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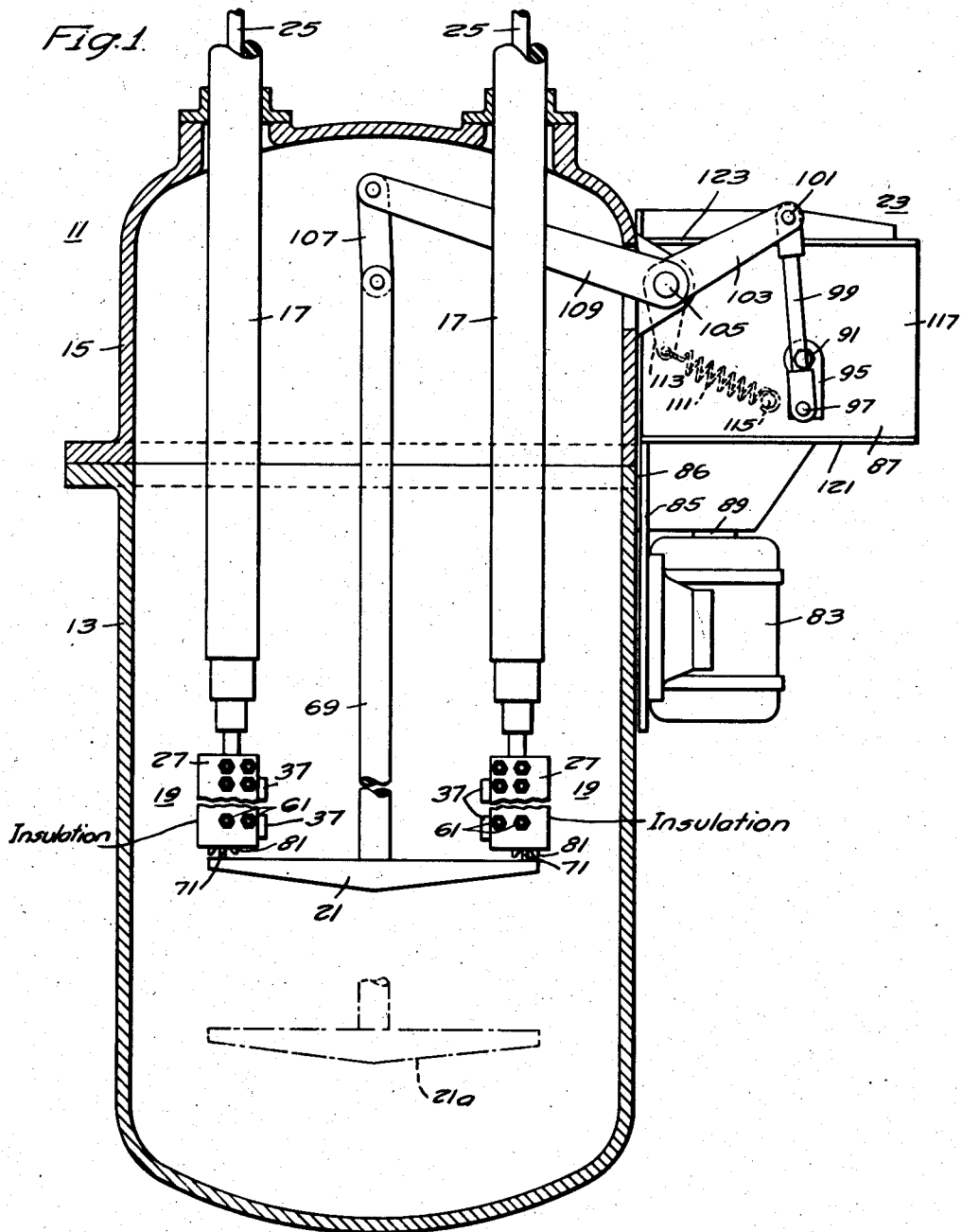
J. B. MacNEILL ET AL

2,385,013

AUTOMATIC RECLOSING CIRCUIT BREAKER

Filed Oct. 17, 1941

5 Sheets-Sheet 1



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Fig. 3

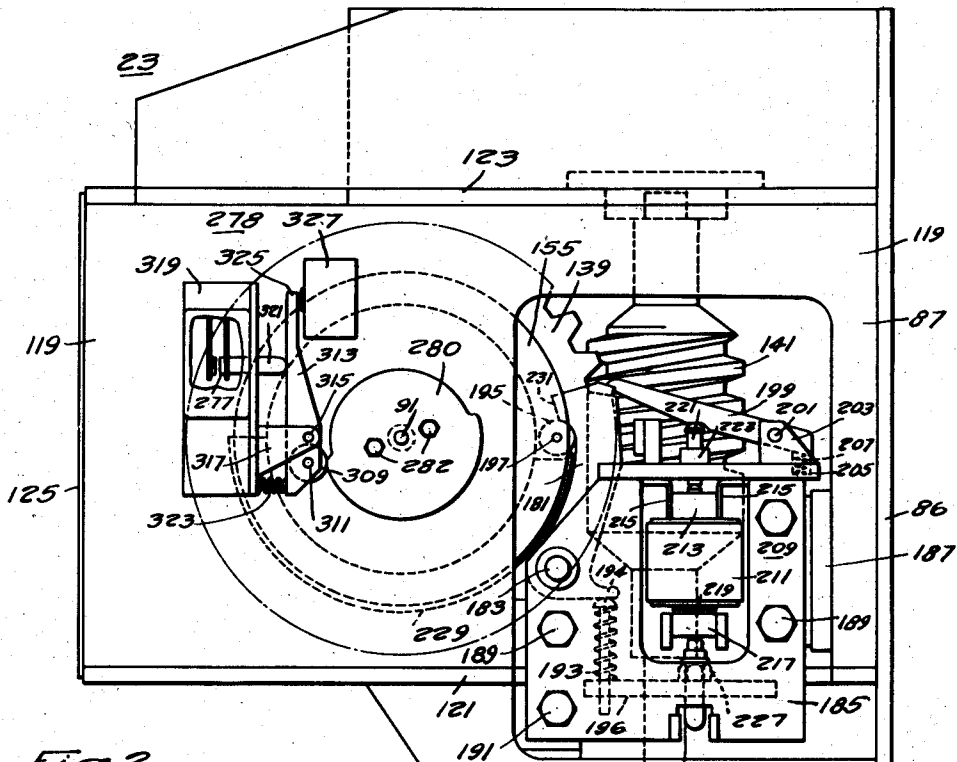
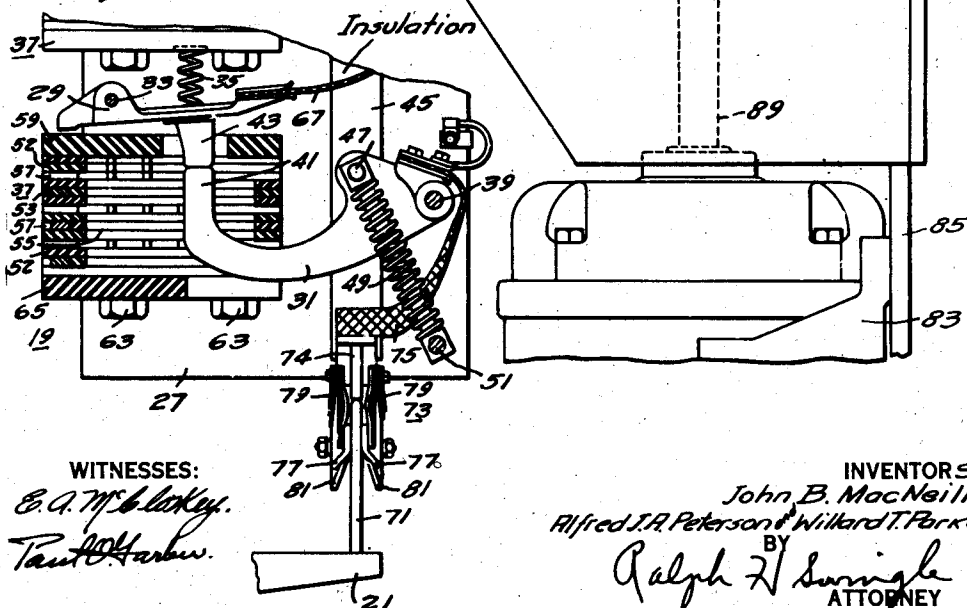


Fig. 2



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Fig. 4.

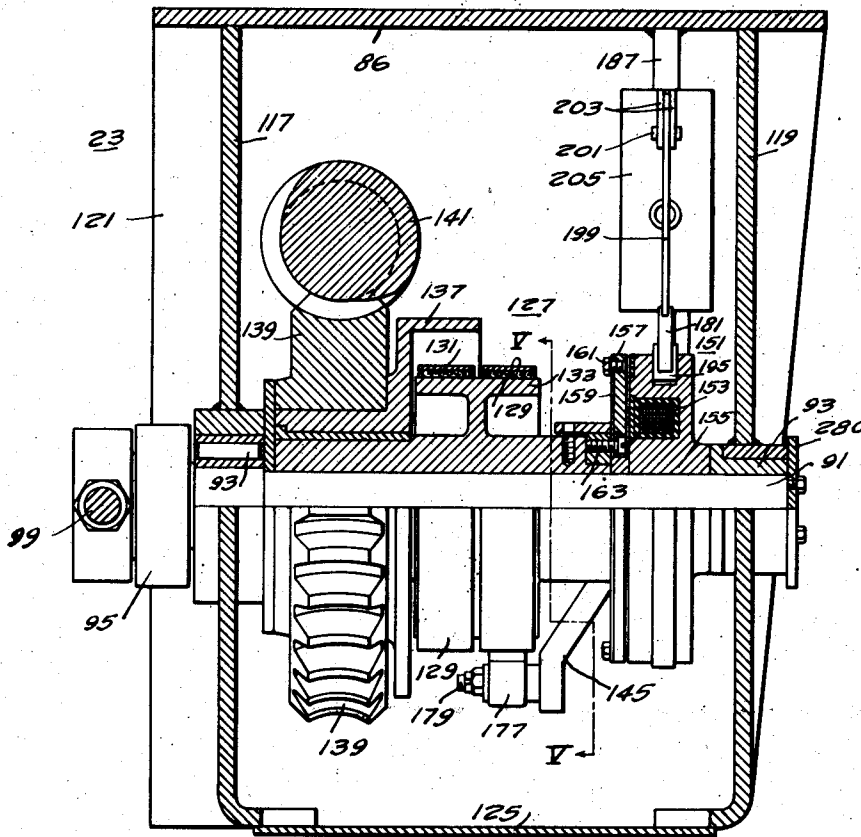
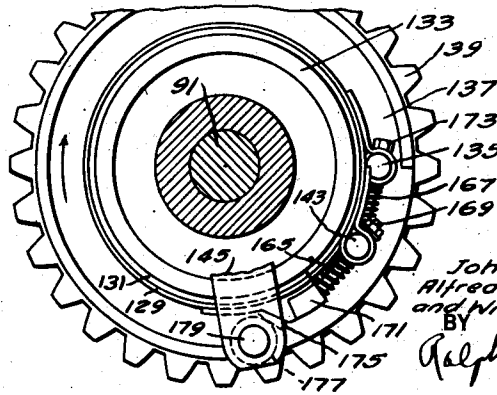


Fig. 5.



