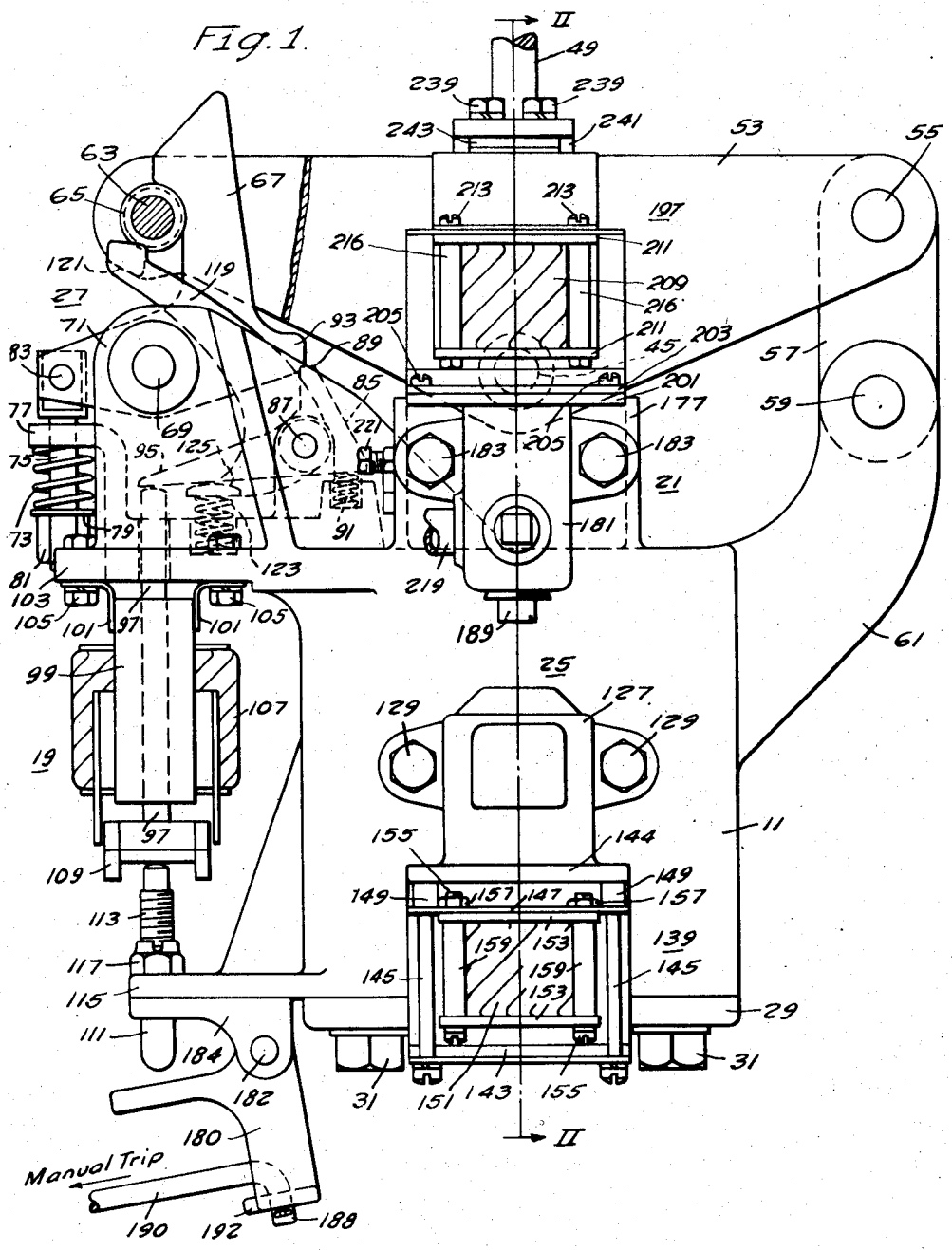
Sept. 18, 1945. J. M. CUMMING ET AL 2,384,801

CIRCUIT BREAKER

Filed June 5, 1942 3 Sheets-Sheet 1

Fig. 1.



WITNESSES:

