

March 28, 1961

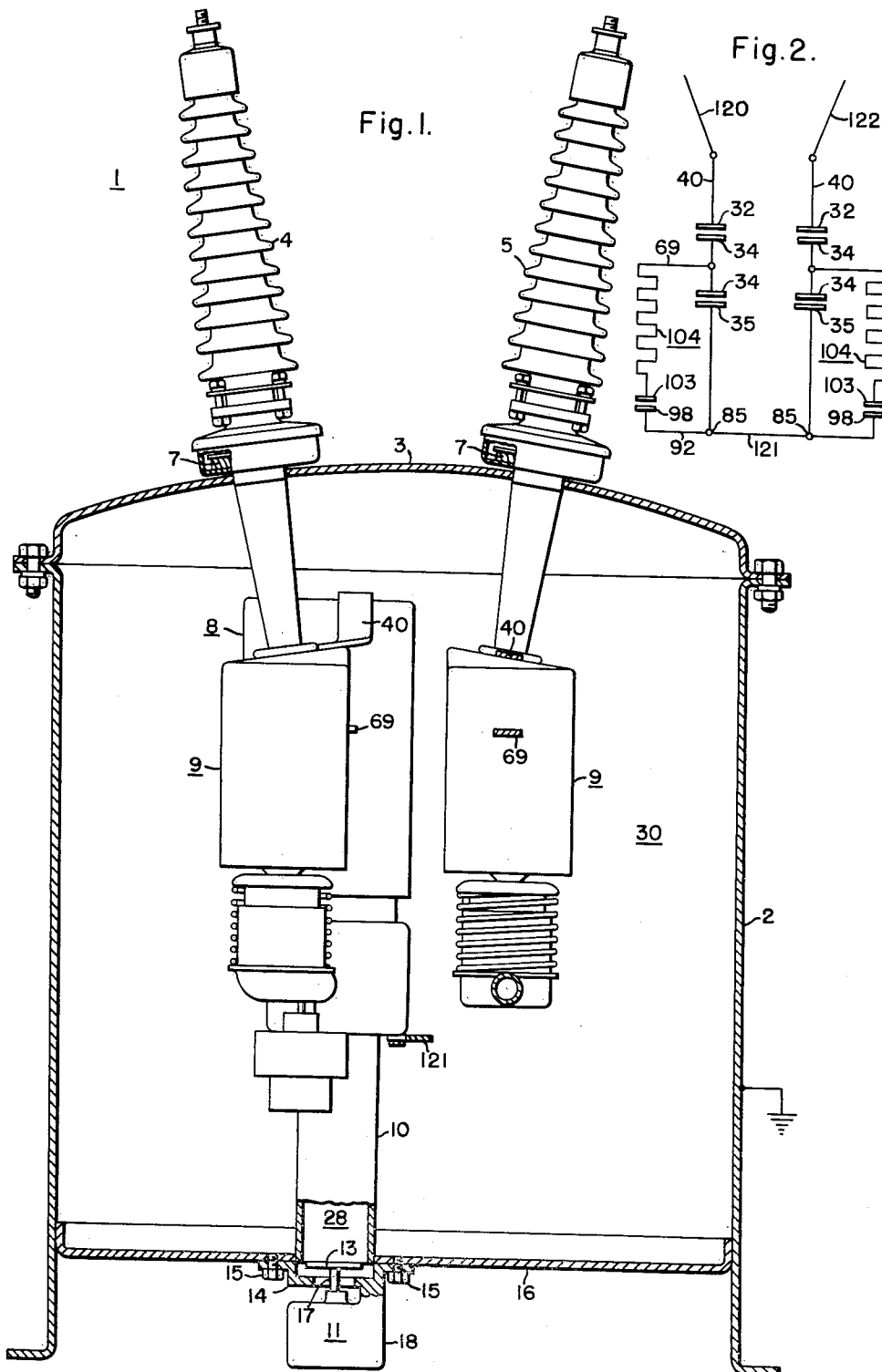
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COMPRESSED-GAS CIRCUIT INTERRUPTER

