

Jan. 16, 1968

C. F. CROMER
COMPRESSED-GAS CIRCUIT BREAKER WITH MOVABLE ORIFICE
CONTACT AND CONFIGURED FLOW DIRECTOR ABOUT
STATIONARY CONTACT ASSEMBLY

3,364,327

Filed Jan. 21, 1965

4 Sheets-Sheet 1

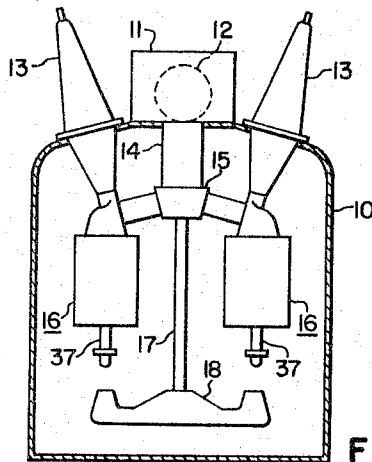


FIG. 1.

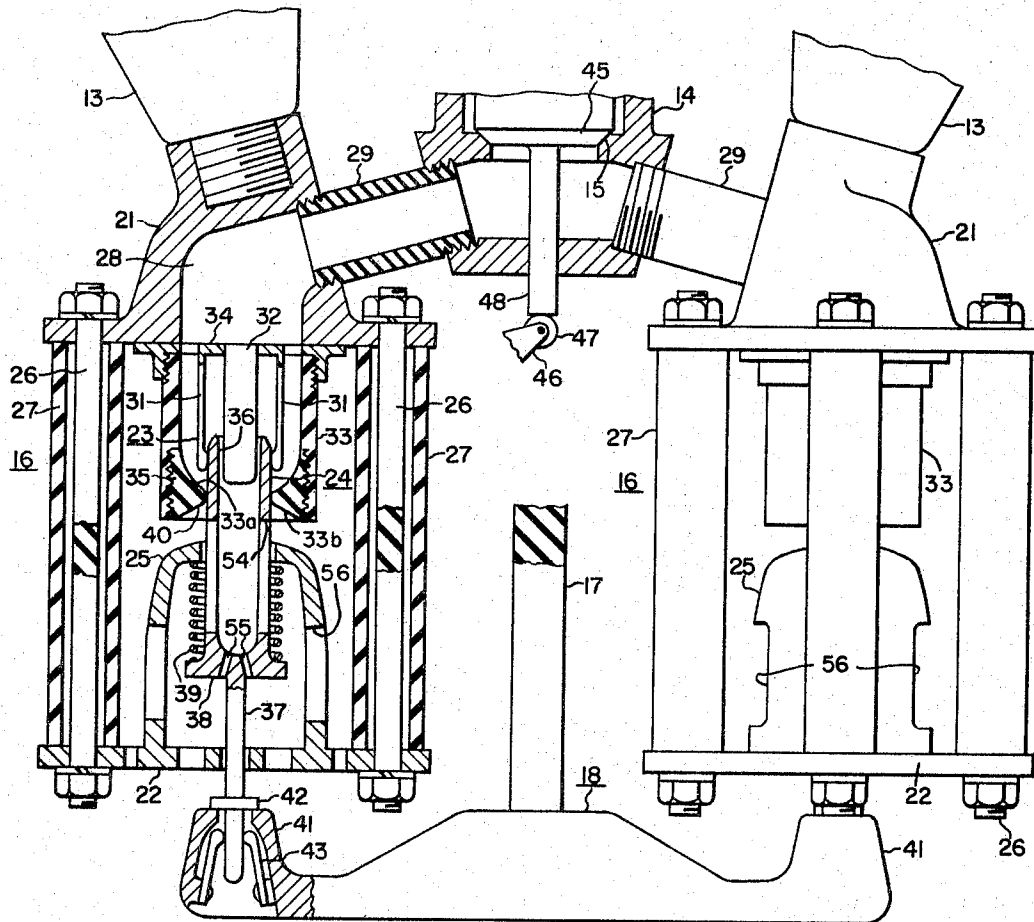


FIG. 2.