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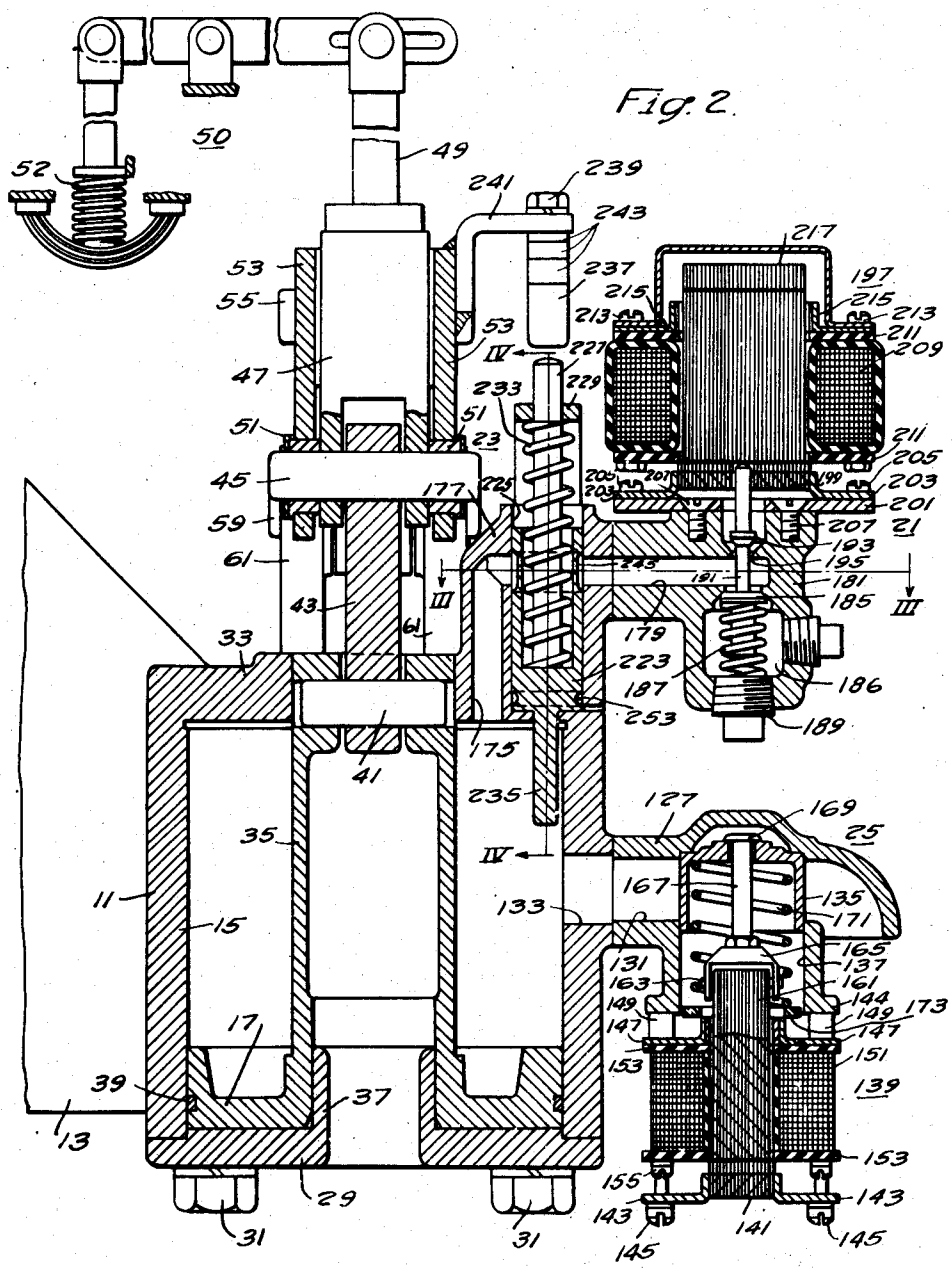
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Sept. 18, 1945. J. M. CUMMING ET AL 2,384,801

CIRCUIT BREAKER

Filed June 5, 1942 3 Sheets-Sheet 2

Fig. 2.



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CIRCUIT BREAKER

Filed June 5, 1942 3 Sheets-Sheet 3

Fig. 3.

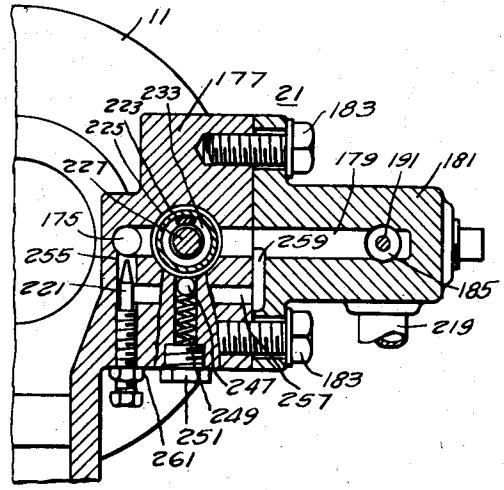
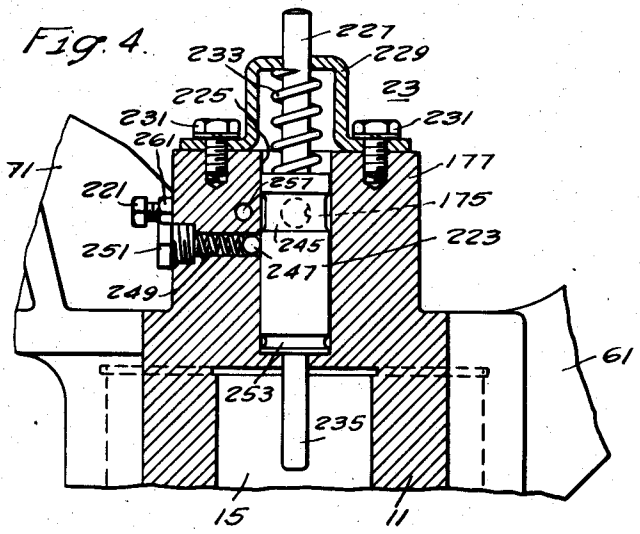


Fig. 4.



WITNESSES:

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Patented Sept. 18, 1945 2,384,801

UNITED STATES PATENT OFFICE

2,384,801

CIRCUIT BREAKER

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Application June 5, 1942, Serial No. 445,881

21 Claims. (Cl. 200—82)

The invention relates to circuit breakers and, more particularly, to circuit breaker operating mechanisms of the fluid pressure type which are operable to produce closing or quick automatic reclosing of the circuit breaker.

This invention is a further development and improvement of the invention disclosed in the copending application of H. L. Peek, Serial No. 445,733, filed June 4, 1942, now Patent No. 2,379,178, issued June 26, 1945, and assigned to the assignee of the instant invention.

One object of the invention is to provide a circuit breaker embodying a fluid pressure operating mechanism of the type operable to effect normal closing and also quick automatic reclosing of the breaker, with an improved means controlled by the piston to reduce the operating force applied during the first part of the closing stroke on closing operations started from the full open position to prevent slamming of the breaker.

Another object of the invention is to provide a circuit breaker embodying a compressed gas operating mechanism operable to effect closing of the breaker from the full open position and quick automatic closing of the breaker, the mechanism being provided with an improved means for causing a greater force to be applied on quick automatic reclosing operations than on normal closing operations.

Another object of the invention is to provide a circuit breaker embodying a compressed air operating mechanism having means for exhausting the air pressure on one side of the piston on opening operations and means operated by the piston during the opening stroke to reduce the rate at which the air is exhausted.

Another object of the invention is to provide a circuit breaker embodying a compressed gas operating mechanism operable to effect normal closing of the breaker and also operable to effect quick automatic reclosing operation of the breaker, the mechanism having an improved arrangement for increasing the force applied to the piston near the end of the closing stroke on normal closing operations, and for causing a greater force to be applied on quick reclosing operations than on normal closing operations.

