted in an opening in an ear 325 formed on the frame 245, so that the actuating member 323 is movable longitudinally under and in a direction generally parallel to the face of the cover 233 and at a right angle to the direction in which the fuse housing 287—289 is moved during removal. The right end of the rod 323 extends through an opening in the upper end of the bracket 279 on the trip bar 241 and has a head 327 to the right of the bracket. The other end of the rod 323 to the left of the ear 325 extends through openings in the trip device cover 237 and in the end wall of the breaker cover 233 and is provided with a rounded head 329 which is biased by means of a spring 331 into engagement with a cam surface 333 rigidly fixed on the cover portion 289 of the fuse housing with the cam surface extending at an angle to the length of the circuit breaker. The spring 331 is compressed between the head 329 and the ear 325.

When the fuse housing is removed, together with the fuses, the plunger 313 of the blown fuse is moved upwardly therewith and permits the spring trip operator 315 to return to its normal position as shown by full lines in FIG. 6. However, by the time the plunger 313 releases the trip operator 315 the cam surface 333 has been moved far enough to permit the spring 331 to move the trip actuator 323 far enough to the left to hold the trip bar 241 in the tripped position or to move it back to the tripped position. When the fuse housing is replaced the cam surface 333 is moved downwardly below the face of the breaker cover 233 so that the cam surface engages and slides across the head 329 of the trip actuator 323 and moves it longitudinally to the right permitting the spring 285 to restore the trip bar 241 to its latching position after which the breaker may be reset and the contacts closed.

The use of a spring-biased trip actuator with stored energy to hold the trip bar in tripped position upon removal of the fuse assembly or fuse cover, as at 323 in FIGS. 5 and 6, or at 217 in FIGS. 4 and 7, or at 141 in FIGS. 1, 2 and 3, has the advantage over structures in which removal of the fuses merely actuates the trip bar to tripped position, that the breaker may not be reset by movement of the breaker handle after the fuses have been removed, since the spring bias holds the trip actuator in tripping position. If the operator should manually hold the trip actuator against its bias and reclose the contacts, the breaker will be again tripped by the spring bias as soon as the trip actuator is released.

The invention provides a circuit interrupting device comprising a manually and automatically operable circuit breaker having current-limiting fuses of high interrupting capacity in series therewith. The operating characteristics of the two devices are so related that the circuit breaker functions in a conventional manner in response to fault currents well within its interrupting capacity and the fuses become effective to interrupt fault currents somewhat below or greater than those which the circuit breaker can safely interrupt. The circuit breaker is mounted in its own insulating housing and the current-limiting fuses are mounted in a separate housing which is removably mounted on the circuit breaker housing. Means is provided for preventing resetting the breaker mechanism and closing the breaker contacts following the blowing of a fuse until the blown fuse is removed. Means is also provided for preventing resetting the breaker mechanism when the fuse housing is removed and until it is replaced in position on the interrupter.

Having described the invention in accordance with the provisions of the patent statutes, it is to be understood that various changes and modifications may be made in the structural details disclosed and in the arrangement of parts without departing from the spirit of the invention.

We claim as our invention:

1. In a circuit interrupting device comprising a circuit breaker having separable contact means and means releasable to effect separation of said contact means, a trip bar movable to a tripping position to effect release of said releasable means, fuse means connected in series relation with said separable circuit breaker contact means, removable housing means for said fuse means having a fixed cam surface thereon extending at an angle to the length of the circuit breaker, an actuating member engaging said cam surface on the housing means and movable in a direction generally at a right angle to the direction in which the housing means is moved during removal for moving the trip bar of said circuit breaker, and stored energy means operable when said housing means is removed to operate said actuating member, to follow said cam surface and move the trip bar to tripping position, said stored-energy means maintaining said trip bar in said tripping position until said housing means is replaced and the cam surface fixed thereon slides across said actuating member and returns it to non-tripping position.

