

[54] **GAS-BLAST DOWNSTREAM-TYPE OF HIGH-VOLTAGE CIRCUIT BREAKER HAVING FIELD-CONTROLLING SHIELDS AND SINGLE VENTING MOVABLE CONTACT**

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[52] U.S. Cl.200/148 B, 200/148 H

[51] Int. Cl.H01h 33/54

[58] Field of Search.....200/148, 148.8, 148.2, 148.4

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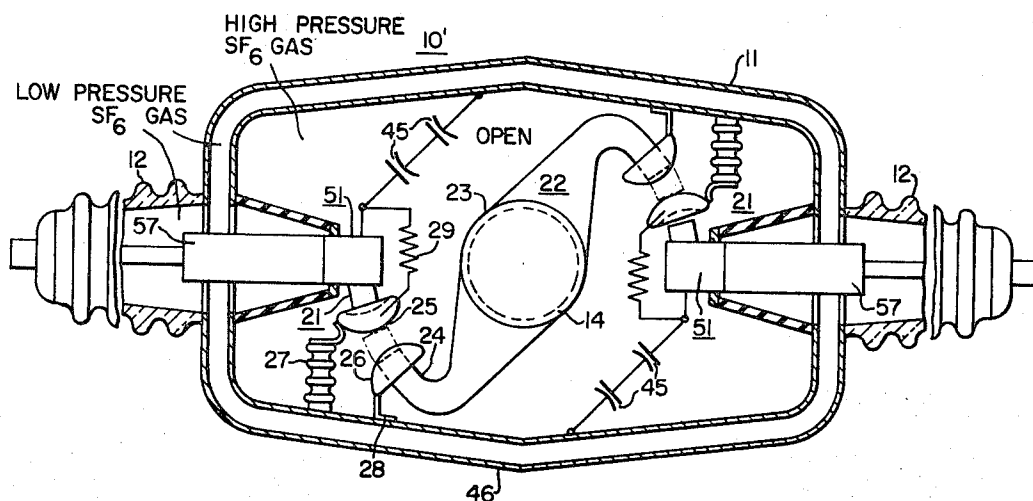
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[57] **ABSTRACT**

In a circuit breaker of the live tank type SF₆, or other gas, is contained in the tank of high-pressure. Two hollow series-connected movable contacts bridge stationary contacts inside the tank. A double break is provided and two stationary shields are provided per break—to give a substantially uniform voltage gradient across the contacts in the open position. Capacitors are used to divide the voltage across the open contacts. A probe arrangement is used to insert resistors into the circuit to reduce the rate of rise of recovery voltage. The shields are contoured to establish a high velocity flow of gas into the arc region. Flow of gas from the high pressure tank through the hollow contacts into a low pressure chamber is controlled by a down stream blast valve. Double flow of the gas can be obtained by providing secondary downstream valves and hollow contacts in each bushing in addition to the main downstream valve.

16 Claims, 15 Drawing Figures



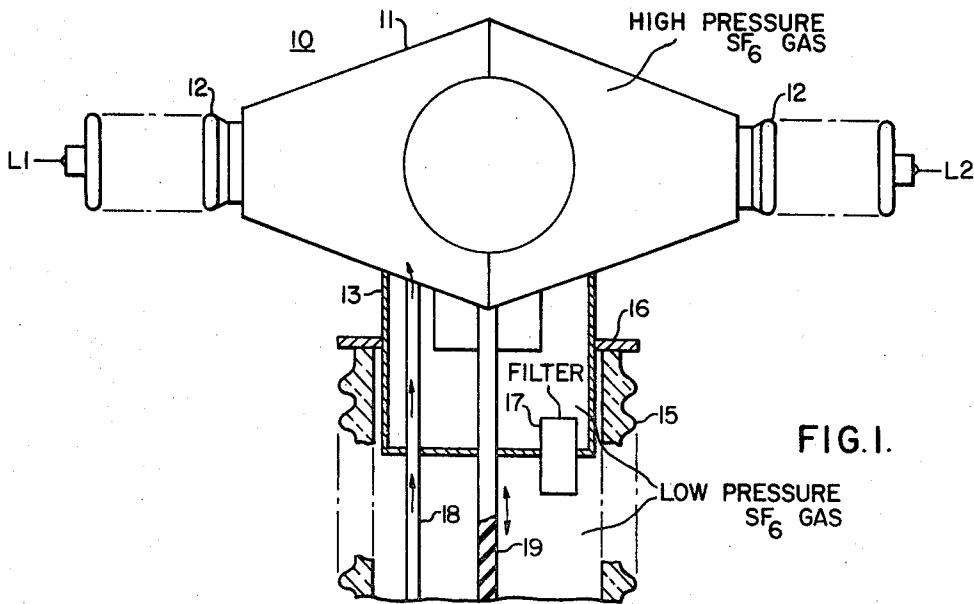


FIG. 1.

