Aug. 14, 1945. C. V. FOULDS 2,382,786

AIR BLAST CIRCUIT BREAKER

Filed Feb. 1, 1943 2 Sheets-Sheet 1

Fig. 1.

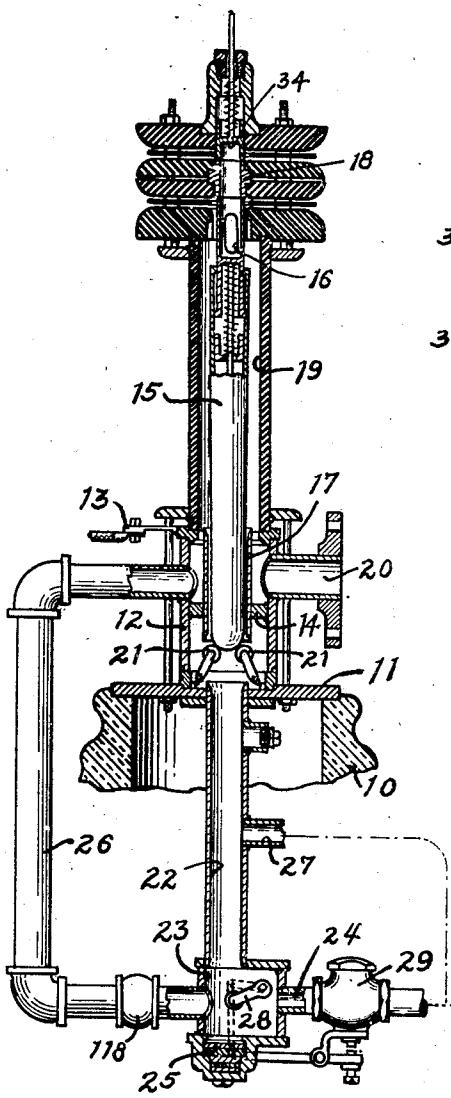


Fig. 2.

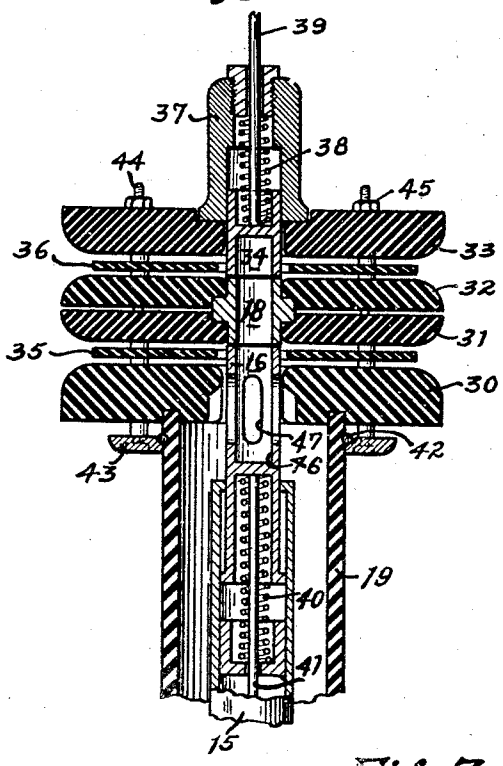
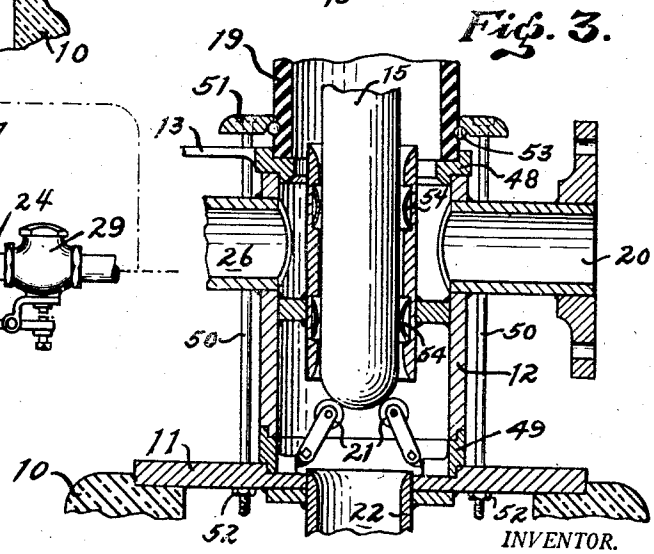


Fig. 3.



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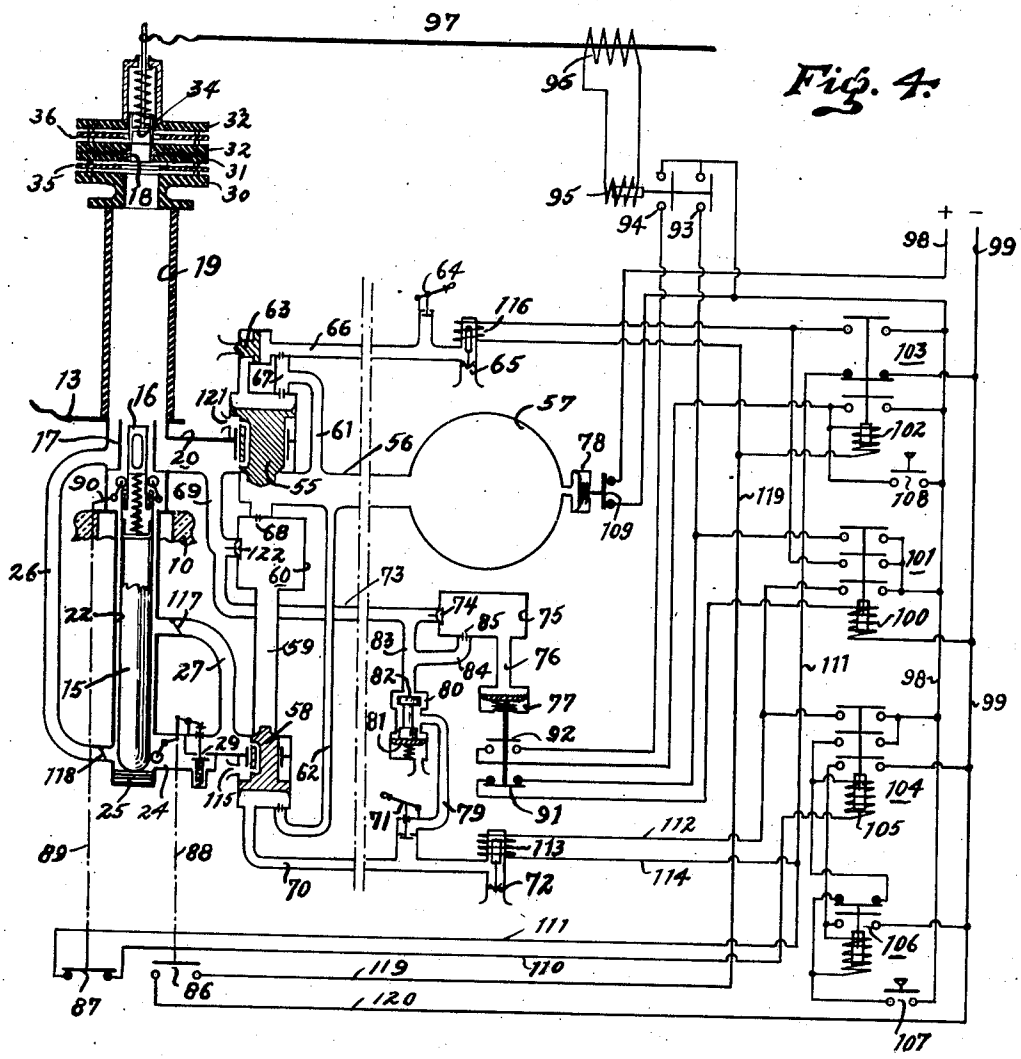
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2 Sheets-Sheet 2

