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Netzel

[11] **3,728,508**

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[54] **OPERATING MECHANISM FOR VACUUM CIRCUIT BREAKER INCLUDING CONTACT PRESSURE SPRINGS**

[75] Inventor: **Philip C. Netzel,** Milmont Park, Pa.

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

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[21] Appl. No.: **192,029**

[52] **U.S. Cl.**.....**200/153 V,** 200/144 B, 200/82 B, 200/153 H

[51] **Int. Cl.**.....**H01h 3/00**

[58] **Field of Search**.....200/144 R, 153 S, 200/153 V, 153 G, 153 H, 82 R, 82 A, 82 B, 144 B

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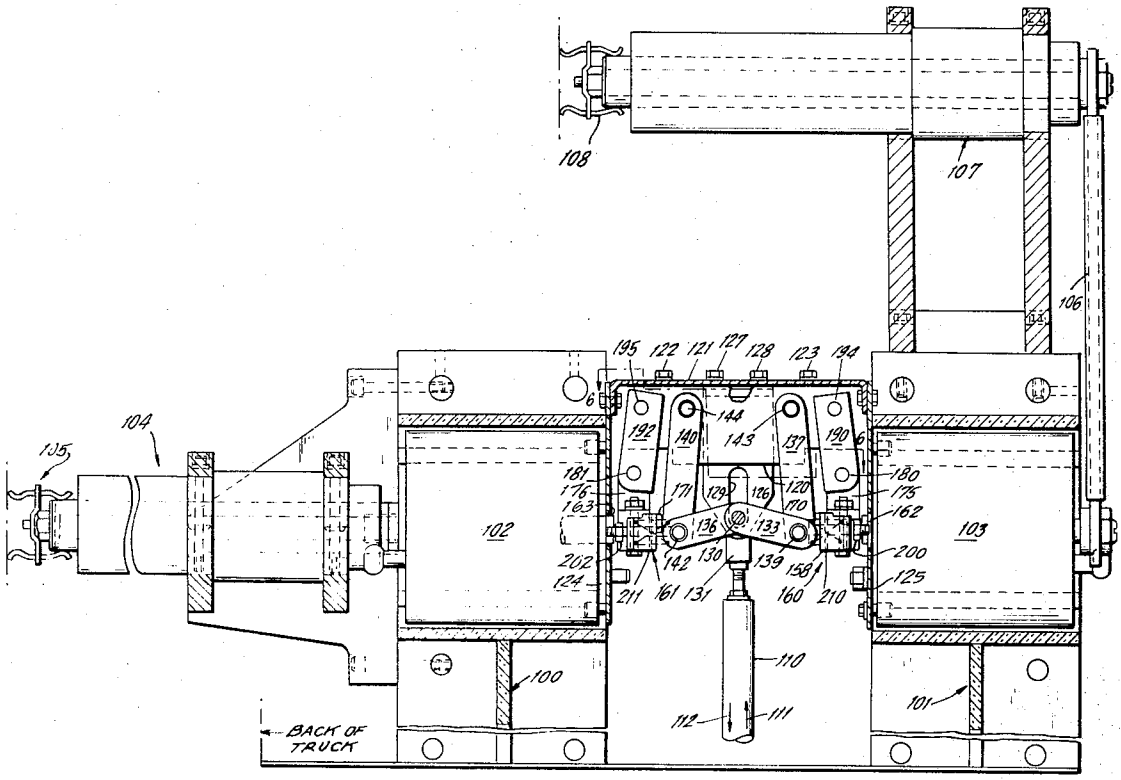
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Primary Examiner—J. R. Scott
Attorney—Ostrolenk, Faber, Gerb & Soffen

[57] **ABSTRACT**

A circuit breaker contains a pair of series-connected vacuum interrupter units which are coaxial with one another and spaced from one another. An operating mechanism is disposed between the vacuum interrupters, and is operated by an operating linkage moving along a line perpendicular to the axes of the vacuum interrupters. The operating linkage includes a toggle-type mechanism between the bottles which is expanded and contracted by the movement of the operating rod in order to operate the vacuum interrupter contacts simultaneously. A pair of conductive links used to connect the interrupters in series are used as parallelogram links for the operating toggle mechanism links. Contact loading springs are placed mechanically between the ends of the toggle links and the vacuum interrupter bottles. The contact spring forces are adjustable by the use of shims between the preloading springs and their spring carriers.

