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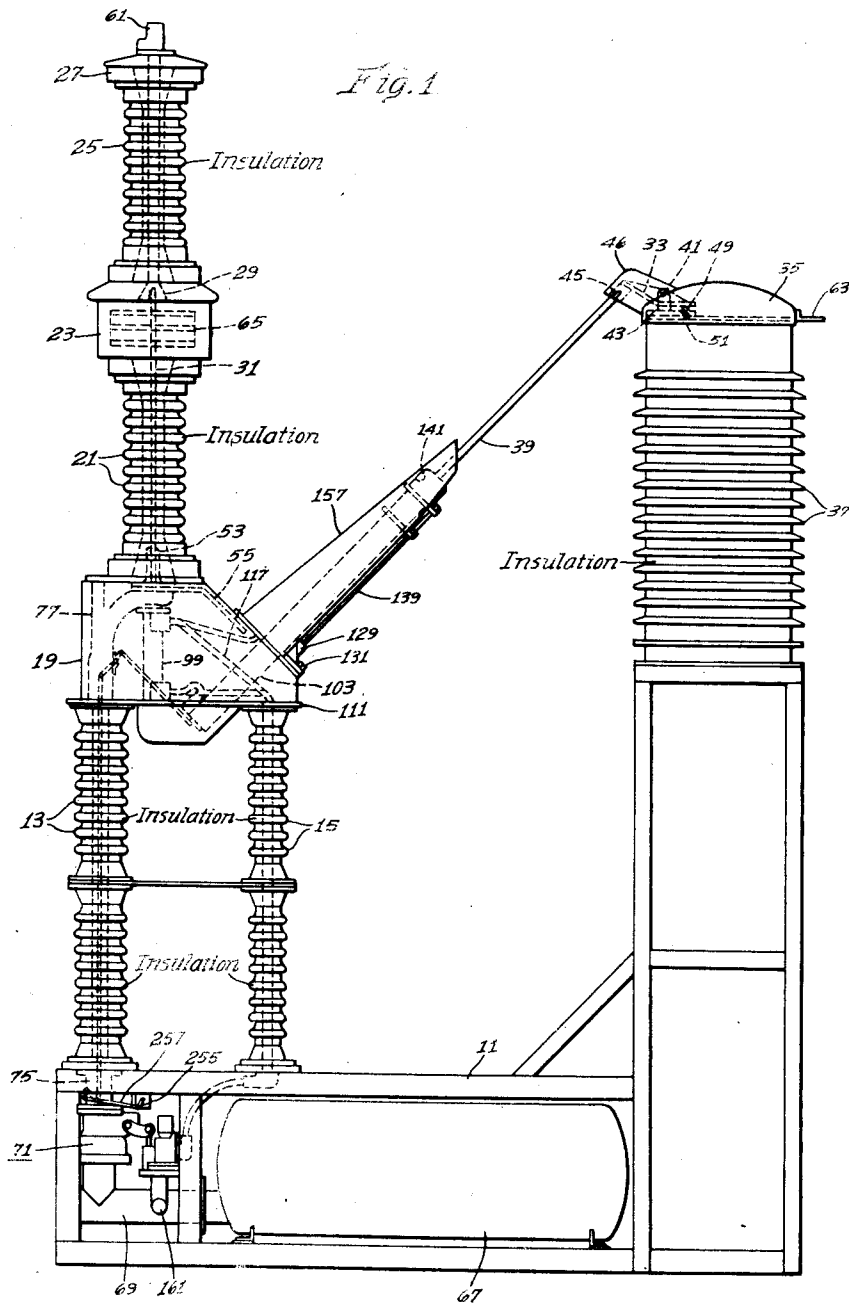
B. P. BAKER ET AL

2,363,283

CIRCUIT INTERRUPTER

Filed Feb. 16, 1942

4 Sheets-Sheet 1



WITNESSES:

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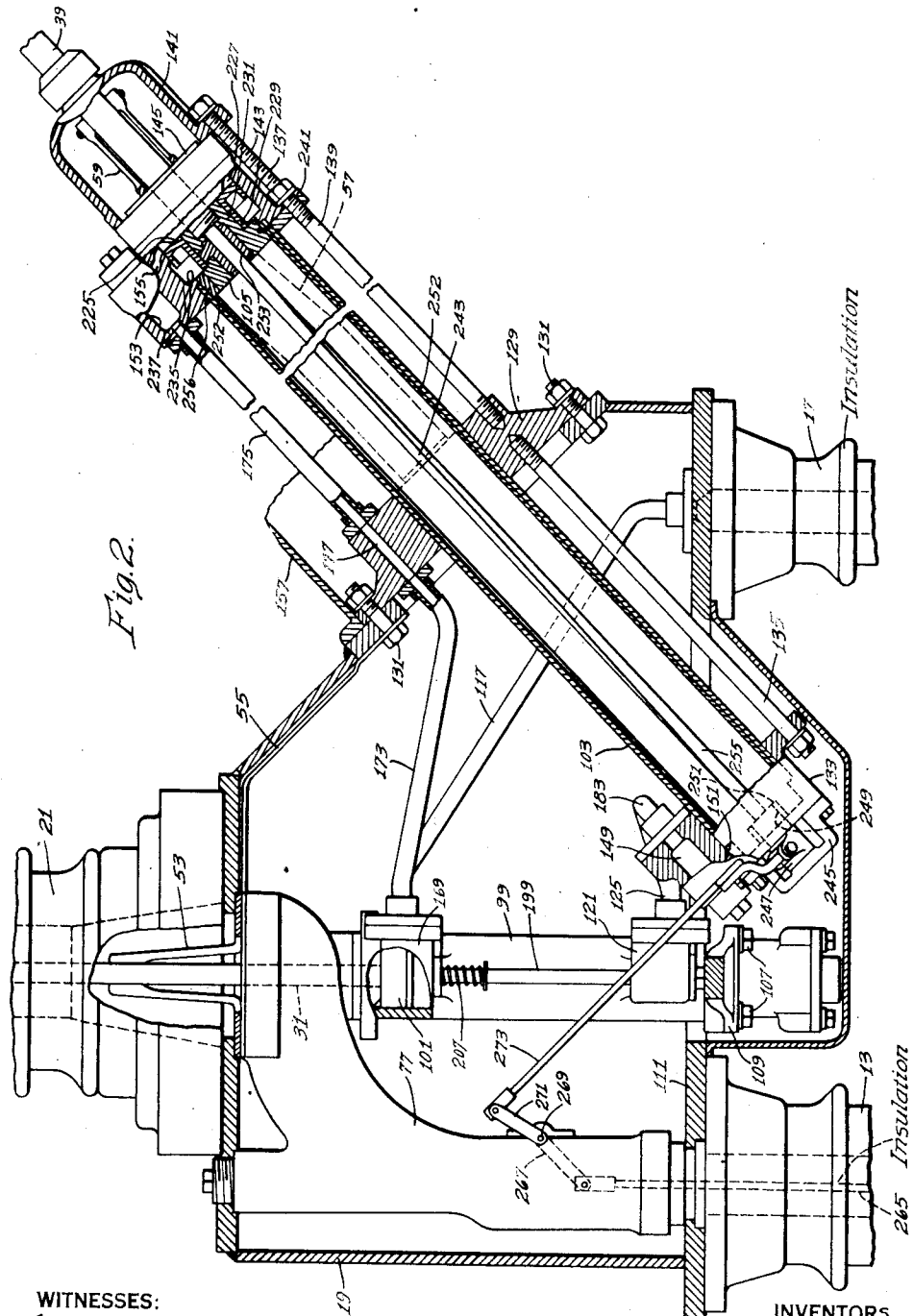
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CIRCUIT INTERRUPTER