Another object of the invention is to provide a circuit breaker embodying an operating mechanism operable to effect normal closing operations and also quick automatic reclosing operations of the breaker, with means operated by the piston for reducing the operating force on normal closing operations, and means operable independently of the reducing means to regulate the operating force.

Another object of the invention is to provide a circuit breaker embodying an operating mechanism which is pneumatically operated to produce normal closing of the breaker, and also operated to produce quick automatic reclosing operations, the mechanism being provided with an automatically operated valve for reducing the air pressure applied to the operating piston on normal closing operations and to cause greater driving force to be applied on quick reclosing operations, and having means independent of the valve for regulating the rate of flow of compressed air.

Another object of the invention is to provide a circuit breaker embodying an operating mechanism operated by compressed air to produce normal closing and quick reclosing of the breaker with rapid reversal of switching movement of the breaker, the mechanism having an automatically operable valve for reducing the air pressure applied to the piston on normal closing operations and to cause full air pressure to be applied to the piston on quick reclosing operations, and having a bypass around the throttle valve for admitting compressed air to the piston on normal closing operations when the throttle valve is closed.

Another object of the invention is to provide a circuit breaker operating mechanism operated by compressed air to produce normal closing and also to produce quick automatic reclosing of the breaker with rapid reversal of the switching movement of the breaker, the mechanism having a valve operable to closed and open positions by the mechanism to reduce the air pressure applied to the piston on normal closing operations and to cause full air pressure to be applied to the piston on quick reclosing operations, and having a bypass channel for admitting compressed air to the piston independently of the throttle valve, the bypass channel having adjusting means to regulate the rate of flow of compressed air applied to the piston on normal closing operations.

Another object of the invention is to provide a circuit breaker operating mechanism wherein the operation of a pressure exhaust valve is initiated by an electromagnet and the valve is thereafter moved to full open position by fluid pressure.

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 one embodiment thereof when read in conjunction with the accompanying drawings; in which:

Figure 1 is an elevational view, partly in section, of a compressed air mechanism for operating a circuit breaker embodying the principles of the invention, the mechanism being shown in the breaker closed position;

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

Fig. 3 is a fragmentary horizontal sectional view taken substantially on line III—III of Fig. 2 showing the inlet valve, the throttle valve and the bypass channel, and partly broken away to show the throttle valve latch; and

Fig. 4 is a fragmentary vertical sectional view taken on line IV—IV of Fig. 2 showing the throttle valve and throttle valve latch.

Referring to Figs. 1 and 2 of the drawings the circuit breaker operating mechanism comprises, generally, a main casting 11 provided with mounting members 13 whereby the main casting may be secured to a suitable support, for instance, the side of a circuit breaker housing, an operating cylinder 15 in the casting, a piston 17 movable in the cylinder, a trip device indicated generally at 19 (Fig. 1), an inlet valve 21 (Fig. 2) for admitting compressed air to the cylinder to effect closing movement of the piston 17, a valve 23 for controlling the air intake, an exhaust valve mechanism 25, and a latch mechanism indicated generally at 27 (Fig. 1).

The lower end of the cylinder 15 is closed by means of a closure member 29 secured to the main casting 11 by means of bolts 31, the upper end of the cylinder 15 being closed by a portion 33 of the casting. The piston 17 includes an upwardly extending hollow tube 35 which slidably fits within an opening in the portion 33 of the casting 11. The lower end of the tube 15 fits over an inwardly extending annular flange 37 in the closed position of the piston. During downward or closing movement of the piston the air trapped by the piston between the flange 37, the cylinder wall 15 and the closure 29 acts as a cushion for the piston and the operating mechanism. The piston 17 is provided with one or more piston rings 39 (only one being shown).

The tube 35 is connected at its upper end by means of a pivot pin 41 to a link 43, which, in turn, is connected at its upper end, by means of a pivot pin 45, to a coupling 47 secured on the lower end of a breaker operating rod 49. The operating rod 49 is connected by suitable linkage to the circuit breaker mechanism shown schematically at 50 (Fig. 2) which may be an air breaker or an oil breaker of any conventional type. The breaker mechanism is biased to open position and actuated to open the breaker contacts by means of an accelerating spring 52.

The pivot pin 45 (Fig. 2) which connects the link 43 to the coupling 47, extends beyond the sides of the coupling and is connected by means of suitable bearing members 51 to an operating lever 53 comprising a pair of spaced parallel levers. As shown in Fig. 1 the levers 53 are pivotally supported, at their right hand ends, by means of a pivot pin 55, on the upper end of a link 57 whose lower end is pivoted on a pivot pin 59 mounted in a pair of ears 61 projecting outwardly and upwardly from the main casting 11.

The left hand ends (Fig. 1) of the levers 53 are rigidly connected by means of a rod 63 and are spaced apart by a roller 65 rotatably mounted on the rod 63 between the levers. The latch mechanism 27 normally cooperates with the roller 65 to releasably restrain the breaker mechanism in closed position.

The latch mechanism 27 includes a main latch 67 pivotally supported on a pivot pin 69 mounted in projections 71 extending upwardly from the main casting 11. The main latch 67 is biased to latching position by means of a spring 73 coiled around a rod 75 and compressed between a projection 77 of the casting 11 and a washer 79 supported on the lower end of the rod 75 by a nut 81. The rod 75 extends upwardly through a guide opening in the projection 77 and is pivotally connected at its upper end by means of a pivot pin 83 to the main latch 67.

The configuration of the latching surface of the main latch 67 is such that it will not, by itself, retain the operating mechanism in closed position. An auxiliary latch 85 is provided to maintain the main latch 67 in latching position. The auxiliary latch 85 is pivoted on a pivot pin 87 supported in the projection 71 of the casting 11 and a latching projection 89 thereof is biased by means of a spring 91 into latching engagement with a tail 93 of the main latch.