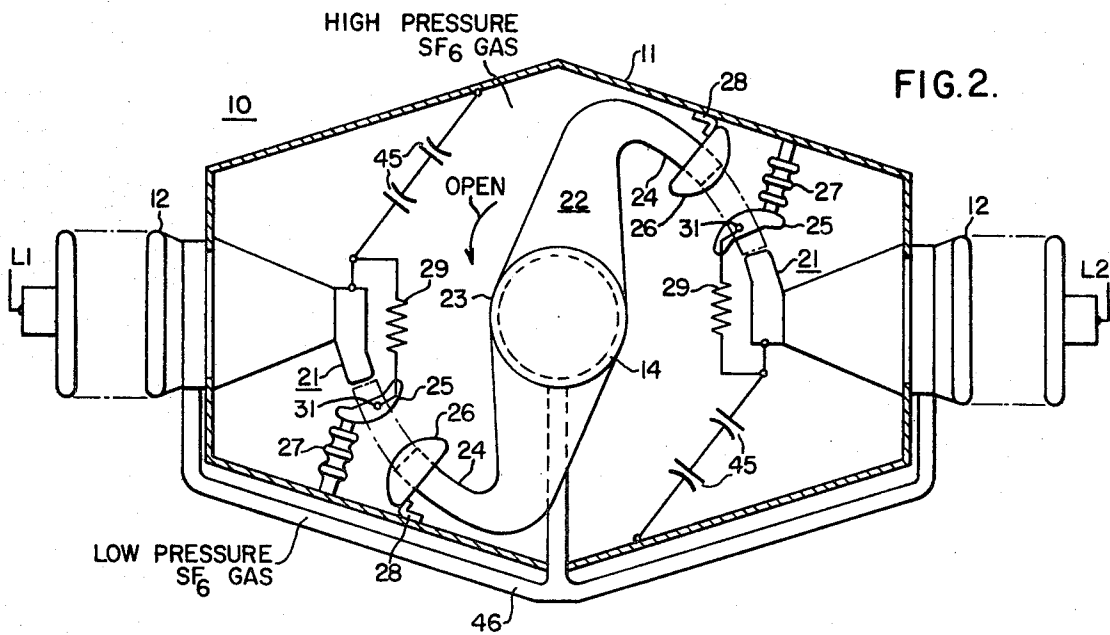


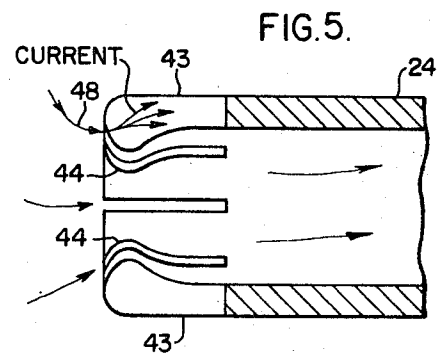
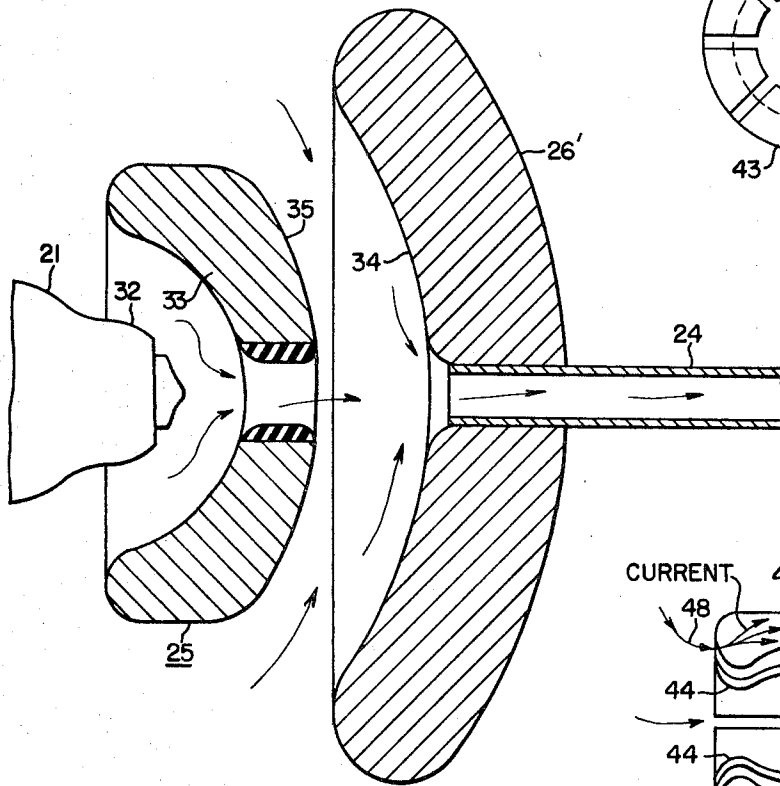
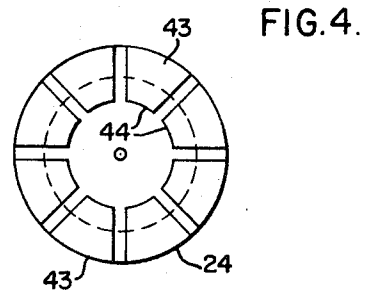
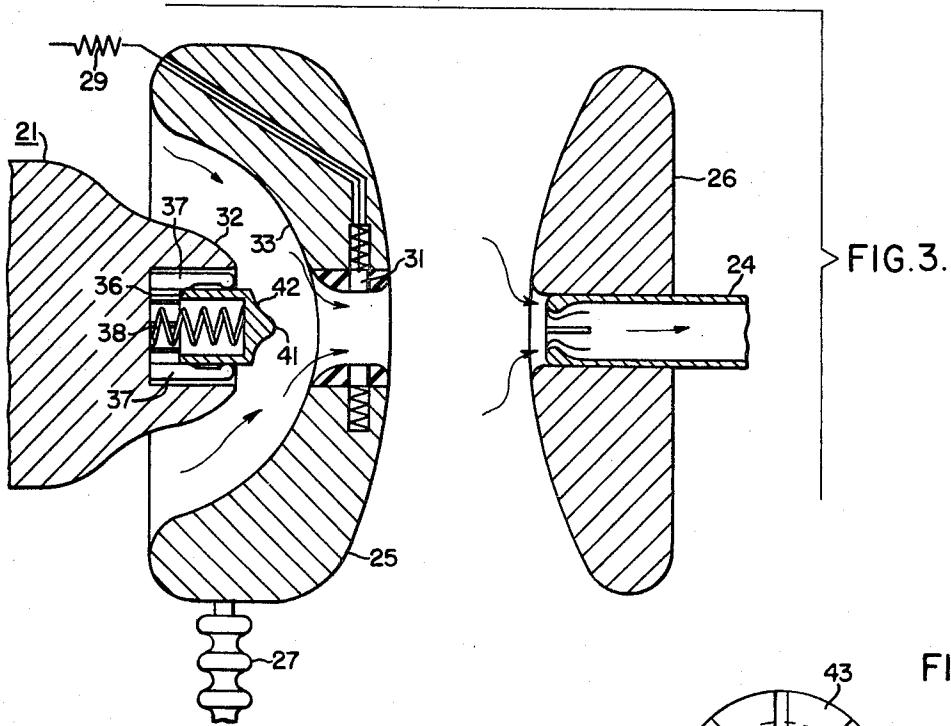
FIG. 2.