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4 Sheets-Sheet 2



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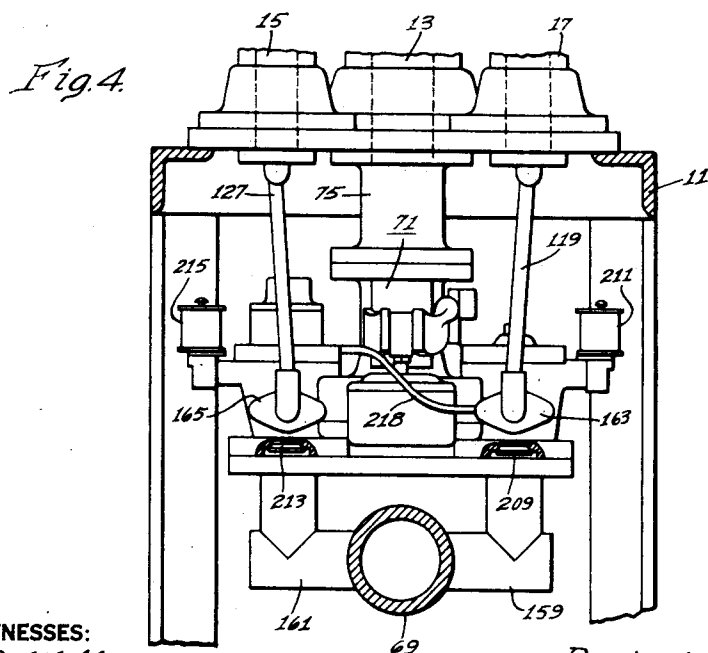
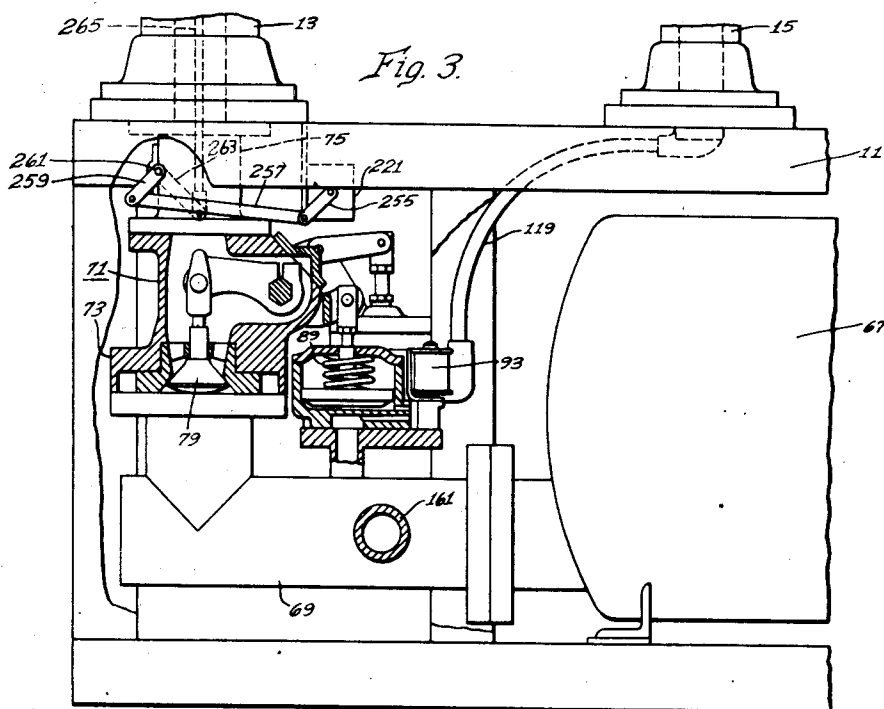
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4 Sheets-Sheet 3



