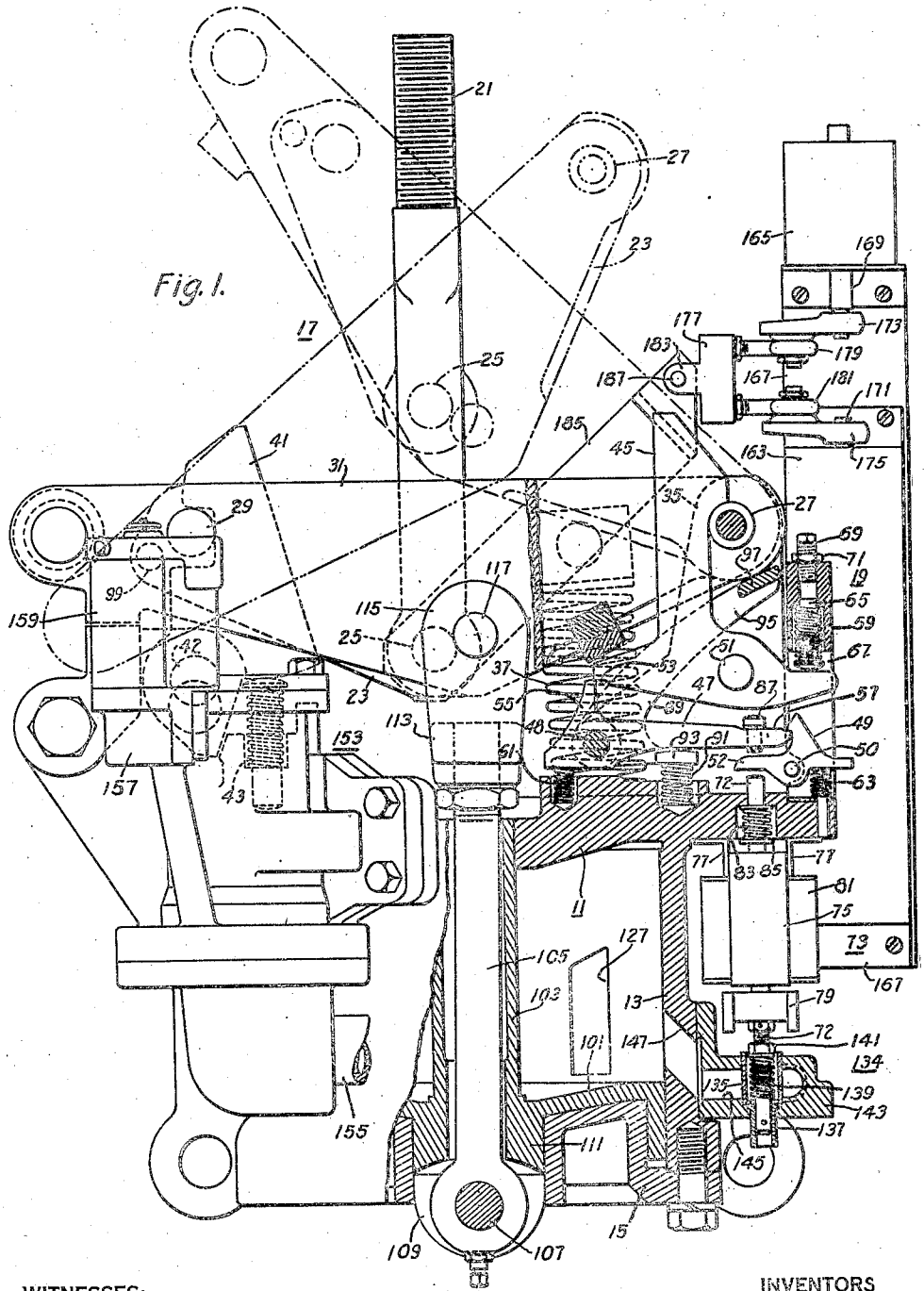
July 2, 1946. A. W. HILL ET AL 2,403,082

CIRCUIT BREAKER

Filed April 4, 1942 3 Sheets-Sheet 1

Fig. 1.



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CIRCUIT BREAKER

Filed April 4, 1942 3 Sheets-Sheet 2

Fig. 2.

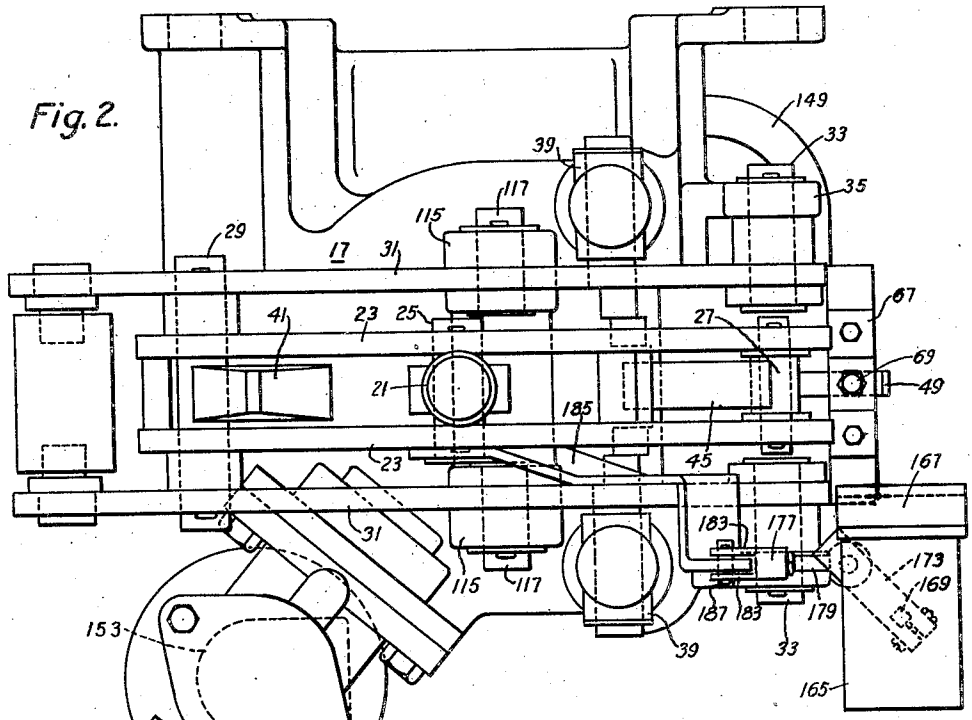


Fig. 3.