WITNESSES

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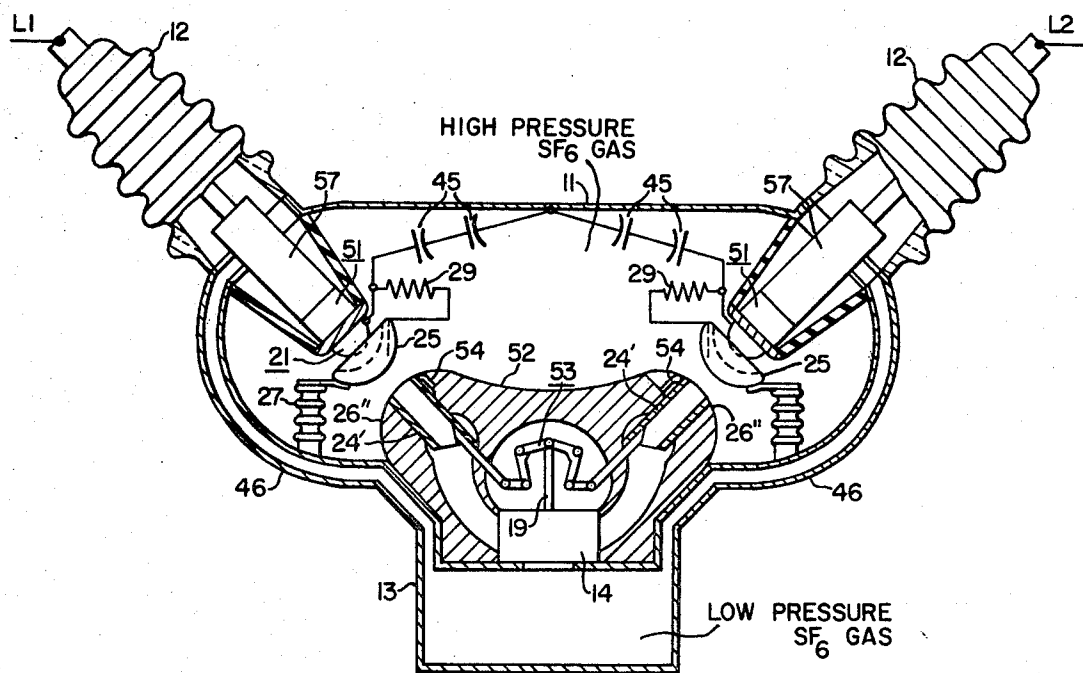
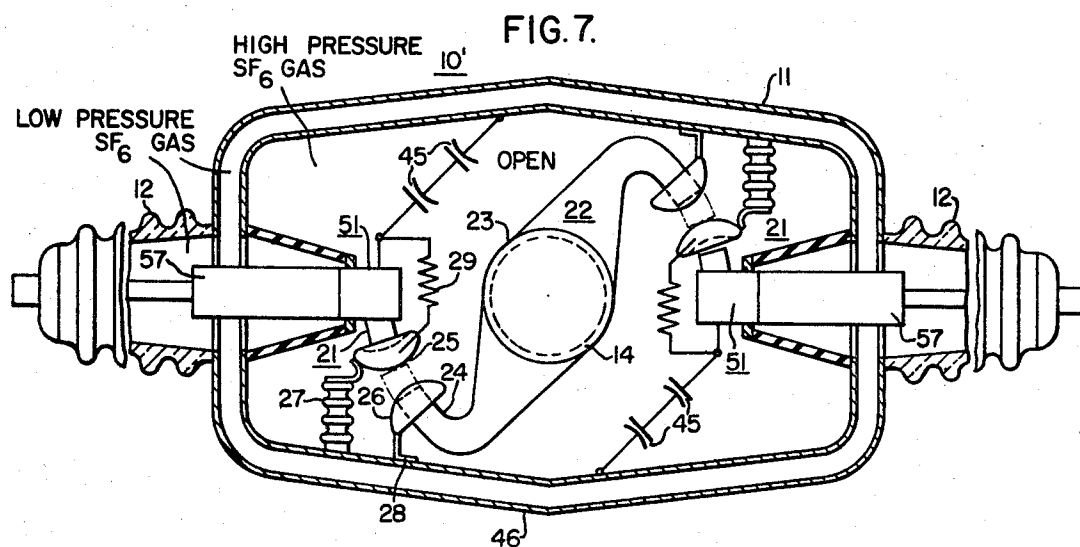


FIG. 8.

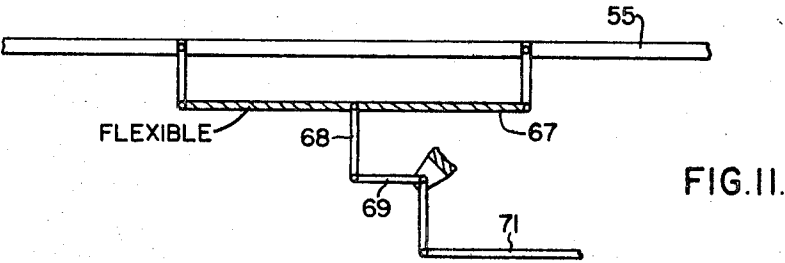
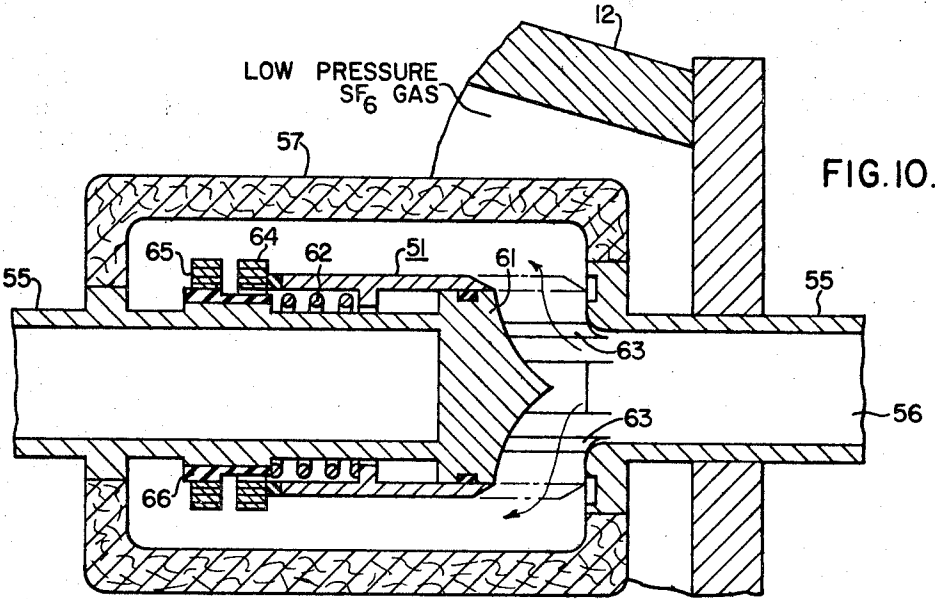
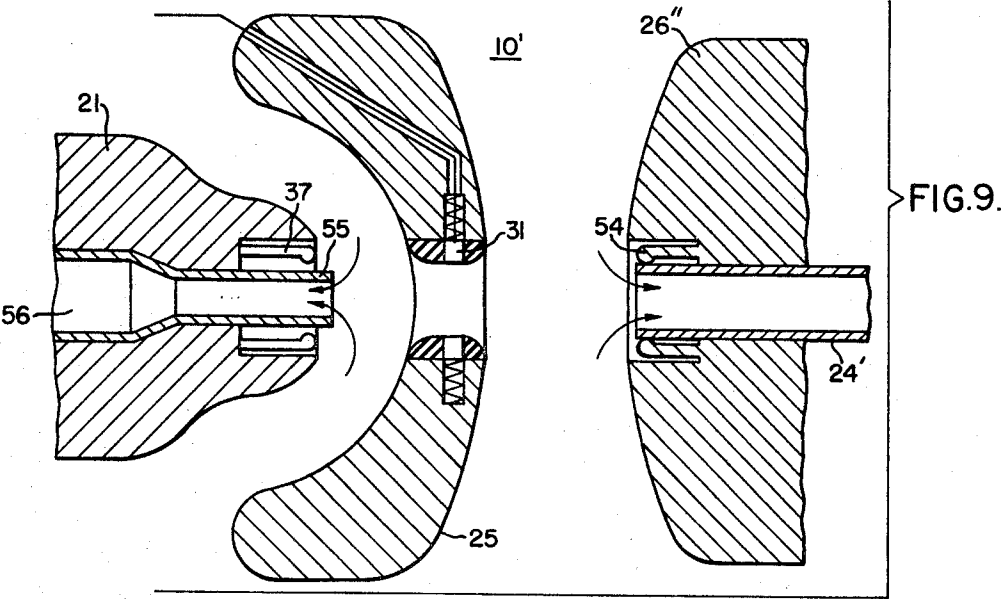