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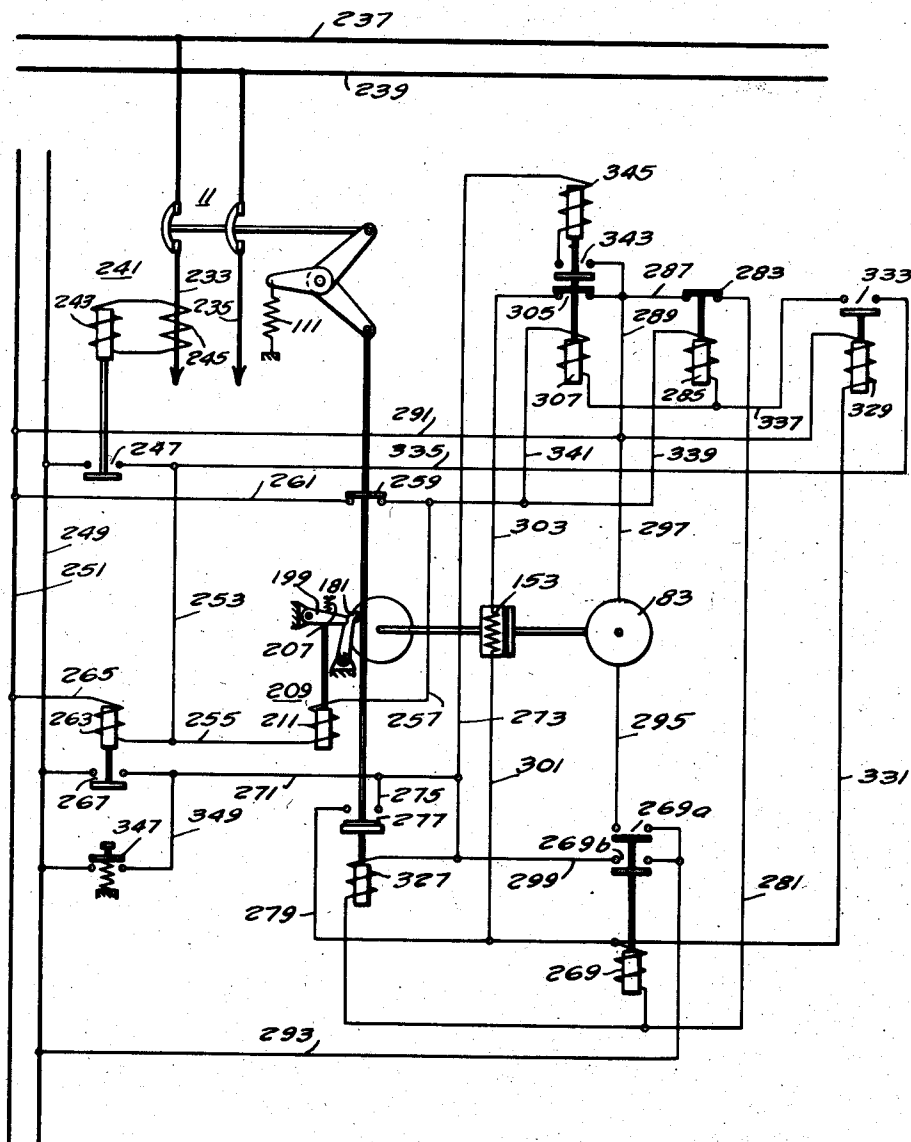
**2,385,013**

# AUTOMATIC RECLOSING CIRCUIT BREAKER

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*Fig. 6.*



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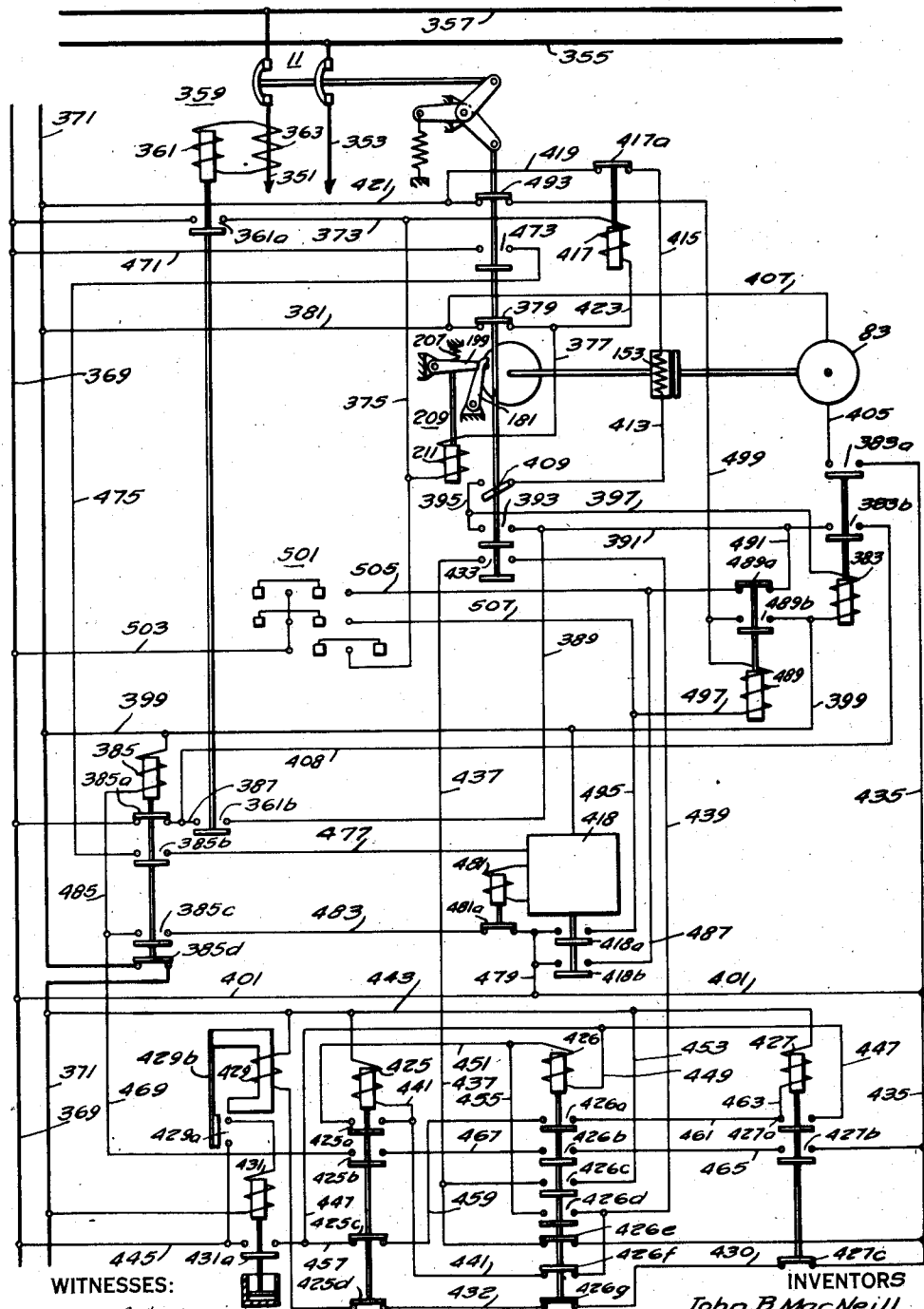
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AUTOMATIC RECLOSING CIRCUIT BREAKER

Filed Oct. 17, 1941

5 Sheets-Sheet 5



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FIG. 7.

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## UNITED STATES PATENT OFFICE

2,385,013

## AUTOMATIC RECLOSING CIRCUIT BREAKER

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Application October 17, 1941, Serial No. 415,394

27 Claims. (Cl. 175—294)

This invention relates to electrical circuit breakers for electrical transmission and distribution systems and more particularly to circuit breakers of the type which are automatically operable to open and reclose the circuit.

An object of the present invention is the provision of an improved trip-free circuit breaker that is automatically operable to quickly interrupt and instantaneously reclose the circuit.

Another object of the invention is the provision of an improved automatic reclosing trip-free circuit breaker embodying an operating mechanism that is automatically operable to initiate reclosing movement of the breaker at least by the time the breaker reaches open position.

Another object of the invention is the provision of an improved automatic reclosing trip-free circuit breaker embodying an operating mechanism that is automatically operable to initiate reclosing movement of the breaker immediately after interruption of the circuit and before the breaker reaches full open position.

Another object of the invention is the provision of a circuit breaker having means for interrupting the current flow during the initial portion of the opening stroke of the breaker, the remaining portion of the stroke serving to provide a safe gap in the circuit and an improved motor operating mechanism connected to the breaker through a trip-free connection and automatically operable to initiate reclosing of the breaker immediately after interruption of the current of the circuit and before the breaker reaches full open position.

Another object of the invention is the provision of a circuit breaker having a plurality of current interrupting devices connected in series and a movable contact member which causes operation of the current interrupting devices to interrupt the current flow during the initial portion of the opening stroke of the breaker and separates from the series of current interrupting devices during the remainder of the opening stroke to provide a safe gap in the circuit, and an improved operating mechanism connected to the contact member through a trip-free connection and automatically operable during an opening operation to initiate reclosing of the breaker immediately after the current flow is interrupted and before the breaker reaches full open position.