Filed Oct. 22, 1956

2 Sheets-Sheet 1



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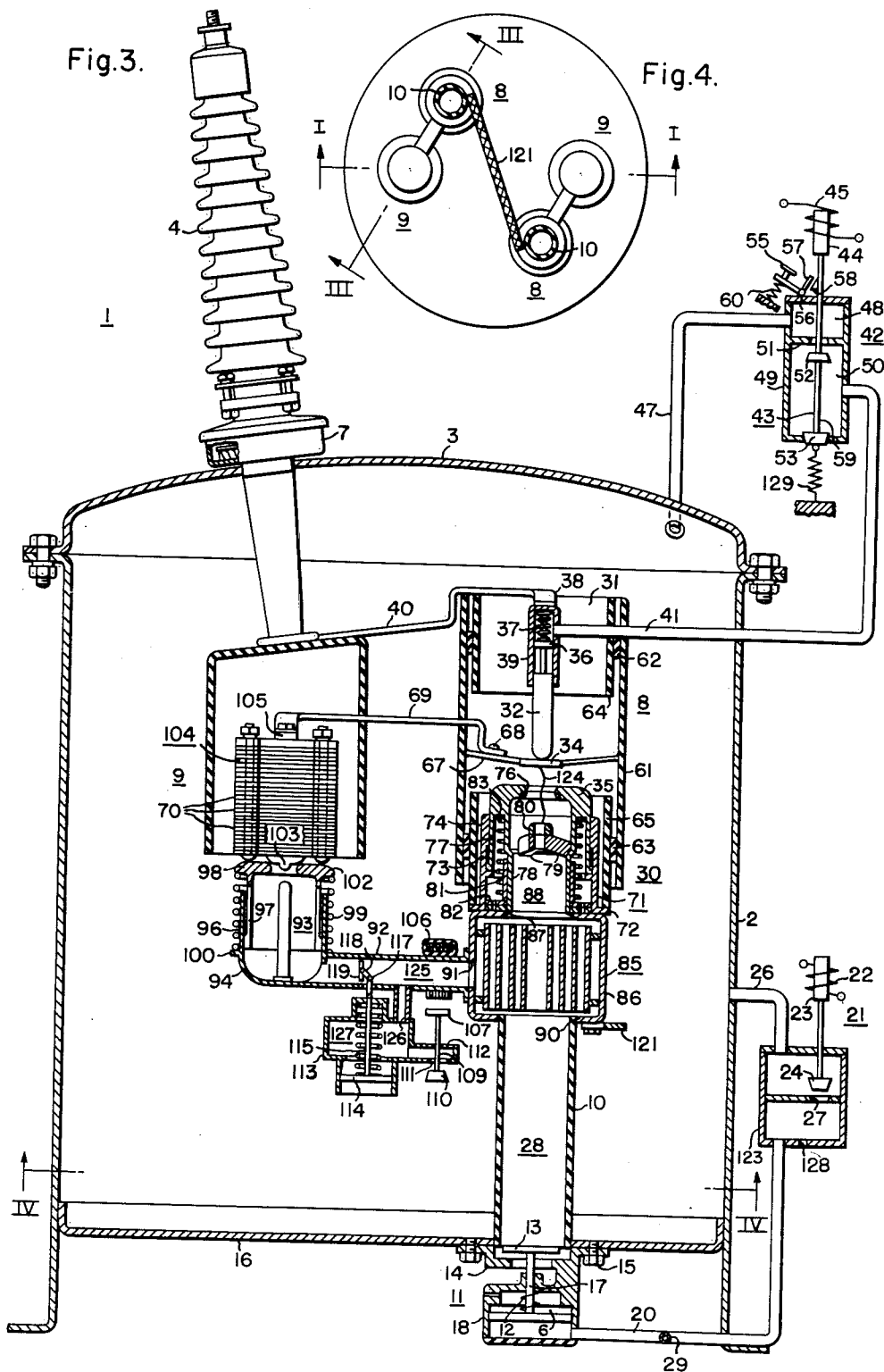
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1

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COMPRESSED-GAS CIRCUIT INTERRUPTER

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9 Claims. (Cl. 200—146)

This invention relates to circuit interrupters, in general, and more particularly to circuit interrupters of the compressed-gas type.

A general object of the invention is to provide an improved compressed-gas circuit interrupter which will operate more efficiently than circuit interrupters utilized heretofore, and will be particularly advantageous in the interruption of high-power circuits.

In United States patent application filed May 27, 1955, Serial No. 511,731, by Carl C. Smith and Daniel H. McKeough, and assigned to the Canadian Westinghouse Company, Ltd., there is described and claimed a circuit interrupter having particular adaptability for use with compressed gas. The circuit interrupter of this patent application employs a grounded circuit interrupter tank, preferably of metal, and pressurized, with a pair of terminal bushings extending into the upper end thereof. Connected between the lower interior ends of the pair of terminal bushings is one, or a plurality of, arc-extinguishing units, connected in series, and actuated by the operation of a blast valve, disposed at the exterior end of a blast tube, which extends within the grounded tank and supports one of the circuit interrupting units.

It is another object of the present invention to improve upon the construction of the circuit interrupter set out in the aforesaid application, rendering it more suitable for high-power application. For instance, one of the circuit interrupters of the foregoing application is adapted for the interruption of high power and has, in one case, a three-cycle interruption rating, when used on 115 kv., of 5,000,000 kva. The foregoing interrupter has a continuous 60-cycle current rating of 1,200 amperes. The interrupting rating is of the order of 26,000 amperes.

It is a further object of the present invention to provide a novel circuit interrupting structure somewhat similar in design to that set out in the foregoing patent application, but which will be suitable for interrupting 10,000,000 kva. at 138 kv. line voltage.

Still a further object of the present invention is to provide an improved structural arrangement for supporting a main current interrupting unit and an impedance current interrupting unit within an enclosure.

Still another object of the present invention is to provide suitable magnetic means for speeding up the opening operation of the impedance interrupting unit so as to decrease the amount of energy absorption within the impedance interrupting unit during the interruption of heavy fault currents.

Another object is to provide an improved compressed-gas circuit interrupter having a pair of main arcing contacts shunted by a pair of impedance contacts in series with an impedance, in which a time delay is provided between opening the main arcing contacts and the opening of the impedance contacts, and to provide means for shortening this time delay proportional to the magnitude of the impedance current.

A further object is to provide an improved compressed-

2

gas circuit interrupter having a time delay between the opening of a pair of main arcing contacts and the opening of a pair of shunting impedance contacts, in which the time delay is shortened when the impedance current attains a predetermined amperage value.

Still a further object of the present invention is to provide an improved compressed-gas circuit interrupter utilizing a grounded metallic tank and into which extends a pair of terminal bushings, each terminal bushing having associated therewith a main current interrupting unit and an impedance current interrupting unit.

