United States Patent

[11] 3,603,754

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[54] **CONTACT STRUCTURE FOR HIGH-VOLTAGE CIRCUIT INTERRUPTER WITH LINER COMPONENTS**
10 Claims, 8 Drawing Figs.

[52] U.S. Cl. .... 200/148 R
[51] Int. Cl. H01h 33/02
[50] Field of Search .... 200/148 R, 148 B, 148 C, 148 D, 148 G, 144

[56] References Cited
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2,447,674 8/1948 Strom et al. 200/148
2,555,898 6/1951 Paterson et al. 200/148

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ABSTRACT: A separable contact structure is provided for a high-voltage compressed-gas circuit interrupter involving at least one of the contacts being tubular to provide a gas flow therethrough, and having a liner component therein. To facilitate movement of the terminal end of the arc, a relatively thin tubular member is inserted interiorly of the hollow contact, and, by electrically connecting the same to the inner anterior end of the hollow contact, the magnetic field situation is such that the terminal end of the arc is encouraged to move axially along the relatively thin tubular liner member to thereby effect considerable elongation of the established arc, and thereby to effect the extinction of the same by a more effective gas flow condition.

As a further extension of this same concept, a cooperable tubular contact structure may be provided, through which gas also exhausts, and a similar relatively thin tubular liner member may also be associated therewith to act in a similar manner.