Fig. 4.



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AIR BLAST CIRCUIT BREAKER

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10 Claims. (Cl. 200—82)

My present invention relates to fluid-blast circuit interrupters, and more particularly to a circuit interrupter of the automatic reclosing type that is adapted to interrupt and also isolate high potential circuits, and wherein a fluid under pressure is employed both as an operating and as an arc extinguishing medium.

A principal object of the invention is to provide a fluid-blast type of circuit interrupter that is capable of interrupting and restoring a circuit in the event of a temporary overload or fault condition upon the line and which, in the event of a sustained overload or fault, will function to interrupt and isolate the overload or fault from the remaining portion of the system.

Another object of the invention is to provide a novel arrangement of cooperating fluid-pressure responsive circuit interrupting contacts and a fluid-blast operating means in which a blast of fluid under pressure will operate the contacts to open the circuit and will also function as an arc extinguishing medium at the instant the contacts separate.

Another object of the invention is to provide an electro-pneumatic system of control and a fluid-blast type of circuit interrupter which, in the event of a temporary overload or fault, will operate to interrupt and reclose the circuit and, in the event of a continuing overload or fault, will interrupt and reclose the circuit and finally operate to completely isolate the overload or fault.

Another object of the invention is to provide an electro-pneumatic system of control for a fluid-blast reclosing circuit interrupter of the character described, having both a circuit interrupting and a circuit isolating operation, in which the circuit interrupting and reclosing operations and the circuit isolating operation are controlled in a novel manner.

With circuit interrupters of the fluid-blast type, current interruption and arc extinction has been found to take place most advantageously when the arcing contacts are rapidly separated a distance sufficient to permit a high velocity blast of fluid under pressure between the contacts and transversely of the arc. However, in order to be sure that a restriking of the arc does not occur between the thus separated contacts, it is customary to provide separate isolating or disconnecting contacts that are opened after the arc between the arcing contacts has been extinguished. With an arrangement of this type separate actuating means must be provided for the two sets of contacts, and in order to obtain the proper relationship and sequence of operation, the arcing and disconnecting contacts must be interlocked by complicated arrangements so as to insure consecutive operation. This necessitates a large initial expense, high maintenance costs and large space requirement. It is, therefore, another object of my invention to provide a fluid-blast circuit interrupter in which both the arc-interrupting and the circuit isolating functions are obtained with a single pair of contacts and in which the circuit isolating function will occur subsequent to the arc-interrupting function.

Other objects and advantages of my invention will be in part evident to those skilled in the art and in part pointed out hereinafter in the following description taken in connection with the accompanying drawings, wherein there is shown by way of illustration and not of limitation preferred embodiments thereof.

In the drawings;

Figure 1 is a diagrammatic sectional view showing a circuit interrupter embodying the essential features of my present invention,

Figure 2 is an enlarged fragmentary view illustrating the contact arrangement of the circuit interrupter shown in Figure 1,

Figure 3 is a similar enlarged fragmentary view showing further details of the circuit interrupter illustrated in Figure 1, and

Figure 4 is a diagrammatic view schematically illustrating the manner in which the circuit interrupter of Figure 1 is electro-pneumatically controlled either manually and/or in an entirely automatic manner in response to current conditions upon a power distribution circuit.

For convenience and simplicity the circuit interrupter is illustrated in Figure 1 as of the single pole type, and while a circuit interrupter of this character may find many applications, it will be understood that two or more of these circuit interrupters may be combined so as to simultaneously control the several lines of a multiphase transmission circuit. In its preferred form the circuit interrupter is adapted to be mounted in an insulated and elevated position where the circuit interruption will take place in a zone of high potential and, therefore, its operating mechanism is shown as mounted upon and insulated from ground by means of a suitable supporting insulator 10. At the top of the supporting insulator 10 there is a foundation plate 11 that carries a suitable fluid-pressure housing 12 upon one part of which there is provided a line terminal 13 of the circuit to