The auxiliary latch 85 is provided with a horizontally extending portion 95 the free end of which is disposed directly above and in alignment with a vertically disposed trip rod 97 forming a part of the trip device 19. The trip device includes, in addition to the trip rod 97, a trip magnet comprising an E-shaped magnet core 99 supported by means of a pair of brackets 101 on the under side of a projection 103 of the casting 11, the brackets 101 being secured to the projection 103 by means of bolts 105. An energizing coil 107 surrounding the center leg of the core 99 and suitably supported in the magnet frame, is provided to energize the trip magnet. A movable armature 109 secured on the lower end of the trip rod 97 cooperates with the magnet core 99 when the coil 107 is energized to thrust the trip rod upwardly to effect tripping of the breaker. The downward movement of the armature 109 and of the trip rod 97 is limited by engagement with a manual trip rod 111 vertically slidably mounted in a guide sleeve 113 threadedly secured on a horizontal projection 115 of the casting 11. The vertical movement of the manual trip rod 111 is limited by means of an annular collar (not shown) thereon engaging shoulder (also not shown) formed on the inner wall of the sleeve 113. The sleeve 113 is locked in position by means of a lock nut 117.

Upon energization of the trip device 19 the armature 109 is attracted thrusting the trip rod 97 upwardly. The trip rod, at this movement, engages the portion 95 of the auxiliary latch 85 and rocks this latch clockwise to disengage the latching projection 89 thereon from the tail 93 of the main latch 67. The upward force exerted on the operating rod 49 and the lever 53 by the breaker accelerating spring overcomes the relatively weaker spring 73 and forces the main latch 67 clockwise as the lever 53 rotates clockwise about the pivot 55 to open position. As soon as the roller 65 escapes the latch 67, the spring 73 acts to restore the latch to its latching position. When this occurs the spring 91 tends to move the auxiliary latch 85 to latching engagement with the main latch. Should this occur it is obvious that the latch roller 65 could not be restored to latching engagement with the main latch 67. In

order to prevent the auxiliary latch from reengaging the main latch following a tripping operation and until the mechanism is restored to full closed position a holding lever 119 is provided. The holding lever 119 comprises a U-shaped lever pivotally supported on the pivot pin 87 and having the two arms thereof rigidly joined at their free ends by a cross bar 121. A spring 123, seated in a spring seat in the casting 11 biases the cross bar 121 into contact with the latch roller 65 so that, when the lever 53 and the roller 65 move in opening direction the spring 123 causes the holding lever 119 to rotate in a clockwise direction about the pivot 87. During this movement of the holding lever a lateral extension 125 thereon engages the portion 95 of the auxiliary latch 85 and, since the spring 123 is relatively stronger than the spring 91, holds the auxiliary latch in its unlatching position until the breaker is closed.

When the trip device is operated to release the operating lever 53, the accelerating spring 52 moves the operating rod upwardly as the breaker mechanism moves to open position. Due to the connecting link 43 (Fig. 2) the piston 17 moves therewith to the top of the cylinder 15. In order that the piston 17 may move rapidly upwardly in the cylinder to provide for high speed interruption of the circuit the exhaust valve mechanism indicated generally at 25 (Fig. 2) is provided and is energized simultaneously with the energization of the trip device 19 (Fig. 1). The exhaust valve mechanism is supported on housing 127 (Figs. 1 and 2) secured to the side of the main casting 11 by means of bolts 129. The housing 127 is provided with a passage 131 which is in alignment with an exhaust port 133 in the wall of the cylinder 15. The exhaust passage 131 is normally closed by means of an electromagnetically operated piston valve 135 disposed for vertical movement in a cylinder 137 formed integral with the housing 127.

An electromagnet, indicated generally at 139 (Figs. 1 and 2), is provided to operate the exhaust valve 135 to open position and is energized simultaneously with the trip device 19 to quickly dump the air above the piston 17 when the breaker is tripped and moved to open position. The electromagnet 139 includes a U-shaped stationary core 141 of laminated magnetic material supported by means of angular brackets 143 from the lower flanged end 144 of the cylinder 137. The brackets 143 are secured on opposite sides of the lower end of the stationary core 141. Screws 145 pass through each end of each of the brackets 143, through brackets 147 secured to the upper end of the core 141 and threadedly engage tapped holes in the flanged lower end 144 of the exhaust valve cylinder 137. Spacers 149 surround the screws 145 between the brackets 147 and the cylinder 137 to properly locate the magnet core.

An energizing coil 151 mounted between insulating members 153 is supported on the brackets 147 by means of bolts 155 passing through the members 153 and the brackets 147 and having nuts 157 (Fig. 1) on the upper ends thereof. Spacers 159 are provided on each of the bolts 155 to space the members 153 apart. The coil 151 is provided with a suitable central opening to receive a movable core 161 of laminated magnetic material pivotally supported by means of a pivot pin 163 on a yoke 165 secured to the lower end of a piston rod 167. The upper end of the rod 167 passes loosely through the head of the valve 135, and is headed as at 169 and operatively engages the closed end of the cup-like piston valve 135.

The valve 135 and the movable core 161 are biased to the closed position by a coil spring 171 compressed between a washer 173, supported on the brackets 147, and the head of the valve 135.

As was stated previously the exhaust valve magnet 139 is energized simultaneously with the trip device 19 (Fig. 1), and when energized, attracts the movable core 161 (Fig. 2) drawing the valve 135 downwardly in the cylinder 137 to open the exhaust passages 131. If there is any compressed air in the breaker operating cylinder above the piston 17 at the time the exhaust valve 135 is opened by the electromagnet 139, the compressed air will push the exhaust valve down to its full open position thereby quickly dumping the air from the cylinder so that the air will not retard opening of the breaker. As the breaker moves to open position drawing the piston 17 upwardly in the cylinder 15, the air above the piston is quickly exhausted to the atmosphere through the relatively large passage 133—131.

