United States Patent [19]

Aumayer

[11] **3,909,571**

[45] **Sept. 30, 1975**

[54] **CONTACT STRUCTURE FOR HIGH VOLTAGE GAS BLAST CIRCUIT INTERRUPTER**

[75] Inventor: **Hansruedi Aumayer,** Harleysville, Pa.

[73] Assignee: **I-T-E Imperial Corporation,** Spring House, Pa.

[22] Filed: **Sept. 19, 1973**

[21] Appl. No.: **398,871**

[52] **U.S. Cl.** ..... **200/148 R;** 200/148 B; 200/145

[51] **Int. Cl.**[2] **H01H 33/64**

[58] **Field of Search** ..... 200/148 R, 148 B, 148 E, 200/148 BV; 145

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Primary Examiner—Robert S. Macon

Attorney, Agent, or Firm—Ostrolenk, Faber, Gerb & Soffen

[57] **ABSTRACT**

The cooperating stationary and movable contacts of a gas blast interrupter are each formed as elongated, tubular contacts which are slotted from one end to form contact fingers flexible at only one end. The fingers of the stationary contact engage the solid hub end of the movable contact, and the movable contact fingers slide on a stationary conductive tube.

7 Claims, 6 Drawing Figures

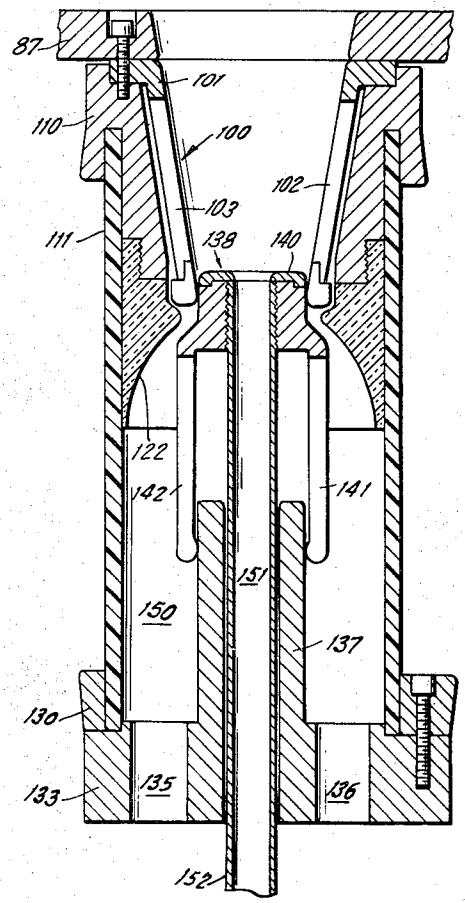
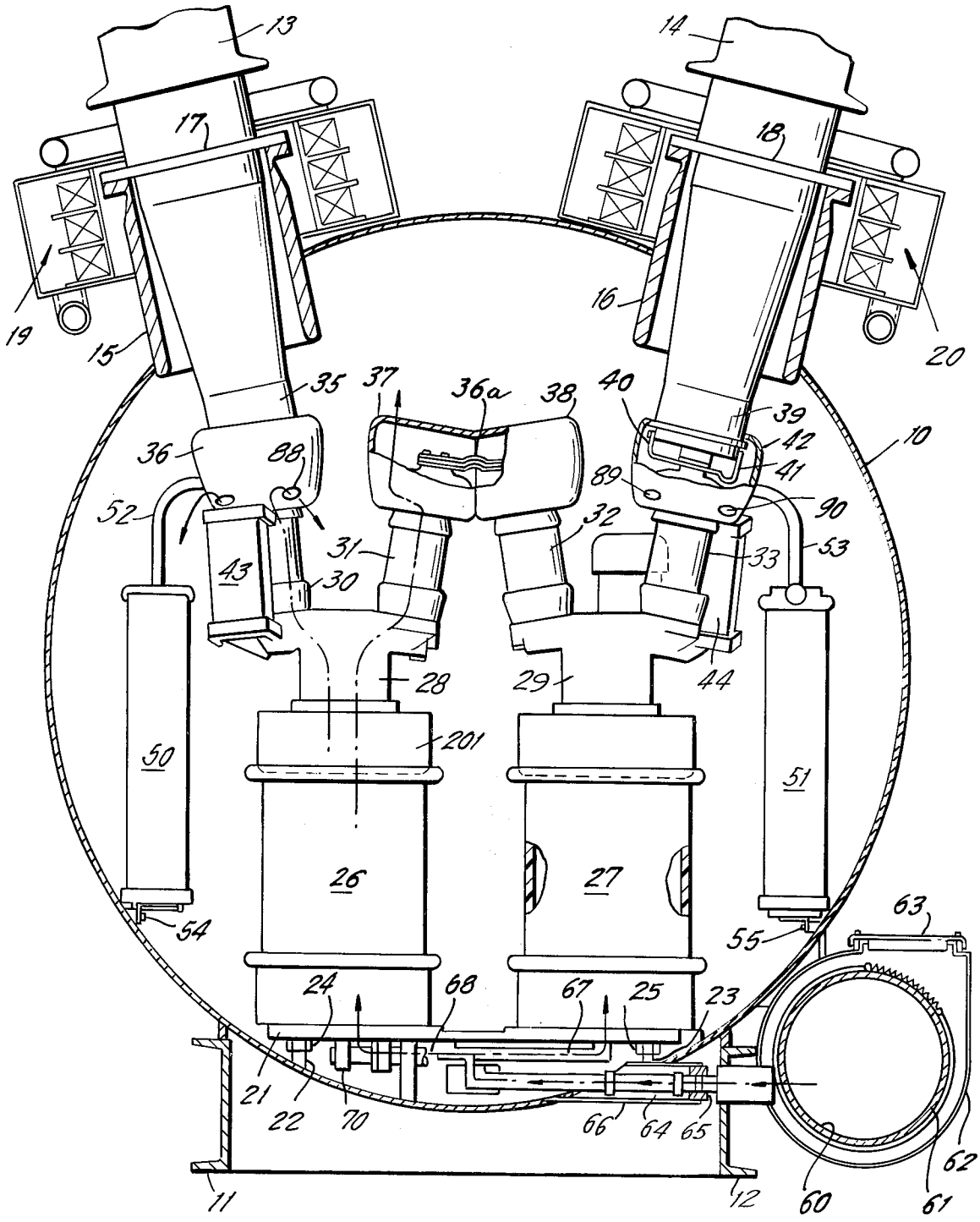