be controlled. The housing 12 is also shown as having a transverse partition 14 through which a vertically movable contact supporting ram 15 that carries a circuit interrupting contact 16 is adapted to move. The partition 14 is provided with an elongated cylindrical throat forming member 17 that is adapted to guide the contact supporting ram 15 so as to bring the circuit interrupting contact 16 carried thereby into register with a cooperating stationary contact 18 mounted thereabove and to which another line of the controlled circuit is adapted to be associated. As will hereinafter appear, the stationary contact 18 is mounted in cooperating relation with a series of spaced horizontally disposed baffles between which a blast of fluid under pressure is directed to extinguish any arc that may be established upon a separation of the circuit interrupting contacts. The stationary contact 18 and the fluid-blast directing baffles are here shown as supported by and mounted upon the upper end of an insulating cylindrical member 19 which may be of fibre, porcelain or other suitable material. This cylindrical member 19, in addition to forming a support for the stationary contact 18 and the above referred to fluid-blast directing baffles, also serves to function as a fluid-pressure cylinder for effecting the circuit opening or downward movements of the movable contact supporting ram 15. In its preferred form this cylindrical member 19 will constitute a substantially blast-tight chamber when the movable contact 16 is in contact making engagement with the stationary contact 18. Located immediately above the partition 14 of the fluid-pressure housing 12 there is a conduit 20 through which a blast of operating fluid may be directed to the interior of the cylindrical member 19. When the movable contact supporting ram 15 is in its uppermost position, as here illustrated, it is adapted to be held against any downward movement, due to gravity, by a pair of pivotally mounted latching rollers 21. Supported by and extending downwardly from the foundation plate 11 there is a second ram operating fluid-pressure cylinder 22 into which the movable contact supporting ram 15 is adapted to be positioned when in its lowermost or circuit open position. At its lower end this fluid-pressure cylinder 22 has an enlarged chamber portion 23 to which there is connected a fluid-blast inlet conduit 24 for the introduction of fluid to move the ram 15 into its circuit closed position. This enlarged chamber portion 23 carries a suitable cushioning means 25 against which the movable contact supporting ram 15 is adapted to impact as it moves into its final open circuit position. As an additional means to reduce the impact of the ram 15 as it is moved into its final open circuit position, there is a conduit 26 which connects the enlarged chamber portion 23 with the fluid-pressure housing 12. This conduit 26 is of a size which will result in what might be termed a precharging of the fluid-pressure cylinder 22, and as the contact supporting ram 15 moves downwardly therein, the pre-charging fluid in the cylinder 22 will provide a damping action which will be proportional to the force exerted by the downwardly moving contact supporting ram 15 and, as a result, the contact supporting ram 15 will be brought substantially to a stop at the lower end of the fluid-pressure cylinder 22 without any objectionable shock or impact. Cooperating with the pre-charging conduit 26, the fluid-pressure cylinder 22 is also shown as having an exhaust pipe 27 intermediate its ends in which there is provided a check valve (to be later explained) which will permit the escape of the pre-charging fluid from the fluid-pressure cylinder 22 during the initial ram retarding operation of the fluid entering the enlarged chamber portion 23 by way of the conduit 26 as it occurs during the circuit isolating movement of the contact supporting ram 15. Also disposed within this enlarged chamber portion 23 there is a valve operating lever 28 which is adapted to control a special valve 29 when the ram 15 is in its lowermost position, as will be hereinafter pointed out.

Upon now referring to Figure 2 of the drawings it will be noted that the cylindrical insulating member 19 is substantially closed at its upper end by means of a horizontally disposed disc 30 of insulating material which has a central aperture through which the movable contact 16 is adapted to extend when in contact making engagement with the lower end of the stationary contact 18, which is here shown as secured in a fixed position by means of similar, but oppositely arranged, discs 31 and 32 of insulating material. Immediately above the disc 32 there is an additional disc 33 of insulating material which has a central partition through which a second movable contact 34 is adapted to extend and make contact with the upper end of the stationary contact 18. The discs 30 and 31 are so positioned that they will provide a radial fluid-blast directing space immediately adjacent the lower end of the stationary contact 18, and the discs 32 and 33 are so positioned and spaced that they will provide a similar fluid-blast directing space immediately adjacent the upper end of the stationary contact 18. As a further expedient to insure a high velocity blast at these points, there is also provided in these spaces one or more relatively thin arc splitting baffles 35 and 36 over which any arc established between the movable contacts 16 and 34 and the stationary contact 18 will be blown at the time of contact separation. While it is conceivable that a circuit breaker constructed in accordance with my invention would successfully operate without the additional movable contact 34, it is considered that for interrupting extremely high voltage circuits, this additional movable contact will be highly desirable. As shown, the movable contact 34 is adapted to be operated by fluid pressure simultaneously with the operation of the movable contact 16 and it is, therefore, shown as slidably mounted within a cylindrical guide 37 which carries a biasing spring 38 that operates to move and hold the contact 34 in circuit completing contact with the upper end of the stationary contact 18. To complete the circuit from this movable contact 34 there is provided an upwardly extending centrally disposed stem 39 to which a connection with the power line may be made in any suitable manner. At this point it will also be noted that the movable contact 16 is mounted so as to telescope into the upper end of the movable contact supporting ram 15, and as a means for biasing the movable contact 16 into good circuit establishing contact with the stationary contact 18, the supporting ram 15 carries a compression spring 40. The movable contact 16 is also here shown as having a guiding stem 41 which serves to guide it in its movements relative to the supporting ram 15. As a means for securing the discs 30 to 33 and the stationary contact 18 in fixed relation at the upper end of the cylindrical

insulating member 19, the latter member is shown as provided with a recessed metallic ring 42, the extending portion of which is engaged by an annular collar 43 from which a number of radially spaced bolts 44 extend upwardly. These bolts 44 carry suitable spacing bushings along their length which serve to properly space the several discs 30 to 33 and the arc splitting baffles 35 and 36, and at their upper ends they carry nuts 45 which hold the parts in secured cooperating relation. At this point it will be noted that the cylindrical guide 37 is centered upon the insulating disc 33 so as to position the movable contact 34 in registering relation with the upper end of the stationary contact 18, which is here shown as having a cylindrical outline. With this arrangement it will be seen that the movable contact 34 will move as a piston within the cylindrical guide 37 when fluid pressure is exerted thereagainst. Likewise, the movable contact 16 is here better shown as having a cylindrical extending portion 46 with a plurality of elongated radially disposed apertures 47 through which any pressure established by a blast of fluid to the cylindrical member 19 will be transmitted to exert a contact separating pressure upon the movable contacts 16 and 34 and cause them to move simultaneously out of contact making engagement with the opposite ends of the stationary contact 18.

Upon referring to Figure 3 of the drawings it will be noted that the insulating cylindrical member 19 is positioned upon the fluid-pressure housing 12 by means of a flanged ring 48 which carries the line terminal 13. It will also be noted that the housing 12 is centered upon the foundation plate 11 by means of a second flanged, but somewhat longer, annular ring 49 within which the latching rollers 21 are pivotally mounted and positioned in cooperating relation with the lower end of the movable contact supporting ram 15. At this point it will be understood that when the movable contact supporting ram 15 is forced downwardly, as during a circuit interrupting operation, it will be projected into the lower or second ram operating fluid-pressure cylinder 22 where, as will hereinafter appear, it will be in a position for a fluid blast reclosing operation of the circuit breaker. While the fluid-pressure housing 12 may be constructed in any suitable manner, in the arrangement shown the several elements are held in clamped engagement by means of a number of radially spaced tie-rods 50 which extend downwardly from a collar 51 and through the foundation plate 11 where they are secured by nuts 52. The collar 51 encircles the lower end of the insulating cylindrical member 19 and is held against axial displacement by means of a split ring 53 which, like the ring 42, is recessed into the lower end of the insulating cylindrical member 19. In this figure of the drawings it will also be noted that the cylindrical throat forming member 17 is supported rigidly within the fluid-pressure housing 12 by means of the transverse partition 14, and since this member 17 functions without a tight fit and merely as a guide for the movable contact supporting ram 15, it is shown as provided with a plurality of bowed circuit completing members 54 that serve to complete an electrical circuit between the movable contact supporting ram 15 and the terminal 13 which, as previously stated, is carried by the flanged ring 48 that forms a part of the fluid-pressure housing 12.