FIG. 12.

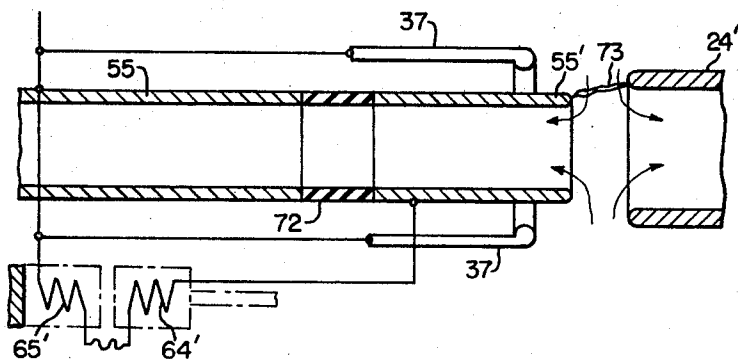


FIG. 13.

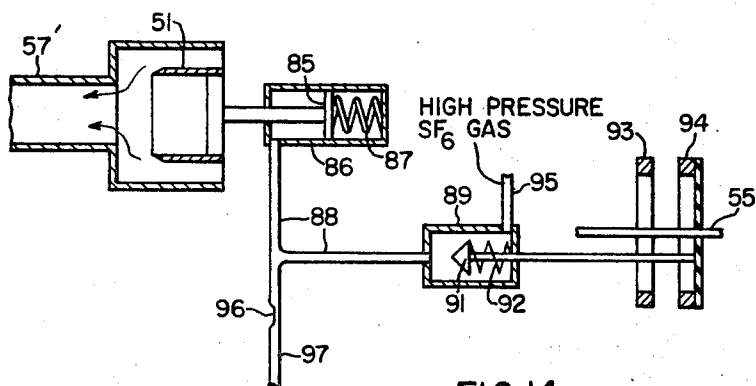
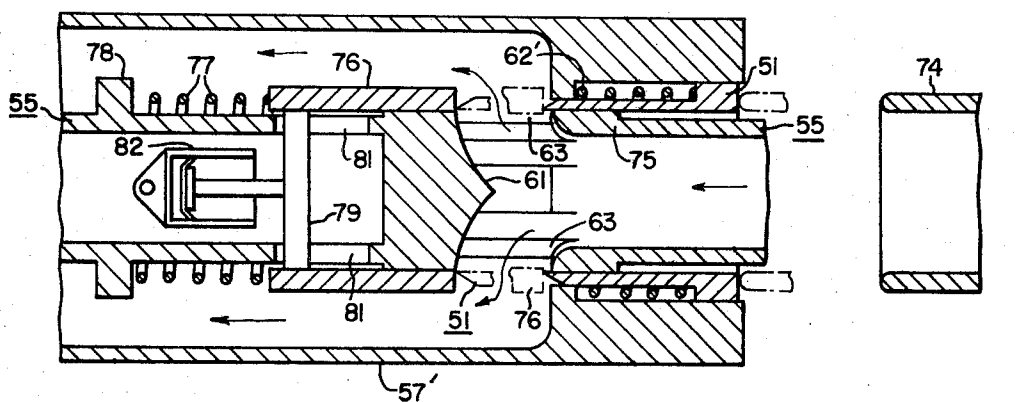


FIG. 14.