FIG. 1


13
14
17
18
19
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16
20
35
37
36a
38
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39
42
41
10
36
88
89
90
52
32
53
31
33
43
30
28
29
44
201
50
51
26
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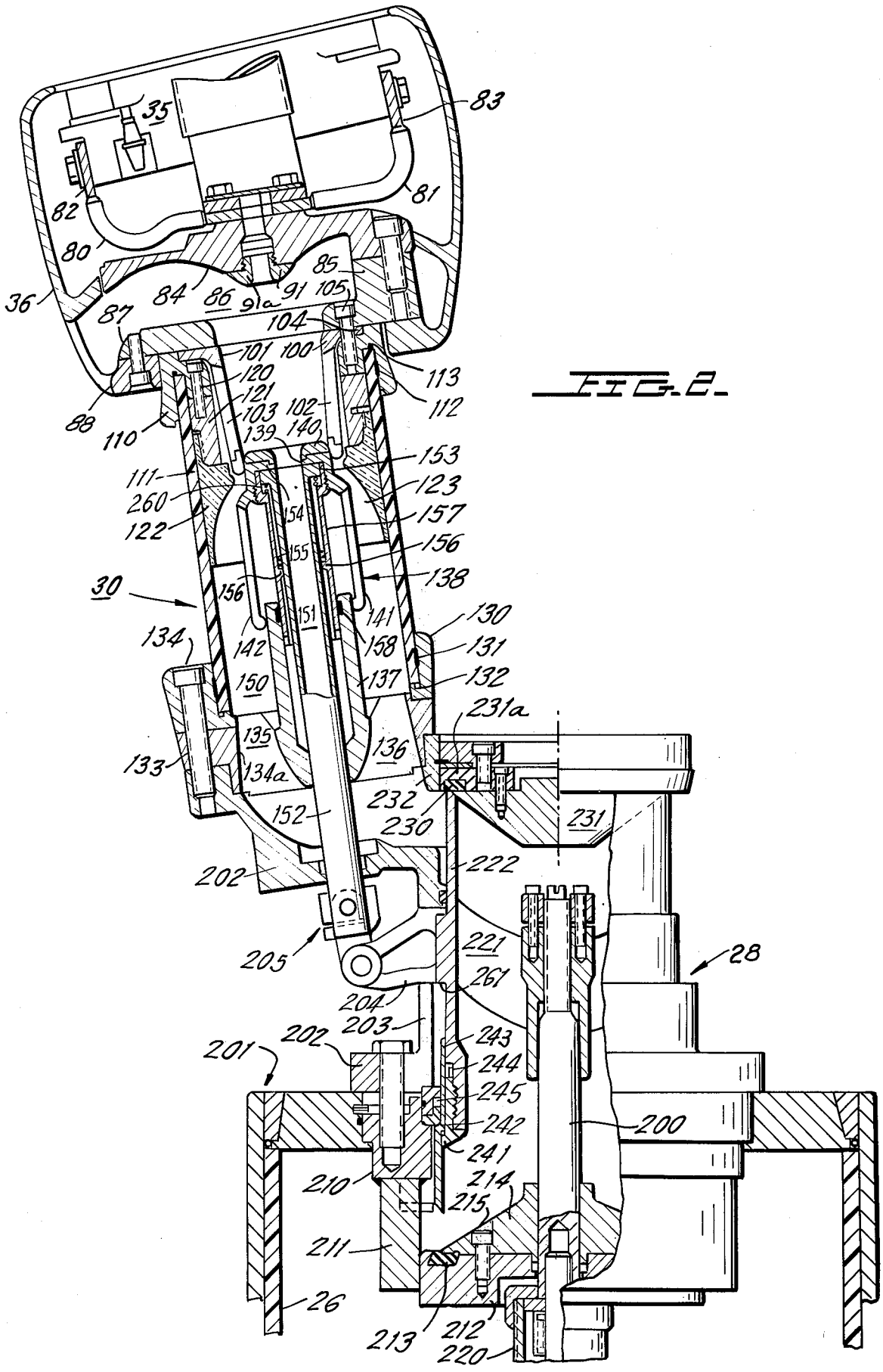

35
83
81
82
80
85
36
84
86
91a
91
105
87
104
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100
120
113
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112
88
110
103
102
139
140
153
111
123
260
154
157
122
155
156
138
30
156
151
141
130
134
142
158
131
150
137
132
231a
135
136
133
134a
232
230
231
152
222
202
205
221
28
261
204
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201
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211
26
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212
220

