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Chabala

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[54] **HIGH VOLTAGE CIRCUIT INTERRUPTING DEVICE**

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[73] Assignee: **S&C Electric Company,** Chicago, Ill.

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[52] **U.S. Cl.**..... **200/148 A;** 200/148 B; 200/148 F; 200/150 G

[51] **Int. Cl.²**..... **H01H 33/70**

[58] **Field of Search**..... 200/148 A, 150 G, 150 F, 200/148 D, 144 B, 167 R, 148 F

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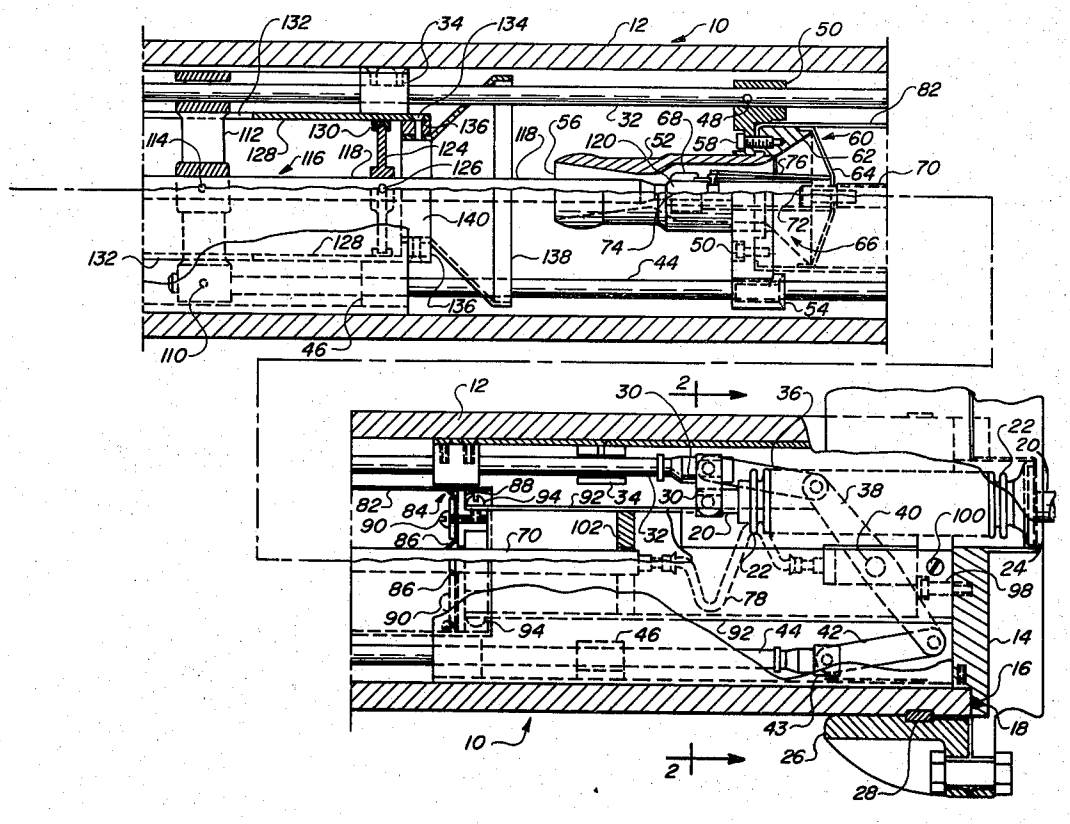
[57] **ABSTRACT**

A high voltage circuit interrupting device has two movable contacts mounted within a sealed arc quenching gas containing housing. The contacts are operably connected by lever linkage which causes the contacts to move in opposite directions to break contact and interrupt the circuit thus increasing the relative contact separation speed. An arc quenching gas pump arrangement is connected to the contacts to cause the arc quenching gas to flow through a nozzle surrounding the contacts to suppress the arc formed when the contacts separate under electrical load conditions.