WITNESSES

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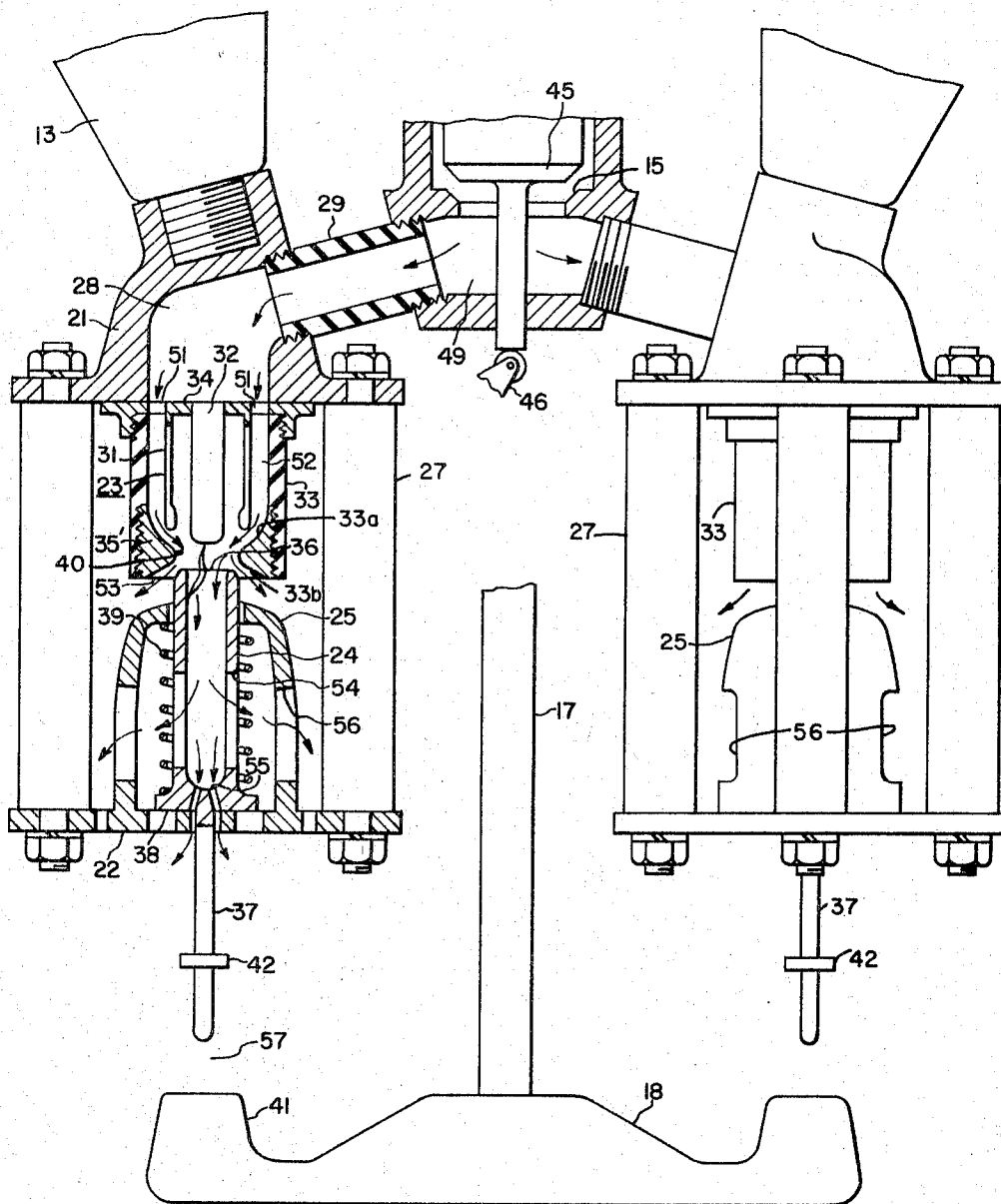


FIG. 3.