6 Claims, 7 Drawing Figures

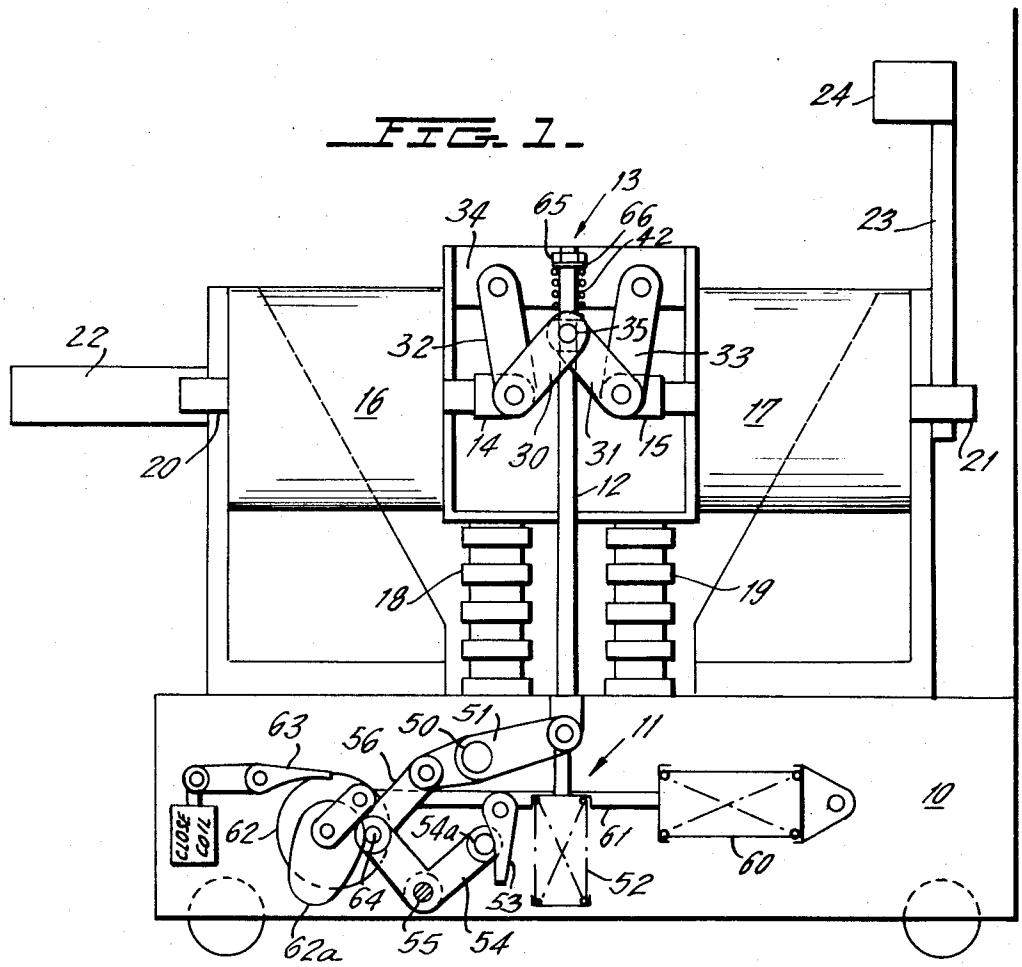


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SHEET 1 OF 4

FIG. 1.



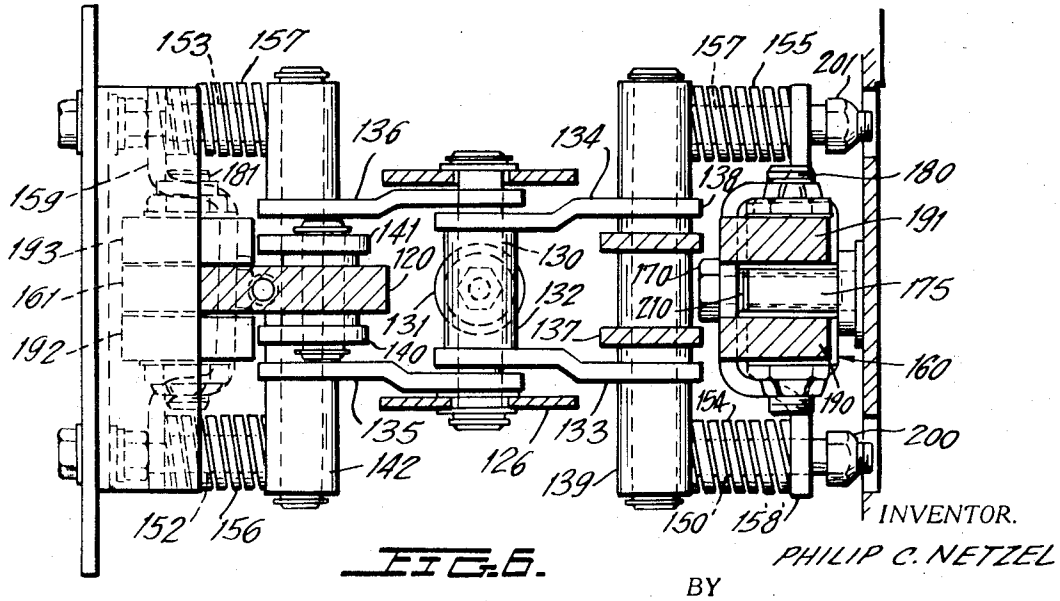


FIG. 6.

