Jan. 11, 1966 G. G. SCHOCKELT 3,229,067

HIGH VOLTAGE GAS TYPE CIRCUIT INTERRUPTER

Filed July 10, 1963 7 Sheets-Sheet 1

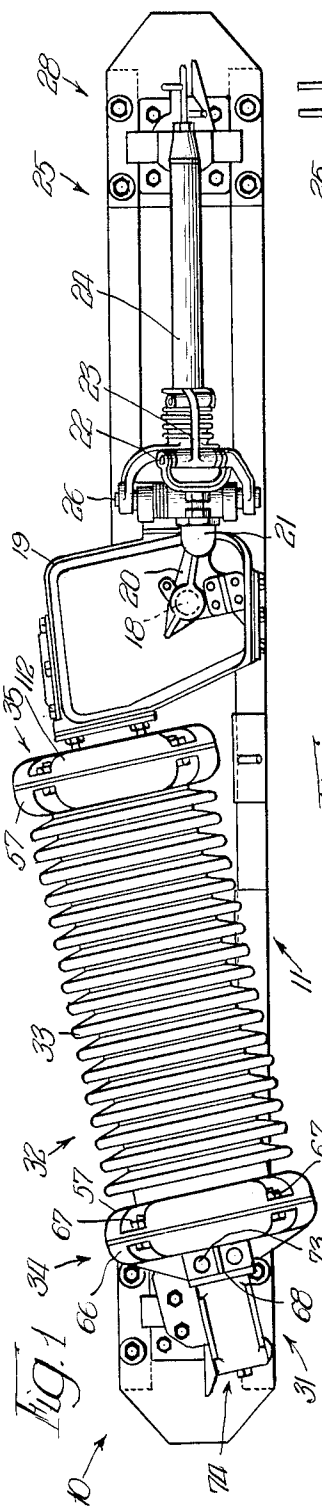


Fig. 1

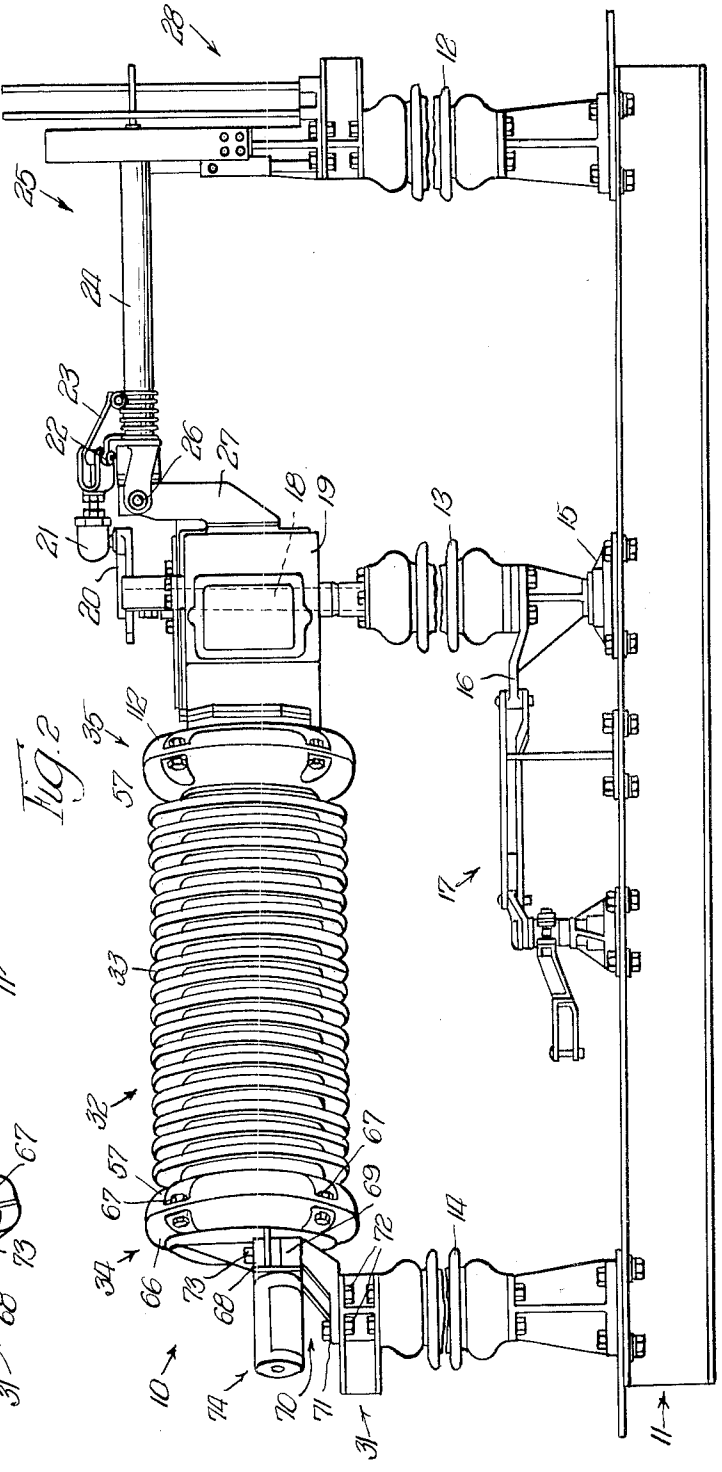


Fig. 2

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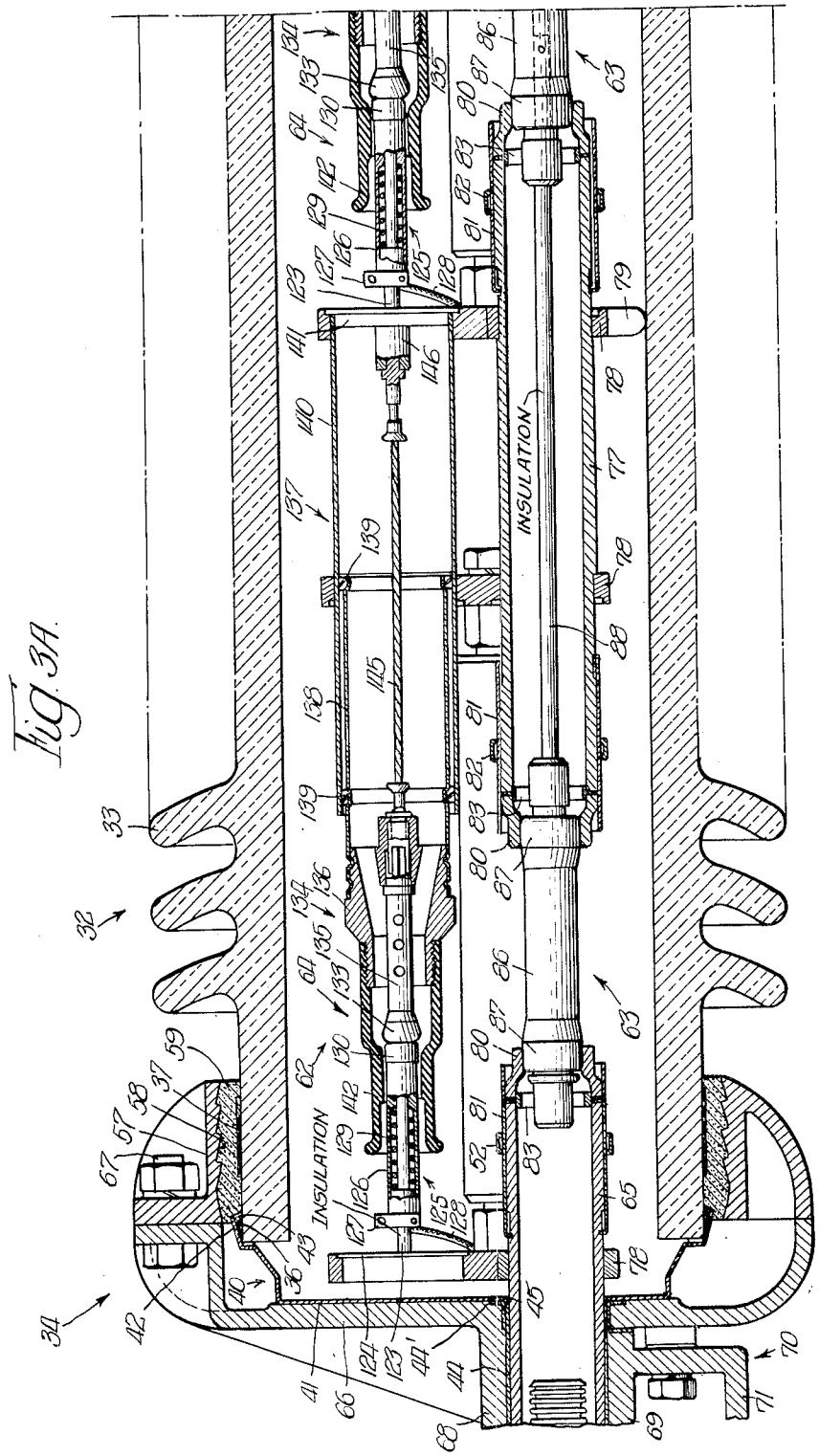


Fig. 3A.