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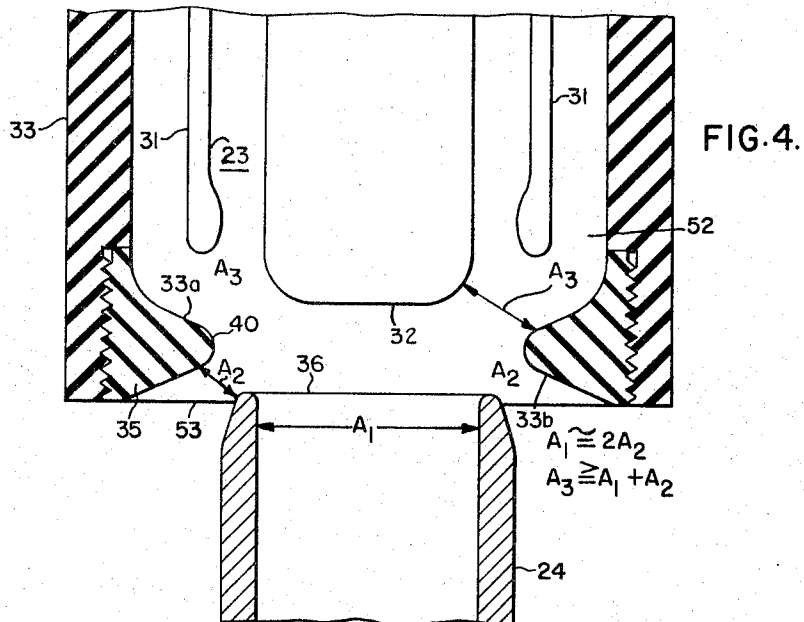
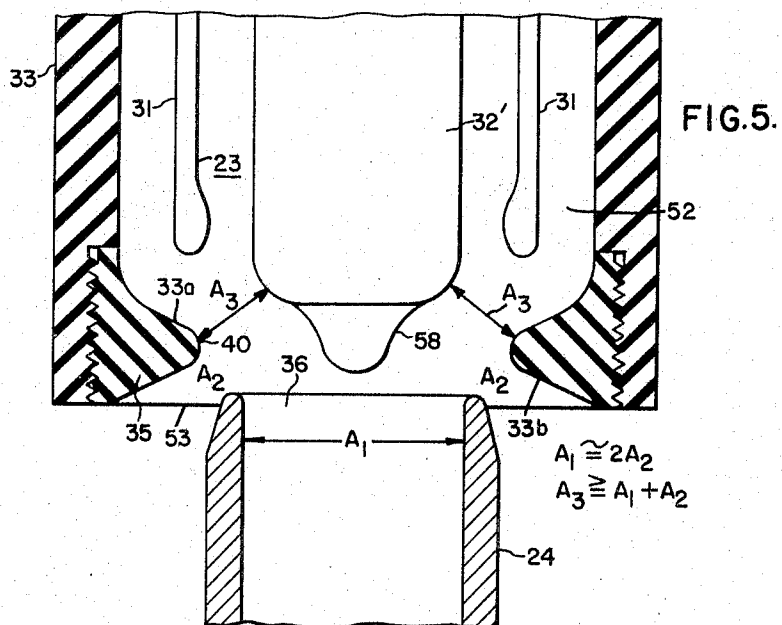
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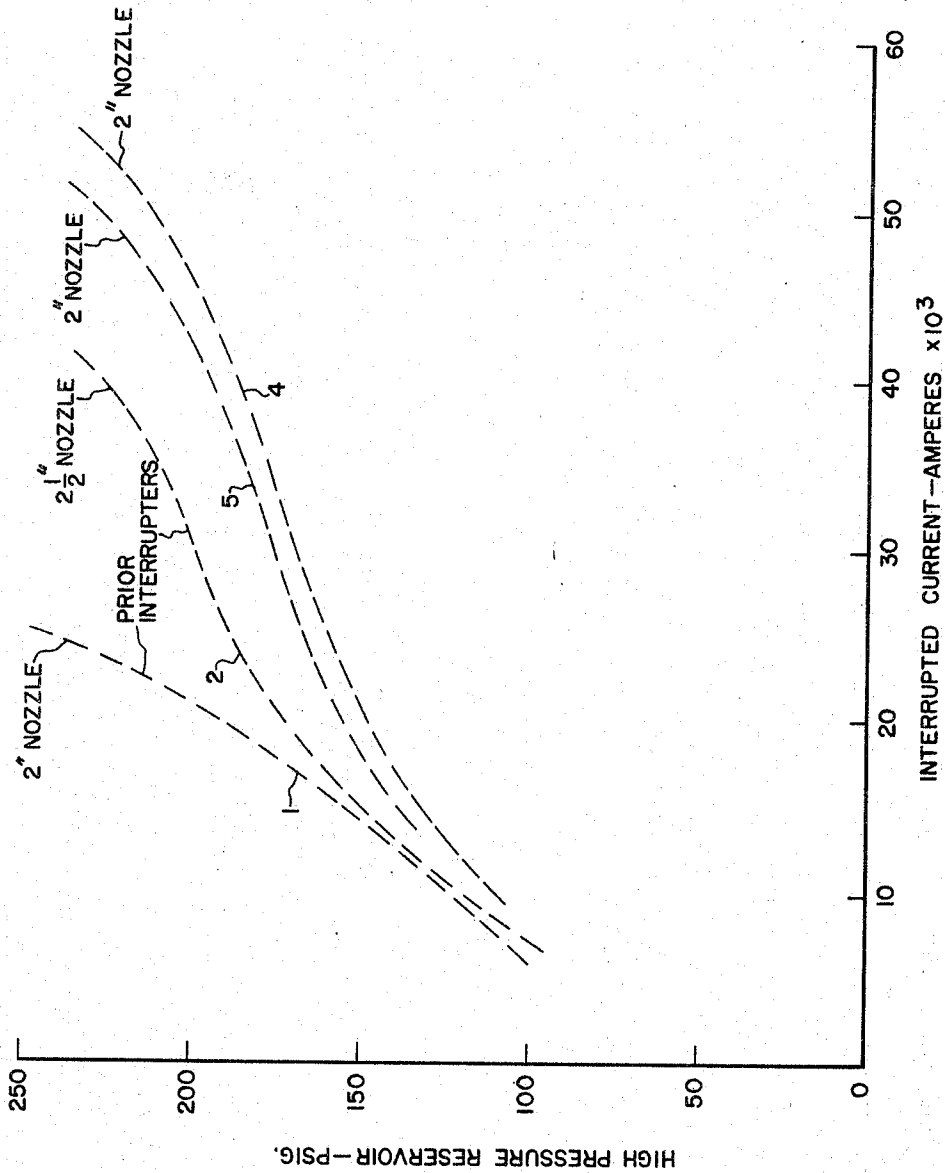


