United States Patent [19]
Milianowicz

[11] 3,814,883
[45] June 4, 1974

[54] GAS-BLAST CIRCUIT INTERRUPTER WITH INSULATING ARC SHIELD

[75] Inventor: Stanislaw A. Milianowicz, Monroeville, Pa.

[73] Assignee: Westinghouse Electric Corporation, Pittsburgh, Pa.

[22] Filed: Nov. 3, 1972

[21] Appl. No.: 303,579

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 51,709, July 1, 1970, abandoned.

[52] U.S. Cl. .... 200/148 G, 200/150 G
[51] Int. Cl. H01h 33/70
[58] Field of Search......... 200/148 G, 150 G, 148 R

[56] References Cited

UNITED STATES PATENTS

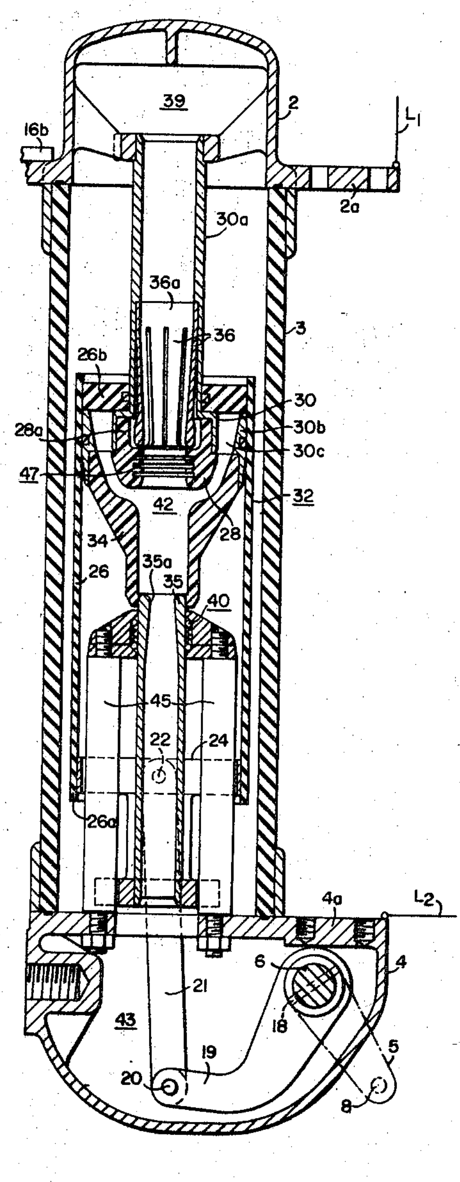
2,442,010	5/1948	Leeds et al.	200/150 G
3,095,490	6/1963	Cromer et al.	200/148 A
3,291,948	12/1966	Telford	200/148 A
3,555,225	1/1971	Saffold et al.	200/148 A

Primary Examiner—Robert S. Macon
Attorney, Agent, or Firm—W. R. Crout

[57] ABSTRACT

A gas-blast circuit interrupter has a pair of separable contacts, at least one of which is movable, and a stationary insulating arc shield is disposed immediately adjacent the contacts, and encompasses a critical portion of the initial travel of the cooperable movable contact, so that the space vacated by the movable contact, during initial opening travel, does not communicate with the pressurized space, which contains the interrupting gas to be used later in the interruption of the established arc. Following withdrawal of the movable contact from the insulating arc shield, of at least one inch in length, it is exposed to a radially inward flow of cool gas supplied by suitable piston means, or another high-pressure source, if desired.