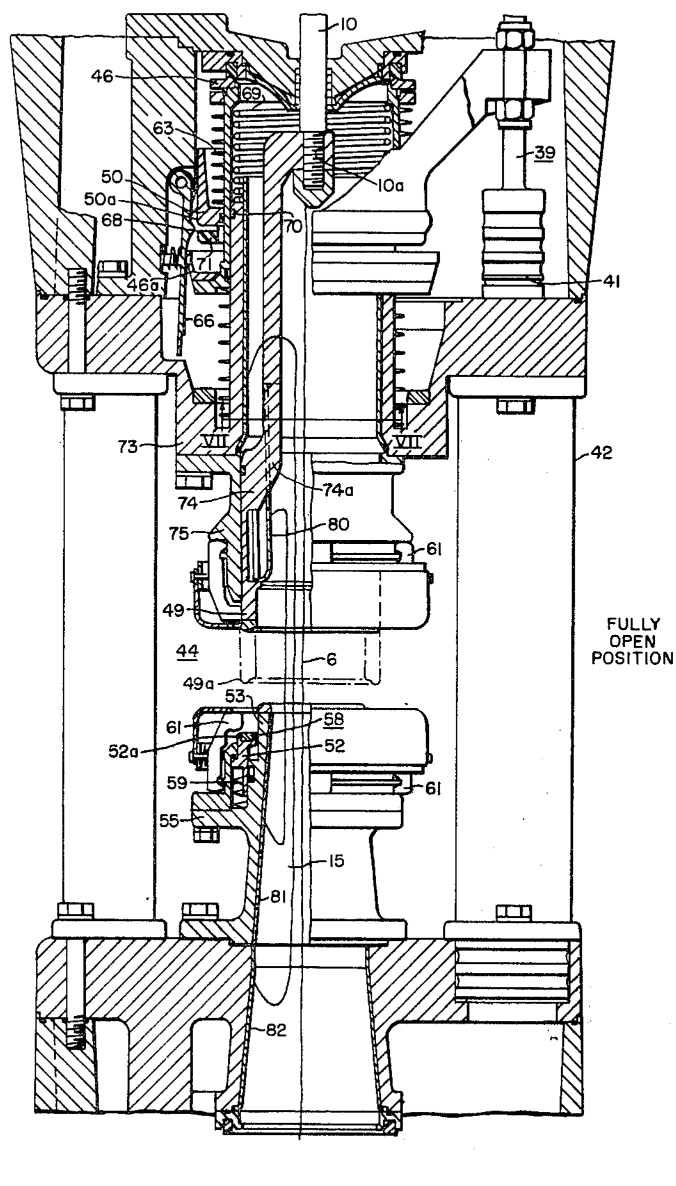


Fig.2

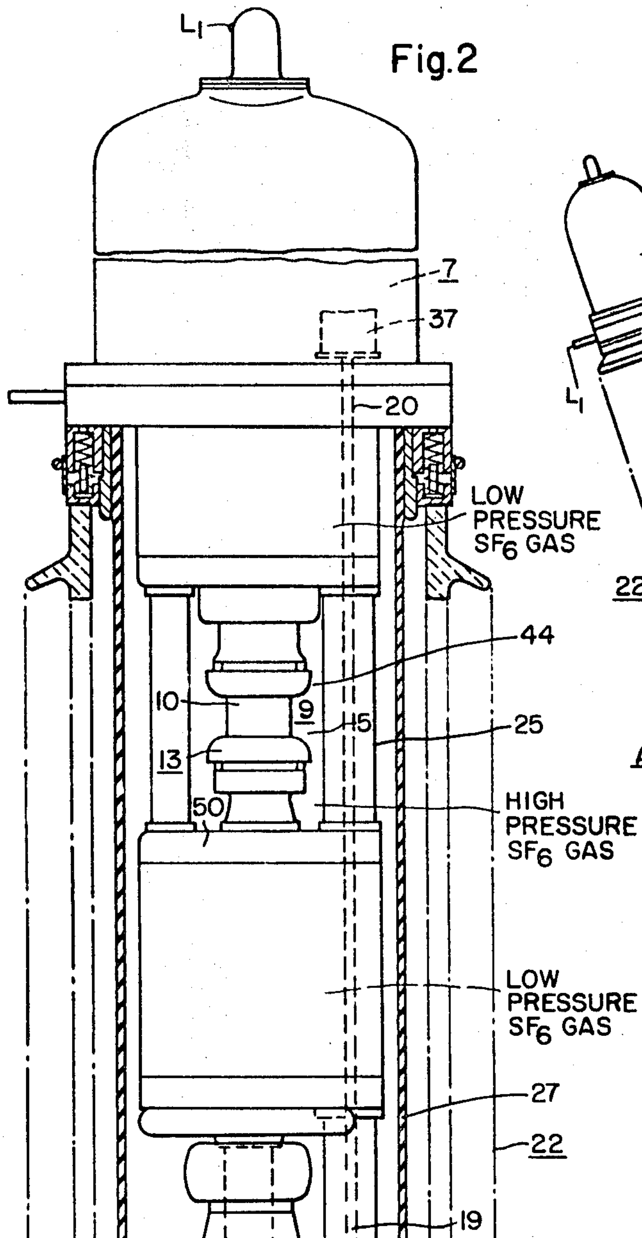
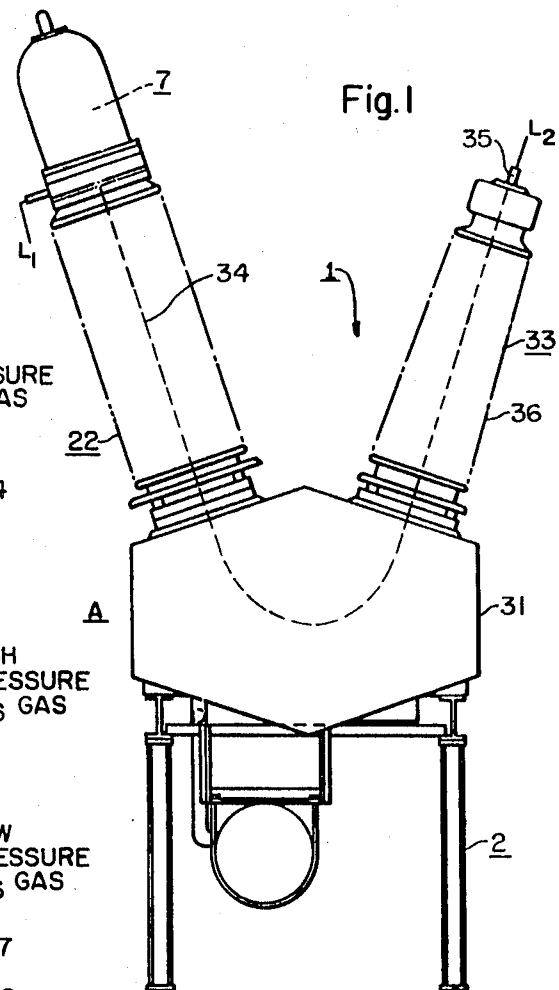


Fig.1



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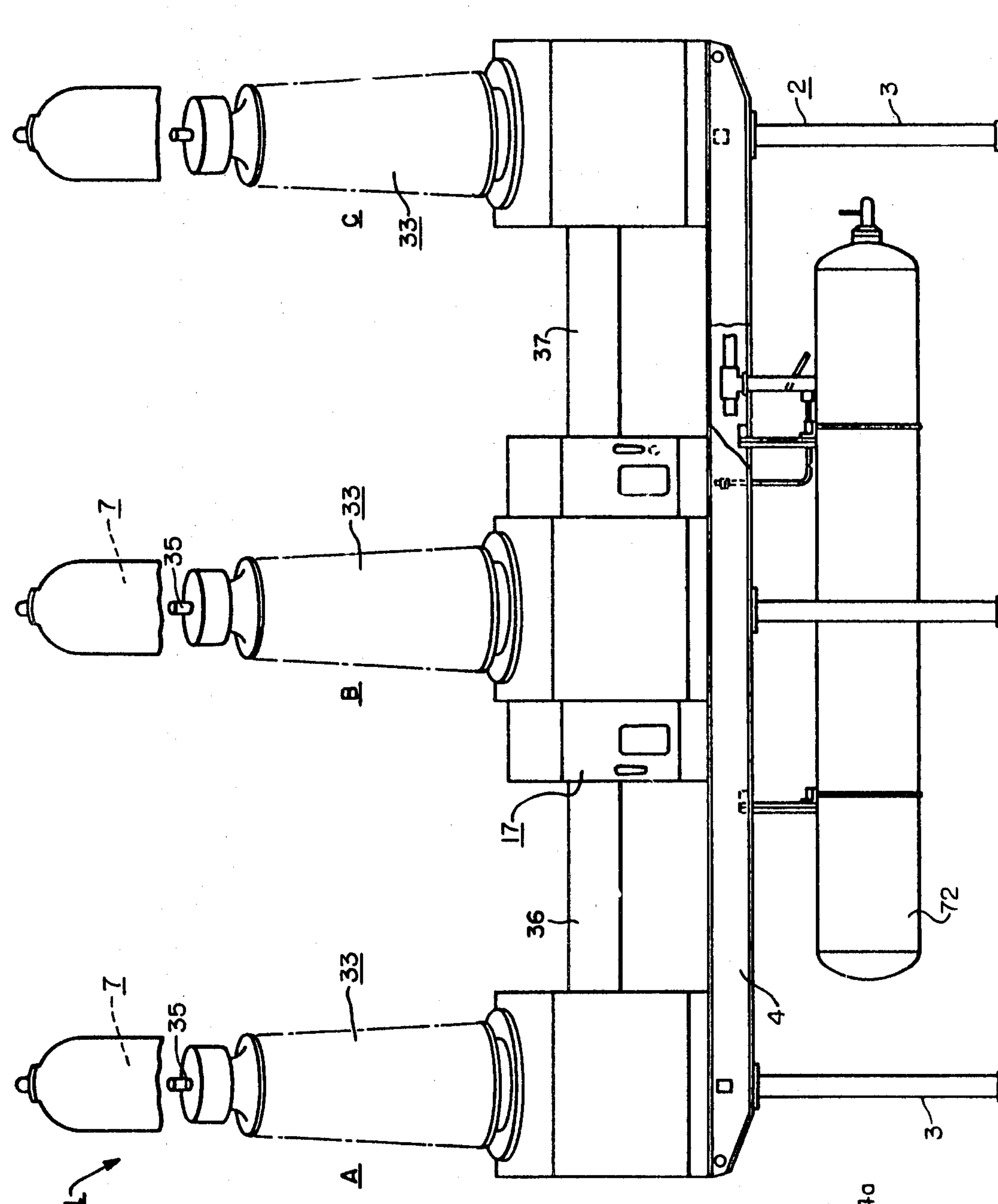