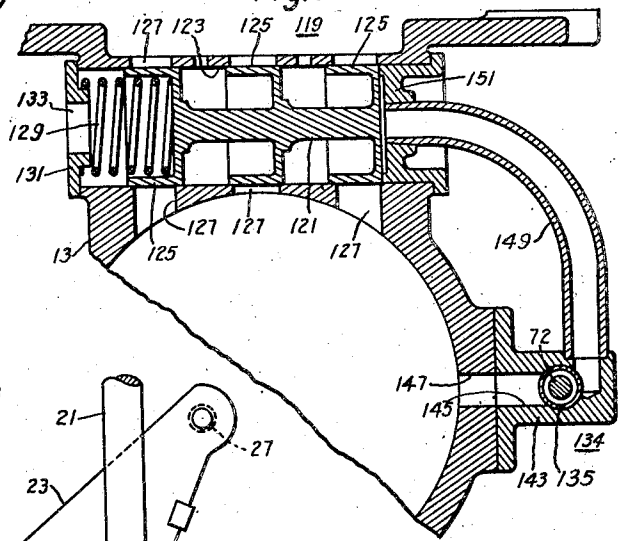


Fig. 4.

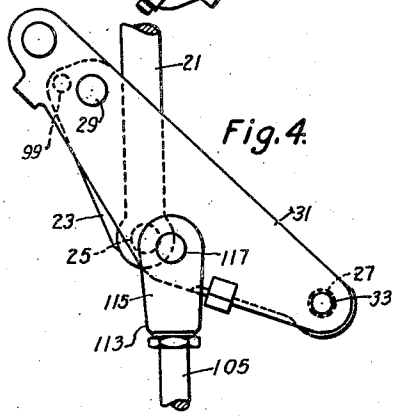
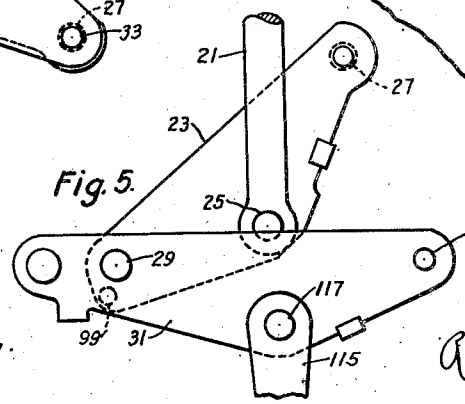


Fig. 5.



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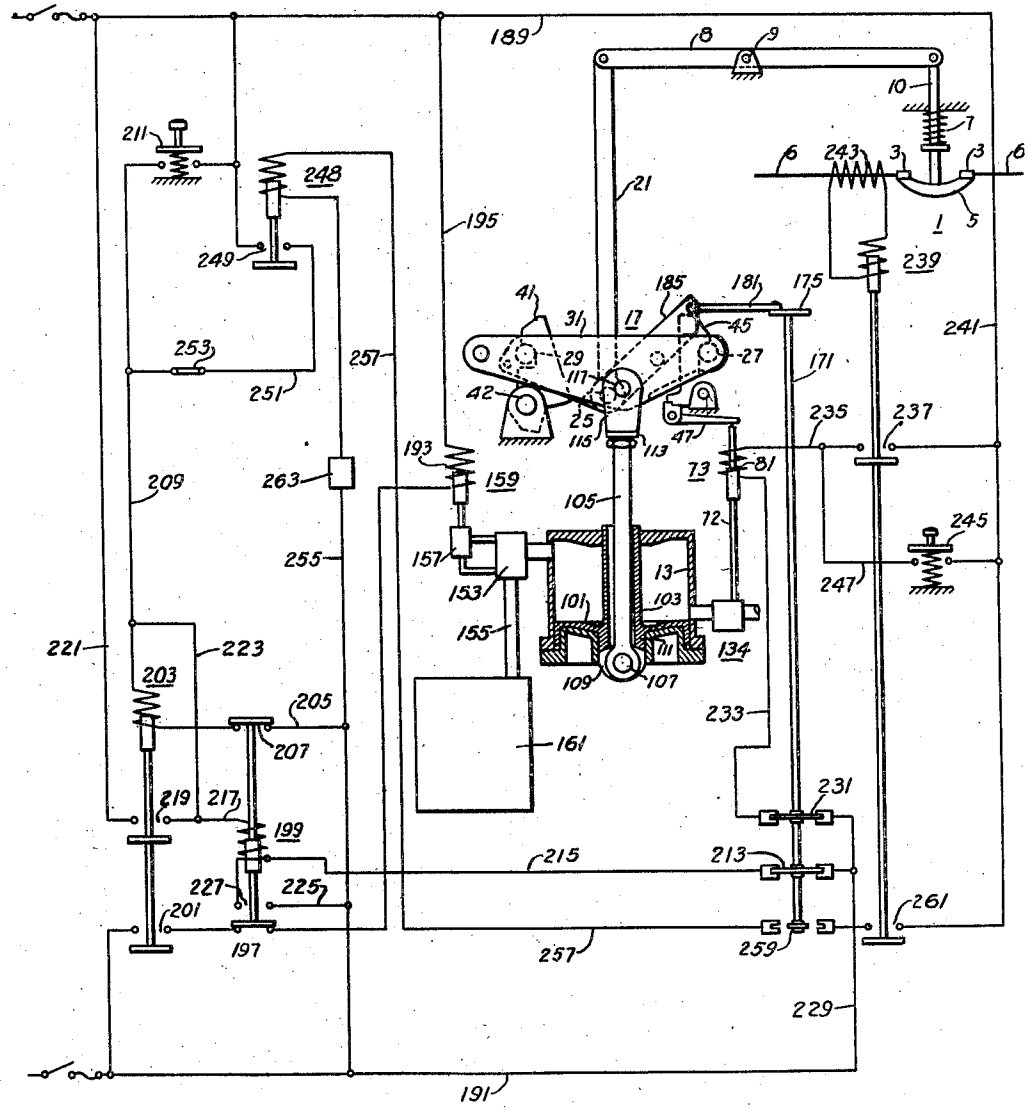
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CIRCUIT BREAKER

Filed April 4, 1942 3 Sheets-Sheet 3

Fig. 6.



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Patented July 2, 1946 2,403,082

UNITED STATES PATENT OFFICE

2,403,082

CIRCUIT BREAKER

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Application April 4, 1942, Serial No. 437,669

20 Claims. (Cl. 200—82)

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This invention relates to circuit breakers, and more particularly to high speed circuit breaker operating mechanisms of the fluid pressure operated type.

An object of the invention is the provision of an improved fluid pressure operated circuit breaker operating mechanism which is mechanically trip free and capable of effecting high speed opening and reclosing of the circuit breaker.

Another object of the invention is to provide a circuit breaker operating mechanism operable by fluid pressure to close the breaker and embodying an improved pressure exhaust valve construction for the operating cylinder which permits quick retrieving and relatching of the closing means with the breaker following an opening movement of the breaker.

Another object of the invention is to provide a circuit breaker operating mechanism operable by fluid pressure wherein the breaker is releasably connected to the operating mechanism by means of an improved high speed, light load latching mechanism comprising a series of latches arranged to occupy a minimum amount of space.

Another object of the invention is to provide a circuit breaker having an operating mechanism operable by fluid pressure to close the breaker, wherein the breaker is trip free of the operating mechanism and the mechanism embodies an improved automatic pressure exhaust valve construction which permits high speed retrieving and relatching of the operating mechanism with the breaker.