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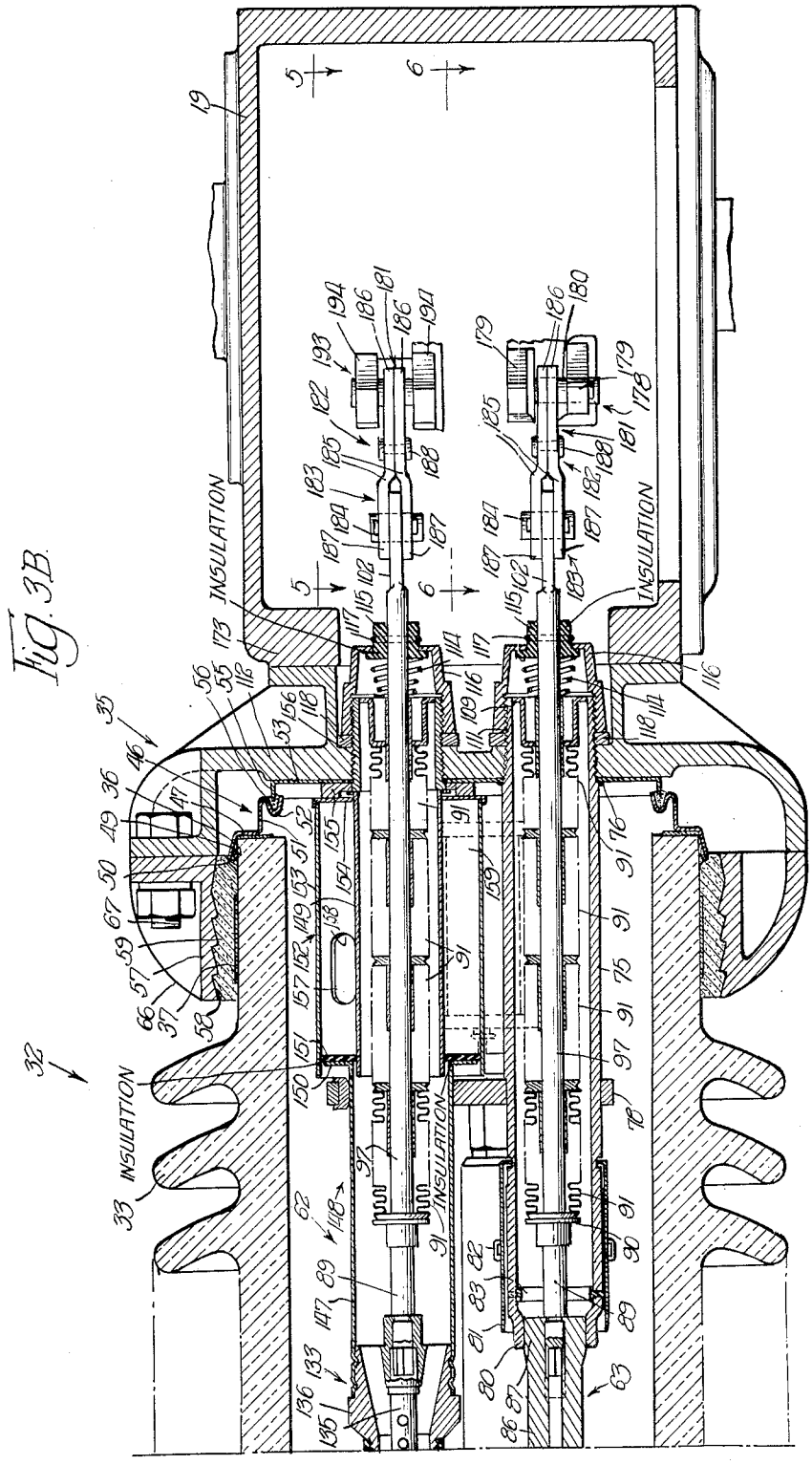


Fig. 3B

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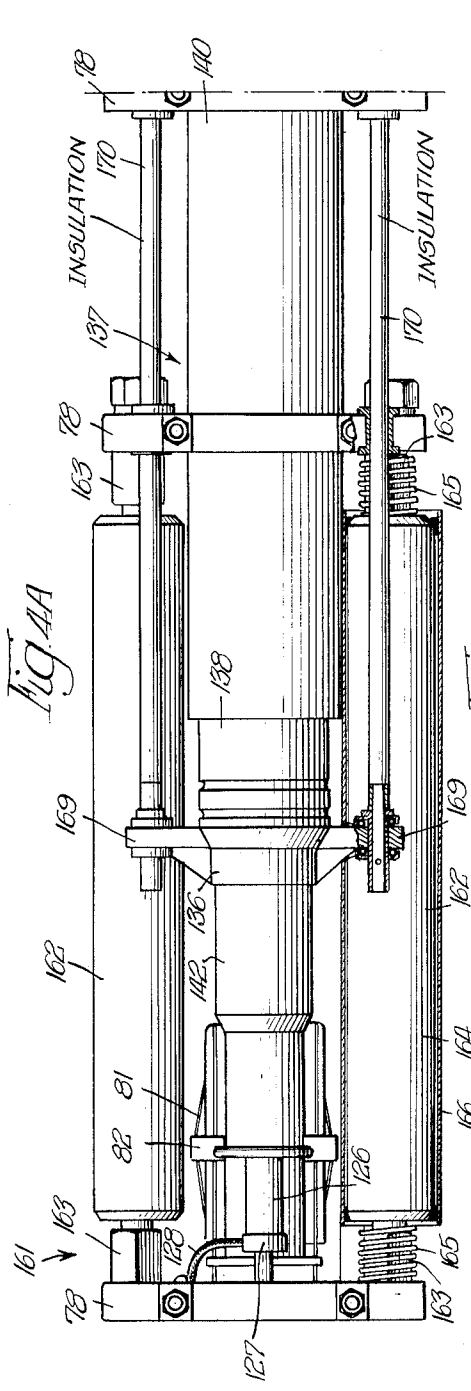


