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CIRCUIT BREAKERS

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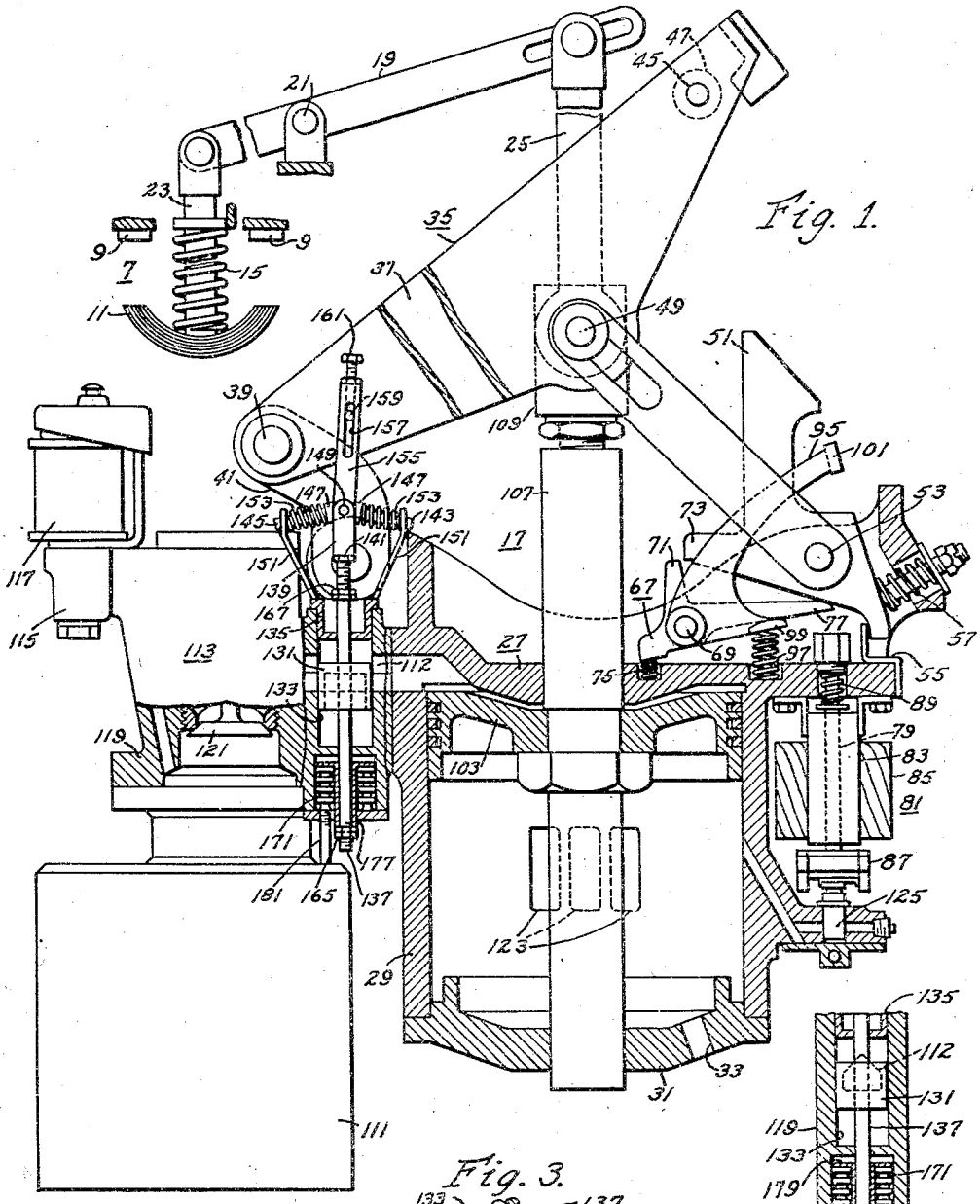


Fig. 1.

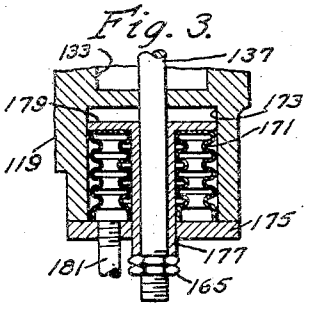


Fig. 3.

Fig. 2.

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CIRCUIT BREAKER

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Application June 5, 1942, Serial No. 445,880

16 Claims. (Cl. 200—82)

The invention relates to circuit breakers and more particularly to circuit breaker operating means of the fluid or gas pressure type.