Still a further object of the present invention is to provide an improved main current interrupting unit associated with an impedance current interrupting unit in which the main current interrupting unit is provided with a movable isolating contact for maintaining the circuit open following reclosure of the main contacts and the parallel-disposed impedance contacts.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

Fig. 1 is a vertical sectional view through a compressed-gas circuit interrupter embodying the principles of the present invention and shown in the partially open circuit position, taken substantially along the line I—I of Fig. 4;

Fig. 2 is a diagrammatic representation of the circuit elements utilized in the circuit interrupter of Fig. 1;

Fig. 3 is a vertical sectional view of the circuit interrupter of Fig. 1 taken substantially along the line III—III of Fig. 4, and illustrating the position of the several parts during the initial portion of the opening operation; and

Fig. 4 is a somewhat diagrammatic inverted plan view illustrating the structural location of the circuit interrupting elements of the circuit interrupter of Figs. 1-3 taken substantially along the line IV—IV of Fig. 3.

Referring to the drawings, and more particularly to Fig. 1 thereof, the reference numeral 1 generally designates a circuit interrupter preferably of the compressed-gas type. The circuit interrupter 1 includes a grounded metallic tank 2, which may be filled with any suitable arc-extinguishing gas, such as compressed air, helium, hydrogen, sulfur hexafluoride, selenium hexafluoride, such latter two gases either used alone or admixed with at least one of the group of inert gases consisting of helium, carbon dioxide, air, nitrogen, and argon. As will become more apparent hereinafter, the novel features of the invention do not depend upon the particular nature of the gas which is employed, but may be used with any suitable arc-extinguishing gas.

Extending through the cover 3 of the circuit interrupter 1 is a pair of terminal bushings 4, 5 preferably having a construction similar to that set out in the foregoing patent application. If desired, the terminal bushings 4, 5 may have suitable current transformers 7, disposed thereabout for measuring the current flow through the interrupter 1. Disposed at the interior lower end of the terminal bushing 4 is a main current interrupting unit, generally designated by the reference numeral 8, associated with an impedance interrupting unit, generally designated by the reference numeral 9.

Each of the terminal bushings 4, 5 has associated with it such a main current interrupting unit 8 and an impedance current interrupting unit 9, as diagrammatically represented in Fig. 4 of the drawings.

Preferably, each of the main current interrupting units 8 is supported, at least in part, by an insulating blast tube 10, more clearly shown in Fig. 3. The blast tube, or exhaust tube 10 is used to dump the gas pressure below two movable contact structures, as described hereinafter. Associated with the lower end of the blast tube

10 is an exhaust valve, or a dump valve, generally designated by the reference numeral 11. More specifically, the exhaust valve 11 has a dump valve 13 which seats upon an apertured plate 14, the latter being secured, as by bolts 15 to the lower base plate 16 of the tank 2. Preferably, the valve 13 is supported by a valve stem 17, the lower end of which is connected to a piston 6 slidable within an operating cylinder 18. The valve 13 is biased downwardly to its closed position by a spring 12, and is opened by admitting high-pressure gas through a conduit 20 leading to an electropneumatic opening valve generally designated by the reference numeral 21, and shown more in detail in Fig. 3. Thus, energization of the solenoid 22 will effect raising of the armature 23 to effect opening of a pilot valve 24 to admit high pressure gas from the tank 2 through a pipe 26, through a port 27 and through the conduit 20 to the lower side of the piston 6 which actuates the exhaust valve 13. Thus, the valve 13 will be moved upwardly against the spring pressure to thereby bring about an exhausting of the region 28 interiorly of the blast tube 10 and a consequent dumping of the gas pressure between the aforesaid two movable contact structures.

Preferably, two such exhaust valves 11 are employed, one such exhaust valve 11 controlling each of the two blast tubes 10 associated with the two main current interrupting units 8. The conduit 20 has a branch 29 (Fig. 3) which leads to the other exhaust valve 11, not illustrated in Fig. 3.

As mentioned, the region 30 within the tank 2 is pressurized with any suitable arc-extinguishing gas. This pressure within the region 30 communicates through the upper open end 31 of the main current interrupting unit 8. The main current interrupting unit 8 briefly includes a movable isolating contact 32, a stationary intermediate contact 34 and a movable orifice-shaped main contact 35 opened by gas pressure, as hereinafter described. The movable isolating contact 32 is piston actuated, having a piston 36 secured to its upper end. The piston 36 is biased downwardly to close the movable isolating contact 32 against the intermediate contact 34 by a compression spring 37. The lower end of the compression spring 37 seats upon the piston 36, whereas the upper end of the compression spring 37 bears against the base 38 of an inverted cup-shaped operating cylinder 39. Communicating with the region above the piston 36 is a conduit 41, with leads through the side wall of the tank 2 to an electropneumatic opening valve, generally designated by the reference numeral 42. The opening valve 42 includes a two-way valve 43 secured to an armature 44, which may be actuated by the energization of a coil 45. A high-pressure conduit 47 leads from the interior of the tank 2 to the upper chamber 48 of the valve casing 49. The lower chamber 50 of the valve casing 49 is separated by an apertured partition plate 51, the opening through which is controlled by the upper valve 52. The lower valve 53 permits a dumping of the gas out of the lower chamber 50 upon the energization of the coil 45.

