April 22, 1958 J. E. SCHRAMECK ET AL 2,831,933

CIRCUIT INTERRUPTERS

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Fig. 1.

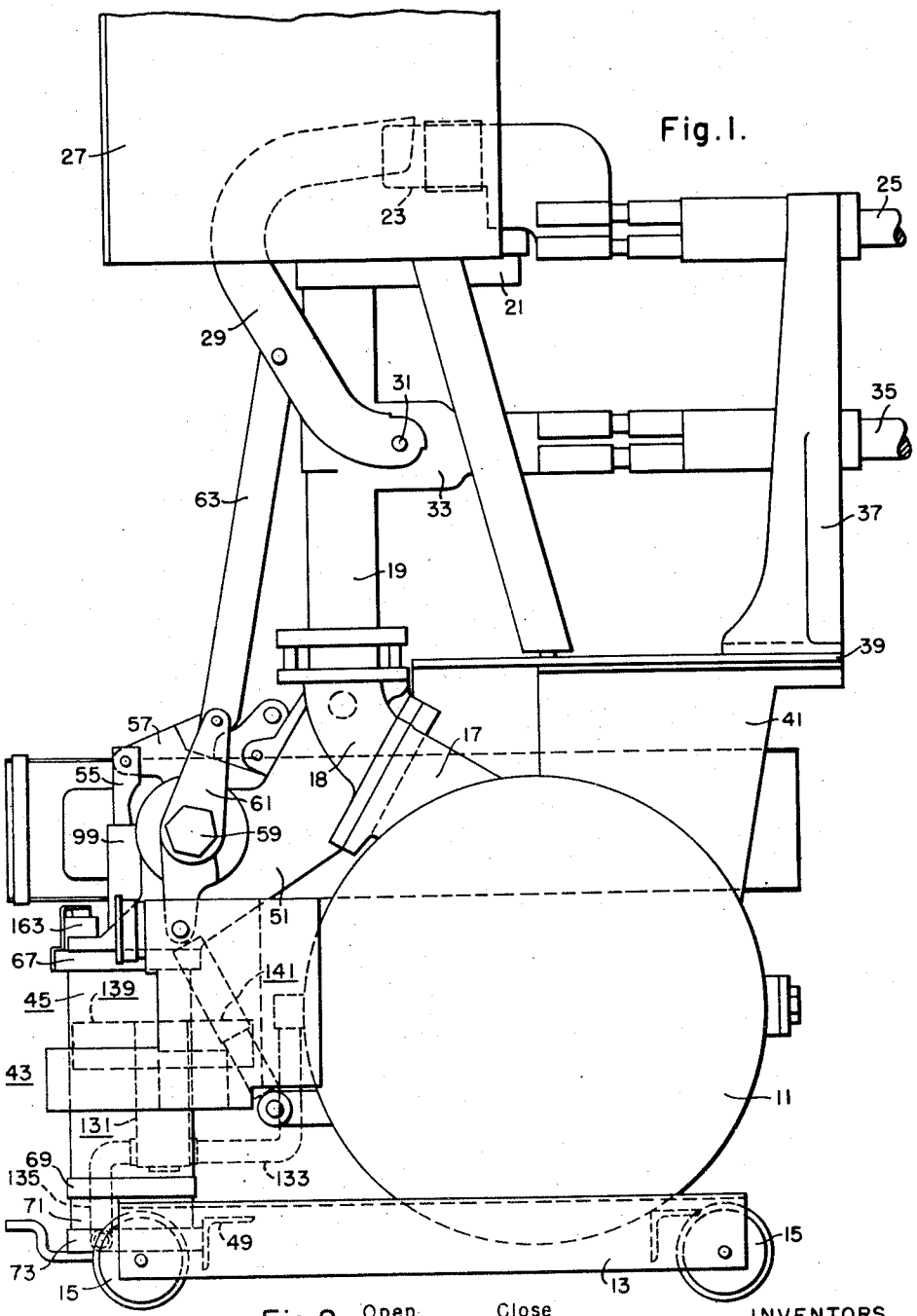
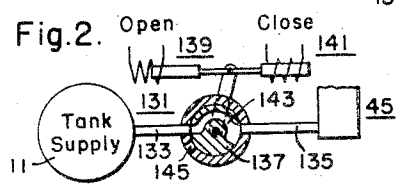


Fig. 2.