10 Claims, 6 Drawing Figures



PATENTED JUN 4 1974

3,814,883

SHEET 1 OF 3

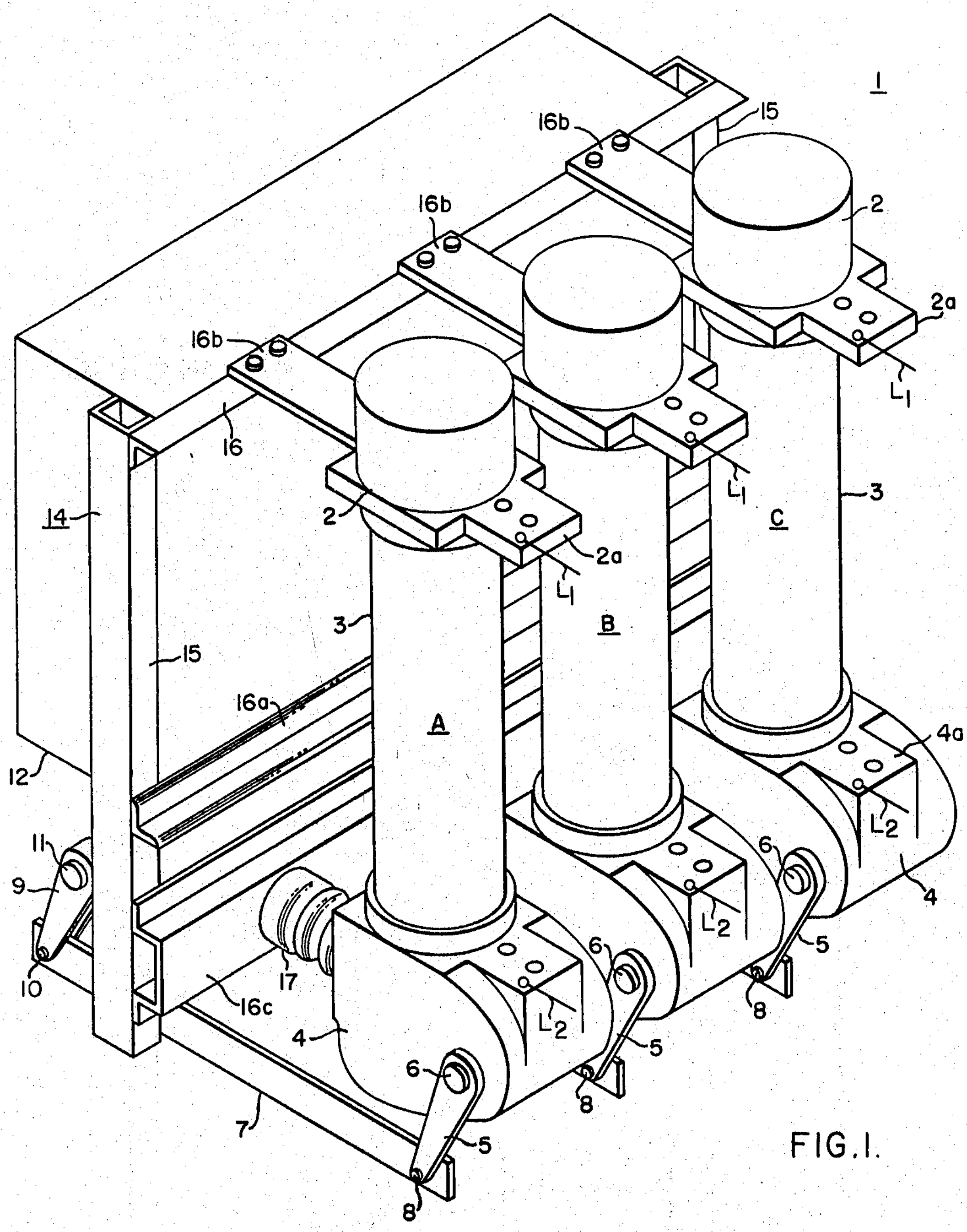


FIG. 1.