Fig. 4A

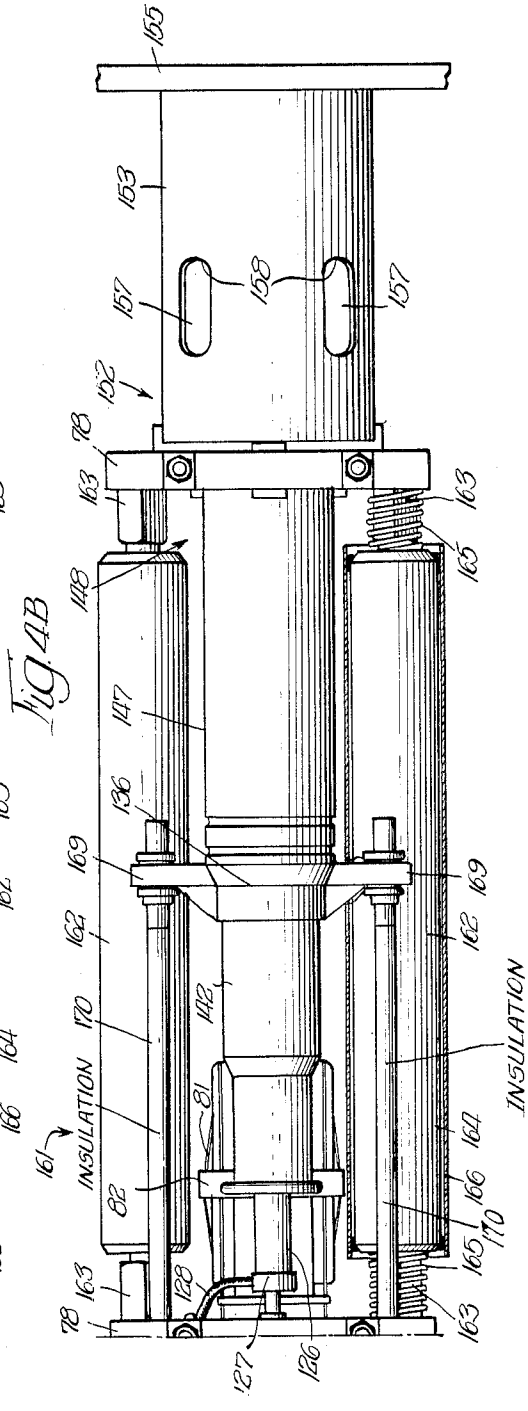


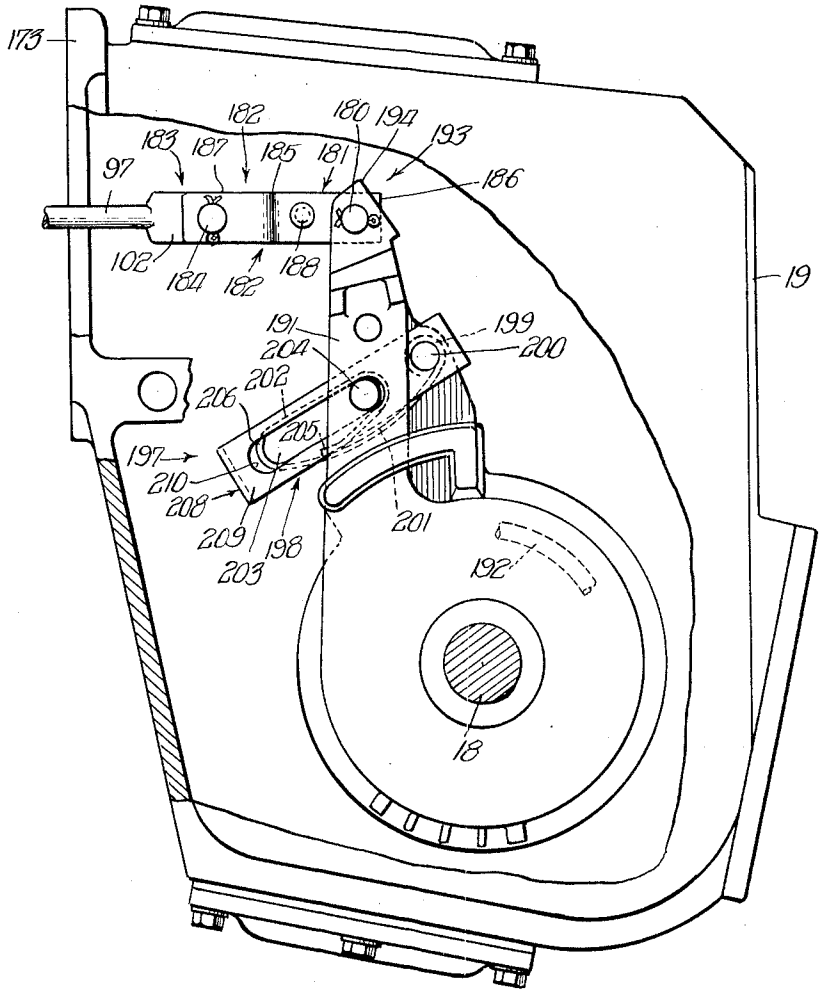
Fig. 4B

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Fig. 5



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Fig. 6

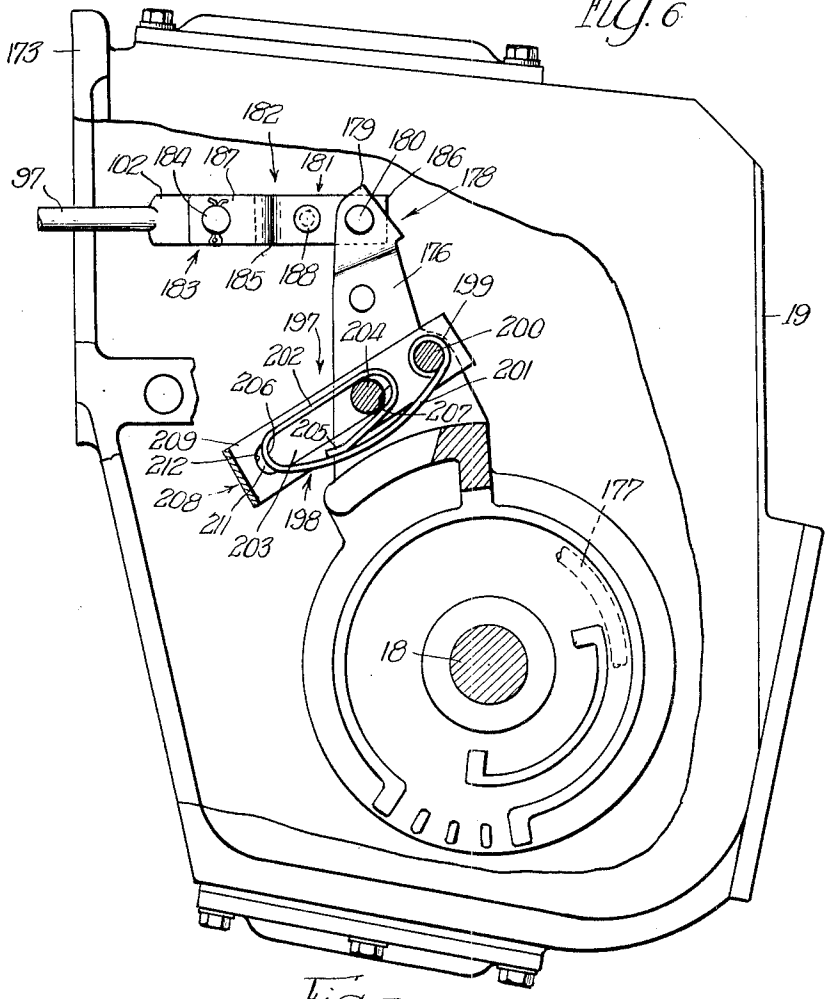


Fig. 7

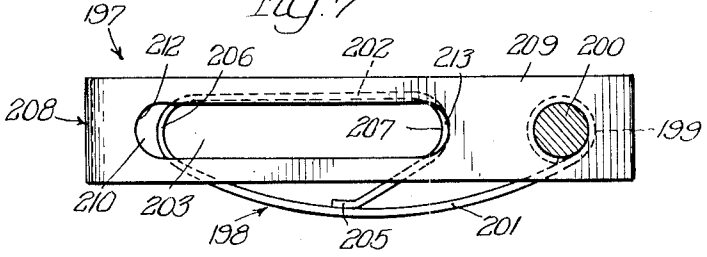
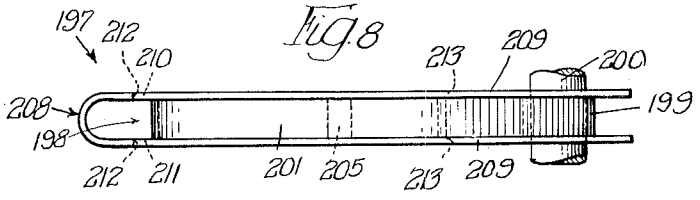


Fig. 8



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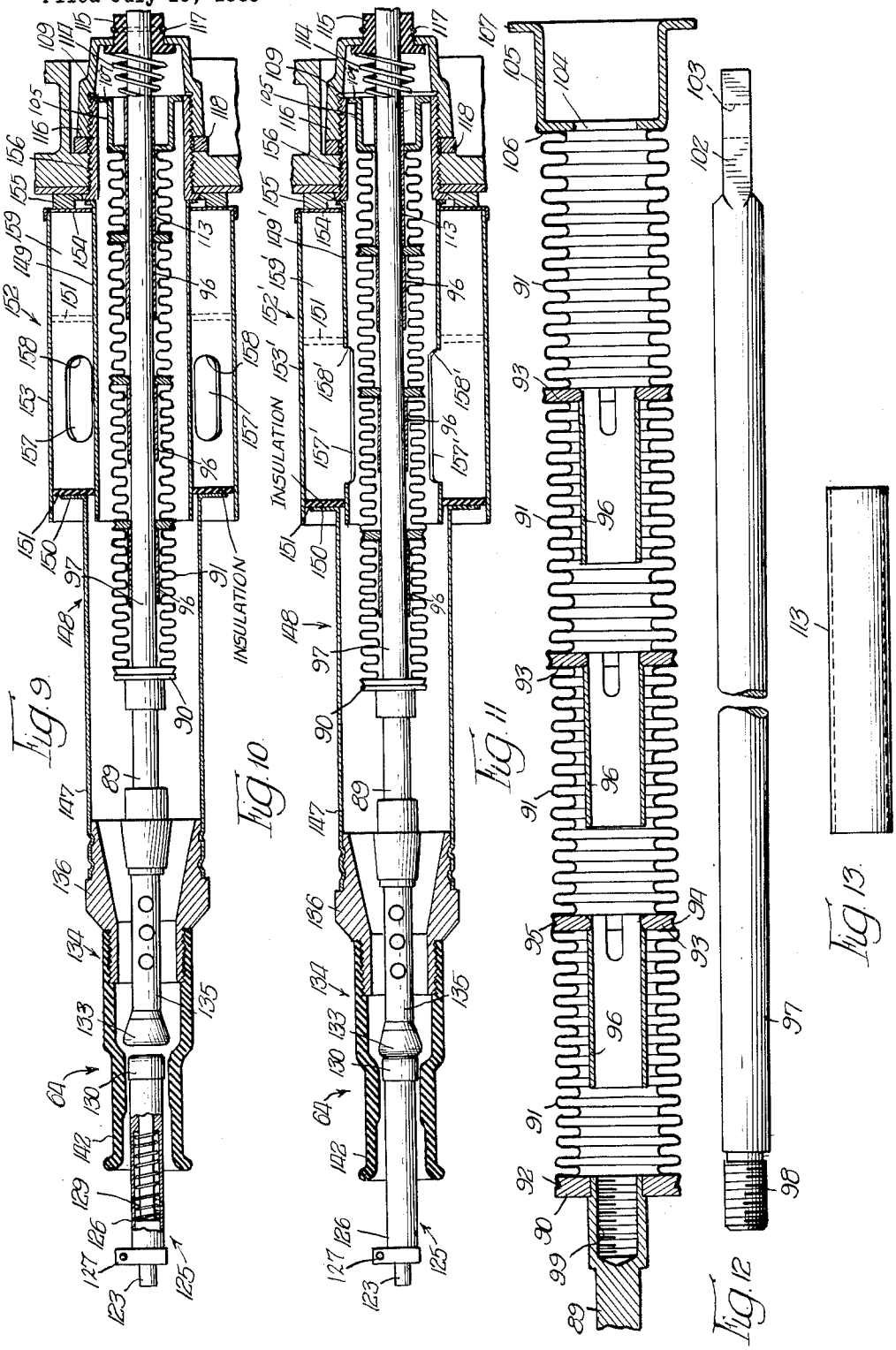


Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

United States Patent Office 3,229,067 Patented Jan. 11, 1966

3,229,067

HIGH VOLTAGE GAS TYPE CIRCUIT INTERRUPTER

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Filed July 10, 1963, Ser. No. 294,056
12 Claims. (Cl. 200—148)

This invention relates, generally, to circuit makers and breakers and it has particular relation to such devices for use on high voltage alternating current electric power systems operating at voltages of the order of 34.5 kv. and above. It constitutes an improvement over the constructions shown in U.S. Patent No. 3,030,481, issued April 17, 1962, to W. A. Gussow et al., and in Patent No. 3,163,736, issued December 29, 1963, to J. J. Mikos et al.