WITNESSES

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CIRCUIT INTERRUPTERS

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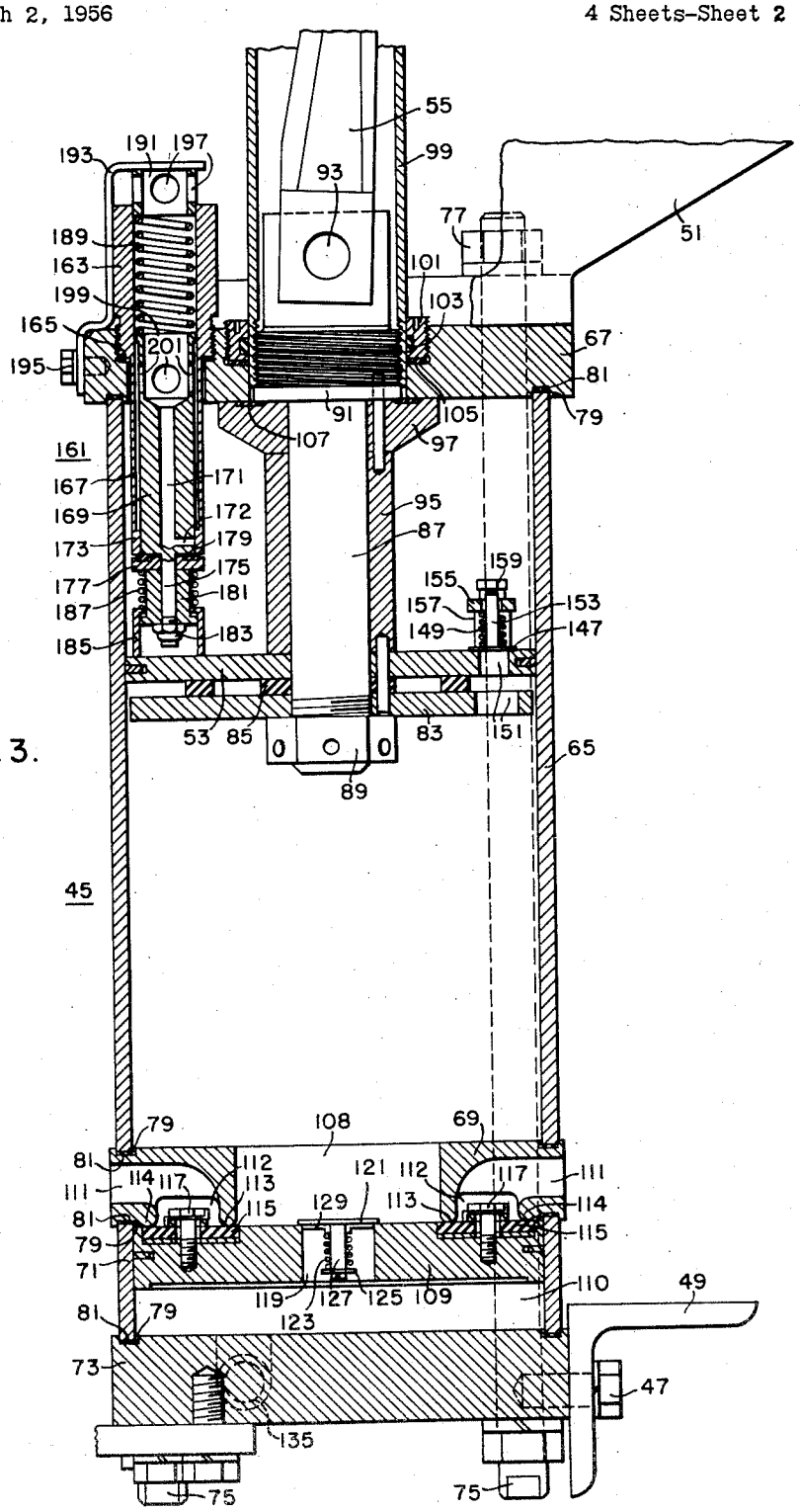
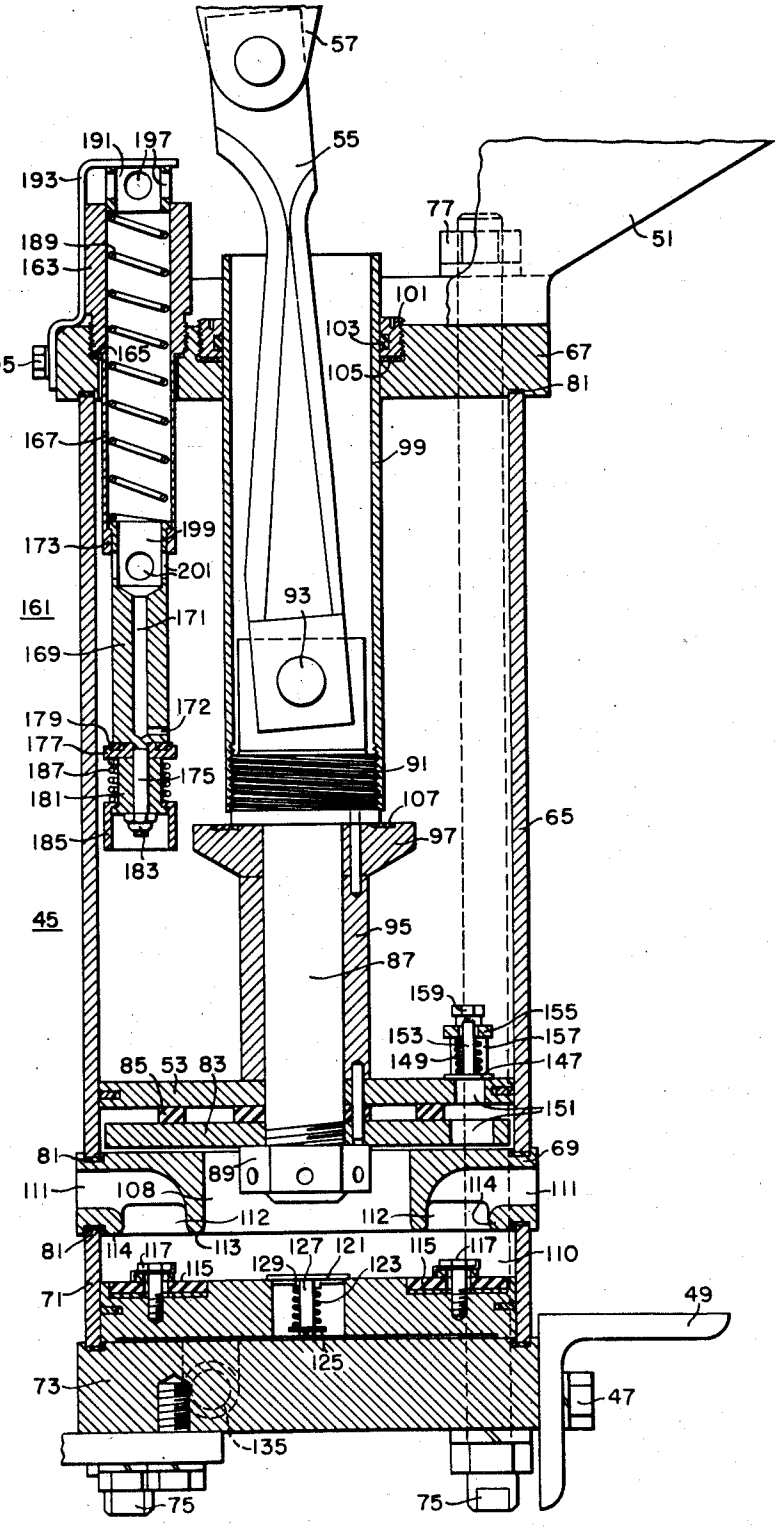


Fig. 3.