FIG. 2

FIG. 2a

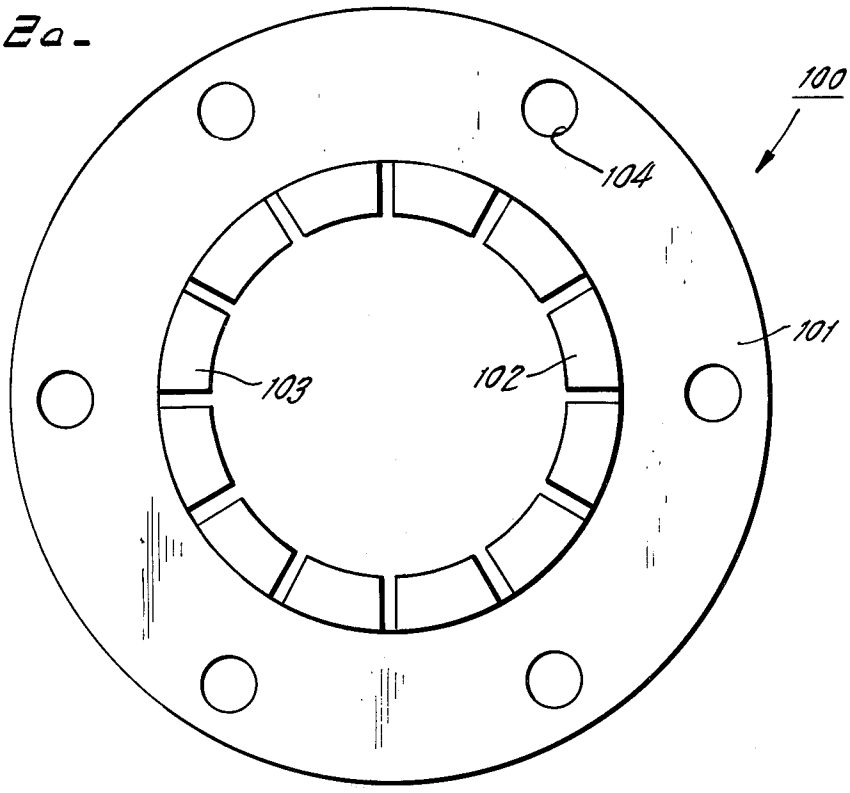


FIG. 2b

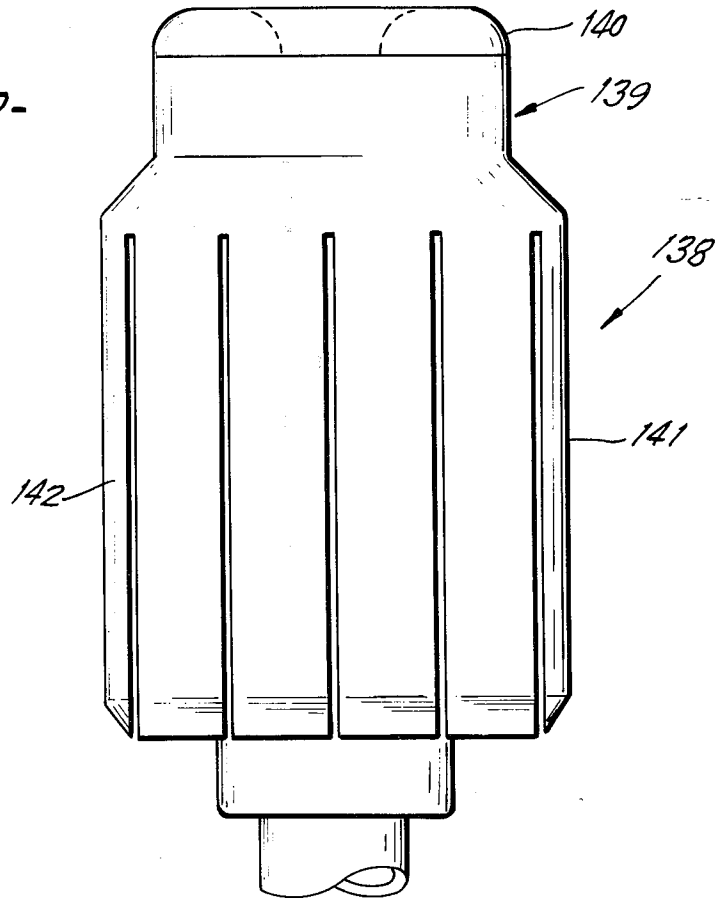


FIG. 3

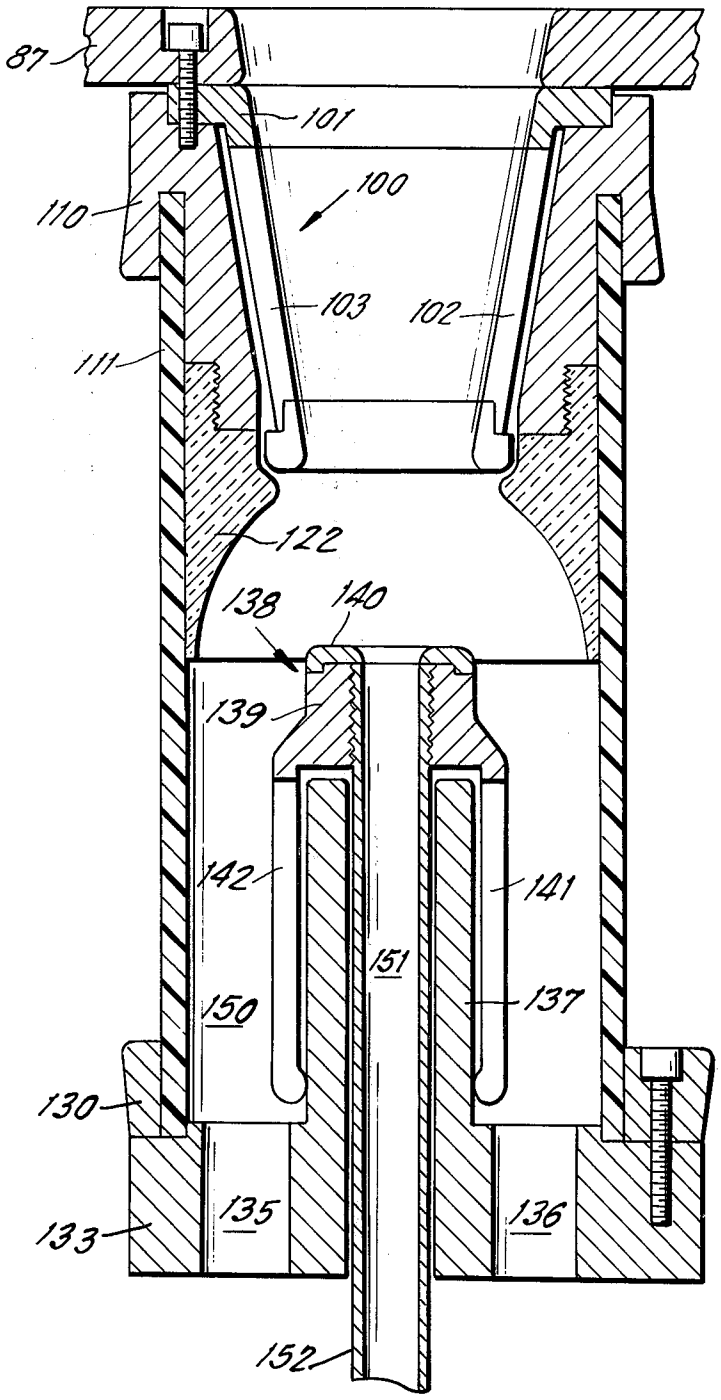
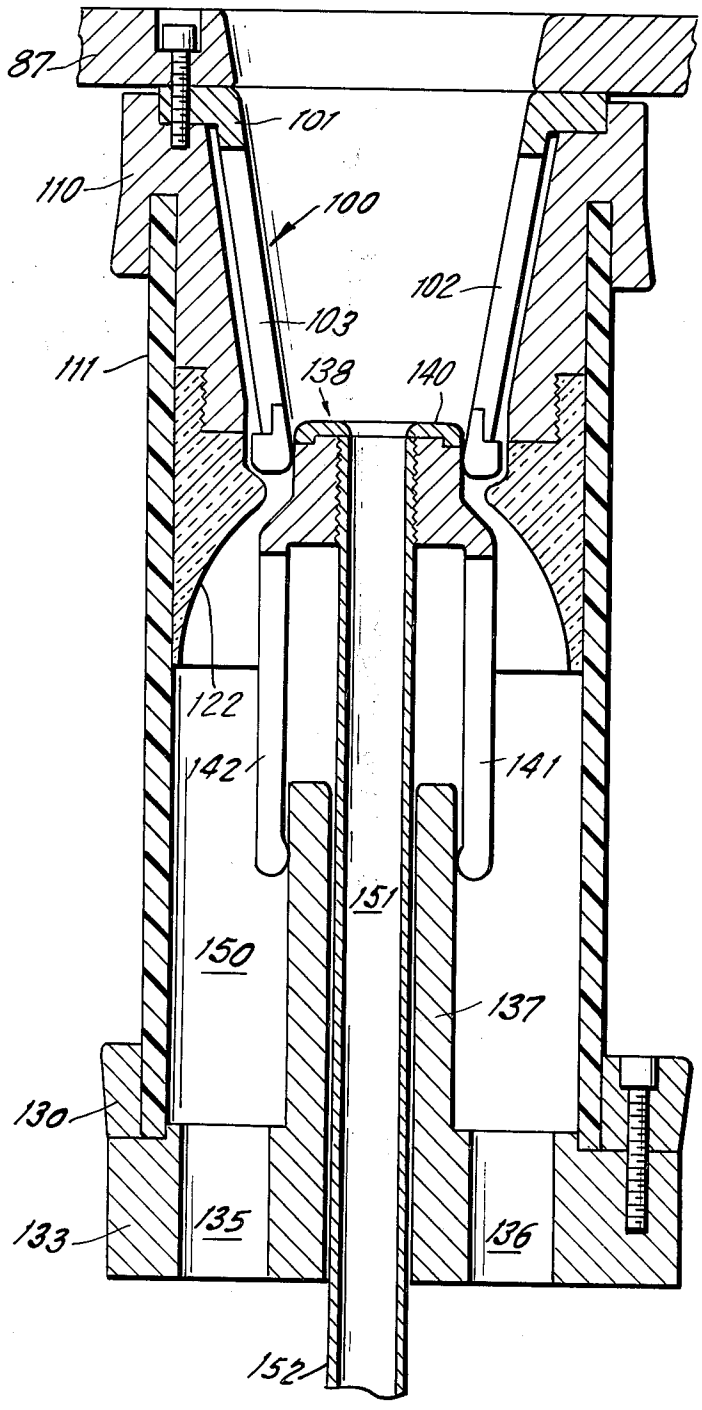