For a better understanding of the invention and its mode of operation, reference should now be had to Figure 4 of the drawings, wherein the circuit interrupter, constructed as above outlined, is shown as associated with an electro-pneumatic system of control by which the transmission line circuit may be opened and/or closed, either manually, as required, or in an entirely automatic manner in response to current conditions upon the circuit to be interrupted. In connection with this figure of the drawings it will be understood that while the pneumatic and electromagnetic control elements are shown as of a particular type, it is contemplated that the circuit interrupter may be controlled with other arrangements without departing from the spirit of the present invention. As here shown, the fluid-blast inlet conduit 20 which connects with the cylindrical member 19 of the interrupter is illustrated as controlled by a blast valve 55 that is positioned in a conduit 56 which connects with a fluid-pressure tank or reservoir 57 which, it will be understood, will be maintained charged with a suitable operating fluid at a predetermined high, blast producing pressure. Likewise, the fluid-blast inlet conduit 24 at the lower end of the fluid-pressure cylinder 22 is controlled by a blast valve 58 which is interposed in a conduit 59 that connects through a pressure surge chamber 60 to the fluid-pressure conduit 56. The blast valves 55 and 58 are of the fluid operated balanced pressure type and are arranged to be held in their closed position by fluid under pressure which is piped respectively to their operating cylinders by means of conduits 61 and 62. As a means to control the operation of the blast valve 55, there is a fluid-pressure responsive vent valve 63 which is in turn controlled by a manually operated exhaust valve 64 or an electromagnetically operated exhaust valve 65 at the end of a conduit 66. At this point it should be noted that the conduit 61 terminates at its upper end in a manifold 67 from which the fluid under pressure is adapted to flow through restricted openings to the operating cylinder of the blast valve 55 and to the operating side of the vent valve 63. These restricted openings serve to properly time the operation of these devices, as will hereinafter appear. Likewise, the pressure surge chamber 60 is shown as having a restricted charging inlet 68 which, in connection with an additional conduit 69 leading from the fluid-pressure conduit 20, operates to influence the operation of the blast valve 58. As a means for controlling the blast valve 58 there is shown a cylinder venting conduit 70 that is adapted to be exhausted by a manually operated valve 71 or an electromagnetically operated valve 72. In order to pneumatically interlock the fluid-pressure controlling valves with the electromagnetic controlling relays, the pneumatic system is also shown as including a conduit 73 which connects through a check valve 74 with a pressure storage chamber 75 from which fluid under pressure flows through a conduit 76 to a spring biased pressure operated two-position switch 77. As an additional adjunct, the fluid-pressure storage tank 57 is shown as having a pressure responsive circuit controlling switch 78 that will serve to render the electromagnetic control system inoperative in the absence of a fluid under pressure in the storage reservoir 57. As a means to provide for a trip free action of the interrupter, as during a closing operation of the circuit interrupter by use of the valve 71, this latter valve is shown as adapted to exhaust through a conduit 79 and into a cylinder 80 in which there is a piston 81 having a valve

head 82 that will serve to block the discharge of fluid under pressure through the valve 71 and thus prevent an operation of the reclosing fluid blast controlling valve 58 at any time when the blast controlling valve 55 is open. At the top of the cylinder 80 there is a conduit 83 which connects directly with the conduit 73, and leading to the pressure storage chamber 75 there is also a conduit 84 which has a fluid flow regulating orifice 85.

As a means to further interlock the mechanical operation of the circuit interrupter with the electromagnetic control elements of the system, the interrupter is shown as equipped with the conventional *a* and *b* switches 86 and 87 which are respectively closed and open when the circuit interrupter contacts 16 and 18 are in their closed circuit position. The *a* switch 86, as indicated by dot and dash lines 88, is connected to and operated by the lever 28 at the lower end of the fluid-pressure cylinder 22, and the *b* switch 87, as indicated by dot and dash lines 89, is connected to and operated by a lever 90 carried by one of the pivotally mounted latching roller members 21. In addition to the *a* and *b* switches 86 and 87, the fluid-pressure operating switch 77 has two sets of contacts 91 and 92 which are responsive to fluid-pressure conditions in the pneumatic control system. These contacts 91 and 92 are in series circuit with contacts 93 and 94 of an over-current relay 95 which is energized from a current transformer 96 that is associated with one of the lines of the power circuit, here designated by the numeral 97. To provide a low voltage current for operating the fluid-pressure control valves 65 and 72 and the several electromagnetically responsive relays, to be described, the control system is shown as energized from two service busses or conductors 98 and 99 which may connect with any suitable source of electric power. In the arrangement shown the contacts 91 of the pressure operated switch 77 serve, in conjunction with the contacts 93 of the over-current relay 95, to complete a circuit for an operating coil 100 of a momentary circuit interruption controlling relay 101, and the contacts 92 of the pressure operated switch 77 serve, in conjunction with the contacts 94 of the over-current relay 95 and the *a* switch 86, to complete a circuit for an operating coil 102 of a normal circuit interruption and isolation controlling relay 103. An interrupter closing relay 104 having an operating coil 105 is also shown as connected across the conductors 98 and 99 through normally closed contacts of the relay 103, the interlocking *b* contacts 87 of the circuit interrupter, normally closed contacts of a trip free relay 106 and a manually operated interrupter closing push-button switch 107. In addition to the manual circuit interrupter closing push-button switch 107, the system also includes a second push-button 108 by means of which the opening operation of the circuit interrupter may be controlled manually. At this point it should be noted that the pressure responsive circuit controlling switch 78 has contacts 109 that are connected in and operate to open the service bus or conductor 98 whenever there is a failure of fluid pressure in the fluid-pressure storage tank or reservoir 57. In this diagram the conduits 56, 66, 70 and 73 are shown as interrupted by two vertically extending and parallel dot and dash lines. This is to indicate that these conduits may be of any suitable length and that somewhere along their length there will be provided a suitable insulating connection which will serve to insulate those parts of the pneumatic system which are connected to the high potential circuit from the control valves and other elements that operate at ground potential. In this connection it should also be stated that the operating connections 88 and 89 which control the *a* and *b* switches 86 and 87 should also be of insulating construction.