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Fig. 4.



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Fig. 5.

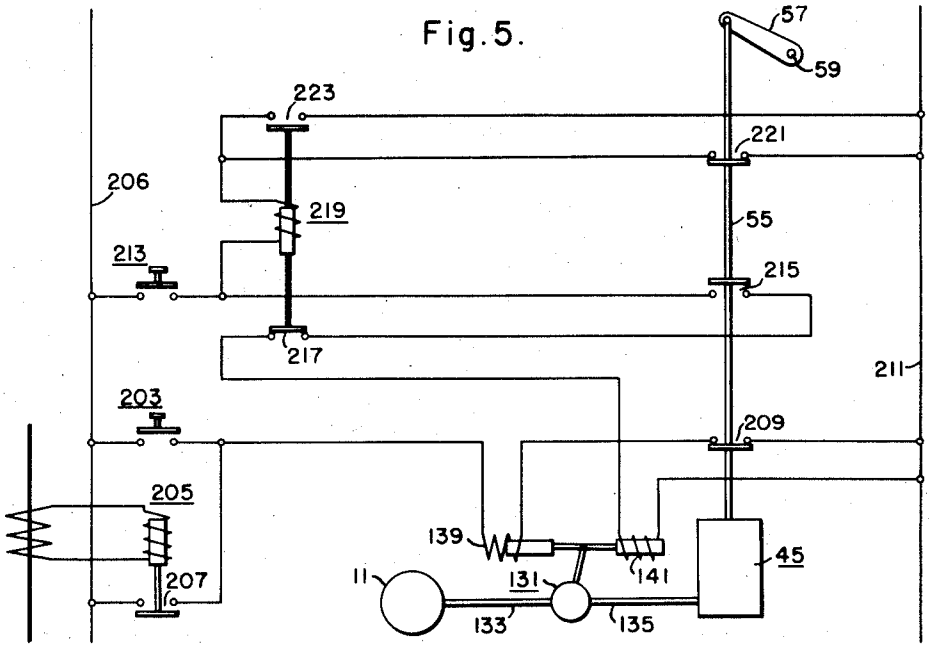
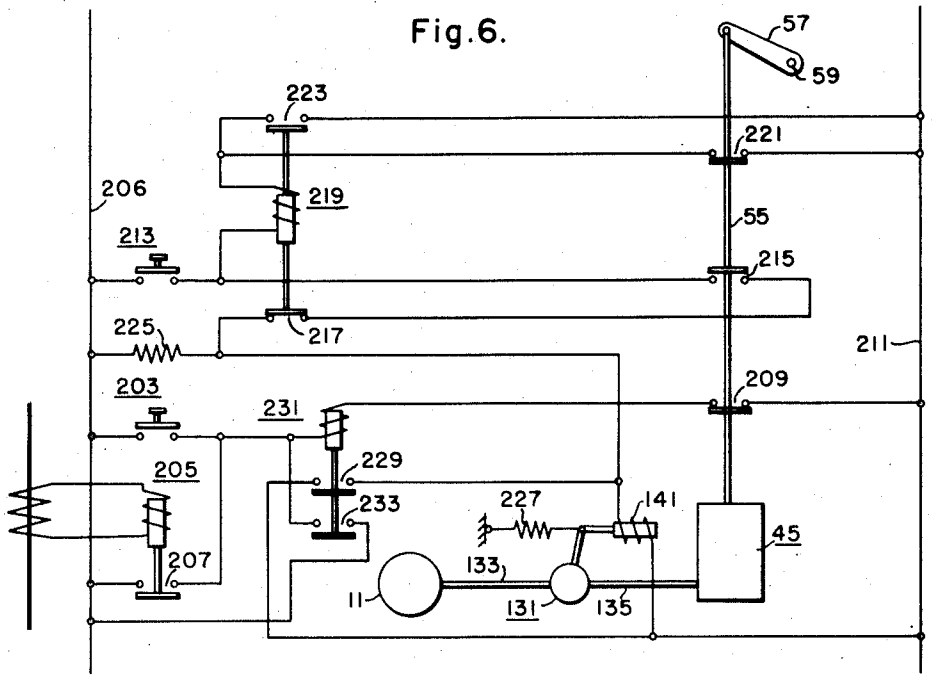


Fig. 6.



United States Patent Office 2,831,933 Patented Apr. 22, 1958

2,831,933

CIRCUIT INTERRUPTERS

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Application March 2, 1956, Serial No. 569,190

11 Claims. (Cl. 200—82)

This invention relates to circuit interrupters and more particularly to circuit interrupters of the type that is operated by a fluid pressure operating mechanism in both opening and closing directions.

The invention is illustrated as applied to a circuit interrupter of the general type disclosed in Patent No. 2,501,302, issued March 21, 1950, to B. P. Baker and assigned to the assignee of the present invention.

The circuit interrupter disclosed in the Baker patent is operated to both open and closed positions by compressed gas admitted alternately to opposite sides of the operating piston under the control of two separate inlet valves. The speed of operation of such compressed fluid operating mechanism is limited by the time lost in moving the compressed fluid from a fluid storage tank through the connecting piping, through the opening inlet valve and to the working side of the piston. Also, when the piston is at one end or the other of its operating strokes the volume available at the working side of the piston is small, thus limiting the amount of fluid pressure immediately available to accelerate the piston. The rapid increase in this volume or space as the piston moves causes cavitation which reduces the available driving force thereby further limiting the speed of operation of the mechanism.

An object of the invention is to provide a circuit interrupter embodying an improved, high-speed operating mechanism of the fluid pressure operated type that is operated by compressed fluid stored in the operating cylinder against the operating piston.

Another object of the invention is to provide a circuit interrupter embodying an improved, high-speed operating mechanism of the fluid pressure operated type which is operated to open position by compressed fluid stored in the operating cylinder against the operating piston.