21 Claims, 3 Drawing Figures



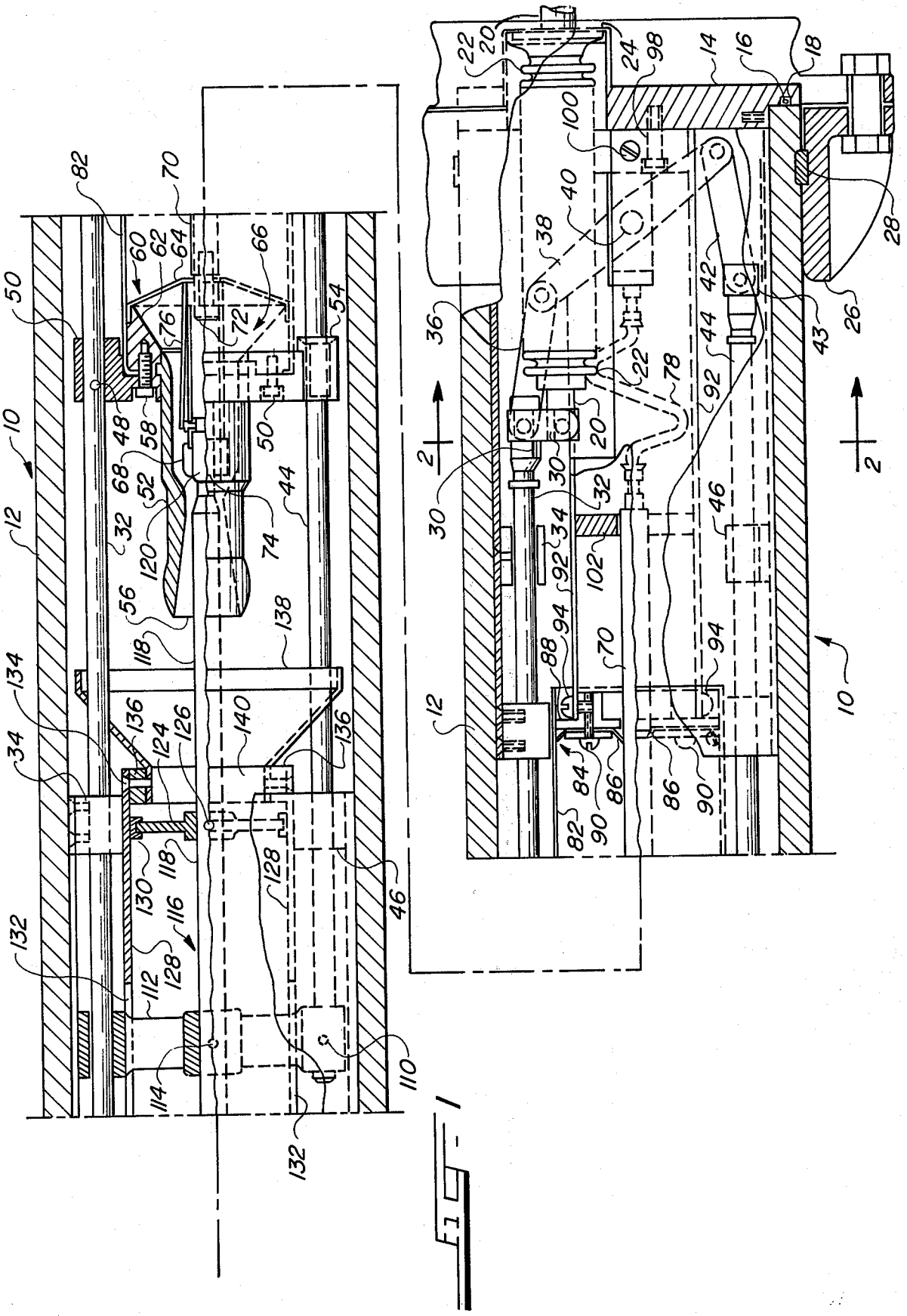

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FIG. 1

FIG - 1A

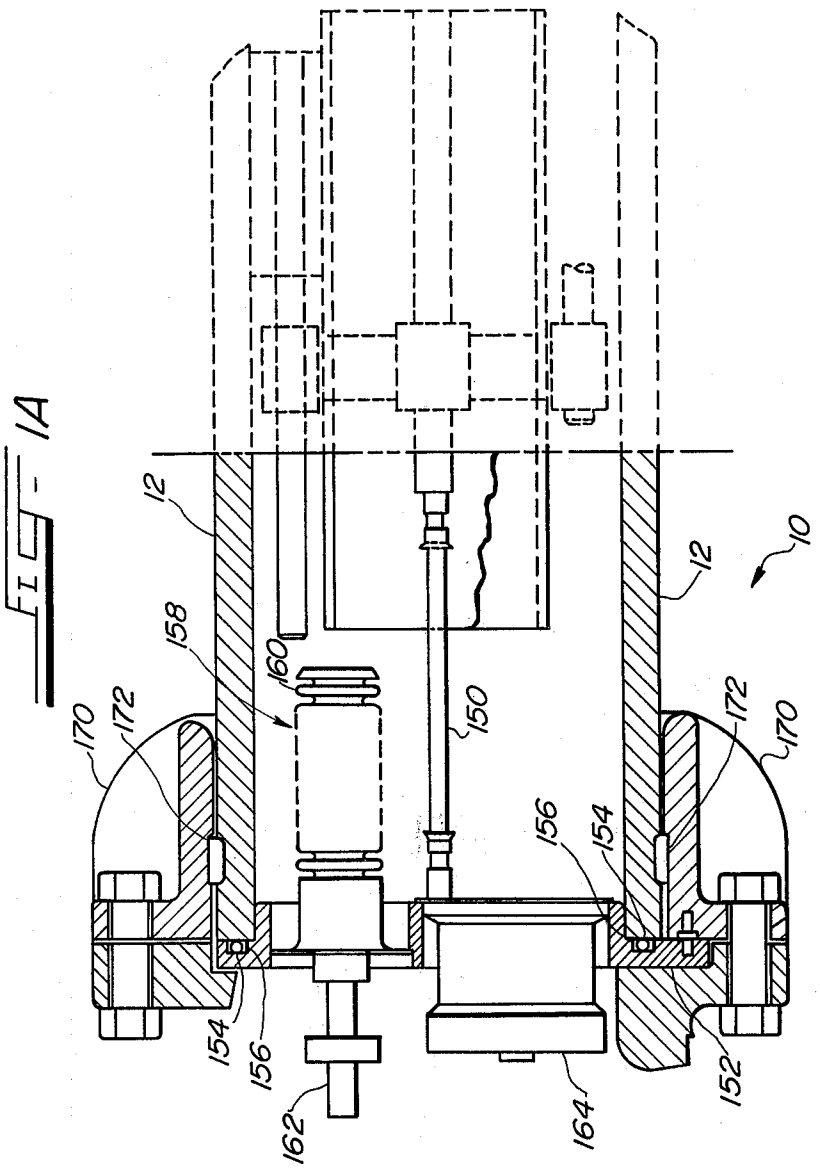

Fig. 2

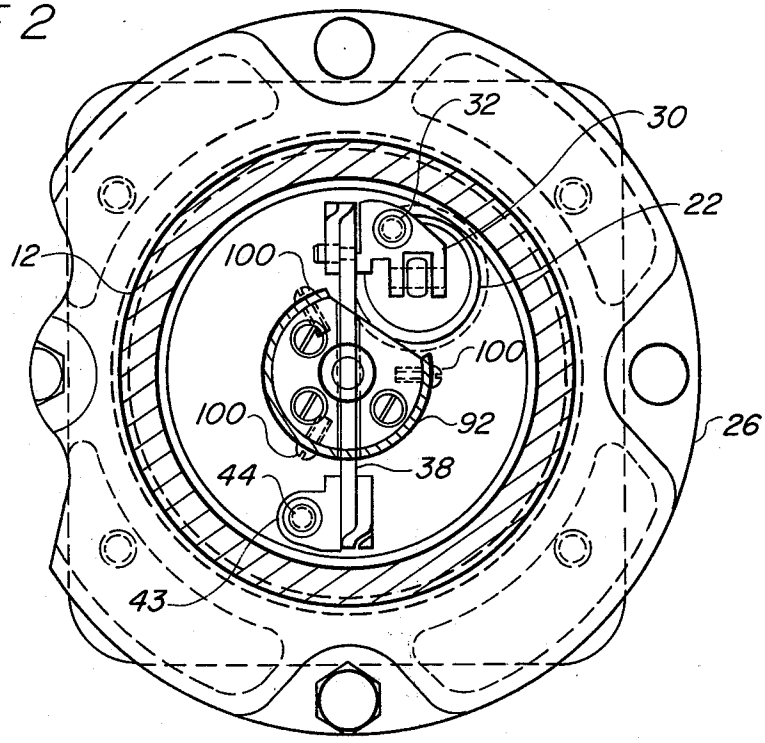
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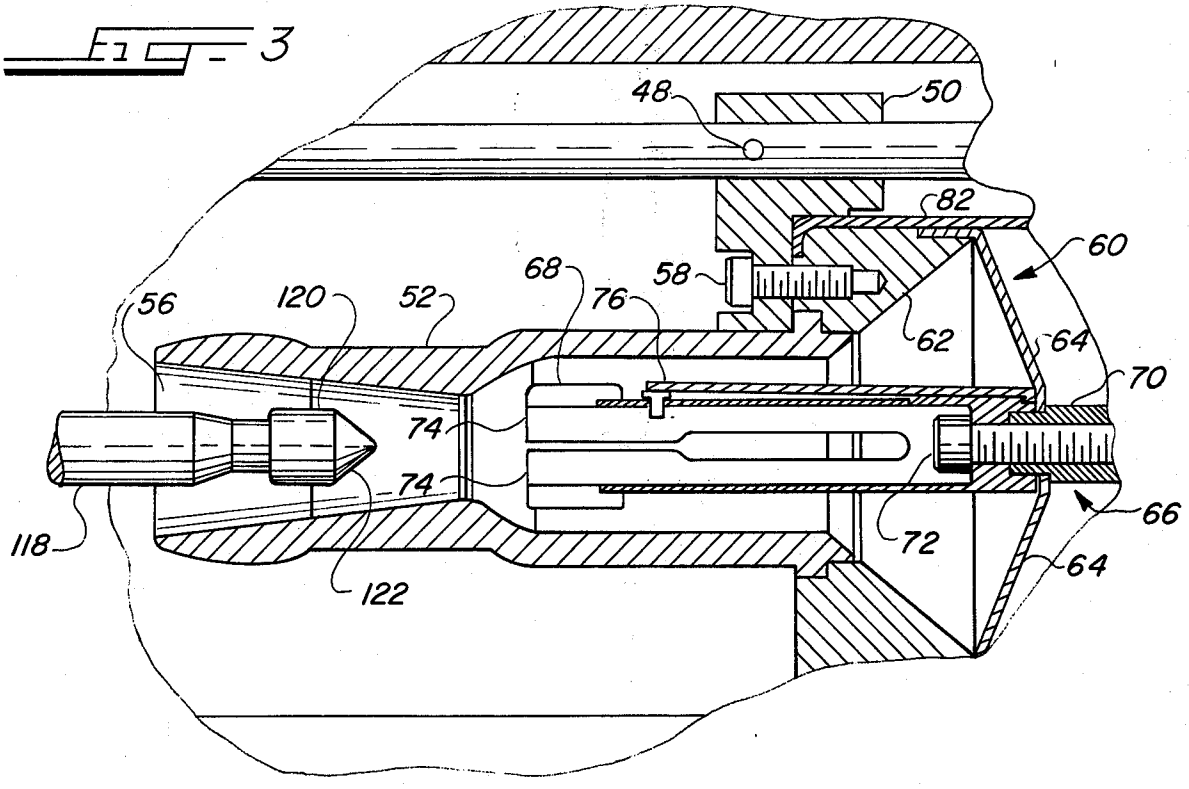
Fig. 3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HIGH VOLTAGE CIRCUIT INTERRUPTING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to high voltage circuit interrupting devices and more particularly to high voltage circuit interrupting devices enclosed within a sealed housing containing an arc quenching gas such as sulfur hexafluoride to suppress the arcs formed when the circuit is interrupted.

