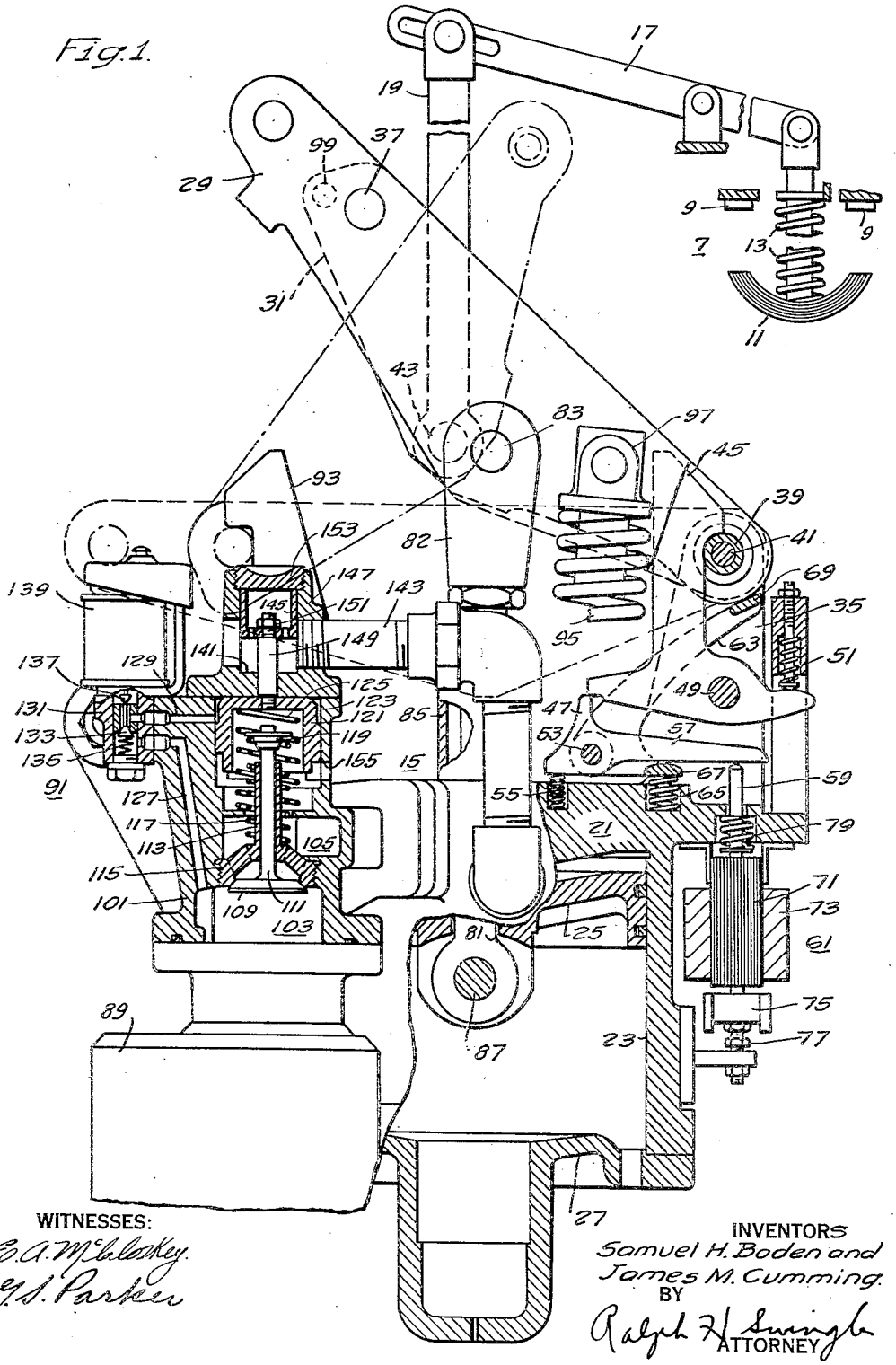
Nov. 19, 1946. S. H. BODEN ET AL 2,411,360

CIRCUIT BREAKER

Filed Aug. 26, 1943 2 Sheets-Sheet 1

Fig. 1.



WITNESSES:

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CIRCUIT BREAKER

Filed Aug. 26, 1943 2 Sheets-Sheet 2

Fig. 2.