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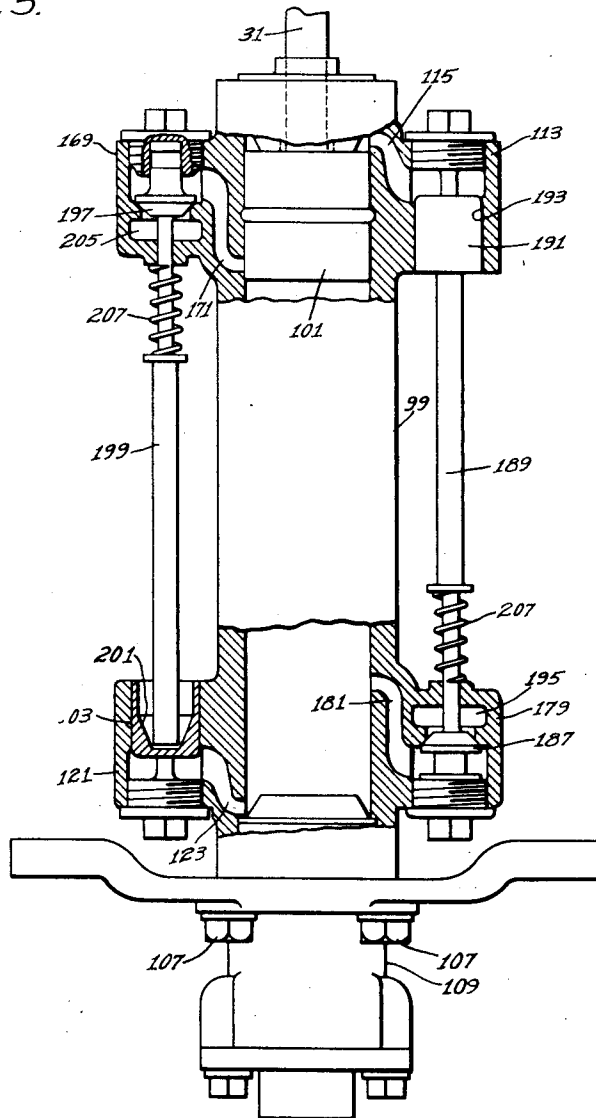
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CIRCUIT INTERRUPTER

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4 Sheets-Sheet 4

Fig. 5.



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2,363,283

CIRCUIT INTERRUPTER

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Application February 18, 1942, Serial No. 431,395

7 Claims. (Cl. 200—81.4)

The invention relates to circuit interrupters, and more particularly to operating means for high-voltage outdoor circuit interrupters or switches.

Outdoor disconnect switches and high-voltage outdoor circuit interrupters of the type having exposed disconnect contacts must operate satisfactorily under all kinds of weather conditions. In the case of more or less severe ice conditions, a very large driving force is necessary to break the contacts loose and start cracking ice which forms on the contacts and other movable parts. Once the ice is cracked and motion has started a very much reduced force is necessary to complete the switching operation and to prevent excessive contact speed and stopping difficulties.

An object of the present invention is the provision of an improved operating means for the disconnect contact member of an outdoor switch or circuit interrupter which will satisfactorily operate the contact member under all kinds of weather conditions including severe ice conditions.

Another object of the invention is the provision of a circuit interrupter or switch embodying an improved fluid actuated operating means which is operable to apply a large starting force for initiating the movement of the contact member followed by the application of a reduced force sufficient to complete the operation of the contact member.

Another object of the invention is the provision of a switch or circuit interrupter embodying an improved fluid actuated operating means comprising two pistons for operating the contact member, one of large diameter for applying a large force to start the motion of the contact member and the other of smaller diameter to maintain speed and complete the operation of the contact member.

Another object of the invention is the provision of a switch or circuit interrupter embodying an improved fluid actuated operating means as described in the preceding paragraph, wherein the large piston is mounted as a floating piston and moves the regular piston for only a short distance of the initial motion of the regular piston.

Another object of the invention is the provision of an improved high-voltage circuit interrupter having a straight line motion contact member.

Another object of the invention is the provision of a circuit interrupter or switch having a contact member connected directly to a fluid actuated operating piston, and an improved coupling

means for transmitting the motion of the contact member to an auxiliary switch means.

Another object of the invention is the provision of a circuit interrupter or switch having a contact member that is reciprocally movable in a straight line, and an improved coupling means for transmitting the motion to an auxiliary switch means which is adapted to be operated in accordance with the position of the contact member.

Another object of the invention is the provision of a circuit interrupter or switch having a contact member reciprocally operated in a straight line by a fluid actuated operating piston and having a coupling means comprising a twisted member which is caused to rotate by the motion of the piston to transmit the motion to an auxiliary switch means for control or indicating purposes.

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

Figure 1 is a side elevational view, partly in section, of a high-voltage circuit interrupter embodying the features of the invention.

Fig. 2 is a view, partly in section, of the contact operating means and showing the details of construction of the compressed air operating means for the movable disconnect contact member and a portion of the coupling means for transmitting the motion of the contact member to the auxiliary switch means.

Fig. 3 is an enlarged view, partly in section, showing a portion of the control valve means for controlling the operation of the interrupter.

Fig. 4 is a view, partly in section, and taken at right angles to Fig. 3, showing the opening and closing valves, and

Fig. 5 is a view partly in section of the operating cylinder for the movable arcing contact.

The features of the present invention are illustrated as applied to a circuit interrupter of the same general construction as fully disclosed in the copending application of L. R. Ludwig et al., Serial No. 431,394, filed February 18, 1942, and assigned to the assignee of the present application.

Referring to the drawings, the reference numeral 11 indicates a framework which may be formed of structural steel or other suitable ma-

terial. Rising from the left-hand side of the framework are a plurality of hollow insulators 13, 15 and 17, only the first two of which are shown in Fig. 1, the latter being shown in Fig. 2. Supported upon the upper end of the insulators 13, 15 and 17 is a casing 19 for housing the operating means more clearly shown in Fig. 2. The casing 19 supports a hollow insulator 21 which, in turn, supports a circuit interrupting element 23. A hollow insulator 25 extends upwardly from the element 23 and has a metallic terminal cap 27 secured on its free end. A stationary contact member 29 extends downwardly from the terminal cap 27 into the circuit interrupting element 23. A movable contact member 31 coacts with the stationary contact member 29 and extends downwardly through the element 23 and through the hollow insulator 21. The lower end of the contact member 31 extends into the casing 19 and is connected to a piston of the operating means as shown in Fig. 2, and which will be more fully described hereinafter.