Another object of the invention is to provide a circuit interrupter having an improved operating mechanism of the fluid pressure operated type comprising a cylinder and a piston operable therein in which the piston is operated in both directions by compressed fluid admitted to the cylinder under the control of a single valve device.

Another object of the invention is to provide a circuit interrupter embodying an improved operating mechanism of the balanced fluid pressure operated type wherein the operation of the interrupter in both directions is controlled by a single valve device.

The invention, both as to structure and operation, together with additional objects and advantages thereof, will be best understood from the following detailed description thereof when read in conjunction with the accompanying drawings.

In said drawings:

Figure 1 is a side elevational view of a circuit interrupter embodying the principles of the invention.

Fig. 2 is a schematic view of the control valve.

Fig. 3 is an enlarged vertical sectional view through the operating cylinder showing the parts in the position they assume in the closed position of the interrupter.

Fig. 4 is a view similar to Fig. 3, but showing the parts in the position they assume at the end of an opening operation.

Fig. 5 is a schematic diagram showing the control circuit for controlling the operation of the interrupter.

Fig. 6 is a schematic diagram showing a modification of the control circuit.

Referring to Fig. 1 of the drawing, the circuit interrupter is of the roll-out type and comprises a storage tank 11 mounted on a metal frame 13 which is provided with wheels 15 to facilitate rolling the interrupter into and out of a cubicle in order to connect and disconnect the interrupter in an electric circuit.

The circuit interrupter is of the multi-pole type (only one pole being shown) and for each pole of the interrupter there is a flanged conduit 17 rigidly secured to the tank 11. Mounted on the flanged conduit 17 is a blast valve casing 18 on which is mounted a tubular insulator column 19 having an air passage therethrough, and an insulating arc chute support 21 is secured to the upper end of the tubular insulator column 19. The support 21 has mounted thereon a stationary contact 23 provided with a terminal connector 25. An arc chute 27 is secured to the support 21 and surrounds the stationary contact 23 and the upper end of a movable contact blade 29 which cooperates with the stationary contact 23 to open and close the circuit. The lower end of the movable contact blade 29 is bifurcated and the two legs thereof are pivoted at 31 to a conducting bracket 33 securely clamped to the tubular insulator 19. The movable contact 29 is not biased to move to either open or closed position and will normally remain in the position to which it has last been moved. A terminal connector 35 extends to the right from the bracket 33 and serves, together with the terminal 25, to connect the interrupter in an electrical circuit. The terminals 25 and 35 are supported in a bracket 37 mounted on a support plate 39 which, in turn, is mounted on brackets 41 (only one being shown) secured to the tank 11.

The operating mechanism, indicated generally at 43 (Fig. 1), which is of the compressed gas operated type, comprises an operating cylinder 45 (Figs. 1, 3 and 4) mounted at its lower end by means of bolts 47 on a cross member 49 of the frame 13 and at its upper end is rigidly secured to a bracket 51 formed integral with the blast valve housing 18. An operating piston 53 (Figs. 3 and 4) movable in the cylinder 45 is connected by means of a connecting rod 55 to an arm 57 secured to an operating shaft 59 journalled in the bracket 51. Arms 61, one for each pole of the interrupter, are secured to the shaft 59 and are connected by means of insulating operating rods 63 to the movable contact blades 29 for the three poles of the interrupter. Operation of the piston in the cylinder 45 rotates the shaft 59 and causes unitary movement of the movable contact blades 29 for all of the poles of the interrupter.

The cylinder 45 (Figs. 3 and 4) is made from a metallic tubular member 65 and is provided with an upper cylinder head 67 and an intermediate member or casting 69. Below the intermediate casting 69 is disposed a cylindrical member 71 which is provided with a lower cylinder head 73. The cylinder heads 67 and 73, the intermediate member 69 and the cylindrical members 65 and 71 are all rigidly held together under pressure by means of rods 75 which pass through openings in the upper and lower cylinder heads 67, 73 outside of the cylinder 65, 71 and the intermediate member 69, and have nuts 77 threaded onto the upper ends of the rods. The facing surfaces of the cylinder heads 67, 73 and the intermediate member 69 are provided with annular grooves 79 for receiving the cylinders 65 and 71 with gaskets 81 in the grooves to provide an airtight seal.

The piston **53**, together with a bumper plate **83** and a resilient member **85** between the piston and the bumper plate, is rigidly mounted on the lower end of a piston rod **87** by means of a nut **89** which is threaded onto the lower end of the piston rod. The upper end of the piston rod **87** is enlarged as at **91** and is pivotally connected to the connecting rod **55** by means of a pin **93**. A sleeve **95** surrounds the piston rod **87** and an abutment **97** is disposed between the upper end of the sleeve **95** and the enlarged upper end **91** of the piston rod **87**, all of the parts mounted on the piston rod being held rigidly together by the nut **89**.

A cylindrical guide **99**, threaded onto the enlarged upper end **91** of the piston rod **87**, extends through a central opening in the upper cylinder head **67** and through a sealing collar **101** threaded into a counterbore in the cylinder head **67**. The collar **101** is provided with an internal gasket **103** bearing against the periphery of the cylindrical guide member and a gasket **105** is disposed between the bottom of the sealing member **101** and the bottom of the counterbore to provide an airtight seal. There is also a gasket **107** disposed in an annular groove in the upper face of the abutment **97** sealing the space between the bottom of the cylinder head **67** and the portion **91** of the piston rod **87** in closed or upper position of the piston.

A dump valve or abutment **109** (Figs. 3 and 4) is disposed in a chamber **110** defined by the intermediate member **69**, the lower cylinder head **73** and the annular member **71**. The dump valve **109** is in the form of a piston and is movable between the positions shown in Figs. 3 and 4. The member **69** is provided with a large central passage **108** and has a plurality of exhaust ports **111** which communicate with an annular area or passage **112** defined by inner and outer valve seats **113** and **114**, respectively. The valve seats **113** and **114** are adapted to be engaged by a circular valve facing **115** disposed in an annular groove in the upper face of the dump valve **109** and held in place by screws **117**. Disposed centrally in the dump valve **109** is a passage **119** controlled by a valve **121** which is biased to closed position by means of a spring **123** compressed between a washer **125** secured on the lower end of the valve stem **127** and a spider **129** fixedly mounted in the passage **119**.