Another object of the invention is to provide a circuit breaker having an operating mechanism operable by fluid pressure embodying an improved high speed latch mechanism for releasably connecting the operating mechanism to the breaker, an improved high speed exhaust valve construction for quickly exhausting the fluid pressure from the operating mechanism to permit high speed retrieving and relatching of the operating mechanism to the breaker and electroresponsive means for simultaneously operating the trip mechanism and the exhaust valve.

Another object of the invention is to provide a circuit breaker having an improved operating mechanism operable by fluid pressure to close the breaker, the operating mechanism being connected to the breaker by means of a trip free mechanism and embodying an improved latch means for releasably connecting the breaker to the operating mechanism, an electroresponsive trip device for causing high speed unlatching and a novel high speed exhaust valve construction

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operable by the trip device for quickly exhausting the air pressure to permit quick retrieving and relatching of the operating mechanism to the breaker.

Another object of the invention is to provide an improved automatic reclosing circuit breaker having a fluid motor operating mechanism including a releasable coupling providing a trip-free connection between the motor and the breaker, the mechanism being automatically operable to initiate a 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 to provide an improved automatic reclosing circuit breaker embodying an operating mechanism operable by fluid pressure having a trip-free connection between the operating mechanism and the breaker and having an improved fluid pressure exhaust means controlled by the breaker tripping means to permit quick reconnection of the operating mechanism to the breaker before the breaker reaches full open position.

Another object of the invention is to provide an improved circuit breaker operating mechanism of the pneumatic type, which is simple, reliable in operation and inexpensive to manufacture.

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 detailed description of a single embodiment thereof when read in conjunction with the accompanying drawings, in which:

Figure 1 is a view partly in side elevation and partly in section of a circuit breaker operating mechanism embodying the principles of the invention,

Fig. 2 is a plan view of the mechanism showing the latching means and the trip-free lever system of the mechanism,

Fig. 3 is a fragmentary horizontal sectional view through the operating cylinder and the dump valve therefor,

Figs. 4 and 5 are side elevational views of a portion of the operating mechanism shown in Fig. 1 illustrating different positions of the levers of the mechanism,

Fig. 6 is a wiring diagram of the circuits for controlling opening and closing of the breaker,

the operating mechanism and the circuit breaker being illustrated diagrammatically.

Referring to the drawings, the circuit breaker 1 shown schematically in Fig. 6, may be of any conventional construction either of the oil break, air break or gas blast type. The circuit breaker, as shown comprises stationary contact means 3 and cooperating movable contact means 5 for controlling a main circuit shown diagrammatically by a single line 6. While the circuit breaker is illustrated as comprising a single pole, it is to be understood that the circuit breaker may be of the multi-pole type provided with a set of contact means 3—5 for each pole with the movable contacts mechanically connected for simultaneous operation in the conventional manner. The circuit breaker is biased to open position by means of an accelerating spring 7 shown schematically (Fig. 6), and the breaker is mechanically connected to the operating mechanism by connecting means represented schematically as comprising a lever 8 pivoted at 9 on a fixed support. One end of the lever 8 is pivotally connected to the breaker lift rod 10 and the other end is pivotally connected to the breaker operating rod 21 which, in turn, is mechanically connected to a lever of the mechanism.

Referring now to Fig. 1 of the drawings, the circuit breaker operating mechanism comprises generally a main casting 11 which forms an operating cylinder 13 having its lower end closed by a closure 15 secured to the main casting 11. Operating levers indicated generally at 17 are mounted on the upper portion of the casting 11 and are retained in closed circuit position by means of a latching mechanism 19 and a latch 41.

The circuit breaker is normally biased to an open circuit position by the accelerating spring 7 and is connected by means of the operating rod 21 to an inner lever 23 of the levers indicated generally at 17, through the agency of a pivot pin 25 (Fig. 2). The lever 23 carries a latching roller 27 rotatably mounted in one end thereof and adapted to be engaged by the latching mechanism 19 to releasably retain the circuit breaker in closed circuit position.

The lever 23 is pivotally supported at its left-hand end (Figs. 1, 2, 4 and 5) on a pivot pin 29 mounted in an outer lever 31 which is pivotally mounted at its opposite end on the casting 11 by means of a pair of pivot pins 33 (Fig. 2) supported in projections 35 (Fig. 2) extending upwardly from the main casting. Each of the levers 23 and 31 comprise a pair of levers and each pair is suitably secured together for unitary movement.

In the closed circuit position, indicated by the full lines in Fig. 1, the outer lever 31 is biased clockwise by means of a pair of retrieving springs 37, one end of each of which springs is securely attached to its corresponding lever 31 by means of a bracket 39 (Fig. 2), while the other ends of said springs abut against the upper face of the casting 11. The lever 31 is normally prevented from clockwise rotation about its pivot 33 by means of a latch 41 pivotally mounted on pivot pin 42 supported on the casting 11 and biased by a spring 43 into latching engagement with the pin 29 which pivotally connects the levers 23 and 31.

The latch mechanism 19, as previously stated normally restrains the circuit breaker mechanism in closed contact position against the opening force of the accelerating spring 7 (Fig. 6).

The latch mechanism 19 is adapted to be operated in response to predetermined conditions in the circuit controlled by the breaker to release the inner lever 23 (Fig. 1) and thereby permit opening of the circuit breaker.

The latch mechanism 19 includes a main latch member 45 (Figs. 1, 2 and 6), an intermediate latch 47 supported on a pivot pin 48 and which releasably restrains the main latch in latching position, and a trigger latch 49 supported on a pivot pin 50 for releasably restraining the intermediate latch in latching position. The main latch 45 is pivotally supported on a pivot pin 51 and has a latching surface 53 with which a latching projection 55 of the intermediate latch 47 cooperates to restrain the main latch in latching position. The latch pivots 48, 50 and 51 are supported in the projections 35 of the main casting (Figs. 1 and 2). A latch projection 57 of the intermediate latch 47 is adapted to be engaged by the trigger latch 49 to restrain the intermediate latch in latching position. Springs 59, 61 and 63 respectively bias the latches 45, 47 and 49 in latching direction. The spring 59 surrounds a headed rod 65 slidable vertically in a bracket 67 secured to the casting 11, the spring 59 being compressed between the head of the rod 65 and a spring seat in the bracket 67. The spring 61 is compressed between a spring seat in the casting 11 and a projection of the latch 47, and the spring 63 is compressed between the lower portion of the bracket 67 and the trigger latch 49. In order to conserve space the latch members 45, 47 and 49 are mounted in the same plane and are disposed substantially parallel to each other in nested relationship.

The unlatching movement of the main latch 45 is adjustably limited by means of an adjusting screw 69 in the upper end of the bracket 67. A lock nut 71 is provided to lock the screw 69 in its adjusted position. By limiting the inward movement of the spring pressed rod 65, the unlatching movement of the main latch 45 is limited so that there is but very slight overtravel in unlatching direction.