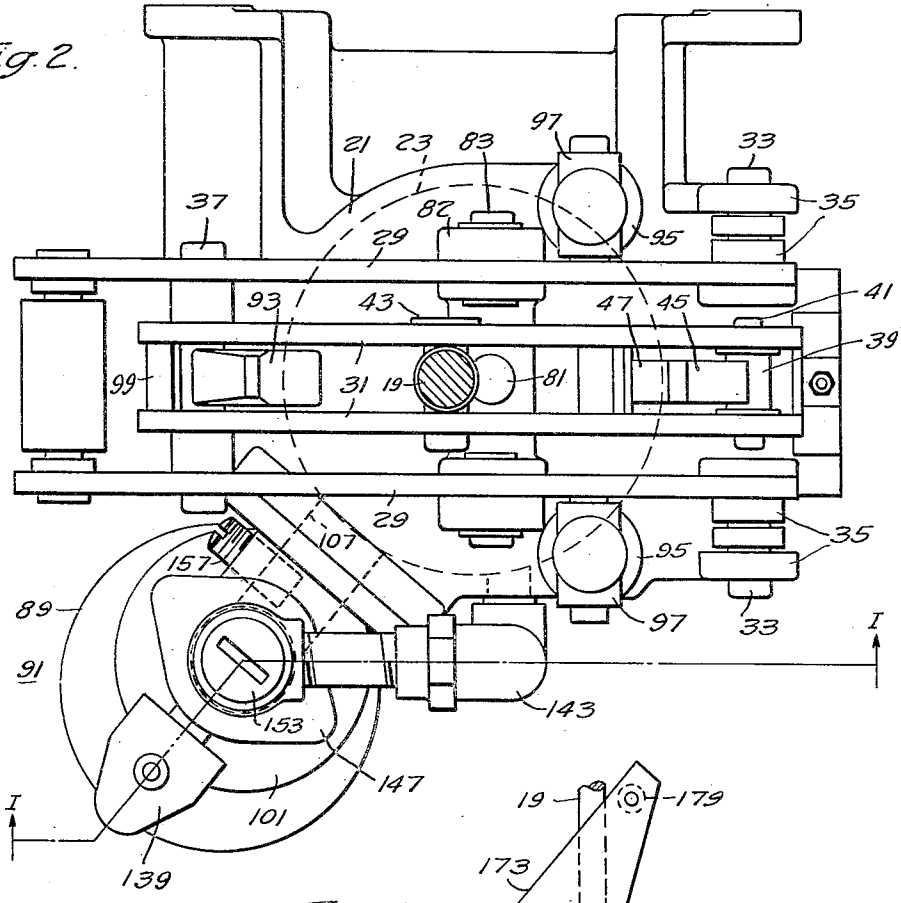
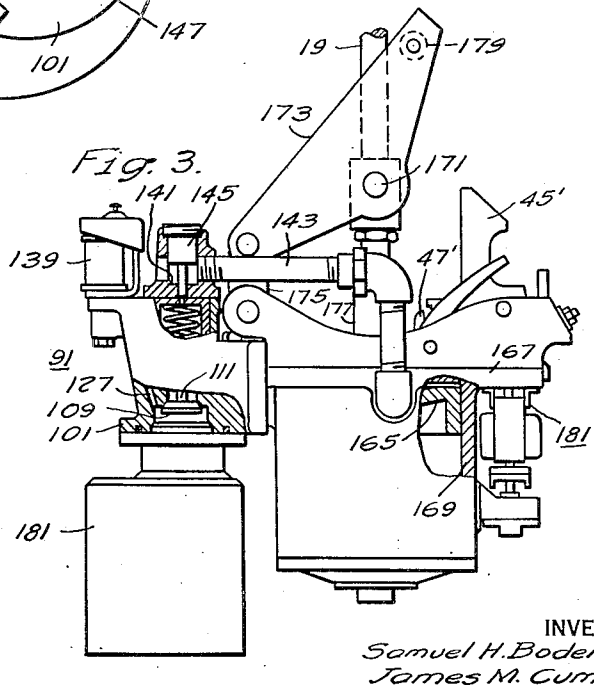


Fig. 3.



WITNESSES:

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Patented Nov. 19, 1946

2,411,360

UNITED STATES PATENT OFFICE

2,411,360

CIRCUIT BREAKER

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Application August 26, 1943, Serial No. 500,062

8 Claims. (Cl. 200—82)

1

The invention relates to circuit breakers and, more particularly, to circuit breaker operating mechanisms of the pneumatic type.

Circuit breakers for electrical power systems are desired which operate at very high speed and in which the motion of the parts can be quickly reversed, in order to obtain quick interruption and also quick reclosing of the electrical circuit. Where an operating mechanism of the pneumatic type is employed for operating the circuit breaker, back fluid pressure in the operating cylinder tends to retard the speed of operation of the operating piston, and to obtain the desired high speed operation and quick reversal of the mechanism some means must be provided for quickly dissipating the back pressure. The valve means for controlling fluid flow should provide for adequate fluid flow and should operate very quickly despite the limitation of small available electrical-control energy. The usual types of three-way valves for admitting fluid pressure to the cylinder and venting the cylinder have not been found satisfactory for pneumatic circuit-breaker operating mechanisms for various reasons. They are too slow in operation, do not provide adequate and rapid exhaust flow, and require too much electrical control energy.

An object of the present invention is the provision of a circuit breaker with an improved operating mechanism of the pneumatic type capable of effecting high-speed operation of the circuit breaker and operating piston and quick reversal of the moving parts.

Another object of the invention is the provision of a circuit-breaker operating mechanism of the pneumatic type with an improved quick-acting intake and exhaust valve device whereby quick response and high-speed operation of the circuit breaker and its operating means are obtained.

Another object of the invention is the provision of a circuit-breaker operating mechanism of the pneumatic type with an improved quick-acting intake and exhaust valve device of simple and inexpensive construction for admitting fluid to the operating cylinder and for also rapidly and fully venting the cylinder to atmosphere to permit high-speed operation and quick reversal of the breaker-operating piston.

Another object of the invention is the provision of a circuit breaker with an improved operating mechanism of the pneumatic type capable of effecting high-speed opening and quick reclosing of the circuit breaker.

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

2

Figure 1 is a view of a circuit-breaker operating mechanism embodying the invention, taken substantially along the section line I—I of Fig. 2, the circuit breaker being shown schematically, and the mechanism being partly broken away and shown in the open-retrieved position,

Fig. 2 is a plan view of the circuit-breaker operating mechanism, the parts being shown in the closed and latched position, and

Fig. 3 is a view, partly in section, showing a modification of the invention wherein the control valve device is applied to a different type of circuit-breaker operating mechanism.