2. A circuit interrupting device comprising an insulating base, a circuit breaker structure mounted on said base at one end thereof comprising separable contact means, means releasable to effect separation of said contact means and trip means operable to effect release of said releasable means, fuse means mounted at the other end of said base, an insulating cover for said circuit breaker structure, separate cover means for said fuse means, a cam surface rigid with said separate fuse cover means and extending at an angle to the length of the circuit breaker, said rigid cam surface extending downwardly below the face of said insulating cover for the circuit breaker structure, and a member movable longitudinally in a direction generally parallel to the face of said insulating cover for the circuit breaker structure and biased to engage said cam surface and be moved thereby to actuate said trip means by said generally parallel movement when said separate fuse cover means is removed.

3. In a circuit interrupting device comprising an insulating base, a multipole circuit breaker structure mounted on said base at one end thereof comprising separable contact means, and means including only a single common trip bar extending across the poles of the breaker and releasable to effect separation of said contact means, a plurality of current responsive trip members each movable to a tripping position to actuate the common trip bar and effect release of said releasable means, a plurality of fuse means mounted together as a unit on the other end of said base for removal there-

from as a unit while said common trip bar remains in place, a plurality of extensions at spaced intervals on said common trip bar, a plurality of individually movable members on said removable fuse unit each actuated when one of the fuse means blows, each of said individually movable members engaging and actuating a different one of said extensions on the common trip bar to move it to tripping position and to hold said common trip bar in tripping position until the blown fuse is removed, an enclosing cover for said fuse means removable with said fuse unit away from said common trip bar, and means actuated when said fuse unit and its cover is removed to move said trip bar to tripping position and to hold said trip bar in tripping position until said fuse unit and its cover is replaced.

4. A multipole circuit interrupting device comprising separable contact means for each pole of the interrupter and means releasable to effect separation of the contact means for all of the poles, a trip bar common to all of the poles of the interrupter movable to a tripping position to effect release of said releasable means, electroresponsive trip means for each pole operable in response to overload currents to move said trip bar to tripping position, a plurality of fuses with one in each pole of said interrupter, each of said fuses having a plug-in terminal positioned centrally at one end of the fuse and a second terminal member terminating at the side of the fuse, a plug-in connector directly under the end of each fuse and close to the end thereof for receiving the plug-in terminal centrally at the end of each fuse and removably connecting said fuses in series relation with the separable contact means, a removable fuse housing member enclosing and securing all of said fuses together as a unit for simultaneous plug-in movement in a direction longitudinally of the fuses and normal to the bottom of the circuit interrupter, and a member to engage said common trip bar and actuate said trip bar to tripping position when said fuse housing member and said fuses are removed in a direction longitudinally of the fuses.

5. In a circuit interrupting device comprising an insulating base, a multipole circuit breaker structure mounted on said base comprising separable contact means adjacent one end of the base, and means including a trip bar common to all the poles releasable to effect separation of said contact means, a plurality of trip members each movable to a tripping position to actuate the common trip bar and effect release of said releasable means, a plurality of fuse means mounted adjacent the other end of said base, each of said fuse means having one terminal under one end of the fuse means and the other terminal at one side of the fuse means, and each of said fuse means having its longitudinal axis generally perpendicualr to said insulating base of the circuit interrupter, a removable fuse cover member, and means actuated when said fuse cover member is removed to engage and move said common trip bar to tripping position.

6. A multipole circuit interrupting device comprising separable contact means for each pole of the interrupter and means releasable to effect separation of the contact means for all of the poles, a single trip bar common to all of the poles of the interrupter releasably restraining said releasable means and movable to a tripping position to effect release of said releasable means, electroresponsive trip means for each pole operable in response to overload currents to engage and move said common trip bar to tripping position, fuse means in each pole of said interrupter connected in series relation with said separable contact means, a plug-in contact connected in the circuit of each pole and positioned close to one end of each fuse means, and a plug-in contact for each fuse means engageable with one of the first said plug-in contacts by an endwise movement of the fuse means in a direction perpendicular to the base of the circuit interrupter.