Before going into a detailed description of the operation of the above apparatus, it might be pointed out that when fluid under pressure is admitted to the ram operating fluid-pressure cylinder 22, the movable contact supporting ram 15 will move upwardly until the contact 16 at the upper end thereof is in contact making engagement with the stationary contact 18. At this point the ram 15 will be latched in this position by means of the pivotally mounted latching rollers 21. Now, with the circuit interrupter in its closed circuit position, as shown in Figure 1, when fluid under pressure is admitted to the interior of the cylindrical member 19, the fluid pressure will first operate upon the relatively movable contacts 16 and 34 and cause them to move out of circuit making engagement with the stationary contact 18 after which, in the event of a sustained application of fluid pressure to the interior of the cylindrical member 19, the movable contact supporting ram 15 will be forced downwardly against the action of the pivotally mounted latching rollers 21 and into the lower ram operating fluid-pressure cylinder 22. Under normal operating conditions the separation of the movable contacts 16 and 34 from the stationary contact 18 will be sufficient to interrupt the current flow, and the exhausting blast of fluid therebetween will function to extinguish any arc established at these points. Then the subsequent downward movement of the ram 15 will serve to further separate the movable contact 16 and the stationary contact 18 to thereby provide a separation of these contacts which will prevent any restriking of the arc and thus completely isolate the circuit under control. In accordance with another mode of operation of the circuit interrupter, it is contemplated that, in the event of a sustained over-current condition upon the circuit, the admission of fluid pressure to the interior of the cylindrical member 19 and the fluid-pressure cylinder 22 will be regulated both as to direction and time to provide for an initial opening of the circuit by a separation of the movable contacts 16 and 34 from the stationary contact 18, that will be followed by an immediate reclosure of the circuit through these contacts and finally, by a subsequent and complete opening of the circuit by the above referred to circuit isolating movement of the movable contact supporting ram 15.

With the several elements of the electro-pneumatic control system in the positions illustrated in Figure 4 of the drawings, the normal closing operation of the interrupter can be initiated by an actuation of the manually operated push-button 107. This will complete an energizing circuit for the operating coil 105 of the closing relay 104 which can be traced from the positive bus 98, through the push-button switch 107 to the normally closed contacts of the trip free relay 106, through the coil 105, via the conductor 110 to the *b* switch 87 and back by way of the conductor 111 through the normally closed contacts of the opening relay 103 to the negative bus 99. At the same time the operation of the closing relay 104 will establish a locking circuit for the operating coil of the trip free relay 106. This locking circuit may be traced from the positive bus 98 through the push-button 107 to the operating coil of the trip

free relay 106, and through the lower contacts of the closing relay 104 to the negative bus 99. The interruption established in the circuit from the push-button 107 to the coil 105 of the relay 104, by the opening of the normally closed contacts of the trip free relay 106, will prevent any immediate and subsequent operation of the closing relay 104 until after the push-button 107 has been released. When the closing relay 104 operates, as above indicated, its upper set of contacts will also complete a circuit from the positive bus 98 to a conductor 112 which connects with one side of an operating coil 113 of the electromagnetically operated valve 72 and then back via conductor 114 to the conductor 111 and through the normally closed contacts of the opening relay 103 to the negative bus 99. The energizing of the coil 113 in this manner will cause the electromagnetically operated valve 72 to open and permit the escape of fluid under pressure from the operating cylinder of the blast controlling valve 58 and, as a result, the blast valve 58 will open and permit a blast of fluid under pressure to flow from the pressure surge chamber 60 to the inlet conduit 24 at the lower end of the ram operating fluid-pressure cylinder 22. When this occurs, the movable contact supporting ram 15 will be moved upwardly until the movable contact 16, yieldingly supported at the upper end thereof, is moved into engagement with the stationary contact 18 to complete the high potential circuit between the terminals 13 and 39 of the circuit interrupter. During the final upward movement of the ram 15, fluid under pressure will be admitted to the pressure surge chamber 60 through the restricted charging inlet 68 to complete a final latching of the ram 15 by the pivotally mounted latching rollers 21. As the movable contact supporting ram 15 moves upwardly and out of engagement with the valve operating lever 28 at the bottom of the cylinder 22, the *a* switch 86 will be closed, and when the latching rollers 21 move into their latching position with respect to the ram 15, the *b* switch 87 associated therewith will be caused to open and thus the control circuit will be in condition to control a subsequent opening operation of the circuit interrupter. In the absence of an abnormal current condition upon the high potential circuit, the latching rollers 21 will retain the ram 15 in its elevated position and, at the same time, the opening of the *b* switch 87 will deenergize the operating coil 105 of the closing relay 104, thus opening the circuit of the coil 113 of the exhaust valve 72. After this occurs, fluid under pressure will flow through the conduit 62 from the storage tank or reservoir 57 and close the blast controlling valve 58. At this point it should be stated that the surge pressure chamber 60 is designed to contain a sufficient volume of fluid under high pressure to give a rapid initial acceleration to the ram 15 which will be followed by a diminution of the driving force to avoid a successive terminal velocity in the ram 15. At the same time, the restricted charging inlet 68 of the surge pressure chamber 60 is so proportioned as to admit fluid under pressure through the surge pressure chamber 60 to effect a low speed final movement of the ram 15 against the action of the contact pressure producing spring 40 that is interposed between the ram 15 and the movable contact 16. After the blast valve 58 has closed, the air trapped in the ram operating fluid-pressure cylinder 22 will escape therefrom through a by-pass port 115 which is provided in the blast valve 58.