Another object of the invention is the provision of an improved automatic reclosing circuit breaker having a motor operating mechanism including an electromagnetically controlled clutch pro-

viding a trip-free connection between the motor and the breaker, said motor and clutch being automatically operable to initiate reclosing movement of the breaker after the current flow of the circuit is interrupted and at least by the time the breaker reaches full open position.

Another object of the invention is the provision of an automatic reclosing circuit breaker as described in the preceding paragraph, wherein the closing motor is automatically energized upon the initiation of a circuit opening operation and the clutch is engaged to initiate reclosing of the breaker before the breaker reaches full open position.

Another object of the invention is the provision of an automatic reclosing circuit breaker as previously described wherein the electromagnetically controlled clutch is deenergized in response to abnormal conditions in the circuit to trip the breaker free of the closing means.

Another object of the invention is the provision of an automatic reclosing trip-free circuit breaker embodying an improved operating mechanism that is automatically operable to produce a plurality of instantaneous reclosing operations in response to predetermined abnormal circuit conditions and that is also operable to trip the breaker free of the closing means at any time in response to predetermined abnormal circuit conditions.

Another object of the invention is to provide an improved operating means for a circuit breaker which is operable to cause a plurality of successive reclosing operations each of which reclosing operations is initiated when the movable contact member of the breaker has reached a predetermined position in its opening movement before the movable contact member reaches full open position, said operating means embodying tripping means operable at any time in response to predetermined circuit conditions to trip the breaker free of the closing means.

Another object of the invention is to provide an improved circuit breaker having a control system which will effect a series of substantially instantaneous reclosing operations in response to abnormal circuit conditions each of which reclosing operations is initiated when the movable contact member of the breaker has reached a predetermined position in its opening movement, the control system being so arranged as to automatically cause a plurality of time delay reclosing operations following the series of instantaneous reclosures if the breaker fails to remain closed

for a predetermined time following the series of instantaneous reclosures.

Another object is to provide a circuit breaker having a plurality of series related interrupting switches and a disconnecting switch with an operating means which is operable to initiate a reclosing operation after the interrupting switches are opened but before the disconnecting switch opens, said operating means embodying tripping means operable at any time in response to predetermined circuit conditions to trip the breaker free of the closing means.

Another object is to provide a circuit breaker having an improved motor operated reclosing mechanism and which is trip-free of the operating mechanism in all positions, with a control system for causing the mechanism to produce a plurality of quick fractional stroke reclosing operations of the breaker in response to abnormal circuit conditions, said operating mechanism including tripping means operable at any time in response to predetermined circuit conditions to trip the breaker free of the reclosing mechanism.

The novel features that are considered characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to structure and operation, together with additional objects and advantages thereof, will be best understood from the following description of several embodiments thereof when read in conjunction with the accompanying drawings in which:

Figure 1 is an elevational view, partly in section, illustrating a circuit breaker embodying the principles of the invention;

Fig. 2 is an enlarged detail view, partly in section, showing one of the lowermost pair of the plurality of pairs of current interrupting contacts and also showing one pair of the disconnecting contact members;

Fig. 3 is an enlarged elevational view showing part of the motor operating mechanism;

Fig. 4 is an enlarged detail view, partly in section, showing the construction of the clutch mechanism and a part of the motor drive;

Fig. 5 is a fragmentary sectional view taken substantially on line V—V of Fig. 4 and showing a part of the clutch mechanism in elevation;

Fig. 6 is a diagrammatic view of a control circuit which controls the breaker to make a quick fractional stroke reclosure in response to a fault and to then lock the breaker in open position; and

Fig. 7 is a diagrammatic view of a control circuit for causing the breaker mechanism to make a plurality of quick reclosing operations followed by a plurality of time delayed reclosing operations and to then lock the breaker in open position.

Referring to Figure 1 the circuit breaker, designated generally by the reference character 11, includes a tank 13 of steel or other suitable material, a flanged cover 15 suitably secured to the tank 13, a pair of insulating terminal bushings 17 rigidly supported by the cover 15 and extending through openings therein into the tank 13, an interrupter contact assemblage 19 mounted on the lower end of each of the bushings 17, a movable disconnecting switch member or blade 21 which forms a disconnecting contact member movable into and out of engagement with the interrupter contact assemblages to effect opening and closing of the breaker, and an actuating mechanism indicated generally at 23 for moving the disconnecting switch member 21 from one position to the other. A terminal conductor 25 extends through

an axial opening in each of the bushings 17 in order to connect the circuit breaker in an electrical circuit. The tank 13 is filled with oil or other suitable insulating fluid to a level sufficiently high that the interrupter contact assemblages 19 are submerged.

The interrupter contact assemblages 19 are mounted between a pair of support plates 27 of insulating material. The upper ends of the support plates 27 are suitably secured to and supported by the lower ends of the terminal conductors 25.

Each of the interrupter contact assemblages 19 comprises a plurality of pairs of separable circuit interrupting contact members 29 and 31 (Fig. 2). While only the lowermost pair of separable contact members 29 and 31 has been illustrated in detail in Fig. 2 it is to be understood that any desired number of pairs of contact members 29 and 31 may be assembled on the lower end of each of the terminal members 25. Each of the plurality of pairs of contact members 29 and 31 and the associated structure are the same, consequently only one pair of contacts will be described.

The contact member 29 (Fig. 2) is pivotally supported on a pin 33 which extends through both support plates 27 and is biased toward the contact 31 by springs 35 (only one being shown). The springs 35 are spaced apart and are compressed between the contact member 29 and the bottom of an arc extinguishing device 37 for the adjacent pair of contacts, there being an arc extinguisher 37 associated with each pair of the interrupting contacts.

The other contact member 31 is pivotally supported on a pin 39 which extends through the support plates 27. The contact member 31 is provided with a contact portion 41 which is adapted to cooperate with a contact portion 43 of the contact member 29. The contact members 31 for each of the interrupter assemblages are operatively connected to a bar 45 of insulating material by means of pins 47 in such a manner that vertical movement of the bar simultaneously moves all of the contact members 31 to open and close the interrupter contacts 41—43. The mechanically connected contact members 31 are biased toward open position by means of tension springs 49 (only one being shown) disposed one on each side of the lowermost contact member 31. One end of each of the springs 49 is connected to the pin 47 connecting the lowermost contact member 31 (Fig. 2) to the tie bar 45. The other ends of the springs 49 are connected to a pin 51 extending through the support plates 27.

As mentioned previously there is an arc extinguisher 37 associated with each pair of contacts 41—43. Each of these arc extinguishers comprises a stack of slotted plates 52 of insulating material and having slotted iron plates 53 interposed at spaced intervals between the insulating plates. These slotted iron plates cause the arc to be drawn out horizontally in the chamber 55 formed by the slots in the plates.

Since the level of the insulating fluid is above the contact assemblages 19, the chambers 55 will contain a quantity of oil, there being a plurality of openings 57 communicating from the main tank to each of the chambers 55. When the arc is drawn this oil or other insulating fluid is partially volatilized causing a transverse blast through the arc and out the vents 57 to effect a quick extinguishing of the arc in a manner well known in the art.

An upper insulating plate 59 of each of the arc extinguishers 37 is secured to the support plates 27 by means of bolts 61 (Fig. 1), and bolts 63 extend through openings in a bottom plate 65 and the stack of slotted plates to secure these parts to the upper plate 59.

The contact members 29 are connected by flexible shunt conductors 67 (only one being shown) to the contact member 31 immediately above, and the upper contact member 29 of each assemblage 19 is connected by a similar flexible shunt conductor (not shown) to its corresponding terminal conductor 25, thus electrically connecting the several pairs of contact members 29 and 31 in series with each other and with the breaker terminal 25.

The switch member 21 of conducting material is securely mounted intermediate its ends on the lower end of an actuating rod 69 of insulating material which is operatively connected to the breaker actuating mechanism. The disconnecting switch member 21 is provided with a pair of flat vertical projections or contacts 71 adapted to engage and actuate the contacts of the interrupter assemblages 19. Mounted on the lower end of each of the bars 45 is a contact 73 which is electrically connected to the lowermost one of the contact members 31 by means of a flexible shunt conductor 75. The contact 73 comprises opposed contact fingers 77 secured to a member 74 of conducting material, and biased toward each other by leaf springs 79. The member 74 is secured to the lower end of the bar 45. V-shaped guides 81 facilitate entrance of the vertical contact portions 71 of the disconnecting switch member 21 into engagement with the contacts 73.

The circuit breaker is shown in Fig. 1 in the closed circuit position. When the breaker is tripped the disconnecting switch member 21 moves downwardly away from the two interrupter assemblages 19. During this movement the springs 49 which bias the connected contact members 31 away from the contacts 29 cause the contacts 31 to move toward open position. As a result a series of arcs is formed, one in each of the arc extinguishing chambers 55.

The distance between the pivot pin 39 for the contact member 31 and the pin 47 which connects the contact members 31 to the tie bar 45 is considerably less than the distance from the pivot pin 39 to the point of engagement of the contact 41—43, consequently the speed of separation of the pairs of contacts 41—43 is much greater than the speed of movement of the disconnecting switch member 21. Continued downward or opening movement of the disconnecting switch member 21, after the contacts 41—43 are fully open, causes the vertical contact portions 71 of the switch member 21 to disengage the contacts 73 on the lower ends of the bars 45. The extent of the downward movement of the disconnecting switch member 21 is arranged to provide a predetermined gap of considerable length between the vertical contact portions 71 and the contacts 73.

Movement of the disconnecting switch from its fully open position to its closed position first closes the gap between the contact projections 71 and the contacts 73, after which the continued upward travel of the disconnecting switch actuates the bars 45 simultaneously to close all of the interrupting contacts 41—43. The circuit breaker per se described above is of the same general type that is fully disclosed in United States Patent

2,192,772, granted March 5, 1940, to J. B. MacNeill, and which is assigned to the assignee of this invention.