The contacts 29—31 form arcing contacts of the interrupter and are electrically connected in series with a pair of disconnect contacts which are arranged to be opened after the arcing contact opens during a circuit opening operation of the circuit interrupter, and closed after the arcing contacts have closed during a closing operation of the circuit interrupter. The disconnect contacts comprise a stationary disconnect contact member 33 mounted in a terminal cap 35 on the upper end of a hollow insulator 37, and a cooperating movable disconnect contact member 39 in the form of a hollow tubular rod which is mounted in bearing means on the casing 19 for straight line movement in the direction of its longitudinal axis, the axis of movement of the contact member 39 being at an angle to the axis of movement of the arcing contact member 31.

The stationary disconnect contact member 33 comprises an arm pivotally mounted intermediate its ends by pivot pin 41 on a bracket 43 which is secured to a plate within the terminal cap 35. The left-hand end of the contact arm carries a finger contact assembly 45 having spring pressed fingers adapted to receive and engage the free end of the movable disconnect contact member 39 in the closed position of the movable disconnect contact member. The finger contact assembly 45 is disposed in an opening formed in a sleet hood 46 on the terminal cap 35. The stationary disconnect contact arm 33 is movable only a very small amount about its pivot 41, the movement thereof in each direction being limited by stops (not shown). A compression spring 51 is disposed beneath the tail portion of the contact arm 33 for biasing the same in a counterclockwise direction.

The movable arcing contact member 31 and the movable disconnect contact member 39 are electrically connected in series by means of a resilient connector contact means 53 slidably engageable by contact member 31, and by connector strips 55 and 57 (Fig. 2). The latter conductor strip 57 is electrically connected to a similar connector contact means 59 (Fig. 2) that is slidably engageable by the movable disconnect contact member 39.

The hollow insulator 37 may be supported from the right-hand end of the framework 11, and this insulator serves as a housing for transformers and other suitable instruments necessary for the control of the circuit interrupter.

External circuit connections to the interrupter are made to a terminal 61 carried by the terminal cap 27 and to a terminal 63 on the terminal cap 35. Thus from the foregoing description, it is apparent that when the circuit interrupter is in closed position, current flows through the interrupter from the terminal 61, through the terminal cap 27, stationary arcing contact 29, movable arcing contact 31, connector contact means 53, conducting strips 55 and 57, connector contact means 59, movable disconnect contact member 39, stationary disconnect contact member 33 and through a flexible shunt conductor (not shown) to the terminal cap 35 and terminal 63. If the movable arcing contact 31 is operated to open circuit position while the interrupter is carrying a load, an arc will be drawn by the movable arcing contact member 31. Extinction of arcs drawn by the movable arcing contact member 31 may be accomplished by any suitable arc extinguishing means but preferably by an arc extinguisher of the fluid blast type which, for example, may be of the form fully disclosed in the copending application of L. R. Ludwig and B. P. Baker, Serial No. 373,856, filed January 9, 1941, and assigned to the assignee of this application. Since the present application is not concerned with the arc extinguishing structure, it is believed that the general designation of the arc extinguishing unit 65 which is supplied with a blast of arc extinguishing fluid such as compressed air will be sufficient for the purpose at hand.

Fluid under pressure, in this instance compressed air, for extinguishing the arc and also for the operating means of the interrupter may be stored in a tank 67 mounted within the framework 11. Extending from the left-hand end of the tank 67 is a pipe 69 which has mounted thereon and in communication therewith a blast valve mechanism indicated generally at 71. The blast valve mechanism has a housing 73 (Fig. 3) which communicates through a short section of pipe 75 with the passage through the interior of the insulator 13. The passage through the insulator 13 communicates through a pipe 77 and through the hollow insulator 21 with the chamber of the circuit interrupting element 23. Thus a blast of air under pressure from the tank 67 is conducted to the arc extinguisher 65 by way of the pipe 69, blast valve 71, hollow insulator 13, pipe 77 and tubular insulator 21. The blast valve mechanism 71 is of the same construction as that disclosed in the aforementioned copending application of L. R. Ludwig et al., Serial No. 431,394, and consequently only a very brief description thereof will be given since reference to the aforementioned application of L. R. Ludwig et al. Serial No. 431,394, may be had for details of construction. Briefly, the blast valve mechanism includes a valve 79 in the housing 73 which is biased to closed position by a spring and which is caused to be opened upon energization of a solenoid 93. The contact members 31 and 39 are operated to open position in a predetermined sequence and also to closed position in a predetermined sequence by a compressed air operating means comprising an operator cylinder 99 having a double acting piston 101 therein connected to the lower end of the arcing contact member 31, and an operating cylinder 103 having a double acting piston 105 therein connected to the lower end of the movable disconnect contact member 39. The operating cylinder 99 is mounted within the

casing 19 and has a lower cylinder head 109 secured thereto by bolts 107, the cylinder head being in turn secured to the bottom plate 111 of the casing 19 by a plurality of bolts (not shown). The lower portion of the arcing contact rod member 31 slidably extends through the offset portion of the pipe 77 and through an opening provided therefor in the upper head of the cylinder 99, the lower end of the contact member being connected to the piston 101. Referring to Fig. 5, the cylinder 99 has a projection 113 formed integral therewith adjacent the upper end, and this projection has a passage 115 leading to the upper end of the interior of the cylinder and a port communicating with the passage which is connected by a pipe 117 (Fig. 2) to the passage of the hollow insulator 17. This passage of the hollow insulator 17 is, in turn, connected by a pipe 119 (Fig. 4) to an opening valve mechanism for controlling the flow of compressed air to effect an opening operation of the circuit interrupter. The lower end of the operating cylinder 99 is also provided with an integral projection 121 (Fig. 5) having a passage 123 therein communicating with the lower end of the cylinder, and also has a port in communication with the passage which is connected by a pipe 125 (Fig. 2) to the passage through the hollow insulator 15 which conducts air for closing the circuit interrupter. The passage of the hollow insulator 15 is, in turn, connected by a pipe 127 (Fig. 4) to a closing valve mechanism which will be hereinafter described.