87
101
100
110
103
102
111
122
138
140
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142
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137
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135
136
133
152

FIG. 4


87
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152

CONTACT STRUCTURE FOR HIGH VOLTAGE GAS BLAST CIRCUIT INTERRUPTER

RELATED APPLICATIONS

This application is related to copending application Ser. No. 398,870, filed Sept. 19, 1973, entitled CONTACT FOR HIGH VOLTAGE GAS BLAST CIRCUIT BREAKER WITH TIME-DELAYED OPENING, in the name of L. J. Kucharski; Ser. No. 398,869, filed Sept. 19, 1973, entitled MECHANICAL SUPPORT OF TRANSIENT RECOVERY VOLTAGE CAPACITOR WITHIN CIRCUIT BREAKER LOW PRESSURE TANK, in the name of L. D. McConnell; and Ser. No. 398,868, filed Sept. 19, 1973, entitled GAS CIRCUIT BREAKER INSULATING TUBE SUPPORT AND HIGH PRESSURE VESSEL, in the name of G. P. Guaglione et al., all of which are assigned to the assignee of the present invention.

BACKGROUND OF THE INVENTION

This invention relates to high voltage gas blast interrupters, and more specifically relates to a novel cooperating contact structure for high voltage gas blast breakers.

High voltage gas blast breakers are well known to the art, and are shown, for example, in U.S. Pat. 3,526,734, issued Sept. 1, 1970, entitled DEAD TANK GAS BLAST CIRCUIT BREAKER WITH INTERRUPTER STRUCTURE IMMERSED IN LOW PRESSURE OF DEAD TANK, in the name of D. H. McKeough, and in copending application Ser. No. 175,507, filed Aug. 27, 1971, now issued as U.S. Pat. No. 3,823,289, entitled INTERRUPTER STRUCTURE FOR CIRCUIT BREAKER WITH INDIVIDUAL BLAST VALVES AND TIME-DELAYED UPSTREAM CUTOFF VALVE, in the name of L. D. McConnell et al., each of which is assigned to the assignee of the present invention.

It has been found that, in contact structures where a movable contact slides on a stationary contact tube, as in the above arrangements, there is burning between the sliding movable contact and the conductive tube which slidably supports the movable contact. This burning is believed to be due to bounce of the movable contact fingers on the conductive tube at the time of contact separation between the movable and stationary interrupter contacts. The construction of contacts of the prior art devices is also complicated and required numerous complexly machined parts and separate contact finger biasing springs.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with the present invention, both the stationary and moving contacts are formed by tubular conductive members, one end of each being solid and the remainder being slotted to define self-biased and segmented contact fingers. The solid central hub of the movable contact is engageable and disengageable with the segmented end of the stationary contact. The segmented fingers of the movable contact slide over the outer surface of a conductive member. It has been found that, when using this arrangement, substantially no shock wave is transmitted through the movable contact fingers at the time of contact separation. Therefore, little or no burning due to contact bounce is experienced on the movable contact fingers or the surface of the conductive support on which they slide.

A further significant advantage of the invention is that the contact fingers of both the stationary and movable contacts are relatively simply constructed and are self-biased to a given rest position. The fingers are then flexed to a greater diameter when they engage their respective solid cylindrical surfaces (the solid movable contact hub is engaged by and spreads the stationary contact fingers, and the outer surface of a stationary conductive cylinder is slidably engaged by and spreads the movable contact fingers) to cause inherent strong contact biasing forces since the contact fingers are elastically deformed and tend to return to their rest position. Therefore, contact springs are avoided and, in general, considerable economy and reliability is achieved with the use of the new contact structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view of a circuit breaker which employs the novel contacts of the present invention where a portion of the grounded support tank of the circuit breaker has been removed to expose the various components therein.

FIG. **2** is a cross-sectional view through one of the interrupters of the circuit breaker of FIG. **1** and illustrates the novel contact structure of the present invention.

FIG. **2***a* is a top plan view of the stationary contact of FIG. **2.**

FIG. **2***b* is a side plan view of the movable contact of FIG. **2.**

FIG. **3** is a cross-sectional view of a contact structure constructed in accordance with the invention without the time delay feature of the contact shown in FIG. **2** where the contacts are in the open position.

FIG. **4** is similar to FIG. **3** and illustrates the contacts in their closed position.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring first to FIG. **1,** there is shown, in partial section, one phase of a high voltage circuit breaker which incorporates the present invention, as will be later described. The circuit breaker of FIG. **1** can, for example, be rated at 230,000 volts and at 63,000 amperes. Conventionally, the breaker will be a three-phase breaker and two other and identical phases to the one shown in FIG. **1** will also be provided.