The operating mechanism 23 for operating the circuit breaker comprises a motor 83 (Figs. 1 and 3) of any suitable type which is supported on a plate 85 extending downwardly from the base plate 86 of a housing 87 which encloses a trip-free connecting mechanism for coupling the motor to the circuit breaker mechanism. The base plate 86 of the housing 87 is secured to the cover 15 of the tank in any suitable manner. The motor 83 is adapted to drive a shaft 89 which extends into the housing 87 where it is connected through a trip-free connection to a shaft 91 (Fig. 4) rotatably mounted in bearings 93 supported in the side members of the housing, as will be more fully described later.

Referring now to Fig. 1 it can be seen that one end of the shaft 91 projects outside of the housing 87 and has secured thereto a crank arm 95 the free end of which is connected by means of a pin 97 to one end of a link 99. The other end of the link 99 is pivotally connected by a pin 101 to the free end of an arm 103 secured on a shaft 105 also rotatably supported in the housing side members. A link 107 operatively connects the upper end of the circuit breaker actuating rod 69 to the free end of an arm 109 which is also secured on the shaft 105. An accelerating or circuit opening spring 111 having one end attached to the free end of an arm 113 secured to the shaft 105 and the other end attached to a fixed pin 115 is provided to quickly open the circuit breaker.

The housing 87 which encloses the actuating mechanism 23 includes the base plate 86 to which is secured a pair of side members 117 and 119, a bottom plate 121, a top plate 123 and a cover plate 125. These members are suitably secured together to form an enclosing structure substantially in the form illustrated in Figs. 1 and 4 of the drawings.

Referring now particularly to Fig. 4 the actuating mechanism 23 mounted in the housing 87 includes a clutch device 127 for establishing a driving connection between the motor 83 and the shaft 91 which is operatively connected to the disconnecting switch member 21. The clutch, indicated generally at 127 (Fig. 4) is of the friction band type and is provided with a primary clutch band 129 and a secondary clutch band 131. These clutch bands are adapted to cooperate with a clutch drum 133 mounted for rotation with the shaft 91. One end of the secondary clutch band 131 is secured by means of a pin 135 (Fig. 5) to a member 137 which is rotatable on the hub of the drum 133. The member 137 is secured to and rotatable with a worm gear 139. The worm gear 139 meshes with and is driven by a worm 141 connected to the upper end of the drive shaft 89. The other end of the secondary clutch band 131 is connected by a pin 143 to one end of the primary clutch band 129 the other end of which cooperates with a clutch arm 145.

In order to actuate the clutch bands 129 and 131 and establish a driving connection between the motor driven worm gear 139 and the operating shaft 91 there is provided an electromagnetic clutch indicated generally at 151 (Fig. 4). A clutch coil 153 is enclosed in but insulated from a housing 155 of magnetic material mounted for rotation with the shaft 91. The electromagnetic clutch 151 also includes an armature 157 secured by means of a disc spring 159 to the hub of the clutch arm 145. Screws 161 secure the outer por-

tion of the disc spring to the armature 157, and screws 163 secure the inner portion of the disc spring to the hub of the clutch arm 145.

As long as the coil 153 remains unenergized, the armature 157, the clutch arm 145, the clutch bands 129 and 131, the member 137 and the worm gear 139 driven by the worm 141, are free to rotate about the shaft 91. When the clutch coil 153 is energized, however, it attracts the armature 157 which moves into frictional engagement with the face of the housing 155. This effects tightening of the clutch bands 129 and 131 on the drum 133 whereupon the drum and the shaft 91 will be rotated to effect closure of the circuit breaker contacts.

The primary clutch band 129 and the secondary clutch band 131 are normally held out of contact with the clutch drum 133 by means of clutch release springs 165 and 167 respectively. Referring to Fig. 5 the spring 165 surrounds a screw bolt 169 projecting through an opening in the pin 143 and through a portion of the clutch band 129 which is looped around the pin. The bolt 169 is screwed into a block 171 secured to the other end of the clutch band 129. The spring 165 is compressed between the looped portion of the clutch band and the block 171 to prevent engagement of the clutch band 129 with the drum 133 and to disengage the clutch band from the drum. Similarly the spring 167 surrounds a bolt 173 extending through the pins 135 and 143 and is compressed between the looped ends of the clutch band 131 surrounding the pins to prevent engagement of the secondary clutch band 131 with the drum 133 and to release the band 131 from the drum. A wedge shaped member 175 secured to the block 171 cooperates with a roller 177 on a pin 179 in the clutch arm 145 to initially tighten the primary clutch band 129.

When the motor 83 is running and the clutch coil 153 is unenergized, the worm gear 139 and the member 137 rotate in a clockwise direction (Fig. 5). The secondary clutch band 131 is rotated about the drum 133 in the same direction through the agency of the pin 135, and the spring 167 transmits this movement to the pin 143 which carries the primary clutch band 129 also in a clockwise direction about the drum 133. As the primary clutch band rotates, the wedge shaped member 175 cooperating with the roller 177 causes the clutch arm 145 and the armature 157 to rotate clockwise relative to the clutch coil housing 135, the shaft 91 and the drum 133.

When the clutch coil 153 is energized, as will be hereinafter described, the armature 157 is attracted and frictionally engages the housing 155. This frictional engagement attempts to stop the rotation of the clutch arm 145 and by means of the wedge member 175 forces the primary clutch band 129 into engagement with the drum 133, causing compression of the springs 165 and 167 and tightening both the primary and the secondary clutch bands on the drum 133. This forms a driving connection between the motor drive shaft 89 and the operating shaft 91 whereby the motor 83 operates the breaker to closed contact position.

The shaft 91, the crank arm 95 and the link 99 are held in the closed position by means of a latch 181 (Fig. 3) in order to hold the circuit breaker in closed circuit position. The latch 181 is pivotally supported on a pin 183 supported on a pair of U-shaped spaced plates 185 (only one being shown). The plates 185 are spaced apart by suitable spacers (not shown) and are secured on a

projection 187 extending inwardly from the plate 185, by means of bolts 189. The plates 185 are also secured by bolts 191 to a boss (not shown) on the bottom plate 121.

A spring 193 biases the latch 181 into latching engagement with a latch roller 195 rotatably mounted on a pin 197 in the clutch coil housing 155, the roller 195 being disposed in a semi-angular groove in the periphery of the housing 155. The spring 193 is compressed between a projection 194 on the latch 181 and a plate 196 (Fig. 3) mounted between the plates 185 and suitably secured thereto. The latch 181 is normally locked in latching engagement with the latch roller 195 by means of a trigger latch 199. The trigger latch is pivoted on a pin 201 supported in projections 203 extending upwardly from a plate 205 secured to the tops of the plates 185. A spring 207 biases the notched end of the trigger latch 199 into latching engagement with the latch member 181.

Referring to Fig. 1, it can be seen that the accelerating spring 111 acting through the arm 113, shaft 105, the arm 103 and the link 99 biases the crank arm 95 and the shaft 91 in a clockwise direction. In Fig. 3, which is a view of the mechanism looking in the opposite direction from Fig. 1, the shaft 91 and the clutch coil housing 155 are biased in a counterclockwise direction, but are prevented from rotation by the latch 181.

The trigger latch 199 is operated to free the latch 181 and cause opening of the breaker by means of an electromagnetic trip device 209 including a trip coil 211 (Fig. 3). The coil 211 is mounted on a stationary core 213 which is supported by angular brackets 215 depending from the plate 205. A movable armature 217 is mounted on a trip rod 219 extending through an axial opening in the stationary core 213. The upper end of the trip rod 219 is in axial alignment with a strip pin 221 slidable vertically in an opening in the plate 205 and in a boss 223 secured to the plate. The lower end of the trip rod 219 extends through an opening in the plate 196 and a nut 227 is provided on a threaded portion of the trip rod 219 for the purpose of adjusting the open air gap of the movable armature 217 and for limiting the downward movement of the movable core 217.

When the trip coil 211 is energized, as will be described later, the trip rod 219 is thrust upwardly striking the trip pin 221 which operates the trigger latch 199 to release the main latch 181. The spring 111 (Fig. 1) then acts to operate the breaker mechanism to open circuit position as previously set forth. As the clutch coil housing 155 rotates to open position, the roller 195 rocks the latch 181 clockwise and an arcuate surface 229 of the housing 155 engages a portion 231 of the latch 181 to restrain the latch in its disengaged position. During the time the latch 181 is in its disengaged position, the spring 207 biases the trigger latch against the free end of the latch 181.

When the trip coil 211 is deenergized, the movable core 217 and the trip rod 219 drop downwardly to the unattracted position, but the trigger latch 199 is held up by the latch 181 until the circuit breaker is moved to the closed circuit position through the agency of the motor actuating mechanism 23. As the breaker arrives at the closed position, the latch 181 (Fig. 3) is moved into latching engagement with the latch roller 195 by the spring 193, at which time the spring 207 moves the trigger latch 199 into engagement

with the latch 181, thus latching the breaker in the closed position.

In ordinary opening operations of the circuit breaker, that is, when the breaker is opened permanently, the interrupting or arcing contacts 41-43 (Fig. 2) are opened during the first part of the downward movement of the breaker actuating rod 69. After the interrupting contacts have reached their full open position, the actuating rod continues in a downward direction disengaging the contacts 71-77 and introduces a large additional gap in series with the interrupter contacts.

One of the objects of this invention is to provide a reclosing mechanism which permits the accelerating spring 111 (Fig. 1) to operate the actuating rod 69 toward open position a sufficient amount to fully open the circuit interrupting contacts 41-43, but which initiates a reclosing movement of the rod before the disconnecting contacts open. As the actuating rod travels toward open position, the interrupting contacts 41-43 are opened. Since the majority of fault currents are interrupted and the arcs extinguished within the interrupters 19, it is unnecessary that the actuating rod travel toward open position beyond the point where the interrupting contacts 41-43 have reached their fully open positions. Therefore the operating mechanism previously described is energized at a time such that it will initiate the reclosing movement of the breaker when the interrupting contacts have reached their open positions and before the disconnecting contacts 71-77 open. The downward travel of the actuating rod 69 is reversed at this point and the rod moved back toward closed position to immediately reclose the interrupting contacts and reestablish the circuit. By thus limiting the opening travel of the actuating mechanism to that required to extinguish the arc on automatic reclosing operations and initiating the reclosing from this fractional part of the stroke, a considerable reduction of the time interval for interruption and reclosing of the circuit is obtained.