Fig. 3

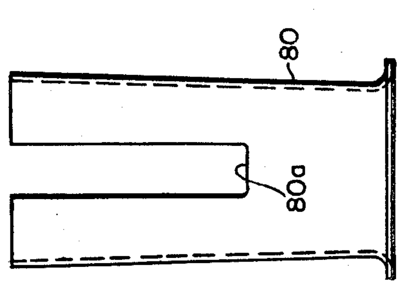

Fig.6

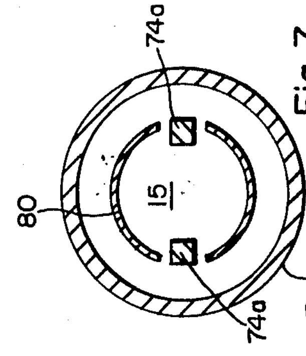

Fig. 7

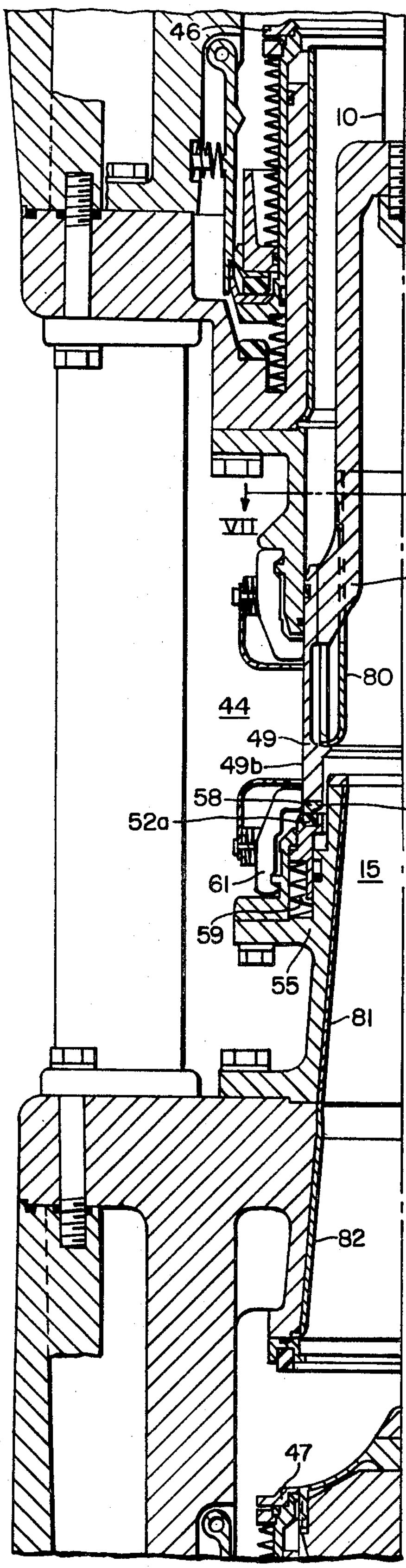
CLOSED
POSITION
46
10
VII
VII
74a
80
44
49
49b
58
52a
49a
61
15
59
55
81
82
47