During its upward travel the piston 17 passes the exhaust port 133 after which the air above the piston is compressed to absorb the kinetic energy of the moving mass of the breaker. However, the air thus compressed in the upper end of the operating cylinder 15 exhausts to the atmosphere through an air inlet passage 175 (Figs. 2 and 3) extending vertically through the upper portion 33 of the casting 11 and an extension 177 thereof, past the throttle valve and through a passage 179 in the housing 181 of the inlet valve to the atmosphere. As the piston approaches the limit of its upward or opening travel, it operates the throttle valve 23 further restricting the passage 175, as will be later described in detail, thus increasing the cushioning effect as the piston and the connected operating mechanism is brought to rest in fully open position.

The circuit breaker may be manually tripped open by energizing the electrical circuit for the trip device 19 and the exhaust magnet 139 by means of a manually controlled switch (not shown). The circuit breaker may be tripped open mechanically, in case of failure of current in the control circuit (not shown) by manually operating the trip rod 97 (Fig. 1). This is accomplished by operating a bell crank 180 (Fig. 1) pivotally supported by means of a pivot pin 182 mounted in a bracket 184 secured to the under side of the projection 115 which supports the manual trip rod 111. The bent end 188 of a pull rod 190 projects through an opening in an ear 192 of the downwardly extending arm of the bell crank 180 and is suitably retained in place by a cotter pin.

When it is desired to trip the breaker mechanically the pull rod 190 is drawn toward the left (Fig. 1) which rotates the bell crank 180 clockwise thrusting the manual trip rod and the trip rod 97 upwardly to operate the latch mechanism 27. The circuit breaker then moves to the open position, the air above the operating piston 17 being expelled from the cylinder through the fully open passage 175—179 (Figs. 2 and 3) since the exhaust magnet 139 is not energized upon mechanical operation of the trip device.

In order to close the breaker 50 compressed air is admitted to the cylinder 15 above the piston 17 through the inlet passage 179—175 by operation of the inlet valve mechanism 21. The inlet valve mechanism includes the housing 181 which is securely mounted by means of bolts 183 (Fig. 1) on the side of the extension 177 of the

main casting. An inlet valve 185 disposed for vertical movement within the housing 181, is biased to closed position by means of a spring 187 disposed in an air inlet chamber 186 and seated on a plug 189, screwed into the bottom of the housing 181. The upper end of the spring 187 bears against the valve 185. The valve 185 is secured on a rod 191 which also carries an exhaust valve 193. When the inlet valve 185 is closed the exhaust valve 193 is open connecting the upper end of the operating cylinder 15 to the atmosphere through the passage 175—179 and an exhaust port 195. When the inlet valve 185 is operated to open position to admit compressed air to the cylinder 15 the valve 193 is moved to close the exhaust port 195.

The inlet valve 185 and the exhaust valve 193 are operated respectively to open position and closed position by means of an electromagnet indicated generally at 197 (Figs. 1 and 2). The magnet 197 includes a U-shaped stationary core member 199 of laminated construction supported on a plate 201 by means of angular brackets 203 suitably secured, for instance, by welding, to the core member. The brackets 203 are secured by means of screws 205 to the plate 201 which, in turn, is secured to the top of the inlet valve housing 181 by means of screws 207 (Fig. 2). An energizing coil 209 is mounted between insulating plates 211 secured by means of bolts 213 to angular brackets 215 welded to the upper end of the core member 199. Spacers 216 (Fig. 1) are provided to space the plates 211 apart. The lower portion of the core member 199 is provided with a clearance opening (not shown) through which the valve stem 191 passes, and the coil 209 has a central opening (also not shown) in which is disposed a T-shaped movable core 217.

The control circuits for the trip device 19 and the inlet valve electromagnet 197 are preferably the same as the control circuits disclosed in the copending application of James M. Cumming and Richard C. Cunningham, Serial No. 410,686, filed September 13, 1941, and assigned to the assignee of the present invention. The control circuits have not been shown in this case as they are not necessary for a complete understanding of the present invention. It is believed sufficient for the purpose at hand to mention that the inlet valve electromagnet may be energized in response to the operation of a manual closing control switch or automatically in response to the closing of an auxiliary switch which may be set to close at an intermediate position in the opening stroke of the breaker so as to initiate quick reclosing of the breaker. The trip device 19 is energized in response to an overload or other fault condition. For details of the control circuits reference may be had to the aforementioned copending application. As previously pointed out the exhaust valve electromagnet 139 is energized simultaneously with the trip device 19.

When the electromagnet 197 is energized, the magnet attracts the movable core 217 which thrusts the valve stem 191 downwardly closing the exhaust valve 193 and opening the inlet valve 185. The inlet air chamber 186 is connected by means of a pipe 219 (Fig. 1) to a source (not shown) of compressed air. When the inlet valve 185 (Fig. 2) is opened air under pressure is admitted through the passage 179—175 to the upper end of the operating cylinder 15 moving the piston 17 toward the bottom of the cylinder and moving the connected breaker operating mechanism to closed position.

The driving force required for normal closing operations where the closing movement is initiated from the full open position is much less during the first portion of the closing stroke than during the final portion of the closing stroke when the heavy contact load is being overcome, and is also much less than that required to quickly reverse the switching movement and automatically reclose the breaker after interruption of the circuit and before the breaker reaches full open position. The automatically operable valve 23 (Fig. 2) is effective to reduce the flow of compressed air admitted to the operating cylinder during the first part of the closing stroke on normal closing operations, but permits the full flow of air pressure to the cylinder during the final portion of the closing stroke. The valve 23 is also effective to permit full flow of compressed air during quick reclosing operations to provide additional power required to quickly reverse the movement of the breaker and quickly reclose the same.