In designing compressed air or gas operating means for circuit breakers, a combination of operating gas or air pressure and operating piston area must be selected which will develop sufficient power to overcome the contact load of the breaker which is picked up during the latter portion of the closing stroke. In many types of breakers the contact load is of very considerable magnitude due to the contact pressure springs. Also if the circuit breaker is to be used for quick automatic reclosing service the operating means must develop sufficient power to quickly reverse the movement of the breaker before the full open position is reached and reclose the breaker at high speed. If the large driving force required for these conditions is applied during the first part of the closing stroke on normal closing operations or on automatic reclosing operations started when the breaker is at rest in the full open position, the breaker may be operated at such a high speed and the kinetic energy developed may be so high as to produce destructive slamming. The copending application of H. L. Peek, Serial No. 445,733, filed June 4, 1942 and assigned to the assignee of the present invention, discloses and claims a compressed air circuit breaker operating means embodying an automatic means which is effective to admit compressed air to the mechanism at a predetermined rate during the first part of closing operations started from the full open position to prevent slamming, and which is automatically operable during the latter portion of the closing stroke and also during quick automatic reclosing operations to admit air at a much faster rate to provide greater driving power. This system works very satisfactorily if the compressed air in the air reservoir is always maintained substantially at a predetermined pressure. However, if the air pressure drops a substantial amount, for example, 30 or 40 pounds from a normal value of 150 pounds, and the throttle is adjusted so that the mechanism will close without slamming at the normal pressure, the automatic means may not deliver air into the cylinder fast enough to close the breaker at all when the source pressure drops. If this condition exists the mechanism will either fail to close the breaker or will close too slowly. Also only a relatively small number of operations will be possible without recharging the main reservoir. It is very desirable that a mechanism will be able to operate a given number of times after the power from the compressor motor fails.

An object of the present invention is the provision of a circuit breaker with a fluid pressure operating means embodying automatic means which will automatically change the rate at which fluid is supplied to the operating mechanism in response to a change in magnitude of the fluid pressure in a portion of the fluid pressure supply system.

Another object of the invention is the provision of a circuit breaker with a fluid pressure operating mechanism embodying means responsive to the fluid pressure in a portion of the fluid pressure supply system for automatically providing the proper rate of flow of fluid to the mechanism despite changes in fluid pressure in said portion of the supply system.

An object of the present invention is the provision of a circuit breaker with a fluid pressure operating means embodying means for automatically maintaining the driving power delivered to the operating mechanism substantially the same when the fluid pressure in the supply system decreases a substantial amount as when the pressure is at normal value.

Another object of the invention is the provision of a circuit breaker with a compressed gas operating mechanism having means responsive to a decrease in gas pressure in a portion of the compressed gas supply system for automatically providing an increased supply of compressed gas to the mechanism over what would be obtained from said portion of the supply system at the decreased pressure.

Another object of the invention is the provision of a circuit breaker with a compressed gas operating mechanism having automatic means for delivering compressed gas to the mechanism at a predetermined rate during the first part of a closing operation and at an increased rate during the latter part of a closing operation and during quick reclosing operations, and means responsive to a decrease in gas pressure in a portion of the compressed gas supply system for automatically providing an increased supply of compressed gas to the mechanism over what would be obtained from said portion of the supply system at the decreased pressure.

Another object of the invention is the provision of a compressed gas operating means for a circuit breaker with an automatic throttle device and a means responsive to the pressure in the gas reservoir for automatically increasing the size of the throttle opening as the pressure in the

reservoir decreases and for restoring the throttle opening to normal size when the gas pressure in the reservoir is restored to normal.

Another object of the invention is the provision of a compressed air operating mechanism for a circuit breaker with an automatically operated valve and means responsive to a decrease in the pressure of the air in a portion of the compressed air supply system for automatically opening the valve to make up for the decrease in driving power.

Another object of the invention is the provision of a circuit breaker operating means of the fluid pressure type having an automatic valve maintained in one position during the first part of closing stroke of the operating mechanism starting from the full open position of the breaker and automatically operated to a wide open position during the latter part of the closing stroke, and means responsive to the fluid pressure in a portion of the fluid pressure supply system for automatically opening the valve as the pressure in the reservoir decreases.

Another object of the invention is the provision of a compressed air circuit breaker operating mechanism having an automatic means including a valve operative to cause compressed air to be delivered to the mechanism at a predetermined rate during the first part of the closing stroke starting from the full open position of the breaker and automatically operated to an open position during the latter portion of the breaker closing stroke to permit compressed air to flow to the mechanism at an increased rate, and means responsive to a decrease in pressure in a portion of the compressed air supply system for automatically providing for an increased supply of compressed air to the mechanism over what would be obtained from said portion of the system at the reduced pressure.

Another object of the invention is the provision of a circuit breaker with an improved compressed gas operating means embodying an automatic means for delivering the proper amount of power to the mechanism to maintain proper speed of operation despite variations in operating load and in the available gas pressure.

Further objects and advantages of the invention will become apparent from the following detailed description of one embodiment thereof when read in conjunction with the accompanying drawing in which:

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

Fig. 2 is a fragmentary detail sectional view showing the throttle valve as viewed at right angles to the showing thereof in Fig. 1; and

Fig. 3 is an enlarged detail sectional view of the device for controlling the throttle opening in response to changes in air pressure in the air reservoir.

The present invention constitutes a further development and improvement over the compressed air circuit breaker operating means disclosed in the aforementioned copending application of H. L. Peek, Serial No. 445,733, and the invention is illustrated as applied to the same type of compressed air operating mechanism.