FIG. 4

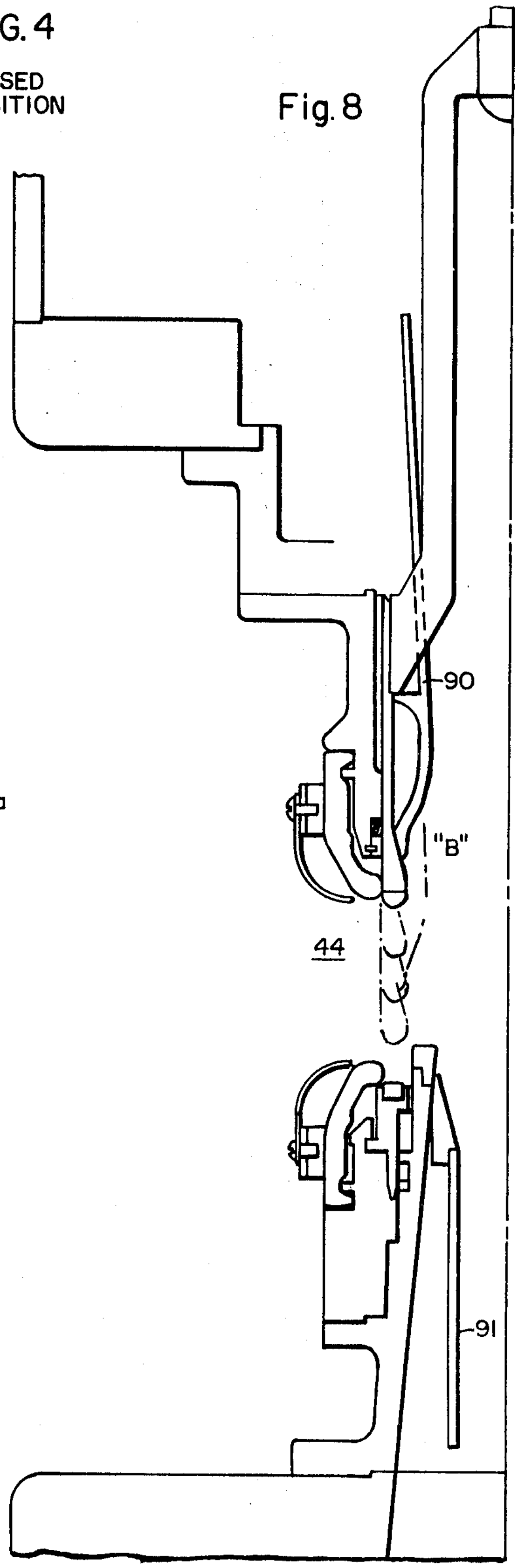
90
"B"
44
91

Fig. 8

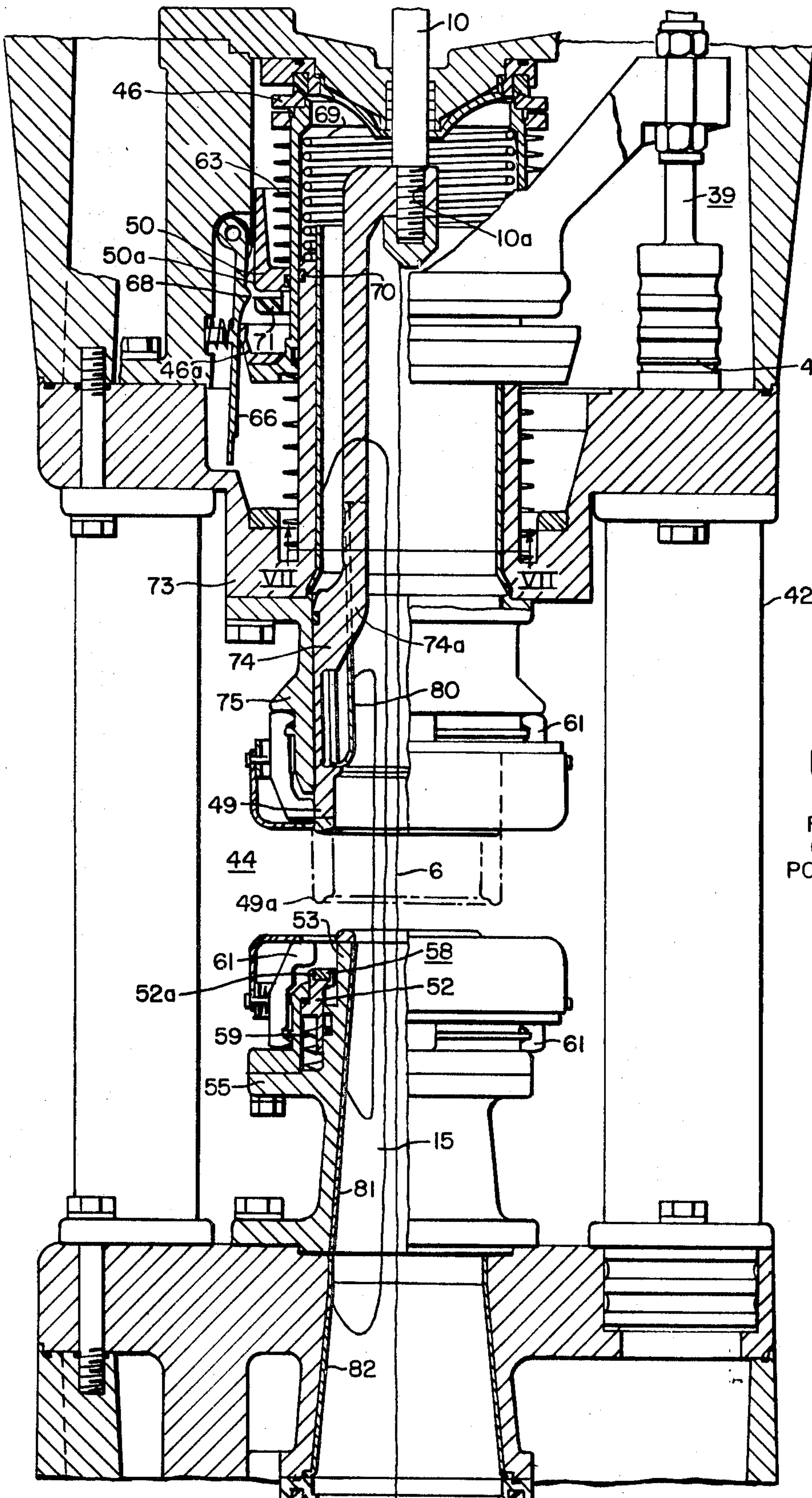

Fig. 5

FULLY OPEN POSITION

CONTACT STRUCTURE FOR HIGH-VOLTAGE CIRCUIT INTERRUPTER WITH LINER COMPONENTS

CROSS-REFERENCES TO RELATED APPLICATIONS

Reference may be made to U.S. Pat. application filed Dec. 30, 1968, by Frank L. Reese and Hayes O. Dakin, Jr., entitled "DELAYED-ACTING BLAST-VALVE OPERATOR CONSTRUCTION," Ser. No. 787,658, and assigned to the assignee of the instant application.