The present invention in certain aspects is a further development and improvement of the invention disclosed and claimed in the copending application of James M. Cumming, Serial No. 499,800, filed August 24, 1943, and assigned to the assignee of the present invention, now Patent No. 2,399,328, issued April 30, 1946.

The invention is illustrated in Fig. 1 as embodied in a circuit-breaker operating mechanism of the mechanically trip-free type wherein the circuit breaker is connected to the operating piston through a trip-free structure or linkage which permits the circuit breaker to be tripped open free of the operating piston.

Referring to Figs. 1 and 2 of the drawings, the circuit breaker itself, represented very schematically at 7, may be of any conventional type and construction either of the oil break, air break or gas blast type. As schematically shown, the circuit breaker comprises stationary contact means 9, and cooperating movable contact means 11. The circuit breaker is biased to open position by spring means 13, and is connected to the trip-free linkage of the operating mechanism 15 by any suitable connection shown schematically by a pivoted lever 17 and rod 19.

The operating mechanism 15 comprises a metal casting 21 which is formed to provide an operating cylinder 23 and a top portion which closes the upper end of the cylinder and forms a support for some of the parts. An operating piston 25 is reciprocably movable in the cylinder and is adapted to be operated by fluid under pressure, such as compressed air, to effect closing of the circuit breaker. A closure member 27 is

secured to the bottom of the cylinder, this closure member having one or more ports therein open to atmosphere.

Mounted on the top portion of the casting is a trip-free linkage comprising a closing lever 29 pivoted on a fixed pivot on the casting at its right-hand end, and a trip-free breaker lever 31 pivoted at its left-hand end to the free end of the closing lever 29. The closing lever 29 consists of a pair of spaced parallel levers (Fig. 2) which are pivoted at their right-hand ends on a pair of aligned pivot studs 33 carried by lugs 35 projecting from the top of the casting 21. The breaker lever 31 also consists of a pair of spaced parallel levers (Fig. 2) pivoted at their left-hand ends on a pivot pin 37 carried by and connecting the left-hand ends of the parallel levers which form the closing lever 29. The breaker lever 31 is disposed in the space between the sides of the closing lever 29, and the right-hand end of the breaker lever carries a latch roller 39 which is rotatably mounted on a pin 41 carried by and connecting the right-hand end of the spaced levers which form the breaker lever 31.

The circuit-breaker rod 19 is pivotally connected to the midpoint of the breaker lever 31 by a pivot pin 43. The breaker lever 31 is biased upwardly by the opening bias of the circuit breaker, and the latch roller 39 carried by the right-hand end of this lever is normally engaged and held in a position of alignment with the fixed pivot axis 33 of the closing lever, by a high-speed latching means consisting of a main latch 45 of slip-off type and an auxiliary latch 47 which holds the main latch in latching engagement with the roller 39, both latches being pivotally mounted on the top of the casting 21. The main latch 45 is pivoted on the top portion of the casting by a pivot pin 49 and is biased to latching position by a spring means 51. The auxiliary latch 47 is pivoted on the top portion of the casting by a pivot pin 53 and this latch is biased by a spring 55 to latching position in which it engages and holds the main latch 45 in latching position. The auxiliary latch 47 is provided with an extension 57 which extends directly over a trip plunger 59 of an electro-magnetic trip device 61.

A holding lever 63, pivoted on the pivot pin 53, is provided for holding the auxiliary latch 47 in released position when the latch roller 39 on the breaker lever is away from latched position in order to permit the roller to push back and pass the latch end of the main latch when the breaker lever is retrieved to its latching position. This holding lever is biased counterclockwise by a spring 65, stronger than the spring 55, and the lever is provided with a lateral projection 67 disposed under the extension the auxiliary latch 47. The lever also has a lateral projection 69 disposed to be engaged by the end of the breaker lever 31 to hold the holding lever down in the inoperative position shown when the latch roller 39 is in latched position.

The trip device 61 is supported from the top portion of the casting 21 and comprises an E-shaped stationary core 71, an energizing winding 73 disposed around the center leg of the core, and a movable armature 75 connected to the trip plunger. The trip plunger 59 slidably extends upwardly through an opening in the center leg of the core and through an opening in a portion of the casting 21. The trip plunger and armature are biased downwardly to unattracted position against a stop screw 77, by means of a spring 79. The trip device is adapted to be energized

to trip the circuit breaker, by a suitable trip control circuit (not shown) of any conventional type upon the occurrence of an abnormal condition in the main circuit, such as an overload or short circuit condition, and also by a manual trip control switch.

When the latch roller 39 on the end of the breaker lever 31 is held latched by the latching means 45—47, the breaker lever is operatively connected to the closing lever 29 so that the two levers are rigidly connected together. The closing lever 29 is connected to the operating piston 25 by a connecting rod 81 which is pivotally connected at its upper end to the midportion of the closing lever 29 by a yoke-shaped connecting element 82 and a pivot pin 83. The connecting rod extends through an integral sleeve 85 of the piston, which slides through an opening in the top of the cylinder 23. The lower end of the connecting rod is pivotally connected to the piston 25 by a cross pin 87.