For a normal opening of the interrupter, the complete operation can be initiated by an actuation of the push-button 108. This will establish an energizing circuit for the coil 102 of the opening relay 103. At the same time, the lower contacts of the relay 103 will complete a locking circuit for its energizing coil 102. The upper contacts of the relay 103 will also complete an energizing circuit for an operating coil 116 which controls the exhaust valve 65, and the intermediate contacts of the relay 103 will interrupt the circuits of the coil 105 of the closing relay 104 and the winding 113 which controls the exhaust valve 72. The purpose of these latter circuit interruptions is to insure an immediate response to an over-current condition, even though the movable contact supporting ram 15 may, at the time, be in operation to effect a closing operation of the circuit interrupter. In other words, with this arrangement there is secured an electrical trip free action which will prevent a manual closing of the circuit interrupter in the event of an abnormal current condition upon the high potential transmission line. The energizing of the operating coil 116 in this manner will open the exhaust valve 65 and thus permit a pressure drop in the cylinder of the vent valve 63 and thereby vent the cylinder of the blast valve 55. This will permit the blast valve 55 to open and admit a blast of fluid under pressure from the reservoir 57, through the inlet conduit 20, to the interior of the insulating cylindrical member 19 of the circuit interrupter. As this occurs, fluid under pressure will enter between the contacts 16 and 34, through the openings 47 in the former contact and cause these contacts to move out of contact with the stationary contact 18 and against the action of their respective biasing springs 40 and 38. As this occurs, the circuit will be interrupted at each end of the stationary contact 18 and any arc formed therebetween by this contact separation will be blown outwardly and over the arc splitting baffles 35 and 36 where they will be extinguished. Then, when the contact 16 reaches the end of its travel against the action of its biasing spring 40, the fluid under pressure operating upon the movable contact supporting ram 15 will overcome the action of the latching rollers 21 and, as a result, the ram 15 will be moved downward rapidly and into the fluid-pressure cylinder 22. During the first part of the downward stroke of the movable contact supporting ram 15 into the fluid-pressure cylinder 22, the fluid in this cylinder will be discharged freely through the pipe 27 which, is here illustrated as having a flap valve 117, and thence out through the auxiliary port 115 of the valve 58. However, after the lower end of the movable contact supporting ram 15 passes the discharge pipe 27, the remaining air in the cylinder 22 will be trapped and form a cushion which will tend to absorb energy and slow down the movement of the ram 15 before its impact with the cushioning means 25 at the lower end of the cylinder 22. As an additional adjunct, the fluid-pressure cylinder 22 is shown as connected to the interior of the cylindrical member 19 by means of a conduit 26 which has a flap valve 118. The purpose of the conduit 26 is to permit a limited flow of the fluid under pressure from the interior of the cylindrical member 19, which will operate to pre-charge the fluid-pressure cylinder 22 and thus further assist in reducing the speed, and consequently the impact, of the movable contact supporting ram 15 against the cushioning means 25. When the ram 15 engages the lever 28 at the lower end of its stroke, the valve 29 will be

opened to thus release the fluid under pressure trapped within the fluid-pressure cylinder 22 and prevent any rebound or upward movement of the ram 15 due to pressure within the cylinder 22. At the same time, the operation of the lever 28 will cause the *a* switch 86 to open and interrupt the circuit through conductors 119 and 120 which connect with both the coil 102 of the opening relay 103 and the coil 116 of the opening vent valve 65. When the vent valve 65 closes, fluid under pressure will enter the cylinder of the blast valve 55 through the conduit 61 to thus close the blast valve 55 and shut off the flow of fluid under pressure from the reservoir 57 to the interior of the cylindrical member 19. As in the case of the closing blast valve 58, the interrupter opening blast valve 55 is also equipped with an auxiliary port 121 through which any entrapped fluid under pressure within the insulated cylindrical member 19 may escape when the blast valve 55 is in its closed position.

The operation of the circuit interrupter, under fully automatic control in response to an abnormal current condition upon the line, and where it is desired to take full advantage of the invention as disclosed, with an initial momentary opening of the circuit which is followed by a reclosing and then a final opening and isolation of the circuit, is as follows. This mode of operation will occur in the event of a sustained fault or abnormal current condition upon the line. When such a condition occurs, the over-current relay 95 will first respond and establish a circuit through its contacts 93 to energize the coil 100 of the momentary opening relay 101. This circuit may be traced from the positive bus 98 through the normally closed contacts of the pneumatic timing switch 77, to the coil 100 of the momentary opening relay 101 and to the negative bus 99. Then, when the relay 101 operates, its upper contacts will complete a holding circuit for the coil 100 from the positive bus 98 to the contacts 91 of the timing switch 77 and back to the negative bus 99. At the same time, the intermediate contacts of the relay 101 will establish a circuit for the operating coil 116 of the exhaust valve 65, this circuit being traced from the positive bus 98 through the intermediate contacts of the relay 101, to the operating coil 116, through the contacts of the *a* switch 86 which, under these conditions will be closed, and back to the negative bus 99. Likewise, the lower contacts of the relay 101 will complete a circuit for the operating coil 113 of the exhaust valve 72 by establishing a circuit from the positive bus 98, along the conductor 112, to the coil 113 and back by way of conductor 114 to the conductor 111 and through the normally closed contacts of the opening relay 103 to the negative bus 99. The energizing of both the exhaust valve operating coils 113 and 116, which are associated respectively with the exhaust valves 72 and 65, will simultaneously open the blast valves 55 and 58 and, as a result, the fluid pressures established within both the insulating cylindrical member 19 and the fluid-pressure cylinder 22 will be of substantially equal value, and the ram 15 as a whole will have no tendency to move downwardly against the action of the latching rollers 21. During this period, fluid under pressure will flow to the pressure surge chamber 60 through the conduit 69 and the check valve 122 and thus neutralize the effect of the orifice 68 so that an equal pressure will be promptly built up in the fluid-pressure cylinder 22 and prevent any unbalance of pressure which would tend to move the ram 15 downwardly. At the same time, the fluid pressure thus established in the insulating cylindrical member 19 will be available to operate upon and cause the piston-type contacts 16 and 34 to move out of circuit maintaining relation with the stationary contact 18 and thus the transmission line circuit will be interrupted at two points, as hereinabove described. When the piston-type contacts 16 and 34 are thus moved to interrupt the circuit, the relay 95 will open. But, due to the fact that the relay 101 is sealed in by a circuit through the contacts 91 of the pneumatic timing switch 77, this latter switch will be required to operate before the holding circuit of the relay 101 is interrupted. Therefore, when the pressure builds up in the chamber 75, the timing switch 77 will operate to open the circuit through its contacts 91. This will deenergize the coil 100 of the momentary opening relay 101 and the blast valves 55 and 58 will then be caused to close. The closing of these blast valves will permit the escape of fluid under pressure within the insulating cylindrical member 19 and the movable contacts 16 and 34 will then be moved by their respective operating springs 40 and 38 into engagement with the opposite ends of the stationary contact 18 and thus reclose the line circuit. After a predetermined time delay, the fluid under pressure within the pressure storage chamber 75 will cause the pneumatic timing switch 77 to open its contacts 91 and close the circuit through its contacts 92, and in this way the timing switch 77 will fix the duration of the momentary circuit interruption and condition the control circuit for a complete opening and isolating operation of the circuit interrupter upon any second successive operation of the over-current relay 95. At this point it should be stated that this timing in the operation of the interrupter might also be effected with a standard electrical relay, but for simplicity it is here shown as of a pneumatic type. The timing switch 77 is of a conventional pressure responsive type and has considerable range between its circuit opening and circuit closing movements.