WITNESSES

Edwin E. Bassler

James F. Young

INVENTOR

Stanislaw A. Milianowicz

BY

Willard R. Crout

ATTORNEY

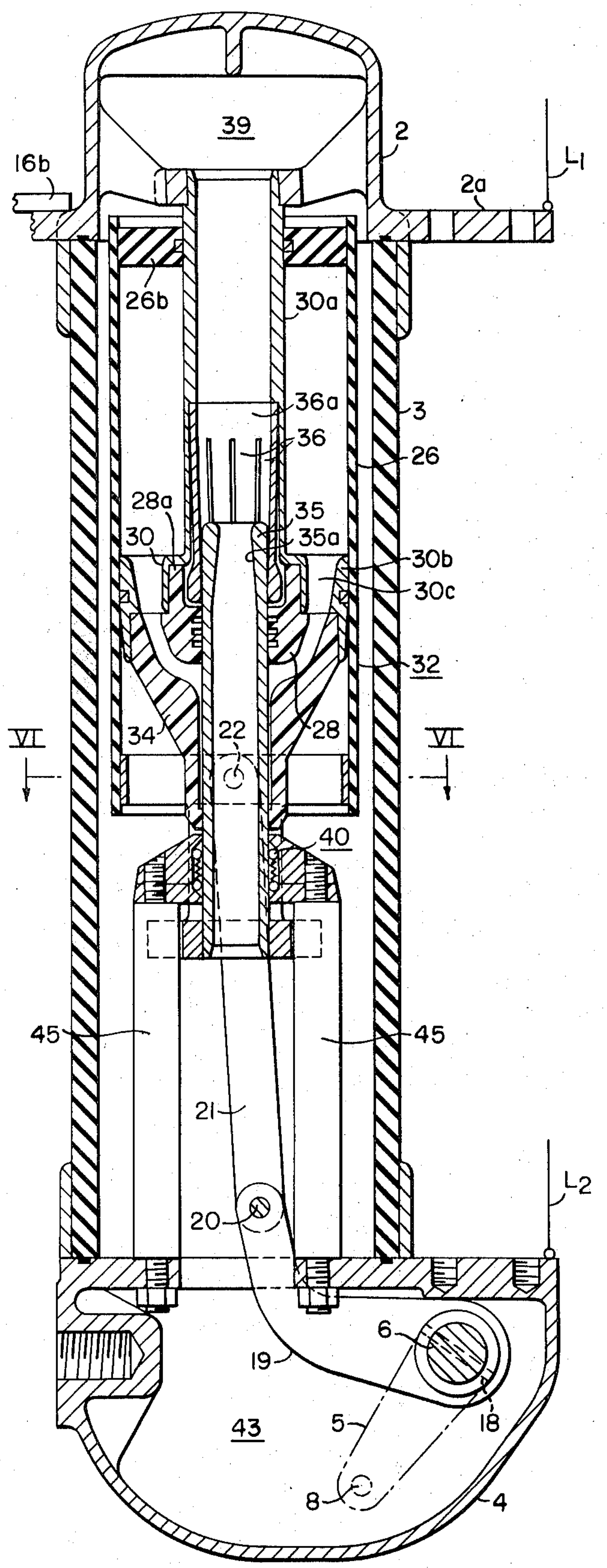


FIG. 2.

CLOSED

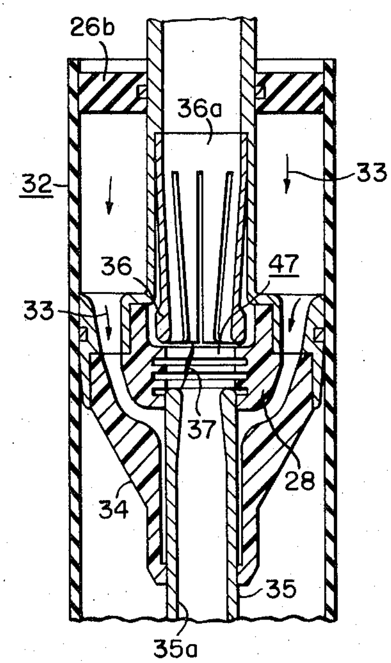


FIG. 3.

PATENTED JUN 4 1974 3,814,883

SHEET 3 OF 3

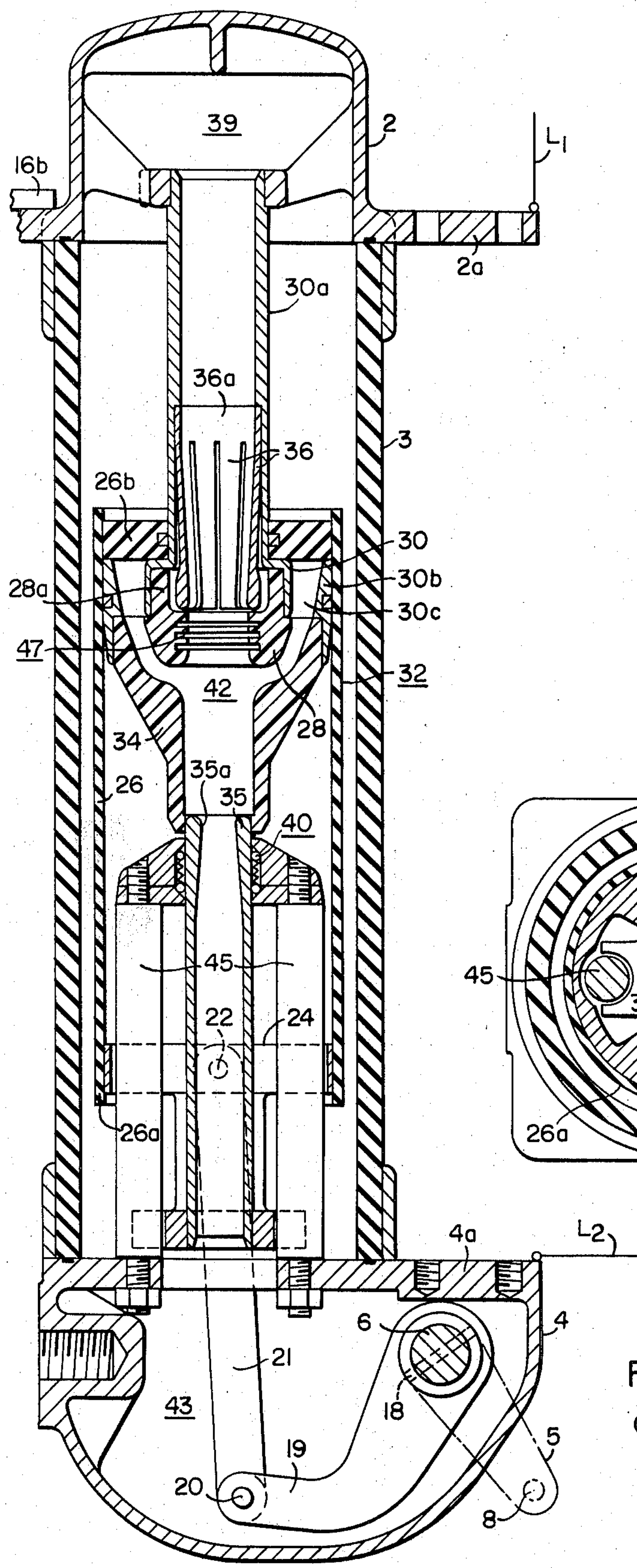


FIG.5.