In order to control the circuit breaker and the motor operating mechanism therefor to accomplish interruption of the circuit in response to predetermined abnormal conditions in the circuit and the quick automatic reclosing operation, the control system illustrated diagrammatically in Fig. 6 is provided.

Referring now to Fig. 6, two of the circuit breaker units 11 are connected to a single operating mechanism 23 previously described and the breakers are shown as connecting load circuit conductors 233 and 235 to main conductors 237 and 239. A protective device 241 is provided which includes an energizing coil 243 arranged to be energized from the secondary winding 245 of a current transformer associated with one of the load conductors. When a fault occurs on the power line, the protective device 241 is energized and closes its contacts 247. Closure of the contacts 247 completes a circuit through the trip coil 211 from one source conductor 249 of an auxiliary power source comprising the conductor 249, and a source conductor 251, through the contacts 247, a conductor 253, a conductor 255, the trip coil 211, a conductor 257, auxiliary contacts 259 of the breaker which are closed when the breaker is closed, and a conductor 261 to the source conductor 251. Energization of the trip coil 211, as previously described, operates the trigger latch 199 (Figs. 3 and 6) to free the latch 181 and permit

the spring 111 (Fig. 1) to operate the breaker toward open position.

Closure of the contacts 247 also energizes the coil of a reclosing relay 263 simultaneously with the energization of the trip coil 211. The circuit for energizing the relay 263 extends from the source conductor 249 through the contacts 247, the conductors 253 and 255, coil of relay 263 and a conductor 265 to the source conductor 251. When the relay 263 is energized, it closes its contacts 267 establishing a circuit through a motor control relay coil 269 extending from the source conductor 249 through the contacts 267, conductors 271 and 275, the contacts 277 of a cam-operated limit switch 278 (Fig. 3) which closes as soon as the breaker 11 starts to open, a conductor 279, the coil of relay 269, a conductor 281, the contacts 283 of a relay 285, conductors 287, 289 and 291 to the source conductor 251.

Energization of the relay 269 supplies energy to the motor 83 over a circuit from the source conductor 249 through a conductor 293, the contacts 269a, a conductor 295, the windings of the motor 83 and the conductors 297 and 291 to the conductor 251. The motor 83 now starts to accelerate and at the same time the clutch coil 153 is energized by closure of the contacts 267 and couples the motor to the breaker mechanism. The circuit for energizing the clutch coil extends from the source conductor 249 through the contacts 267, conductors 271 and 275, contacts 277, conductors 279 and 301, the clutch coil 153, a conductor 303, contact 305 of a relay 307 and conductors 287, 289 and 291 to the source conductor 251. The relay 269 seals itself in parallel with the contacts 267 through its own contacts 269b in order to keep the motor 83 and clutch coil 153 energized after the relay 263 is deenergized and the contacts 267 opened. The holding circuit for the relay 269 can be traced from the source conductor 249 through the conductor 293, the contacts 269b, conductors 299, 273 and 275, contacts 277, the conductor 279, coil of relay 269, conductor 281, contacts 283 of relay 285, and conductors 287, 289 and 291 to the source conductor 251.

As the motor 83, which is now running, is coupled to the breaker actuating mechanism by energization of the clutch coil 153, the movement of the switch member 21 (Fig. 1) of the breaker toward open position is stopped and immediately returned to closed position. Just before reaching the closed position, the contacts 277 are opened which deenergizes the relay 269 and the clutch coil 153. When the relay 269 is deenergized, the contacts 269a and 269b open, deenergizing the motor 83. Deenergization of the clutch coil 153, disconnects the motor 83 from the breaker mechanism.

If the fault condition causing the overload has been cleared, as the breaker reaches the closed position, the latch 181 (Fig. 3) moves into engagement with the latch roller 195 and the trigger latch 199 engages the latch 181 to hold the breaker in closed position.

The contacts 277 of the limit switch 278 are operated by a cam 280 (Fig. 3) adjustably secured on the end of the shaft 91 by screws 282. The cam 280 cooperates with a roller 309 rotatably mounted on a pin 311 carried by a cam arm 313. The cam arm is pivotally mounted on a pin 315 supported in a bracket 317 projecting from a closure 319 which houses the contacts 277. The closure 319 is suitably secured to the side members 119 of the housing 87 and has a plunger 321 slidably projecting therefrom and biased into co-

operative relation with the cam arm 313 by the spring blade of one of the contacts 277. The inner end of the plunger 321 cooperates with the limit switch contacts 277 and is adapted, when moved into the closure 319, to close said contacts.

The cam arm 313 (Fig. 3) is biased in a counterclockwise direction, i. e., in a direction to close the contacts 277, by a spring 323. As previously stated the shaft 91 is rotated in a counterclockwise direction when the breaker is tripped and moved toward open position. The configuration of the cam 280 is such that shortly after the shaft 91 starts its counterclockwise or opening movement, it permits the spring 323 to rock the cam arm 313 counterclockwise to close the contacts 277. The contacts 277 remain closed until just before the breaker mechanism arrives at the closed position whereupon the cam 280 rocks the cam arm 313 clockwise permitting the contacts 277 to open.

The free end 325 of the cam arm 313 (Fig. 3) forms an armature which, under certain conditions, is attracted by a lockout coil 327 (Figs. 3 and 6) to prevent closure of the contacts 277.

If the circuit breaker should be closed against a fault, it will immediately be tripped free of the closing means and return to the open position. As the breaker approaches closed position under this circumstance, the protective relay 241 again functions to close the contacts 247. This energizes the trip coil 211 which holds the trigger latch 199 out of engagement with the latch member 181 thus preventing the breaker from latching up in the closed position.

In order to disengage the clutch coil 153 and open the energizing circuit to the motor 83 when the breaker closes against a fault, relays 285 and 307 are provided. These relays, when energized, respectively open the circuits to the motor relay 269 and clutch coil 153 permitting the breaker to go to its fully open position where it is locked out. This provides a trip free operation, that is, deenergization of the clutch coil 153 when the breaker closes against a persistent fault immediately disconnects the breaker mechanism from the closing motor and permits the circuit breaker to immediately open.

When the relay coil 269 was energized on the initial opening operation of the breaker by the contacts 267 and 277, a relay 329 was energized simultaneously therewith through a conductor 331, coil of relay 329 and the conductor 291 to the source conductor 251. Energization of the relay 329 closes its contacts 333 setting up a circuit to energize the relays 285 and 307, the circuit for these relays extending from the source conductor 249 through the contacts 247 of the protective relay, a conductor 335, the contacts 333, a conductor 337, the coils of relays 285 and 307 which are wired in parallel, conductors 339 and 341 respectively, breaker auxiliary contacts 259 and conductor 261 to the source conductor 251. As the breaker approaches closed position with a fault on the line the contacts 259 close and the protective relay functions to close the contacts 247 momentarily energizing the relays 285 and 307. Energization of the coil of relay 285 causes opening of the contacts 283 which opens the circuit for the coil of the motor control, the relay 269 causing this relay to drop out. This opens the circuit to the motor 83 and also opens the holding circuit for relay 269. At the same time energization of the relay coil 307 causes this relay to open the contacts 305 and close contacts 343. Opening of the contacts 305 de-

energizes the clutch coil 153 and closing of the contacts 343 establishes a circuit through a holding coil 345 which, when energized, holds the clutch circuit open at the contacts 305 until the contacts 267 open upon deenergization of the protective relay 241. The coil 345 is energized over a circuit extending from the source conductor 249 through the contacts 267, the conductors 271 and 273, coil 345, contacts 343, and the conductors 289 and 291 to the source conductor 251. Operation of the coil 345 prevents reenergization of the clutch coil 153 following a trip free operation of the breaker and prevents "pumping" action of the breaker. The breaker, therefore, goes immediately to its open position and may not be reclosed until the control circuit is energized by operation of a manual switch 347.

As soon as the breaker starts to open the protective relay 241 is deenergized opening the contacts 247 and deenergizing the relay 263. This opens the contacts 267 deenergizing the coil 345 permitting the contacts 343 to open and contacts 305 to close. At the same time, auxiliary contacts 259 open deenergizing relay coils 285 and 307. The contacts 283 of the relay 285 now close but the circuit for the motor control relay 269 is open at the contacts 267 and the relay 269 remains deenergized.

The circuit breaker is now in its fully open position with the disconnecting switch member 21 (Fig. 1) in the fully opened position indicated by dot and dash lines at 21a, and the interrupting contacts 41-43 are in the open position. In order to close the breaker, the manual switch 347 is closed which energizes the control circuit in parallel with the contacts 267, the circuit extending from the source conductor 249 through the contacts of the manual switch 347, a conductor 349, the conductors 271 and 273, the contacts 277 closed when the breaker is open, the conductor 279, coil of the motor control relay 269, the conductor 281, the contacts 283 and conductors 287, 289 and 291 to the source conductor 251. This energizes the motor 83 as previously described and at the same time the clutch coil 153 is energized over the conductor 301, clutch coil 153, contacts 305 and conductors 287, 289 and 291 to the source conductor 251. The switch 347 is closed momentarily or until the previously described holding circuit through the contacts 269b has been established by the relay coil 269.

If the breaker is closed, by manipulation of the manual switch 347, against a fault on the transmission line it will be immediately tripped open free of the closing means by deenergization of the clutch in the manner previously described.

The majority of faults occurring on electrical transmission lines are of very short duration and usually disappear within a few half cycles of the alternating current when the ionizing potential is removed from the line. Thus if the circuit is interrupted and quickly reclosed the fault usually disappears and normal conditions may be resumed. Conventional circuit breakers for use on high voltage transmission lines are usually constructed to automatically trip open in response to a fault on the line and to immediately reclose. Such breakers, however, usually reopen and are locked out in an open position if the fault persists beyond the time required for one quick reclosure.

It frequently happens that the fault persists for a very short time after the circuit has been interrupted a second time. In this condition it is desirable to provide a series of instantaneous reclosures, two or more, so that should the fault

have disappeared on any one of the series of reclosure the breaker will remain closed and normal conditions prevail.