FIG. 6.

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COMPRESSED-GAS CIRCUIT BREAKER WITH MOVABLE ORIFICE CONTACT AND CONFIGURED FLOW DIRECTOR ABOUT STATIONARY CONTACT ASSEMBLY

Charles F. Cromer, Penn Township, Trafford County, Pa., assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania
Filed Jan. 21, 1965, Ser. No. 426,762
12 Claims. (Cl. 200-148)

ABSTRACT OF THE DISCLOSURE

A compressed-gas circuit interrupter has an interrupting unit with a movable orifice contact and an insulating flow director with a constriction surrounding the stationary contact structure. The gas flow is directed by the gas-flow director through the movable hollow contact and laterally out the annular side exit opening after the movable contact has come to a predetermined stopped position. The area through the movable orifice contact is approximately twice that of the annular side exit opening.

This invention relates, generally, to compressed-gas circuit breakers and, more particularly, to circuit breakers having circuit interrupters of the metallic orifice type.

As the interrupting capacity of compressed-gas circuit breakers having interrupters of a previously known metallic orifice type is increased, the area of the orifice and/or the differential pressure must also be increased to avoid clogging during the interrupting operation. In prior dual-pressure interrupters, the gas is confined and forced to be discharged through the orifice, or moving contact. As the interrupter is called upon to handle higher currents, more arc products and thermal heating occur, and larger orifices are required to handle these larger volumes. Also, if the arc space, or the distance between terminals, is permitted to increase with time, additional heating of the upstream gas occurs.

In a copending application Ser. No. 82,847, filed Jan. 16, 1961, now U.S. Patent 3,160,726, issued Dec. 8, 1964, to Charles F. Cromer and assigned to the assignee of the present application, an interrupter is disclosed in which the moving contact member is stopped after it has traveled a predetermined distance, thereby fixing the distance between terminals and reducing heating of the upstream gas. However, a flow director confines the gas and forces it to flow through the orifice.

An object of this invention is to provide for increasing the interrupting capacity of a compressed-gas circuit breaker having interrupters of the orifice type without increasing the size of the orifice for each interrupter.

Another object of the invention is to prevent clogging of the orifice of a compressed-gas circuit interrupter during the interrupting operation.

A further object of the invention is to provide a flow director for the interrupter which gives a converging flow of the gas toward the orifice of the moving contact during the initial movement of the contact member.

Still another object of the invention is to provide a side dumping exit for the gas between the flow director and the moving contact to permit an escape of the thermally-expanding gas, which occurs as the instantaneous magnitude of the current is passing through its higher values.

A further object of the invention is to restrict the length of the arc to a nominal value.

A still further object of the invention is to prevent arcing between the moving contacts and the cross-arm of a circuit breaker having two movable contacts connected in

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series through the cross-arm when the breaker is closed and separated from the cross-arm when the breaker is fully opened.

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

In accordance with one embodiment of the invention, each pole-unit of a compressed-gas circuit breaker has two interrupters, each of which has an interrupting break and an isolating break. When the circuit breaker is closed, the two interrupters are connected in series by a bridging cross-member. Each interrupter comprises a fixed contact assembly, a flow director and a moving contact of a metallic orifice type, which is stopped after a predetermined displacement. The flow director is contoured to give a converging flow of gas toward the metal orifice of the moving contact during the first part of the interrupting operation. The movement of the moving contact is stopped with the moving contact so positioned as to provide a side dumping exit between the flow director and the moving contact, thereby permitting an escape of the thermally-expanding gas, which occurs as the instantaneous magnitude of the current is passing through its higher values. The flow director is also contoured to give a diverging downstream flow of gas between the director and the moving contact. As the current approaches zero, the arc is swept into the metallic orifice and is interrupted. Gas flowing through the tubular moving contact is allowed to escape radially through slots provided for this purpose, and also axially through the contact.