The circuit breaker is adapted to be closed and automatically reclosed by compressed air from an auxiliary air reservoir or tank 89, the compressed air being admitted into the upper end of the operating cylinder 23 by a control valve device indicated generally at 91 which will be hereinafter described. The compressed air drives the piston 25 downwardly rotating the closing lever 29 and connected breaker lever 31, about the fixed pivot axis of the pivots 33 and roller shaft 41, down to the closed position indicated by the dotted outline of the closing lever, thereby closing the circuit breaker. In the closed position, the closing lever 29 is held latched down by a latch 93 pivoted on the top portion of the casting by a pivot (not shown). The latch 93 engages the cross pin 37 on the closing lever to hold the closing lever down in closed position, this latch being biased to latching position by a spring (not shown).

The closing lever is biased in a clockwise direction about its fixed pivots 33 by means of a pair of helical retrieving springs 95 of compression type which are pivotally connected by connecting elements 97 at their upper ends to the sides of the closing lever 29 and bear at their lower ends in spring seats on the top portion of the casting 21. The retrieving springs serve to move the closing lever 29 up to the position shown in full lines in Fig. 1 after release of the levers; in order to rotate the breaker lever clockwise about the pivot connection 43 to return the latch roller end of the breaker lever to latching position as shown in Fig. 1. The mechanism is shown in the retrieved position in Fig. 1.

Assuming the circuit breaker is in closed position with the closing lever 29 held down by the latch 93 and the breaker lever 31 held down by the latch means 45—47, the trip device 61 will be energized upon the occurrence of an overload or short circuit in the main circuit and cause the trip plunger to be moved upwardly to release the latches 47 and 45. This releases the operative connection between the breaker lever 31 and the closing lever 29 and consequently the circuit breaker will be quickly moved to open position by the opening spring 13, free of any restraint by the closing lever and piston. The opening movement of the circuit breaker causes the breaker lever 31 to rotate counterclockwise about the pivot pin 37 towards the open position indicated by the dot-dash outline in Fig. 1. The breaker lever during the early part of its counterclockwise opening movement automatically moves the latch

93 to released position by means of a pin 99 on the breaker lever which engages and moves the latch 93 to released position as the lever 31 moves in opening direction. When the free end of the closing lever 29 is thus released, the retrieving springs immediately rotate the closing lever in a clockwise direction to the position shown by the full lines in Fig. 1. This retrieving movement rotates the breaker lever clockwise about the pivot 43 restoring the latch roller on the breaker lever back to latched position where it is re-engaged by the latch means 45—47. The linkage is thus reset with the breaker lever 31 again operatively connected to the closing lever 29 and piston 25 so that the mechanism is now in condition to reclose the breaker.

The operating mechanism is operable to produce normal closing operation of the circuit breaker and also instantaneous automatic reclosing operation of the circuit breaker, by means of a suitable control circuit (not shown) of conventional type for energizing the control electromagnet of the control valve device 91. The control circuit for controlling energization of the valve electromagnet and the trip coil 73 may be similar to the circuit breaker control circuit disclosed in the copending application of James M. Cumming and Richard C. Cunningham, Serial No. 410,686, filed September 13, 1941, now Patent No. 2,408,199, issued September 24, 1946, except that a conventional latch-checking switch (not shown) would be added in series in the closing control circuit to prevent energization of the electromagnet of the control valve device 91 until the latch roller 39 of the breaker lever 31 is in latched position. This latch checking switch can be closed by the latch roller end of the breaker lever 31 when this end of the lever is in latched position.

Compressed air for operating the circuit breaker is stored in the air reservoir 89 from a large main air-storage tank (not shown) which is supplied by a suitable motor-driven compressor unit (not shown).

In accordance with the present invention, the operating mechanism is provided with an improved control valve device 91 for admitting compressed air to the operating cylinder 23 to effect closing and automatically reclosing operations of the circuit breaker, and for also rapidly and fully venting the operating cylinder directly to atmosphere to permit high-speed unretarded movement of the operating piston in the reverse direction. The control valve device 91, by rapidly and fully venting the operating cylinder directly to atmosphere in the Fig. 1 embodiment, permits the operating piston 25 to be moved upwardly at high-speed by the retrieving springs, unretarded by back air pressure in the cylinder. Consequently, very fast retrieving of the mechanism is obtained to quickly reestablish the operative connection between the circuit breaker and the operating piston. As a result, reclosing operation of the circuit breaker can be initiated very quickly after interruption of the circuit, and the total time required for opening and reclosing the circuit breaker is materially reduced.

The control-valve device 91 comprises a valve housing 101 which is secured to the side of the main-cylinder casting 21 by a plurality of bolts (not shown). The valve housing has a chamber or opening 103 which communicates with the interior of the compressed air-storage tank 89, and also has a somewhat flat rectangular-shaped inlet passage 105 communicating with an inlet port 107

(Fig. 2) formed in the upper end of the circuit-breaker operating cylinder 23. The flanged neck of the air-storage tank 89 is secured to the valve housing 101 by a plurality of bolts (not shown), a suitable sealing gasket being provided to make the joint air-tight. A main inlet valve element 109 disposed in the valve housing has a stem 111 slidably mounted in a guide sleeve 113 carried by a bushing 115. The bushing is threaded in an opening in the housing between the chamber 103 and the inlet passage 105, and this bushing serves as a valve seat for the inlet valve 109. The guide sleeve 113 is connected to the bushing by a plurality of spider-arms which permit the compressed air to flow when the valve is opened. The inlet valve element is biased to closed position to close off the inlet passage from the source of compressed air by a helical compression spring 117 which surrounds the guide sleeve, the lower end of the spring bearing on the spider arms of the bushing 115 and the upper end of the spring bearing against a spring support 119 secured to the upper end of the valve stem. The inlet valve element is adapted to be opened by means of a valve piston 121 to open the inlet passage and admit compressed air to the upper end of the circuit-breaker operating cylinder 23 to effect closing or automatic reclosing of the circuit breaker. The valve piston 121 is movable in a valve cylinder 123 formed in a valve housing and this piston is biased upwardly to a position against the head of the valve cylinder by means of a helical compression spring 125 which surrounds a portion of the valve spring and is disposed between the underside of the valve piston 121 and a circular shoulder formed in the valve housing.