Heretofore it has not been possible to obtain more than one quick automatic reclosing operation, i. e. a reclosing operation initiated before the breaker reaches full open position, and still retain the important trip free feature. This is because with the prior art constructions, it is necessary to wait for the mechanism to reset before a second reclosing operation can be initiated. The present invention provides a circuit breaker operating mechanism which can be operated to provide two or more successive quick automatic reclosing operations each initiated before the breaker reaches full open position and yet the breaker can always be tripped free of the closing means at any time in response to a fault.

If the fault has not been cleared by two or more successive quick reclosing operations, it is desirable in some cases to provide for one or more time delayed reclosing operations following the quick reclosing operations as a final resort to clear the fault. A control arrangement for controlling the motor operated circuit breaker mechanism previously described to provide a plurality of substantially instantaneous reclosures followed by a plurality of time delay reclosures is illustrated diagrammatically in Figure 7. Since this control system is applied to the circuit breaker mechanism illustrated in Figures 1 through 5, the same reference characters are applied to the corresponding mechanical parts.

Referring now to Fig. 7, let it be assumed that the circuit breaker is in the closed position connecting electrical conductors 351 and 353 to the main power supply lines 355 and 357. A protective relay 359 is provided having an energizing winding 361 arranged to be energized from the secondary winding 363 of a current transformer associated with one of the conductors. When a fault occurs on the line 351—353, the protective relay 359 is operated and closes contacts 361a and 361b. Closure of contacts 361a energizes the previously described trip coil 211 which actuates the trigger latch 199 allowing the breaker to move toward open position. The circuit for energizing the trip coil 211 can be traced as follows: from a source conductor 369 through the contacts 361a, conductors 373 and 375, the trip coil 211, a conductor 377, auxiliary contacts 379 of the circuit breaker and conductor 381 to the source conductor 371. Energization of the trip coil 211 unlatches the breaker in the previously described manner and allows it to open.

At the same time closure of the contacts 361b energizes a motor control relay 383, the energizing circuit extending from the source conductor 369 through the contacts 385a of a transfer relay 385, a conductor 387, the contacts 361b, a conductor 389, a conductor 391, breaker auxiliary contacts 393 closed when the breaker starts to open, conductors 395 and 397, the winding of the motor control relay 383 and a conductor 399 to the source conductor 371. Energization of the relay coil 383 closes two sets of contacts 383a and 383b. Closure of contacts 383a energizes the winding of the reclosing motor 83. The circuit for the motor extends from the source conductor 369 through a conductor 401, a wire 435, the contacts 383a, a conductor 405, the winding of the motor 83, a conductor 407, and the conductor 381 to the conductor 371. Closure of the contacts 383b establishes a holding circuit for the relay 383 from the conductor 369,

through contact 385a, conductor 387, a conductor 408, the contacts 383b, the conductor 391, auxiliary contacts 393, the conductors 395 and 397, coil of relay 383, conductor 399 to the conductor 371.

During the opening movement of the breaker, the clutch coil 153 is energized and mechanically connects the motor 83 to the breaker. This stops the downward movement of the switch member 21 and starts the breaker toward closed position. The clutch coil 153 is energized by means of an adjustable limit switch 409, which may be adjusted to close at any point in the opening travel of the switch member 21, but which is adjusted in the present case to close just before the disconnecting contacts 71—73 open, but after the series interrupters 41—43 have opened. The circuit for energizing the clutch coil extends from the conductor 369, the transfer relay contacts 385a, conductor 408, the contact 383b, conductor 391, breaker auxiliary contacts 393, conductor 395, limit switch 409, conductor 413, clutch coil 153, conductor 415, contacts 417a of a relay 417 and conductors 419 and 421 to the conductor 371.

Thus the motor is started and clutched to the breaker so as to initiate reclosing of the breaker immediately after the circuit is interrupted and before the disconnecting contacts 71—77 open.

As the breaker approaches the closed position, the contacts 393 open, deenergizing the coil of the motor control relay 383 which deenergizes the winding of the motor 83 and opens the circuit to the clutch coil 153 in order to mechanically disconnect the motor from the breaker. The breaker latches in the closed position, and if the fault on the line has disappeared, the breaker remains in the closed position. If, however, the fault persists, the protective relay 359 is again energized and the breaker again starts to open and quickly recloses from an intermediate position as previously described.

When the breaker closes against a fault, it is necessary to disconnect the motor from the breaker in order that the breaker may immediately open free of the closing means. The motor is disconnected from the breaker by deenergizing the clutch coil 153 and the fast operating relay 417, which has its contacts 417a in the clutch coil circuit, is provided for this purpose. If the breaker closes when the fault is still on the line, the protective relay 359 will be energized shortly before the breaker reaches its fully closed position, thus closing the contacts 361a. This completes a circuit through the coil of relay 417 in parallel with the circuit through the trip coil 211. This circuit may be traced from the conductor 369 through the contacts 361a, conductor 373, coil of the relay 417, a conductor 423, auxiliary contacts 379 and conductor 381 to the conductor 371. The coil of relay 417 thus energized opens the contacts 417a and deenergizes the clutch coil 153.

Provision is made to effect a predetermined number of substantially instantaneous fractional stroke reclosures, that is, reclosures which are initiated before the breaker has reached its fully open position. The means for effecting the plurality of reclosures includes a system of interlocking relays which are energized sequentially and after a predetermined number of quick reclosures energize a transfer relay 385. This transfer relay causes energization of a device 418 herein referred to as a "recloser" which controls the breaker to make a predetermined number of timed

reclosures following the series of substantially instantaneous reclosures if the breaker fails to remain closed.

The interlocking relay system includes relays 425, 426 and 427 each of which is provided with a plurality of make and break contact members.

A timing relay 429 is provided to time the periods during which the breaker is in the closed position. Should the breaker remain closed on any one of its closing strokes beyond the time interval as measured by the timing relay 429, a slow dropout relay 431 is provided to automatically reset the interlocking relay system to its initial position. The circuit for energizing the timing relay 429 extends from the conductor 369 through the wires 401 and 435, contacts 427c of the relay 427, a conductor 430, contacts 426g of the relay 426, a conductor 432, the contacts 425d of the relay 425, a conductor 434, coil of the timing relay 429 and the conductor 443 to the conductor 371.

On the initial or first opening stroke of the breaker, an auxiliary contact member 433 of the circuit breaker closes and establishes a circuit for energizing the winding of relay 425 from the conductor 369 through the conductor 401, conductor 435, contacts 426e of the relay 426, a conductor 437, auxiliary contacts 433, a conductor 439, contacts 426f, a conductor 441, coil of relay 425, and conductor 443 to the conductor 371.

It can be seen that when the winding of relay 425 is energized on the first opening stroke of the breaker, the timing relay 429 which is energized when the breaker is in the closed position will now be deenergized through the opening of the contact members 425d of the relay 425. Deenergization of the timing relay 429 causes its pendulum member 429b to vibrate and intermittently open and close its contacts 429a for the predetermined time interval for which the relay 429 has been set. The slow drop out relay 431 which is energized when the contacts 429a of the timing relay are closed is so constructed that it will remain closed and hold its contact members 431a in closed position as long as the vibrating pendulum 429b continues to intermittently open and close its contacts 429a.

When the relay coil 425 is energized, it establishes a circuit for energizing the relay coil 426 in series with the coil 425. This circuit extends from the conductor 369 through a conductor 445, the contact 431a, conductors 447 and 449, the coil of relay 426, conductor 451, the contacts 425a, conductors 441, coil of relay 425, and conductor 443 to the conductor 371.

If the disturbance persists upon the first quick reclosure of the breaker, the protective relay 359 is again energized and the breaker is tripped and permitted to open as previously described. During the second opening stroke of the breaker, the contacts 433 again close and at this closure shunt out the coil of relay 425 causing this relay to open its contacts 425a and 425b. The shunt circuit for the coil 425 may be traced from one side of the coil 425 through conductors 443 and 453, contacts 426c, conductor 437, contacts 433, conductor 439, contacts 426d, conductors 455 and 451, contacts 425a, and conductor 441 to the other side of the coil 425.

As the relay 425 now opens, the relay 427 is energized from the auxiliary power source through the contacts 425c and 426a, the circuit extending from the conductor 369, conductor 445, contacts 431a, conductor 457, contacts 425c of the relay

425, a conductor 459, contacts 426a, conductors 461 and 463, coil of the relay 427, conductor 443 and to the conductor 371.

As the breaker moves toward its open position for the second time, the motor 83 is again energized by the motor control relay contacts 383 and the clutch coil 153 is energized by the contacts 409 causing the motor to pick up the breaker and close it again. During the second closure, the contacts 433 open deenergizing the relay coil 426 which, after the relay 425 dropped out, was energized over these contacts, the circuit extending from the conductors 369 through the conductor 445, contacts 431a, conductors 447 and 449, coil of relay 426, conductors 451 and 455, contacts 426d, conductor 439, contacts 433, conductor 437, contacts 426c, conductors 453 and 443 to conductor 371.

The coil of relay 427, when energized, seals itself through the contacts 427a, the circuit extending from the conductor 369 through conductor 445, contacts 431a, conductor 447, contacts 427a, conductor 463, coil of relay 427, conductor 443 to the conductor 371.

The circuit breaker has now been closed for the second time and if the fault is still present on the main power line the protective relay 359 is again energized and causes the breaker to move toward open position for a third time.

As the breaker opens for the third time, the contacts 433 are closed and again energize the relay coil 425 over the previously described circuit including the contacts 426e, contacts 433 and the contacts 426f. The previously described electrical instrumentalities now function to cause the breaker to close for a third time. When the relay coil 425 is energized and closes its contacts, the relay coil 426 is again energized in series with relay coil 425 through the previously described circuit which extends from the conductor 369 through the conductor 445, contacts 431a, conductors 447 and 449, coil of relay 426, conductor 451, contacts 425a, conductor 441, coil of relay 425 and conductor 443 to the conductor 371.

The relay coils 425, 426 and 427 at this time are all energized together for the first time and the transfer relay 385 will now be energized from the auxiliary power supply conductors 369 and 371 through the contact members of all three relays. The circuit for energizing the transfer relay coil 385 extends from the conductor 369 through conductors 401 and 435, contacts 427b, conductor 405, contacts 426b, conductor 467, contacts 425b, conductor 469, coil of relay 385, conductor 399 to the conductor 371.