From the above it will be seen that, in the event of a sustained or continuing overload condition, the normally closed contacts 91 of the timing switch 77 will serve to condition the momentary opening relay 101 to respond to a first operation of the over-current relay 95. Then, as the momentary interruption occurs in the transmission line, the fluid pressure admitted to the insulating cylindrical member 19 will enter the pressure storage chamber 75 through the conduit 73 and the check valve 74 to effect an operation of the timing switch 77. This will open the circuit through the contacts 91 of the timing switch 77 and thereby deenergize the coil 100 of the momentary opening relay 101. This opening of the contacts 91 will be followed by a closing of the contacts 92 of the timing switch 77 and, as a result, the normal opening and isolating relay 103 will be conditioned to respond to the next operation of the over-current relay 95 as it occurs upon a reclosing of the circuit through the movable contacts 16 and 34 by virtue of their reengagement with the stationary contact 18. Then, when the over-current relay 95 again operates, the normal opening and isolating relay 103 will operate through its upper contacts to establish an energizing circuit for the coil 116 of the exhaust valve 65. This will result in an opening of the exhaust valve 65 and

an operation of the blast valve 55 independently of the blast valve 58. As a result, a predominating fluid pressure will be established in the insulating cylindrical member 19 which will not only cause the movable contacts 16 and 34 to disengage the stationary contact 18, but will also move the contact supporting ram 15 downwardly so as to carry the movable contact 16 into its circuit isolating position. After this occurs, the air trapped in the pressure storage chamber 75 will slowly escape through the orifice 85 and permit the contacts 91 of the timing switch 77 to assume their normally closed position for a repetition of the momentary opening cycle described above.

While I have, for the sake of clearness and in order to disclose the invention so that the same can be readily understood, described and illustrated specific devices and arrangements, I desire to have it understood that this invention is not limited to the specific means disclosed, but may be embodied in other ways that will suggest themselves to persons skilled in the art. It is believed that this invention is new and it is desired to claim it so that all such changes as come within the scope of the appended claims are to be considered as part of this invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a fluid-blast circuit interrupter, the combination of a fixed tubular current conducting member, a movable contact member engaging each end of said tubular current conducting member, said movable contact members being responsive to fluid pressure within said tubular current conducting member and forming the opposite terminals of an electrical circuit to be interrupted, and means for introducing a fluid under pressure into said tubular current conducting member, whereby said movable contact members will be moved in opposite directions and out of contact with said current conducting member to interrupt the circuit and permit an outward blast of an arc extinguishing fluid under pressure at each end of said tubular current conducting member.

2. In a fluid-blast circuit interrupter, the combination of a fixed tubular current conducting member, a piston-like contact member in contact making engagement with each end of said tubular current conducting member and forming the opposite terminals of an electrical circuit to be interrupted, means for positioning said piston-like contact members for movement out of contact with said tubular current conducting member in response to fluid pressure, and means for introducing a blast of fluid under pressure into said tubular current conducting member, whereby said piston-like contact members will be moved axially out of contact with said tubular current conducting member to interrupt the electrical circuit and permit radial blast of an arc extinguishing fluid under pressure between the ends of said fixed tubular current conducting member and each of said piston-like contact members.

3. In a pneumatically operated fluid-blast circuit interrupter, the combination of a substantially fluid-tight cylindrical insulating column, a stationary contact at one end of said insulating column to which one of the terminals of a high potential circuit may be connected, a movable contact supporting ram mounted to move within said insulating column axially with respect to said stationary contact and to which the other terminal of the high potential circuit is connected, means for temporarily restraining said supporting ram in an operative position with respect to said stationary contact, a movable fluid pressure responsive contact mounted upon the end of said supporting ram, means yieldingly biasing said movable contact member into contact with said stationary contact when said supporting ram is in its operative position, and means for introducing an initial blast and a subsequent blast of fluid under pressure into said insulating column, whereby upon the occurrence of said initial blast of fluid under pressure said movable contact will be moved relative to said supportnig ram and out of engagement with said stationary contact to interrupt the circuit and subsequently moved with said supporting ram into a circuit isolating position upon the occurrence of said subsequent blast of fluid under pressure.

4. In a pneumatically operated fluid-blast circuit interrupter, the combination of a substantially fluid-tight hollow insulating column, a stationary contact at the upper end of said insulating column to which one of the terminals of a high potential circuit may be connected, a movabel contact supporting ram mounted to move vertically within said insulating column and axially with respect to said stationary contact and to which the other terminal of said high potential circuit is connected, means for temporarily restraining said supporting ram in an operative position with respect to said stationary contact, a fluid pressure responsive contact mounted in telescopic relation upon said supporting ram, means yieldingly biasing said fluid pressure responsive contact into contact with said stationary contact when said supporting ram is in its operative position, and means for introducing an initial blast and a subsequent blast of fluid under pressure into said insulating column, whereby upon the occurrence of said initial blast of fluid under pressure said fluid pressure responsive contact will be moved relative to said ram and out of contact with said stationary contact to interrupt the circuit and upon the occurrence of said subsequent blast of fluid under pressure said fluid pressure responsive contact will be moved with said supporting ram into a circuit isolating position.

5. In a pneumatically operated fluid-blast circuit interrupter, the combination of a substantially fluid-tight cylindrical insulating column, a stationary contact to which one of the terminals of a high potential circuit may be connected mounted at one end of said insulating column, a movable contact supporting ram mounted to move within said insulating column and axially with respect to said stationary contact, means for temporarily restraining said supporting ram in an operative position with respect to said stationary contact, a movable contact mounted in telescopic relation upon said supporting ram, means yieldingly biasing said movable contact into contact with said stationary contact when said supporting ram is in its operative position, means for introducing an initial short blast and a subsequent sustained blast of fluid under pressure into said insulating column, whereby upon the occurrence of said initial blast of fluid under pressure said movable contact will be moved relative to said ram and out of contact with said stationary contact to interrupt the circuit and subsequently moved with said supporting ram into a circuit isolating position upon the

occurrence of said sustained blast of fluid under pressure, and arc splitting baffle means forming a restricted fluid discharge outlet from said insulating column into which any arc drawn between said stationary and said movable contact will be blown and extinguished by said fluid under pressure as said contacts separate.