In order to operate the piston **53** to effect opening and closing of the interrupter compressed gas is admitted to and exhausted from the chamber **110** below the dump valve **109** by means of an electromagnetically operated control valve device indicated generally at **131** (Figs. 1 and 2) and shown schematically in Fig. 2. The control valve is connected by a conduit **133** to the storage tank and by a conduit **135** to the chamber **110** below the dump valve **109**. The movable element **137** of the valve **131** is connected to be operated to two positions by an opening electromagnet **139** and a closing electromagnet **141**. The movable element **137** of the control valve **131** is not biased in either direction but when operated to one or the other of its positions by the magnet **139** or **141** remains in the last operated position until the other magnet is energized. The electromagnets **139—141** are energized momentarily to actuate the valve and are then deenergized, the valve remaining in the position to which it was last actuated. For instance, as shown in Fig. 2, the valve element **137** was last actuated by the closing magnet **141** which was then deenergized allowing the element **137** to remain in the position shown. It will be seen that in the position shown, the conduits **133**, **135** and a passage **143** through the valve element connect the tank **11** directly to the chamber **110** below the dump valve **109**. The end of the passage **143** through the valve element **137** adjacent the conduit **135** is enlarged so that when the element **137** is actuated in a counterclockwise direction the passage **143** is brought into registry with the conduit **135** and with an exhaust port **145** in the valve housing thus exhausting the air pressure from the chamber **110** below the dump valve **109** to atmosphere.

The compressed gas operating means is of the balanced pressure type, that is, with the control valve **131** in the position it assumes (Fig. 2) when the closing magnet **141** has been operated, full gas pressure is maintained in the chamber **110** below the dump valve **109** and in the operating cylinder **45** both below and above the piston **53**. In this condition the piston **53** will be in its upper or closed position as shown in Fig. 3.

Upon a predetermined drop in the air pressure in the operating cylinder **45** below the piston, the valve **121** in the dump valve **109** opens admitting compressed air through the passage **108** to this space to balance the pressure above and below the dump valve. Also, if the pressure in the operating cylinder **45** above the piston **53** should drop below a predetermined value, a valve **147** mounted on the piston **53** and biased by a spring **149** to normally close a passage **151** through the piston **53** and the bumper plate **83** opens admitting compressed gas to the cylinder above the piston. The valve **147** is mounted on a valve stem **153** which is guided by a bar **155** supported on spaced supports **157** (only one being shown) secured by means of bolts **159** to the upper surface of the piston **53**.

In the closed position of the interrupter, compressed gas is prevented from escaping from the cylinder **45** above the piston **53** by means of a valve device indicated generally at **161** (Fig. 3). The valve **161** comprises a tubular valve member **163** threaded into a counterbore in the upper cylinder head **67** and having a sealing gasket **165** between a shoulder on the valve member **163** and the bottom of the counterbore. The valve member **163** has an integral reduced portion **167** which extends into the cylinder **45** above the operating piston **53** in which is disposed for vertical sliding movement a valve **169** having an axial opening **171** therethrough which terminates in a port **172** at its lower end. The lower end of the portion **167** of the valve member **163** has an inwardly formed bearing portion **173** providing a close sliding bearing for the valve **169**. The lower end of the valve **169** is reduced to form a rod **175** on which is mounted a sealing disc **177** having a resilient facing **179** thereon for engaging the lower end of the valve member **163** to seal off the small space between the bearing **173** and the valve **169**. Mounted on the rod **175** below the sealing disc **177** is a flanged member **181** and a nut **183** is threaded onto the lower end of the rod **175** to rigidly hold the member **181** and the sealing disc **177** in place. A cylindrical member **185** is mounted for sliding movement on the flanged member **181** and is biased downwardly by means of a spring **187** compressed between the sealing disc **177** and the cylindrical member **185**.

The valve **169** is biased downwardly by means of a spring **189** compressed between a spring seat **191** and the top of the valve **169**. The spring seat **191** is held in place by a bracket **193** secured to the side of the top cylinder head **67** by a bolt **195**. The spring seat **191** is provided with air ports **197**. The upper end of the passage **171** through the valve **169** is enlarged as at **199** and is provided with air ports **201** spaced downwardly from the upper end of the valve **169**.

As previously set forth, in the closed portion of the interrupter the valve **131** is in the position shown in Fig. 2 directly connecting the tank **11** to the chamber **110** below the dump valve **109** and maintaining balanced pressure above and below the dump valve **109** and above and below the operating piston **53**. In this condition, the interrupter is prevented from opening by the overset toggle formed by the operating rods **63** (Fig. 1) and the arms **61** on the shaft **59**. Due to the fact that the area of the bottom space of the dump valve **109** is greater than the area of the passage **108**, the pressure below the dump valve holds the dump valve **109** tightly closed sealing off the passage **108** and the exhaust ports **111**.

With the interrupter in the closed position as shown in Figs. 1, 2 and 3, an opening operation is effected by en-

ergization of the opening magnet 139 which may be effected by automatic or manual means in a well-known manner. Energization of the opening magnet 139 (Fig. 2) turns the valve element 137 counterclockwise and aligns the passage 143 thereon with the conduit 135 and the exhaust port 145 which quickly dumps the compressed air from the chamber 110 below the dump valve 109. As soon as this occurs, the high pressure air in the cylinder 45 below the piston 53 snaps the dump valve down against the lower cylinder head 73 opening the passage 108 and the exhaust ports 111. This quickly dumps the compressed air from the operating cylinder below the piston to atmosphere through the large passage 108 and the plurality of exhaust ports 111 and the high pressure air above the piston 53 immediately drives the piston downwardly to open the interrupter. The downward movement of the piston 53 acts through the connecting rod 55 and arm 57 (Fig. 1) to move the shaft 59 counterclockwise, and this movement of the shaft 59, acting through the arms 61 thereon, draws the operating rods 63 downwardly and opens the contacts for all of the poles of the interrupter.