Referring to the drawing, the circuit breaker represented very schematically at 1 may be of any conventional construction either of the oil break or air break type. The circuit breaker, as schematically shown, comprises stationary contact means 9 and movable contact means 11. Most conventional circuit breakers usually embody a contact pressure spring construction for maintaining the desired pressure engagement of the contacts in the closed position. The main bridging contact is usually backed by springs to secure contact pressure. The contact pressure securing means is represented very schematically in the drawing by the resilient laminated leaf spring construction of the movable contact means 11.

Although illustrated as a single pole circuit breaker, it will, of course be understood that the breaker may be a multipole circuit breaker having a set of contacts 9 and 11 for each pole thereof with the movable contacts mechanically connected for simultaneous operation in the usual manner. The circuit breaker is biased to open circuit position by means of an accelerating spring shown schematically at 15, and the breaker is mechanically connected to the operating mechanism indicated generally at 17 by a suitable connecting means. The connecting means is represented schematically as comprising a lever 19 pivoted at 21 on a fixed support, one end of the lever being pivotally connected to the breaker lift rod 23 and the other end being pivotally connected to an operating rod 25 which is, in turn, mechanically connected to the operating mechanism 17.

The operating mechanism comprises a main casting 27 which is formed to provide a cylinder 29 closed at the upper end by an integral part of the casting. A closure member 31 is secured to the lower end of the cylinder 29, this closure member having a relatively large port 33 therein open to the atmosphere. An operating or latching lever 35 is pivotally mounted at one end on the casting 27. The operating lever consists of two spaced parallel levers 37 which are pivotally connected at one end by means of a pivot pin 39 to the upper end of a pair of links 41 (only one being shown) pivotally mounted on the main casting 27. The free end of the levers 37 comprising the operating lever are connected by a cross member and carry a short shaft 45 therebetween on which is rotatably mounted a latching roller 47 disposed between the levers 37. The breaker operating rod 25 is pivotally connected by a pivot pin 49 to the mid-point of the operating lever 35, the pivot pin extending transversely through the levers 37 and engaging an opening in the lower end of the rod 25. The breaker operating lever is adapted to be held in closed position to hold the breaker closed by means of the high speed latching mechanism comprising a main latch 51 which is pivoted on the main casting 27 by a pivot pin 53. The latch 51 is adapted to extend between the parallel levers 37 and its latch end is adapted to engage and restrain the latching roller 47 carried by the free end of the operating lever 35. The latch 51 is biased to latching position by means of a spring pressed plunger 57. A stop 55 limits clockwise movement of the latch 51. An auxiliary latch 67 is provided for normally engaging and holding the main latch 51 in latching position. The auxiliary latch 67 is pivoted on the casting 27 by a pivot pin 69 and has a latch projection 71 adapted to engage under a projection 73 of the latch 51. A spring 75 biases the auxiliary latch 67 to latching position. The auxiliary latch is provided with a projection 77 which extends directly over the upper end of the trip plunger 79 of an electromagnetic trip device 81.

The trip device 81 comprises, in addition to the trip plunger 79, an E-shaped core 83 of magnetic material, an energizing winding 85 mounted on the center leg of the core and the movable armature 87 cooperating with the core 83. The trip plunger 79 is secured to the center portion of the armature 87, and slidably extends upwardly through a guide opening in the center leg of the core 83 and through an opening in the horizontal portion of the main casting 27. A spring 89 biases the armature 87 downwardly to unattracted position.

When the trip device 81 is energized, the armature 87 thereof is moved upwardly against the core 83 causing upward movement of the trip plunger 79. This upward movement of the trip plunger moves the auxiliary latch 67 counterclockwise and disengages the projection 73 of the main latch 51 whereupon the accelerating spring 15 of the circuit breaker moves the breaker to open position, the operating lever 35 being rotated counterclockwise about its pivoted end by the opening movement of the breaker. During the initial opening movement of the operating lever 35, the roller 47 pushes the main latch 51 in a counterclockwise direction as it clears the latch. In order to prevent the auxiliary latch 67 from returning to latching position until the breaker lever 35 is returned to closed position, there is provided a U-shaped balance lever 95, the legs of which are pivotally mounted on the extending ends of the pivot pin 69 on opposite sides of the auxiliary latch 67. The balance lever 95 is biased counterclockwise by a compression spring 97 which is seated in a recess in the casting 27 and engages the under side of a projection 99 of the balance lever. A cross member 101 on the free end of the balance lever 95 is disposed directly beneath the free end of the operating lever 35 so that the balance lever will be held down in an inoperative position when the operating lever 35 is in closed and latched position. However, when the operating lever 35 is released, the balance lever 95 is rocked counterclockwise and the portion 99 thereof engages and holds the auxiliary latch 67 in unlatching position until the breaker operating lever 35 is returned to its closed position and its roller has become reengaged under the latch face of the main latch 51. For this purpose, the biasing spring 97 is stronger than the auxiliary latch spring 75.