The construction shown in U.S. Patent No. 3,030,481 employs parallel connected main and auxiliary separable contacts in series with a disconnecting switch blade for opening and closing a high voltage alternating current power circuit. The contacts sequentially open the circuit in air with the arc incident thereto being drawn between the auxiliary contacts and extinguished by air type arc interrupting means followed by opening of the switch blade. These operations are accomplished in the desired sequence by rotation of a shaft on which main and auxiliary operating arms are rotatably mounted with a spring mechanism biasing them and the main and auxiliary contacts, respectively connected thereto, toward the open position. Suitable latch mechanism is provided to hold the operating arms against the biasing action of the spring mechanism until the shaft has been rotated to a position where the latch for the main operating arm is released. The spring mechanism then rotates the main operating arm to open the main contacts and to trip the latch for the auxiliary arm which then initiates movement of the auxiliary contacts to open position and interrupt the current flow in the circuit. A lost motion connection comprising a rigid link with an elongated slot is provided between the main and auxiliary operating arms whereby kinetic energy incident to movement of the main operating arm and parts movable therewith is applied to the auxiliary operating arm for assisting the spring mechanism in opening the auxiliary contacts at a relatively high speed. Subsequent further rotation of the shaft swings the disconnecting switch blade to open position, recloses the main and auxiliary separable contacts, and recharges the spring mechanism. The circuit is reclosed by rotating the shaft in the opposite direction to swing the disconnecting switch blade to the closed position.

An important improvement over the air type interrupter shown in the patent above referred to is disclosed in the above application, Serial No. 111,998, filed May 23, 1961, now Patent No. 3,163,736. The main and auxiliary separable contacts in this construction are enclosed in a gas tight housing in an atmosphere of arc extinguishing gas, such as SF_6, under pressure above atmospheric pressure. Pump means are provided in connection with the auxiliary separable contacts for directing a flow of the gas into the space therebetween on opening to assist in extinguishing the arc. Since an arc space of the order of several inches, for example four inches, in provided between the stationary and movable contacts in their open positions, corresponding movement is required for the main and auxiliary rod-like operators that are employed for moving the main and auxiliary contacts and are operated by the main and auxiliary operating arms. Since the mechanical connection to the main and auxiliary contacts in the gas filled and sealed housing by the main and auxiliary rod-like operators is made to the main and auxiliary operating arms exteriorly thereof, such movement must be accommodated while maintaining the gas tight seal. For this purpose specially guided bellows sections in tandem are telescoped with the main and auxiliary rod-like operators and are hermetically sealed thereto and to the housing terminal through which the operators extend. They are slidably mounted for connection to the distal ends of the spring biased rotatable main and auxiliary operating arms. The bellows accommodate the four inch movement of the main and auxiliary rod-like operators while maintaining the gas tight seal for the gas filled housing. The construction is such that several thousand circuit interruptions within the capability of the switch mechanism can be accomplished without substantial impairment of the gas tight seal.

The arrangement and construction of the gas type circuit interrupter are such that the bellows units associated with the auxiliary rod-like operator are subjected to relatively severe operating conditions. The speed of this operator at a maximum exceeds two hundred inches per second. The high speed is desirable to effect interruption of the circuit and extinction of the arc or arcs drawn in the circuit interrupter prior to opening of the disconnecting switch blade.

Certain problems have been created in this construction which were difficult to detect and required extensive study using high speed photographic equipment and careful analysis of the resulting films showing many phases of the operation. It was learned that the final opening movement of the auxiliary rod-like operator should be cushioned in order to reduce the shock incident to stopping the opening movement thereof. Because of the mechanical connection between the auxiliary rod-like operator and the distal end of the auxiliary rotating operating arm employing a pair of spaced links, it was discovered that they tended to cause the rod-like operator to bow intermediate its end. During the opening movement of the auxiliary rod-like operator, it was subjected to the mechanical shock incident to the impact of the transfer of kinetic energy from the main rotatable operating arm and parts moving therewith at the end of the lost motion provided by the rigid link connection to the auxiliary operating arm. This mechanical shock caused undulating movement of the bellows units.

Accordingly, among the objects of this invention are: To provide for increasing the operating life of the gas type circuit interrupter of the kind and character herein described; to improve the conditions under which the bellows units are required to operate, particularly those bellows units associated with the relatively high speed auxiliary rod-like operator used for opening the auxiliary contacts and effecting circuit interruption; to provide for cushioning the final opening movement of the auxiliary rod-like operator; to overcome the tendency of the auxiliary operating rod to flex because of its mechanical connection to the distal end of the auxiliary rotatable operating arm; and to cushion the transfer of kinetic energy from the main rotatable operating arm and parts movable therewith to the auxiliary rotatable operating arm and parts movable therewith.

In the drawings:

FIG. 1 is a top plan view of switch means embodying the present invention, the switch means being shown in the closed position.

FIG. 2 is a view, in side elevation, of the switch means shown in FIG. 1.

FIGS. 3A and 3B, taken together with the views being placed in end to end relation, show at an enlarged scale a vertical cross sectional view of the current interrupter which forms a part of the switch means shown in FIGS. 1 and 2.

FIGS. 4A and 4B, taken together in end to end relation, constitute a top plan view of the series connected

contact structure within the insulating housing of the current interrupter shown in FIGS. 3A and 3B, certain parts being broken away in order to show details of construction.

FIG. 5 is a horizontal sectional view taken generally along the line 5—5 of FIG. 3B and shows certain details of construction of the operating mechanism.

FIG. 6 is a horizontal sectional view taken generally along the line 6—6 of FIG. 3B and shows additional details of construction of the operating mechanism.

FIG. 7 is a view of the spring link that interconnects the main and auxiliary rotatable operating arms and shows its relationship to the link shield that is associated therewith, the pin on the main rotatable operating arm being shown in section.

FIG. 8 is a view, in side elevation, of the link assembly shown in FIG. 7.

FIG. 9 is a vertical sectional view through the pump and dashpot construction that is employed in connection with the circuit interrupter that is provided with two sets of main and auxiliary contacts in series.

FIG. 10 is a view, similar to FIG. 9, but showing the pump construction and dashpot arrangement used in connection with a current interrupter in which only a single gap is employed, such interrupter being used for lower voltage circuits than the voltage for which the multiple gap interrupter is used.

FIG. 11 is a vertical sectional view, at an enlarged scale, showing the bellows units.

FIG. 12 is a view, at an enlarged scale, of one of the rod-like operators that is telescoped with the bellows units and is employed for making the mechanical connection between the main or auxiliary movable contacts and the main or auxiliary rotatable operating arms.

FIG. 13 is a view, in side elevation, of the end spacer that is employed in conjunction with the operator shown in FIG. 12 when it is positioned within the bellows units.

Referring now particularly to FIGS. 1 and 2 of the drawings, it will be observed that the reference character **10** designates, generally, switch means in which the present invention is embodied. The switch means **10** includes a base, indicated generally at **11**, that may be formed of a pair of rolled steel channels suitably secured together. Mounted on the base **11** are a first insulator **12**, a second insulator **13**, which is rotatable, and a third insulator **14**. The second insulator **13** is rotatably mounted on a bearing **15** that is carried by the base **11** and it has an arm **16** extending therefrom for connection to a suitable operating linkage that is indicated, generally, at **17**. It will be understood that, for three phase operation, three of the switch means **10** are mounted on a suitable switching structure in proper spaced relation, depending upon the voltage of the circuit, and that suitable operating means, connected to the operating linkage **17**, is provided for effecting simultaneous rotation of the second insulator **13** of each such switch means **10** for either opening or closing the circuit as may be required. Such an operating mechanism is illustrated and described in U.S. Patent No. 3,030,481, above referred to.

Extending upwardly from and rotatable with the second insulator **13** is a shaft **18**. The shaft **18** extends through and is rotatably mounted on a mechanism housing **19** the details of construction of which are set forth in the patent above referred to together with the operating mechanism therein which is controlled by the shaft **18**. Certain modified details of construction of the operating mechanism will be set forth hereinafter. For present purposes it is pointed out that the shaft **18** extends through the mechanism housing **19** and carries at its upper end a switch crank **20** which is rotatable therewith. The switch crank **20** is pivotally connected to a link **21** that is pivoted at **22** to an arm **23** which extends from a switch blade **24** that forms a part of a disconnecting switch, indicated generally, at **25**. The switch blade **24** is pivoted at **26** on a bracket **27** which is carried by one wall of the mechanism housing **19**. At its distal end the switch blade **24** is arranged to move into and out of high pressure contact engagement with a line contact member, shown generally at **28**, which is carried by the first insulator **12**. It will be understood that, on rotation of the second insulator **13** by the operating linkage **17**, a corresponding rotation of the switch crank **20** is effected for swinging the switch blade **24** out of or into high pressure contact engagement with the line contact member **28**, depending upon the direction of rotation. The details of construction of the disconnecting switch **25** are conventional and may be as disclosed in U.S. Patent No. 2,818,474, issued December 31, 1957, to W. A. Gussow.