Energization of the transfer relay coil 385 closes two sets of contacts 385b and 385c and open two sets of contacts 385a and 385d. Opening of the contacts 385a opens the circuit for energizing the motor control relay coil 383 and the clutch coil 153. Closing of the contacts 385b establishes a circuit through the automatic reclosing device 418, the circuit extending from the conductor 369 through a conductor 471, auxiliary breaker contacts 473, conductor 475, the contacts 385b, conductor 477, the recloser 418, and conductor 399 to the conductor 371. The functioning of the recloser 418 will be more fully set forth later.

Closing of the contacts 385c sets up a holding circuit for the relay coil 385 to prevent its dropping out when relay coils 425, 426 and 427 are deenergized. This holding circuit may be traced from the conductor 369, through conductors 401 and 479, contacts 481a of a relay 481, a conductor

483, contacts 385c, conductor 485, relay coil 385 and the conductor 399 to the conductor 371. The circuit through the transfer relay coil 385 will thus be maintained until the coil of relay 481 is energized which occurs momentarily as the recloser 418 is automatically reset after completing its functions.

Opening of the contacts 385d opens that part of the source circuit 369—371 which supplies the relays 425, 426 and 427 and causes these relays to drop out. The timing relay 429 was deenergized when the breaker first opened but the coil of the slow dropout relay 431 was kept energized by the intermittent closing and opening of the contacts 429a due to the vibration of the pendulum member 429b. After the time interval for which the member 429b was set has expired, the contacts 429a remains open deenergizing the coil of relay 431 which causes opening of the contacts 431a to complete the resetting of the interlocking relay system.

While the structure disclosed provides for three consecutive instantaneous or fractional stroke reclosures, it is to be understood that by the provision of additional relays in the previously described interlocking relay system, additional quick reclosures may be effected. For illustrative purposes only, the interlocking relay system limits the number of quick fractional stroke reclosures to three.

The automatic recloser 418 may be of any suitable type which, when energized by closure of the auxiliary contacts 473 upon opening of the breaker, effects reclosure of the breaker a predetermined number of times with relatively long time intervals between successive reclosures in the event that the breaker fails to remain closed after its initial reclosure. Such automatic reclosing means are well known in the art and since the electrical circuits and detail construction thereof form no part of the instant invention, the reclosing means has been illustrated in a general manner as indicated at 418 of the circuit diagram (Fig. 7).

If the fault condition persists after the series of quick fractional stroke reclosures described previously, the automatic recloser 418 controls the breaker to make a plurality of time delay reclosures. As stated previously, the automatic recloser 418 receives an initiating impulse by the closing of auxiliary contacts 473 and is energized over the transfer contacts 385b. When so energized, the recloser is adapted to repeatedly close two sets of contacts 418a and 418b with a relatively long time interval between each closure.

Closure of the contacts 418b energizes the motor control relay coil 383 and the coil 153 of the clutch magnet, the circuits being traceable from the source conductor 369 through conductors 401 and 479, the contacts 418b, a conductor 487, conductor 505, contacts 489a of a relay 489, a conductor 491 and the conductor 391, the auxiliary contacts 393 (closed when the breaker is open), the conductor 397, coil of relay 383, and conductor 399 to the conductor 371. Energization of the relay coil 383 closes the contacts 383a and energizes the motor 83. At the same time, a circuit is established through the clutch coil 153 through contacts 393, the conductor 395, the contacts 409, conductor 413, clutch magnet coil 153, conductor 415, contacts 417a, and conductors 419 and 421 to the conductor 371.

Energization of the clutch coil couples the motor, which is now running due to the closure of contacts 383a to the breaker mechanism. The

motor moves the breaker to closed position closing auxiliary contacts 493 which establishes a circuit through the relay coil 489. This causes the contacts 489a to open thus deenergizing the coil of relay 383 and the coil of the clutch magnet 153, disconnecting the motor from the breaker mechanism. The circuit for the coil of relay 489 extends from the conductor 369 through the conductors 401 and 479, contacts 418a, conductors 495 and 497, the coil of relay 489, a conductor 499, auxiliary contacts 493 and conductor 421 to conductor 371. The relay coil 489 seals itself in parallel with contacts 493 through its own contacts 489b and conductor 399 to the conductor 371. The relay 489 therefore prevents the breaker from the so-called "pumping" action. As soon as the breaker is closed and the contacts 473 opened, the recloser 418 causes contacts 418a and 418b to open.

If the breaker remains closed, due to disappearance of the fault on the line, the initiating contacts 473 remain open and the recloser 418 proceeds to a reset position without again closing the contacts 418a and 418b. However, should the fault persist, the protective relay device 359 will again function to trip the breaker. The contacts 473 again close to provide an initiating impulse to the recloser 418, which after a predetermined time delay, again closes the contacts 418a and 418b to effect another reclosing operation in the previously described manner.

Automatic reclosing devices of the type referred to are usually designed to effect a predetermined number of timed reclosures and if the breaker trips open after the last reclosure of the breaker the recloser automatically locks out and the circuit breaker must now be reclosed manually. A manual control switch indicated generally at 501 is provided for this purpose. This switch is arranged, when operated, to complete the circuits from the conductor 369 over a conductor 503, through the several contacts of the switch 501, and conductors 505 and 507 respectively to the motor relay coil 383 and the anti-pumping relay coil 489. Energization of these instrumentalities effect closing of the breaker in the manner previously described.

If the breaker remains closed after any one of the reclosures, the recloser 418 goes to its normal or "start" position. As it approaches the start position, a contact (not shown) therein is momentarily closed by the recloser mechanism to energize the coil of the relay 481 causing this relay to open its contacts 481a. Opening of the contacts 481a opens the holding circuit for the transfer relay coil 385 permitting the relay to drop out, opening the contacts 385b and 385c and closing contacts 385a and 385d. The interlocking relay system, the transfer relay 385 and the automatic recloser 418 are now in their normal positions.

From the foregoing description it will be apparent that by the provision of the multiple break interrupters whereby the circuit is broken at more than two points, the arc is extinguished in a much shorter travel of the breaker operating mechanism and in a much shorter time interval than is required for the conventional double break construction. By shortening the stroke necessary to extinguish the arc and by providing a motor operated closing mechanism which may be connected to the movable contact member at any point in the opening stroke, the circuit may be interrupted, the arc extinguished and the breaker reclosed in a much shorter time interval than has

been possible heretofore in circuit breakers of the double break type.

The circuit breaker is trip free of the operating motor under all conditions by virtue of the clutch mechanism whereby the movable contact member may be disconnected from the closing motor at any point in the closing stroke or from the closed position.

A further advantage resides in the provision of a plurality of quick fractional reclosures, that is, reclosures which are initiated before the movable contact member has reached its full open position. The majority of faults will have disappeared from the transmission line within the time required for one opening and fast reclosure. Two or more fast reclosures prevent undue interruption of the service when a fault or short circuit persists for a longer time than that required for a single reclosure. In addition, there is provided an automatic reclosing device for effecting the reclosing of the breaker a predetermined number of times with a relatively long time interval between successive reclosures in case the circuit breaker fails to remain closed after the series of high speed reclosures.

It is thus apparent that we have provided a circuit breaker which has a simple motor operated closing mechanism, which provides a plurality of series breaks to shorten the arc extinguishing stroke, which automatically effects one or more high speed fractional stroke reclosures, and which is trip free in all positions.

Having described several embodiments of the invention in accordance with the patent statutes, it is to be understood that various changes and modifications may be made in the structural details disclosed without departing from some of the essential features of the invention. It is, therefore, desired that the language of the appended claims be given as reasonably broad interpretation as the prior art permits.

We claim as our invention:

1. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, power operated means operable to move the movable contact members from an open position to a closed position, trip means operable in response to predetermined circuit conditions to cause an opening movement of the movable contact members, means operable during an opening movement of the movable contact members and before said contact members have reached full open position to energize said power operated means and to connect the movable contact members to the power operated means to reclose the breaker, and means operable to disengage said contacts from said power means and thereby effect an opening movement of the contact members irrespective of the energized condition of the power operated means.

2. A circuit breaker comprising relatively movable contact members movable to an open and to a closed position, trip means operable in response to predetermined circuit conditions for causing movement of said contact members to open position, power operated means operable to move the contact members to closed position, said power operated means being normally deenergized and disconnected from said contact members, and means operable during an opening movement of the contact members but before said members have reached full open position to energize said power operated means and to connect said power operated means to the movable contact members, said trip means being operable to cause an open-

ing movement of said movable contact members irrespective of the energized condition of the power operated means.

3. A circuit breaker comprising relatively movable contact members movable to an open position and to a closed position, power operated means operable to move the contact members to closed position, said power operated means being normally disconnected from said contact members, means operable during a movement of the contact members to open position and before said members reach full open position to energize said power operated means and to connect said power operated means to the contact members, and means operable in response to predetermined circuit conditions to effect operation of the connecting means to disconnect the power operated means from the contact members and thereby cause opening of the contact members irrespective of the supply of energy to the power operated means.

4. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, power operated means operable during opening movement of the contact members for initiating movement of said contact members to closed position, means to control the power operated means to initiate a plurality of reclosures several of which reclosures are initiated at least by the time the breaker reaches full open position, and means responsive to predetermined circuit conditions to effect opening movement of the movable contact members irrespective of the supply of energy to the power operated means.

5. A circuit breaker comprising relatively movable contacts for opening and closing an electrical circuit, power operated means for operating said movable contacts to the closed position, means for connecting the contacts to said power operated means, means for controlling the connecting means to effect a predetermined number of reclosures of said contacts several of said reclosures being initiated before the contacts have reached full open position, and means for controlling said connecting means to effect opening movement of the contacts irrespective of the supply of energy to said power operated means.

6. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, power operated means operable during opening movement of the contact members for initiating reclosing movement of said contact members before said members have reached full open position, means for controlling the power operated means to initiate a plurality of reclosing operations of said contact members several of said reclosing operations being initiated before said contact members have reached full open position, and means for effecting opening movement of the contact members irrespective of the flow of energy to said power operated means.