An operating piston 103 is reciprocably movable within the operating cylinder 29, and this piston has a piston rod 107 which slidably extends in a fluid-tight manner through an opening provided therefor in the top wall of the cylinder 29. The upper end of the piston rod 107 has a connecting element 109 threadedly connected thereto which is pivotally connected to the pivot pin 49 carried by the operating or latching lever 35. Thus the operating piston 103 is mechanically connected directly to the circuit breaker operating rod 25.

The operating piston 103 is adapted to be moved downwardly in the cylinder 29, to close or automatically reclose the circuit breaker, by compressed air from an auxiliary air reservoir or tank 111, the compressed air being admitted to the upper end of the cylinder 29 through an inlet passage 112 controlled by a main inlet valve indicated generally at 113. The opening operation of the main inlet valve is controlled by a pilot valve 115 operated by an electromagnet or solenoid 117.

Compressed air is stored and maintained at a predetermined normal pressure in the air reservoir 111 from a large main reservoir (not shown) supplied by a conventional motor driven compressor (not shown).

The inlet valve mechanism is of the same construction as that disclosed in the copending application of J. M. Cumming and R. C. Cunningham, Serial No. 410,686, filed September 13, 1941, and assigned to the assignee of the present invention. The inlet valve 113 comprises a valve housing 119 and a main valve element 121 mounted in the valve housing. The main valve element 121 is adapted to be operated to open position by an air actuated valve piston (not shown) upon energization of the valve controlling electromagnet 117, and the valve is returned to closed position by spring means (not shown) upon deenergization of the electromagnet 117.

In order to provide for quick reversal of movement of the operating piston 103 and circuit breaker 7 to provide the effect of trip-free operation of the circuit breaker, the mechanism is provided with an air pressure exhaust means similar to that disclosed in the above mentioned copending application, Serial No. 410,686. The air pressure exhaust means causes quick collapse of air pressure in the operating cylinder above the piston 103 whenever the trip device 81 is operated so as to dump the pressure air to atmosphere and thereby permit quick opening of the circuit breaker. The air pressure exhaust means is fully disclosed in the aforementioned copending application Serial No. 410,686 and comprises air pressure exhaust ports 123 formed in the side of the operating cylinder 29 which are adapted to be connected to atmosphere by a main exhaust valve (not shown). The main exhaust valve is automatically opened by the air pressure above the operating piston 103 when a pilot valve 125 is opened in response to operation of the trip device 81. The exhaust ports 123 are of larger size than the compressed air inlet passage 112 so that the breaker will be opened quickly upon operation of the trip device 81 even though the main inlet valve may be open and admitting compressed air to the cylinder at the time the trip device is operated. Thus the breaker is trip free of the closing means.

The compressed air operating means is operable to produce normal closing operations of the circuit breaker starting from the full open position of the breaker, and is also operable to effect quick automatic reclosing operations of the breaker wherein the reclosing movement is initiated at an intermediate point in the opening stroke of the breaker after the circuit is interrupted but before the breaker reaches full open position. The control circuits for controlling the operation of the inlet valve electromagnet 117 and the trip device 81 are preferably the same as the control circuits disclosed in the aforementioned copending application Serial No. 410,686. These control circuits have not been shown in this application as they are unnecessary for a complete understanding of the present invention. It is believed sufficient to state that the tripping electromagnet 81 is energized in response to an overload or short circuit in the main circuit, and also by a manual trip control switch. For quick automatic reclosing operations, the inlet valve controlling electromagnet 117 is automatically energized by an auxiliary switch at an intermediate point in the opening stroke of the breaker to cause the inlet valve to admit compressed air to the operating cylinder at this time. The auxiliary switch is

adjustable so that regular automatic reclosing operation from the full open position may be obtained if desired. The electromagnet 117 may also be energized by a manual closing control switch to effect closing operation of the circuit breaker from the full open position of the breaker. Reference may be had to the aforementioned copending application, Serial No. 410,686 for the details of the control circuits for accomplishing the above operations.

An automatic throttle device is provided which is effective to throttle the flow of compressed air to the operating cylinder a predetermined amount during the first part of the closing stroke of the operating piston on closing operation of the circuit breaker started from the full open position, and which is automatically operated to an open or non-throttling position during the latter portion of the closing stroke to permit compressed air to flow to the operating cylinder at an increased rate during the final portion of the closing stroke. Compressed air is admitted relatively slowly by the throttle during the first part of the closing operation thus decreasing the tendency of the operating mechanism to slam. A larger quantity of compressed air is admitted to the operating cylinder by the throttle during the final portion of the closing stroke thereby providing sufficient driving power to overcome the relatively heavy contact load imposed by the contact pressure spring means during the final portion of the closing stroke. The throttle means is also constructed so that it will remain in wide open position during the major portion of the opening stroke of the operating piston and during quick reclosing operations, thereby admitting the larger quantity of compressed air necessary to quickly reverse the movement of the circuit breaker and quickly reclose the same.