OPEN

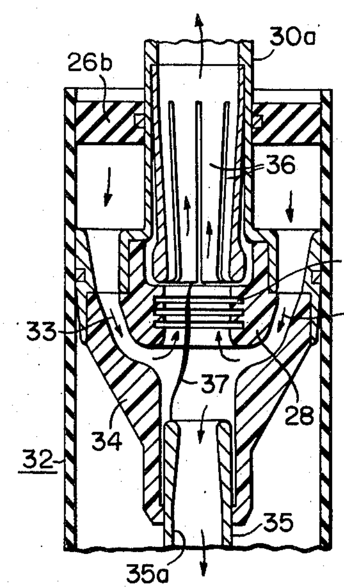


FIG.4.

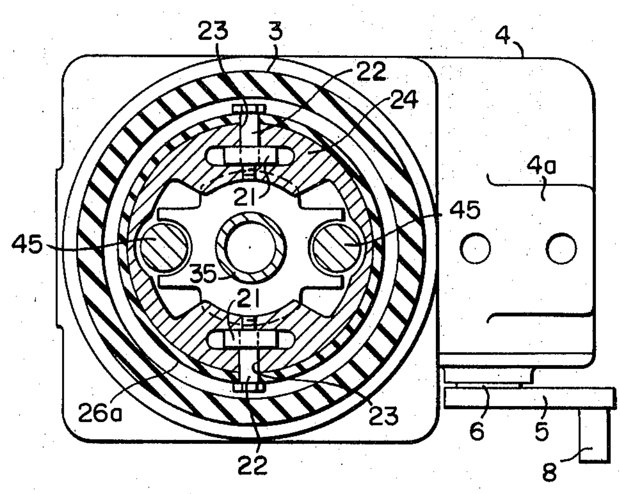


FIG.6.

GAS-BLAST CIRCUIT INTERRUPTER WITH INSULATING ARC SHIELD

CROSS-REFERENCES TO RELATED APPLICATIONS

This patent application is a continuation-in-part of my patent application filed July 1, 1970, Ser. No. 51,709 and now abandoned.

Applicant is not aware of any related application, which is pertinent to the present invention. Reference, however, may be made to U.S. patent application filed July 31, 1967, Ser. No. 657,122, by Russell E. Frink and Stanislaw A. Milianowicz, entitled "Delayed-Blast Fluid-Flow Circuit Interrupter," which generally outlines gas-blast circuit interrupters of the type herein considered.

BACKGROUND OF THE INVENTION

It is an established fact that in order to interrupt large short-circuit currents at a significant value of transient recovery voltage, there must be a gap of considerable length between the arcing electrodes. The interruption of power arcs does not readily take place with very short electrode separations. The removal of arc products from the vicinity of the arcing electrodes by providing a flow of cool gas through the arcing region is at present the major requirement in a successful type of fluid-flow circuit interrupter.

The contamination of the arc chamber with the arc products during the time when the contact separation is insufficient to attempt interruption, has been accepted, heretofore, as a natural consequence of the fact that the contacts separate, and take time to move apart to a distance where the interruption can occur.

Indeed, U.S. Pat. No. 2,442,010 by Winthrop M. Leeds and Benjamin P. Baker, describes an interrupter, which requires a plurality of axially-disposed chambers separated by insulating plates, which are required to effect a current interruption. FIG. 2 in U.S. Pat. No. 2,442,010 shows clearly that the arc, and consequently the arc products, have free access to the interrupting fluid for about 50 percent of the movable contact travel after the contacts separate. In contrast to this, with reference to the interrupter described in my invention, arc products have access to the interrupting gas for a distance of only 12.5 percent of movable contact travel after contact separation, this construction being accomplished by only one arc shield.