The valve-operating piston 121 is adapted to be moved downwardly to open the main-inlet valve 109 by compressed air from the tank 89 admitted to the top of the valve piston through passages 127 and 129 in the valve housing. The passages 127 and 129 communicate with cooperating passages in a pilot-valve housing 131 which is secured to the main-valve housing 101. Communication between the air tank 89 and the top of the valve piston 121 is normally shut off, however, by a pilot valve 133 disposed in the pilot-valve housing. The pilot valve is biased to closed position against its seat by a compression spring 135. In this closed position, the pilot valve connects the upper end of the valve cylinder 123 to atmosphere through an exhaust-pilot valve element 137 and an exhaust port in the pilot-valve housing, the exhaust pilot valve being connected by a stem with the pilot valve 133. The pilot valve 133 is adapted to be operated to open position to admit compressed air to the valve-operating piston 121 to cause opening of the main-inlet valve, by means of an electromagnet 139 when the electromagnet is energized.

The control-valve device 91 is also adapted to rapidly and fully vent the breaker operating cylinder 23 directly to atmosphere when the inlet-valve element is closed, in order to facilitate high-speed retrieving movement of the operating piston 25 and fast retrieving of the mechanism unretarded by back pressure in the breaker-operating cylinder. For this purpose, the control-valve device 91 is provided with a large exhaust passage 141 which communicates with the upper end of the circuit-breaker operating cylinder through a pipe connection 143. The passage for the exhaust of air from the operating cylinder through the pipe 143 and exhaust pas-

sage 141 is separate from the inlet passage 105 through which compressed air is admitted to the operating cylinder. The exhaust passage 141 is normally opened to atmosphere by a cup-shaped exhaust-valve element 145 of the sleeve type, and this exhaust-valve element is slidably mounted in a transverse opening provided therefor in a housing section 147 secured to the valve housing 101. The housing section 147 may be formed integral with the housing 101, if desired. The exhaust-valve element 145 is mechanically connected to the top of the valve-operating piston by a rod 149 which slidably extends through an opening in the top wall of the valve cylinder. The lower end of the rod 149 is threadedly connected to the top of the valve piston and the upper end of the rod has a screw-threaded connection 151 to the bottom portion of the exhaust-valve element 145. A screw plug 153 is threaded in an opening in the housing section 147 immediately above the exhaust-valve element 145. This screw plug provides a means for adjusting the open position of the exhaust-valve element 145. The valve 145 is biased to open position by the compression spring 125 which biases the valve-operating piston 121 to its upper position. The single-valve operating piston 121, when moved downwardly by compressed air upon opening of the pilot valve, serves to move the exhaust-valve element 145 to closed position and open the main-inlet valve 109.

The exhaust-valve element 145 and connected actuating piston 121 are movable relative to the inlet valve element 109, a space being provided between the upper end of the valve piston 121 and the top of the inlet-valve stem 111 so that the piston, when operated, will actuate the exhaust valve to closed position prior to opening the inlet valve 109. This prevents wastage of compressed air through the exhaust when the inlet valve opens.

An additional exhaust for the operating cylinder is provided by a plurality of atmosphere exhaust ports 155 provided in the cylinder portion of the valve housing. These atmosphere exhaust ports are opened when the valve piston 121 is in its upper inoperative position, but are closed by the skirt portion of the valve piston as the valve piston moves downwardly to open the inlet-valve element 109.

The rate of flow of compressed air into the circuit-breaker operating cylinder through the inlet passage 105 is adjusted by means of an adjusting screw 157 (Fig. 2) which determines the effective cross-sectional area of the passage through which air is admitted to the operating cylinder. This screw is set to obtain the desired closing speed of the breaker.

The amount of venting of the operating cylinder which takes place back through the inlet passage 105 and out through the exhaust ports 155 alone is insufficient to permit the desired high-speed full venting of the cylinder, due to the necessarily restricted size of the inlet passage and passage through the ports 155. The exhaust passage through the pipe connection 143 and the exhaust valve 145 is relatively large however so that rapid and full venting of the cylinder is obtained.

The operation of the circuit-breaker mechanism is briefly as follows. Assuming the circuit breaker is in open position as shown in Fig. 1, closing of the circuit breaker is effected by energizing the electromagnet 139 of the control-valve device. When the electromagnet is

energized, the pilot valve 133 opens and admits compressed air from the tank 89 to the top of the valve-actuating piston 121. The valve-actuating piston is moved downwardly, closing the exhaust valve 145 and opening the intake valve 109. Compressed air is thereupon admitted from the tank 89 directly into the upper end of the main operating cylinder and drives the operating piston 25 downwardly to the bottom of the cylinder to effect closing operation of the circuit breaker. As soon as the circuit breaker reaches closed position, the electromagnet 109 is deenergized and the pilot valve 133 closes allowing the valve cylinder to be vented to atmosphere whereupon the springs 117 and 125 immediately close the intake valve 109 and open exhaust valve 145 fully venting the circuit breaker operating cylinder to atmosphere.