2. Description of the Prior Art

High voltage circuit interrupting devices are well known in the art. A circuit interrupter is a device utilized to interrupt the flow of current in a high voltage circuit. Typically, a circuit interrupter utilizes either a vacuum or an arc quenching gas such as sulfur hexafluoride to suppress arcing which occurs as the interrupter contacts separate. Other types of prior art circuit interrupters typically utilize oil or compressed gases such as air to suppress arcs formed as the interrupter contacts separate.

Various problems have been experienced with the prior art circuit interrupter devices. Vacuum type interrupters are subject to leaks and once air has leaked into the interrupter the device is rendered inoperative. Prior art arc quenching gas containing circuit interrupters have also not proved totally effective. Such prior art interrupters are subject to leaks which permits the arc quenching gas to escape from the interrupter thereby reducing the arc quenching effectiveness of the gas. Consequently, expensive or sealing bellows must be used around the operating shafts to prevent leaks. In addition, unless the arc quenching gas is caused to be moved past the interrupter contacts at the instant of separation, the effectiveness of the interrupter is diminished. Consequently, it is desirable to provide a high voltage circuit interrupting device which effectively causes the arc quenching gas to flow by the contacts as they separate to interrupt the circuit.

Further, the relative speed of separation of the contacts is a factor in current interruption. The slower the relative separation speed the greater the likelihood that the arcing time will be unnecessarily prolonged. Consequently, it is highly desirable to increase the relative contact separation speed of the contacts during circuit interruption.

Prior art interrupters typically have utilized a single movable contact which is moved away from a relatively stationary contact to effect circuit interruption. To increase the relative separation speed of the contacts, it is necessary to increase the kinetic energy input into the interrupter device. However, because of friction and other mechanical factors, there is an upper limit of separation speed in such a single movable contact interrupter device. Further, increased kinetic energy input increases the likelihood of a failure of the seal around the input operating shaft thus resulting in a loss of arc quenching gas. Consequently, it would be a very desirable advance in the art to provide a circuit interrupter which increases the relative contact separation speed at a minimum kinetic energy input requirement.

BRIEF SUMMARY OF THE INVENTION

In accordance with the present invention a high voltage circuit interrupting device comprises a hollow sealed gas tight housing having an arc quenching gas such as sulfur hexafluoride contained therein. First and second movable electrical contacts are positioned within the housing and are normally engaging to complete an electrical circuit. An operating means is provided for causing relative movement between the first and second contacts in opposite directions to electrically disconnect the first and second contacts to interrupt the circuit. A gas pump means is provided for causing movement of the arc quenching gas past the first and second contacts as they are separated by the operating means to inhibit the formation of an electrical arc as the contacts separate. The present invention accomplished the high voltage circuit interrupting function of conventional prior art circuit interrupting devices but accomplishes this desirable function at a relative contact separation speed far greater than the prior art devices in relation to the kinetic energy input required to operate the operating means. This desirable result is achieved because of the relative movement of the contacts in opposite directions during contact separation. Thus, the relative separation speed is increased by virtue of the movement of both contacts in opposite directions. Further, because of the double movable contact feature of the present invention, the increased relative contact separation speed is achieved at a minimum kinetic energy input, and at a reduced distance of stroke of the input operating rod.