Reference also may be had to U.S. Patent Application filed July 31, 1967, Ser. No. 657,122 by Russell E. Frink and Stanislaw A. Milianowicz, entitled "Delayed-Blast Fluid-Flow Circuit Interrupter," and assigned to the assignee of the instant application, for a general description of a fluid-flow circuit interrupter in which puffer means is utilized to supply a blast of gas, such as sulfur hexafluoride (SF_6) gas, toward an established arc to effect the latter's extinction. Additional reference may be made to U.S. patent application filed Sept. 25, 1967 Ser. No. 670,168 by Thomas F. Saffold and Russell E. Frink entitled "Fluid-Flow Circuit Interrupter with Arc-Assisted Piston Action," and similarly assigned to the same assignee, for a further description of an SF_6 fluid-flow type of circuit interrupter.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, there is supplied a pair of separable cooperable contacts, both of which must be vented into the general gas enclosure. An insulating arcing shield encompasses a portion of the stationary contact structure, and extends axially at least one inch in the direction of opening travel of the movable contact, so that for at least one inch of initial arcing distance, the arc products are not allowed to enter the fluid-forcing chamber, which contains clean and cool gas. This is very important and has been proven by trying shorter lengths of the arcing shield. For example using a one-half inch long arcing shield, the interrupter could interrupt only about half the valve of current, as compared with the 1-⅛ inches long arcing shield which was used in the experiment, which latter dimension I prefer. However, I believe that this performance is not a discontinuous function, and that a fair degree of improvement can be obtained with a shield which is one inch long. Consequently, the shield should be at least one inch in length. During this initial opening travel of the movable contact, fluid-flow means, such as puffer means are operable, being mechanically connected, for example, to the movable contact, so as to cause a compression of an arc-extinguishing gas, which is injected laterally inwardly into the arc column only following the withdrawal of the movable arcing contact out of the confines of the encompassing insulating arc shield.

It will be noticed that when the movable contact is within the confines of the arcing shield there is no communication between the gas in the vicinity of the arc and any part of gas within the arc chamber and piston cylinder system, except that which occurs from clearances between parts resulting from required tolerances. At this stage of the current-interrupting operation, the arc products must be vented to the general gas enclosure unlike the interrupter described in the U.S. Pat. No. 2,442,010 by W. M. Leeds and B. P. Baker, where the arc products are partly injected into their arc control device in order to assist the interrupting of the current.

This injection of cool gas laterally inwardly into the arc, after it has attained an initial length, causes rapid arc interruption.

It should be stated that another important feature of my improved circuit interrupter is the effect of the axial length of the arc shield on the amount of pre-compression of the gas in the piston-cylinder system where this method of gas-forcing means is used. Using a 1-⅛ inches long arc shield, and SF_6 gas in the interrupter housing at 75 PSIG ambient pressure, a pressure differential of 60 PSI is produced between the cool gas in the piston-cylinder space and the general gas enclosure, before the cool gas is allowed to enter the arc region. Further to the importance of the value of the pressure differential, it was established by means of many experimental trails that the venting areas, and the ratio of piston area to the total venting area, were critically important.

The total venting area for both contacts, which allows for the high performance of this interrupter, lies between the limits of 1.4 sq. in. to 1.7 sq. in. and the ratio of piston area of the total venting area is contained in the range of numbers between 9 and 12. The preferred piston area was, for example, 15.7 sq. inches when a piston is used.

My preferred limits for the length of the shielding nozzle is from one to two inches, and my preferred range of nozzle length is from 1-⅛ to 1-⅝ inches.

To date, the interrupter described in this patent application, and used in a three-pole circuit breaker on a three-phase circuit has successfully completed current interrupting tests to the American National Standards Institute requirements for 63,000 amperes at 15 KV rating. This fact permits the capability to build 15 KV, 1,500 MVA switchgear equipment in a standard 36 inch switchgear cubicle, using circuit breakers with no exhaust of any kind. There is none such available in the entire world, to my knowledge.

To date, a transient recovery voltage of 1,100 volts per microsecond has been obtained at 63,000 amperes interruption, and a current of 89,000 amperes has been successfully interrupted.

The above results show that a major breakthrough in the art of power arc interruption has occurred.

Indeed, it is the unprecedented high level performance of this interrupter that supports the claim to the novelty of this invention, and prior to this no other device, however superficially similar, could produce such a high performance.

Those skilled in the art may also recognize the fact that the high performance of this interrupter may be due not to any single feature of this invention, but to the combination of many features described herein.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a perspective view of a three-pole circuit interrupter embodying the principles of the present invention;

FIG. 2 is a considerably enlarged longitudinal sectional view taken through one of the pole-units of FIG. 1, the contact structure being illustrated in the closed-circuit position;

FIGS. 3 and 4 fragmentarily illustrate the separation of the contact structure at different distances;

FIG. 5 illustrates the fully-open circuit position of the movable contact structure; and,

FIG. 6 is a sectional view taken substantially along the line VI—VI of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral **1** generally designates a three-pole fluid-blast circuit interrupter comprising three spaced pole assemblies A, B and C. As will be apparent from FIG. **1**, each pole assembly includes, generally, an upper end plate **2**, a generally upstanding cylindrical housing **3**, and a lower end plate and mechanism housing **4**. Disposed exteriorly of the mechanism housing **4** is a drive-crank **5** affixed to an operating shaft **6**, and a generally horizontally reciprocally movable insulating operating rod **7** is pivotally secured to the external operating crank **5**, as at **8**, and is connected to a drive crank **9** through a pivotal connection **10**. The three drive cranks **9**, only one of which is shown, are affixed and rotatable with an operating drive shaft **11**, which is connected to a suitable mechanism **12**, which constitutes no part of the present invention, and may be of the type set forth in U.S. Pat. No. 3,183,332 issued May 11, 1965 to Russell E. Frink and Paul Olsson, and assigned to the assignee of the present invention.