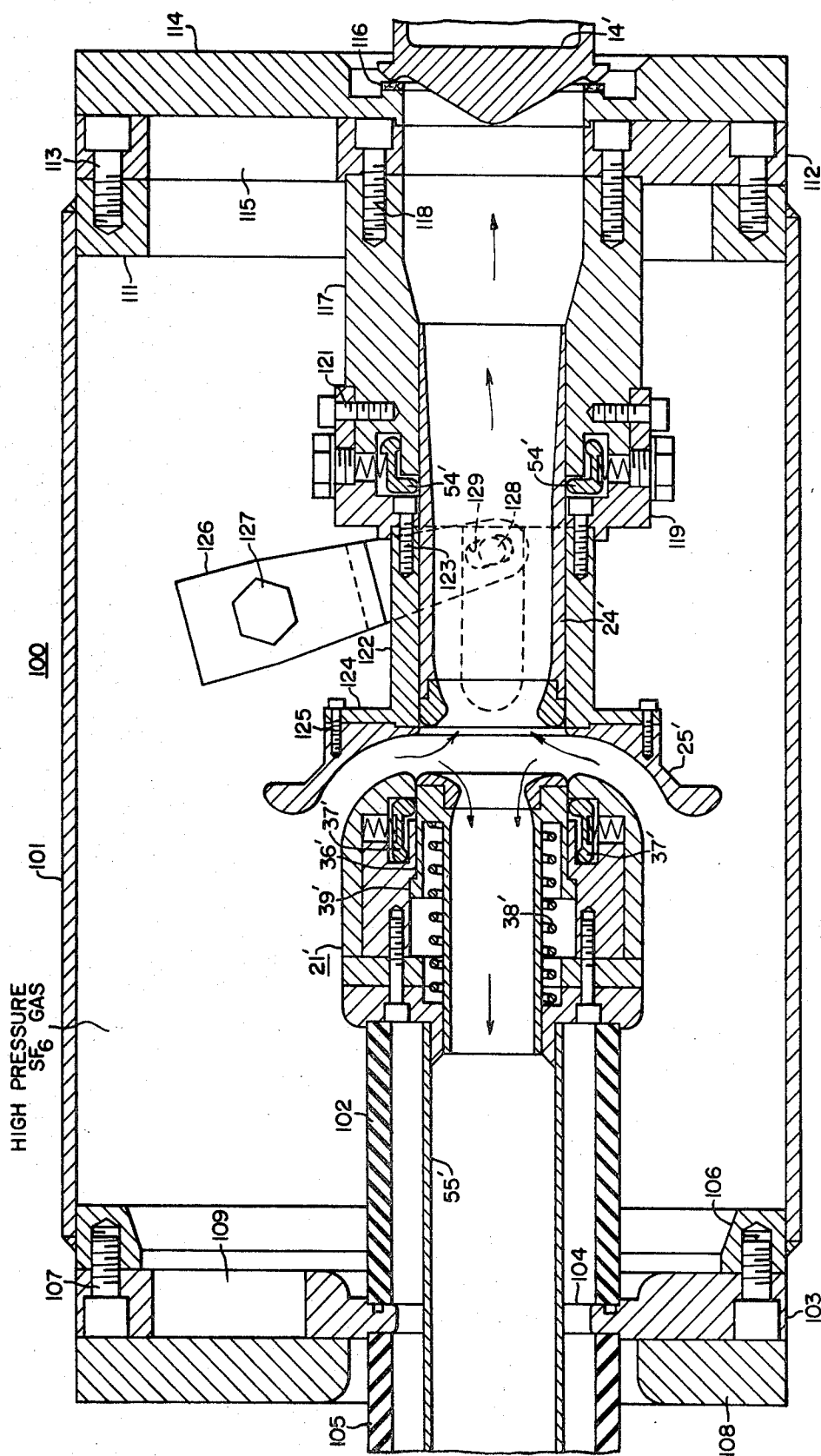


FIG. 15.

GAS-BLAST DOWNSTREAM-TYPE OF HIGH-VOLTAGE CIRCUIT BREAKER HAVING FIELD-CONTROLLING SHIELDS AND SINGLE VENTING MOVABLE CONTACT

BACKGROUND OF THE INVENTION

This invention relates, generally, to circuit breakers and, more particularly, to circuit breakers of the compressed-gas type suitable for extra-high-voltage (EHV) service.

Prior EHV circuit breakers have required a plurality of modules or interrupting units per phase. For example, a recent breaker for 500KV service has three series-connected modules per phase. An object of this invention is to provide a single module 345KV, 50,000 amperes interrupting capacity compressed-gas breaker unit, thereby reducing the cost of EHV circuit breakers.

Another object of the invention is to provide a double-break compressed-gas circuit interrupter having a downstream valve for controlling the flow of interrupting gas through the contacts of the interrupter.

A further object of the invention is to provide a double-break, downstream double-flow compressed-gas circuit interrupter.

Still another object of the invention is to provide means for operating the downstream valves of the interrupter.

A still further object of the invention is to provide for inserting resistance means in parallel with the interrupting arcs to reduce the rate of rise of recovery voltage.

Another object of the invention is to provide static shields in the interrupter which give a substantially uniform voltage gradient across the contacts in the open position.

A further object of the invention is to utilize the shields to establish a high velocity flow of gas into the arc region, thereby insuring that the arc terminals will remain on the moving and the stationary contacts.

Another object of the invention is to provide a contact arrangement in the interrupter such that the current path produces a magnetic force tending to drive the arc into or toward the center of the hollow moving contact.

Other objects of the invention will be explained fully hereinafter or will be apparent to those skilled in the art.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the invention, sulfur-hexafluoride (SF_6) gas is contained in a tank at a relatively high pressure. Relatively stationary contacts are mounted on the inner ends of two bushings extending through opposite ends of the tank. Two hollow series-connected movable contacts bridge the stationary contacts when in the closed position. A double break is provided when the movable contacts are separated from the stationary contacts. Two stationary metal shields are provided per break to give a substantially uniform voltage gradient across the contacts in the open position. A cylindrical portion of each movable contact passes through two shields. A resistor probe in one of each pair of shields inserts a resistor in parallel with the interrupting arc, thereby reducing the rate of rise of recovery voltage. The shields are contoured

to establish a high velocity flow of gas into the arc region, thereby insuring that the arc terminals will remain on the moving and stationary contacts. The flow of gas from the high-pressure tank through the hollow contacts into a low-pressure chamber is controlled by a downstream blast valve. Double flow of the gas can be obtained by providing secondary downstream valves and hollow contacts in each busing in addition to the main downstream valve. Various methods for operating the secondary valves are disclosed. Capacitors are provided to divide the voltage across the open contacts.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the nature and objects of the invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of an interrupter head and supporting structure embodying principal features of the invention;

FIG. 2 is a diagrammatic view of an interrupter head in which the movable contacts are carried by a rotatable bridging cross-arm;

FIG. 3 is a detail view showing the contact and shield arrangement utilized in FIG. 2;

FIG. 4 is an end view of one of the movable contacts for the structure shown in FIG. 2;

FIG. 5 is a view, partly in elevation and partly in section of the contact shown in FIG. 4;

FIG. 6 is a view, similar to FIG. 3, showing a modified shield arrangement;

FIG. 7 is a view, similar to FIG. 2, showing the location of downstream valves for double flow of the interrupting gas;

FIG. 8 is a diagrammatic view of an interrupter head having reciprocating contacts;

FIG. 9 is a detail view showing the contact and shield arrangement utilized in FIG. 8;

FIG. 10 is a detail view showing an electromagnetic method of operating a secondary downstream valve;

FIGS. 11 and 12 are detail views showing alternate electromagnetic methods of operating the valves;

FIG. 13 is a detail view showing a mechanical method of operating a downstream valve;

FIG. 14 is a diagrammatic view showing a downstream valve operated by fluid-pressure; and

FIG. 15 is a view, in section, of a prototype interrupter embodying features of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawings, and particularly to FIG. 1, the circuit breaker 10 shown therein may be generally of the type described in U.S. Pat. No. 3,291,947 issued Dec. 13, 1966 to R. C. Van Sickle and assigned to the Westinghouse Electric Corporation. As shown in FIG. 1, the circuit breaker 10 comprises a metal tank or interrupting head 11 having a terminal bushing 12 extending through each end of the tank 12, an intermediate chamber 13 located at the bottom of the tank 11 and connected to the tank through a main blast valve, shown diagrammatically at 14, and a hollow insulating column 15 having a cap attached to the chamber 13 for supporting the tank 11 and the chamber 13 and insulating them from ground. The tank 11 contains a high-dielectric-strength interrupting gas,

such as sulfur-hexafluoride (SF_6) gas at a relatively high pressure.