The operation of the electropneumatic opening valve 42 is such that, in the closed-circuit position of the interrupter 1, the coil 45 is deenergized, and high-pressure gas may pass from the conduit 47 through the valve casing 49, and through the conduit 41 to the upper side of the piston 36 to maintain the movable isolating contact 32 in engagement with the stationary intermediate contact 34. In other words, since the same high pressure exists upon the top of piston 36 as acts upwardly upon the cross-sectional area of movable contact 32, as shown in Fig. 3, the compression spring 37 will prevail to effect contact closure. The control circuit is so arranged that following a suitable time delay after the energization of the coil 22 of the opening valve 21, the coil 45 of the electropneumatic opening valve 42 is similarly energized, as explained more in detail hereinafter.

A pivotally mounted closing button 55 is provided, pivotally mounted at 56 upon the valve casing 49 of the opening valve 42. The closing button is provided with a prop 57, which latches under a nose 58 movable with the valve stem 59 of the opening valve 42. The closing button 55 is biased by a compression spring 60 in a clockwise direction.

The main current interrupting unit 8 includes an insulating casing 61, within which is a pair of spacers 62, 63 which respectively position in place additional cylinders 64, 65. The cylinder 64 guides the gas blast downwardly through the main current interrupting unit 8. The stationary intermediate contact 34 is supported by a spider plate 67, which has a terminal 68 connected to a conductor 69 leading to the upper end of a plurality of serially related resistor grids 70, more fully described hereinafter.

Supported at the lower end of the insulating cylinder 65 is a relatively stationary contact support, generally designated by the reference numeral 71, and having an outwardly extending flange portion 72. The contact support 71 in addition has an upstanding cylindrical portion 73, the upper end of which constitutes a plurality of split fingers 74 which bear upon the outer surface of the movable orifice-shaped contact 35. The movable orifice-shaped contact 35 has an orifice 76 associated therewith, and through it passes the gas blast passing downwardly through the main current interrupting unit 8 and downwardly through the blast tube 10.

The movable contact 35 is opened by gas pressure. Normally, the same high pressure exists upon the top and bottom of contact 35, but upon a dumping, or exhausting of gas pressure below the movable contact 35, as effected by opening dump valve 13, the gas pressure acting upon the top surface of contact 35 will effect the opening thereof, as described hereinafter.

The movable orifice-shaped contact 35 also has a downwardly extending cylindrical guide portion 77 and an inwardly disposed additional cylindrical guide portion 78. Secured by a plurality of spaced arms 79 to the guide portion 78 is a centrally disposed apertured conducting arc catcher 80, movable with the movable orifice-shaped contact 35 to maintain a fixed distance between the orifice 76 and the upper surface of the arc catcher 80.

A compression spring 81 having its lower seat bearing upon a plate 82 of the stationary contact support 71, and having its upper end bearing against a recess 83 provided by the guide cylinder portions 77, 78, biases the movable orifice-shaped contact 35 upwardly into engagement with the intermediate contact 34. Disposed below the stationary contact support 71 is a cooling structure, generally designated by the reference numeral 85, and including a casing 86, the upper end of which is open, as at 87, and leads into the region 88 interiorly of the cylindrical guide portion 78 of the movable orifice-shaped contact 35. The lower end of the casing 86 has an opening 90, which registers with the upper open end of the blast tube 10.

The cooling casing 86 has a lateral opening at 91 which registers with a laterally extending blast tube 92, which leads into the interior 93 of a stationary cup-shaped contact support member 94. The support member 94 has an upstanding cylindrical guide portion 96, interiorly of which bears a plurality of split fingers 97 associated with an orifice-shaped movable impedance contact 98. A compression spring 99, having its lower end seating upon a flange portion 100 of the contact support 94, and having its upper end bearing against an outwardly extending flange 102 integrally formed with the movable impedance contact 98, serves to bias said movable impedance contact 98 upwardly into contacting engagement with a relative stationary impedance contact 103. The stationary impedance contact 103 is connected to one end of the serially related resistor grids 70, where-

5

as, as mentioned, the upper end of the grid stack, generally designated by the reference numeral 104, is connected at a terminal 105 to the connector 69.

The movable impedance contact 98 is opened by gas pressure. As was the case with movable contact 35, normally the same high pressure gas acts above and below contact 98, so the spring 99 keeps the contact 98 closed. However, upon a dumping, or an exhausting of gas pressure below the contact 98, the latter will open and separate from contact 103.

Partially encircling the exhaust tube 92 is a U-shaped magnetic yoke member 106 having an armature 107 associated therewith. The armature 107 is fixed to the upper end of a valve stem 109, to the lower end of which is supported an accelerating valve 110. The accelerating valve 110 controls an opening 111 provided in an extension 112 of an operating cylinder casing 113, within which slidably moves a piston 114. The piston 114 has a piston rod 115, the upper end of which is pivotally connected at 117 to a rotatable arm 118 secured to a butterfly exhaust valve 119 controlling the exhaust of gas toward the right through the blast tube 92.

With particular reference to Fig. 2, which diagrammatically indicates the interrupting elements, it will be observed that the electrical circuit passes through the conductor stud 120, extending interiorly through the terminal bushing 4 of Fig. 1. The circuit then extends through a connector 40 to the movable isolating contact 32 which cooperates with the intermediate contact 34. Connected to the intermediate contact 34 is the connector 69 leading to the upper end of the resistor stack 104. The lower end of the resistor stack 104 is connected to the relatively stationary resistor contact 103, which cooperates with the movable impedance contact 98, the latter being electrically connected through the blast tube 92, which is of conducting material, to the cooling structure 85, and hence to the movable orifice-shaped contact 35. Electrically interconnecting the cooling structure 85 to the cooling structure 85 associated with the other terminal bushing 5 is an electrical connector 121, partially shown in Fig. 3, and diagrammatically represented in Fig. 4 electrically connecting the two cooling structures 85 together.