The operating cylinder 103 is mounted in the casing 19 and the upper portion thereof projects outside of the casing 19, through an opening provided in an annular casting or support member 129 which is secured to the wall of the casing 19 by a plurality of bolts 131. The member 129 serves to support the cylinder 103. The lower end of the operating cylinder 103 fits into a cylinder head 133 which is secured on this end of the cylinder by a plurality of elongated bolts 135, only one being shown. The bolts 135 pass through a flange of the cylinder head 133 and thread into the annular support member 129. The upper end of the operating cylinder 103 fits into a cylinder head 137 which is secured thereon by a plurality of bolts 139, only one being shown. The bolts 139 extend through openings provided in a flange of the cylinder head 137 and the lower ends of the bolts thread into the angular support member 129, thus securely clamping the cylinder head on the end of the cylinder. A metallic cover 141 is mounted at the upper end of the cylinder head and is secured thereto by a plurality of bolts 143, only one being shown. The bolts 143 pass through a flange of the cover 141 and through the flange of the cylinder head 137. A metallic closure cap 145 is securely clamped over the upper end of the cylinder head 137 by the cover 141, suitable packing gaskets or other packing material being disposed between the cap 145 and the upper end of the cylinder head 137. The tubular disconnect contact member 39 extends through bearing openings in the cover 141 and end cap 145 into the interior of the cylinder 103, and the lower end of this contact member is connected to the operating piston 105.

The lower cylinder head 133 of the operating cylinder 103 is provided with passages 149 and 151 which communicate with the lower end of the interior of the cylinder 103. The compressed air for closing the disconnect contact member is adapted to flow through these passages to the

under side of the piston 105. The upper cylinder head 137 is also provided with passages 153 and 155 which communicate with the interior of the cylinder head at the upper end of the cylinder 103 for conducting the flow of compressed air to the upper side of the piston 105 to effect opening operation of the disconnect contact member 39. A sleet hood 157 is provided for protecting the exposed portion of the cylinder assembly 103.

Compressed air for operating the pistons 101 and 105 to effect opening and closing of the circuit interrupter is derived from the air storage tank 67. For this purpose, the pipe 69 is provided with two branch pipes 159 and 161 (Fig. 4). The pipe 159 leads to the opening valve mechanism generally indicated at 163, whereas the branch pipe 161 leads to the closing valve mechanism indicated generally at 165. Compressed air from the opening valve mechanism 163 is conducted through the pipe 119 and passage of the hollow insulator 17 and pipe 117 to the upper end of the operating cylinder 99 above the uppermost position of the operating piston 101. The closing valve mechanism 165 controls the flow of compressed air from the pipe 161, through the pipe 127, passage of the hollow insulator 15 and pipe 125 to the lower end of the operating cylinder 99 below the lowermost position of the operating piston 101 to effect closing operation of the circuit interrupter.

It is important that the disconnect contact member 39 should be opened only after the arcing contact member 31 has been moved to full open position during a circuit opening operation, and it is also desirable that the disconnect contact member 39 should close after the arcing contact member 31 has reached closed position during a closing operation, in order to eliminate the necessity of providing a blast of arc extinguishing fluid for the arcing contact during the closing operation. In order to accomplish this sequence of operation of the contact members 31 and 39, the operating pistons 101 and 105 are pneumatically interlocked to insure the desired sequence of operation. For this purpose, the operating cylinder 99 is provided with a projection 169 (Fig. 5) integral therewith adjacent the upper end, and this projection has an air passage 171 formed therein which communicates at one end with the interior of the cylinder at a predetermined point below the upper end of the cylinder. The other end of the passage 171 communicates with a port in the projection 169 which is connected by a pipe 173 (Fig. 2), passage 177 in support member 129, and a pipe 175 to the passages 153 and 155 leading to the upper end of the operating cylinder 103. The point of entry of the passage 171 into the cylinder 99 is so located that it is uncovered by the piston 101 after the piston has moved downwardly a predetermined distance in an opening direction, so that the operating piston 101 will have overcome static friction and come up to nearly full speed before compressed air is admitted through the pipes 173 and 175 to the upper end of the operating cylinder 103. The construction is such that movable arcing contact member 31 will have reached full open position before the compressed air applied to the upper side of the operating piston 105 starts to move the disconnect contact member 39 to the open position.

A similar projection 179 (Fig. 5) is formed integral with the cylinder 99 adjacent the lower end thereof, and this projection has a passage

181 which communicates at one end with the interior of the cylinder 99 at a point a predetermined distance above the lower end of the cylinder. The other end of the passage 181 communicates with a port in the projection 179 which is connected by a pipe 183 (Fig. 2) to the passages 149 and 151 of the cylinder head 133, leading to the lower end of the operating cylinder 103. The point of entry of the passage 181 into the cylinder 99 is arranged to be uncovered by the operating piston 101 after the piston has moved upwardly a predetermined distance in the closing direction to admit air to the lower end of the operating cylinder 103 beneath the piston 105. The location of the passage 181 is such that the arcing contact member will have been moved to the completely closed position before the compressed air acting on the underside of the operating piston 105 moves the movable disconnect contact member 39 to closed position.

In order to obtain high speed opening and high speed reclosing of the operation of the circuit interrupter, it is necessary to dump the air in the cylinders ahead of the direction of movement of the operating pistons to atmosphere so as to prevent air ahead of the pistons from retarding the movement thereof. Two dump valves 187 and 197 (Fig. 5) are provided for this purpose. The dump valve 187 is mounted in the projection 179 at the passage 181 thereof, and this valve has a rod 189 connected thereto, the upper end of which is connected to a piston 191 movable in a cylinder 193 of the projection 113. The dump valve 187 is biased to closed position by a spring 207, and it is adapted to be operated to open position by the piston 191 immediately upon the flow of compressed air to the upper side of the arcing contact operating piston 101. Opening of the valve 187 opens the lower end of both cylinders 99 and 103 to atmosphere through an atmosphere exhaust port 195, so that the air below the two operating pistons will be at low pressure and will not retard the opening movement of the two pistons. The other dump valve 197 is mounted in the projection 169 of the cylinder 99 and has a rod 199 connected thereto, the lower end of which is connected to a piston 201 mounted in a cylinder 203 of the projection 121. The dump valve 197 is biased to closed position by a spring 207 and is adapted to be opened by the piston 201 immediately upon the flow of compressed air to the lower end of the operating cylinder 99 through the passage 123. Opening of the dump valve 197 connects the upper ends of both cylinders 99 and 103 to atmosphere through an exhaust port 205, thereby causing the air above the operating pistons to be at a low pressure, so that it will not retard the closing movement of the operating pistons.