As will be described more fully hereinafter, during an interrupting operation gas flows from the high-pressure tank 11 through the main blast valve 14 into the intermediate chamber 13. It then flows through a filter 17 and into the upstanding supporting column 15, which is at a relatively low pressure. The gas is drawn from the column 15, compressed by a compressor (not shown) and stored in a main high-pressure reservoir located at the base of the upstanding column 15. The high-pressure reservoir, which is not shown, is connected to the tank 11 by an insulating high-pressure feed pipe 18. An operating rod 19 connects a main operating mechanism (not shown) with a mechanism for operating the contacts of the interrupter located inside the tank 11. As shown, the feed pipe 18 and the operating rod 19 are located inside the vertical insulating column 15.

As shown in FIG. 2, a stationary contact member 21 is mounted on the inner end of each terminal bushing 12. A hollow cross arm 22 is rotatably mounted on a hollow bearing support 23 mounted inside the tank 11. The blast valve 14 may be located inside the bearing support 23 and operated when the arm 22 is rotated in the manner described in the aforesaid Van Sickle patent. Each end of the arm 22 has a generally cylindrical portion 24 thereon which engages one of the stationary contacts 21 when in the closed position. In the closed position current is carried by one of the terminal bushings 12 through a stationary contact 21, a movable contact 24, the arm 22, the other movable contact 24, and the other stationary contact 21 to the other terminal bushing 12. Line conductors 21, 22 may be connected to the outer terminals of the bushings 12. When the arm 22 is rotated in a direction to open the contacts, the circuit is interrupted at two places, thereby providing a double-break of the circuit.

In order to give a more uniform voltage gradient across the contacts in the open position, two stationary contoured shields are provided per break. One shield 25 is spaced from each stationary contact 21 and is supported by an insulator 27 attached to the inside wall of the tank 11. The other shield 26 of each pair of shields is spaced from the shield 25 and is supported by a bracket 28 attached to the inside wall of the tank 11. One cylindrical contact portion 24 of the rotatable arm 22 passes through the two shields 25 and 26 of each pair of shields when in the closed position.

In order to reduce the rate of rise of recovery voltage, a resistor 29 is connected in parallel with the interrupting arc during interruption of the main arc. As shown more clearly in FIG. 3, a spring-biased contact member 31 is slidably disposed in the shield 25 to engage the moving contact member 24 when it passes through the shield 25. The contact member 31 is connected to one terminal of the resistor 29, and the other terminal of the resistor 29 is connected to the stationary contact 21 as shown in FIG. 2. When the breaker opens to interrupt a fault, an arc is drawn between the moving contact 24 and the stationary follower contact 36. The contact or resistor probe 31 is in contact with the moving contact 24 while it is being drawn through the shield 25, thereby connecting the resistor 29 in parallel with the interrupting arc. The interrupting arc is extinguished by the time the moving contact leaves the shield 25.

During the interrupting operation, the downstream valve 14 is opened to permit the high pressure gas to flow from inside the tank 11 through the hollow arm 22 and the valve 14 into the intermediate chamber 13. As shown in FIG. 3, the end portion 32 of the stationary contact 21 is generally convex in shape. A surface of the shield 25, which is spaced from, and faces the convex surface 32, is generally concave in shape, as shown at 33. Thus, the contact 21 and the shield 25 are so spaced and contoured as to establish a high-velocity flow of gas into the arc region and to direct the gas into the hollow moving contact portion 24, thereby insuring that the arc terminals will remain on the moving and stationary contacts.

As shown in the modified construction of FIG. 6, the shield 26' may be provided with a concave surface 34, which faces and is spaced from a convex surface 35 on the shield 25. Thus, a high-velocity flow of gas is also established into the resistance arc region should this become necessary to stabilize the arc position.

Referring again to FIG. 3, a spring-biased contact follower 36 is slidably disposed in the end of arrows stationary contact member 21. The follower 36 is engaged by contact fingers 37 disposed in the contact member 21. The structure of the follower 36 and the fingers 37 is shown in more detail in FIG. 15. The follower 36 is biased outwardly by a spring 38, the outward movement being limited by a flange 39 on the inner end of the follower 36. The outer end of the follower 36 has a projection 41 thereon, thereby providing an inwardly curved surface 42 on the outer end of the follower 36. As shown more clearly in FIGs. 4 and 5, the hollow cylindrical end of the movable contact 24 is divided into a plurality of segments 43, each one of which has a portion extending radially inwardly with a curved surface 44 thereon, which cooperates with the curved surface 42 on the follower 36 to provide an inwardly bending loop 48 in the path of the arc current flowing through the contact members when they are separated. As shown by the arrow in FIG. 5, a magnetic force on the arc has a tendency to drive the arc into or toward the center of the moving contact, thereby aiding in the stabilization of the arc, which results in a more stable and more easily controlled arc.

As shown in FIG. 2, capacitors 45 are connected between each stationary contact 21 and the tank 11. The capacitors function in the usual manner to divide the voltage across the open contacts. The tank 11 and the arm 22, which carries the moving contacts 24, are at the same potential. As also shown in FIG. 2, a passageway 46 provides low-pressure communication to the bushings 12, thereby permitting the bushings 12 to be filled with low-pressure gas.

In the interrupter shown in FIG. 7, which is similar to the interrupter shown in FIG. 2, a secondary downstream valve 51 is provided at each stationary contact 21, thereby improving the performance of the interrupter 11 by double flow of the interrupting gas through the contacts 21, 24, as indicated by the arrows in FIG. 9. The structure and the manner of operation of the secondary valve 51 will be described more fully hereinafter.

In the modified interrupter shown in FIG. 8, the movable contact members 24' are of the reciprocating type. They are slidably disposed in a central housing 52 and are operated by a linkage mechanism 53, which, in

turn, is actuated by the operating rod 19. The main blast valve 14 can be actuated by the operating mechanism in the manner described in the aforesaid copending application. Contact fingers 54 are provided in the housing 52 for slidably engaging the moving contact members 24'. A secondary downstream blast valve 51 is provided in each terminal bushing 12.

As shown more clearly in FIG. 9, a hollow double flow contact 55 is provided in each stationary contact member 21. A passageway 56 extending through the contact member 21 permits gas to flow to the downstream valve 51 shown in FIG. 10. A downstream filter and baffle 57 encloses the secondary downstream valve 51. The shield 25 is similar to the one previously described. The shield 26'' is incorporated in the central housing 52 as shown in FIG. 8. These shields function in the manner previously described to give a more uniform voltage gradient across the contacts in the open position. The hollow contacts 24' and the central housing 52 bridge the two bushings and are at tank potential. The hollow contacts extend through the shields in the breaker closed position.