In general, the circuit breaker phase of FIG. **1** is contained within a generally flattened spherical metallic tank **10** which is supported on metallic frame angle members **11** and **12.** Angles **11** and **12** are suitably reinforced and extend rearwardly and support additional tanks to tank **10,** which are spaced from the tank **10** and disposed generally parallel to tank **10** and constitute the other phases of the circuit breaker. The metallic tank **10** is a grounded housing and the circuit breaker shown herein for purposes of illustrating the invention is shown in a "dead tank" configuration.

The terminal bushings for the breaker may be of any standard type and are shown for illustration herein as including the bushings **13** and **14** which extend through cylindrical shrouds **15** and **16,** respectively, which are appropriately welded or otherwise secured to the tank **10** and are sealed relative to the interior of the tank. Gas barriers **17** and **18,** respectively, are provided to prevent the leakage of gas from tank **10.** Thus, tank **10** is filled with sulfur hexafluoride gas (or a gas mixture which includes sulfur hexafluoride) at a pressure of

about 3 atmospheres. For purposes of the invention, any dielectric gas at any appropriate pressure could be used. For the embodiment described herein, the gas pressure within tank **10** will be designated a relatively low pressure.

Each of the bushings **13** and **14** is further associated with current transformers **19** and **20**, respectively, which may also be of any desired construction.

A grounded flat support platform **21** is contained within the tank **10** and is supported from the bottom of tank **10** by welded support members, such as bolts **22** and **23** and others not shown. Platform **21** sits on leveling nuts, such as nuts **24** and **25**, respectively, of the support bolts. The platform **21** then serves as a level mount for the circuit interrupter equipment to be contained within tank **10**. In the case of the breaker shown in FIG. **1**, four interrupters are to be connected in series with one another to define the circuit breaker voltage rating of 230 KV. Platform **21** supports two spaced hollow tubular insulation support members **26** and **27**, respectively, which further serve the purpose of high pressure gas reservoirs as is more fully described in copending application Ser. No. 398,868, referred to above.

Each of the insulation support members **26** and **27** support, at their tops, respective blast valve housings **28** and **29** which, in turn, support series-connected interrupter units **30–31** and **32–33**, respectively. Each of the interrupter units contains a pair of interrupter contacts which are simultaneously opened in the presence of a blast of gas which assists in extinguishing the arc. It is to be noted that the tubes **26** and **27**, blast valve housings **28** and **29**, and interrupters **30** to **33** are mechanically supported solely from the platform **21** and that none of these components are supported from the bushings **13** and **14** or intermediate supports for the interrupters **31** and **32**.

The top of interrupter **30** is electrically connected to the stud **35** of terminal bushing **13** through a flexible connection, which will be later described. The connection between the top of interrupter **30** and stud **35** is then covered by a corona shield **36**.

The bottom of interrupter **30** is then connected through housing **28** to the bottom of interrupter **31**. The top of interrupter **31** is connected through flexible shunts **36a** to the top of interrupter **32** with the tops of interrupters **31** and **32** and flexible connectors covered by corona shields **37** and **38**, respectively.

The bottom of interrupter **32** is then connected through the blast valve housing **29** to the bottom of interrupter **33**. The top of interrupter **33** is in turn connected to the stud **39** of bushing **14** by flexible connectors, such as flexible connectors **40** and **41**. The connection previously referred to between interrupter **30** and stud **35** incorporates flexible connectors, such as the connectors **40** and **41**. The connection to stud **39** is then covered by the corona shield **42**.

FIG. **1** also shows voltage distributing impedances **43** and **44** connected across interrupters **30** and **33**, respectively. Note that any suitable arrangement of parallel-connected capacitors or resistors could be used across the various interrupters **30** to **33** in order to assure appropriate distribution of steady state and transient voltages across the series-connected breaks.

FIG. **1** illustrates the provision of transient recovery voltage capacitors **50** and **51** which are to be connected from either of the line sides of the breaker to ground. It will be noted that the flattened elliptical shape of tank **10** makes available free space in the outer central regions of the tank so that these capacitors can be mounted within this space without interference with the operation of the breaker or without interference with the dielectric integrity of the breaker. The mounting of these capacitors is the subject of copending application Ser. No. 398,869.

It will be noted from FIG. **1** that the upper terminals of each of capacitors **50** and **51** are connected by relatively rigid conductors **52** and **53** to the tops of interrupters **30** and **33**, respectively, and are directly and solidly connected to the bushing studs **35** and **39**, respectively. The bottoms of capacitors **50** and **51** are then mechanically and electrically connected to the tank wall **10** by the support and grounding brackets **54** and **55**, respectively.

The transient recovery voltage across the breaker is then controlled by the capacitors **50** and **51** in the manner generally set forth in U.S. Pat. No. 3,383,519, it being noted that each of capacitors **50** and **51** may have a value of approximately 0.0025 microfarads or any other desired value selected by the circuit designer.

The interior of the insulation reservoirs **26** and **27**, which communicate with the blast valve housings **28** and **29** and thence to the interrupters **30** to **33** is at a relatively high pressure, such as **15** atmospheres of the same dielectric gas which fills tank **10**.

The major pressure source for the breaker is an elongated cylinder **60** which is filled with gas at high pressure and which may be covered with a heater blanket **61** to ensure that the gas temperature will always be sufficiently high to maintain it in a gaseous state. A protective shroud **62** covers the cylinder **60** (which may extend the full length of all of the phases of the breaker), with portholes such as porthole **63** being available to permit maintenance of the cylinder **60** and the blanket **61**. A suitable gas control system, which need not be described to understand the present invention, provides suitable gas conduits and gas controls to conduct gas from the cylinder **60** through the conduit **64** which passes through a sealing plug **65** in tube **66** which is secured to tank **10**.

The high pressure conduit **64** then extends through a T-shaped member and into conduits **67** and **68** as generally outlined by the arrows, in FIG. **1**, such that high pressure gas is admitted to the interior of insulation reservoirs **26** and **27**. As will be later described, this gas is normally sealed at the blast valve housings **28** and **29** and high pressure gas is released through the interrupters **30** and **33** and into low pressure tank **10** only when the contacts of the interrupters are operated.

A suitable mechanical operating mechanism (not shown herein) is provided to mechanically actuate crank arms, such as crank arm **70** associated with tube **26**, which drive operating rods which extend through the center of support tubes **26** and **27** and upwardly to blast valve housings **28** and **29**. Similar crank arms will be associated with each of the other interrupters of each phase of the breaker. Any conventional operating mechanism, such as a spring operated mechanism or hydraulically operated mechanism is then connected to each of the crank arms so that all blast valves and contacts can be simultaneously operated to either open or close all interrupter contacts.