BACKGROUND OF THE INVENTION

The present invention is particularly concerned with the separable contact structure applicable to a high-voltage compressed-gas circuit interrupter. As set forth in the aforementioned U.S. Pat. application, Ser. No. 787,658, for a particular type of compressed-gas circuit interrupter, there is involved a pair of separable contacts, each of which is tubular and permits the exhausting of gas flow therethrough to effect arc interruption therein. Actually, in the aforesaid construction, the movable contact, in effect, constitutes a primary blast-valve separating a high-pressure gaseous region, located externally of the contact structure, from the relatively low-pressure region provided interiorly of the separable contact structure. When it is desired to open the circuit interrupter, the movable contact structure is withdrawn from the stationary contact, thereby performing two functions. The first function is the opening of a so-called primary blast valve at the contacts, and the second function is the establishment of an arc between the movable and the separable stationary contact structures. The radially inwardly directed gas flow rapidly carries the terminal ends of the arc within the separated tubular contact structures, and effects a lengthening of the terminal ends of the arc within the separable tubular contact structures until interruption is achieved. Reference may be had to the aforesaid U.S. Pat. application Ser. No. 787,658 for a general description of such a type of separable contact structure and its operation, the aforesaid application relating its use to a new line of high-voltage circuit interrupters, accommodating a wide variety of current and voltage ratings.

In the fabrication of relatively heavy castings for the contact structures, heretofore use has been made of "Cupaloy" which is a registered trademark of the Westinghouse Electric Corporation, and refers to an alloy of copper. Difficulty has, however, been encountered with porosity of the castings which permitted leakage of high-pressure gas exteriorly of the separable contact structure interiorly into the region disposed within the separable contact structure, in addition, the use of this alloy "Cupaloy" was quite expensive.

In an effort to provide a substitute for the alloy "Cupaloy," attempt has been made to use aluminum, either using permanent mold castings, or ordinary castings. However, aluminum has a relatively low melting temperature, as contrasted with "Cupaloy," and consequently protection is needed to prevent the pitting, erosion or other deterioration resulting from the movement of the terminal ends of the hot arc within the separable contact structures.

SUMMARY OF THE INVENTION

According to the present invention, a more effective gas flow and arc movement is provided by the insertion within at least one of the separable tubular contacts of a relatively thin tubular member, preferably being made of a magnetic material, such as stainless steel, or steel. Preferably, the construction is such that the inner end of the relatively thin tubular member is electrically attached to the inner anterior extremity of the movable tubular contact, so that a magnetic field is set up, which is favorable to arc elongation within the separable tubular contact structure. In addition, the structure has the advantage that a relatively cheap material, such as aluminum castings, may be employed in the fabrication of the main contact-supporting structure. Due to the relatively high melting temperature of the relatively thin tubular member of stainless steel, or steel, there arises the advantage of a resistance to arc erosion of the relatively thin tubular member.

Accordingly, a general object of the present invention is the provision of an improved separable contact structure for a compressed-gas circuit interrupter, which is of a relatively inexpensive construction by using a relatively cheap material, such as aluminum, of lightweight, and also favorable to the considerable elongation of the arc terminals within the separable tubular contact structure, while being subjected to effective gas flow conditions.

Another object of the present invention is the provision of an improved separable contact for a high-voltage compressed-gas circuit interrupter in which arc elongation is magnetically encouraged by a liner construction where magnetic looping of the arc is encouraged.

A further object of the present invention is the provision of an improved, relatively cheap, and lightweight contact structure for a high-voltage circuit interrupter, in which arc elongation is encouraged, and arc extinction is thereby facilitated.

An auxiliary object of the present invention is the provision of a relatively cheap separable tubular contact construction for a compressed-gas circuit interrupter, in which the magnetic fields are controlled in an advantageous manner to encourage axial elongating movement of the arc terminals within the separable tubular contact structure. Obviously, this facilitates arc extinction in a much shorter time than would otherwise be possible.

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 is an end elevational view of a three-phase compressed-gas circuit interrupter embodying the principles of the present invention;

FIG. 2 is a vertical sectional view, partially in side elevation, of the interrupter assemblage associated with the circuit interrupter of FIG. 1, and extending upwardly from the left-hand side thereof;

FIG. 3 is a side elevational view of the three-phase circuit interrupter of FIG. 1, as viewed from the side indicated by the arrows A—A of FIG. 1;

FIG. 4 is a considerably enlarged sectional fragmentary view of the separable contact structure, the contact structure being illustrated in the closed-circuit position;

FIG. 5 is a view somewhat similar to that of FIG. 4, but illustrating, in full lines, the separable contact structure in its fully open-circuit position, with the dotted lines illustrating the intervening contact positions, in which arc establishment is initiated and elongated;

FIG. 6 illustrates, in an enlarged manner, a side elevational view of the relatively thin liner-tube structure, which is utilized in the present invention, and inserted within the contact structure;

FIG. 7 is a sectional view taken along the line VII—VII of FIG. 4; and,

FIG. 8 is a diagrammatic view illustrating the principles of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, and more particularly to FIGS. 1-3 thereof, the reference numeral 1 generally designates a three-phase circuit breaker. As shown in FIGS. 1-3, it will be apparent that the circuit breaker structure 1 is supported by a metallic framework 2, which may be composed of heavy angle-iron braces 3 and beams 4. The circuit breaker structure 1 is, generally, of the dual-pressure type involving the use of a suitable arc-extinguishing gas 5 at two different pressure levels, namely a high pressure, say 230 p.s.i., suitable for use for injecting into the arc 6 (FIG. 5) to effect the extinction thereof, and, additionally, being used in the operating mechanism 7 (FIG. 3), to effect actuation of a piston structure (not shown) associated with the arc-extinguishing unit 9 (FIG. 2). The reference numeral 10 designates the piston rod in FIG. 5 of the drawings, which actuates the movable contact assemblage 11 in the opening and closing movements.