The rate of flow of compressed air to the cylinder 15 to effect closing of the circuit breaker is controlled by the previously mentioned valve 23 and by an adjustable metering pin 221 (Figs. 1, 3 and 4) in an auxiliary air passage. The valve 23 includes a piston type valve 223 (Figs. 2 and 4) disposed for vertical movement in a cylinder 225 formed in the projection 177 of the main casting. The valve 223 is cup-shaped and has an operating rod 227 secured to the inside bottom portion thereof and extending vertically beyond the valve through an opening in a guide bracket 229. The bracket 229, which is secured to the top of the extension 177 by means of bolts 231 (Fig. 4), also serves as a retainer for a valve spring 233 which is coiled about the rod 227 and bears against the under side of the bracket 229 and against the inside bottom of the valve 223 to bias the valve 223 to open or non-throttling position. An operating rod 235 projects downwardly from the bottom of the valve 223 through an opening in the top of the operating cylinder 15 and extends for some distance into the cylinder where it is adapted to be engaged by the piston 17 during the opening stroke to move the valve to closed position.

The valve 223 is adapted to be moved downwardly to open position as the breaker mechanism approaches closed position by means of a tappet 237 (Figs. 1 and 2) secured by means of bolts 239 to an angle bracket 241 which is secured by means of welding to the adjacent operating lever 53. Shims or spacers 243 of different thicknesses may be assembled between the tappet 237 and the bracket 241 in order to vary the distance of the operating end of the tappet from the valve operating rod 227 thus adjustably determining the time during the closing stroke when the throttle valve 223 will be operated to open position.

The valve 223 is shown in Figs. 2 and 4 in the open position in which an annular groove 245 on the outer periphery of the valve is in alignment with the passages 175 and 179 thereby connecting these passages to admit compressed air to the operating cylinder 15. Means comprising a spring pressed ball 247 (Figs. 3 and 4) is provided to latch the valve in its upper or closed position when it has been moved to this position by the piston 17. The ball 247 is disposed in a horizontal opening in the portion 177 of the main casting and is pressed against the periphery of the valve 223 by means of a spring 249 which is re-

tained in place by a retaining plug 251 threadedly engaging the casting. A latching groove 253 is provided near the bottom of the valve 223 and is adapted to be engaged by the ball 247 when the valve is raised to closed position, to retain the valve in closed position against the force of the spring 233.

The metering pin 221 is disposed in an opening 255 (Fig. 3) in the casting 177, which forms part of a bypass channel 257 connecting the passage 175 through an off set passage 259 to the passage 179. The metering pin 221 threadedly engages the opening 255 in the casting and is adjustable by rotating it in either direction to move the tapered inner end thereof relative to the channel 257 to thereby regulate the flow of air through the bypass channel around the valve 223 and independently of the valve. A lock nut 261 is provided to lock the metering pin in its adjusted position.

It was stated previously that the operating piston 17 during the opening stroke moves the valve 223 to closed position. This is effected by the piston engaging the operating rod 235 and thrusting the valve 223 upwardly against the opposing force of the spring 233 until the piston arrives at the limit of its upward travel in which position the groove 253 is in line with the ball 247. The spring 249 now forces the ball 247 into the groove 253 thus latching the valve 223 in its closed position. Early in the upward movement of the valve 223 the groove 245 is moved out of alignment with the passages 175 and 179 thus blocking these passages and restricting the flow of air to the cylinder to the bypass channel. Thereafter, during the opening stroke of the piston 17, the air in the top of the cylinder 15 escapes to atmosphere through the bypass channel 255, 257 and 259 under the control of the metering pin 221. Since the bypass channel greatly restricts the flow of air from above the piston the air remaining in the cylinder acts to cushion the blow of the breaker mechanism as it reaches full open position.

When the closing magnet 197 (Figs. 1 and 2) is energized to initiate a closing movement of the operating mechanism, it closes the exhaust valve 193 (Fig. 2) and opens the inlet valve 185. This admits compressed air from the source (not shown) through the inlet chamber 186, inlet valve 185, passage 179, bypass channel 259, 257 and 255 (Fig. 3) and the passage 175 to the upper end of the operating cylinder 15 above the piston 17. This forces the piston downwardly and moves the connected operating mechanism toward closed position, the metering pin 221 acting to throttle the flow of air to the cylinder a predetermined amount. As the piston 17 (Fig. 2) moves downwardly in the cylinder, the lever 53 is rotated in a counterclockwise direction (Fig. 1) and, at a predetermined time during this movement, the tappet 237 engages the upper end of the valve rod 227 and moves the valve 223 downwardly to disengage it from the ball latch 247. As soon as the valve 223 is unlatched the spring 233 acts to quickly move the valve to its lower or open position in which the groove 245 is aligned with the passage 175—179. This occurs shortly before the breaker contacts engage, thus providing an increased volume of compressed air to bring the movable contacts quickly into pressure engagement with the stationary contacts.

The valve 223 is automatically controlled by the piston 17 and the operating lever 53 according to the position of the breaker in such a manner that the valve will remain in its open position upon a quick automatic reclosing operation when the reclosing movement of the breaker is initiated when the breaker is in an intermediate or partially open position. This provides for the admission of a full volume of compressed air to the operating cylinder in order to quickly reverse the movement of the operating piston and breaker operating mechanism and to operate said mechanism to fully closed position.

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

We claim as our invention:

1. In an operating mechanism for a circuit breaker, fluid pressure operated means for closing said breaker, means including an inlet valve operable to admit fluid pressure to effect closing of the breaker, a second valve disposed in a passage connecting said valve and the fluid pressure operated closing means, said second valve being operable by the fluid pressure operated means when the breaker is moved to open position to substantially close said passage, means for restraining said second valve in closed position during a substantial portion of the closing movement, and means including an auxiliary passage for admitting a predetermined fluid pressure independently of said second valve to operate the breaker to closed position.

2. In an operating mechanism for a circuit breaker, an operating cylinder, a piston in said cylinder for moving said breaker to closed position, an inlet valve operable to connect said cylinder to a source of air under pressure to effect closing of the breaker, means operable to cause opening of the breaker, means for operating said valve to effect closing of the breaker, a second valve operable by the piston when the breaker is moved to open position to reduce the air pressure admitted to said cylinder, means for holding said second valve closed for a predetermined time during the closing movement of said piston, and means comprising a bypass channel around said second valve for permitting compressed air to flow to said cylinder at a predetermined rate irrespective of the position of said second valve.