The shape of the latch face of the main latch 45 which engages the roller 27 is such that the force exerted thereon by the roller 27 tends to rotate the main latch in unlatching direction and consequently the latch 45 by itself does not serve to hold the breaker mechanism in closed position. Obviously the latch 45 could be constructed so that it alone would hold the circuit breaker in closed position, however, if the latch were so constructed the force required to trip the breaker would necessitate an undesirably large and powerful trip device. It is to reduce the latch load at the ultimate tripping point and to increase the speed of unlatching that the intermediate latch 47 and the trigger latch 49 are provided.

The angle of the latch surface 53 of the main latch 45 and of the engaging projection 55 of the intermediate latch 47 is such that the latch 47 will not by itself serve to hold the main latch in latching position against the force tending to open the breaker. The trigger latch 49 normally engages the end of the long latching arm 57 of the latch 47, which extends directly beneath the latch 45, to restrain the intermediate latch in its latching position. The load applied to the trigger latch 49 by the intermediate latch 47 is but a very small fraction of the force applied to the latch 45 by the breaker accelerating spring 7 (Fig. 6) through the lever 23 and the latch roller 27. The trigger latch 49 is provided with

an arm which extends beneath the arm 57 of the latch 47 and is disposed directly above and in the path of travel of a trip rod 72 of a trip device 73.

The trip device 73 in addition to the trip rod 72 comprises a magnet core 75 of magnetic material attached to the casting 11 by means of brackets 77, a movable armature 79 and an energizing coil 81. The magnet core 75 is E-shape and the coil 81 is mounted on the center leg thereof. The trip rod 72 is secured to the center portion of the armature 79 and extends vertically through an opening in the magnet core and through a guide opening in a horizontally extending portion of the casting 11. The armature 79 and the trip rod 72 are biased downwardly by means of a spring 83 surrounding the upper end of the trip rod 72 and compressed between a collar 85 secured on the rod 72 and the bottom of a counterbore in the casting 11.

When the trip device 72 is energized, the armature 79 is moved upwardly against the core 75 moving the trip rod 72 upwardly therewith. This upward movement of the trip rod causes its upper end to engage the arm 52 and rock the trigger latch 49 clockwise and disengage the arm 57 of the intermediate latch 47. The trip rod 72 is given a slight overthrow which causes the arm 52 to engage an adjustable screw 87 in the arm 57 to accelerate the unlatching movement of the intermediate latch 47. This accelerating force together with the force applied by the angular cam face 53 of the main latch 45 to the projection 55 of the intermediate latch 47 causes the latch to immediately release the main latch 45. The accelerating spring for the circuit breaker now moves the breaker to open circuit position, the upward movement of the rod 21 (Fig. 1) occasioned by the opening movement of the breaker rotating the operating lever 23 counterclockwise about its pivot 29. As the operating lever 23 starts its counterclockwise travel the roller 27 forces the main latch 45 in a counterclockwise direction. As the roller 27 clears the main latch 45 the spring 59 immediately acts to restore the latch to its latching position. In order to prevent the intermediate latch 47 from prematurely returning to its latching position, a holding lever 89 is provided. This lever is pivoted on the pin 48 and is biased in a counterclockwise direction by means of a spring 91 compressed between a spring seat in the casting 11 and one arm 93 of the lever 89, which arm extends beneath the latch 47 and across the plane of movement thereof. The other arm 95 of the holding lever 89 is provided with a projection 97 which is biased counterclockwise into contact with the end of the lever 23. This restrains the holding lever in inoperative position when the lever 23 is in closed circuit position. When the operating lever 23 is released and rotates toward its open position, the spring 91 acts to rotate the holding lever 89 counterclockwise and, since the spring 91 is stronger than the latch spring 61, the arm 93 engages the latch 47 and holds it in unlatched position until the roller end of the lever 23 is returned to latching position. During the retrieving movement of the operating lever 23, the roller 27 engages and rotates the main latch 45 counterclockwise. As the lever 23 arrives at its retrieved latching position, the spring 59 rotates the latch 45 to latching engagement with the roller 27 and at the same time the end of the operating lever 23 engages and rotates the holding lever 89 clockwise to its ineffective position. This permits the spring 61 to restore the intermediate latch 47 to its latching position where it is engaged by the trigger latch 49 and restrained in latching position.

During the initial portion of the movement of the operating lever 23 toward the open position shown in dotted lines in Fig. 1 and also shown in Fig. 5, a projection 99 thereon engages the body portion of the latch 41 and rotates said latch clockwise to release the pin 29. When the latch 41 releases the pin 29, the retrieving springs 37 expand and rotate the lever 31 clockwise about its fixed pivot 33. This clockwise movement of the lever 31 causes the breaker lever 23 to be rotated in a clockwise direction about the pivot 25 toward the position shown in Fig. 4 wherein the latching roller 27 is in its latching position in axial alignment with the pivot pin 33 for the lever 31.

The operating levers 23 and 31 now both occupy the positions shown in Fig. 4 and the circuit breaker is in the open circuit position ready to be closed. In order to close the circuit breaker there is provided a piston 101 reciprocably movable within the operating cylinder 13. The piston 101 is provided with a central hollow cylindrical tube 103 which is slidable in a central opening in the casting 11. A connecting rod 105, extending axially through the tube 103, is pivotally connected to the piston 101 by a pin 107 extending through an opening in the rod 105 and through openings in spaced ears 109 (only one being shown) on a projection 111 extending downwardly from the bottom of the piston 101 and slidably fitting within an opening in the bottom closure 15.

The upper end of the connecting rod 105 is threadedly connected to a yoke 113 having spaced arms 115 which are pivotally connected to the sides of the outer lever 31 by pivot pins 117. In this manner the piston 101 is operatively connected to the breaker operating rod 21 through the agency of the trip-free operating levers 23 and 31.

When, as previously described, the latch 41 is operated to release the lever 31 and the springs 37 act to move the lever 31 to the Fig. 4 position, the piston 101 is moved upwardly toward the top of the cylinder 13. In order to permit quick and unretarded upward movement of the piston 101, the cylinder is provided with an improved exhaust valve indicated generally at 119 (Fig. 3) which is operated under the control of the trip device 73 to cause quick collapse of the fluid pressure in the cylinder 13 above the operating piston. The exhaust valve 119 comprises a multiple valve member 121 (Fig. 3) slidable in a valve cylinder 123 formed integral with the main casting 11. A plurality of piston valves 125 formed integral with the valve member 121 cooperate with a plurality of exhaust ports 127 extending through the wall of the operating cylinder 13 and through the outer wall of the exhaust valve cylinder 123 to the atmosphere. The exhaust ports, however, are normally closed by the piston valves 125. The valve member 121 is biased to closed position in which the piston valves 125 close their respective exhaust ports 127, by means of a compression spring 129 disposed in one end of the valve cylinder 123. One end of the spring 129 bears against the left-hand end of the valve member 121 and the other end of the spring bears against a plate 131 which forms the closure for the left-hand end of the valve cylinder 123. The plate 131 is provided with an opening 133 to prevent trapping of the fluid between the plate 131

and the left-hand piston valve 125 upon operation of the valve member 121.