In addition, the present invention further maximized the flow of arc quenching gas past the separating contacts by utilizing gas pump means to force the arc quenching gas past the contacts as they are separated. This desirable result is achieved by utilizing first and second piston means operably connected to the first and second contacts respectively to increase the efficiency of the gas flow as the contacts are separated. In addition, a nozzle means is provided around the first and second contacts to confine the flow of the arc quenching gas to the area immediately adjacent the contacts as they are separated thereby further maximizing the arc quenching capabilities of the arc quenching gas.

The relative movement of the first and second contacts is achieved by utilization of a mechanical linkage arrangement which produces the relative movement of the contacts in opposite directions. Thus, maximum contact separation speed is achieved at a relatively reduced input movement of the operating rod thereby reducing the kinetic energy input. An additional advantage of the present invention is that the reduced operating rod movement permits a more economical and shorter gas sealing bellows to be utilized to prevent the escape of arc quenching gas from the housing at the point where the operating rod extends outside the housing.

Additional features of the present invention are the utilization of a pressure indicating means to indicate when the pressure of the arc quenching gas within the housing has fallen below a predetermined level thus preventing a reduction in the effectiveness of the arc quenching medium. In addition, a pressure release means may be provided to release arc quenching gas from the housing in case the pressure exceeds a predetermined level thereby preventing an explosion of and damage to the device in case the pressure exceeds a predetermined level.

Thus, it is a primary object of the present invention to provide a high voltage circuit interrupting device

having a pair of movable contacts which move in opposite directions during circuit interruption so that the relative contact separation speed is increased relative to the input kinetic energy.

Another object of the present invention is to provide a high voltage circuit interrupting device which provides an efficient gas pump to force relatively large quantities of arc quenching gas past the contacts during contact separation to inhibit the formation of a separation arc.

Another object of the present invention is to provide a high voltage circuit interrupting device having linkage within the device to maximize the relative contact separation speed while minimizing the operating rod movement thereby permitting the utilization of low cost economical sealing bellows around the operating rod.

Yet another object of the present invention is to provide a high voltage circuit interrupting device which provides gas moving and directing features on the exit side of a gas directing nozzle to control the flow of the gas expelled from the nozzle.

A further object of the present invention is to provide a high voltage circuit interrupting device which minimizes the use of conducting materials within the interrupting unit to avoid excessive voltage gradient adjacent to the inside diameter of the housing.

These and other objects, advantages, and features of the present invention will hereinafter appear, and for the purpose of illustration, but not of limitation, an exemplary embodiment of the present invention is illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 1A are side elevational views of a preferred embodiment of the present invention.

FIG. 2 is a cross-sectional view of the preferred embodiment of the present invention taken substantially along line 2—2 in FIG. 1.

FIG. 3 is a cross-sectional partially fragmentary view of the contacts of the preferred embodiment of the present invention showing the contacts in a separated position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIGS. 1, 1A, 2, and 3, a circuit interrupting device 10 comprises cylindrical housing 12 formed of an electrical non-conducting material such as porcelain or cast epoxy resin. A first end plate 14 is connected to one end of cylindrical housing 12 and a gasket 16 is positioned in an annular groove 18 formed in first end plate 14 to provide a gas tight seal between the cylindrical housing 12 and the first end plate 14. Extending through first end plate 14 is operating rod 20. A gas sealing expandable and contractable metal bellows 22 is attached at one end to operating rod 20 and at an opposite end to a flange member 24 mounted on end plate 14. Metal bellows 20 is either welded or brazed to operating rod 20 and flange member 24 to provide a gas tight seal to prevent the escape of an arc quenching gas such as sulfur hexafluoride confined within the interrupter cylindrical housing 12 to the exterior ambient air. Mounting end flange 26 is joined to cylindrical housing 12 by split ring 28 trapped in suitable grooves formed in housing 12 and flange 26.

The interior end of operating rod 20 is connected to pull rod 32 by pivot member 30 so that movement of operating rod 20 causes corresponding movement of pull rod 32. Pull rod 32 is slidably mounted within cylindrical housing 12 by guide blocks 34. A linkage member 36 is pivotably connected at one end to pull rod 32 and at its opposite end to walking beam lever 38. Walking beam lever 38 is pivotably mounted at approximately its middle by pin 40. Pivotably attached at one end to the lower end of walking beam lever 38 is linkage member 42 which is also pivotably attached at its opposite end to pull rod 44 by pivot member 43. Pull rod 44 is slidably mounted within cylindrical housing 12 by guide block 46.

Pinned to pull rod 32 by pin 48 is carrier member 50 upon which is mounted nozzle 52. Nozzle 52 has a hollow gas confining channel 56 formed therethrough. At the lower edge of carrier member 50 a guide hole 54 is formed which slidably accepts and supports pull rod 44. Bolted to carrier member 50 by bolts 58 is spider assembly 60. Spider assembly 60 comprises annular support block 62 upon which is mounted a contact supporting member 64 having four legs centrally joined. Mounted at the central junction of the legs of contact supporting member 64 is first contact assembly 66. First contact assembly 66 comprises hollow contact head 68 which is mounted to contact rod 70 by bolt 72. Hollow contact head 68 is segmented into fingers 74 which are spring biased inwardly by springs 76. Attached to the end of contact rod 70 is flexible conducting cable 78. Cable 78 is also attached to block 80 connected to first end plate 14 so that an electrical conducting path is formed from first end plate 14 to hollow contact head 68.