It is desirable that the switch blade **24** be opened only after the circuit has been opened previously by some other means. The reason for this is to prevent the drawing of an arc between the distal end of the switch blade **24** and the line contact member **28** when the circuit is interrupted under load which might result in damage to these parts or the creation of a fault by arcing over to an adjacent phase or to ground. For this purpose there is mounted between the mechanism housing **19** and a line terminal **31**, which is carried by the third insulator **14**, a current interrupter that is indicated, generally, at **32**.

FIGS. 3A and 3B illustrate the details of construction of the current interrupter **32**. Here it will be observed that the current interrupter **32** is provided with an insulating housing **33** that preferably is a one piece hollow porcelain housing having a cylindrical interior and external corrugations to increase its flashover value between the ends. At its ends the insulating housing **33** is provided with terminals that are indicated, generally, at **34** and **35**. Provision is made as described in the aforesaid J. J. Mikos et al. patent for securing the terminals **34** and **35** to the ends of the insulating housing **33**. As there disclosed the end portions of the insulating housing **33** have a platinum band **36** on each and spaced therefrom is a sand band **37**. At the left end of the insulating housing **33**, FIG. 3A, there is provided a pan-shaped diaphragm **40** having a flat bottom **41** and an outflared rim **42** which is secured by solder **43** to the juxtaposed platinum band **36**. Below the central portion of the flat bottom **41** of the diaphragm **40** there is a tubular extension **44** having a radial flange **44'** that is brazed at **45** to the overlying portion of the flat bottom **41**. At the right end of the insulating housing **33**, FIG. 3B, there is positioned a pan-shaped diaphragm **46** having an annular portion **47** which overlies the adjacent end portion of the insulating housing **33**. The diaphragm **46** has an outflared rim **49** that is secured by solder **50** to the juxtaposed platinum band **36**. The diaphragm **46** also includes a cylindrical portion **51** that extends endwise from the insulating housing **33** and it has an annular outwardly opening grooved end portion **52** for connection to a backup plate **53**. The backup plate **53** has an annular rim **55** along its periphery for interfitting with the annular grooved end portion **52** of the diaphragm **46** and the two are secured together by solder **56**. This construction facilitates the assembly of the separable contact structure in the insulating housing **33** as will be described presently.

In order to mount the insulating housing **33**, adapter rings **57** are mounted on its ends. They are provided with corrugated inner surfaces **58**. A filling of Portland cement **59** overlies the corrugated inner surfaces **58** and the sand bands **37** to provide the necessary rigid mechanical connection.

As pointed out hereinbefore the insulating housing **33** contains a separable contact structure which is employed for interrupting the flow of current in the circuit in which the switch means **10** is connected and drawing and extinguishing the arc or arcs that may be incident thereto. The rigid separable contact structure is indicated, generally, at **62** and it comprises, for the construction shown in FIGS. 3A–3B, series connected sets of separable main contacts, indicated generally at **63**—**63**, and series con-

nected sets 64—64 of separable auxiliary contacts with the sets of contacts being connected in parallel and the arrangement being such that the sets of main contacts 63—63 are opened first to transfer the entire flow of current to the series connected auxiliary contacts 64—64. Thereafter the series connected auxiliary contacts 64—64 are opened to draw and extinguish arcs within the insulating housing 33 that is filled with an arc extinguishing gas, such as SF_6, under pressure that is greater than atmospheric pressure.

As shown in FIG. 3A a heavy gage copper tube 65 forms a part of the separable main contacts 63 at the left end of the insulating housing 33. The copper tube 65 extends through a terminal end adapter 66 which overlies the flat bottom 41 of the diaphragm 40. It is secured by bolts 67 to a radially outwardly extending flange on the adjacent adapter ring 57. As described in more detail in the aforesaid J. J. Mikos et al. patent semicircular sections 68 and 69 are associated with the terminal end adapter 66 for the purpose of mounting it on the terminal end support 70 which has a pad portion 71 to facilitate mounting on the line terminal 31 to which a line conductor can be connected. Bolts 72 serve to secure the pad portion 71 to the line terminal 31 and bolts 73 interconnect the semicircular sections 68 and 69 and clamp them to the heavy gage copper tube 65.

Since the heavy gage copper tube 65 opens into the interior of the insulating housing 33, advantage is taken of this arrangement to provide an exterior indication as to whether the desired predetermined pressure of arc extinguishing gas is being maintained within the insulating housing 33. For this purpose an indicator, shown generally at 74 in FIGS. 1 and 2, is employed. The details of construction of the indicator 74 are set forth in U.S. Patent No. 3,077,527, issued February 12, 1963, to W. R. Goldbach et al.

At the right end of the insulating housing 33, FIG. 3B, there is positioned a heavy gage copper tube 75 in alignment with the copper tube 65 at the left end. It extends through the backup plate 53 and is brazed thereto as indicated at 76. Intermediate the copper tubes 65 and 75 and in alignment therewith is an intermediate heavy gage copper tube 77, FIG. 3A. It will be understood that the heavy gage copper tubes 65, 75 and 77, which form parts of the separable main contacts 63—63, are employed for conducting the normal load current through the current interrupter 32 under normal operating conditions. It is for this reason that these parts are formed of relatively good conducting material having substantial cross section.

The intermediate heavy gage copper tube 77 is mounted intermediate its ends on support plates 78—78. As shown in FIG. 3A these support plates are spaced from the inner surface of the insulating housing 33 by bumpers one of which is indicated at 79. Attention is directed to the fact that there are four support plates 78. They are arranged in pairs with a rigid supporting structure therebetween that will be described presently. The facing ends of the copper tubes 65, 75 and 77 are longitudinally slotted to provide contact fingers 80 which are urged inwardly by leaf springs 81 that are held in position by retainer rings 82. A spreader ring 83 extending underneath each set of contact fingers 80 serves to limit the inward movement thereof.

It will be observed that the ends of the intermediate copper tube 77 are spaced from the inner ends of the copper tubes 65 and 75. This arrangement provides the necessary air gap in the gaseous atmosphere in the insulating housing 33. In the construction shown in FIGS. 3A and 3B two gaps in series are provided. For bridging these gaps cylindrical movable contacts 86—86 are employed. They have large diameter ends 87—87 for the purpose of making good contact engagement with the inner surfaces of the juxtaposed contact fingers 80. In FIGS. 3A and 3B the cylindrical movable contacts 86—86 are shown in the circuit closed positions and it will be understood that they are moved endwise conjointly when the circuit is to be opened. For this purpose the cylindrical movable contacts 86—86 are interconnected by an insulating operating rod 88 which extends through the intermediate copper tube 77 and is rigidly secured at its ends to the movable contacts 86—86.

At the right end of the movable contact 86 shown in FIG. 3B, it is connected to an operating rod insert 89 in a suitable manner. The other end is rigidly secured to an end guide washer 90, FIG. 11, that is located at one end of a number of bellows units 91 arranged in tandem. The left end of the left bellows unit 91 is soldered as indicated at 92 to the end guide washer 90. Intermediate guide washers 93 are located between the juxtaposed ends of the bellows units 91 and these ends are soldered thereto. For this purpose each of the intermediate guide washers 93 is formed with an annular V groove 94 in which the respective ends of the bellows units 91 are positioned and are secured thereto by soldering as indicated at 95. Intermediate tubular spacers 96 are suitably secured to the inner portions of the intermediate guide washers 93 for the purpose of limiting the compression of the respective bellows unit 91. In addition the tubular spacers 96, as outlined in the aforesaid J. J. Mikos et al. patent, serve to guide the bellows units 91 in their movement between the circuit closed and the circuit open position.

Telescoped with the bellows units 91 is a rod-like operator 97 the details of construction of which are shown more clearly in FIG. 12 of the drawings. It will be understood that the rod-like operator 97, which is connected through the operating rod insert 89 to effect conjoint movement of the movable contacts 86—86, is considered to be the main rod-like operator and is so referred to hereinafter and in certain of the claims. Mention is made of this in view of the fact that the same bellows construction and rod-like operator are employed in conjunction with the movement of the auxiliary movable contacts that will be described presently.

At its left end the rod-like operator 97 is externally threaded at 98. It is arranged to engage the internally threaded opening 99 in the operating rod insert 89. This construction facilitates the manufacture and assembly of the bellows units 91 together with the operating rod insert 89 and intermediate tubular spacers 96 as shown in FIG. 11 and permits insertion of the rod-like operator 97 subsequently. The right end of the rod-like operator 97 is flattened as indicated at 102 and is provided with a transverse aperture 103 to permit connection to the main rotatable operating arm in the mechanism housing 19 in a manner to be described.