It will be apparent from FIG. **1** that a suitable supporting grounded framework **14** is utilized comprising vertical channel members **15** with interbracing structural steel members **16, 16***a* having horizontally extending insulating support straps **16***b* secured thereto, which assist in supporting the interrupting assemblies. Additionally, lower insulator supports **17** may be employed extending generally horizontally from a channel support member **16***c*, the latter being affixed to the vertical support channels **15**.

FIGS. **2** and **3** more clearly illustrate the internal construction of each of the interrupting assemblies. With reference to FIG. **2**, it will be noted that there is provided the cylindrical housing **3** of a suitable insulating material having at one end thereof the end closure plate **2** having a line terminal connection **2***a* constituting an integral part thereof. At the opposite end of the tubular housing **3** is the operating casting **4**, within which extends the rotatable operating shaft **6** having affixed thereto, as by a key pin **18**, an internally-disposed operating crank **19**, the latter being pivotally connected, as at **20**, to a pair of metallic operating links **21**. The upper ends of the operating links **21**, as viewed in FIGS. **2**, **3** and **5**, are pivotally connected to a pivot pin **22**, the latter extending through apertures **23** provided in a spider-like actuator **24**, which is fastened, to the end **26**a of a movable operating cylinder **26** having a closed end plate portion **26***b*.

It will be observed that an insulating arc shield **28** has an axially-extending flange portion **28***a*, which is interposed within a cup-shaped stationary contact housing **30**, which is elongated, as at **30***a*, to provide a guiding support for the movable cylinder end plate **26***b* of the puffer assembly, generally designated by the reference numeral **32**. Items **30** and **30***b*, comprise the stationary piston which is supported by tubular guide **30***a*. Item **30***c* is a multiple opening in piston **30**/**30***b* which admits gas to the insulating arc chamber **42**. Preferably, the shield **28** extends for 1-⅛ inches axially from the stationary contact.

Thus, during the opening operation of the interrupter, the operating linkage **21**, pivotally connected to the movable puffer assembly **32**, causes downward gas-compressing motion of the movable cylinder end plate **26***b* over the tubular guide support **30***a*, and causes gas to flow in a direction indicated by the arrows **33** into the insulating stationary arc chamber **34**.

It will be observed that the movable contact **35** is vented, having a vent opening **35***a* therethrough, and cooperates with a plurality of flexible stationary contact fingers **36**, which constitutes generally a slotted tubular member **36***a* inserted into the cylinder guide support **30***a*.

Thus, during the initial portion of the opening operation, the initially-established arc **37** is confined by the corrugated insulating arc shield **28** for at least 1-⅛ inches in the test interrupter considered, and is protected from the lateral blasting effect of relatively cool gas caused by compressing motion of the movable piston ring **26***b*, in the test interrupter, thus causing less energy to be released at the arc than if it had not been so protected by the shield.

However, when the movable tubular vented contact **35** has approached the position indicated in FIG. **4**, it is subjected to a lateral inflowing action of cool un-ionized gas, compressed by the downward opening motion of the piston ring 26*b*, and heretofore protected from arc by the arc shield **28**, so that rapid arc extinction at this time occurs. It will be noted that the compressed gas, directed laterally into the arc stream **37**, flows in opposite directions through the movable tubular vented contact **35** and also through the hollow vented guide support **30*a*** into the exhaust chamber **39**.

Preferably, a sliding ball contact assembly **40** maintains electrical contact with the movable tubular contact **35**, and transfers the current therefrom to the lower terminal plate **4*a***, which is connected with the lower line terminal L2 of the interrupting device.

U.S. Pat. No. 3,301,986 issued Jan. 31, 1967 to Russell E. Frink and assigned to the assignee of the instant application, generally describes and claims such a ball-type sliding contact structure.

The present invention is not only applicable to sulfur-hexafluoride (SF_6) gas-type circuit breakers, either of the puffer-type, as illustrated herein, or of the dual-pressure type, as illustrated in U.S. Pat. No. 3,057,983, but also it can be applied to any other gas-flow type of circuit interrupter, such as an air-blast type of circuit breaker. The invention functions to increase the interrupting capability of the interrupter by preventing the dissipation of the interrupting qualities of the entering gas stream by a confinement of the hot arc gases during the initial arc-lengthening operation. The invention generally utilizes the arc shield **28**, which contains the electrical arc **37** for at least one inch distance along the moving contact path immediately following the contact-part vicinity. The arc shield **28** is preferably made of arc-resistant insulating material, such as polytetrafluoroethylene, commonly sold under the trade name "Teflon" by the E. I. Dupont Company.