If there is no fault condition such as an overload or short circuit in the main circuit at the time the circuit is completed by the breaker, the circuit breaker will be latched closed and held closed by the latching means. However, if there is a fault condition such as an overload or short circuit condition at the time the circuit breaker completes the main circuit, the trip device 61 will be immediately energized and effect release of the latching means 45—47 to trip the circuit breaker free of the operating piston 25.

With the circuit breaker in the closed circuit position, if an overload or short circuit occurs in the main circuit controlled by the breaker, the trip device 61 will be immediately energized. Operation of the trip device causes release of the high-speed latch means 47—45 whereupon the circuit breaker is immediately tripped open free of the operating piston 25, by the release of the breaker lever 31. During the initial counter-clockwise opening movement of the breaker lever 31 towards the open position indicated by the dot-dash lines in Fig. 1, the pin 99 thereon moves the latch 93 to released position to release the closing lever 29. The closing lever when released is immediately moved quickly upwardly by the retrieving springs 95 causing return of the latch roller end of the breaker lever 31 back to its latched position where it is latched by the latching means 45—47. This reestablishes the operative connection between the circuit breaker and the operating piston 25 so that the breaker is ready to be reclosed. During the retrieving movement of the levers 29 and 31, the operating piston 25 is pulled upwardly with the closing lever 29 to which it is connected. The exhaust-valve element 145 is in open position at this time as are the exhaust ports 155, so that the upper portion of the operating cylinder above the piston is fully vented to atmosphere. Consequently, air above the operating piston as it moves up is rapidly exhausted to atmosphere and does not retard the upward movement of the piston and the retrieving operation of the mechanism levers. As a result the retrieving springs will retrieve the mechanism very rapidly.

If the control circuit is set for instantaneous automatic reclosing, the electromagnet 139 of the control valve device will be energized the instant the latch roller 39 reaches the latched position. Energization of the electromagnet 139 opens the pilot valve 133 and causes compressed air to move the valve piston 121 down to quickly close the exhaust valve 145 and open the intake valve 109, thereby admitting compressed air into the upper end of the operating cylinder to effect reclosing of the circuit breaker. If the fault condition has

been cleared by the time the circuit breaker reaches the closed position, the circuit breaker will be latched and held closed by the latching means. However, if the fault condition is still present upon completion of the main circuit, the circuit breaker will immediately be tripped open free of the operating piston 25 by the operation of the trip device 61.

The control-valve device is of very simple and compact construction and the valve elements thereof respond and operate very quickly through relatively short strokes, and only a small amount of electrical control energy is required for operation of the device. There is substantially no loss or wastage of compressed air from the tank through the valve device because the exhaust-valve element closes prior to opening of the intake-valve element and the two valve elements are returned to their normal position substantially simultaneously.

The improved control valve device of the present invention is illustrated in Fig. 3 as embodied in a different circuit-breaker operating mechanism of the pneumatic type wherein the circuit breaker is non-releasably connected by its rod directly to the operating piston 165. The structure of the mechanism shown in Fig. 3, except for the control valve device, is similar to the mechanism disclosed in the aforementioned Patent No. 2,399,328, issued April 30, 1946, to James M. Cumming. The mechanism comprises a casting 167 formed to provide a cylinder 169 in which the operating piston 165 is movable. The circuit-breaker rod 19 is connected by a pivot pin 171 to a latching lever 173 which is pivotally mounted at one end on the casting 167 by means of a pivoted link 175. The pivot pin 171 also connects the circuit-breaker rod and latching lever directly to the connecting rod 177 of the operating piston 165. The circuit breaker is adapted to be releasably held in closed circuit position by a high-speed latching means 45'—47' for engaging and holding a latch roller 179 carried by the free end of the latching lever 173. The latching means is adapted to be released to trip the circuit breaker by means of a trip device 181 upon the occurrence of predetermined abnormal conditions in the main circuit such as an overload or short circuit condition. The latching means 45'—47' and the trip device 181 are similar in construction to the high-speed latching means and trip device shown and described in the original embodiment of the invention.

The control valve device 91 is of the same construction as that shown in Fig. 1 and described in connection therewith, and the parts thereof are identified by the same reference characters. The inlet-valve element 109 is adapted to admit compressed air from an auxiliary air-storage tank 181 directly into the upper end of the operating cylinder 169 to effect closing or automatic reclosing operation of the circuit breaker, upon energization of the electromagnet 139 which controls operation of the valve device. The housing of the valve device is secured to the casting of the mechanism, and the inlet passage of the valve housing communicates directly with an inlet port in the upper end of the cylinder. The exhaust passage 141 of the valve device communicates with the upper end of the operating cylinder through the pipe connection 143 as in the original embodiment shown in Fig. 1, the exhaust passage being normally opened directly to atmosphere by the exhaust-valve element 145.