With reference again directed to Fig. 2, it will be seen that the circuit returns to the terminal stud 122 of the terminal bushing 5 in a similar manner, so that when all of the contacts are closed, the electrical circuit through the interrupter 1 includes terminal stud 120, contacts 32, 34, 35 to the cooling structure 85 and thence, through the electrical connector 121 to the other main current interrupting unit 8. Here the circuit passes through the contacts 35, 34, 32, in reverse order to that previously mentioned, to the other terminal stud 122 associated with the other terminal bushing 5.

Generally, the opening operation includes first separating the contacts 34, 35, by a dumping of the high-pressure gas below movable contact 35 to force the current to pass through the impedance 104, which will considerably reduce the current and will improve the power factor. Subsequently, the contacts 98, 103 are separated by a delayed dumping of the high-pressure gas below movable contact 98 to interrupt the residual current through the impedance unit 9. This will completely halt all current flow through the interrupter 1, and then it is desirable to isolate the circuit by upward isolating movement of the movable isolating contacts 32 away from the stationary intermediate contacts 34, so that upon reclosure of the blast valves 13, and a consequent equalization of the pressure on both sides of movable contacts 35, 98, the contacts 34, 35 and 98, 103 may all reclose without, however, reclosing the circuit. Thus, although the contacts 34, 35 and 98, 103 reclose, due to the spring pressures associated therewith, and the gas equalization, nevertheless the circuit remains open because of the separation between the contacts 32, 34, which provide

6

isolating gaps to maintain the circuit open. The movable isolating contacts 32 remain in their upward, retracted position as long as the interrupter is open. To effect reclosure of the interrupter, it is merely necessary to effect engagement between the movable isolating contacts 32 and the intermediate contacts 34.

Following the above general statement of the overall method of operation, a more detailed explanation is now presented. During the opening operation suitable means, not shown, effects energization of the solenoid 22. As is well known by those skilled in the art, this energization of solenoid 22 may take place by actuating an opening push button by a station attendant, or by an overload relay, responsive to the current magnitude passing through the interrupter 1, as indicated by the current transformer 7. Such energization will raise valve 24 to permit high-pressure gas to pass through the valve casing 123 from conduit 26 and through conduits 20 and 29 to act on the lower surfaces of the pistons actuating the two dump valves 13. Considering only one dump valve, this will raise the exhaust valve 13 against its spring pressure, and will exhaust the regions 28 and 38 within the exhaust tube 10 and below the movable main contact 35.

High-pressure gas from the region 30 within the tank 2 will pass downwardly through the main current interrupting unit 8 to act upon the top surface of the movable orifice-shaped contact 35 to cause the separation of the same by gas pressure to move downwardly away from the stationary intermediate contact 34 to draw a main current arc 124, indicated in Fig. 3. The gas flow through the orifice 76 will effect the extinction of the main current arc 124, and will force the circuit to pass through the impedance, or grid stack 104, thereby reducing the value of the current and improving the power factor.

It will be observed that the exhausting or dumping of the pressure within the region 28 within the blast tube 10 will also lower or dump the pressure within the region 125 within the conducting exhaust tube 92. The size of the opening 111 in the extension 112 is so proportioned to the size of the conduit 126 at the upper end of the operating cylinder casing 113 that there is a predetermined time delay before the pressure within the region 127, within operating cylinder casing 113, has reduced sufficiently to permit the high pressure gas below piston 114 to effect upward motion of the same, thereby opening the pivotally mounted butterfly dump valve 119.

Thus, there is a predetermined time delay provided, following the separation of contacts 34, 35, before the pressure within the interior 93 of the contact support 94 is reduced or dumped sufficiently to permit the pressure acting on top of contact 98 to cause downward opening movement of the movable impedance contact 98. This time delay, however, is desirable to insure that the main current arc 124 is extinguished before the contacts 98, 103 of the impedance interrupting unit 9 are separated.

The separation between the contacts 98, 103 of the impedance interrupting unit 9, as previously described, effects interruption of the residual current arc drawn therebetween by a blast of gas downwardly through movable orifice contact 98, which brings about complete circuit interruption.

During this time, of course, the dump valve 13 is open and gas is exhausting out of the tank 2 through the exhaust tube 10 and the opened dump valve 13.

As mentioned heretofore, suitable means, not shown, energizes the solenoid 45 at a predetermined time after the energization of the solenoid 22, which time is sufficient to insure that the current passing through the interrupter 1 is interrupted at both contacts 35 and 98. When the solenoid 45 is energized, it will raise the valves 52, 53, dumping the high-pressure gas out of the lower chamber 50, to thereby dump the gas from the top surface of the piston 36 operating the movable isolating contact 32, thereby effecting a raising of the same. This occurs because high-pressure gas is acting upwardly upon isolat-

ing contact 32 tending to force it upwardly within cylinder 39. The prop 57 will latch under the nose 58 of the valve stem 59, and will maintain the reduced pressure above the piston 36, thereby maintaining the movable isolating contact 32 in its upward, raised, isolating position as long as the interrupter 1 is open.