The second pressure level, associated with the arc-extinguishing unit 9, is of a relatively low pressure, say 5 p.s.i., for example, and is present interiorly of the contact structure 13 (FIG. 2) in the closed-circuit position thereof within the region 15, as illustrated in FIG. 4 of the drawings.

Generally, as shown in FIG. 3, the several pole-units A, B and C are spaced laterally apart upon the grounded supporting framework 2, and are mechanically interconnected to a common mechanism 17 at ground potential. The ground mechanism 17 is described in detail in U.S. Pat. application filed Nov. 18, 1968, Ser. No. 776,510, by William H. Fischer and Wayne S. Aspey and assigned to the assignee of the instant application.

Briefly, the manner of operation of the circuit breaker structure 1 is such as to cause the actuation of a ground potential operator 17 to effect motion of a mechanical linkage 19, which interconnects the several three-way valve control rods 20, extending upwardly, individually, within the three arc-extinguishing assemblages 22, more clearly shown in FIG. 2 of the drawings. As illustrated in FIG. 2 of the drawings, the valve control rod 20, moving only a short distance, extends upwardly within insulating supporting tubes 24, 25 disposed interiorly of an insulating inner tension tube 27 serving to spatially relate the one or more pairs of contact structures 13, which may be employed.

As shown in FIG. 2, only a single pair of separable contact structures 13 is utilized; however, for higher voltages and higher ratings, a plurality of pairs of contact structures 13 may be utilized, if desired.

Generally, the arc-extinguishing assemblage 22 comprises an outer insulating weatherproof casing 29, which may be formed either of porcelain, or of a suitable resinous material serving to enclose the arc-extinguishing structure 9 of the interrupter 1. The arc-extinguishing structure, or assemblage 22, is supported upon the grounded housing 31 and is slanted, or canted away from a terminal bushing structure 33, which serves to cause the current path to be conducted in a generally U-shape, as indicated by the dotted line 34 (FIG. 1). The terminal bushing structure 28 (FIG. 1) generally, has a terminal rod 35 at high voltage extending therethrough, and is spaced within an outer weatherproof casing 36 composed of a suitable insulating material, such as porcelain. A suitable arc-extinguishing gas, which has high qualities, may be enclosed within the terminal bushing structure 33 at a relatively low pressure, say of 25 p.s.i. This gas may be the same gas 5 as described heretofore, such as SF_6, but at a much lower pressure.

FIG. 2 shows a vertical cross-sectional view taken through the interrupting structure 9 of a single pole-unit A of the three-phase circuit interrupter 1. As well known by those skilled in the art, there are three such structures A, B, and C to control the three phases of a transmission system.

In the circuit breaker structure 1 under consideration, a suitable highly effective arc-extinguishing gas 5, such as sulfurhexafluoride (SF_6) gas, may be used as the arc-extinguishing gas, and also as an insulating gas to enable a close spacing of the live parts. It is also used as the insulating gas within the terminal bushing structure 33. U.S. Pat. 2,757,261 describes the arc-extinguishing characteristics of this particular gas 5.

As mentioned hereinbefore, generally, the manner of operation of the circuit interrupter is the simultaneous actuation of the three valve control tripping rods 20, which extend upwardly into the top of the arc-extinguishing assemblages 22. As described in the aforesaid Pat. application Ser. No. 787,658, the valve control tripping rods 20 actuate three-way control valves 37 to their operating position to admit a high-pressure gas below piston structures (not shown), which effect upward movement of the operating rods 10 (FIG. 5), and consequently upward opening movement of the separable contact structure 13. As illustrated in FIG. 5, the piston structure, not shown, is mechanically tied, by means of a piston rod 10, to a generally ladder-shaped structure 39, which comprises a pair of laterally spaced insulating operating rods 41, which extend axially of the arc-extinguishing assemblage 22 through a pair of hollow supporting tubes 42.

The region 44, immediately adjacent the contact structure 13, and externally thereof in the closed-circuit position, as illustrated in FIG. 4, is at a relatively high pressure, say 230 p.s.i., as more clearly described in U.S. Pat. application Ser. No. 759,992, filed Sept. 16, 1968, by Lee E. Berkebile, the arc-extinguishing structure, or unit 9 being of the so-called downstream type, in which high-pressure gas 5 moves radially into and through the separated contact structure 13 during the opening operation, until the flow of gas is halted by the closing operation of a pair of downstream, or secondary blast-valves, indicated by the reference numerals 46 and 47 in FIGS. 4 and 5 of the drawings.

MOVABLE CONTACT STRUCTURE (11)

As briefly pointed out hereinbefore, the movable contact assemblage 39 comprises a generally ladder-shaped movable structure secured at its upper end to a yoke-shaped member, not shown, which, in turn, is mechanically adjustably secured, as at 10*a*, to the movable tubular contact 49. A pair of spaced insulating side operating rods 41, constituting a portion of said ladder-shaped structure 39, extend interiorly of hollow insulating supporting tubes 42, serving to space the interrupting units 9 axially apart, when a plurality of such units are used.

With reference being directed particularly to FIG. 5 of the drawings, it will be observed that the piston rod 10 is adjustably secured, as at 10*a*, to the hollow movable contact 49. The side operating rods 41 additionally are secured to a movable blast-valve activator 50 having a configuration more clearly shown in FIG. 5 of the drawings, and more fully described hereinafter.

The moving contact 49 makes separable engagement with a movable hollow sealing structure 52 (FIG. 5), which is supported by a stationary hollow contact structure 53, which is fixably supported upwardly from a base support 55. As shown in more detail in FIG. 5 of the drawings, an exhausting flow of arc-extinguishing fluid 5, at high pressure, occurs across the arc 6, and diametrically in opposite directions through the interior of both the movable and stationary hollow contacts 49, 53, as indicated by the arrows 56 in FIG. 5.