The automatic throttle means comprises a cylindrical piston shaped valve element 131 slidably mounted in a vertically disposed cylindrical recess 133 which crosses the inlet air passage 112 in the inlet valve housing 119. A closure cap 135 is secured in the upper end of the cylindrical recess 133 for closing the upper end of this recess. The valve element 131 is threadedly mounted on the central portion of a rod 137 which slidably extends in a fluid-tight manner through openings provided therefor in the closure member 135 and in the bottom of the valve housing 119. The valve element 131 is secured in mounted position on the rod 137 by a retaining pin (not shown). The upper end of the rod 137 is threadedly connected to a U-shaped connecting element 139, a lock nut 141 being provided to secure the connection. The valve element 131 is adapted to be actuated to a throttling position and to an open or non-throttling position by a snap acting spring toggle comprising a pair of rods or links 143 and 145 having U-shaped rod ends 147 which are pivotally connected together and to the connecting element 139, by a pivot pin 149 which forms the knee of the actuating toggle. The free ends of the toggle rods 143 and 145 slidably extend through enlarged openings provided therefor in a pair of supporting arms 151 which are secured to the closure member 135. A compression spring 153 is mounted on each toggle rod and disposed in compression between the rod head 147 and supporting arm 151 of the rod.

The valve element 131 is adapted to be actuated to its throttling position shown in Fig. 1 during the latter part of the opening stroke of the breaker and operating piston, and actuated downwardly to its open or non-throttling position during the latter portion of the closing stroke of the breaker operating piston. A link 155 is provided for the purpose of initiating the actuation of the valve element 131 at the proper time. The connecting link 155 is pivotally connected at its lower end to the knee of the actuating toggle by means of the pivot pin 149, and the upper portion of the link is provided with an elongated slot 157 which engages a pin or stud 159 projecting laterally from the breaker operating lever 35. An adjusting screw 161 is threaded into the upper end of the link 155 and the lower end of this screw is adapted to extend into the upper portion of the slot 157. The adjustment of the screw 161 determines the point in the opening stroke of the breaker operating piston at which actuation of the valve element 131 to its throttling position will be initiated. An adjustable collar 163 may be mounted on the link 155 adjacent the lower end of the slot 157 to determine the point at which actuation of the valve element 131 to its open position will be initiated.

Adjustment of the throttling position, that is, the degree of throttling of the valve 131 is accomplished by means of a pair of lock nuts 165 which are threaded on the extending lower end of the valve rod 137. These lock nuts act as an adjustable stop to determine the upper or throttling position of the valve element 131. Adjustment of the open or non-throttling position of the valve element 131 is accomplished by means of a pair of lock nuts 167 which are threaded on the upper portion of the valve rod 137. These lock nuts 167 limit the amount of downward movement of the valve element 131 and thus determine the size of the air opening provided in the open position of the valve element 131. The inlet air passage 112 is of general triangular shape, as shown by the dotted lines in Fig. 2, so as to provide for a maximum range of adjustment of the throttle opening provided by the valve element 131 in the throttle position thereof. In the position of the parts shown in Figs. 1 and 2, the valve element 131 provides a relatively high degree of throttling since only the apex of the triangular shaped inlet passage 112 is uncovered by the valve element in the throttling position thereof. If the lock nuts 165 are backed off, the size of the throttle opening will be increased and if the lock nuts are screwed upwardly on the rod the size of the throttle opening will be decreased.

The operation of the mechanism is briefly as follows: When the circuit breaker is in the full open position, as shown in Fig. 1, the throttle valve element 131 is maintained in the throttling position as shown, in which it will act to throttle the flow of compressed air to the upper end of the cylinder a predetermined amount. To close the circuit breaker, the inlet valve controlling electromagnet 117 is energized. Energization of the electromagnet 117 opens the pilot valve 115 and thereby causes opening of the main inlet valve 121. Upon opening of the main inlet valve 121 compressed air flows through the inlet passage 112 into the upper end of the operating cylinder 29 and moves the operating piston 103 downwardly to closed position to effect closing of the circuit breaker. During the first part of the closing stroke, the throttle valve 131 is maintained in throttling position in which it throttles the flow of compressed air to the cylinder a predetermined amount admitting air to the operating cylinder relatively slowly. Shortly

before the contacts of the circuit breaker touch, the projecting pin 159 will engage the bottom of the slot 157 in the link 155 and thereby initiate actuation of the throttle valve 131 to its open position. As soon as the knee pin 149 of the actuating toggle is moved downwardly through the dead-center position, the spring toggle actuates the valve element 131 downwardly to its open position with a snap action, thus the valve element 131 is actuated to open throttle position during the latter portion of the closing stroke of the breaker operating piston and allows the compressed air to flow at an increased rate into the operating cylinder and thereby provide a relatively large driving force during the final portion of the closing stroke of the operating piston. When the circuit breaker reaches the fully closed position, the latching roller 47 is engaged under the main latch 51 and the breaker is held latch closed by the latching mechanism. As soon as the breaker reaches the fully closed position, the valve controlling electromagnet 117 is deenergized and the main inlet valve 121 returns to closed position shutting off the flow of compressed air to the operating cylinder 29.