Following a suitable time delay, means not disclosed are effective to deenergize the solenoid 22 of the electro-pneumatic opening valve 21 and thereby bring about reclosure of the pilot valve 24. Because of the provision of a vent 123 in the valve casing 123, the high pressure gas below the piston 6 actuating the blast valve 13 will be dumped, and the spring pressure 12 acting upon said piston 6 together with the high-pressure gas flowing downwardly through the blast tube 10 will all contribute toward a fast reclosure of the blast valve 13. When this occurs, the pressure within the blast tube 10 will be raised quickly to that of the tank pressure, and the springs 81 and 99 will effect rapid reclosure of the movable contacts 35, 98 because of the gas equalization across these contacts. Even though these contacts reclose, nevertheless the open position of the movable isolating contact 32 maintains the circuit open through the interrupter 1.

To effect reclosure of the interrupter 1, it is merely necessary to press the closing button 55 against the pressure exerted by the spring 60 to unlatch the latching nose 58 on the valve stem 59. When this is done, the tension spring 129 will move the valve stem 59 downwardly to permit high-pressure gas to pass through the conduits 47, 41 to the upper surface of the piston 36 of the movable isolating contact 32. This high-pressure gas, above the piston 36, together with the spring pressure exerted by the compression spring 37, will act together to effect rapid reclosure of the movable isolating contact 32 against the intermediate contact 34. Since the movable contacts 35, 98 have previously been closed, the circuit will immediately be reestablished through the interrupter 1.

During the interruption of heavy fault currents, to avoid the passage of several thousand amperes of current flowing through the impedance 104, the magnetic yoke 106, affected by the magnetic field resulting from current flow through tube 92, will pick up the armature 107 to raise the accelerating valve 110, and thereby permit the conduit 126 to rapidly exhaust the region 127 thereby immediately causing upward movement of piston 114 and hence opening the butterfly dump valve 119 without any appreciable time delay. This will cause the movable impedance contact 98 to open quickly, by the pressure drop therebeneath, and to interrupt the resistor current before excessive energy is absorbed in the resistor stack 104.

Thus, there is provided in a compressed-gas circuit interrupter having main arcing contacts shunted by a pair of impedance contacts a time delay between the opening of the main arcing contacts and the opening of the impedance contacts, which time delay is shortened when the impedance current attains a predetermined value and is sufficient to cause pickup of armature 107 and consequent closure of accelerating valve 110. Moreover, the speed of pickup of armature 107 will be somewhat proportional to the magnitude of the impedance current, and hence the shortening of the time delay will be somewhat proportional to the magnitude of the impedance current.

Prompt interruption of the resistor current following heavy faults also hastens the process of deionizing the arcing fault in anticipation of a high speed reclosure.

From the foregoing description it will be apparent that the circuit interrupter of the present invention considerably increases the interrupting capacity of the interrupter of the foregoing application, and renders it suitable for very high-power interruption. It will be noted that the movable orifice-shaped impedance contact 98 is mechanically, electrically and pneumatically connected to the cooling structure 85, the latter being electrically at

the same potential as the movable contact 35 of the main current interrupting unit 8.

The butterfly valve 119 controls the flow of compressed gas in the hollow conduit 92, providing a desired time delay, but, during the interruption of heavy fault currents, the magnetic yoke 106 becomes effective to cause immediate opening of the butterfly valve 119. This avoids excessive release of energy within the grid stack 104.

It will also be apparent that the particular location of the main current interrupting units and the impedance interrupting units in relation to their supporting terminal bushings renders the interrupter 1 very compact, and additional support for the interrupting structures is afforded by the insulating blast tubes 10.

Although there has been shown and described a specific structure embodying the principles of the invention, it is to be clearly understood that the same was merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the invention.

I claim as my invention:

1. A compressed-gas circuit interrupter including a grounded metallic tank containing gas under pressure and thus constituting a high-pressure reservoir, one or more terminal bushings extending interiorly into said metallic grounded tank, an arc-extinguishing assemblage associated with the interior end of one terminal bushing for interrupting the circuit including a main-current interrupting unit and an impedance interrupting unit, an insulating blast tube extending from the arc-extinguishing assemblage to one wall of the metallic grounded tank, an exhaust valve operable to exhaust high-pressure gas out of the blast tube and to the region exteriorly of said grounded metallic tank, said main-current interrupting unit including a movable isolating contact, a movable piston-operated main contact and a relatively stationary intermediate contact interposed between said movable isolating and main contacts and cooperable therewith, means biasing the piston-operated movable main contact against the relatively stationary intermediate contact to the closed position, the opening of said exhaust valve serving to dump the pressure behind the piston-operated movable main contact to effect the opening thereof to draw a main current arc, said impedance interrupting unit including an impedance and a pair of cooperable piston-actuated separable impedance contacts serially arranged, biasing means for biasing the cooperable piston-actuated impedance contacts to the closed position, connecting means for connecting said impedance interrupting unit in shunt relationship across said relatively stationary intermediate contact and said piston-operated main contact for lowering the rate of rise of the recovery voltage transient during circuit interruption, conduit means interconnecting said piston-actuated impedance contacts to said blast tube so that opening of said exhaust valve will also serve to effect dumping of gas back of one of the piston-actuated impedance contacts to effect the opening thereof subsequent to the opening of the main movable contact, means for effecting separation between the movable isolating contact and said relatively stationary intermediate contact subsequent to breaking the residual current arc at said impedance contacts, and the exhausting flow of high-pressure gas out of the tank through said blast tube helping to effect extinction of the main-current arc between the intermediate and main movable contacts and also extinction of the residual current arc between the impedance contacts.