The specific details of one interrupter structure, such as the interrupter **30** of FIG. **1** and a portion of the blast

valve housing **28**, are shown in FIG. **2**. Referring now to FIG. **2**, the interrupter and blast valve are shown in cross-section and at the top of FIG. **2**. As will be later described, interrupters **30** to **33** are subassembled units which can be easily installed when the breaker is assembled. Thus, FIG. **2** shows two flexible shunts **80** and **81** which have upper connectors **82** and **83** which are appropriately bolted to the stud **35** of bushing **13**, while the other ends of shunts **80** and **81** are bolted to an upper conductive adapter member **84** of the interrupter **30**. Note that the stud **35** does not serve as a mechanical support for the interrupter components.

The upper adapter **84** is bolted to a second adapter portion **85** with the two components **84** and **85** defining a volume **86** which leads to discharge ports such as the discharge port **87** which is positioned adjacent a similar port **88** in the shield **36**. Note the position of port **88** in FIG. **1**.

Additional ports are distributed around the periphery of shield **36** which lead to similar openings defined between adapter members **84** and **85**. Two further ports of this general type are shown in FIG. **1** for shield **42** as the ports **89** and **90**.

The adapter member **84** further serves to threadably receive a tubular arcing terminal **91**. Note that arcing terminal **91** has an opening **91***a* therethrough which extends upwardly so that some arc venting can be directly vertically upward along the axis of the opening in arcing terminal **91**.

The use of flexible shunts to make the connection from the top of interrupter **30** to the terminal bushing stud **35** is made possible since the entire mass of interrupter structure **30** is supported on top of the blast valve housing **28**. In prior art arrangements, such as the arrangement shown in U.S. Pat. No. 3,526,734, the stationary contact structure of the interrupter is rigidly fastened to and carried by the end of the terminal bushing. This structure required careful alignment of the interrupter components during assembly of the breaker and during its operation. The structure shown in FIG. **2** eliminates the need for alignment during assembly of the circuit breaker and simple flexible shunt members **80** and **81** are used to connect the top of the preassembled interrupter **30** to the terminal bushing stud **35**. Similar advantages apply to the connection between the top of interrupter **33** of FIG. **1** and the terminal bushing stud **39**.

As previously described in connection with FIG. **1** the tops of interrupters **31** and **32** are connected in series by the flexible shunt **36***a*. This is to be contrasted to the prior art arrangement of U.S. Pat. No. 3,526,734 which required a separate support insulator extending from the top of the housing **10** which would physically carry the stationary contacts for interrupters **31** and **32**. By supporting interrupters **31** and **32** from the blast valve housings **28** and **29**, the separate support insulator and the alignment problems which were caused by the separate mounting of the stationary contacts of these interrupters are eliminated.

The interrupter **30** of FIG. **2** contains an elongated, generally tubular stationary contact member **100** which has an upper solid ring-shaped end **101** and slots which form segmented contact fingers, such as fingers **102** and **103** in its other end. The segmented fingers of contact **100** are also shown in FIG. **2***a* which is a top end view of the contact **100**. It will be further noted that the ends of the segmented contacts, such as segmented finger contacts **102** and **103** terminate with arcing contact inserts which may have been formed as an insert ring which was brazed to the tubular contact member before the tubular member was slotted to form the segmented finger.

FIG. **2***a* further illustrates openings such as opening **104** in the solid flange **101** which accepts the bolts, such as bolt **105** which secures the stationary contact to adapter member **85**. The bolts which pass through the openings in flange **101** of stationary contact **100** are threaded into a conductive ring **110** which clamps the end side of flange **101** against adapter member **85**. Ring **110** serves as an upper support for the insulation tube **111** which is the interrupter housing tube. Tube **111** may be made of any desired material, such as an epoxy reinforced glass tube or the like. The upper end of tube **111** is suitably secured to and sealed with respect to ring **110** as by the securing key **112** and sealing ring **113**.

A set of bolt openings is formed in the inner diameter of ring **110** and these bolt openings receive bolts, such as bolt **120**, which threadably engage ring member **121** and hold it in position. The exterior lower portion of ring **121** is threaded and threadably receives the insulation baffle **122** which may be of a suitable arc-resistant material such as Teflon, and serves as a guide for blast gases during the opening operation of the interrupter, and as a means to protect or shield tube **111** from the hot gases created during arc interruption. Baffle **122** also contains a plurality of thin, axially directed and circumferentially spaced fins, such as fin **123**. These fins then prevent the formation of a vortex in the gas blast which is guided by baffle **122**.

The lower end of insulation tube **111** is fixed in a conductive support ring **130** and is fixed therein and sealed thereto as by the key **131** and sealing ring **132**. The ring **130** is, in turn, secured to a spider plate **133** as by bolts, such as bolt **134**, where the spider plate is formed of a conductive disk **134***a* having radially extending web sections such as sections **135** and **136** which are joined to a centrally extending hollow conductive shaft **137**. The shaft **137** then slidably receives the segmented movable contact **138** which is slidably engaged with the outer surface of shaft **137**.

The movable contact **138** consists of a generally tubularly shaped member having a solid ring-shaped end **139** which receives a solid arcing ring **140**, with the lower end of contact **138** being segmented to form separate contact fingers, such as fingers **141** and **142**.

FIG. **2***b* shows a side plan view of the movable contact **138**. The segmented finger elements **138** and **142** along with other similar fingers are flexed outwardly from their normal relaxed position, and are therefor biased inwardly and into sliding engagement with the outer surface of shaft **137**. The solid upper end **139** of movable contact **138** is movable into and out of engagement with the segmented fingers, such as fingers **102** and **103** of stationary contact **100**. When the segmented fingers **102** and **103** engage the contact **100**, they are elastically flexed outwardly to inherently provide contact pressure to form a good low resistance contact.

It will be noted, during contact operation, that the baffle **122** will lead high pressure gas up from the annular volume **150** which surrounds movable contact **138** and into the baffle **122** and then between the separating contacts **138** and **100**. The gas will also flow in two di-

rections through the arc, both through the center of stationary contact **100** and the opening in arc terminal **91,** and through the central opening in contact **138** shown as opening **151.**

The movable contact **138** is connected to an operating shaft **152** (which contains the opening **151**) and the upper end of shaft **152** is provided with flange **153.** The flange **153** is engageable with the rear surface **154** of the movable contact **138** and also receives a compression spring **155.** The compression spring **155** is seated at its bottom on a ledge **156** of a spring retaining cylinder **157** which is threadably secured within the upper end of contact **138.** The bottom of cylinder **157** slides within the interior of conductive tube **137** and slides on a seal **158** within the shaft **137.** The operation of the interrupter contacts described above will be later described after the blast valve arrangement and support of the interrupter from the blast valve housing **28** is described.