The operating mechanism shown in Fig. 3 is adapted to effect normal closing operations of the circuit breaker started from the full-open position thereof and is also automatically operable to effect quick automatic reclosing of the circuit breaker initiated at an intermediate point in the opening stroke after the current arc is extinguished and before the circuit breaker reaches the full-open position. The control circuit (not shown) for the valve electromagnet 139 and the trip coil of the trip device 181 in this modification is the same as the control circuit disclosed in the aforementioned copending application of James M. Cumming and Richard C. Cunningham, Serial No. 410,686, filed September 13, 1941. The control circuit has not been shown since it is not necessary to a complete understanding of the present invention. It is believed sufficient to state that the coil of the trip device 181 is energized in response to an overload or short circuit in the main circuit, and can also be energized by a manual trip-control switch. For quick automatic reclosing operations, the electromagnet 139 of the control valve device is arranged to be automatically energized by an auxiliary switch at an intermediate point in the opening stroke of the circuit breaker to cause the valve to admit compressed air to the operating cylinder to initiate the reclosing operation before the breaker reaches the full-open position. The electromagnet 139 may also be energized by a manual closing-control switch.

The operation of the circuit breaker mechanism shown in Fig. 3 is briefly as follows. Closing of the circuit breaker is effected upon energization of the electromagnet 139 which causes operation of the control valve device to close the exhaust-valve element 145 and open the intake valve 109 thereby admitting compressed air to the operating cylinder to effect closing of the circuit breaker. With the circuit breaker in closed position, if an overload or short circuit condition occurs in the main circuit, the trip device 181 will be energized causing the latching means 45'—47' to release the latching lever 173 whereupon the circuit breaker is actuated to open position at high speed by its opening spring. At this time the exhaust valve element 145 is in open positon and consequently the cylinder space above the operating piston is rapidly and fully vented directly to atmosphere so that the opening movement of the operating piston and circuit breaker is not retarded by back pressure in the cylinder. This facilitates high-speed opening movement of the circuit breaker and piston.

If the control circuit is set for quick automatic reclosing, the electromagnet 139 will be energized at an intermediate point in the opening stroke causing the valve mechanism to close the exhaust valve 145 and open the intake valve 109 thereby admitting compressed air from the tank 181 into the upper end of the operating cylinder to effect reclosing operation of the circuit breaker. The reclosing movement is initiated before the breaker reaches full open position. The electromagnet 139 is deenergized as soon as the breaker reaches the closed position thereby causing the intake valve element 109 to close and the exhaust valve element 145 to open. If the fault condition which causes tripping of the breaker has been cleared by the time the circuit has been reclosed, the breaker will be latched and held closed by the latching means. Otherwise, the breaker will immediately trip open at high speed.

In the embodiment of the invention shown in Fig. 3, the control valve device provides for quick

reversal of movement of the circuit breaker and piston and high-speed opening movement of these parts because of the rapid and full venting of the cylinder by the exhaust valve 145. The control-valve device also facilitates quick reversal of movement of the parts from opening to closing direction because of the quick closing of the exhaust valve and opening of the intake valve. As a result, high-speed opening and reclosing of the circuit breaker is obtained.

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 combination and arrangement of parts may be made without departing from some of the essential features of the invention.

We claim as our invention:

1. An operating mechanism of the pneumatic type for operating an electrical circuit breaker comprising a cylinder, a movable operating piston in said cylinder disengageably related with the circuit breaker, means normally restraining said circuit breaker in closed position, said means being operable to permit said breaker to move to open position irrespective of said piston, a source of compressed gas, and a control valve device for admitting compressed gas to said cylinder to move said piston in one direction to operate the breaker and for also rapidly venting said cylinder directly to atmosphere to permit high speed reengagement of said piston to said circuit breaker, said valve device having an inlet passage communicating with said cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere connected to said cylinder apart from the connection of the inlet passage to the cylinder, an intake valve element biased to closed position to close off said inlet passage from said source, an exhaust valve element biased to open said exhaust passage, and a single actuating piston connected to said exhaust valve and operable when energized to close said exhaust valve element and engage and open said intake valve element.

2. An operating mechanism of the pneumatic type for an electrical circuit breaker comprising an operating cylinder, an operating piston in said cylinder releasably connected to the circuit breaker, a source of compressed gas, and a control valve device associated with said cylinder for admitting compressed gas to said cylinder to move said piston in one direction to operate the breaker and for also rapidly venting said cylinder directly to atmosphere to permit high-speed reverse movement of said piston, reconnect said pistons to said circuit breaker, said valve device comprising an inlet passage connected to said operating cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere connected to said operating cylinder apart from the connection between the inlet passage and the cylinder, an inlet valve element biased to normally close said inlet passage, an exhaust valve element movable relative to said inlet valve element and biased to normally open said exhaust passage, and valve actuating means including a single actuating element connected to said exhaust valve element and operable when said actuating means is energized to close said exhaust valve element and engage and move said inlet valve element to open position.

3. An operating mechanism of the pneumatic type for operating an electrical circuit breaker comprising a cylinder, an operating piston in said cylinder for operating the circuit breaker, a source of compressed gas, and a control valve device associated with said cylinder for admitting compressed gas to said cylinder to move said piston in one direction to operate the circuit breaker and for also rapidly venting said cylinder directly to atmosphere to permit high-speed reverse movement of said piston, said valve device having an inlet passage connected to said cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere connected to said cylinder apart from the connection of said inlet passage to the cylinder, an inlet valve element biased to closed position to close said inlet passage, an exhaust valve element movable relative to said inlet valve element and biased to open said exhaust passage, spring means for biasing said inlet valve element closed and said exhaust valve element open, a second exhaust passage separate from said large exhaust passage, valve actuating means comprising a single piston operable by compressed gas to close said exhaust valve element and open said inlet valve element, said actuating piston when operated to open said inlet valve directly closing said second exhaust passage, and a pilot valve for controlling operation of said valve piston.