Mounted to the periphery of annular support block 62 is hollow cylinder 82 which surrounds contact rod 70. The hollow interior portion of cylinder 82 communicates at one end through gas channel 56 in nozzle 52 and through the annular opening in annular support block 62 to the interior portion of device 10. Positioned within cylinder 82 is cylinder head assembly 84 which comprises cup seal 86 attached to annular piston member 88 by bolts 90. Cup seal 86 engages the edges of hollow cylinder 82 and contact rod 70 to provide a gas tight sliding seal around those members. Piston member 88 has an opening through its center which slidably supports contact rod 70 so that contact rod 70 can freely slide through piston member 88. Piston member 88 is mounted to a piston support tube 92 by bolts 94. Piston tube 92 is mounted in a cantilever fashion to first end plate 14 by mounting block 96. Mounting block 96 is mounted to first end plate 14 by bolts 98 and piston support tube 92 is mounted to mounting block 96 by screws 100. Positioned within piston support tube 92 is guide block 102 having an opening in the middle thereof for slidably supporting contact rod 70.

Pinned to second pull rod 44 by pin 110 is carrier member 112. Mounted at approximately the center of carrier member 112 by pin 114 is second contact assembly 116. Second contact assembly 116 comprises a second contact rod 118 and contact head 120. Contact head 120 is attached to the end of second contact rod 118 by a suitable means such as brazing. Contact head 120 has a cone-shaped extension 122 which is adapted to facilitate the entry of contact head 120 into the hol-

low interior portion of hollow contact head **68** between fingers **74.**

A second piston assembly **124** is pinned to second contact rod **118** by pin **126.** Second piston assembly **124** slides within cylinder **128** and a gas tight seal is effected by annular sealing member **130** around the periphery of second piston **124.** Thus, when second pull rod **44** is moved, corresponding movement is imparted to second pull rod **118** and second piston **124** through carrier member **112.**

Cylinder **128** is supported and held in a stationary position by guide blocks **34** and **46.** Cylinder **128** has grooves **132** formed in the rear portion thereof to permit member **112** to slide freely therein. Mounted to the interior of one end of cylinder **128** by screws **134** is annular support block **136** and gas shield **138.** Gas shield **138** is a hollow cone shaped member having an opening **140** which communicates with the interior of cylinder **128.** The purpose of gas shield **138** is to direct the flow of arc quenching gas expelled from nozzle **52** into cylinder **128** as will be more fully described below.

Second contact rod **118** is connected to one end of flexible electrical conducting cable **150.** The opposite end of cable **150** is connected to second end plate **152** to provide an electrical conducting path from second end plate **152** to contact head **120** through second contact rod **118.** Second end plate **152** is mounted on cylindrical housing **12,** and a gasket **154** is positioned in an annular groove **156** in second end plate **152** to provide a gas tight seal between the cylindrical housing **12** and second end plate **152.** Mounted to the end of cylindrical housing **12** by split ring **172** is mounting end flange **170.**

A gas pressure indicator assembly **158** is sealably mounted through second end plate **152** comprising a flexible bellows **160** and an indicator rod **162** which extends outwardly from second end plate **152.** Also provided through second end plate **152** is a pressure release device **164** of the type disclosed in U.S. Pat. No. 3,229,848, issued Jan. 18, 1966 to permit release of gas from within the cylindrical housing **12** if the pressure exceeds a predetermined level.

When circuit interrupting device **10** is in its normal conducting position, hollow contact head **68** and contact head **120** are in an engaged position as shown in FIG. **1** thereby completing an electrical circuit from first end plate **14** to second end plate **152** through block **80,** flexible electrical cable **78,** contact rod **70,** hollow contact head **68,** contact head **120,** second contact rod **118,** and flexible conducting cable **150.** To effectuate circuit interruption, operating rod **20** is moved towards the right as viewed in FIG. **1** thereby collapsing metal bellows **22** and causing first pull rod **32** to move in a corresponding direction. Second pull rod **44** is correspondingly moved towards the left as viewed in FIG. **1** by the action of walking beam lever **38,** linkage member **36** and linkage member **42.**

Movement of first pull rod **32** causes corresponding movement of carrier member **50** which is pinned to first pull rod **32** by pin **48.** Movement of carrier member **50** causes nozzle **52,** hollow cylinder **82,** and first contact assembly **66,** to move concurrently with first pull rod **32.** Since cylinder head assembly **84** is stationarily mounted by piston support tube **92** as hollow cylinder **82** slides over cylinder head assembly **84** a reduction in the interior volume of hollow cylinder **82** results causing the arc quenching gas contained therein to be forced through nozzle **52** past hollow contact head **68** and contact head **120.**

Similarly, the movement of second pull rod **44** towards the left as viewed in FIG. **1** causes carrier member **112** pinned to second pull rod **44** by pin **110** to move in a corresponding direction. The movement of carrier member **112** causes second contact assembly **116** pinned to carrier member **112** by pin **114** to move in a corresponding direction. Thus, as movement of first pull rod **32** causes hollow contact head **68** to move towards the right, the movement of second pull rod **44** causes contact head **120** to move towards the left thereby disengaging hollow contact head **68** and contact head **120** breaking the electrical connection and interrupting the circuit. The gas expelled through nozzle **52** by the action of hollow cylinder **82** and cylinder head assembly **84** effects the interruption of the electrical arc established as the contacts **68** and **120** separate.