The opening valve mechanism 163 and the closing valve mechanism 165 are of the same construction as disclosed in the aforementioned copending application of L. R. Ludwig et al., Serial No. 431,394, and only a brief description thereof will be given in this application, as the details of construction of the valve mechanisms are not necessary to a complete understanding of the present invention. Referring to Fig. 4, the opening valve mechanism 163 has a valve 209 which is biased closed and which is caused to be opened by air pressure from the pipe 159 upon energization of a solenoid 211. Similarly, the closing valve mechanism 165 has a valve 213 which is biased closed and which is caused to

be opened by compressed air from the pipe 161 upon energization of a solenoid 215. The valve mechanisms 163 and 165 are pneumatically interlocked by means of a piston in the valve mechanism 165 and by a pipe 218 connecting the housings of the valve mechanisms 163 and 165 as disclosed in the aforementioned copending application of L. R. Ludwig et al., Serial No. 431,394, so that an opening impulse will always take precedence over a closing impulse.

The control circuits for controlling the solenoid 93 of the blast valve mechanism 71 and the solenoids 211 and 215 of the opening and closing valve mechanisms are the same as disclosed in the aforementioned copending application of L. R. Ludwig et al., Serial No. 431,394, and are not shown in this application as the details thereof are not necessary to a complete understanding of the present invention. It is believed sufficient to state that the solenoid 93 of the blast valve mechanism and the solenoid 211 of the opening valve mechanism are adapted to be simultaneously energized to effect opening of their respective valves in response to the operation of an opening relay. The opening relay is caused to be energized in response to the operation of an overload current responsive protective relay or by the closing of a manual opening control switch. The solenoid 93 of the blast valve 71 is caused to be deenergized by auxiliary contacts of an auxiliary switch means 221 as soon as the disconnect contact member 39 starts its opening movement, consequently the blast valve 71 is returned to its closed position. As soon as the opening operation of the circuit interrupter is completed and the disconnect contact member 39 reaches full open position, the opening relay is deenergized by the opening of another pair of auxiliary contacts of the auxiliary switch means 221, so that the opening valve returns to closed position. The solenoid 215 of the closing valve means is caused to be energized by the operation of a closing relay. The closing relay is, in turn, caused to be operated by either a reclosing relay or by a manual closing control switch. As soon as the closing operation of the circuit interrupter has been completed and the disconnect contact member 39 has reached the fully closed position, the closing relay is deenergized by the opening of a pair of auxiliary contacts of the auxiliary switch means 221.

The circuit interrupter is adapted for outdoor application, and consequently must operate satisfactorily under all kinds of weather conditions, including severe ice conditions. In the case of severe ice conditions, a very large driving force is necessary to break the disconnect contacts loose and start cracking the ice from around the sliding contact member 39. Once the ice has been cracked and motion is started, a very reduced force is necessary to prevent excessive contact speed and stopping difficulties. In accordance with the present invention, a large starting force is applied to the disconnect contact member 39 for a short distance only of its initial opening movement, by means of an auxiliary floating piston 225 (Fig. 2) which is mounted for sliding movement through a short stroke in the cylinder head 137 of the operating cylinder 103. The piston 225 is of annular construction and is slidably mounted in a short cylinder 227 formed in the cylinder head 137, as shown in Fig. 2. The auxiliary piston 225 is of larger diameter than the main operating piston 105 and is provided with a sleeve 229 which is adapted to receive a reduced cylindrical portion 231 of the main operating

piston when the main operating piston is in its uppermost position, as shown in Fig. 2. In the fully closed position of the disconnect contact member 39 both pistons 105 and 225 are in their uppermost positions as shown. When compressed air is admitted to the upper end of the cylinder 103, through the passages 153 and 155 for effecting an opening operation of the disconnect contact member 39, the compressed air acts on the large surface of the auxiliary piston 225 and moves it downwardly. As the auxiliary piston 225 moves downwardly, it carries with it the main piston 105. The auxiliary piston 225 is moved downwardly only a very short distance, however, when it strikes a stop surface provided by a shoulder 235 formed in the cylinder head. At this position the auxiliary piston 225 has opened a bypass passage 237 formed in the cylinder head 137 so as to admit the compressed air around a portion of the side of the auxiliary piston 225 to the upper surface of the main piston 105 at the time the auxiliary piston reaches its stop. This insures that the movement of the main piston 105 will continue at the time the auxiliary piston stops. After the main piston separates from the auxiliary piston, the compressed air then flows through the central opening in the tubular part 229 of the auxiliary piston. The main piston 105 is moved on by the flow of compressed air to the full open position, but at a very much reduced driving force due to the smaller pressure-reactive area of the piston 105. This arrangement provides for a very large starting force to initiate the movement of the disconnect contact member followed by the application of a much reduced force sufficient to complete the switching movement. When compressed air is admitted to the lower end of the cylinder 103 for closing the disconnect contact member 39, the piston 105 is moved upwardly to its uppermost position and during the latter portion of this movement carries the auxiliary piston 225 with it to its uppermost position, as shown in Fig. 2, so that the two pistons are ready for the next opening operation. A spring pressed ring 241 of cylindrical cross section is mounted in a ring groove on the main operating piston 105, and this spring pressed ring is adapted to engage in either of two grooves provided at each end of the operating cylinder for retaining the disconnect contact member 39 in open or closed position.