It is established fact that in order to interrupt short-circuit currents at a significant value of transient recovery voltage, that there must be a gap of considerable distance between the arcing electrodes. This invention in a test interrupter as described heretofore used 1-⅛ inches as this dimension for the gap distance between the arcing electrodes in this particular test interrupter.

The removal of arc products from the vicinity of the arcing electrodes **35, 36** by providing a flow of cool gas through the arcing region is at present the major requirement in a successful type of fluid-flow circuit interrupter.

The contamination of the arc chamber **42** with the arc products during the time when the contact separation is insufficient to attempt the interruption, has been accepted heretofore as a natural consequence of the fact that the contacts separate, and take time to move apart to a distance where the interruption can occur. In order not to contaminate the arc chamber **42** with arc products during the time when no interruption is possible, the arc shield **28**, as used in the present invention, is employed to contain the arc **37**, thereby allowing the arc products to go to the ambient gas enclosure **39, 43** but preventing them from entering the arc chamber **42**. When the moving contact **35** does emerge from the arc shield **28**, as shown in FIG. 3, the distance between the contacts **35, 36** is sufficient to allow interruption to occur, and the gas in the arc chamber **42** is clean, which it would not be, had there been no arc shield **28**, or had the arc shield been made of insufficient length.

The presence of the arc shield **28** increases the capability of an interrupter considerably. Experimental tests of the first prototype of the disclosed gas-blast circuit interrupter have shown that for a 13.2 KV device, the fault current interrupted as 70,000 amperes at a transient recovery voltage of 650 volts per microsecond. This value was reached in a series of 10 KA steps. There were no failures, and the maximum performance of this interrupter is yet to be established. With a particular device under tests, it was only 6 inches in inside diameter, and 30 inches long, and only required 250 foot pounds per operation. As a result, it will be realized that a major step in the art of power circuit interruption by gas flow has been taken by the use of the arc shield **28** of the present invention of a critical minimum length. Examination of the test results indicated that the arc column **37** itself was being considerably influenced.

During the closing operation of the device, the rotation of the operating crank **19** causes, through the linkage **21**, closing inward travel of the movable tubular vented contact **35** through the arcing chamber **42** and into the confines of the corrugated arc shield **28**, and into engagement with the flexible stationary contact fingers **36**. FIG. 2 represents the device in the closed-circuit position in which the current passes therethrough from the terminal plate **2*a***, through the tubular guide **30*a***, stationary contact fingers **36**, movable tubular vented contact **35**, roller sliding contact assembly **40**, stationary conducting post **45** to the lower crank housing **4** and to the line terminal L2.

From the foregoing description it will be apparent there there has been illustrated and described an improved gas-blast circuit interrupter, in which remarkable interrupting performance has been achieved by the use of an insulating arcing shield **28**, which confines at least one inch of the initial travel after contact separation of the movable tubular vented contact **35**. As a result, cool inward gas flow is provided, uninfluenced by the hot gases generated within the initial arcing region **47**.

In the preferred execution of my invention I incorporate a stationary and movable venting contact member. However, as will be apparent to one skilled in the art, performance of the device will not be altered if the stationary contact is made to move, and the moving contact is held stationary; or furthermore, if both contacts are made to move. The only requirement in this respect is relative motion of the two contacts. Also, in FIG. 5, which shows the interrupter in the open position, contact **35** is still in contact with the nozzle **34**. However, in some cases it may be desirable to slightly increase the relative travel of the contacts so that in the fully open position the contact **35** is relatively completely withdrawn from the nozzle **34**.

Although there has been illustrated and described a specific structure, 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 gas-blast circuit interrupter including, in combination:

a. separable cooperable tubular venting contacts at least one of which is movable,

b. nozzle-like interrupting structure comprising a relatively stationary annular imperforate arc shield (28) extending at least one inch along the line of movement of said one movable venting contact;

c. operating means operable to withdraw the movable venting contact out of said imperforate arc shield (28);

d. said annular arc shield (28) encompassing a minimum portion of at least one inch of the initial arcing travel of said one movable tubular venting contact, thereby forcing the drawn arc to assume a minimum length of at least one inch prior to the injection thereto of gas; and,

e. fluid-flow producing means to inject relatively cool fluid under pressure laterally into the arc stream after said one movable venting contact has withdrawn from the imperforate arc shield (28).

2. The gas-blast circuit interrupter of claim **1**, wherein the inner surface of the stationary imperforate arc shield (**28**) is corrugated.

3. The combination according to claim **1**, wherein means defines an outer annular second insulating nozzle member (**34**) spaced outwardly from said inner first nozzle member to thereby define an intervening substantially annular inlet passage permitting gas to flow radially inwardly at a fixed level at times toward the arc.