In the breaker closed position the current is carried from one stationary contact through the hollow contacts and central housing to the other stationary contact. When the breaker opens to interrupt a fault, an arc is drawn between the moving contact and the stationary contact. At the same time, or slightly before, the downstream valves are opened and SF_6 flow is established into the hollow contacts. As previously explained, double-flow interrupters have been proven to give good performance. The baffle and filter 57 which is located downstream of the stationary contact reduces bushing contamination and also prevents a direct blast on the bushing.

There are three general ways in which the stationary contact downstream valve 51 can be operated. They are: (1) Electromagnetic (2) Mechanical (3) Fluid or Gas. An electromagnetic means is shown in FIG. 10. The valve 51 is generally cylindrical in shape and is slidably mounted on an enlarged portion 61 of the conductor 55. The valve is biased to the closed position by a spring 62. When the valve is opened, gas is permitted to flow through openings 63 in the conductor 55 into the filter 57 which surrounds the valve. An induction ring or coil 64 is attached to the one end of the valve 51. Another induction ring or coil 65 is mounted on an enlarged portion of the conductor 55 and is insulated from the conductor by insulation 66. The valve is opened when a sufficiently high magnitude of fault current flows through the conductor 55, thereby inducing current in the rings or coils 64 and 65. This current produces a flux which creates an attractive force between the rings or coils, thereby opening the valve against the force of the spring 62. The distance between the coils should be relatively small to make them fast and effective.

Another method of operating the downstream secondary valve is shown diagrammatically in FIG. 11. The main conductor 55 carries the current to be interrupted. A flexible conductor 67 physically and electrically parallels the conductor 55. A link 68 mechanically connects the conductor 67 to a pivotally mounted lever 69 which, in turn, is connected to the valve (not shown) by means of a link 71. When a sufficiently high

magnitude of fault current flows through the conductors they attract each other, thereby actuating the linkage mechanism to operate the valve.

Still another method for operating the secondary valve 51 is shown in FIG. 12. The end portion 55' is insulated from the remainder of the conductor 55 by insulation 72. The driving coils 64' and 65' are connected between the insulated portion 55' and the main conductor 55. When the moving contact member 24' separates from the contact fingers 37 the arc 73 transfers to the contact portion 55' which functions as an arc probe, thereby energizing the driving coils 64' and 65' to operate the valve in the manner hereinbefore described.

A mechanical method of operating the valve 51 is shown in FIG. 13. An actuator 74 moves with the moving contact member 24'. The valve 51 is slidably disposed on an enlarged portion 75 of the stationary conductor 55. The valve is biased to the open position by the spring 62' disposed in a recess in the baffle 57' which encloses the valve structure. A seal follower 76 is slidably disposed on the enlarged portion 61 of the conductor 55. The follower 76 is biased to the right towards the valve 51 by a spring 77 disposed between a shoulder 78 on the conductor 55 and the left hand end of the cylindrical seal 76. The travel of the seal is limited by a cross member 79 inside the seal and extending through oppositely disposed slots 81 in the conductor 55. A dashpot 82 is connected to the cross member 79. The dashpot is so constructed that it provides a delayed movement of the seal 76 to the right and permits a free return movement to the left. Delayed movement of the seal 76 could also be accomplished by increasing its weight to increase its inertia. The valve 51 is shown in full lines in the breaker open position. When the breaker is closed, the actuator 74 moves to the left, thereby moving the valve 51 to the left, as shown by the dash lines, to engage the seal 76, thereby preventing gas flow through the openings 63 in the conductor 55. When the breaker is opened, the actuator 74 moves to the right permitting the spring 62 to open the valve 51 and permit gas flow through the openings 63. After a predetermined time interval the seal follower 76 is moved to the right by the spring 77 to engage the end of the valve 51 and stop the flow of gas through the openings 63. The delayed action of the seal is obtained by the dashpot 82 in the manner hereinbefore described. When the breaker closes the dashpot permits the seal to move freely to the left along with the valve 51. Thus, the seal follower stops the flow of gas after the interrupting operation is completed.

Another method of actuating the valve 51 is by a fluid-pressure actuated piston controlled either directly or by a pilot valve. A pilot scheme is shown diagrammatically in FIG. 14. The valve 51 is connected to a piston 85 disposed in a cylinder 86. A spring 87 biases the piston 85 and the valve 51 to its closed position. One end of the cylinder 86 is connected by a line 88 to an enclosure 89 having a pilot valve 91 inside the enclosure. The valve 91 is biased to the closed position by a spring 92 and it may be opened either by induction coils 93 and 94 as shown, or by a mechanical actuator. The induction coils are energized by the current flowing through the main conductor 55. High pressure fluid, such as the high pressure interrupting gas, is applied to an opening 95 in the enclosure 89.

When the breaker opens under fault conditions, the high current in the conductor 55 energizes the induction coils 93 and 94, which are wound to repel each other, thereby opening the pilot valve 91 and admitting high pressure gas to the cylinder 86 to open the valve 51 which permits the high pressure gas from the contact region to flow past the valve 51 into the low pressure region inside the baffle 57'. When the arc is interrupted and current ceases to flow in the conductor 55, the induction coils 93 and 94 are deenergized and the spring 92 recloses the pilot valve 91, thereby stopping the flow of high pressure gas to the cylinder 86. The cylinder 86 exhausts through a bleed hole or restricted portion 96 in an extension 97 of the line 88 which is connected to the low pressure region. After a time delay, the valve 51 is reclosed by the spring 87, thereby stopping the flow of gas past the valve.

A prototype interrupter 100 embodying features of the present invention is shown in FIG. 15. The interrupter 100 is of the double flow downstream type. This interrupter has been tested in a laboratory of the assignee of this application. The interrupter comprises a metal cylinder 101, a stationary contact 21', a movable contact 24', a static shield 25' and a downstream blast valve 14'. The stationary contact 21' is supported on one end of an insulating sleeve 102 the other end of which terminates at a metal cover 103 having an opening 104 therein through which hollow conductor 55' extends. The contact 21' is connected to the inner end of the conductor 55' which may extend through a terminal bushing (not shown). An insulating sleeve 105 surrounds the conductor 55' outside of the cover 103. The cover 103 is attached to a ring 106 by bolts 107. The ring 106 may be welded in the end of the cylinder 101. A cover 108 is attached to the cover 103 to close an access opening 109 in the cover 103. A ring 111 is welded in the other end of the cylinder 101 and a cover 112 is attached to the ring 111 by bolts 113. A cover plate 114 is attached to the cover 113 to close an access opening 115 in the cover 113. A valve seat 116 is provided in the cover plate 114 for the valve 14'. A conducting sleeve 117 is attached to the cover 112 by bolts 118. An end cover 119 is attached to the sleeve 117 by screws 121. Spring-biased contact fingers 54', which slidably engage the movable contact 24', are retained in position by the end cover 119. A flanged sleeve 122 is attached to the end cover 119 by bolts 123. The static shield 25' is attached to the flanged end 124 of the sleeve 122 by screws 125. The movable contact member 24' may be reciprocated inside the sleeves 122 and 117 by means of a lever 126 which is driven by a shaft 127 extending to the outside of the cylinder 101. The lever 126 may be attached to the contact 24' by means of a pin 128 disposed in an elongated slot 129 at one end of the lever 126.