3. In an operating mechanism for a circuit breaker, means comprising a fluid motor operable to close the breaker, an inlet valve operable to admit fluid pressure to said motor to effect closing of the breaker, means for operating said valve to effect normal closing of the breaker from full open position, a second valve disposed in a passage connecting said valve and the fluid motor and operable by said motor when the breaker is opened to substantially close said passage, means for latching said second valve in closed position during a portion of the closing operation of said motor, means including an auxiliary passage for admitting fluid at a predetermined rate to the motor, and adjustable means in said auxiliary passage to vary the rate at which fluid is admitted to said motor.

4. An operating mechanism for a circuit breaker comprising a fluid motor movable to open and closed positions to open and close the

breaker, an inlet valve operable to admit fluid under pressure to said motor to effect closing movement of said breaker, means comprising an automatically operable valve disposed in a passage connecting said valve and the motor, said automatic valve being operable at a predetermined intermediate point near the end of the opening movement of the motor to substantially close said passage, restraining means for releasably restraining said automatic valve in closed position, an auxiliary passage bypassing said automatic valve for admitting a predetermined amount of fluid pressure to the motor to effect closing of the breaker from full open position, and means operable at a predetermined point near the end of the closing stroke to release said automatic valve and cause opening of the automatic valve to cause greater fluid pressure to be applied near the end of the closing operation than at the beginning of the closing operation.

5. An operating mechanism for a circuit breaker comprising a cylinder and a piston in said cylinder for moving said breaker to closed position, means including an inlet valve operable to connect one end of said cylinder to a source of air under pressure to close the breaker, means operable to cause opening of the breaker, means for operating said valve to effect closing operation of the breaker, a second valve disposed in a passage connecting the cylinder to the valve, said second valve having a projection extending into the cylinder and engageable by said piston as the piston approaches full open position to substantially close said passage to reduce the air pressure applied to the cylinder on normal closing operations, means independent of said piston for restraining said second valve in said substantially closed position during a substantial portion of the closing movement, and an auxiliary passage bypassing said second valve for permitting compressed air to flow at a predetermined rate to the cylinder when said second valve is closed to effect normal closing operation of the breaker.

6. An operating mechanism for a circuit breaker comprising a cylinder and a piston movable therein for moving said breaker to closed position, means operable to cause opening of the breaker, an inlet valve operable to connect one end of said cylinder to a source of compressed air to close said breaker, a second valve disposed in a pasasge between the inlet valve and the cylinder, said second valve having a projection extending into said cylinder and separably engageable by the piston when the breaker nears its open position to move said second valve to closed position, a second passage for admitting a predetermined amount of compressed air to said cylinder independently of the second valve to close the breaker, and means other than said piston engageable with the second valve at a predetermined time during the closing movement of the breaker for opening said second valve to thereby increase the amount of compressed air admitted to the cylinder near the end of the closing stroke of the breaker.

7. An operating mechanism for a circuit breaker comprising a cylinder and a piston movable therein for moving said breaker to closed position, a trip device operable to cause opening of the breaker, an inlet valve operable to connect one end of said cylinder to a source of compressed air to close the breaker, a passage connecting said inlet valve and said cylinder, a second valve disposed in said passage and operable at a predetermined intermediate point in the opening movement of the breaker to close the passage, a second passage connecting the inlet valve to the cylinder for admitting independently of the second valve a predetermined amount of compressed air to the cylinder to close the breaker, adjustable means disposed in said second passage for adjustably determining the amount of compressed air to be admitted to the cylinder to initiate the closing movement of the breaker, and means operable during the closing stroke of the breaker to cause opening of said second valve thereby increasing the amount of compressed air admitted to the cylinder near the end of the closing stroke.

8. An operating mechanism for a circuit breaker comprising a cylinder and a piston movable therein for moving said breaker to closed position, trip means operable to cause opening of the breaker, an inlet valve operable to connect one end of said cylinder to a source of compressed air to close the breaker, a second valve disposed in a passage intermediate the inlet valve and the cylinder and biased to open position, said second valve having a part projecting into the cylinder and engageable by the piston when the breaker moves to open position to actuate said second valve to close a portion of the passage to thereby reduce the amount of compressed air admitted to the cylinder during the first part of the closing movement of the breaker, restraining means to restrain the second valve in closed position, and means operable during the closing movement of the breaker to cause opening of the second valve to increase the amount of compressed air admitted to the cylinder near the end of the closing movement of the breaker.

9. An operating mechanism for a circuit breaker comprising a fluid motor for closing the breaker, an inlet valve operable to admit fluid under pressure to said motor to effect closing of the breaker, a plurality of passages connecting said valve to said motor, a valve disposed in one of said passages and operable by the motor when the breaker moves to open position to reduce the force applied to the motor to close the breaker, means disposed in another of said passages to adjustably determine the amount of force to be applied to the motor to effect the closing movement of the breaker, and means operable during the closing movement of the breaker to cause said second mentioned valve to open the first named passage to thereby increase the force applied to the motor during the latter part of the closing movement of the breaker.

10. In a circuit breaker comprising relatively movable contacts, operating mechanism for said circuit breaker comprising a fluid motor for closing said breaker, an inlet valve operable to admit fluid under pressure to said motor to effect closing of the breaker, a plurality of passages connecting said valve and the motor, a second valve disposed in one of said passages, and operable by the motor at a predetermined time during the opening movement of the breaker to cause a reduced force to be applied to the motor through a second passage to close the breaker, means independent of said motor for restraining said second valve in said operated position during a substantial portion of the closing movement, and means operable during the closing movement of the breaker for operating said second valve to increase the force applied to the motor at a predetermined time during the closing movement.