If an overload or short circuit occurs in the circuit controlled by the circuit breaker, the trip device 81 will be immediately energized and the trip plunger 79 thereof quickly moved upwardly to effect release of the latching mechanism and at the same time opening of the exhaust pilot valve 125. The release of the latching mechanism comprising the auxiliary latch 67 and main latch 51 permits the circuit breaker to be moved quickly to open position by its accelerating spring 15. The opening of the exhaust pilot valve 125 will cause the main exhaust valve to open if there is any substantial air pressure in the operating cylinder above the piston 103, to thereby dump the air to atmosphere through the exhaust ports 123.

If the circuit breaker is set for quick automatic reclosing operation, the inlet valve controlling electromagnet 117 will be automatically energized early in the opening stroke of the circuit breaker thereby causing the inlet valve 121 to open and admit compressed air to the operating cylinder during the opening movement. The throttle valve 131 remains in the open or non-throttling position during the major portion of the opening stroke and hence will be in open position at the time compressed air is admitted for quick reclosing and will remain open during the quick reclosing operation. This is due to the length of the slot 157 in the connecting link 155. Since the throttle valve 131 is in the open throttle position a large quantity of compressed air will be admitted to the operating cylinder and the compressed air will quickly reverse the movement of the operating piston and initiate the reclosing movement of the operating piston at an intermediate point in the opening stroke before the circuit breaker reaches full open position. The reclosing movement proceeds and if the fault or overload condition which caused the initial opening has been cleared, the circuit breaker will be driven to the fully closed position and relatched. The inlet valve controlling electromagnet 117 will be deenergized and the inlet valve 121 returned to closed position when the breaker reaches the fully closed and latched position. However, if the overload or fault condition is still present at the time the circuit breaker contacts reach the touch position during the reclosing movement, the trip device 81 will be immediately energized in response to the overload condition and will retrip the breaker by releasing the latching mechanism and simultaneously opening the exhaust pilot valve 125. The opening of the exhaust pilot valve 125 will cause the main exhaust valve to open and dump the closing air from the operating cylinder to atmosphere so that it will not retard the opening movement of the circuit breaker.

The circuit breaker may be manually tripped by means of the manual trip control switch which effects energization of the trip device 81. The circuit breaker will be moved quickly to the full open circuit position and during the latter part of the opening movement shortly before the breaker reaches its full open position, the projecting pin 159 on the breaker operating lever 35 will engage the adjusting screw 161 adjacent the end of the slot 157 and initiate actuation of the throttle valve element 131 to its throttling position shown in Fig. 1. The snap action toggle will thereby be caused to move to its upper over-center position shown moving the valve with a snap action to its throttling position. The mechanism is now ready for a normal closing operation.

From the foregoing, it will be seen that the automatic throttle valve 131 causes the flow of compressed air to the operating cylinder to be throttled a predetermined amount during the first part of each closing operation started from full open position, and the throttle valve is automatically opened during the latter part of the closing stroke of the operating piston thereby admitting a large quantity of air to the upper side of the operating piston during the final portion of the closing stroke. The throttle valve remains in the open throttle position during the major portion of the opening stroke of the operating piston and during quick reclosing operations, due to the elongated slot 157 in the connecting link 155, so that an increased quantity of air will be admitted to the operating cylinder on quick reclosing operations.

The compressed air circuit breaker operating means as thus far described in detail above is the same as disclosed in the aforementioned copending application of H. L. Peek, Serial No. 445,733, and the same reference characters have been used to designate the corresponding parts. In some cases quick (fractional stroke) automatic reclosing may not be desired. In such instance the auxiliary switch (not shown but disclosed in the aforementioned copending application of J. M. Cumming and R. C. Cunningham Serial No. 410,686) which effects energization of the inlet valve controlling electromagnet 117 and initiates the reclosing operation, may be adjusted to close when the breaker reaches the full open position so that automatic reclosing movement of the breaker will be initiated shortly after the breaker reaches the full open position. In this instance the automatic throttle valve functions in the same manner as on normal closing operation as previously described.

In accordance with the present invention a means is provided, responsive to the pressure of the air in the air reservoir 111, for automatically changing the size of the throttle opening provided by the automatic throttle valve as the pressure of the air in the reservoir changes. The pressure responsive device serves to automatically open the throttle valve wider as the pressure in the reservoir decreases, and returns the throttle valve to the normal throttle position when

the air pressure in the reservoir is returned to normal.

Referring to the drawing the pressure responsive device comprises an annular expandable and contractable metal bellows 171 disposed in a circular recess 173 in the bottom of the valve housing 119. The bellows is secured to a closure plate 175 which is in turn secured to the valve housing over the bottom of the recess 173. A movable sleeve shaped stop member 177 is slidably mounted on the throttle valve rod 137 in the recess 173, the lower end of the stop member slidably extending through an opening provided in the bottom closure plate 175. The upper end of the member 177 has a circular flange 179 the under side of which is rigidly secured to the top of the annular metal bellows 171 so that the stop member is movable by the bellows. The bellows is constructed of resilient material and formed so that it normally tends to assume a collapsed position due to the resiliency of the material and the corrugated shape of the bellows. A small diameter pipe 181 connects the interior chamber of the bellows to the interior of the compressed air reservoir 111 so that the bellows, which is of air tight construction, is thus made responsive to the pressure in the air reservoir 111.