When the contact members of the interrupter are closed, a current path through the interrupter extends from the conductor 55' through the stationary contact 21' which includes the contact follower 36' and the contact fingers 37', then through the movable contact 24' and the contact fingers 54' to the sleeve 117 and then through the cover 112 and the cover plate 114 which may be connected to a power conductor. The cylinder 101 contains SF₆ gas at a relatively high pressure, for example, 200 psi. The region outside the cover plate 114 may be enclosed by an enclosure (not shown)

for containing the gas at a low pressure. When the movable contact member 24' is separated from the stationary contact 21' and the blast valve 14' and a secondary downstream valve, such as the valve 51 previously described, are opened, the high pressure gas flows between the surfaces of the stationary contact 21' and the static shield 25' into the hollow movable contact 24' and out through the blast valve 14' in the manner hereinbefore described. The gas also flows through the hollow stationary contact 21' and conductor 55' as previously described. Thus, a double-flow downstream interrupter is provided which gave very good performance on tests. As explained hereinbefore, the performance can be increased or improved by adding a secondary downstream valve to provide double flow of the interrupting gas in the manner hereinbefore described.

From the foregoing description it is apparent that the invention provides a circuit interrupter which is suitable for extra high voltage service. The cost of a high voltage circuit breaker is reduced by reducing the number of modules or interrupting units required for a given voltage. The static shields provide a substantially uniform voltage gradient across the open contacts, thereby enabling the interrupter to withstand a high voltage per break. The static shields also function to establish a high velocity flow of gas into the arc region, thereby insuring that the arc terminals will remain on the moving and double-flow contacts. There is no bridging insulation across the open contact other than the porcelain bushings and voltage dividers even though two downstream valves are provided. The electromagnetic methods of valve operation have the advantage of dumping the pressure downstream of the contacts well in advance of contact separation. They use double flow only when needed, that is, at high fault currents. A resistor for reducing the rate of rise of recovery voltage is incorporated without the use of auxiliary contact operation. High density gas is maintained at the contacts with substantially no pressure drop of the gas, thereby improving the interrupting performance. A downstream valve interrupter has high pressure SF₆ gas available at the contacts right away. There is no delay as with an upstream type. The interrupter is relatively simple in structure with a minimum of parts which may be readily manufactured and assembled and easily maintained.

As mentioned previously, this idea has the advantage of operating only at high currents. For example, it could be designed to operate only at currents above 20,000 amperes. It has the advantage of being self-operating requiring not linkage, etc. It has a still further advantage which is quite important. When the breaker is called on to interrupt a highly inductive or capacitive low magnitude current, it is very desirable not to chop or force the current to zero before it normally would. Since in this design only one valve of the double flow design would operate at low currents, the tendency to chop or force an early zero would be greatly reduced.

Since numerous changes may be made in the above-described construction and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all subject matter contained in the foregoing description or shown in the accompanying drawings shall be interrupted as illustrative and not in a limiting sense.

We claim as our invention:

1. In a circuit interrupter, in combination, a metal tank containing an interrupting gas at a relatively high pressure, terminal bushings extending through opposite ends of the tank, a hollow stationary contact supported by the inner end of each bushing, hollow movable contacts for engaging the stationary contacts to establish a circuit through the interrupter, means for actuating the movable contacts to interrupt the circuit at two breaks, a main blast valve controlling the flow of gas from inside the tank through the movable contacts to the exterior of the tank, and a secondary blast valve at each stationary contact responsive to the current flow through the interrupter controlling the flow of gas from inside the tank through the stationary contacts to the exterior of the tank during interruption of the circuit.

2. The combination defined in claim 1, including electromagnetic means for operating the secondary blast valves.

3. The combination defined in claim 2, wherein the electromagnetic means is inductively energized by the current to be interrupted.

4. The combination defined in claim 1, including a main conductor for the current to be interrupted, a flexible conductor physically and electrically paralleling the main conductor, and linkage means connected to the flexible conductor for operating a secondary blast valve.

5. The combination defined in claim 1, including an arc probe at each stationary contact, and electromagnetic means connected to the arc probe to be energized by the arc current to operate a secondary blast valve.

6. The combination defined in claim 1, including mechanical means for operating the secondary blast valves, and time delay means for stopping the flow of gas a predetermined time after the secondary valves are opened.

7. The combination defined in claim 1, including fluid-pressure actuating means for opening the secondary blast valves, and means for reclosing the secondary valves a predetermined time after interruption of the circuit.

8. The combination defined in claim 1, including a cross arm rotatably mounted in the tank, and wherein the hollow movable contacts are on the ends of the cross arm, and the circuit through the interrupter is in-

errupted at two breaks when the cross arm is rotated in one direction.

9. The combination defined in claim 1, including a central housing disposed within the tank, and wherein the hollow movable contacts are reciprocally disposed in the central housing, and including linkage means for actuating said movable contacts.

10. The combination defined in claim 9, wherein the central housing connects the movable contacts in series-circuit relation.

11. A compressed-gas circuit interrupter including, in combination, stationary contact means, first shield means spaced away from said stationary contact means and having a first orifice opening provided therethrough, resistance contact means disposed within said first orifice opening, resistance means electrically connected between said stationary contact means and said resistance contact means for lowering the rate of rise of the recovery-voltage transient during the opening operation, second shield means having a second orifice opening therethrough, a movable tubular venting contact movable through said second orifice opening and through said first orifice opening and also into contacting engagement with the stationary contact means during the closing operation, whereby during the opening operation a resistance arc is established between the movable tubular venting contact and the resistance contact means, means for forcing a blast of compressed gas through the movable tubular venting contact to effect extinction of the resistance arc, and the two shield means directing the gas flow during the opening operation and additionally providing a substantially uniform voltage gradient across the separated contacts in the open-circuit position.

12. The combination according to claim 11, wherein venting means is additionally provided through the stationary contact means.

13. The combination according to claim 12, wherein a secondary blast-valve is associated with the venting means through the stationary contact means.

14. The combination of claim 13, wherein the secondary blast-valve is electromagnetically operated.

15. The combination of claim 13, wherein a filter surrounds the secondary blast-valve.

16. The combination of claim 14, wherein induction coils are utilized.

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