The purpose of the multiple piston valve and multiple exhaust port construction is to provide a substantially instantaneous exhaustion of the fluid pressure in the operating cylinder 13 whenever the trip device 73 is operated and to thus prevent fluid pressure in the cylinder above the operating piston from retarding upward movement of the piston 101 and of the operating lever 31. The construction thus permits high speed retrieving operation of the levers 31 and 23, and the strength of the retrieving springs is preferably such that the breaker lever 23 is retrieved to its latching position before the breaker reaches full open position or at least by the time the breaker reaches full open position. This permits a substantially instantaneous reclosure of the breaker. It can be seen that these exhaust valves moving a given distance will uncover three times the exhaust port area as would a single valve traveling the same distance, and they thus dump the fluid pressure in a much shorter time.

A pilot valve, indicated generally at 134 (Figs. 1 and 3) is operated by the trip device 73 to start the exhaust valve member 121 in opening direction, the valve member 121 being moved to full open position by the fluid pressure from the main operating cylinder 13.

The pilot valve comprises a cylindrical cup-shaped valve member 135 biased against a flanged collar 137 secured to the lower end of the trip rod 72, by means of a spring 139. One end of the spring 139 bears against the valve member 135 and the other end of the spring bears against the bottom of a nut 141 on the trip rod 72. The pilot valve 135 is slidable in a pilot valve housing 143 and the flange of the collar 137 is seated against a shoulder formed in the opening in the housing 143 which receives the valve 135. The pilot valve is disposed in an air passage 145 in the housing 143 and this passage on one side of the valve 135 communicates with the main operating cylinder 13 by means of a port 147 formed in the casting 11. From the other side of the pilot valve 135, the air passage 145 communicates with the exhaust cylinder 123 through the agency of a tube 149 (Fig. 3) having one end connected to the valve housing 143 and the other end connected to an end closure member 151 in the valve cylinder 123.

When the trip device 73 is energized and the trip rod moves upwardly to operate the latch mechanism 19, the pilot valve 135 is raised therewith by means of the collar 137, opening the passage 145 and admitting air pressure through the tube 149 (Fig. 3) to the end of the cylinder 123. At the same time, the retrieving springs 37 (Fig. 1) acting on the lever 31 move the piston 101 upwardly and the rush of compressed air through the passages 147 and 145 forces the pilot valve 135 upwardly compressing the spring 139 and opening the valve a greater extent. The compressed air admitted through the passages 147, 145 and 149 starts the exhaust valve toward the left in opening direction. As soon as the exhaust valves 125 are open a small distance the air pressure passing over the right-hand sides of the exhaust valves 125 forces the exhaust valves toward the left to fully open position and maintains them in this position until the rising piston 101 closes the exhaust ports 127, whereupon the spring 129 reacts to close the exhaust valve. The air pressure on the bottom of the pilot valve 135 maintains this valve in open position against the force

of the spring 139 until the air pressure falls to a point where the spring 139 acts to close the pilot valve.

The exhaust ports 127 are located in the side wall of the operating cylinder 13 at a point intermediate the end positions of the operating piston 101 so that these ports will be closed by the piston 101 after the breaker has opened a distance sufficient to interrupt the circuit and before the operating piston reaches the position in its upward travel at which compressed air is admitted for a quick automatic reclosing operation. This arrangement prevents dumping of the quick reclosing air pressure and also allows a time interval during which the main exhaust valve member 121 is moved to close the exhaust ports 127. The quick dumping of the air pressure in the main operating cylinder permits a fast retrieving movement of the piston 101 and of the lever 31. It will thus be seen that the rapid upward movement of the piston 101 permits relatching of the circuit breaker mechanism with the operating piston before the breaker is fully open or at least by the time the breaker reaches full open position and thus provides for a quick reclosure.

A pair of auxiliary switch devices 163 and 165 (Fig. 1) is mounted on a bracket 167 secured to the main casting 11. Each of the auxiliary switch devices is of conventional design and comprises a multi-pole auxiliary switch wherein the individual switch members are adjustable relative to their operating shafts 169 and 171, respectively. By this means the auxiliary switches may be adjusted to operate at predetermined points in the operation of the main circuit breaker. The operating shafts 169 and 171 have secured, respectively, thereto, crank arms 173 and 175 which are pivotally connected to a yoke member 177 by means of links 179 and 181. The yoke member 177 is provided with a pair of ears 183, and one end of a link 185 is connected thereto by means of a pivot pin 187. The link 185 is formed substantially as shown in Fig. 2 and has its other end connected to the pin 25 which connects the circuit breaker operating rod 21 to the operating lever 23. Thus the auxiliary switch devices 163 and 165 are operated in accordance with the movement of the circuit breaker 1.

Referring to the circuit diagram (Fig. 6) which diagrammatically illustrates the circuits for controlling an inlet valve electromagnet 159 and the trip device 73, a pair of supply conductors 189 and 191 are connected to a source of electric energy (not shown). The winding 193 of the electromagnet 159 which controls the admission of compressed air to the upper end of the operating cylinder for closing the circuit breaker is connected in an energizing circuit 195 extending from the supply conductor 189, through the winding 193, through contacts 197 of a release relay 199, through contacts 201 of an operating relay 203 to the supply conductor 191. The energizing winding of the operating relay 203 is connected in an energizing circuit extending from the supply conductor 191, through a conductor 205, back contacts 207 of the release relay 199, winding of the operating relay 203, a conductor 209 and through a manual control switch 211 to the supply conductor 189. The winding of the release relay 199 is connected in an energizing circuit extending from the supply conductor 191, through an auxiliary switch 213 which is adapted to be closed when the circuit breaker reaches closed position, a conductor 215, winding of the release relay 199, conductor 217, contacts 219 of the op-

erating relay 203 and through a conductor 221 to the supply conductor 189.

A stick circuit is provided for maintaining the operating relay 203 energized after a momentary operation of the manual closing switch 211. This circuit extends from the supply conductor 191, through the conductor 205 and contacts 207 of the release relay 199, winding of the relay 203, through a conductor 223, conductor 217, contacts 219 of the relay 203 and the conductor 221 to the supply conductor 189. A holding circuit is provided for maintaining the release relay 199 energized until the manual closing switch 211 is opened. This holding circuit extends from the supply conductor 191, a conductor 225, contacts 227 of the relay 199, the winding of the relay 199, conductor 223, conductor 209 and the manual closing switch 211 to the supply conductor 189.

The winding 81 of the trip device 73 is connected in an energizing circuit extending from the supply conductor 191 through a conductor 229, through an auxiliary switch 231 which is closed when the circuit breaker is closed, a conductor 233, winding 81 of the trip device 73, a conductor 235 and contacts 237 of a fault responsive relay 239, through a conductor 241 to the supply conductor 189. The fault responsive relay 239 is adapted to be operated to close its contacts upon the occurrence of an overload of predetermined magnitude, such, for example, as a short circuit in the main circuit 6 controlled by the circuit breaker 1. For this purpose, the winding of the protective or fault relay 239 is energized by a current transformer 243 associated with the circuit 6.