7. In a multi-pole circuit interrupter, a base of insulating material, a plurality of separable contacts and releasable operating mechanism for controlling the contacts mounted on said base, a circuit breaker cover over said contacts and operating mechanism and terminating short of one end of the base, a multi-pole trip unit mounted on said base and having electro-responsive elements and a common trip bar operable to cause release of said operating mechanism and separation of the contacts, a plurality of plug-in contacts mounted close to the base adjacent the trip unit and facing upwardly away from the base, a plurality of fuses each having a plug-in contact extending longitudinally from the lower end thereof and engaging one of the plug-in contacts close to the base with the longitudinal axis of the fuses extending generally perpendicularly to the base, said fuses being positioned on the base beyond the short end of said circuit breaker cover and being removable by endwise movement in a direction generally perpendicularly to the circuit breaker cover, and each fuse having a member movable upon rupture thereof to cause movement of the common trip bar and separation of the contacts.

8. In a multi-pole circuit interrupter, a base of insulating material, a plurality of separable contacts and releasable operating mechanism for controlling the contacts mounted on said base, a circuit breaker cover over said contacts and operating mechanism, a multi-pole trip unit mounted on said base and having electro-responsive elements and a common trip bar operable to cause release of said operating mechanism and separation of the contacts, a plurality of plug-in contacts mounted on the base adjacent the trip unit and facing upwardly away from the base, a plurality of fuses each having a plug-in contact extending longitudinally from the lower end thereof and engaging one of the plug-in contacts on the base with the longitudinal axis of the fuses extending generally perpendicularly to the base, said fuses being positioned outside of said circuit breaker cover, a single fuse cover of insulating material extending across the upper ends of said plurality of fuses, means securing said plurality of fuses to said fuse cover, and said plurality of fuses and the fuse cover being removable as a unit by movement in a direction longitudinally of the fuses and generally perpendicularly of the circuit breaker base and cover.

9. In a circuit interrupter, a plurality of tubular fuses each having a plug-in contact positively secured to and forming part of each fuse and extending from the lower end thereof in the direction of the axis of the fuse tube, a terminal conductor at the upper end of each fuse and having a portion extending downwardly at one side of each fuse, a single fuse cover member of insulating material extending across all of the upper ends of the plurality of tubular fuses, another member of insulating material extending across all of the lower ends of the plurality of tubular fuses and holding the upper ends of all of the tubular fuses upwardly against the fuse cover, and said member at the lower ends of the fuses having the plug-in contacts at the lower ends of the fuses accessible for plug-in engagement by motion in a direction endwise of the fuse tubes.

10. In a multi-pole circuit interrupter, a base of insulating material, a plurality of separable contacts and releasable operating mechanism for controlling the contacts mounted on said base, a circuit breaker cover over said contacts and operating mechanism, a multi-pole trip unit mounted on said base and having electro-responsive elements and a common trip bar operable to cause release of said operating mechanism and separation of the contacts, a cover over said trip unit to protect it from tampering, a bracket secured to and movable with the common trip bar and extending outside of the trip unit cover, a plurality of fuses, a fuse cover over said fuses, a member biased to move upon removal of said fuse cover, and said

biased member engaging said bracket outside of the trip unit cover and moving the common trip bar to cause separation of the contacts upon removal of the fuse cover.

11. A multi-pole circuit interrupter comprising a main base having thereon separable contacts for each pole and means releasable to effect separation of the contact means for all of the poles, a trip unit having a separate base mounted on the main base, a trip bar common to all of the poles and mounted on the trip unit base, said trip bar being movable to a tripping position to effect release of said releasable means, means on said trip unit base responsive to overload currents in each of a plurality of poles to move said trip bar to tripping position, a plurality of extensions at spaced intervals on the trip bar on the trip unit base, a fuse housing removably mounted on the main base, a plurality of fuses on said fuse housing, a plurality of members on the fuse housing each of which is independently movable with respect to the other members when one of the fuses blows, and each of said plurality of members on the fuse housing engaging a different one of said plurality of spaced extensions on the trip bar on the trip unit base to move the trip bar to tripping position and effect release of said releasable means and separation of the contact means.