2. A compressed-gas circuit interrupter including a grounded metallic tank containing gas under pressure and thus constituting a high-pressure reservoir, one or more terminal bushings extending interiorly into said metallic grounded tank, an arc-extinguishing assemblage associated with the interior end of one terminal bushing for

interrupting the circuit including a main-current interrupting unit and an impedance interrupting unit, an insulating blast tube extending from the arc-extinguishing assemblage to one wall of the metallic grounded tank, an exhaust valve operable to exhaust high-pressure gas out of the blast tube and to the region exteriorly of said grounded metallic tank, said main-current interrupting unit including a movable isolating contact, a movable piston-operated main contact and a relatively stationary intermediate contact interposed between said movable isolating and main contacts and cooperable therewith, means biasing the piston-operated movable main contact against the relatively stationary intermediate contact to the closed position, the opening of said exhaust valve serving to dump the pressure behind the piston-operated movable main contact to effect the opening thereof to draw a main current arc, said impedance interrupting unit including an impedance and a pair of cooperable piston-actuated separable impedance contacts serially arranged, biasing means for biasing the cooperable piston-actuated impedance contacts to the closed position, connecting means for connecting said impedance interrupting unit in shunt relationship across said relatively stationary intermediate contact and said piston-operated main contact for lowering the rate of rise of the recovery voltage transient during circuit interruption, conduit means interconnecting said piston-actuated impedance contacts to said blast tube so that opening of said exhaust valve will also serve to effect dumping of gas back of one of the piston-actuated impedance contacts to effect the opening thereof subsequent to the opening of the main movable contact, the movable main contact and said one impedance contact having orifice openings therethrough, through which high-pressure gas may flow to effect arc extinction and subsequent exhaust out of the metallic tank, means for effecting separation between the movable isolating contact and said relatively stationary intermediate contact subsequent to breaking the residual current arc at said impedance contacts, and the exhausting flow of high-pressure gas out of the tank through said blast tube helping to effect extinction of the main-current arc between the intermediate and main movable contacts and also extinction of the residual current arc between the impedance contacts.

3. A compressed-gas circuit interrupter including a grounded metallic tank containing gas under pressure and thus constituting a high-pressure reservoir, one or more terminal bushings extending interiorly into said metallic grounded tank, an arc-extinguishing assemblage associated with the interior end of one terminal bushing for interrupting the circuit including a main-current interrupting unit and an impedance interrupting unit, an insulating blast tube extending from the arc-extinguishing assemblage to one wall of the metallic grounded tank, an exhaust valve operable to exhaust high-pressure gas out of the blast tube and to the region exteriorly of said grounded metallic tank, said main-current interrupting unit including a movable isolating contact, a movable piston-operated main contact and a relatively stationary intermediate contact interposed between said movable isolating and main contacts and cooperable therewith, the impedance interrupting unit being positioned below said one terminal bushing and the three contacts of the main current unit being in substantial alignment with the blast tube, means biasing the piston-operated movable main contact against the relatively stationary intermediate contact to the closed position, the opening of said exhaust valve serving to dump the pressure behind the piston-operated movable main contact to effect the opening thereof to draw a main current arc, said impedance interrupting unit including an impedance and a pair of cooperable piston-actuated separable impedance contacts serially arranged, biasing means for biasing the cooperable piston-actuated impedance contacts to the closed position, connecting means for connecting said impedance

interrupting unit in shunt relationship across said relatively stationary intermediate contact and said piston-operated main contact for lowering the rate of rise of the recovery voltage transient during circuit interruption. conduit means interconnecting said piston-actuated impedance contacts to said blast tube so that opening of said exhaust valve will also serve to effect dumping of gas back of one of the piston-actuated impedance contacts to effect the opening thereof subsequent to the opening of the main movable contact, means for effecting separation between the movable isolating contact and said relatively stationary intermediate contact subsequent to breaking the residual current arc at said impedance contacts, and the exhausting flow of high-pressure gas out of the tank through said blast tube helping to effect extinction of the main-current arc between the intermediate and main movable contacts and also extinction of the residual current arc between the impedance contacts.

4. A compressed-gas circuit interrupter including a grounded metallic tank containing gas under pressure and thus constituting a high pressure reservoir, a pair of terminal bushings extending interiorly into said metallic grounded tank, an arc-extinguishing assemblage associated with the interior end of each of said two terminal bushings for interrupting the circuit, each arc-extinguishing assemblage including a main-current interrupting unit and an impedance interrupting unit, a pair of insulating blast tubes extending from the two arc-extinguishing assemblages to one wall of the metallic grounded tank, an exhaust valve operable to exhaust high-pressure gas out of at least one of the blast tubes and to the region exteriorly of said grounded metallic tank, each main-current interrupting unit including a movable isolating contact, a movable piston-operated main contact and a relatively stationary intermediate contact interposed between said movable isolating and main contacts and cooperable therewith, means biasing the piston-operated movable main contact of each of the main-current interrupting units against the associated relatively stationary intermediate contact to the closed position, the opening of said exhaust valve serving to dump the pressure behind the piston-operated movable main contact of at least one main-current interrupting unit to effect the opening thereof to draw a main-current arc, the impedance interrupting unit for each arc-extinguishing assemblage including an impedance and a pair of cooperable piston-actuated separable impedance contacts serially arranged, biasing means for biasing the cooperable piston-actuated impedance contacts of each impedance interrupting unit to the closed position, connecting means for connecting the impedance interrupting unit of each arc-extinguishing assemblage in shunt relationship across the relatively stationary intermediate contact and the piston-operated main contact for the respective arc extinguishing assemblage for lowering the rate of rise of the recovery voltage transient during circuit interruption, conduit means interconnecting the piston-actuated impedance contacts of each arc extinguishing assemblage to the respective blast tube so that opening of said exhaust valve will also serve to effect dumping of gas back of one of the piston-actuated impedance contacts of at least one arc extinguishing assemblage to effect the opening thereof subsequent to the opening of the main movable contact of the main current interrupting unit for the respective arc extinguishing assemblage, second connecting means interconnecting the two movable main contacts of the two arc extinguishing assemblages in series relation, means for effecting separation between the movable isolating contact and said relatively stationary intermediate contact of each main current interrupting unit subsequent to breaking the residual current arc at the impedance contacts associated with the respective arc extinguishing assemblage, and the exhausting flow of high pressure gas out of the tank through the pair of blast tubes helping to effect extinction of the main current arcs drawn be-