At its right end the rod-like operator 97 extends through an aperture 104, FIG. 11, in a bellows head 105 which forms a part of the assembly of the bellows units 91. The aperture 104 is formed in a radially inwardly extending flange to which the adjacent end of the adjacent bellows unit 91 is soldered as indicated at 106. At the other end the bellows head 105 has a radially outwardly extending flange 107 that is soldered as indicated to the right end of an externally threaded portion 111 on the heavy gage copper tube 75. Here it will be observed that the end portion 111 is threaded through a mechanism end adapter 112 that is secured by bolts 67 to the adapter ring 57 in the same manner that the adapter ring 57 at the opposite end of the insulating housing 33 is secured to the terminal end adapter 66.

Slidably mounted on the rod-like operator 97 and extending through the aperture 104 in the bellows head 105 is a tubular end spacer 113 which is shown separately in FIG. 13 of the drawings. The right end of the tubular end spacer 113 is engaged by the left end of a spiral bumper spring 114 the other end of which reacts against an insulating bushing 115 which extends through a clamp nut 116 that is threaded onto the threaded end portion 111 of the heavy gage copper tube 75. A snap ring 117

limits the inward movement of the insulating bushing **115** with respect to the clamp nut **116**. A spring washer **118**, interposed between the clamp nut **116** and the juxtaposed face of the mechanism end adapter **112**, assists in holding the clamp nut **116** in position. It will be observed that the right end of the rod-like operator **97** extends through the insulating bushing **115** which serves to guide it in its movement between closed and open circuit positions.

As pointed out series connected separable auxiliary contacts **64** are connected in parallel circuit relation with the series connected separable main contacts **63**. During the circuit opening operation the separable main contacts **63** are opened first and the entire current flow is transferred to the series connected separable auxiliary contacts **64**. They are opened to interrupt the circuit in two places when two sets of separable auxiliary contacts **64** are employed. The details of construction of the separable auxiliary contacts **64** essentially are duplicated in each. As shown in FIG. 3A a guide stem **123** of insulation extends from an adapter plate **124** which is mounted on the adjacent support plate **78**. The guide stem **123** slidably supports a relatively stationary auxiliary contact **125** which comprises a contact tube **126** having a terminal **127** at one end to which flexible cable **128** is connected for making connection to the associated support plate **78**. Within the contact tube **126** and around the guide stem **123** there is positioned a coil compression spring **129** which urges a contact tip **130** of arc resisting metal on the right end of the contact tube **126** into contact engagement with a contact tip **133** of arc resisting metal that is carried by a relatively movable auxiliary contact **134**. Suitable means are provided for limiting the outward movement of the auxiliary contact **125** on movement away therefrom of auxiliary contact **134**. The resilient mounting for the relatively stationary auxiliary contact **125** insures that adequate contact pressure is achieved between the contact tips **130** and **133** while permitting some variation in the position of the relatively movable auxiliary contact **134** in the fully closed position. The contact tip **133** is carried by a contact tube **135** that is suitably mounted on a contact carrier **136** for movement therewith.

Referring now particularly to FIG. 3B of the drawings, it will be observed that the contact carrier **136** there shown is mounted for movement in a manner similar to that in which the movable contact **86** forming a part of one of the separable main contacts **63** is moved. The contact carrier **136** is mounted on the operating rod insert **89** associated therewith which is secured to a rod-like operator **97** that extends outwardly through the mechanism end adapter **112** in the manner previously described. The same bellows sealing arrangement is provided and the description thereof will not be repeated. It is pointed out that the rod-like operators **97** are referred to in the claims as main and auxiliary rod-like operators and it will be understood that they are associated, respectively, with the main and auxiliary separable contacts **63** and **64**.

It is desirable that provision be made for causing a flow of the arc extinguishing gas between the contact tips **130** and **133** when they are separated for each of the sets of separable auxiliary contacts **64** in order to assist in extinguishing the arcs drawn therebetween. For this purpose as shown in FIG. 3A a pump, indicated generally at **137**, is employed. The pump **137** includes a piston cylinder **138** which is secured to and moves with the contact carrier **136**. Piston rings **139** are positioned near the ends of the piston cylinder **138** and they provide a seal with the inner surface of a pump cylinder **140** which is stationarily mounted on the intermediate support plates **78** which, in turn, are mounted on the intermediate heavy gage copper tube **77**. The bottom of the pump cylinder **140** is closed by an adapter plate **141**. When the contact carrier **136** is moved to the right, as viewed in FIG. 3A, or toward the circuit open position, the arc extinguishing gas within the piston cylinder **138** and the pump cylinder **140** is compressed and is caused to flow outwardly through openings in the contact carrier **136** and through a nozzle **142** of suitable insulating material which directs the flow of arc extinguishing gas to the space between the contact tips **130** and **133** when they are separated. The manner in which the contact carrier **136**, shown in FIG. 3A, is moved conjointly with the contact carrier **136**, shown in FIG. 3B, and directly connected to the rod-like operator **97** will be described presently.

Electrical connection to the relatively movable auxiliary contact **134** is provided by a flexible conductor **145** which extends from the contact tube **135** through the pump cylinder **140** and is connected to a terminal **146** that is carried by the adapter plate **141**.

It will be observed that the contact carrier **136**, FIGS. 3B and 9, has mounted thereon and movable therewith a piston cylinder **147** which forms a part of a pump that is indicated, generally, at **148**. The purpose of the pump **148** is the same as the purpose of the pump **137**, but its construction is different in certain respects. The piston cylinder **147** is telescoped over a pump cylinder **149** which surrounds the belows units **91** that are associated with the rod-like operator **97** which is employed for moving the auxiliary separable contacts **64**. At the base of the piston cylinder **147** there is a radial flange **150** which loosely carries an annular piston **151** that is formed preferably of a thin plate of insulating material. The action of the pump **148** is essentially the same as the action of the pump **137** to the end that the arc extinguishing gas within the piston cylinder **147** and the pump cylinder **149** is compressed as the associated contact carrier **136** is moved toward the right with the result that this gas is forced through the openings in the contact carrier **136** and into the space between the contact tips **130** and **133** of the set of separable auxiliary contacts **64** shown to the right of FIG. 3A and in FIG. 9.

It has been found that, under normal operating conditions, the arcs drawn between the separable auxiliary contacts **64** are extinguished by the time that the respective contact carriers **136** and relatively movable auxiliary contacts **134** have moved through a substantial portion of the complete opening stroke. In order to prolong the life of the bellows units **91** associated with the separable auxiliary contact **64** it has been found that the high speed of movement of the parts associated with the contact carriers **136** should be reduced during the final portion of the opening stroke in such manner that a minimum shock is caused at the terminal portion of the opening stroke which shock otherwise is transmitted to the moving parts and particularly to the bellows units **91**.

In order to cushion the final portion of the movement of the parts associated with the relatively movable auxiliary contacts **34**, a dashpot shown generally at **152** is employed. As shown in FIGS. 3B and 9 the dashpot **152** includes a dashpot cylinder **153** that surrounds the pump cylinder **149**. Its right end is closed by an annular end plate **154** which bears against a pump cylinder adapter **155** that is located on the inner side of the backup plate **53** and is mounted on the inner end of a threaded coupling sleeve **156** which corresponds to a similar portion of the heavy gage copper tube **75** and is threaded into the mechanism end adapter **112**. The flange **107** on the bellows head **105** is soldered at **109** to the outer end of the coupling sleeve **156**.

It will be observed that the annular piston **151**, which is loosely carried by the radial flange **150**, is movable around the pump cylinder **149** and inside of the dashpot cylinder **153**. With a view to permitting high speed movement of the relatively movable auxiliary contacts **134** during the initial or opening portion of the opening stroke, elongated slots **157** are formed in the dashpot cylinder **153**. Preferably four of the slots **157** are provided in the dashpot cylinder **153**. Instead of elongated slots holes can be provided to permit the free passage of the arc ex-

tinguishing gas therethrough during the initial part of the opening movement of the movable auxiliary contacts **134**. This free movement is permitted until the annular piston **151** moves past the ends **158** of the slots **157** in the dashpot cylinder **153**. Thereafter the continued movement of the annular piston **151** compresses the arc extinguishing gas in the space **159** at the right end of the dashpot cylinder **153**. The dashpot **152** then functions to provide the retarding action through the compression of the gas in the annular space **159** during the final portion of the opening stroke of the relatively movable auxiliary contacts **134** with the result that the kinetic energy of the moving parts is relatively gradually dissipated and final movement thereof is arrested without any substantial shock. During this final portion of the opening movement the action of the pump **148** persists and the gas continues to be forced into the arc space.

The retarding action of the dashpot **152** depends upon a number of factors including: the clearance between the piston **151** and the outer and inner surfaces of the cylinders **149** and **153**; the size, shape and number of the slots **157**, and the speed of the piston **151**. By combining these variables differently, various dashpot actions can be obtained.

With a view to mounting rigidly the two intermediate support plates **78** and the parts secured thereto, including the intermediate heavy gage copper tube **77**, insulating bridging structures, shown generally at **161—161** in FIGS. 4A–B are employed. These structures each include pairs of porcelain insulating rods **162—162** having metallic support posts **163** at their ends. The support posts **163** at the ends of the insulating rods **162** extend into and are mounted rigidly on the associated support plates **78**. Also attention is directed to the fact that the left support plate **78**, FIG. 3A, is rigidly mounted on the heavy gage copper tube **65** that is clamped to the terminal end adapter **66**. The right support plate **78**, FIG. 3B is rigidly mounted on the heavy gage copper tube **75** that is threaded into the mechanism end adapter **112**.