11. An operating mechanism for a circuit

breaker comprising a cylinder and a piston in said cylinder for moving said breaker to closed position, means including an inlet valve operable to connect one end of said cylinder to a source of air under pressure to close the breaker, means operable to cause opening of the breaker, means for operating said valve to effect normal closing of the breaker from full open position, a second valve disposed in a passage connecting the cylinder to the valve, said second valve having a projection extending into the cylinder and engageable by said piston as the piston approaches full open position to cause said valve to close said passage to thereby reduce the flow of compressed air to the cylinder on normal closing operations, means comprising a by-pass channel for permitting compressed air to flow at a predetermined rate to the cylinder when the second valve is closed to effect normal closing operation of the breaker, and means for opening said second valve during the latter portion of the closing stroke.

12. An operating mechanism for a circuit breaker comprising a cylinder and a piston in said cylinder for moving said breaker to closed position, means including an inlet valve operable to connect one end of said cylinder to a source of gas under pressure to close the breaker, means operable to cause opening of the breaker, means for operating said valve to effect normal closing operation of the breaker from full open position, means for controlling the rate of flow of gas to the cylinder comprising a second valve having one position in which said means permits gas to flow at a predetermined rate to the cylinder and having an open position in which said means permits gas to flow at an increased rate to said cylinder, said second valve having a projection extending into the cylinder and engageable by said piston as the piston approaches full open position to actuate said second valve to said one position, and means movable with said piston and engageable with said second valve during the latter portion of the closing stroke for initiating actuation of said second valve to open position.

13. An operating mechanism for a circuit breaker comprising a cylinder and a piston in said cylinder for moving said breaker to closed position, an inlet valve operable to connect one end of said cylinder to a source of compressed air, means operable to effect opening of the breaker, means for operating said valve to effect normal closing of the breaker from full open position, a second valve disposed in a passage connecting the cylinder to the valve, said second valve having a part projecting into the cylinder and engageable by the piston at a predetermined time during the opening stroke of the breaker to actuate said second valve to closed position to reduce the flow of compressed air to the cylinder on normal closing operations, latch means for latching said second valve in closed position, means biasing said second valve to open position, and means engageable with said second valve at a predetermined time during the latter part of the closing stroke to unlatch said valve and permit said biasing means to actuate the valve to open position to thereby increase the flow of compressed air to the cylinder.

14. In an operating mechanism for a circuit breaker, fluid pressure operated means for closing said breaker, means comprising an inlet valve operable to admit fluid pressure to effect closing of the breaker, means including a valve operable to quickly reduce the pressure in said pressure operated means, electromagnetic means comprising an armature having a lost motion connection with said valve for moving said valve a predetermined distance in opening direction to admit fluid pressure to the top of said valve, said valve being operable relative to said armature by fluid pressure to full open position.

15. In an operating mechanism for a circuit breaker, an operating cylinder, a piston in said cylinder for moving the breaker to closed position, an inlet valve operable to admit fluid pressure to said cylinder to close the breaker, means operable to cause opening of the breaker, means comprising an exhaust valve operable to exhaust the pressure in said cylinder, an electromagnet including a movable armature for initiating opening movement of said exhaust valve at least to a point where fluid pressure is admitted to the top of said valve, said valve being then operated independently of said armature to its full open position by fluid pressure to quickly exhaust the pressure in said cylinder.

16. In an operating mechanism for a circuit breaker, means comprising a fluid motor operable to close the breaker, an inlet valve operable to admit fluid pressure to said motor to effect closing of the breaker, means operable to cause opening of said breaker, means comprising an exhaust valve for collapsing the fluid pressure in said motor, electromagnetic means including an armature having a lost motion connection with said exhaust valve operable to initiate an opening movement of said exhaust valve, said exhaust valve being thereafter operated by fluid pressure to full open position independently of said armature.

17. In an operating mechanism for a circuit breaker, means comprising a fluid motor operable to close the breaker, means comprising an inlet valve operable to admit fluid pressure to said motor to effect closing of the breaker, means operable to cause opening of said breaker, an exhaust passage communicating the motor to the atmosphere, a piston type valve disposed in said passage and operable to cause quick collapse of the fluid pressure in said motor during a breaker opening movement, means for moving said valve a predetermined distance in opening direction, said valve being thereafter moved to full open position by fluid pressure, a second passage communicating the motor to the atmosphere, a valve disposed in said second passage, said valve being operable by the motor near the end of the opening movement of the breaker to restrict said second passage to thereby cushion the opening movement of the breaker.

18. In an operating mechanism for a circuit breaker, fluid pressure operated means for closing the breaker, valve means operable to admit fluid pressure to effect closing of said breaker, a second valve disposed between said valve means and said fluid pressure operated means, said second valve being biased to open position and operable to a closed position, means for operating said second valve to closed position, latch means for holding said second valve in closed position against its bias, and means operable at a predetermined time during a closing operation to operate said latch means and permit movement of said second valve to open position.

19. In an operating mechanism for a circuit breaker, fluid pressure operated means for closing the breaker, an inlet valve operable to admit fluid pressure to effect closing of the breaker, a second valve disposed between said inlet valve

and said fluid pressure operated means, means biasing said second valve to open position at all times, means operable during an opening operation of said breaker to move said second valve to closed position against said biasing means, latch means for releasably holding said second valve in closed position, and means operable during a closing operation to release said second valve and permit said biasing means to move said valve to open position.

20. In an operating mechanism for a circuit breaker, a fluid motor operable to close the breaker, an inlet valve operable to admit fluid pressure to said motor to effect closing of said breaker, valve means disposed between said inlet valve and said motor for controlling the flow of pressure to said motor, means at all times biasing said valve means to open position, means for operating said valve means to closed position, a ball type latch engageable with said valve means for releasably holding said valve means in closed position, and means operable at a predetermined time during a closing operation to release said valve means and permit said biasing means to move said valve means to open position.

21. In an operating mechanism for a circuit breaker, a fluid motor for closing said breaker, a valve for controlling the admission of fluid pressure to said motor, spring means at all times biasing said valve to open position, means operable at a predetermined time during an opening movement of said breaker to move said valve to closed position, latch means for engaging and releasably restraining said valve means in closed position, and means operable at a predetermined time during a closing operation of said breaker to release said valve means and permit said spring means to quickly move said valve means to open position.

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