Generally, there is provided a primary blast-valve 58 (FIG. 4) constituted by the lower tip portion 49*a* of the movable contact 49 making abutting engagement with a relatively stationary primary blast-valve seat 52*a* resiliently supported upon the stationary contact support 55, as shown in FIG. 5. A compression spring 59 provides a desired contact pressure there between, and provides for a limited amount of overtravel of the movable contact 49. Additionally, there is provided a plurality of circumferentially disposed stationary contact fingers 61, which make contacting engagement with the external side 49*b* of the movable tubular contact 49.

In addition to the primary blast-valve support, there is provided a pair of secondary downstream blast-valves 46, 47, which are closed near the end of the opening operation, as described more clearly hereinafter.

In the arrangement of FIG. 5, it will be noticed that there is provided a double-exhausting flow of gas, inasmuch as both the stationary and movable contacts 49, 53 are hollow, and provide for exhaust outlets therethrough. However, for higher voltage ratings, where a double-break is desired, additional arc-extinguishing units 9 may be provided as shown in U.S. Pat. application (W.E. 39,242).

LATCHING STRUCTURE FOR THE SECONDARY BLAST VALVES (46, 47)

The circuit interrupter 1 of the present invention provides a means for operating the secondary blast-valves 46, 47. On the circuit breaker of the present invention, as previously pointed out, a gas-operated piston mechanism **7** is used to open and to close the movable contacts **49** of the interrupter **1**.

The movable contact **49** of the interrupter forms a seal with a relatively stationary primary blast-valve seat **52***a* (FIG. **5**) constituting a primary blast-valve **58**, so that when the breaker contacts **49** are closed, the seal **52***a* at the primary blast-valve **58** prevents the high-pressure gas from flowing into the center **15** of one or both of the moving separable contacts **49, 53**. At this time, the secondary blast-valves **46, 47** are open. When the moving contact **49** opens, during the opening operation, the secondary blast-valves **46, 47** are going closed to stop the exhausting gas flow into the low-pressure region **15**.

In the circuit-interrupter construction as described, it is desirable that when the contacts **49** of the interrupter open, they arrive in the fully open-circuit position in the shortest period of time. The open position can be reached while there is still an arc **6** between the contacts **49, 53**. It is quite necessary that the secondary blast valves **46, 47** remain open at this time to allow gas flow to interrupt the arc **6**. Hence, the secondary blast-valve closing must have a travel curve, which is delayed from that of the moving contacts **49**. The following deals with a means of delaying the secondary blast-valve travel.

With reference to FIGS. **4** and **5**, it will be observed that the tubular moving contact **49** is directly connected to the mechanism **7**, and has a certain travel characteristic. The blast-valve activator **50** is also directly connected to the movable contact **49**, and has hence, consequently, the same travel. As the movable contact **49** moves to the open position, the blast-valve activator **50** starts compressing a compression spring **63**. This compression spring **63** becomes loaded, since the opposite spring seat **64** is prevented from moving, since this spring seat **64** is a part of the blast-valve device, and the blast-valve is prevented from moving by two latches **66** (FIG. **5**), which are spaced 180° apart. There is some free movement of the activator **50** before starting to compress the compression spring **63**, since it is necessary to keep the load on the operating mechanism **7** to a minimum when starting the opening motion. After the activator **50** has moved a specific distance, and thereby compressed the spring **63**, protrusions **50***a* on the activator **50** hit a raised surface **68** on the latches **66**, thereby causing the latches **66** to move back, and allow the secondary blast-valves **46, 47** to go closed, with a travel curve, which is delayed as compared to that of the moving contact **49**. When the secondary blast-valve **46, 47** is closed, there is some compression on it due to the position of the activator **50** compressing the spring **63**, additionally due to an inner spring **69**, inside blast valve **46**, and basic mounting plate number **70**, plus a differential pressure holding it closed, due to the geometry of the blast-valve face.

When the circuit breaker contacts **49** are being closed, the second blast-valves **46** and **47** are closed. The activator **50** with its rubber bumper **71** strikes the secondary blast-valve **46**, and moves it to the open position. A small gas dashpot is also formed between the activator **50** and the blast valve **46** to help reduce the shock. At this time, the latches **66** fall under the shoulders **46***a* (FIG. **5**) and the blast-valve **46** is ready for another contact opening operation.

The pneumatic mechanism **7**, disposed within the cap structure and concerning the dual action of the piston is set forth and claimed in the U.S. Pat. application filed Dec. 10, 1968, Ser. No. 782,631, by William H. Fischer and Wayne S. Aspey, and assigned to the assignee of the present invention.

The exhausting gas flow during the opening operation is collected in low-pressure chambers and eventually is conducted by means of the hollow operating rod tube down to the low-pressure tank **72** (FIG. **3**) at the base of the supporting framework **2**. A suitable compressor, not shown, is used to recompress the gas to the high-pressure level of 220 p.s.i., for example.

As mentioned hereinbefore, in the aforesaid construction of the gas circuit breaker, a general method of interrupting the arc is to discharge gas **5** through moving or stationary cylindrical contact structures **49, 53**, which form the contacts of the interrupter **9**. The materials used for the cylindrical contact structures are usually copper, or a copper alloy, such as "Cupaloy," due to the requirements of good electrical conductivity plus having a high melting temperature, since the arc **6** can impinge on the interval walls of the tubular contact structure **49** or **53**.

The copper alloy "Cupaloy" is an alloy of copper, the trademark being owned by the Westinghouse Electric Corporation, and containing as alloy components 0.01 percent–5 percent silver (Ag), 0.05 percent–5 percent chromium (Cr), and the balance being copper (Cu).