tween the intermediate and main movable contacts of the two main current interrupting units and also extinction of the residual current arcs between the impedance contacts of the two impedance interrupting units.

5. A compressed-gas circuit interrupter including a grounded metallic tank containing gas under pressure and thus constituting a high-pressure reservoir, one or more terminal bushings extending interiorly into said metallic grounded tank, an arc-extinguishing assemblage associated with the interior end of one terminal bushing for interrupting the circuit including a main-current interrupting unit and an impedance interrupting unit, an insulating blast tube extending from the arc-extinguishing assemblage to one wall of the metallic grounded tank, an exhaust valve operable to exhaust high-pressure gas out of the blast tube and to the region exteriorly of said grounded metallic tank, a piston operated by the high-pressure gas from the metallic tank for operating the exhaust valve, said main-current interrupting unit including a movable isolating contact, a movable piston-operated main contact and a relatively stationary intermediate contact interposed between said movable isolating and main contacts and cooperable therewith, a piston secured to the movable isolating contact, a control valve disposed externally of the tank for dumping the pressure behind said last-mentioned piston to effect opening of the movable isolating contact, means biasing the piston-operated movable main contact against the relatively stationary intermediate contact to the closed position, the opening of said exhaust valve serving to dump the pressure behind the piston-operated movable main contact to effect the opening thereof to draw a main current arc, said impedance interrupting unit including an impedance and a pair of cooperable piston-actuated separable impedance contacts serially arranged, biasing means for biasing the cooperable piston-actuated impedance contacts to the closed position, connecting means for connecting said impedance interrupting unit in shunt relationship across said relatively stationary intermediate contact and said piston-operated main contact for lowering the rate of rise of the recovery voltage transient during circuit interruption, conduit means interconnecting said piston-actuated impedance contacts to said blast tube so that opening of said exhaust valve will also serve to effect dumping of gas back of one of the piston-actuated impedance contacts to effect the opening thereof subsequent to the opening of the main movable contact, means for effecting separation between the movable isolating contact and said relatively stationary intermediate contact subsequent to breaking the residual current arc at said impedance contacts, and the exhausting flow of high-pressure gas out of the tank through said blast tube helping to effect extinction of the main-current arc between the intermediate and main movable contacts and also extinction of the residual current arc between the impedance contacts.

6. A compressed-gas circuit interrupter including a pair of separable main contacts, an impedance, a pair of separable impedance contacts, means connecting said impedance and said pair of separable impedance contacts in shunt across said pair of separable main contacts, means for exhausting the gas behind one of said impedance contacts to effect the opening thereof, valve means associated with said exhausting means to regulate the exhaust of gas therethrough, and magnetic means responsive to the magnitude of current flow through said pair of separable impedance contacts to quickly open said valve means to accelerate the opening of said pair

of separable impedance contacts to minimize the energy absorption within said impedance.

7. The combination in a compressed-gas circuit interrupter of a pressurized tank filled with an arc-extinguishing gas under pressure, a terminal bushing extending interiorly within said tank, an impedance interrupting unit and a main current interrupting unit associated with the interior end of said terminal bushing, said impedance interrupting unit including an impedance and a serially arranged pair of separable impedance contacts, said main current interrupting unit including a movable isolating contact, an intermediate contact and a movable main contact separable from said intermediate contact, means for exhausting the gas behind one of said impedance contacts to effect the opening thereof, valve means associated with said exhausting means to regulate the exhaust of gas therethrough, and magnetic means responsive to the magnitude of current flow through said pair of separable impedance contacts to quickly open said valve means to accelerate the opening of said pair of separable impedance contacts to minimize the energy absorption within said impedance.

8. A compressed-gas circuit interrupter including a pair of separable main arcing contacts, an impedance, a pair of separable impedance contacts in series with said impedance and arranged in shunt relationship across said main arcing contacts, means for delaying the time of opening said impedance contacts with respect to the main arcing contacts, means for shortening this time delay when the impedance current through said impedance contacts exceeds a certain predetermined value, a movable isolating contact cooperable with one of said main arcing contacts, and means reclosing said pairs of separable main and impedance contacts in the open circuit position of the interrupter.

9. A compressed-gas circuit interrupter including a pair of separable main arcing contacts, an impedance, a pair of separable impedance contacts in series with said impedance and arranged in shunt relationship across said main arcing contacts, means for delaying the time of opening said impedance contacts with respect to the main arcing contacts, means for shortening this time delay somewhat proportionally to the magnitude of the impedance current passing through said impedance contacts, a movable isolating contact cooperable with one of said main arcing contacts, and means reclosing said pairs of separable main and impedance contacts in the open circuit position of the interrupter.

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