When a predetermined overload condition or a short circuit occurs in the main circuit 6, the fault responsive relay 239 is energized sufficiently to close its contacts 237, thus causing energization of the trip device 73. When the trip device is energized, it causes operation of the latching mechanism 19 (Fig. 1) to release the operating lever 23, whereupon the circuit breaker is quickly moved to open position in the previously described manner.

The circuit breaker may also be tripped open manually by means of a manually operable switch 245 (Fig. 6) connected in series with a conductor 247 which is arranged to shunt the contacts 237 of the fault relay 239.

The circuit breaker is adapted to be automatically reclosed immediately following interruption of the circuit, through the agency of a reclosing relay 248. The contacts 249 of the reclosing relay are connected by means of a conductor 251 in shunt relation with the contacts of the manual closing switch 211. In order to prevent quick automatic reclosing operation of the breaker when such operation is not desired, a manually operable switch 253 is connected in the conductor 251. The winding of the reclosing relay 248 is connected in a circuit extending from the supply conductor 191 through a conductor 255, the winding of relay 248, a conductor 257, through an adjustable auxiliary switch 259 which is adjusted to close during the initial opening movement of the circuit breaker, through contacts 261 of the fault relay 239 and conductor 241 to the source conductor 189.

Assuming that the circuit breaker is in the closed position as shown in Figs. 1 and 6, the operation of the mechanism is as follows: When a predetermined overload or short circuit occurs in the main circuit 6, the fault relay 239 is immediately energized and closes its contacts 237 thereby effecting energization of the trip device 73. As previously described energization of the trip device causes operation of the latch mechanism 19 (Fig. 1) to release the breaker operating lever 23. The circuit breaker is immediately moved toward its open position by the accelerating spring 7 (Fig. 6). As the operating lever 23 rotates counterclockwise about the pivot 29, the projection 99 thereon operates the latch 41 to release the lever 31. The operation of the trip device 73 also operates the pilot valve 134 causing the main exhaust valve to be opened and quickly exhaust any pressure that may be in the operating cylinder. When the latch 41 is operated, releasing the lever 31, the retrieving springs 37 (Fig. 1) act to quickly rotate the lever 31 clockwise about the fixed pivots 33. Since the three exhaust ports 127 are open the piston 101 moves upwardly at a rate of speed higher than the speed of opening movement of the breaker operating rod 21. Consequently the clockwise rotation of the operating lever 31 carries the pivot pin 29 therewith and causes rotation of the lever 23 in a clockwise direction about the pivot 25. This results in reengaging roller 27 with the latch 45 before or at least by the time the circuit breaker reaches full open position.

Assuming that the switch 253 is closed, a quick reclosure of the breaker will occur as soon as the operating lever 23 is relatched by the latch member 45, which occurs after the circuit is interrupted but before or by the time the breaker reaches full open position. Quick automatic reclosing of the circuit breaker is effected by the reclosing relay 248 which is energized by the closing of the contacts 261 (Fig. 6) by the fault relay and the closing of the auxiliary switch 259. The contacts 261 are closed simultaneously with the contacts 237 by the fault relay upon the occurrence of an overload or short circuit and immediately prepare the energizing circuit for the reclosing relay 248. The auxiliary switch 259 closes during the initial opening movement of the circuit breaker and completes the circuit for the reclosing relay 248. The relay 248 thereupon closes its contacts 249 completing the previously described circuit for the operating relay 203 which instantly closes its contacts 219 and 201. Closing of the contacts 201 completes the circuit for energizing the electromagnet 159 through the back contacts 197 of the release relay 199. Energization of the electromagnet 159 opens the pilot valve 157 which, in turn, causes opening of the main inlet valve 153. The inlet valve is connected by a pipe 155 to a source of compressed air 161, and upon opening of the inlet valve compressed air is admitted to the upper end of the operating cylinder 13 quickly moving the operating piston 101 downwardly. Since the operating lever 23 is now reengaged with the latch, the downward movement of the piston 101 is communicated by means of the operating levers 23—31 to close the circuit breaker. These operations occur substantially instantaneously so that the reclosing movement of the operating piston is initiated immediately after the circuit has been interrupter and before or at least by the time the breaker reaches full open position.

Closing of the contacts 219 of the operating relay 203 prepares the previously described circuit for the release relay 199. As soon as the circuit breaker reaches closed position, the auxiliary switch 213 completes the circuit for the release relay 199 which immediately operates to open its back contacts 197 and 207 and close its front

contacts 227. The opening of the contacts 197 effects the deenergization of the electromagnet 159 which controls the inlet valve and thereby closes the inlet valve and interrupts the supply of compressed air to the operating cylinder 13. Opening of the contacts 207 causes deenergization of the operating relay 203. Since the contacts 249 of the reclosing relay 248 open before the breaker reaches closed position, the closing of the contacts 227 have no effect during quick automatic reclosing operations.

If the condition which caused the overload or short circuit has been removed by the time the circuit breaker completes the circuit upon a quick automatic reclosing operation, the breaker remains closed and the control circuits return to normal condition as shown in Fig. 6. However, if the fault condition is still present at the time the main circuit 6 is completed by the contacts 3—5 of the circuit breaker during a quick reclosing operation, the fault relay 239 is again energized and causes energization of the trip device 73. Consequently the trip device is again operated and operates the latch mechanism 19 and thereby disconnects the operating lever 23 from the operating piston 101. The accelerating spring 7 immediately moves the breaker toward open position. At the same time, the trip device 73 operates the pilot valve 134, thereby causing the closing air pressure in the operating cylinder to open the main exhaust valves 125 and quickly cause collapse of the air pressure in the operating cylinder, even though the inlet valve 153 may still be open at this time.

A lockout device 263 of any suitable design may be provided in the circuit of the reclosing relay 248 to prevent more than one quick automatic reclosing operation of the circuit breaker, or to open the quick reclosing circuit and transfer the control of the reclosing relay to a time delay reclosing device in a manner well known in the art.

If the lockout device 263 is constructed to provide for only one quick automatic reclosure of the circuit breaker, the breaker goes to its full open position and remains open after one quick reclosure. In this condition of the breaker the operating rod 21 and the operating levers 23 and 31 will assume the position shown in Fig. 4 with the operating piston 101 (Fig. 1) in its upper position in readiness for a normal closing operation.