The present invention is particularly concerned with the use of thin-walled cylinders of stainless steel, or steel, or other conducting magnetic material, which can be inserted within the main contact structural members These thin-walled cylinders can be made of a high melting material, such as stainless steel, other than copper, which can be easily fabricated.

The relatively thin metallic liners of the present invention may be formed of an easily fabricated material, such as stainless steel; or the liners may be made of steel with a coating of nickel. It has been found that previously, the heavy castings of "Cupaloy" had a high porosity, in certain instances, which lead to a leakage of gas flow from the high pressure region **44** through the castings and into the relatively low-pressure region **15** interiorly of the separable tubular contacts **49—53**. To avoid the problem of porosity, when using "Cupaloy," and to provide a relatively inexpensive substitution therefor, such as the material aluminum, we have found it desirable to utilize a protective liner, such as the slotted tubular liner **80**, or the two liners **80** and **81–82**, such as set forth in FIG. **5** of the drawings. The structural support casting **73–75** are preferably made out of aluminum to provide good conductivity, lightweight, and the possibility of using permanent mold castings for an inexpensive construction, avoiding the problem of porosity. These contact liners **80, 81, 82** are shown in more detail in FIGS. **4** and **5** of the drawings.

COMPARISON OF MELTING TEMPERATURE

Part Name (Where Used)	11 Material	Melting Temp. °C.
Lower Arc Horn or (Prior Art)	11 "Cupaloy"	1,075 °C. Moving Contact
End Plate, Upper	Aluminum	659.8 °C. Contact Base, Lower Blast-Valve Support
Heat Shield as Used	Stainless	1,430 –steel 1,470 °C.
Heat Shield	Steel	1,520 °C. (Alternative) Is less Desirable Is Less Desirable Because of Probable Nickel Coating needed Counteracting Heat and Corrosion
	Pure Copper	1,083 °C

Another use can be made of these relatively thin metallic arc chamber liners **80, 81, 82**. If one end of these liners is electrically insulated from the supporting structural casting, the flow of current from the arc terminals can be directed, such that the arc length can be increased by using the magnetic "loop" formed by this current flow. FIG. **8** of the drawings more clearly illustrates this principle, which, to a certain extent, is somewhat similar to the use of arcing horns in air-break circuit interrupters. As well known by those skilled in the art, a magnetic loop circuit is developed, and the magnetic interaction caused by the arc **6** and current flow through the conducting members **80, 81, 82** is such as to loop the arc into an ever-expanding length. This same phenomena can be utilized in the contact structure of the present invention by connecting the relatively thin-walled tubes **80, 81, 82** in good conductive manner to the inner anterior ends of the relatively stationary and movable tubular contacts **49, 53**.

FIG. **8** shows a modified contact structure using the aforesaid principle. With metallic cylinder **90** connected to the movable contact at point "B," the current must flow through this point "B" regardless of where the arc **6** impinges upon the metallic cylinder **90**. The magnetic forces, caused by this loop of current, forces the arc **6** to lengthen thereby increasing the efficiency of arc interruption. Members **90** and **91** of FIG. **8** can be slotted to provide additional control of the current flow, if desired.

From the foregoing description it will be apparent that there has been provided an improved separable contact structure for a high-voltage compressed-gas circuit interrupter, in which the moving contact parts can be made of lightweight material, for example aluminum casting, and the liners **80, 81, 82** utilized of a high melting point material, such as coated steel or stainless steel, and the arc lengthening **6** can be thereby encouraged magnetically by the magnetic loop effect encountered.

Although there has been illustrated and described specific structures, 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.

We claim:

1. A gas-blast circuit interrupter including a pair of separable arcing contacts at least one of which is hollow, means for seperating said separable contacts to establish arcing, means for forcing a radially inwardly flow of gas between the contacts to exhaust through said one hollow arcing contact, and a relatively thin metallic tubular liner member disposed interiorly of said one hollow arcing contact to protect the inner surfaces thereof from the effects of arcing whereby a relatively cheap, low melting temperature material may be used for fabrication of said one hollow arcing contact.

2. The combination of claim **1**, wherein the relatively low melting temperature material is aluminum or an alloy thereof.

3. The combination of claim **1**, wherein the relatively thin metallic tubular liner member is essentially steel.

4. The combination of claim **1**, wherein both arcing contacts are hollow, and both have relatively thin tubular metallic liner members therein to protect the inner surfaces of the arcing contacts.

5. The combination of claim **1**, wherein the liner member is electrically connected to the anterior end of the hollow arcing contact and insulated from the posterior end thereof, so that a magnetic loop effect is achieved to magnetically promote arc elongation.

6. The combination of claim **4**, wherein both liner members are electrically connected to the anterior ends of the respective hollow arcing contacts to achieve a magnetic arc-looping effect.

7. A gas-blast circuit interrupter including a relatively tubular movable sleevelike contact cooperable with a stationary contact to establish an arc, a primary blast-valve effect being achieved by the closure of the movable tubular contact, means generating a high-pressure gaseous region exteriorly of the contacts in the closed position and a relatively low-pressure gaseous region interiorly of the contacts at this time, and a relatively thin metallic tubular liner member disposed interiorly of said one hollow arcing contact to protect the inner surfaces thereof from the effects of arcing, whereby a relatively cheap low melting temperature material may be used for fabrication of said one hollow arcing contact.

8. The combination of claim **7**, wherein both contacts are hollow and both are protected by individual relatively thin metallic liner members.

9. The combination of claim **7**, wherein means provide a secondary blast-valve for the exhausting of gas through the movable tubular contact, and said means closes the secondary blast-valve at the end of the opening operation.

10. The combination of claim **9**, wherein said means opens the secondary blast-valve in the closed contact position.