4. In an electrical circuit breaker having movable contact means, operating means for said breaker comprising spring means biasing said breaker to open position, latching means for holding said circuit breaker closed, an operating cylinder, an operating piston in said cylinder non-releasably connected to the movable contact means for closing the circuit breaker, a source of compressed gas, and a control valve device associated with said cylinder for admitting compressed gas to said cylinder to actuate said piston to close the circuit breaker and for also rapidly venting said cylinder directly to atmosphere to permit high-speed opening of said circuit breaker, said control valve device having an inlet passage connected to said cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere connected to said cylinder apart from the connection of the inlet passage to said cylinder, an inlet valve element biased to closed position to close said inlet passage, an exhaust valve element movable relative to said inlet valve element and biased to open said exhaust passage, and valve actuating means operable when energized to close said exhaust valve element and open said inlet valve element.

5. In an electrical circuit breaker having movable contact means, operating means for said breaker comprising spring means biasing said breaker to open position, latching means for holding said circuit breaker closed, an operating cylinder, an operating piston in said cylinder non-releasably connected to the movable contact means for closing the circuit breaker, a source of compressed gas, and a control valve device associated with said cylinder for admitting compressed gas to said cylinder to actuate said piston to close the circuit breaker and for also rapidly venting said cylinder directly to atmosphere to permit high-speed opening of said circuit breaker, said control valve device having an inlet passage connected to said cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere connected to said cylinder, an inlet valve element biased to closed position to close said inlet passage, an exhaust valve element movable relative to said inlet valve element and biased

to open said exhaust passage, spring means biasing said inlet valve element closed and said exhaust valve element open, and valve actuating means comprising a single piston connected to said exhaust valve element and operable by compressed gas to close said exhaust valve element and engage and move said inlet valve element to open position after it has initiated closing movement of said exhaust valve element, and an electromagnetically controlled pilot valve for controlling operation of said valve piston.

6. In an electrical circuit breaker having movable contact means biased to open circuit position, operating means for said breaker comprising a cylinder, an operating piston in said cylinder operable in one direction to close said breaker, trip-free resettable connecting means releasably connecting said circuit breaker to said piston, latching means for holding said circuit breaker closed and for holding said connecting means in connecting condition, tripping means for releasing said latching means to cause tripping of said circuit breaker free of said piston, means operable upon opening movement of said circuit breaker for causing said piston to be moved in reverse direction to reset said trip-free connecting means, a source of compressed gas, a control valve device associated with said cylinder for admitting compressed gas to said cylinder to close the circuit breaker and for also rapidly venting said cylinder directly to atmosphere to permit high-speed reverse movement of said piston, said valve device having an inlet passage through which compressed gas is admitted to said cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere, an inlet valve element biased to normally close said inlet passage, an exhaust valve element movable relative to said inlet valve element and biased to normally open said exhaust passage, actuating means for said valve elements comprising a single piston operable by compressed gas to close said exhaust valve element and move said inlet valve element to open position, and an electromagnetically controlled pilot valve for controlling operation of said valve piston.

7. A fluid pressure operating mechanism of the trip-free type for an electrical circuit breaker comprising a cylinder, a piston in said cylinder movable in one direction to close the circuit breaker, means disengageably relating said piston to said circuit breaker, latching means for holding said circuit breaker closed, said latching means when released permitting said circuit breaker to trip open free of said piston, a source of compressed gas for operating said piston, and a control valve device associated with said cylinder for admitting compressed gas to said cylinder to close the circuit breaker and for also rapidly venting said cylinder directly to atmosphere to permit high-speed reengagement of said piston to said circuit breaker, said control valve device comprising an inlet passage connected to said cylinder through which compressed gas is admitted to said cylinder, a large exhaust passage for rapidly venting said cylinder directly to atmosphere connected to said cylinder apart from the connection of said inlet passage to the cylinder, an inlet valve element biased to close said inlet passage, an exhaust valve element biased to open said exhaust passage, and actuating means operable when energized to close said exhaust valve element and open said inlet valve element.

8. A fluid pressure operating mechanism of the trip-free type for an electrical circuit breaker comprising a cylinder, a piston in said cylinder movable in one direction to close the circuit breaker, means disengageably relating said piston to said circuit breaker, latching means for holding said circuit breaker closed, said latching means when released permitting said circuit breaker to trip open free of said piston, a source of compressed gas for operating said piston, and a control valve device associated with said cylinder for admitting compressed gas to said cylinder to close the circuit breaker and for also rapidly venting said cylinder directly to atmosphere, said control valve device comprising an inlet passage connected to said cylinder through which compressed gas is admitted to said cylinder, a large exhaust passage connected to said cylinder for rapidly venting said cylinder directly to atmosphere to permit high speed resetting of said trip-free mechanism, an inlet valve element biased to close said inlet passage, an exhaust valve element movable relative to said inlet valve element and biased to open said exhaust passage, spring means biasing said inlet valve element closed and said exhaust valve element open, and valve actuating means comprising a single actuating piston connected to said exhaust valve element and operable by compressed gas to close said exhaust valve element and engage and move said inlet valve element to open position after it has initiated closing of said exhaust valve element, and an electromagnetically controlled pilot valve for controlling operation of said valve piston.

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