As second contact rod **118** moves towards the left, second piston **124** correspondingly moves towards the left thereby increasing the volume within cylinder **128.** Thus, the arc quenching gas expelled from gas channel **56** in nozzle **52** is directed by gas shield **138** into the increased volume of cylinder **128** thereby facilitating the flow of arc quenching gas past hollow contact **68** and contact **120** as they separate.

FIG. **3** shows hollow contact head **68** and contact head **120** after separation between these contacts. Because of the movement of contact head **120** and hollow contact head **68** in opposite directions, the distance between these contacts is rapidly increased thereby increasing the recovery voltage withstand capability of the interrupter. Further, the arc quenching gas flowing through channel **56** in nozzle **52** acts upon the arc to assist in its rapid interruption.

The efficiency of the gas pumping action of the circuit interrupting device **10** is increased by virtue of the utilization of cylinder head assembly **84** to force the arc quenching gas through nozzle **52,** and the action of second piston **124** which tends to suck the gas expelled from nozzle **52** into cylinder **128.** This operation produces a more desirable controlled gas flow during the interruption operation thereby increasing the arc interrupting properties of the arc quenching gas as it flows past the separating contact heads **68** and **120.**

The utilization of the linkage arrangement comprising walking beam member **38** and linkage members **36** and **42** produces the desirable increase of contact head separation speed and also maximizes the separation distance between the separated contact heads while minimizing the distance of the input stroke of operating rod **20.** Thus, the amount of input of kinetic energy through operating rod **20** is minimized and the contact separation speed and distance is maximized by virtue of this linkage arrangement.

In addition, to help obtain uniform voltage gradients along the interior of cylindrical housing **12** and across other longitudinally disposed parts of circuit interrupting device **10** to inhibit the formation of corona, the present embodiment uses non-electrical conducting materials for such items as carrier member **112,** carrier member **50,** gas shield **138,** cylinders **82** and **128,** and first and second pull rods **32** and **44.**

Additional advantageous features of the subject invention are the gas pressure indicating assembly **158** and the pressure release device **164.** Gas pressure indi-

cator assembly **158** indicates the internal pressure within circuit interrupting device **10** by the expanstion and contraction of flexible metal bellows **160.** Increased pressure tends to collapse flexible metal bellows **160** thus moving indicator rod **162** outwardly from second end plate **152.** Reduced pressure within circuit interrupting device **10** causes flexible bellows **160** to expand thereby tending to move indicator rod **162** toward second end plate **152.** Some type of visual indicator means may be attached to indicator rod **162** to facilitate the determination of the pressure within circuit interrupting device **10.**

Pressure release device **164** is normally in a sealed position to maintain the arc quenching gas within circuit interrupting device **10.** However, if the pressure within circuit interrupting device **10** exceeds a predetermined level for any reason, pressure release device **164** will release the gas from circuit interrupting device **10** thereby preventing the occurrence of dangerously high pressure.

It should be understood that various changes, modifications, and variations in the structure and the function of the present invention may be effected without departing from the spirit and scope of the present invention as defined in the appended claims.

I claim:

1. A high voltage electrical circuit interrupting device interrupting current flow between a first portion of the circuit and a second portion of the circuit comprising:

a hollow sealed gas tight housing;

an arc quenching gas contained in said housing;

a first movable electrical contact connected to the first portion of the circuit mounted within the housing;

a second movable electrical contact connected to the second portion of the circuit within the housing normally engaging said first contact to complete the electrical circuit;

operating means including:

an operating rod extending through a wall of said housing;

a first pull rod connected to said first contact;

a second pull rod connected to said second contact;

a first mechanical linkage connecting said first pull rod and said operating rod so that movement of said operating rod causes movement of said first pull rod; and

second mechanical linkage connecting said first and said second pull rods so that movement of said first pull rod in one direction causes movement of said second pull rod in an opposite direction;

whereby movement of said operating rod produces movement of said first and second pull rods in opposite directions thereby causing said first and second contacts to move in opposite directions to interrupt the electrical circuit.

2. A high voltage circuit interrupting device, as claimed in claim **1,** further comprising:

gas pump means for causing movement of the arc quenching gas past said first and said second contacts as said first and said second contacts move in opposite directions to electrically disengage.