The lower end of the sleeve shaped stop member 177 is engageable by the lock nuts 165 on the lower end of the throttle valve rod 137 and thus acts as a movable stop to limit the upward movement of the throttle valve and thereby determine the throttling position of the valve and hence the size of the throttle opening for any given adjustment of the lock nuts 165.

As previously described a supply of compressed air is maintained in the air reservoir 111 at a predetermined normal pressure from a large reservoir tank supplied by a conventional automatic compressor unit (not shown). The normal air pressure will depend of course on the size of the mechanism, for example, an air reservoir pressure of 150 pounds per square inch has been found suitable for a mechanism having an 8 inch diameter piston. With the normal air pressure in the tank 111, the lock nuts 165 are initially adjusted to give the proper size throttle opening so that the mechanism will not slam on closing operations started from the full open position, and the lock nuts 167 are adjusted so that an ample quantity of air will be admitted during the latter portion of the closing stroke, and for quick reclosing operations if quick reclosing is desired.

If the air pressure in the reservoir 111 decreases any substantial amount from the normal value, due to some defect or failure of the compressor, the pressure responsive bellows contracts proportionally and moves the stop member 177 downwardly as the pressure decreases. This movement of the stop member is transmitted through the lock nuts 165 and the valve rod 137 causing downward movement of the throttle valve 131 thereby increasing the size of the throttle opening. Thus the valve 131 is opened wider as the air pressure in the reservoir decreases thereby admitting compressed air at a faster rate at the lowered pressure than it does at higher pressures. As a result the speed of operation of the mechanism is maintained substantially constant despite a decrease in available air pressure. As the pressure builds back up to normal value the bellows expands and allows the throttle valve 131 to be returned by the spring toggle to its normal throttling position. The device will not only tend to maintain the normal operating speed but it will also increase the number of operations possible at a given reservoir pressure.

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 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 interpretation permissible in the light of the prior art.

We claim as our invention:

1. In combination, a circuit breaker, compressed gas operating mechanism for operating said circuit breaker, a gas pressure supply system for supplying compressed gas to actuate said operating mechanism, means for controlling the rate of flow of compressed gas to said mechanism, actuating means for said rate controlling means controlled in response to predetermined movements of said circuit breaker, and pressure responsive means connected to said supply system for automatically controlling said first mentioned means in response to changes in gas pressure of said supply system.

2. In combination, a circuit breaker, compressed gas operating mechanism for operating said breaker, a gas pressure supply system for supplying compressed gas to actuate said operating mechanism, means including a variable orifice means controlled by predetermined movement of said circuit breaker for controlling the rate of flow of gas to said operating mechanism, and pressure responsive means connected to said gas pressure supply system for automatically increasing the flow area of said variable orifice means in response to reduction in gas pressure of said supply system.

3. In combination, a circuit breaker, compressed gas operating mechanism for operating said circuit breaker, a gas pressure supply system for supplying compressed gas to actuate said operating mechanism, means comprising a valve for automatically controlling the rate of flow of compressed gas to said operating mechanism in response to predetermined operations of said mechanism, a movable stop member for determining one of the positions of said valve, and pressure responsive means connected to said supply system for automatically moving said stop member in response to changes in pressure of said supply system.

4. A circuit breaker operating means of the compressed air type comprising a cylinder, a piston in said cylinder for operating the breaker, an air pressure supply system for supplying compressed air to actuate said piston, means including an automatic valve for controlling the rate of flow of compressed air to said cylinder, actuating means for said valve controlled in response to predetermined movements of said breaker and means movable in response to changes in the air pressure of said supply system for controlling the position of said valve.

5. In combination, a circuit breaker movable to open and to closed circuit position, compressed gas operating mechanism for operating said breaker to closed circuit position, a gas pressure supply system for supplying compressed gas to said operating mechanism to effect closing of said circuit breaker, means including an automatic

valve for controlling the rate of flow of compressed gas to said operating mechanism, actuating means for said valve operable to actuate said valve from one position to an open position during the latter part of a closing stroke of said operating mechanism started from full open position of the breaker, and means responsive to the gas pressure of said supply system for automatically changing the flow area in said one position of said valve in response to changes in gas pressure of said supply system.

6. In combination, a circuit breaker movable to open and to closed circuit position, compressed gas operating mechanism for operating said breaker to closed circuit position, a gas pressure supply system for supplying compressed gas to said operating mechanism to operate the breaker, means including an automatic valve for controlling the rate of flow of compressed gas to said operating mechanism, actuating means for said valve operable to actuate said valve from one position to an open position during the latter portion of a closing stroke of said mechanism started from full open position of the breaker, and operable to actuate said valve to said one position during the latter portion of the opening stroke of the operating mechanism, and pressure responsive means connected to said supply system for automatically moving said valve in opening direction in response to decrease in air pressure of said supply system.