In the raised or closed position of the piston 53 (Fig. 3) the cylindrical member 185 rests on the upper face of the piston with the spring 187 slightly compressed. The force of the spring 187 together with the pressure in the operating cylinder above the piston acts on the sealing disc 177 to press the facing 179 firmly against the lower end 173 of the valve member 163 thus sealing the space between the valve 169 and the bearing surface 173 against leakage of high-pressure air.

As the piston 53 moves downwardly during an opening stroke, the spring 189 moves the valve 169 downwardly in the valve member 163 until the flanged upper end of the valve 169 engages the bearing 173 at the lower end of the valve member 163, at which time the downward movement of the valve 169 is arrested while the piston 53 continues its downward or opening movement until it is stopped by engagement of the bumper plate 83 with the intermediate member 69. The parts are shown in Fig. 4 in the fully open position. Almost as soon as the piston 53 and the valve 169 started their downward movement, the small port 172 in the lower end of the latter cleared the lower end of the fixed valve member 163. The small amount of high-pressure gas vented through the port has no retarding effect on the opening operation of the piston.

It is desirable to reduce the pressure of the gas above the piston 53 during the latter portion of its downward travel in order to prevent slamming of the parts. This is effected by the ports 201 near the upper end of the valve 169 which clear the lower end of the fixed valve member 163 just before the downward movement of the valve 169 is arrested, venting some of the high-pressure gas through the ports 201, upwardly through the tubular valve member 163 and through the ports 197 in the spring seat 191 to atmosphere.

The parts remain in the position shown in Fig. 4 until the closing magnet 141 (Fig. 2) is energized. This may be effected by well-known means either manually or automatically. Energization of the closing magnet 141 opens the passages 133, 143 and 145 admitting gas under pressure from the tank 11 to the chamber 110 below the dump valve 109 forcing it upwardly to seat the valve facings 115 on the valve seats 113 and closing the passage 108 and the exhaust ports 111. The high-pressure air below the dump valve 109 opens the relatively large valve 121 admitting high-pressure air to the passage 108 below the piston 53 which drives the piston upwardly to close the interrupter. Since the space above the piston 53 at this time is at atmospheric pressure, the high-pressure air below the piston opens the relatively small valve 147 in the piston admitting compressed air to the space above the piston. The air admitted to the space above the piston 53 is leaked to atmosphere through the ports 201 in the valve 169 and the ports 197 in the spring seat 191 so as not to interfere with the closing movement of the piston 53. As the piston moves upwardly during the closing operation, it engages the cylindrical member 185 and moves the valve 169 upwardly to its closed position. During the early part of the upward movement of the valve 169, the ports 201 move above the bearing 173 closing off these ports. Compressed air continues to exhaust to atmosphere through the small ports 172 at the lower end of the valve 169 until just before the valve 169 reaches its closed position (Fig. 3) at which time the port 172 is closed off by the bearing surface 173 and the space between the bearing 173 and the valve 169 is sealed off by the facing 179. After the valve 169 is seated, the piston 53 moves a short distance until it is stopped by the abutment 97 striking the upper cylinder head 67, the latter part of the movement of the piston 53 moving the cylindrical member 185 relative to the member 181 slightly compressing the spring 187. The interrupter is now completely closed and the toggles 61—63 (Fig. 1) are overset to hold the movable switch blades in the closed position.

High-pressure air from the space below the piston 53 continues to flow through the valve 147 to the space above the piston until the pressure above and below the piston is balanced. At this time, the pressure above and below the dump valve is also balanced and the operating mechanism remains in this condition until the opening or trip magnet 139 (Fig. 2) is again energized.

Referring to Fig. 5 of the drawing which illustrates the circuit diagram, the opening magnet 139 is energized by means of a manual opening switch 203 or by the operation of a protective relay 205. Closure of the switch 203 or of the contacts 207 of the protective relay 205 energizes the opening magnet 139 from one line 206 of a control circuit over auxiliary contacts 209 which are closed in the closed position of the interrupter to the other side 211 of the circuit. When energized, the opening magnet 139 actuates the valve 131 and effects opening of the interrupter in the manner previously described. The auxiliary contacts 209 open when the interrupter opens, deenergizing the opening magnet 139 and maintaining the circuit through the latter open until the interrupter is closed.

In order to close the interrupter, the closing magnet 141 is energized which is effected by closing a manual switch 213. Closing the switch 213 energizes the closing coil 141 from the line 206, switch 213, auxiliary contacts 215 closed when the interrupter is open, contacts 217 of a relay 219, and the closing magnet 141 to the line 211. Energization of the closing magnet 141 opens the valve 131 and admits compressed air to the cylinder 45 below the dump valve 109 (Fig. 4) to effect closing of the interrupter in the previously described manner. In order to close the breaker, it is necessary to close the switch 213 but momentarily, just long enough for the closing magnet to actuate the valve 131 to the open position. The switch 213 can then be released and the valve 131 will remain open maintaining the air pressure in the cylinder as previously described.

Should the interrupter close against a fault on the line, the protective relay 205 will function to again energize the opening magnet 139 and effect opening of the interrupter. If, under this condition, the closing switch were held closed it would cause the interrupter to pump, that is, it would repeatedly open and close. It is to prevent this that the relay 219 is provided. When the interrupter closes, auxiliary contacts 221 close energizing relay 219 which closes contacts 223 and seals in the relay 219 as long as the switch 213 is held closed. When the relay 219 picks up it opens the contacts 217 and opens the circuit through the closing magnet 141. It is then necessary to open the switch 213 before the interrupter can be closed.