3. A high voltage circuit interrupting device, as claimed in claim **2,** wherein said gas pump means comprises:

a first piston means operably connected to said first contact so that movement of said first contact causes arc quenching gas to flow past said first contact and said second contact;

a second piston means operably connected to said second contact so that movement of said second contact facilitates the flow of arc quenching gas past said first and second contacts.

4. A high voltage circuit interrupting device, as claimed in claim **3,** wherein said first piston means includes a nozzle means positioned around said first and said second contacts for confining the moving arc quenching gas to the area immediately adjacent said first and second contacts as said first and second contacts are moved in opposite directions to be disconnected.

5. A high voltage circuit interrupting device, as claimed in claim **1,** further comprising sealing means positioned around said operating rod for preventing escape of the arc quenching gas at the point where said operating rod extends through the wall of said housing.

6. A high voltage circuit interruptor, as claimed in claim **5,** wherein said sealing means comprises an expandable and contractable metal bellows sealably connected to said operating rod and to the wall of said housing.

7. A high voltage circuit interruptor, as claimed in claim **1,** further comprising a pressure indicating means mounted on said housing for indicating the pressure of arc quenching gas contained in said housing.

8. A high voltage circuit interrupting device, as claimed in claim **1,** further comprising pressure relief means for releasing arc quenching gas from said housing when the pressure of said gas exceeds a predetermined level.

9. A high voltage interrupting device, as claimed in claim **1,** further comprising:

first electrical conductor means for electrically connecting said first contact to the first portion of the circuit;

second electrical conductor means for electrically connecting said second contact to the second portion of the circuit.

10. A high voltage circuit interrupting device, as claimed in claim **9,** wherein said first electrical conductor means comprises a flexible cable and said second electrical conductor means comprises a flexible cable.

11. A high voltage circuit interrupting device, as claimed in claim **1,** wherein said first contact includes spring loaded contact fingers and said second contact is positioned between said contact fingers when said second contact engages said first contact.

12. A high voltage circuit interrupting device, as claimed in claim **1,** wherein said arc quenching gas is sulfur hexafluoride, SF_6.

13. A high voltage circuit interrupting device comprising:

a cylindrical hollow housing formed of an electrical insulating material having first and second open ends;

first and second end plates sealably covering the first and second open ends of said housing respectively;

an arc quenching gas confined within the space formed by said housing and said first and second end plates;

a first electrical contact slidably mounted within said housing;

a second electrical contact slidably mounted within said housing, said first and second contacts normally engaging one another to complete an electrical circuit;

a first flexible conductor electrically connecting said first contact and said first end plate;

a second flexible conductor electrically connecting said second contact and said second end plate;

operating means connected to said first and second contacts for causing said first and second contacts to move in opposite relative directions to electrically disconnect said first and second contacts;

gas pump means for causing movement of the arc quenching gas past said first and second contacts in response to movement of said first and second contacts.

14. A high voltage circuit interrupting device, as claimed in claim **13,** wherein said operating means comprises:

an operating rod extending through the first end plate;

a first pull rod connected to said first contact;

a second pull rod connected to said second contact;

a linkage member connecting said first pull rod and said operating rod so that movement of said operating rod causes corresponding movement of the first pull rod;

a lever linkage member pivotably mounted at about its middle and connected at one end to said first pull rod and connected at its other end to said second pull rod so that movement of said operating rod causes said first and said second pull rods to move in opposite directions thereby causing said first and second contacts to move in opposite directions so that said first and second contacts disconnect.

15. A high voltage circuit interrupting device, as claimed in claim **14,** wherein said gas pump means comprises:

a hollow cylinder;

a nozzle member attached to said first pull rod and positioned at one end of said hollow cylinder; said nozzle member having a channel formed therein positioned around said first and second contacts;

a stationary piston positioned within said cylinder so that movement of said first pull rod moves said cylinder and said nozzle member relative to said stationary piston thereby forcing arc quenching gas through said channel in said nozzle member past said first and second contacts.

16. A high voltage circuit interrupting device, as claimed in claim **14,** further comprising a flexible sealing means connected around said operating rod and said first end plate for preventing the escape of arc quenching gas from the space formed by said housing and said first and said second end plates.

17. A high voltage circuit interrupting device, as claimed in claim **13,** further comprising a pressure indicating means for indicating the pressure of the arc quenching gas contained within the space formed by said housing and said first and said second end plates.

18. A high voltage circuit interrupting device, as claimed in claim **13,** further comprising pressure relief means for releasing arc quenching gas from the space formed by said housing and said first and second end plates when the pressure exceeds a predetermined level.

19. A high voltage circuit interrupting device, as claimed in claim **13,** wherein said first contact includes spring loaded segmented contact fingers and said second contact is positioned between the contact fingers when said first and second contacts are electrically engaging.

20. A high voltage circuit interrupting device, as claimed in claim **16,** wherein said flexible sealing means comprises an expandable and contractable metal bellows.

21. A high voltage circuit interrupting device, as claimed in claim **13,** wherein said arc quenching gas is sulfur hexafluoride, SF_6.

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