In order to effect a normal closing operation of the circuit breaker from the full open position, the manual control switch 211 is closed. This completes a circuit for the operating relay 203 which, when energized, closes its contacts 201 and 219. Closing of the contacts 201 completes the circuit for energizing the inlet valve controlling electromagnet 193 which causes compressed air to be admitted to the operating cylinder to close the breaker. Closing of the contacts 219 prepares the circuit for energizing the release relay 199, this circuit being completed by the auxiliary switch 213 when the circuit breaker reaches the fully closed position. The manual closing switch 211 need be closed for only an instant since closure of the contacts 219 completes the previously described holding circuit for maintaining the operating relay 203 energized until the release relay 199 operates. When the release relay 198 is energized, it opens the contacts 197 and 207 thereby deenergizing the inlet valve control magnet 159 and also deenergizes the operating relay 203 and prevents energization of the operating relay as long as the contacts 207 remain open. The operation of the release relay 199 also closes the contacts 227 to complete the holding circuit for maintaining the release relay 199 energized as long as the manual switch 211 is held closed, thus preventing the circuit breaker from pumping should the breaker fail to remain closed and the manual switch 211 is held in closed position. If the circuit breaker should be closed against an overload or short circuit during a normal closing operation, the trip device 73 will be operated to release the latch 45 and exhaust the air in the cylinder so that the breaker will be immediately opened in the previously described manner.

The circuit breaker may be manually tripped open by closing the manual trip switch 245 which causes energization of the trip device 73.

The circuit breaker is trip free of the operating mechanism in all positions, that is, if a fault occurs during the closing movement, the trip device 73 will be immediately energized to disconnect the breaker mechanism from the operating mechanism and permit the accelerating spring 7 to immediately operate the breaker to open position irrespective of the closing air pressure in the operating cylinder 13.

The circuit breaker may be closed manually by any suitable manually operable closing device which may be attached to the free end of the outer operating lines 31.

Having described one embodiment of the invention in accordance with the patent statutes, it is to be understood that various changes and modifications may be made in the particular embodiment disclosed without departing from some of the essential features of the invention. It is desired, therefore, 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 high speed operating mechanism for a circuit breaker comprising a motor operable by gas under pressure to close the breaker, a source of gas under pressure, an inlet valve for admitting gas under pressure to said motor to close the breaker, latch means for releasably connecting the motor to the circuit breaker, means for quickly reducing the gas pressure in the motor, means for automatically reconnecting the motor to the circuit breaker, and electroresponsive means for operating the latch means and simultaneously initiating operation of the pressure reducing means.

2. An operating mechanism for a circuit breaker comprising a fluid motor, a source of gas under pressure, an inlet valve for admitting gas under pressure to said motor to operate the breaker to closed position, a latch mechanism operable to disconnect the breaker from said motor to permit operation of the breaker to open position, compressed gas operated means to quickly reduce the gas pressure in the motor to permit quick reversal of the motor, means for automatically causing relatching of the motor to the breaker, and electroresponsive means for simultaneously operating the latch mechanism and for admitting compressed gas to operate the pressure reducing means.

3. An operating mechanism for a circuit breaker comprising a fluid motor, a source of gas under pressure, means for admitting compressed gas to said motor to operate the breaker to closed position, a trip free mechanism operatively relating said motor to the breaker and operable to permit operation of the breaker to open position, means comprising a multiple valve operable by

compressed gas to cause quick collapse of pressure on the working side of said motor to permit high speed resetting of said trip free mechanism, a pilot valve operable to admit compressed gas to operate said multiple valve, and trip means operable in response to predetermined circuit conditions to trip said trip free mechanism and simultaneously operate the pilot valve.

4. An operating mechanism for a circuit breaker comprising a fluid motor, means for admitting fluid under pressure to said motor to operate the breaker to closed position, latch mechanism for connecting said motor to the breaker and operable to disconnect the breaker from the motor for permitting opening of the breaker, means comprising a plurality of piston type valves operable to open a plurality of passages and thereby cause quick collapse of the fluid pressure on the working side of said motor, spring means for causing reconnection of the motor to the breaker, and electroresponsive means operable in response to predetermined circuit conditions to operate the latch mechanism and to initiate operation of said valves.

5. A fluid pressure operating mechanism for a circuit breaker comprising a cylinder, a piston reciprocably movable in said cylinder and operable by fluid pressure to close the breaker, a trip free mechanism operatively relating said piston to the breaker, a trip device operable in response to predetermined circuit conditions to trip said trip free mechanism to thereby trip said breaker free of said piston, spring means for moving the piston to cause automatic resetting of the trip free mechanism, means comprising a plurality of piston type exhaust valves operable under the control of the trip device to cause quick collapse of the fluid pressure in the cylinder, and an inlet valve operable to admit fluid under pressure to the cylinder for actuating the piston to close the breaker.

6. An operating mechanism for a circuit breaker comprising a cylinder, a piston in the cylinder, a latch mechanism for releasably connecting said piston to the breaker, an inlet valve operable to admit air pressure to said cylinder for actuating the piston to close the breaker, a trip device operable in response to predetermined circuit condition to operate the latch mechanism and cause opening of the breaker, spring means for actuating the piston to cause relatching thereof to the breaker, means comprising an exhaust valve operable under control of the trip device for causing quick collapse of pressure in the cylinder and thereby permit high speed relatching movement of the piston, said trip device being operable to cause opening of the breaker irrespective of the movement of the piston.

7. An operating mechanism for a circuit breaker comprising a fluid motor operable by fluid under pressure to close the breaker, latching means for releasably connecting said motor to the breaker, said latching means comprising a main latch biased to latching position for engaging a part movable with the breaker and restraining said part in a predetermined position, an intermediate latch for engaging said main latch and restraining said main latch in latching position, said intermediate latch having a part disposed generally parallel to and in nested relation with a portion of the main latch, and a light load trigger latch for engaging and restraining the intermediate latch in latching position, said light load latch having a part disposed in nested relation with the intermediate latch, and a trip device operable in response to predetermined circuit conditions for operating the trigger latch to cause the main latch to release the part movable with the breaker and thereby cause opening of the breaker.

8. The invention according to claim 7, characterized by the provision of means for adjustably limiting the unlatching movement of the main latch to provide for high speed relatching.

9. An operating mechanism for a circuit breaker comprising a fluid motor operable by fluid under pressure to close the breaker, means comprising an inlet valve for admitting fluid to said motor, latch means for releasably connecting the motor to the breaker, electroresponsive means for operating said latch means to cause opening of the breaker, means automatically operable following disconnection of the motor from the breakers to move the motor to cause reconnection thereof with the breaker, and a pneumatically operated exhaust valve for causing quick collapse of the fluid pressure in the motor to permit high speed relatching movement of the motor, said exhaust valve comprising a plurality of piston type valves connected for unitary movement to simultaneously open a plurality of exhaust ports.

10. A circuit breaker comprising relatively movable contacts, a fluid motor operable by fluid under pressure to close said contacts, latch means releasably connecting said motor to the breaker, exhaust means for quickly exhausting the fluid pressure from the motor, a trip device operable in response to predetermined conditions in the circuit controlled by the breaker for operating the latch to cause opening of the contacts, said trip means also operating the exhaust means, reset means operable to cause relatching of the motor to the breaker at least by the time the breaker reaches full open position, and means operable after the contacts have separated and before the breaker reaches full open position to admit fluid under pressure to the motor to initiate a closing movement of the contacts.