7. A circuit breaker comprising a plurality of pairs of interrupting contacts, relatively movable disconnecting contacts, trip means responsive to predetermined circuit conditions to cause opening movement of all of said contacts, actuating means operable during an opening movement to initiate a reclosing movement after the interrupting contacts have separated but before separation of the disconnecting contacts, means for releasably coupling the actuating means to the breaker, said trip means being operable to effect release of the contacts from the actuating means and cause an opening movement of said contacts

irrespective of the position of the actuating means.

8. A circuit breaker comprising a plurality of pairs of interrupting contacts, relatively movable disconnecting contacts disposed in operative relation with said interrupting contacts, means operable to cause opening of said contacts, actuating means operable to move the interrupting contacts and disconnecting contacts to closed position, coupling means between the actuating means and the disconnecting contacts, and means for controlling said coupling means to initiate reclosing movement of the interrupting contacts after the interrupting contacts have separated but before separation of said disconnecting contacts.

9. A circuit breaker comprising a plurality of pairs of interrupting contacts adapted to interpose a plurality of breaks in the circuit controlled by the breaker, relatively movable disconnecting contacts disposed in operative relation with said pairs of interrupting contacts, means for causing opening movement of said contacts, operating means operable to move the disconnecting contacts to a closed position, coupling means between the operating means and the disconnecting contacts, means to control the coupling means to initiate a closing movement after the interrupting contacts have separated but before separation of the disconnecting contacts, and means for controlling the coupling means to effect an opening movement of the contacts independently of the position or flow of energy to the operating means.

10. A circuit breaker comprising a plurality of pairs of interrupting contacts disposed to form a plurality of breaks in the circuit controlled by the breaker, relatively movable disconnecting contacts disposed in operative relation with said interrupting contacts, operating mechanism for moving said contacts to a closed position, means for causing the operating mechanism to initiate a plurality of reclosure operations each of said reclosure operations being initiated after the interrupting contacts have fully separated but before separation of the disconnecting contacts, means for causing opening movement of said contacts irrespective of the position of the operating mechanism, and means for effecting additional reclosure operations with a relatively long time interval between successive reclosures.

11. A circuit breaker comprising a plurality of interrupting contacts, relatively movable disconnecting contacts disposed in operative relation with said interrupting contacts, and trip means responsive to predetermined circuit conditions to cause opening movement of said contacts, power operated means for moving said contacts to a closed position, coupling means between the power operated means and the disconnecting contacts, means for controlling said coupling means and said power operated means to initiate a plurality of reclosures of said interrupting contacts each of said reclosures being initiated after the interrupting contacts have fully separated but before separation of the disconnecting contacts, said trip means being operable to cause an opening movement of said contacts irrespective of the supply of energy to said power operated means.

12. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, closing means operable during opening movement of the contact members for initiating movement of said contact members to closed position, means to control the closing means to initiate a plurality of reclosures each

following an automatic opening operation several of which reclosures are initiated at least by the time the breaker reaches full open position, and means responsive to predetermined circuit conditions to effect opening movement of the movable contact members irrespective of the energized condition of the closing means.

13. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, a closing means operable during opening movement of the contact members for initiating movement of said contact members to closed position, means to control the closing means to initiate a plurality of reclosures several of which reclosures are initiated at least by the time the breaker reaches full open position, means for releasably connecting the closing means to the movable contact members, and means responsive to predetermined circuit conditions for causing said connecting means to disconnect the contact members from the closing means to effect opening movement of the movable contact members irrespective of the condition of the closing means.

14. A circuit breaker comprising a plurality of pairs of interrupting contacts, relatively movable disconnecting contacts electrically connected in series relation with said pairs of interrupting contacts, trip means operable to cause opening movement of said contacts, power operated means for closing the breaker, means for releasably coupling the power operated means to the breaker, means operable to cause opening of the breaker, means for causing operation of the power operated means and said coupling means to initiate reclosing movement of the breaker after interruption of the circuit by said interrupting contacts and before the disconnecting contacts reach full open position, and means operable in response to predetermined conditions in the circuit to cause the coupling means to uncouple the power operated means from the breaker and thereby cause opening of said breaker irrespective of the condition of the power operated means.

15. A circuit breaker having relatively movable contacts, operating means therefor comprising power operated means for closing the breaker, means for releasably coupling said power operated means to the breaker, means operable to cause opening of said breaker, means operable during an opening operation of the breaker for causing energization of said power operated means and the coupling means to initiate reclosing movement of said breaker at least by the time the breaker reaches full open position, and means operable in response to predetermined circuit conditions to cause the coupling means to release the breaker from the power operated means and thereby cause opening of the breaker irrespective of the condition of the power operated means.

16. A circuit breaker having relatively movable contacts, operating means therefor including power operated means for closing the breaker, means for releasably coupling the power operated means to said breaker, means operable to cause opening of the breaker, means operable during an operation of the breaker for causing energization of the power operated means and said coupling means to initiate reclosing movement of the breaker after interruption of the circuit but before the breaker reaches full open position, and means operable in response to predetermined conditions in the circuit to cause said coupling means to release the breaker from the power operated means and thereby cause opening of the breaker

irrespective of the condition of the power operated means.

17. A circuit breaker having relatively movable contacts, operating means therefor including power operated means for closing the breaker, an electromagnetically controlled means for releasably coupling the power operated means to the breaker, means operable to cause opening of the breaker, means operable during an opening operation of the breaker for first causing energization of the power operated means and for later causing operation of the coupling means to initiate reclosing movement of the breaker at least by the time the breaker reaches full open position, and means operable in response to predetermined conditions in the circuit to cause the coupling means to release the breaker and thereby cause opening of the breaker irrespective of the condition of the power operated means.

18. A circuit breaker having relatively movable contacts, operating means therefor including power operated means, an electromagnetically controlled device and band friction clutch for releasably coupling said motor to the breaker, means operable to cause opening of the breaker, means operable after interruption of the circuit but before the breaker reaches full open position for causing energization of the power operated means and for later causing engagement of the clutch to initiate reclosing movement of the breaker, and means operable in response to predetermined conditions in the circuit to deenergize the clutch and thereby cause opening of the breaker irrespective of the condition of the power operated means.

19. A circuit breaker having a pair of terminal members, current interrupting means comprising two or more pairs of interrupting contacts associated with each terminal member, said pairs of interrupting contacts being biased to open position, and a movable bridging contact member movable to closed position to close said interrupting contacts and complete the circuit and movable to open position to first cause opening of said pairs of interrupting contacts and to then separate from said interrupting means to provide a substantial gap in the circuit, means for causing opening movement of said bridging contact member, power operated means operable during opening operation to initiate reclosing movement of the bridging member immediately after the interrupting contacts have opened but before the bridging member disengages the interrupting means, means for causing operation of the power operated means, and means operable in response to predetermined circuit conditions to effect opening movement of the bridging member irrespective of the condition of the power operated means.

20. A circuit breaker having a pair of terminal members, current interrupting means comprising two or more pairs of interrupting contacts associated with each terminal member, said pairs of interrupting contacts being biased to open position, a movable bridging contact member movable to closed position to close the interrupting contacts and complete the circuit and movable to an open position to first cause opening of said pairs of interrupting contacts and then to separate from said interrupting means to provide a substantial gap in the circuit, power operated means for closing the breaker, means for releasably coupling the power operated means to the breaker, means operable to cause opening movement of the bridging contact member, means for

causing operation of the power operated means and said coupling means to initiate reclosing movement of the bridging member immediately after the interrupting contacts have opened but before the bridging member disengages the interrupting means, and means operable in response to predetermined conditions in the circuit to cause the coupling means to disengage the breaker from the power means and thereby cause opening of the breaker irrespective of the condition of the power operated means.

21. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, power operated means operable during opening movement of the contact members for initiating movement of said contact members to closed position, means to control the power operated means to initiate a plurality of reclosures several of which reclosures are initiated at least by the time the breaker reaches full open position, means responsive to predetermined circuit conditions to effect opening movement of the movable contact members irrespective of the supply of energy to the power operated means, and means for effecting one or more reclosures after the breaker reaches full open position.

22. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, power operated means operable during opening movement of said contact members for initiating movement of said contact members to closed position, means to control the power operated means to initiate a plurality of reclosures several of which reclosures are initiated at least by the time the breaker reaches full open position, and means to control the power operated means to initiate one or more reclosures after the breaker has reached full open position.

23. A circuit breaker comprising relatively movable contacts for opening and closing an electrical circuit, power operated means for operating said movable contacts to the closed position, means for connecting the contacts to the power operated means, means for controlling the connecting means to effect a predetermined number of reclosures of said contacts several of said reclosures being initiated before the contacts have reached full open position, and means for controlling the connecting means to effect one or more reclosures after the contacts reach full open position.

24. A circuit breaker comprising relatively movable contacts for opening and closing an electrical circuit, power operated means for operating said movable contacts to the closed position, means for connecting the contacts to the power operated means, means for controlling the connecting means to effect a predetermined number of reclosures of said contacts several of said reclosures being initiated before the contacts have reached full open position, means for controlling the connecting means to effect one or more reclosures after the contacts reach full open position, and means for providing a time delay between successive reclosures from the full open position.

25. In a circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, power operated means operable during opening movement of the contact members for initiating reclosing movement of said contact members before said contact members have reached full open position, means for controlling said power operated means to initiate

a plurality of reclosing operations of said contact members several of said reclosing operations being initiated before said contact members have reached full open position, several of said reclosing operations being initiated after the contact members have reached full open position, and means for providing a time delay between the reclosures from full open position of the contact members and for finally locking said contact members in full open position.

26. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, closing means operable during opening movement of said contact members for initiating movement of said contact members to closed position, means for controlling the closing means to initiate a plurality of reclosures each following an automatic opening operation several of which reclosures are initiated at least by the time the contact members reach full open position, means for causing said closing means to initiate one or more reclosures after the contact members reach full open position, and

a timing device for delaying said reclosures from the full open position of said contact members.

27. A circuit breaker comprising relatively movable contact members for opening and closing an electrical circuit, closing means operable during opening movement of said contact members for initiating movement of said contact members to closed position, means for controlling the closing means to initiate a plurality of reclosures each following an automatic opening operation several of which reclosures are initiated at least by the time the contact members reach full open position, means for causing said closing means to initiate one or more reclosures after the contact members reach full open position, and a timing device for delaying said reclosures from the full open position of said contact members, said timing device being operable to lock said contact members in full open position following the last full stroke reclosure.

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