It is desirable that the main and separable contacts **63** and **64** be bridged by high resistance shunts when they are in the open circuit positions. For this purpose one of the insulating rods **162** of each pair, as shown in FIGS. 4A–4B is provided with a resistance coating material **164** and connection thereto is provided by contact springs **165–165** which, at one end, bear against the resistance coating material **164** and at the other end against the respective support plate **78**. Insulating glass tubes **166** surround the coatings of resistance material **164** to protect them.

It will be recalled that the contact carrier **136**, as shown in FIG. 3B, is mechanically connected by its operating rod insert **89** to the associated rod-like opeartor **97**. As shown in FIGS. 4A–4B, each of the contact carriers **136** is provided with a pair of diametrically extending arms **169—169**. These pairs of arms **169—169** are mechanically rigidly interconnected by insulating rods **170—170** which extend through and are guided in the intermediate support plates **78**. The particular manner in which the insulating rods **170—170** are slidably mounted and connected to the arms **169—169** is described in detail in the aforesaid J. J. Mikos et al. patent.

Referring now particularly to FIG. 9 of the drawings, it will be observed that the relatively movable auxiliary contact tip **133** is spaced slightly from the relatively stationary contact tip **130** which is the condition that exists shortly after movement of the auxiliary contact **134** is initiated to the open position. The movement of the auxiliary contact **134** and parts associated therewith continues in the manner described and the arc extinguishing gas within the piston cylinder **147** and the pump cylinder **149** is compressed and is caused to flow through the openings in the contact carrier **136** and is directed by the nozzle **142** into the space between the contact tips **130** and **133**. The movement continues at the high speed indicated until the annular piston **151** moves completely past the slots **157** in the dashpot cylinder **153** and beyond the ends **158** thereof with an intermediate position of the piston **151** being shown by broken lines. When the annular piston **151** occupies the broken line position the gas in the annular space **159** is being compressed further and the dashpot action is becoming increasingly effective. As the gas leaks past the annular piston **151**, the moving system associated with the relatively movable contacts **134** is slowed down and the kinetic energy incident thereto is gradually reduced in accordance with the degree that the gas is compressed in the annular space **159**. The moving system is finally arrested substantially without shock which otherwise would be transmitted to the bellows units **91**.

It will be understood that, since the main movable contacts **86—86** and parts movable therewith terminate their opening movement at relatively low speed, it is unnecessary to provide a dashpot action in connection with their final movement to prevent damage to the bellows units **51** associated therewith.

FIG. 10 of the drawings shows an arrangement in which only a single set of separable auxiliary contacts **64** is employed. When such a construction is used, it is unnecessary to take into account the presence of the second set of auxiliary contacts and the requirement that the flow of arc extinguishing gas thereto be under substantially identical conditions. As shown in FIG. 10 a dashpot **152'** is employed which is generally similar to the dashpot **152** previously described. However, it is different in that the dashpot cylinder **153'** is not provided with slots **157** as is the case for the dashpot cylinder **153**. Rather, slots **157'** are provided in the pump cylinder **149'**. When the relatively movable auxiliary contact **134** is moved toward the open position, the annular piston **151** causes the gas within the dashpot cylinder **153'** to flow through the slots **157'** and then outwardly through the piston cylinder **147** at a relatively high rate of flow. The pump action continues and the annular piston **151** is moved past the ends **158'** of the slots **157'** or to the position of the piston **151** indicated by broken lines. Further movement of the annular piston **151** into the space **159'** between the pump cylinder **149'** and the dashpot cylinder **153'** provides the dashpot action and serves to cushion the final portion of the opening stroke of the relatively movable auxiliary contact **134** and parts movable therewith. During this final period the pump action persists, but is somewhat reduced, and the gas continues to be forced into the arc space. It will be understood that, when a single set of auxiliary contacts **64** is used, only a single set of main contacts **63** is provided.

It is desirable that the rod-like operators **97** be moved solely with a translatory movement and without bowing as previously mentioned. Also it is desirable that provision be made for a limited degree of misalignment between them and the operating arms in the mechanism housing **19** to be described. The manner in which the desired connections to the rod-like operators **97** are made will be apparent from a consideration of FIGS. 3B, 5 and 6. As shown in the latter two figures, a mounting plate section **173** is formed integrally with the mechanism housing **19** for suitable attachment to the mechanism end adapter **112**.

Referring now particularly to FIGS. 3B and 6, there is shown a main operating arm **176**. FIG. 6 shows the main operating arm **176** freely rotatable mounted on the shaft **18** which, it will be recalled, extends through the mechanism housing **19** and is rotated together with the rotatable insulator **13** for effecting operation of the switch means **10** in the manner described. The main operating arm **176** is biased by a spring **177** to rotate in a direction to open the separable main contacts **63**. As described in U.S. Patent No. 3,030,481, issued April 17, 1962, to W. A. Gussow et al., suitable latch mechanisms, not here discribed, are employed for restraining the spring

177. For present purposes it is pointed out that, on release of the latch mechanism, the spring 177 functions to rotate the main operating arm 176 in a clockwise direction, as viewed in FIG. 6.

The main operating arm 176 has a bifurcated distal end, indicated generally at 178, which is formed by spaced apart arms 179–179 between which a pin 180 extends. In the patent just referred to the connection between the main operating arm and the associated main operating rod was effected through a pair of spaced apart plates which were pivotally connected at one end to the outer sides of the arms of the bifurcated distal end and at the other ends to a cross head that was connected to the respective main operating rod.

In accordance with the construction of the present invention, a pin 180 extends through the arms 179–179 and loosely through an opening in a shank portion 181 of a tie link as indicated, generally, at 182. The tie link 182 has a bifurcated end section that is indicated, generally, at 183, through which a pin 184 extends. It will be observed that the arms forming the bifurcated end section 183 have the flattened end 102 of the rod-like operator 97 associated with the main separable contacts 63 located therebetween with the pin 184 extending with a snug fit through the aperture 103 therein. It will be understood that the rod-like operators are guided for straight line movement by the respective insulating bushings 115 in the associated clamp nuts 116. Thus it is unnecessary to provide any additional guide means for effecting translatory movement of the rod-like operators 97.

Preferably the tie link 182 is fabricated from a pair of plate like members 185–185. They have juxtaposed end sections 186—186 which form the shank portion 181. The bifurcated end section 183 is formed by offset end sections 187—187 to overlie opposite sides of the flattened end 102 of the rod-like operator 97. A rivet 188 extends through the end sections 186—186 for the purpose of providing a unitary construction.

Referring now to FIG. 5 of the drawings, it will be observed that an auxiliary operating arm 191 is freely rotatably mounted on the shaft 18. A spring 192 is employed for biasing it in a circuit opening direction. Suitable latch means are provided, as described in the patent last mentioned, for holding the auxiliary operating arm against opening movement and until the main operating arm has moved to a predetermined position corresponding to an open position of the main separable contacts.

It will be observed in FIG. 5 that the auxiliary operating arm 191 has a bifurcated distal end 193 which is formed by arms 194—194. A tie link, indicated generally at 182, and identical in construction to the tie link shown in FIG. 6 and connected to the distal end 178 of the main operating arm 176 is employed for interconnecting the auxiliary operating arm 191 and the rod-like operator 97 which is connected in the manner described hereinbefore for moving the auxiliary contacts 134 from and to the closed circuit position. Because of the relatively loose connection between the tie link 182 and the bifurcated distal end 193 of the auxiliary operating arm 191, a substantial degree of misalignment can be accommodated between the auxiliary operating arm 191 and the associated rod-like operator 97 without causing bowing or bending thereof as is likely to be present when the double link construction of the Gussow et al. patent is used.

The manner in which the kinetic energy of the moving system associated with the main operating arm 176 is transferred, in part, to the auxiliary operating arm 191 and parts associated therewith will be apparent from a consideration of FIGS. 5, 6, 7 and 8 of the drawings. Here it will be observed that a resilient lost motion connection, indicated generally at 197, is employed. This connection 197 includes a spring member 198 that is formed preferably of a strip of stainless spring steel. One end 199 of the spring member 198 is wrapped around an upstanding pin 200 which is carried by the main operating arm 176. The spring member 198 has an arched intermediate portion 201 which together with a reversely extending straight section 202, provides a slot 203 for receiving a depending pin 204 that is carried by the auxiliary operating arm 191. The section 202 continues around the pin 204 and its distal end 205 is slidable along the inside of the arched intermediate portion 201. The ends of the slot 203 in the spring member 198 are indicated at 206 and 207. When the main operating arm 176 is released for movement under the biasing action of the main spring 177, the spring member 198 is moved from the position shown in FIG. 6 in a clockwise direction. After this movement has continued for a predetermined extent, the end 206 of the slot 203 in the spring member 198 engages the juxtaposed side of the depending pin 204 from the auxiliary operating arm 191 and the transfer of kinetic energy begins to take place. It will be understood that, in the meantime, the auxiliary operating arm 191 has been unlatched in the manner described in the patent last referred to so that it is free to be moved by the forces acting on it. The spring member 198 provides a resilient rather than a rigid connection between the operating arms 176 and 191 with the result that there is a reduction of the peak forces during acceleration of the auxiliary operating arm 191 and parts movable therewith.