In this circuit interrupter, the operation of the disconnect contact member 39 always follows the operation of the movable arcing contact member 31. Consequently, it is desirable to operate the auxiliary switch means 221 in accordance with the position of the disconnect contact member 39. In accordance with the present invention, this is accomplished in a simple and inexpensive manner by means of a twisted square rod 243 which projects into the operating cylinder 103 from the lower end thereof and extends for substantially the full length of the operating cylinder. The lower end of the rod 243 has a reduced cylindrical portion which extends through an opening provided in a bracket 245 secured to the lower end of the cylinder head 133 and has a nut threaded thereon for retaining the rod 243 in mounted position. A crank arm 247 is rigidly secured to the lower portion of the rod 243, and this crank arm 247 has a cylindrical portion 249 which is supported in a journal bearing 251 formed in the cylinder head 133. The rod 243 is thus mounted for rotation in the cylinder 103 about its longitudinal axis

by means of the bearing 251 and the bearing opening in the bracket 245. The twisted square portion of the rod 243 extends through a bab-bitted opening 253 of corresponding shape formed in the main operating piston 105 and also extends into the hollow portion of the movable disconnect contact member 39. The cylinder 103 has a lining sleeve 252 rigidly secured therein, and this sleeve has a straight slot 254 for receiving a key or guide 256 secured to the operating piston 105 for preventing rotation of the piston as it is moved back and forth in the cylinder. The opening 253 in the piston 105 and the twisted square portion of the rod 243 causes the rod to be rotated about its longitudinal axis by the movement of the operating piston from one end position to the other. The crank arm 247 secured to the rod 243 is utilized to operate the auxiliary switch means 221 which is mounted in the framework 11 adjacent the lower end of the insulator 13. The auxiliary switch means 221 has an operating arm 255 (Figs. 1 and 3) which is coupled by a rod 257 to a crank arm 259. The crank arm 259 is fixed to a shaft 261 extending through a portion of the hollow pipe member 75. Also fixed to the shaft 261 interiorly of the hollow pipe 75 is a crank arm 263. The interior crank arm 263 has pivoted thereto the lower end of a pull rod 265 of insulating material. The rod 265 extends upwardly through the passage in the hollow insulator 13 and into the pipe 77 within the casing 19. The upper end of the rod 265 is pivotally connected to a crank arm 267 (Fig. 2) carried by a shaft 269. A portion of the shaft 269 extends exteriorly of the pipe 77 and has a second crank arm 271 thereon. This last-named crank arm is connected by means of a rod 273 to the crank arm 247 of the twisted member 243. It thus appears that when the crank arm 247 is partially rotated in one direction or the other by the movement of the operating piston 105, the crank arm 271 will be correspondingly rotated transmitting motion by means of the insulating rod 265 and the crank arms 263 and 259 and link 257 to the operating arm 255 of the auxiliary switch means 221, thereby operating the auxiliary switch means in accordance with the position of the disconnect contact member 39. The operating mechanism within the housing 19 is at line potential, whereas the auxiliary switch means is at ground potential upon the framework 11. The auxiliary switch means, however, is insulated from the mechanism within the casing 19 and from line potential by means of the insulating rod 265.

The auxiliary switch means may be of any conventional construction having a plurality of sets of contacts forming a plurality of poles, preferably with each set of contacts being adjustable relative to the operating arm 255 of the auxiliary switch means. Some of the individual sets of contacts or poles of the auxiliary switch means 221 may be utilized in the control circuits for the operating means of the circuit interrupter, and other poles of the auxiliary switch means may be used to control indicating or signalling circuits.

It is believed that the details of operation of the circuit interrupter will be clearly understood from the foregoing description. The operation of the circuit breaker is briefly as follows: Assuming the circuit breaker to be in the closed position, opening operation of the circuit breaker is caused to take place upon energization of the solenoid 211 of the opening valve mechanism

163. Opening of the valve 163 causes the flow of compressed air from the tank 67 through branch pipe 159, opening valve 163, through the hollow insulator 17 and pipe 117 to the upper side of the arcing contact operating piston 101. The flow of compressed air to the upper side of the operating piston 101 immediately causes opening of the dump valve 187 (Fig. 5), thereby opening the lower ends of both cylinders 99 and 103 to atmosphere, and the compressed air acting on the top of the operating piston 101 moves the same downwardly to open position effecting movement of the arcing contact member 31 to open position. After the operating piston 101 is moved downwardly a predetermined distance, it uncovers the passage 171 so that compressed air then flows through the passage 171 and pipes 173 and 175 to the upper end of the disconnect contact operating cylinder 103. By the time the arcing contact member 31 reaches full open position, the compressed air acting upon the large diameter floating piston 225 starts the opening movement of the piston 105 and disconnect contact member 39, a large driving force being applied to start the movement of the disconnect contact member 39 by reason of the large diameter of the floating piston 225. The floating piston 225 moves through only a short distance in the downward direction and carries with it the main operating piston 105. By the time the floating piston 225 engages the stop 235, it uncovers the bypass passage 237, thereby admitting compressed air to the upper surface of the operating piston 105 to continue the downward movement of the main operating piston. As soon as the main operating piston 105 disengages the floating piston 235, the compressed air flows directly through the central opening of the floating piston 225 and drives the main operating piston 105 downwardly to its lowermost position to effect complete opening of the disconnect contact member 39. The large diameter floating piston 225 applies a large driving force for a short distance of the initial opening movement of the disconnect contact member 39, after which the smaller diameter regular operating piston 105 continues to drive the contact member 39 on to its full open position, but at a much reduced driving force due to its smaller diameter.

During the opening movement of the piston 105, the twisted rod 243 is caused to be rotated in one direction thereby and this motion is transmitted from the crank arm 247 by the previously described linkage to the operating arm 255 of the auxiliary switch means 221, thereby causing operation of the auxiliary switch means 221.

Since the solenoid 93 of the blast valve 71 is energized simultaneously with the solenoid 211 of the opening valve mechanism, the blast valve 71 is opened to cause a blast of air for extinguishing the arc drawn by the arcing contacts. As soon as the disconnect contact member 39 starts its opening movement the solenoid 93 is deenergized and the blast valve 71 closes.

As soon as the disconnect contact member 39 reaches full open position, the solenoid 211 is deenergized and the opening valve 163 thereupon returns to closed position.