As is shown in FIG. **1,** the blast valve housing **28** supports both interrupters **30** and **31.** One lateral half of the blast valve housing **28** is shown in FIG. **2** insofar as it relates to the support of interrupter **30.** It will be noted, however, that the blast valve housing **28** is symmetric so that the same structure shown in connection with interrupter **30** is provided on the opposite side of the center line **200** in FIG. **2** for the support and operation of interrupter **31.**

The insulation support member **26** of FIG. **1** is partly shown in FIG. **2** and it is seen that a metal end cap **201** is fitted over and sealed to the top of insulation tube **26.** The metal cap **201** then serves as the support for the conductive support casting **202** of the blast valve housing **26.** Casting **202** is provided with a slot **203** therein for passing an arm **204** which is appropriately connected to the operating shaft **152** by the adapter fitting **205.**

Cap **201** further serves to support ring **210** and circumferentially distributed posts such as posts **211** which are welded to ring **210.** The posts **211** are then welded to a valve seat plate **212** which carries the cutoff valve ring **213** of the blast valve as will be later described. The valve ring **213** is then held in position by a clamp **214** which is clamped into engagement with ring **213** by bolts such as bolt **215.**

The main operating rod **220,** which extends from the crank **70** of FIG. **1** then extends through plate **212** and clamping member **214** (in sealed relation therewith) and is connected to radiating arms, such as arm **221** of the blast valve sleeve **222.** Note that sleeve **222** also carries the operating arm **204.**

The upper end of blast valve sleeve **222** is engageable with upper blast valve seal **230** which is clamped in position by the clamping plate **231***a*. The ring-shaped valve seal **230** is carried on plate **231** which is generally supported by a ring **232** which is an integral portion of the casting **202.**

The main blast valve sleeve **222** extends downwardly and is threadably secured to ring-shaped member **240** which has an outwardly projecting flange **241.** Flange **241** is engageable with a shoulder **242** on an auxiliary sliding sleeve **243.** Note that suitable sliding seals **244** and **245** seal these sliding surfaces against pressure loss of high pressure gas which is in the interior of cap **201.**

It is now possible generally to describe the operation of the interrupter and blast valve of FIG. **2.** With the components in the position shown, the interrupter is closed and a current path is formed from terminal bushing stud **35** through the flange shunts **80** and **81** and into the adapter members **84** and **85** and the stationary contact **100.** The current then transfers from stationary contact **100** into the movable contact **138** and the contact fingers **141** and **142** and into the conductive tube **137.** From the conductive shaft **137** the current passes through casting **202** and then to interrupter **31** which is also supported on the blast valve housing **28.** The current then proceeds through the interrupters **31, 32** and **33** in the same manner and exits at bushing **14.**

While the breaker is closed, the high pressure gas from within the insulating support tube **26** fills the volume defined by the annular open gap between the bottom seal **213** and sleeve **243** and upwardly within sleeve **222** and up to the valve seat **230.** The interior of interrupter **30** is at the relatively low pressure of the interior of tank **10,** as contrasted to the high pressure which is held at the valve seat **230.**

In order to open the circuit breaker, the circuit breaker operating mechanism (not shown) is actuated to cause all of the operating rods, such as operating rod **220** to move simultaneously. The downward movement of rod **220** causes the sleeve **222** to move downwardly thereby to open the seal between the upper end of sleeve **222** and the valve seat **230.** This permits the high pressure gas within sleeve **222** to move into the chamber which contains spider members **135** and **136** and upwardly through the annular channel **150** within the insulation tube **111.** Thus, the pressure within the annular volume **150** begins immediately to increase.

At the same time, the downward movement of sleeve **222** causes the shaft **152** to move downwardly and, initially, the upper flanged end **153** of shaft **152** will cause the spring **155** to begin to compress. This introduces an increasing downward force on the seal sleeve **157** and thus on the movable contact **138** which is connected to sleeve **157.** Initially, however, the contact **138** does not move since the frictional forces between the segmented fingers, such as fingers **141** and **142** of the movable contact against the outer surface of shaft **137** and the frictional force between upper contact end **139** and the segmented contacts of the stationary contact **100** are sufficiently high to prevent contact motion. Ultimately, however, the spring force becomes sufficiently high as to drive the movable contact **138** downwardly, thereby causing the separation of the contact **138** from the segmented fingers of the stationary contact **100** with a snap action. Note that eventually the flange **153** will pick up shoulder **260** of sleeve **157** if the movable contact does not begin to move under the force of the compression spring **155** alone.

As the contact tip **140** separates from the arcing contact finger portions of the segmented stationary contact **100,** an arc is drawn between them. Substantial gas pressure has already been established within chamber **150** and high pressure gas may begin to flow between the separating contacts even prior to inception of the arc as when the contact separation is somewhat delayed by the lost motion connection between shaft **152** and the movable contact **138.**

As the contacts **100** and **138** separate, sulfur hexafluoride or a similar interrupting gas passes rapidly through the annular region of contact separation with a portion of the gas flowing into channel **151** and another portion of the gas flowing upwardly and through

the central opening in arc terminal **91**. The majority of the gas, however, is blasted into the interior of tank **10** through openings in the shield **36** such as the port **88** in FIG. **2**.

AS the contacts separate, the upper arc root will seat on the arc terminal **91** and the lower arc root will extend from the arcing tip **140**. The arc is quickly extinguished under the influence of the rapidly moving sulfur hexafluoride gas.

At the time the arc is extinguished, the sleeve **222** has moved sufficiently downward so that the shoulder **261** in the outside of the sleeve **262** has picked up the lower sleeve **243** so that the sleeve **243** is moved downwardly and into engagement with valve seat **213**. This operation then cuts off the further flow of high pressure gas from the interior of cap **201** toward the interrupter, thereby to conserve the high pressure gas in the reservoir.

In order to reclose the breaker, the operating rod **220** is moved upwardly so that the contact operating rod **152** moves upwardly to reclose the contacts. Little or no gas blast is necessary during the closing operation. Therefore, there is a time delay in the re-opening of the blast valve. Thus, the sleeve **243** remains sealed against seal **213** until sleeve **222** and its outwardly facing extension **241** move to a sufficiently high position that extension **241** engages the shoulder **242** of sleeve **243**. At this point, the lower valve seat **213** is opened so that gas can flow for the very short time until the upper end of sleeve **222** seats against seal **230**.