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:

FIGURE 1 is a view, partly in elevation and partly in section, of a circuit breaker embodying principal features of the invention;

FIG. 2 is an enlarged view, partly in elevation and partly in section, of the interrupting units for the circuit breaker of FIG. 1, the contact members being shown in the closed-circuit position;

FIG. 3 is a view, similar to FIG. 2, but showing the contact members in the opened position, the flow director being of a modified structure;

FIG. 4 is an enlarged view of a portion of one of the interrupting units showing relative discharge areas of the interrupter;

FIG. 5 is a view, similar to FIG. 4, of an interrupting unit having a modified arcing horn; and

FIG. 6 is a view of curves showing the performance of different interrupters.

Referring to the drawings, and more particularly to FIG. 1 thereof, the compressed-gas circuit breaker shown therein is generally of the type disclosed in a copending patent application, Ser. No. 160,957, filed Dec. 20, 1961 now United States Patent 3,284,602, issued Nov. 8, 1966, to R. E. Friedrich, R. G. Colclaser and H. Greger. In the present case, only one pole-unit of the circuit breaker is shown. It will be understood that additional pole-units may be provided, as desired. Three pole-units may be mounted in one tank, or each pole-unit may be mounted in a separate tank, both arrangements being disclosed in the aforesaid copending patent application.

As shown, the circuit breaker comprises a metallic tank 10, a housing 11 containing a high-pressure gas reservoir 12, and an operating mechanism (not shown), two terminal bushings 13, a blast tube 14, connected at its upper end to the gas reservoir 12, and having a blast-valve seat 15 at its lower end, two interrupter units 16, an insulating lift-rod 17, and a conducting cross-arm 18, which bridges

the two interrupter units 16 to connect them in series when the breaker is closed.

As shown more clearly in FIG. 2, each interrupter unit 16 comprises a cover member 21, a base member 22, a fixed contact assembly 23, a movable contact member 24 and a blast shield 25. The cover member 21 may be threaded onto the lower end of the terminal bushing 13. The base member 22 is attached to the cover member 21 by a plurality of insulating bolts 26 and spaced from the cover 21 by insulating sleeves 27, which surround the bolts 26. The cover member 21 has an opening 28 therein, which is connected to the valve seat 15 by an insulating blast tube 29.

The fixed contact assembly 23 is generally cylindrical in shape, and comprises a plurality of contact fingers 31 which surround an arc horn 32. A generally cylindrical flow director 33 surrounds and is spaced from the contact fingers 31. The contact fingers 31 and the arc horn 32 may be formed integrally with a flanged support 34, which may be attached to the cover member 21 by suitable screws, or bolts (not shown).

The flow director 33 is composed of insulating material and its upper end is threaded into the conducting support 34. The flow director 33 has an insert 35 which is threaded into the lower end of the cylindrical member 33 and is contoured to give a flow of gas toward the movable contact member 24, as will be described more fully hereinafter. The insert 35 may be composed of polytetrafluoroethylene, which is sold under the trade name "Teflon," or as shown in FIG. 3, the insert 35' may be composed of metal. The outside diameter of the movable contact member 24 is only slightly less than the diameter of the venacontracta 40 of the insert 35 through which the member 24 extends, thereby maintaining a close fit between the member 24 and the insert 35.

The blast shield 25 may be formed integrally with the metal base 22. The shield 25 encloses a portion of the movable contact member 24, and acts as a guide for the movable contact member. The movable contact member 24 is generally tubular in shape having an opening, or orifice 36 at its upper end, and a cylindrical rod portion 37 depending from an intermediate flanged portion 38 of the contact member. A compression spring 39 is disposed between the upper end of the blast shield 25 and the flanged portion 38 of the contact member 24 to bias the member 24 downwardly. The blast shield 25 is contoured to provide a static shield for the moving contact 24 when it is in its lowermost position.

When the circuit breaker is closed, and the movable contact member 24 is in its uppermost or closed position, the upper end of the contact member 24 extends above the lower end of the depending arc horn 32; and the upper end of the contact member 24 is engaged by the contact fingers 31 to establish a circuit through the contact fingers and the contact member. Also, when the breaker is closed the movable contact member 24 is retained in its uppermost position by a projection 41 on the cross-arm 18 engaging a ring 42 secured on the rod portion 37 of the movable contact member. The lower end of the rod 37 is slidably engaged by a plurality of contact fingers 43 disposed inside the hollow projection 41 of the cross-arm 18. In this manner a circuit is established through the cross-arm 18 to connect the two interrupter units 16 in series-circuit relation. The two interrupter units 16 are of similar construction.