The valve 131 is not biased and remains in the position to which it is operated by one of the magnets 139 or 141 until the other magnet is energized. Consequently, if the interrupter is in the closed position it will not open

in response to a loss of voltage in the control circuit. In applications where it is desirable to effect automatic opening of the interrupter in response to loss of voltage or a predetermined drop of voltage in the control circuit, the control circuit arrangement shown in Fig. 6 is used.

As illustrated in Fig. 6, the closing magnet **141** is energized at all times in the closed position of the interrupter over a resistance **225** which bypasses the closing switch **213**. The opening magnet **139** (Fig. 5) is omitted in the Fig. 6 arrangement and the valve **131** is biased by a spring **227** in a counterclockwise or opening direction. Upon loss of voltage or a predetermined drop in voltage across the lines **206—211**, the closing magnet **141** is deenergized and the spring **227** actuates the valve **131** to the position where it dumps the high-pressure air from the operating cylinder and thus effecting automatic opening of the interrupter. The value of the resistance **225** (Fig. 6) is such that the closing magnet **141** is held energized in the closing position and holds the valve **131** on the closing position once it is actuated to the closing position. It will not permit energization of the closing magnet sufficiently to actuate the valve **131** from the opening position to the closing position. Hence, if the interrupter has opened automatically in response to loss or a drop in voltage, it can be closed only by closing the switch **213**. This supplies the full voltage from line **206**, over the switch **213**, auxiliary contacts **215**, contacts **217** of the anti-pump relay **219** and the closing magnet **141** to the line **211**.

The interrupter is opened by shorting out the closing magnet **141** which permits the spring **227** (Fig. 6) to actuate the valve **131** to the position to effect opening of the breaker. The magnet **141** is shorted over contacts **229** of a relay **231** which is energized either manually by closing the switch **203** or automatically by operation of the protective relay **205**. Closure of the switch **203** or the contacts **207** of the relay **205** energizes the relay **231** over the auxiliary contacts **209**. The relay **231** closes its contacts **229** which are connected in parallel relation with the magnet **141** thus shorting out the magnet.

When the relay **231** is energized it seals itself in over contacts **233** and the auxiliary contacts **209** thus holding the closing magnet **141** shorted out long enough to let the flux in the magnet decay sufficiently to permit the spring **227** to operate the valve **131** to the position to effect opening of the breaker.

We claim as our invention:

1. A circuit interrupter having contacts movable to two positions to open and close said circuit, said contacts having no bias sufficient to move them out of the position to which they were last moved, compressed gas operated means for moving said contacts in both directions to each of said two positions, said gas operated means comprising a cylinder and a piston movable therein, a piston rod connected to said piston and extending through one end of said cylinder for operating said contacts, said cylinder having compressed gas stored therein on both sides of said piston, and compresesd gas operated valve means at the end of said cylinder opposite said piston rod for dumping compressed gas from one side of said piston to permit the compressed gas stored on the other side of said piston to apply a force to said piston to move said contacts in one direction to one of said positions.

2. A circuit interrupter having contacts movable to two positions to open and close said circuit, said contacts having no bias to move them out of the position to which they were last moved, compressed gas operated means for moving said contacts in both directions to each of said two positions, said gas operated means comprising a cylinder and a piston movable therein, a piston rod connected to said piston and extending through one end of said cylinder for operating said contacts, said cylinder having compressed gas stored therein on both sides of said piston, and compressed gas operated valve means at the end of said cylinder opposite said piston rod for dumping compressed gas from one side of said piston to permit the compressed gas stored on the other side of said piston to apply a force to said piston to move said contacts in one direction to one of said positions, and means for admitting compressed gas to the side of the piston at which the dump valve means is disposed to move said piston in the other direction to said other position.

3. A circuit interrupter having unbiased contacts movable to two positions to open and close said circuit, said contacts remaining in the positions to which they were last moved, compressed gas operated means for moving said contacts in both directions to each of said two positions, said compressed gas operated means comprising a cylinder and a piston movable therein, a piston rod connected to said piston and extending through one end of said cylinder for operating said contacts, said cylinder having compressed gas stored therein on both sides of said piston, compressed gas operated valve means at the end of said cylinder opposite said piston rod for dumping compressed gas from one side of said piston to permit the compressed gas stored on the other side of said piston to apply a force to said piston to move said contacts in one direction to one of said positions, means for admitting compressed gas to the side of said piston at which said dump valve means is disposed to move said piston in the other direction to said other position, and said piston having a restricted opening therethrough to balance the gas pressure on both sides of said piston after said piston reaches said other position.

4. A circuit interrupter having contacts movable to two positions to open and close the circuit, said contacts normally remaining in the position to which they were last moved, compressed gas operated means for moving said contacts in both directions to each of said two positions, said compressed gas operated means comprising a cylinder and a piston movable therein, said cylinder having compresesd gas stored therein on both sides of said piston, exhaust valve means at one side of said piston for dumping compressed gas from said one side of said piston to permit the compressed gas stored on the other side of said piston to apply a force to said piston to move said contacts in one direction to one of said positions, means for admitting compressed gas to the side of said piston at which said dump valve means is disposed to move said piston in the other direction to said other position, said piston having an opening therethrough to balance the gas pressure on both sides of said piston after the piston reaches said other position, and said cylinder having valve means therein at the other side of said piston that is open at the beginning of the movement of said piston from said one position to said other position, said valve means being engaged by said piston and closed at least by the end of said movement.

5. In a circuit interrupter, separable contact means, operating means comprising a cylinder provided with upper and lower cylinder heads, a piston movable in said cylinder to open and close said contact means, an intermediate member between said piston and said lower cylinder head having a relatively large central opening therein, means defining one or more exhaust ports in said intermediate member, a movable member in said cylinder below said intermediate member controlling said one or more exhaust ports, electromagnetically operated valve means for admitting compressed gas to said cylinder below said movable member, valve means in said movable member admitting compressed gas to said cylinder below said piston to move said piston to close said contact means, and valve means in said piston admitting compressed gas to said cylinder above said piston to balance the fluid pressure above and below said piston, said electromagnetically operated valve means in the closed position of said interrupter maintaining the com-

pressed gas at operating pressure in said cylinder balanced above and below said piston and below said movable member.