11. A circuit breaker comprising relatively movable contacts for opening and closing an electrical circuit, closing means comprising a motor operable by fluid under pressure to move the contacts to closed position, a releasable connection between the motor and the movable contacts, a trip device operable in response to predetermined circuit conditions to disconnect the breaker from the motor to cause opening movement of the contacts, exhaust means operable by said trip device to quickly exhaust the fluid pressure from the motor, spring means operable to cause reconnection of the motor to the breaker before the contacts have reached full open position, and means operable to admit fluid under pressure to the motor to initiate a closing movement of the breaker before the contacts reach full open position, said trip device being operable to initiate an opening movement of the breaker irrespective of the condition of the closing means.

12. A circuit breaker comprising relatively movable contacts, operating means for said contacts comprising an operating cylinder, a piston movable in said cylinder and releasably coupled to the breaker, a source of compressed air for operating said piston, means including an electroresponsive device operable in response to predetermined abnormal circuit conditions to uncouple the breaker from the piston and cause opening of the breaker; pressure exhaust means associated with said cylinder including a normally closed

exhaust valve operable by said electroresponsive device to cause collapse of the pressure in the cylinder, spring means automatically operable to cause recoupling of the piston to the breaker before said breaker reaches full open position, and means including an inlet valve operable to admit compressed air to the cylinder to close the breaker, said electroresponsive device being operable to uncouple the breaker from the piston irrespective of the air pressure in the cylinder.

13. A circuit breaker comprising relatively movable contacts biased to an open position, operating means therefor including an operating cylinder, a piston movable in said cylinder and releasably coupled to said breaker, a source of compressed air for operating the piston to close the breaker, an electroresponsive trip device operable in response to predetermined abnormal conditions in the circuit controlled by the breaker to cause uncoupling of the breaker from the piston and thereby cause opening movement of the breaker independently of the movement of the piston, means including an exhaust valve associated with said cylinder and operable under the control of the electroresponsive means to cause quick collapse of the air pressure in the cylinder, means comprising a spring operable to cause recoupling of the piston with the breaker, and means including an inlet valve operable to admit compressed air to the cylinder to close the breaker.

14. A circuit breaker comprising relatively movable contacts biased to an open position, operating means therefor including a fluid motor releasably coupled to said breaker, a trip device operable to cause uncoupling of the breaker from the motor and opening of the breaker, means for causing automatic recoupling of the motor to the breaker, means operable when said breaker moves to open position to cause compressed fluid to be admitted to the motor and initiate a reclosing movement of the breaker after interruption of the circuit and by the time the breaker reaches full open position, said trip device being operable in response to predetermined abnormal condition in the circuit of the breaker to cause uncoupling of the breaker from the motor and thereby cause opening of the breaker irrespective of the condition of the motor.

15. An operating mechanism for a circuit breaker comprising a cylinder, a piston movable in said cylinder and operable by fluid pressure to close the breaker, means comprising an actuating lever pivoted on a fixed pivot and an operating lever pivoted on said actuating lever for releasably connecting the piston to the breaker, means for restraining said levers in connected relation, a trip device including an electromagnet operable in response to predetermined abnormal conditions in the circuit controlled by the breaker for operating the restraining means and thereby permit opening movement of the operating lever and the breaker irrespective of the position of the piston, an exhaust valve operable by the trip device to cause quick collapse of the fluid pressure from the cylinder, and spring means to automatically move the actuating lever to reestablish the connection of the piston to the breaker at least by the time the breaker reaches full open position.

16. An operating mechanism for a circuit breaker comprising a cylinder, a piston movable in said cylinder and operable by fluid pressure to close the breaker, a pivoted actuating lever pivotally supported on a fixed pivot and operatively connected to said piston, an operating lever pivotally mounted on said actuating lever and operatively connected to the breaker, a plurality of latch members for releasably restraining said levers in a normal position, a trip device including an electromagnet operable to release the operating lever and cause opening of the breaker, said operating lever effecting unlatching of the actuating lever as it moves to an open position, an exhaust valve operable under the control of the trip device to effect quick collapse of pressure in the cylinder, spring means automatically operable to rotate the actuating lever about the fixed pivot to cause relatching of the operating lever at least by the time the breaker reaches open position, and an inlet valve operable when the breaker moves to open position to admit compressed fluid to the cylinder and initiate a closing movement of the piston after interruption of the circuit and by the time the breaker reaches full open position.

17. An operating mechanism for a circuit breaker comprising a fluid motor operable by fluid pressure to close the breaker, means for admitting fluid pressure to said motor, means including a retrieving lever and a trip free lever, means releasably engaging the trip free lever to retain it in a predetermined position, an electromagnet operable in response to predetermined circuit conditions to trip the engaging means to release the trip free lever and permit movement of the breaker to open position, an exhaust valve operable to cause quick collapse of the fluid pressure in the motor, and spring means for automatically moving the retrieving lever to cause the engaging means to reengage the trip free lever at least by the time the breaker reaches full open position.

18. In a circuit breaker, the combination of an operating mechanism comprising a fluid motor operable by fluid pressure to close the breaker, means for admitting fluid pressure to said motor, an actuating lever pivotally supported on a fixed pivot and operatively connected to the motor, an operating lever pivotally mounted on said actuating lever and operatively connected to the breaker, a latch member for releasably restraining the free end of the actuating lever in a normal position, a second latch member for releasably restraining the operating lever in a closed position, a trip device operable in response to predetermined circuit condition to operate the second named latch to release the operating lever and permit movement of the breaker to open position, the first named latch member being operated by the operating lever to release the actuating lever, an exhaust valve operable by the trip device to cause quick collapse of the fluid pressure in the motor, and spring means for automatically moving the actuating lever to cause relatching of the operating lever.

19. An operating mechanism for a circuit breaker comprising a motor operable by compressed gas, a source of gas under pressure, an inlet valve for admitting compressed gas to said motor to close the breaker, latch means for releasably connecting the motor to the circuit breaker, a compressed gas operated valve for quickly reducing the working pressure in the motor, a pilot valve for admitting compressed gas to operate said pressure reducing valve, means for automatically reconnecting the motor to the circuit breaker, and electroresponsive means for operating the latch means to disconnect the breaker from the motor and for operating said pilot valve.

20. A circuit breaker comprising relatively movable contacts biased to an open position, op-

erating means therefor including an operating cylinder, a piston movable in said cylinder, a trip free mechanism operatively relating said piston to the breaker, a source of gas under pressure, an electroresponsive trip device operable in response to predetermined abnormal conditions in the circuit controlled by the breaker to trip said trip free mechanism to trip said breaker free of the piston and thereby cause opening movement of the breaker independently of the movement

of the piston, means including a valve associated with said cylinder and operable under the control of the electroresponsive trip device to cause quick collapse of the gas pressure in the cylinder, means comprising a spring operable to cause resetting of said trip free mechanism, and means including an inlet valve operable to admit compressed gas to the cylinder to close the breaker.

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