A closing or reclosing operation of the circuit interrupter is produced upon energization of the solenoid 215 of the closing valve mechanism 165. The opening of the closing valve 165 causes the flow of compressed air from the tank 67 through the branch pipe 161, closing valve 165, through the passage of the hollow insulator 15 and pipe

125 to the lower side of the arcing contact operating piston 101. This flow of compressed air immediately opens the dump valve 197 (Fig. 5), thereby opening the upper ends of both cylinders 99 and 103 to atmosphere. The compressed air acting on the underside of the operating piston 101 drives the piston to its uppermost position, thereby effecting movement of the arcing contact member 31 to closed position in engagement with the stationary contact 29. As soon as the operating piston 101 is moved a predetermined distance in an upward direction, it uncovers the passage 181, thereby admitting compressed air from the cylinder 99, through passage 181 and pipe 183 to the lower end of the disconnect contact operating cylinder 103. By the time the arcing contact member 31 reaches closed position, the compressed air acting on the underside of the disconnect contact operating piston 105 drives the piston upwardly to its uppermost position, thereby effecting movement of the movable disconnect contact member 39 to closed position. Shortly before the piston 105 reaches its uppermost position it picks up the large diameter floating piston 225 and carries this piston along with it until both pistons reach their uppermost end positions.

The upward or closing movement of the disconnect contact operating piston 105 causes rotation of the twisted rod 243 in a direction opposite to that produced by the opening movement of the piston. This movement of the twisted rod 243 is transmitted by the crank 247 and previously described insulating linkage to the operating arm 255 of the auxiliary switch means 221, thereby operating the auxiliary switch means to a position corresponding to that of the closed position of the disconnect contact 39.

Just before the disconnect contact member 39 reaches the fully closed position, the solenoid 211 is deenergized and the closing valve 165 returned to closed position.

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

We claim as our invention:

1. A circuit interrupter comprising a pair of arcing contacts separable to provide a current interrupting break, a pair of external air break disconnect contacts connected in series therewith, compressed air operating means for said contacts including a cylinder and a piston therein for actuating said arcing contacts, another cylinder and a piston therein for actuating the movable disconnect contact to open and to closed circuit positions, a source of compressed air for operating said pistons, control valve means for controlling the flow of compressed air to said cylinders, means for causing said pistons to be operated in a predetermined sequence during an opening operation to first open said arcing contacts and then open said disconnect contacts, an additional piston means in said disconnect contact operating cylinder adjacent one end thereof, said additional piston means being of larger diameter than said disconnect contact operating piston and being movable through a short stroke by the flow of compressed air to said end of the cylinder to apply a large starting force to said

disconnect contact member for a short distance of the initial portion of the opening stroke of said contact member.

2. A circuit interrupter comprising a pair of arcing contacts separable to provide a current interrupting break, a pair of external air break disconnect contacts connected in series therewith one of which is reciprocally movable in a substantially straight line to open and closed positions, fluid actuated operating means for said pairs of contacts, means controlling said operating means to cause said operating means to first open said arcing contacts and then open said disconnect contacts during an opening operation, a member rotatable about an axis extending in the direction of the axis of movement of said movable disconnect contact and movable about its rotatable axis by the movement of said disconnect contact, an auxiliary switch means, and means connecting said auxiliary switch means to said rotatable member for operation thereby.

3. A circuit interrupter comprising a pair of arcing contacts separable to provide a current interrupting break, a pair of disconnect contacts connected in series therewith one of which is reciprocally movable in a substantially straight line to open and closed positions, compressed air operating means for said pairs of contacts including a cylinder and piston therein for actuating said arcing contacts and another cylinder and piston therein connected to the movable disconnect contact for actuating the same, means for causing said pistons to be operated in a predetermined sequence to first open said arcing contacts and then open said disconnect contacts during an opening operation and to close said disconnect contacts after said arcing contacts are closed during a closing operation, a member extending into said disconnect contact operating cylinder in the direction of the longitudinal axis of said cylinder, said member being mounted for rotation about an axis extending in the direction of the axis of movement of said disconnect contact operating piston and being movable about its axis by the movement of said piston, an auxiliary switch means, and means connecting said auxiliary switch means to said rotatable member for operation thereby.

4. A circuit interrupter having a reciprocable contact member movable in a substantially straight line to open and closed positions, fluid actuated operating means therefor comprising a cylinder, a piston in said cylinder rigidly connected to said contact member for moving said contact member from one of said positions to the other, a rod extending into said cylinder and

mounted for rotation about its longitudinal axis, said rod having a twisted portion extending through an opening in said piston for causing said rod to be moved about its axis of rotation by the movement of said piston, an auxiliary switch means, and means connecting said auxiliary switch means to said rod for operation thereby.

5. A circuit interrupter having a reciprocable contact member movable in a substantially straight line to open and closed positions, fluid actuated operating means therefor comprising a cylinder, a piston in said cylinder rigidly connected to said contact member for moving said contact member from one of said positions to the other, a rod extending into said cylinder in the direction of the longitudinal axis of the cylinder, said rod being mounted for rotation about its longitudinal axis, means coupling said rod to said piston for causing said rod to be rotated by the movement of said piston, an auxiliary switch means, and means connecting said switch means to said rod for operation thereby.

6. A circuit interrupter comprising a reciprocable contact member movable in a substantially straight line to open and closed positions, operating means for moving said contact member to open and closed positions, a member rotatable about an axis extending in the direction of the axis of movement of said contact member and movable about said axis by the movement of said contact member, an auxiliary switch means, and means connecting said rotatable member to said auxiliary switch means for operating said auxiliary switch means by said rotatable member.

7. In a high voltage circuit interrupter having a contact member movable to open and to closed circuit positions through a relatively long stroke, fluid actuated operating means therefor comprising a cylinder and a piston in said cylinder connected to said movable contact member, auxiliary switch means for said circuit interrupter operated in accordance with the motion and position of said contact member, said auxiliary switch means having a short stroke as compared to the long stroke of the contact member, and means for operating said auxiliary switch means by and in accordance with the motion of said piston at a reduced motion relative to the motion of said piston, said last-mentioned means including a rotatable element in said cylinder rotated by the motion of said piston and motion transmitting connections between said rotatable element and said auxiliary switch means.

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