6. In a fluid pressure operated circuit interrupter, the combination of an insulating support, a fluid pressure cylinder of insulating material extending upwardly from said insulating support, a stationary contact mounted at the upper end of said fluid pressure cylinder to which one terminal of a transmission line circuit is connected, a second fluid pressure cylinder disposed in axial alignment below said first fluid pressure cylinder, a ram operatively movable from one to the other of said cylinders in response to predominating fluid pressure in one or the other of said cylinders, means forming an electrical connection between said ram and another terminal of said transmission line circuit, a relatively movable contact member carried by and located at the upper end of said ram, said movable contact member being operatively responsive to fluid pressure in said first cylinder, means for restraining said ram within said first fluid pressure cylinder with said relatively movable contact member in contact with said stationary contact, valve means for simultaneously admitting fluid under pressure into said first and second cylinders to establish equalized pressures therein, whereby said ram will remain stationary while said relatively movable contact member moves out of contact with said stationary contact in response to the fluid pressure in said first cylinder, and means operative after a predetermined time interval to relieve the fluid pressure in said second cylinder, whereby said ram and said relatively movable contact member will respond to a predominating fluid pressure in said first cylinder and move said relatively movable contact member into a circuit isolating position with respect to said stationary contact.

7. In a fluid pressure operated circuit interrupter, the combination of a support, a fluid pressure cylinder of insulating material extending upwardly from said support, a stationary contact mounted at the upper end of said fluid pressure cylinder to which one terminal of a transmission line circuit is connected, a second fluid pressure cylinder disposed in axial alignment below said first fluid pressure cylinder, a ram operatively movable from one to the other of said cylinders in response to predominating fluid pressure, means forming an electrical connection between said ram and another terminal of said transmission line circuit, a relatively movable cooperating contact at the upper end of said ram adapted to complete a circuit between said stationary contact and said ram, said relatively movable contact being responsive to fluid pressure and movable independently of said ram, means for restraining said ram in said first fluid pressure cylinder with said relatively movable cooperating contact in engagement with said stationary contact, valve means for controlling the admission of fluid under pressure in said first and second cylinders, electromagnetic means for effecting an opening of said valve means and establishing equalized pressures in said first and second cylinders, whereby said ram will remain stationary while said relatively movable cooperating contact is moved out of contact with said stationary contact in response to fluid pressure in said first cylinder, and means operative in the event of a sustained opening of said valve means to relieve the fluid pressure in said second cylinder, whereby said ram and said relatively movable cooperating contact will respond to a predominating fluid pressure in said first cylinder and move said relatively movable contact into a circuit isolating position with respect to said stationary contact.

8. In a fluid-pressure operated circuit interrupter, the combination of a first fluid-pressure cylinder, a second fluid-pressure cylinder mounted in axial alignment with said first fluid-pressure cylinder, a contact carrying ram movable from one to the other of said cylinders, said ram having a connection with a terminal of a transmission line circuit, a pressure responsive contact mounted at one end of said ram, a stationary contact at the far end of said first fluid-pressure cylinder having a connection with another terminal of said transmission line and adapted to cooperate with the pressure responsive contact carried by said ram and complete a circuit between said transmission line terminals, separate valve means for controlling the admission of a fluid blast under pressure to each of said cylinders, whereby upon an alternate operation of said separate valve means said ram will be moved from one to the other of said fluid-pressure cylinders, electro-pneumatic means for controlling each of said valve means, an electro-pneumatic control conditioning means for first rendering each of said valve means simultaneously responsive and subsequently independently responsive to said electro-pneumatic means, whereby upon an initial operation of said electro-pneumatic means each of said separate valve means will operate to admit a blast of fluid under pressure to each of said cylinders and cause said pressure responsive contact to move independently of said ram and out of contact with said stationary contact to interrupt the circuit between said terminals and subsequently cause one of said separate valve means to close and thus limit the blast of fluid under pressure to said first fluid-pressure cylinder and effect a movement of said ram with said pressure responsive contact to a circuit isolating position.

9. In a fluid-pressure operated circuit interrupter, the combination of a first fluid-pressure cylinder of insulating material, a second fluid-pressure cylinder mounted in axial alignment with said first fluid-pressure cylinder, a contact carrying ram movable from one to the other of said cylinders, said contact carrying ram having a connection with one terminal of a transmission line, an independently movable pressure responsive contact mounted at the outer end of said contact carrying ram, a stationary contact at the far end of said first fluid-pressure cylinder having a connection with another terminal of said transmission line adapted to cooperate with said independently movable pressure responsive contact to complete a circuit between said transmission line terminals, valve means for controlling the admission of a blast of fluid under pressure to each of said cylinders, whereby said contact carrying ram may be moved from one to the other of said fluid-pressure cylinders, electro-pneumatic means for independently controlling each of said valve means, and additional electro-pneumatic means for initially rendering said first electro-pneumatic means inoperative to independently control said valve means, whereby upon an initial opening operation of the circuit

interrupter said first fluid blast controlling valves will be operated simultaneously to admit a blast of fluid under pressure to each of said cylinders and equalize the pressure upon said ram and cause said movable pressure responsive contact to move relative to said contact carrying ram and out of engagement with said stationary contact.

10. In a fluid-pressure operated circuit interruper, the combination of a first fluid-pressure cylinder, a second fluid-pressure cylinder mounted in axial alignment with said first fluid-pressure cylinder, a contact carrying ram movable from one to the other of said cylinders, a movable contact having a connection with one terminal of a transmission line circuit mounted at one end of said ram, a stationary contact at the far end of said first fluid-pressure cylinder having a connection with another terminal of said transmission line and adapted to cooperate with the movable contact carried by said ram, separate valve means for controlling the admission of a fluid under pressure to each of said cylinders, whereby upon an alternate operation of said separate valve means said movable contact carrying ram may be moved from one to the other of said fluid-pressure cylinders, electro-pneumatic control means for operating each of said separate valve means, an electro-pneumatic means for rendering said first electro-pneumatic control means initially operative to open both of said valve means and subsequently operative to open only one of said valve means, whereby upon a second successive operation of said electro-pneumatic control means one of said fluid controlling valve means will operate to admit fluid under pressure into said first fluid-pressure cylinder only and cause said ram with said movable contact to move into a circuit isolating position.

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