6. In a circuit interrupter, separable contact means, operating means comprising a cylinder having upper and lower cylinder heads and an intermediate member, a piston movable in said cylinder on one side of said intermediate member to open and close said contact means, relatively large exhaust passage means in said intermediate member, an exhaust valve movable in said cylinder below said intermediate member to open and close said exhaust passage, a source of gas under pressure, a two position control valve, an electromagnet operable when energized to move said control valve to one position to admit compressed gas from said source to said cylinder below said exhaust valve to move said exhaust valve and close said exhaust passage, a valve in said exhaust valve admitting compressed gas to said cylinder below said piston to operate said piston and close said contact means, valve means in said piston admitting compressed gas to said cylinder above said piston, and said control valve remaining in said one position to maintain the compressed gas balanced at operating pressure in said cylinder above and below said piston and above and below said exhaust valve.

7. In a circuit interrupter, separable contact means, operating means comprising a cylinder, a partition member in said cylinder having a relatively large exhaust passage therein communicating said cylinder to atmosphere, a piston movable in said cylinder on one side of said partition to open and close said contact means, an exhaust valve movable in said cylinder below said partition to open and close said exhaust passage, valve means controlling a passage through said exhaust valve to admit compressed gas to the cylinder below said piston to operate said piston to close said contact means, a valve controlling a passage through said piston to admit compressed gas to the cylinder above said piston, a two position control valve, an electromagnet operable when momentarily energized to move said control valve to one position to admit compressed gas from a source of compressed gas to said cylinder below said exhaust valve, said control valve remaining in said one position to maintain compressed gas at operating pressure in said cylinder on both sides of said piston and on both sides of said exhaust valve, a second electromagnet operable when momentarily energized to operate said control valve to another position to vent the compressed gas from below said exhaust valve, the compressed gas above the exhaust valve moving said exhaust valve to open said exhaust passage and dump the compressed gas to atmosphere to permit the compressed gas above said piston to operate said piston and effect high-speed opening of said contact means.

8. In a circuit interrupter, separable contact means, operating means comprising a cylinder, a partition in said cylinder having relatively large exhaust passage means therein, a piston movable in said cylinder above said partition to open and close said contact means, restricted passage means communicating opposite sides of said piston, an exhaust valve movable in said cylinder below said partition to open and close said exhaust passage means, relatively large passage means communicating opposite sides of said exhaust valve, a control valve movable to two positions, said control valve when moved to one position admitting compressed gas to said cylinder below said exhaust valve to close said exhaust valve and through said passage in said exhaust valve to said cylinder below the piston to operate said piston and close said contact means, said restricted passage in said piston admitting compressed gas to said cylinder above said piston, said control valve remaining in said one position to maintain compressed gas at operating pressure above said piston in readiness for an opening operation, and said control valve when actuated to another position venting said cylinder below said exhaust valve to effect opening of said exhaust passage means and high-speed dumping of the compressed gas below said piston to permit the compressed gas stored in said cylinder above said piston to actuate said piston and open said contact means.

9. In a circuit interrupter, separable contact means, operating means comprising a cylinder, a partition in said cylinder having relatively large exhaust passage means therein, a piston movable in said cylinder above said partition, an exhaust valve movable in said cylinder below said partition, a control valve movable to two positions and when moved to one of said positions admitting compressed gas to said cylinder below said exhaust valve to move said exhaust valve and close said exhaust passage means, passage means in said exhaust valve and in said piston admitting compressed gas to all parts of said cylinder to store compressed gas at operating pressure above said piston in readiness for an opening operation, said passage in said piston being restricted to permit the compressed gas admitted to the cylinder below said piston to actuate said piston and close said contact means, and said control valve when moved to the other of its positions effecting high-speed dumping of the compressed gas below said piston to permit the compressed gas stored in said cylinder above said piston to actuate said piston and open said contact means.

10. In a circuit interrupter, relatively movable contact means, operating means comprising a cylinder and a piston movable therein to open and close said contact means, a source of fluid under pressure, a control valve movable to two positions, said control valve when moved to one of said positions admitting compressed fluid from said source to said cylinder and maintaining compressed gas at operating pressure in said cylinder, valve means admitting compressed fluid at a predetermined rate to said cylinder below said piston to move said piston and close said contacts, said valve means admitting compressed fluid to said cylinder above said piston to thereby store compressed fluid above said piston preparatory to an opening operation, said control valve when moved to the other of said positions causing high-speed dumping of the compressed fluid below said piston to permit the compressed fluid stored above said piston to move said piston and open said contacts, separate electromagnets operable when momentarily energized to alternately move said control valve to said two positions, said control valve upon deenergization of said electromagnets remaining in the position to which it was last moved by energization of one of said electromagnets until the other of said electromagnets is energized.

11. In a circuit interrupter, relatively movable contacts, operating means comprising a cylinder and an operating piston movable therein to open and close said contacts, a source of fluid under pressure, a control valve movable to two positions, said control valve when moved to one of said positions admitting compressed fluid from said source to said cylinder and maintaining fluid at operating pressure in all parts of said cylinder, pressure operated valve means admitting compressed fluid at a predetermined rate to said cylinder below said operating piston to close said contacts and at a lesser rate to said cylinder above said operating piston, a piston valve venting the cylinder above said operating piston in the open position of said interrupter, said piston valve being operated by said operating piston during a closing operation to reduce the rate of venting and to then close said piston valve to store compressed fluid above said operating piston preparatory to an opening operation, said control valve when moved to the other of said positions causing high-speed dumping of the compressed fluid from the cylinder below said operating piston to permit the compressed fluid stored in said cylinder above said operating piston to move said piston and open said contacts, an electromagnet operable when energized to move said

control valve to said one position, and spring means operable when said electromagnet is deenergized to move said control valve to the other of said positions.

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