The circuit breaker tank 10 preferably contains an interrupting gas, such as sulfur hexafluoride (SF_6) gas. The gas in the pressure reservoir 12 is maintained at a relatively high pressure, for example 220 p.s.i.g. by a compressor (not shown), which may be utilized to compress gas taken from the tank 10 and stored in the reservoir 12 at the high pressure.

As shown in FIG. 2, a blast valve 45 is disposed in the valve seat 15 at the lower end of the blast tube 14. The valve 45 may be of the type described in the afore-

said Patent 3,284,602. The valve is biased downwardly to its closed position by a spring (not shown), and is actuated upwardly by a lever 46 having a roller 47 thereon, which engages the lower end of a stem 48 on the valve 45. The lever 46 and the cross-arm 18 are operated by a mechanism, which may be of the type described in the aforesaid Patent 3,284,602. The mechanism is so constructed that the lever 46 is raised to open the blast valve 45 when the cross-arm 18 is lowered to open the contact members 24 of the circuit interrupters.

As shown by the arrows in FIG. 3, when the blast valve 45 is open, compressed gas flows through an opening 49 in the valve seat 15, the tube 29, and openings 51 in the support 34 of the fixed contact assembly 23 into the area 52 inside the flow director 33. As previously explained, the flow director is contoured, as at 33a, to give a converging flow of gas toward the orifice 36 in the tubular movable contact member 24 while the orifice is above the venacontracta 40 of the flow director. The downward or opening movement of the contact member 24 by the compression spring 39 is stopped by the portion 38 of the contact member 24 engaging the base 22 of the interrupter. Thus, a fixed gap is maintained between the upper end of the contact member 24, which extends above the top of the blast shield 25, and the lower end of the arc horn 32, as shown in FIG. 3.

In order to avoid clogging of the arc products and the gas, a side dumping exit 53 is provided between the upper end of the movable contact member 24 and the lower end of the flow director 33. This side exit 53 is provided to permit an escape of the thermally-expanding gas, which occurs as the instantaneous magnitude of the current is passing through its higher values. As the current approaches zero, the arc is then swept into the metallic orifice 36 and is interrupted. Gas flowing through the tubular movable contact 24 is allowed to escape radially through slots 54 provided for this purpose, and also axially through openings 55 provided in the portion 38 of the movable contact. The gas is permitted to escape from the blast shield 25 through slots 56 in the shield.

The insert 35 of the flow director 33 is contoured, as at 33b, to provide diverging downstream flow when the contact 24 is below the vena-contracta 40 of the flow director 33. The rate of divergence and the minimum annular area between the moving contact and the flow director would be a function of the maximum current to be interrupted and the inside diameter of the hollow moving contact. For optimum performance the ratio between annular area and contact area can be determined empirically. Relative sizes of the discharge areas in interrupters 16 has a marked improvement in interrupting performance, as illustrated in FIGS. 4 and 5. The area A_1 of the orifice end of the movable contact member 24 equals approximately twice the area A_2 between the movable contact member 24 and the constricted end 40 of the flow director 33 when the movable contact member is in its open position as shown in FIGS. 4 and 5. Also, the area A_3 between the arc horn 32 and the constricted end 40 of the flow director is greater than or equals the area A_1 of the orifice end 36 of the movable contact member plus the area A_2 between the movable contact member 24 and the constricted end 40 of the flow director when the movable contact member is in its open position.

As explained in the aforesaid Patent 3,160,726, fixing the arc length or contact separation at a predetermined maximum reduces the amount of arc products and thermal expansion of the gas. Furthermore, the provision of the side dumping exit 53 prevents clogging of the arc products and the gas in the interrupter, thereby enabling the interrupter 16 to interrupt higher values of current. Thus, the interrupting rating of a circuit breaker may be increased without increasing the size of the breaker.

The side dumping action provides for continuous gas flow upstream, preventing accumulation of hot gases and

arc products upstream of the vena-contracta 40 of the flow director. Any relief device located upstream of the flow director would only encourage the accumulation of the hot arc gases in this area to the detriment of successful arc interruption.

As shown in FIG. 3, the cross-arm 18 continues to travel downwardly after the downward movement of the contact member 24 has stopped. In order to avoid arcing between the cross-arm and the movable contact member, the contact fingers 43, which are attached to the cross-arm 18, slide along the lower part of the rod portion 37 of the movable contact member 24. The contact between the fingers 43 and the rod 37 is maintained for a predetermined time interval to permit the interruption of the circuit by the interrupter. Additional travel of the cross-arm 18 provides an isolation gap 57 between the cross-arm and the rod portion 37 of the movable contact 24, as shown in FIG. 3.