4. The gas-blast circuit interrupter of claim **1**, wherein piston means provides the gas flow.

5. A gas-blast circuit interrupter including a pair of cooperable tubular venting contacts at least one of which is movable, nozzle-like interrupting structure comprising a relatively stationary first annular imperforate arc shield (**28**) extending at least one inch along the line of movement of the movable venting contact, means defining an outer annular second insulating nozzle member (**34**) spaced outwardly from said inner first nozzle member to thereby define an intervening substantially annular inlet passage permitting gas to flow radially inwardly at a fixed level at all times toward the arc, said annular first arc shield (**28**) encompassing said minimum portion of at least one inch of the initial arcing travel of the movable tubular venting contact, thereby forcing the drawn arc to assume a minimum length of at least one inch prior to the injection thereto of gas through said inlet passage, whereby to confine the hot arc gases of the initially-drawn portion of the established arc of at least 1 inch while simulataneously permitting a venting therefrom through both of said tubular venting separable contacts, operating means to withdraw the movable tubular venting contact out of said relatively stationary first arc shield (**28**) thereby opening up said inlet passage, and gas-flow-producing means for forcing relatively cool gas under pressure laterally into the arc stream through said relatively stationary inlet passage at said fixed level after the movable tubular venting contact has withdrawn from the first arcing shield (**28**) and the movable tubular venting contact movable along said arc passage formed in the second nozzle member with relatively slight clearance so that the major proportion of the gas flow directed through the arc passage in the direction of opening movement of the movable contact passes interiorly of the movable tubular venting contact for venting and arc-extinguishing purposes, and said movable tubular venting contact pulling free of said relatively stationary inlet passage and retracting away therefrom into the arc passage of the insulating second nozzle member (**34**).

6. The combination according to claim **5**, wherein the inner surface of the annular imperforate arc shield (**28**) is corrugated.

7. A gas-blast circuit interrupter including a first tubular venting contact and a second tubular, venting contact which are cooperable together and relatively movable with respect to each other, a nozzle-like interrupting structure comprising a first annular imperforate arc-shield (**28**) stationary with respect to said first contact and extending at least one inch along the line of relative movement between said two venting contacts, means defining an outer annular second insulating nozzle member (**34**) spaced outwardly from said inner first nozzle member and fixed with respect thereto to thereby define an intervening substantially annular inlet passage permitting gas to flow substantially radially inwardly toward the arc at a fixed level, said annular first arc shield (**28**) encompassing said minimum portion of at least 1 inch of the initial arcing travel of the relatively movable first and second contacts, thereby forcing the drawn arc to assume a minimum length of 1 inch prior to the injection thereto of gas through said inlet passage, whereby to confine the hot arc gases of the initially-drawn portion of the established arc of at least 1 inch while simultaneously permitting a venting therefrom through both of said tubular venting separable contacts, operating means to withdraw said second tubular venting contact out of said first arc shield (**28**) thereby opening up said inlet passage, and gas-flow producing means for forcing relatively cool gas under pressure laterally into the arc stream through said annular inlet passage at said fixed level after said second tubular venting contact has withdrawn out of the first arcing shield (**28**), and said second tubular venting contact being relatively movable along said arc passage formed in said second nozzle member (**34**) with relatively slight clearance so that the major proportion of the gas flow directed through the arc passage in the direction of relative opening movement of said second tubular contact member passes interiorly of the second tubular venting contact for venting and arc-extinguishing purposes, and relative motion between said second tubular venting contact and said inlet passage causing relative retracting away therefrom into the arc passage of the insulating second nozzle member (**34**).

8. A gas-blast circuit interrupter including a pair of relatively movable cooperable tubular venting contacts, at least one of which is movable separable to establish an arc, nozzle-like interrupting structure comprising a relatively stationary annular imperforate arc shield (**28**) having a length from 1 to 2 inches, at least one of said venting contacts withdrawing from said annular imperforate arc shield (**28**), means for establishing a radially inward-flowing gas-blast under pressure into the arc following withdrawal of said one venting contact out of said annular imperforate arc shield (**28**) for effecting arc extinction.

9. A gas-blast circuit interrupter including a pair of relatively movable cooperable tubular venting contacts, at least one of which is movable separable to establish an arc, nozzle-like interrupting structure comprising a relatively stationary annular imperforate arc shield (28) having a length from 1-⅛ inch to 1-⅝ inch, at least one of said venting contacts withdrawing from said annular imperforate arc shield (28), means for establishing a radially inward flowing gas-blast under pressure into the arc following withdrawal of said one venting contact out of said annular imperforate arc shield (28) for effecting arc extinction.

10. The combination according to claim **8**, wherein an additional second insulating nozzle member (**34**) is provided being spaced outwardly from said inner first nozzle member (**28**) to thereby define an intervening substantially annular inlet passage permitting the gas to flow radially inwardly at a fixed level toward the arc following withdrawal of said one contact out of the annular imperforate arc shield (**28**).

* * * * *