An important advantage of the contact structure described above is that the contact structure has few parts and no separate contact biasing springs. Thus, the contact arrangement is inexpensive and reliable. Moreover, it has been found that by arranging the contacts so that the segmented contact fingers extend from solid tubular ends for both contact **100** and contact **138**, a shock wave is not transmitted through the moving contact fingers **138** and **142** at the time of contact separation. Therefore, there is no bouncing of the segmented contact fingers **138** and **142** on the outer surface of conductive shaft **137** so that there is no burning at this surface which burning would cause a high contact resistance.

A further advantage of the structure of FIG. **2** is that a time delay structure is easily built into the movable contact of the segmented contact configuration to ensure that gas blast action has started before the contacts separate.

A further advantage of the contact configuration shown is that, when the contacts open, the nozzle area for allowing rapid flow of gas from annular region **150** is snapped open with the opening of the contacts, thereby allowing an extremely large passage for the flow of high pressure gas immediately after contact separation.

FIGS. **3** and **4** show a second embodiment of the contact structure of the present invention without the time delay feature of FIG. **2** which uses the sleeve **157** and spring **155**. In all other respects, the structure of FIGS. **3** and **4** is similar or identical to the arrangement of FIGS. **2**, **2***a* and **2***b* and similar components have been given similar identifying numerals.

FIG. **3** shows the contact structure of the invention in the open position, where the operating rod **152** has been moved downwardly. Note that the operating rod **152** is secured directly to contact **138** as by threading to the interior in the upper end of opening contact **138**.

In FIGS. **3** and **4**, and as was the case in FIG. **2**, the stationary and moving contacts **100** and **138**, respectively, consist of a plurality of segmented contact fingers. The required contact force is, therefore, obtained by elastic deflection of the contact fingers from their rest position when the contacts engage their respective surfaces. Thus, no additional contact springs are necessary to provide the needed contact pressure. Moreover, the design of FIGS. **3** and **4** has been found to prevent the transmission of a shock wave through the movable contact fingers at the time of contact separation so that there is no bouncing of segments **141** and **142** on the surface of shaft **137** and thus no burning at that surface.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited not by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which, an exclusive privilege or property is claimed are defined as follows:

1. In a circuit interrupter:

an integral, generally tubular stationary contact, one end of said generally tubular contact being segmented in an axial direction to define a generally circular cluster of contact fingers;

an integral, generally tubular movable contact movable into and out of engagement with said stationary contact, one end of said generally tubular movable contact being segmented in an axial direction to define a generally circular cluster of contact fingers, the opposite end of said movable contact being a generally solid ring; said contact fingers extending for the major length of said generally tubular movable contact from said one end of said generally tubular movable contact to said generally solid ring of said generally tubular movable contact;

said tubular stationary and movable contacts being coaxial; said solid ring end of said movable contact being movable into engagement with surfaces of said circular cluster of contact fingers of said stationary contact and having a diameter different than the diameter defined by said surface of said cluster of stationary contact fingers when they are unflexed, thereby to create a given contact pressure when said movable and stationary contacts are in engagement;

a generally stationary conductive tube supported in insulated relation with respect to said stationary contact;

said tubular movable contact being coaxial with respect to said stationary conductive tube and being in sliding contact engagement therewith; said segmented movable contact fingers engaging a surface of said conductive tube; said conductive tube having a diameter different than the diameter defined by the engaging surfaces of said movable contact fingers when they are unflexed, thereby to create a given contact pressure when said movable contact slides relative to said conductive tube; whereby contact bounce of said movable contact fingers is substantially eliminated;

and an operating mechanism for applying high forces over a relatively short time to said movable contact, thereby to move said movable contact into and out of engagement with said stationary contact, and wherein substantially no shock force is transmitted to the region of sliding engagment between said movable contact fingers and said stationary conductive tube when said movable contact moves out of engagement with said stationary contact; said operating mechanism including an elongated operating shaft disposed coaxially with said movable contact and extending through the center of said stationary conductive tube, and having one end thereof fixed to said solid ring end of said movable contact.

2. In the circuit interrupter of claim **1**, wherein said stationary contact fingers engage and are flexed outwardly by the outer surface of said solid ring portion of said movable contact, and wherein said movable contact fingers engage and are flexed outwardly by the outer surface of said conductive tube.

3. In the circuit interrupter of claim **1**, wherein said stationary contact and stationary conductive tubes are connected to respective circuit interrupter terminals.

4. In the circuit interrupter of claim **1** which further includes gas blast means operable by said operating mechanism for producing a blast of gas between said stationary and movable contacts during their movement to a disengaged position.

5. In the circuit interrupter of claim **4** wherein the interior of said stationary contact and of said movable contact are permanently connected to a relatively low pressure region, whereby gas flows from the exterior of said stationary and movable contacts through the interiors thereof to said low pressure region during the operation of said movable contact to a disengaged position relative to said stationary contact.

6. In the circuit interrupter of claim **5**, wherein said stationary contact fingers engage and are flexed outwardly by the outer surface of said solid ring portion of said movable contact, and wherein said movable contact fingers engage and are flexed outwardly by the outer surface of said conductive tube.

7. An electrical contact structure comprising:

an integral, generally tubular stationary contact, one end of said generally tubular contact being segmented in an axial direction to define a generally circular cluster of contact fingers;

an integral, generally tubular movable contact movable into and out of engagement with said stationary contact, one end of said generally tubular movable contact being segmented in an axial direction to define a generally circular cluster of contact fingers, the opposite end of said movable contact being a generally solid ring; said contact fingers extending from said one end of said generally tubular movable contact to said generally solid ring of said generally tubular movable contact;

said tubular stationary and movable contacts being coaxial; said solid ring end of said movable contact being movable into engagement with surfaces of said circular cluster of contact fingers of said stationary contact and having a diameter different than the diameter defined by said surfaces of said cluster of stationary contact fingers when they are unflexed, thereby to create a given contact pressure when said movable and stationary contacts are in engagement;

a generally stationary conductive tube supported in insulated relation with respect to said stationary contact;

said tubular movable contact being coaxial with respect to said stationary conductive tube and being in sliding contact engagement therewith; said segmented movable contact fingers engaging a surface of said conductive tube; said conductive tube having a diameter different than the diameter defined by the engaging surfaces of said movable contact fingers when they are unflexed, thereby to create a given contact pressure when said movable contact slides relative to said conductive tube;

and an elongated operating shaft coaxially disposed relative to said tubular movable contact and having one end thereof fixed to said solid ring end of said movable contact; said operating shaft extending through and being axially movable relative to said stationary conductive tube.

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