The improved performance of the present interrupter is illustrated by the curves in FIG. 6. Curves 1 and 2 show results obtained with prior interrupters having nozzles or orifices of two different sizes. Curve 4 shows the performance of the interrupter 16 shown in FIG. 4, and curve 5 is for an interrupter having the modified arc horn 32' with a tip 58 on its end, as shown in FIG. 5. The best interrupting performance was obtained with the structure shown in FIG. 4. Both of the present structures interrupted higher currents than the prior structures, one of which had a nozzle or orifice with a larger diameter than the present interrupters.

From the foregoing description it is apparent that the invention provides for increasing the interrupting capacity of a compressed-gas circuit breaker without increasing the size of the interrupting units 16 of the breaker. Furthermore, isolating gaps 57 are provided between the movable contact members of the interrupters and the cross-arm which actuates the movable contact members, without permitting arcing to take place between the cross-arm and the movable contact members.

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 interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a compressed-gas circuit interrupter, in combination, a fixed contact assembly including an arc horn, a flow director surrounding and spaced from the fixed contact assembly, said flow director having a constricted opening (40) at one end, a generally tubular contact member having an orifice (36) at one end and movable between a closed position and an open position, said movable contact member engaging the fixed contact assembly when in its closed position and at least partially encompassing said arc horn, the constricted end of said flow director being spaced from the orifice end of the movable contact member when in its open position to provide a side exit (53) for gas flow between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

2. The circuit interrupter defined in claim 1, wherein the area (A_3) between the arc horn and the constricted end of the flow director is greater than or equals the area (A_1) of the orifice end of the movable contact member plus the area (A_2) between the movable contact member and the constricted end of the flow director when the movable contact member is in its open position.

3. In a compressed-gas circuit interrupter, in combination, a fixed contact assembly including an arc horn, 75

a flow director surrounding the fixed contact assembly, a generally tubular contact member having an orifice at its upper end and movable between an uppermost position and a lowermost position, said movable contact member engaging the fixed contact assembly when in its uppermost position, said flow director being contoured (33a) to give a converging flow of gas toward the orifice in the movable contact member, and the lower end of said flow director being spaced from the upper end of the movable contact member when in its lowermost position to provide a side exit (53) for gas between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

4. In a compressed-gas circuit interrupter, in combination, a fixed contact assembly including a plurality of contact fingers surrounding and arc horn, a generally cylindrical flow director surrounding the fixed contact assembly, a generally tubular contact member having an orifice at its upper end and movable between an uppermost position and a lowermost position, said movable contact member being engaged by said contact fingers when in its uppermost position, said flow director being contoured (33a) to give a converging flow of gas toward the orifice (36) in the movable contact member, the lower end of said flow director being disposed between the lower end of the arc horn and the upper end of the movable contact member when in its lowermost position to provide a side exit (53) for gas between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

5. In a compressed-gas circuit interrupter, in combination, a fixed contact assembly including a plurality of contact fingers surrounding an arc horn, a generally cylindrical flow director surrounding the fixed contact assembly, a generally tubular contact member having an orifice at its upper end and movable between an uppermost position and a lowermost position, a blast shield surrounding a portion of the movable contact member, said movable contact member being engaged by said contact fingers when in its uppermost position, the upper end of the movable contact member extending through said shield when in its lowermost position, said flow director being contoured (33a) to give a converging flow of gas toward the orifice (36) in the movable contact member, the lower end of said flow director being spaced from the upper end of the movable contact member when in its lowermost position to provide a side exit (53) for gas between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

6. A compressed-gas circuit interrupter comprising an upper cover member, a lower base member, insulating means retaining said members in spaced relation, a fixed contact assembly including an arc horn depending from the cover member, a generally cylindrical flow director surrounding the fixed contact assembly, a blast shield extending upwardly from the base member, the upper end of said shield being spaced from the lower end of the flow director, a generally tubular contact member having an orifice at its upper end and movable in said shield between an uppermost position and a lowermost position, said movable contact member engaging the fixed contact assembly when in its uppermost position and spaced from said arc horn when in its lowermost posi-

tion, the lower end of the flow director being spaced from the upper end of the movable contact member when in its lowermost position to provide a side exit (53) for gas between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

7. A compressed-gas circuit interrupter, comprising an upper cover member, a lower base member, insulating means retaining said members in spaced relation, a fixed contact assembly including an arc horn depending from the cover member, a generally cylindrical flow director surrounding the fixed contact assembly, a blast shield extending upwardly from the base member, the upper end of said shield being spaced from the lower end of the flow director, a generally tubular contact member having an orifice at its upper end and movable in said shield between an uppermost position and a lowermost position, said movable contact member engaging the fixed contact assembly when in its uppermost position, and spaced from said arc horn when in its lowermost position, the lower end of the flow director being below the lower end of the arc horn and above the upper end of the movable contact member when in its lowermost position to provide a side exit for gas between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