7. In combination, a circuit breaker movable to open and to closed circuit position, compressed gas operating mechanism for operating said breaker to closed circuit position, a gas pressure supply system for supplying gas to said mechanism to close the breaker, means including an automatic valve for controlling the rate of flow of compressed gas to said mechanism, actuating means for said valve controlled in response to predetermined movements of the breaker and operable at times to automatically actuate said valve from one position to an open position independently of changes in pressure in said supply system, and means movable in response to reduction in gas pressure of a portion of said supply system for automatically actuating said valve toward open position to insure an adequate rate of supply of compressed gas to operate said mechanism.

8. In combination, a circuit breaker movable to open and to closed circuit position, compressed gas operating mechanism for operating said breaker to closed circuit position, a gas pressure supply system for supplying compressed gas to said mechanism to close the breaker, an automatic throttle valve for controlling the rate of flow of compressed gas to said mechanism, actuating means for said valve controlled by said circuit breaker operating mechanism, said valve actuating means operating at times to automatically actuate said valve from a throttling position to a wide open position, and pressure responsive means connected to said supply system for automatically changing the throttling position of said valve in response to changes in gas pressure of said supply system.

9. In combination, a circuit breaker movable to open and to closed circuit position, compressed gas operating mechanism for operating said breaker to closed circuit position, a gas pressure supply system for supplying compressed gas to said mechanism to close the breaker, an automatic throttle valve for controlling the rate of flow of compressed gas to said mechanism, actuating means for said valve operable in response to predetermined movements of said breaker to automatically actuate said valve from a throttling position to a wide open position, and pressure responsive means connected to said supply system for automatically increasing the throttle opening provided by said valve in response to decrease in gas pressure of said supply system.

10. In combination, a circuit breaker, compressed gas operating mechanism operable to close the breaker, a compressed gas supply system for supplying gas under pressure to said mechanism to operate the mechanism, means operative to admit compressed gas to said mechanism for a portion of said supply system at a predetermined rate during the first part of the closing stroke of the mechanism and at an increased rate during the latter portion of the closing stroke, and means responsive to a decrease in gas pressure in said portion of the supply system to automatically provide for admitting compressed gas to said mechanism at a rate that is greater than would be obtained from said portion of the supply at the reduced pressure in the absence of said pressure responsive means.

11. A compressed gas operating mechanism for a circuit breaker comprising an operating cylinder, a piston in said cylinder for operating the breaker, a compressed gas supply system for supplying gas under pressure to said cylinder to operate said piston, means operative in response to predetermined movements of said breaker to at times change the rate at which gas under pressure is supplied to said cylinder, and means responsive to a decrease in gas pressure in said supply system to automatically provide for an increased rate of flow of compressed gas to said cylinder over that which would be obtained from the supply system at reduced pressure.

12. In combination, a circuit breaker, compressed gas operating means for operating said circuit breaker, a compressed gas supply system for supplying gas to said mechanism to operate the breaker, means for automatically controlling the rate of flow of gas to said mechanism in response to predetermined movements of said circuit breaker, and means responsive to changes in gas pressure in a portion of said supply system for automatically changing the rate at which compressed gas will be supplied to said mechanism to compensate for the variation in pressure of gas in said portion of the system.

13. In combination, a circuit breaker, compressed gas operating mechanism for operating said circuit breaker, a compressed gas supply system for supplying gas under pressure to said mechanism to operate the breaker, means for controlling the flow of compressed gas to said mechanism including means operative in response to predetermined movements of said breaker for at times changing the rate at which gas is supplied to said mechanism, and means responsive to a decrease in gas pressure in a portion of said supply system for providing for an increased supply of gas to said operating means over what would be obtained from said portion of the system at decreased pressure.

14. In combination, a circuit breaker, compressed gas operating mechanism for operating said circuit breaker, a compressed gas supply system for supplying gas under pressure to said mechanism to operate the breaker, means for controlling the flow of compressed gas to said cylinder including means operative in response to predetermined movements of said breaker for at times changing the rate at which gas is supplied to said cylinder, and means responsive to changes

in gas pressure in a portion of said compressed gas supply system for automatically controlling the flow of compressed gas to said operating mechanism to cause substantially the same driving force to be applied to said mechanism as when the pressure of said portion of the supply system was at normal value.

15. In a fluid pressure operated mechanism for a circuit breaker, in combination, operating means including a cylinder having a piston mounted therein for closing said breaker, a source of supply of fluid under pressure, means including a communication connecting said source to said cylinder, throttling valve means interposed in said communication and operative upon occurrence of a given condition for restricting the flow of fluid to said cylinder, and means responsive to the pressure of fluid in said supply source for rendering said throttling valve ineffective to restrict said supply communication.

16. In a fluid pressure operated mechanism for a circuit breaker, in combination, operating means including a cylinder having a piston mounted therein for closing said breaker, a source of supply of fluid under pressure, means including a communication connecting said source to said cylinder, throttling valve means interposed in said communication and operative upon occurrence of a given condition for restricting the flow of fluid to said cylinder, and means operative upon a predetermined decrease in the pressure of fluid in said supply source for rendering said throttling valve ineffective to restrict said supply communication.

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