12. In a multi-pole circuit interrupting device, a base, a circuit breaker having a set of separable contacts for each pole on the base and electroresponsive means for causing opening of said sets of contacts, a pair of connectors for each pole mounted on said base adjacent one end thereof, a plurality of fuses, a housing for said fuses including two pieces of insulating material between which the plurality of fuses are retained with the upper member of insulating material engaging and covering the upper ends of all of the plurality of fuses and the lower member of insulating material engaging the lower ends of all of the plurality of fuses and having an opening opposite the lower end of each fuse, a plug-in terminal positively secured to and forming part of each fuse projecting out the lower end of each fuse and into the opening in the lower member of insulating material and engaging one of the connectors on the base, a conducting member extending laterally at the upper end of each fuse and downwardly at one side thereof and engaging the other connector on the base at the side of the fuse, and said plurality of fuses and the housing therefor being removable as a unit from the base on which the circuit breaker is mounted by movement in the direction perpendicular to the base of the circuit breaker and endwise of the fuses.

13. In a multi-pole circuit interrupter, a base, a circuit breaker on the base having separable contacts for each pole and releasable operating mechanism for controlling said separable contacts, a pair of connectors for each pole mounted on the base adjacent one end thereof, a pluraiity of fuses each having a pair of terminals, a housing for said fuses including two members of insulating material between which the fuses are retained with the outer member of insulating material engaging the outer end of each of the fuses and the inner member of insulating material engaging the inner end of each of the fuses, each of said fuses in the housing being positioned endwise over one of the connectors on the base and having one terminal of plug-in type projecting centrally and longitudinally from the inner end of each fuse and engaging the connector therebeneath on the base, the other terminal including a conductor extending laterally from the outer end of each fuse to the side thereof and then downwardly and having thereon a terminal portion at the side of the fuse engaging the other connector on the base, said housing and the plurality of fuses being removable as a unit by movement in a direction longitudinally of the fuses and perpendicular to the bottom of the base, and means actuated upon said removal of the housing and fuses to cause release of the operating mechanism and opening of the separable contacts.

14. In a circuit interrupting device comprising a multi-pole circuit breaker having a base carrying separable contact means and means releasable to effect separation of said contact means, a trip bar and current responsive means movable to move said trip bar to a tripping position to effect automatic release of said releasable means, fuse receiving terminals fixed to said base, replaceable fuses having end portions directly engaging said terminals on the base and connected in series relation with said separable circuit breaker contact means, said fuses being positioned between the current responsive means and the end of the base, separate cover means over said fuses only, said cover means being removable away from said fuses and terminals while said fuses remain in engagement with said terminals on the base and connected in series with said contact means, and stored-energy means operable when said cover means is removed from the fuses to operate the trip bar of said circuit breaker and cause opening of its contact means.

References Cited in the file of this patent

UNITED STATES PATENTS

826,888	Sachs	July 24, 1906
974,109	Auel et al.	Nov. 1, 1910
1,028,258	Murray	June 4, 1912
1,962,867	Green	June 12, 1934
1,972,958	Steinmayer et al.	Sept. 11, 1934
2,298,972	Schultz	Oct. 13, 1942
2,330,690	Dannenberg	Sept. 28, 1943
2,376,789	Leonard	May 22, 1945
2,416,951	Prince	Mar. 4, 1947
2,465,079	Fitzgerald	Mar. 22, 1949
2,473,196	Dannenberg	June 14, 1949
2,476,071	Spiro	July 12, 1949
2,663,776	Stratton	Dec. 22, 1953
2,666,824	Dorfman	Jan. 16, 1954
2,761,932	Kozacka et al.	Sept. 4, 1956
2,821,596	Bires et al.	Jan. 28, 1958
2,824,929	Edmunds	Feb. 25, 1958
2,846,545	Edmunds	Aug. 5, 1958
2,888,535	Edmunds	May 26, 1959
2,924,686	Edmunds	Feb. 9, 1960

FOREIGN PATENTS

13,522	Australia	Dec. 13, 1934