8. A compressed-gas circuit interrupter comprising an upper cover member, a lower base member, insulating means retaining said members in spaced relation, a fixed contact assembly including an arc horn depending from the cover member, a generally cylindrical flow director surrounding the fixed contact assembly, a blast shield extending upwardly from the base member, the upper end of said shield being spaced from the lower end of the flow director, a generally tubular contact member having an orifice at its upper end and movable in said shield between an uppermost position and a lowermost position, said movable contact member engaging the fixed contact assembly when in its uppermost position, and spaced from said arc horn when in its lowermost position, the upper end of the movable contact member being above the upper end of the shield when the movable contact member is in its lowermost position, said flow director being contoured to give a converging flow of gas toward the orifice in the movable contact member, the lower end of the flow director being spaced from the upper end of the movable contact member when in its lowermost position to provide a side exit for gas between the flow director and the movable contact member, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

9. A compressed-gas circuit interrupter comprising a fixed contact member, a generally cylindrical flow director surrounding the fixed contact member and having a contracted opening at one end, a generally tubular contact member having an orifice at one end and movable between a closed position and an open position, said movable contact member extending through said contracted opening and engaging the fixed contact member in the closed position, the end of the flow director having the contracted opening being spaced from the orifice end of the movable contact member when in the open position to provide a side exit for gas between the flow director and the movable contact member, said flow director being contoured (33a) to give a converging flow

of gas toward the orifice when the orifice end of the movable contact member is within the contracted opening, said flow director also being contoured (33b) to give a diverging flow of gas when the orifice end of the movable contact member is spaced from the flow director, and the area (A_1) of the orifice end of the movable contact member equalling approximately twice the area (A_2) between the movable contact member and the constricted end (40) of the flow director when the movable contact member is in its open position.

10. A compressed-gas circuit breaker comprising two-spaced interrupters, each interrupter including a fixed contact assembly and a movable contact member having an orifice at its upper end and a flow director with a restriction contoured to give a flow of gas toward the orifice, a bridging cross-arm for raising the movable contact members into engagement with the fixed contact assemblies, spring means for lowering the movable contact members out of engagement with the fixed contact assemblies when the cross-arm is lowered, means for stopping the movable contact members with their upper ends spaced from the lower ends of the flow directors, and said cross-arm slidably engaging the lower ends of the movable contact members prior to separation of the cross-arm from the movable contact members by downward movement of the cross-arm, and the area (A_1) of the orifice end of the movable contact members equalling approximately twice the area (A_2) between the movable contact members and the constricted end (40) of the flow directors when the movable contact members are in their open position.

11. A compressed-gas circuit breaker comprising two spaced interrupters, each interrupter including a fixed contact assembly and a movable contact member having an orifice at its upper end and a flow director with a restriction contoured to give a flow of gas toward the orifice, a bridging cross-arm for raising the movable contact members into engagement with the fixed contact assemblies, spring means for lowering the movable contact members out of engagement with the fixed contact assemblies when the cross-arm is lowered, means for stopping the movable contact members with their upper ends spaced from the lower ends of the flow directors, contact fingers on the cross-arm slidably engaging the lower ends of the movable contact members after the movable contact members are stopped, said cross-arm being separated from the movable contact members when the cross-arm and the movable contact members are in their lowermost positions to provide isolating gaps between the movable contact members and the cross-arm, and the area (A_1) of the orifice end of the movable contact members equalling approximately twice the area (A_2) between the movable contact members and the constricted end (40) of the flow directors when the movable contact members are in their open position.

12. In a compressed-gas circuit interrupter, in combination, a fixed contact assembly including a plurality of contact fingers, a generally cylindrical flow director surrounding the fixed contact assembly and having a contracted opening at one end, a generally tubular contact member having an orifice at one end and movable between a closed position and an open position, a blast shield surrounding a portion of the movable contact member, said movable contact member being engaged by said contact fingers when in its closed position, the orifice end of the movable contact member extending through said shield when in its open position, the end of the flow director having the contracted opening being spaced from the orifice end of the movable contact member when in the open position to provide a side exit for gas between the flow director and the movable contact member, said flow director being contoured (33a) to give a converging flow of gas toward the orifice in the movable contact member when the orifice is within

the contracted opening, said flow director also being con-
 toured (33b) to give a diverging flow of gas when the
 orifice is spaced from the flow director, and the area
 (A₁) of the orifice end of the movable contact mem-
 bers equalling approximately twice the area (A₂) be-
 5 tween the movable contact members and the constricted
 end (40) of the flow directors when the movable con-
 tact members are in their open position.

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ROBERT S. MACON, *Primary Examiner.*