It is desirable that provision be made to insure that the pin 204 cannot escape from the slot 203 and that the auxiliary operating arm is fully moved to the closed and latched position should the spring member 198 fail. For these purposes an inextensible link shield 208 is employed. As shown in FIG. 8 the link shield 208 is generally U-shaped and is formed of plate like material such as stainless steel. The arms 209—209 of the inextensible link shield 208 are provided with slots 210 and 211 which, as will be evident from a consideration of FIG. 7, are slightly longer than the slot 203 in the spring member 198. Thus the ends 212 and 213 of the slots 210 and 211 in the arms 209—209 of the link shield 208 are spaced apart a distance that is somewhat greater than the distance between the ends 206 and 207 of the slot 203 in the spring member 198.

When the main operating arm 176 is rotated in the direction to effect closure of the main contacts 63, end 207 of the slot 203 in the spring member 198 engages the pin 204 depending from the auxiliary operating arm 191 and initiates the movement of the auxiliary operating arm 191 and auxiliary contacts 64 connected thereto. Should the spring member 198 fail, the ends 213 of the slots 210 and 211 in the arms 209—209 of the inextensible link shield 208 are engaged by the pin 204. Thereafter a rigid connection is provided between the operating arms 176 and 191 to complete the closing action of the auxiliary contacts 64.

It will be observed that the construction as herein described reduces the likelihood of failure of the bellows units 91 and particularly those bellows units associated with the auxiliary contacts 64 which are arranged to be separated at a relatively high speed in order to interrupt more effectively the arc or arcs that may be drawn therebetween. The improved results are obtained, in part, by providing the dashpot 152 or 152′ which, as described herebefore, effects a speed reduction during the last part of the opening movement of the auxiliary contacts 134 in the two unit interrupter or the single auxiliary contact 134 in the single unit interrupter. The provision of the tie link 182, particularly between the auxiliary operating arm 191 and the rod-like operator 97 connected to the auxiliary contact 134, takes care of misalignment therebetween and reduces the likelihood of the bending or bowing of this operator. At the beginning of the opening movement of the auxiliary contacts or contacts 134, this action is initiated through the resilient lost motion connection 197 and there is a corresponding reduction in

the peak forces incident to this action. As a consequence of these improvements the conditions under which the bellows units **91** are called to operate are such as to prolong substantially the operating life thereof.

What is claimed as new is:

1. In a circuit interrupter, in combination:
(a) a cylindrical insulating housing,
(b) terminals at the ends of said housing having gas tight connection thereto,
(c) an arc extinguishing gas in said housing at a pressure above atmospheric pressure,
(d) separable main contact means in said housing interconnecting said terminals and including a relatively stationary main contact mounted on one terminal and a relatively movable main contact,
(e) separable auxiliary contact means in said housing also interconnecting said terminals and including a relatively stationary auxiliary contact mounted on said one terminal and a relatively movable auxiliary contact,
(f) main and auxiliary rod-like operators carrying said relatively movable main and auxiliary contacts respectively at one end and at the other end extending through and slidably mounted on the other terminal and having a travel of several inches between closed position and open position,
(g) bellows means telescoped over each operator and secured at one end to the respective operator and at the other end to said other terminal and arranged and adapted to accommodate the travel of several inches of the associated operator,
(h) dashpot means cooperating with said auxiliary operator after it has moved to effect a predetermined separation of said auxiliary contacts for retarding further movement of said auxiliary operator and parts movable therewith,
(i) main and auxiliary operating arms rotatable about a common axis and operatively connected respectively to said main and auxiliary operators,
(j) spring means biasing said main operating arm and thereby said main operator and said relatively movable main contact to open position,
(k) a connection between said main and auxiliary operating arms which, after said main operating arm has been rotated by said spring means through a predetermined extent, rotation of said auxiliary operating arm is initiated to move said movable auxiliary contact to open position,
(l) a pump cylinder extending inwardly from the other terminal and overlying said auxiliary operator and
(m) a piston cylinder telescoped with said pump cylinder and having a nozzle portion secured to and movable with said auxiliary operator for directing a stream of the gas into the space between the auxiliary contacts on separation thereof resulting from movement of said auxiliary operator outwardly,
(n) said dashpot means including:
(1) a dashpot cylinder surrounding said pump cylinder, and
(2) an annular piston carried by said piston cylinder and movable therewith between said dashpot cylinder and said pump cylinder.

2. The invention, as set forth in claim **1**, wherein the dashpot action is effective only during the final portion of the opening stroke of the auxiliary operator.

3. In a circuit interrupter, in combination:
(a) a cylindrical insulating housing,
(b) terminals at the ends of said housing having gas tight connection thereto,
(c) an arc extinguishing gas in said housing,
(d) separable contact means in said housing interconnecting said terminals and including a relatively stationary contact mounted on one terminal and a relatively movable contact,
(e) a rod-like operator carrying said relatively movable contact at one end and at the other end extending through and slidably mounted on the other terminal and having a travel of several inches between closed position and open position,
(f) bellows means telescoped over said operator and secured at one end thereto and at the other end to said other terminal, and arranged and adapted to accommodate the travel of several inches of said operator,
(g) a pump cylinder extending inwardly from said other terminal and overlying said operator,
(h) a piston cylinder telescoped with said pump cylinder and having a nozzle portion secured to and movable with said operator for directing a stream of said gas into the space between said contacts on separation thereof resulting from movement of said operator outwardly of said housing, and
(i) dashpot means cooperating with said operator after it has moved to effect a predetermined separation of said contacts for retarding further movement of said operator and parts movable therewith,
(j) said dashpot means including:
(1) a dashpot cylinder surrounding said pump cylinder, and
(2) an annular piston carried by said piston cylinder and movable therewith between said dashpot cylinder and said pump cylinder.

4. The invention, as set forth in claim **3**, wherein the dashpot cylinder is provided with at least one aperture along the path of the annular piston during the initial portion of the opening stroke of the operator whereby the dashpot action is effective only during the final portion of the opening stroke.

5. The invention, as set forth in claim **3**, wherein the pump cylinder is provided with at least one aperture along the path of the annular piston during the initial portion of the opening stroke of the operator whereby gas in the space between the dashpot cylinder and the pump cylinder is forced to flow into the pump cylinder and the gas in said space is compressed during the final portion of the opening stroke.

6. In a circuit interrupter, in combination:
(a) a cylindrical insulating housing,
(b) terminals at the ends of said housing having gas tight connection thereto,
(c) an arc extinguishing gas in said housing at a pressure above atmospheric pressure,
(d) separable main contact means in said housing interconnecting said terminals and including a relatively stationary main contact mounted on one terminal and a relatively movable main contact,
(e) separable auxiliary contact means in said housing also interconnecting said terminals and including a relatively stationary auxiliary contact mounted on said one terminal and a relatively movable auxiliary contact,
(f) main and auxiliary rod-like operators carrying said relatively movable main and auxiliary contacts respectively at one end and at the other end extending through and slidably mounted on the other terminal and having a travel of several inches between closed position and open position,
(g) bellows means telescoped over each operator and secured at one end to the respective operator and at the other end to said other terminal and arranged and adapted to accommodate the travel of several inches of the associated operator,
(h) main and auxiliary operating arms rotatable about a common axis and operatively connected respectively to said main and auxiliary operators,
(i) spring means biasing said main operating arm and thereby said main operator and said relatively movable main contact to open position, and
(j) a resilient lost motion connection between said main and auxiliary operating arms whereby, after

said main operating arm has been rotated by said spring means through a predetermined extent, rotation of said auxiliary operating arm is initiated with a reduced shock action to move said movable auxiliary contact to open position,

(k) said resilient lost motion connection comprising a spring member pivotally anchored at one end to said main operating arm and having an elongated extensible slot portion at the other end adapted to receive a pin carried by said auxiliary operating arm.

7. The invention, as set forth in claim 6, wherein the spring member is a strip of spring steel having:

(a) the one end extending around a pin carried by the main operating arm,

(b) the intermediate portion arched, and

(c) the slot is formed in part by the arched portion and in part by a section extending from said arched portion and an end section the distal end of which overlies and is slidable along the inner side of said arched portion.

8. The invention, as set forth in claim 6, wherein a relatively inextensible link shield is pivoted to the main operating arm about the pivot axis of the spring member and overlies said spring member and has a slot normally extending beyond the slot in said spring member to limit the movement of the pin carried by the auxiliary operating member with respect to said main operating arm.

9. The invention, as set forth in claim 3, wherein the

rod-like operator at its one end is detachably connected to and inside of the bellows means.

10. The invention, as set forth in claim 9, wherein the one end of the rod-like operator is threaded into a guide washer at the inner end of the bellows means.

11. The invention, as set forth in claim 3, wherein the relation between the pump cylinder, piston cylinder and dashpot means is such that the pump action is relatively great during the initial portion of the opening stroke and continues with a reduced action during the final portion of the opening stroke.

12. The invention, as set forth in claim 5, wherein the gas in the pump cylinder continues to be forced to flow through the piston cylinder during the final portion of the opening stroke.

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