INVENTOR.
PHILIP C. NETZEL
BY
Ostrolenk, Faber, Gerb & Soffen
ATTORNEYS

FIG. 2.

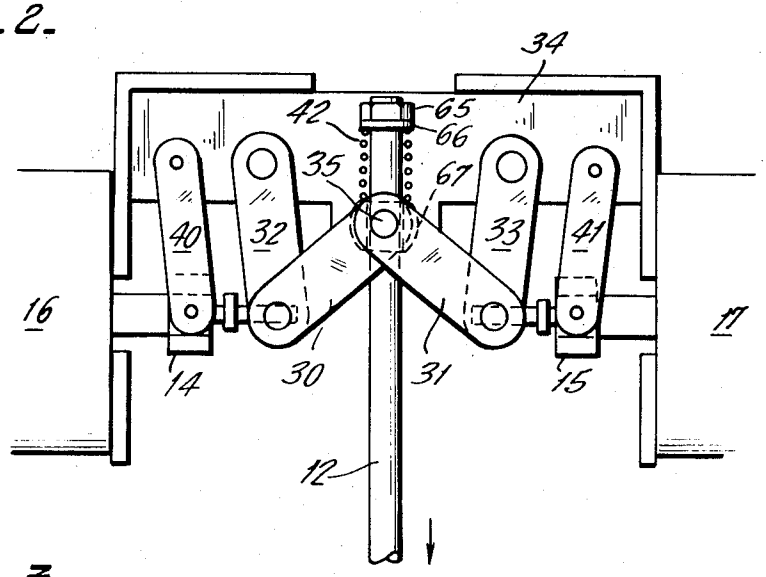


FIG. 3.

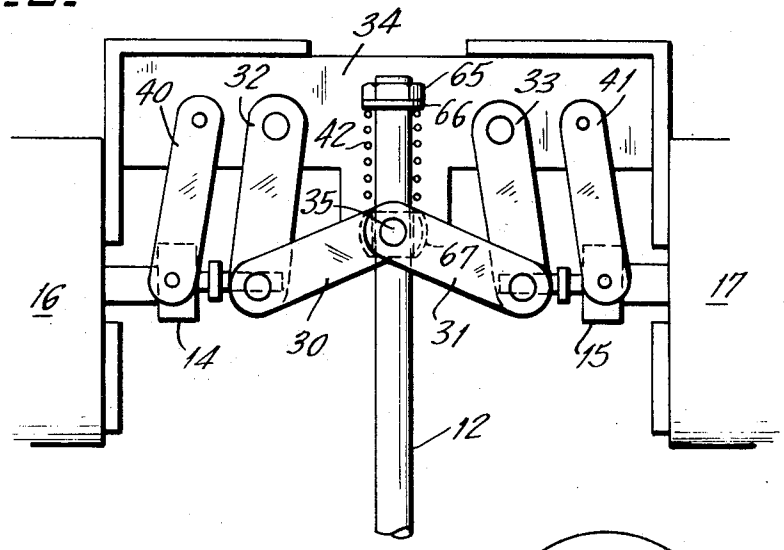
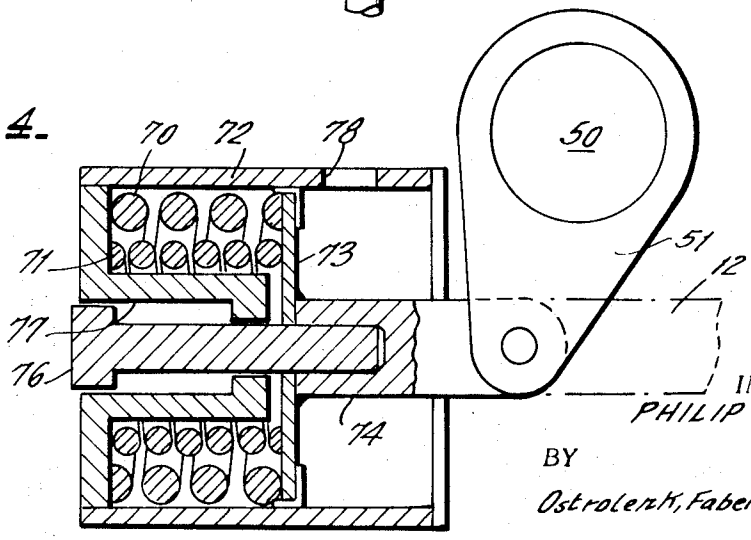


FIG. 4.



INVENTOR.
PHILIP C. NETZEL

BY

Ostrolenk, Faber, Gerb & Soffen

ATTORNEYS

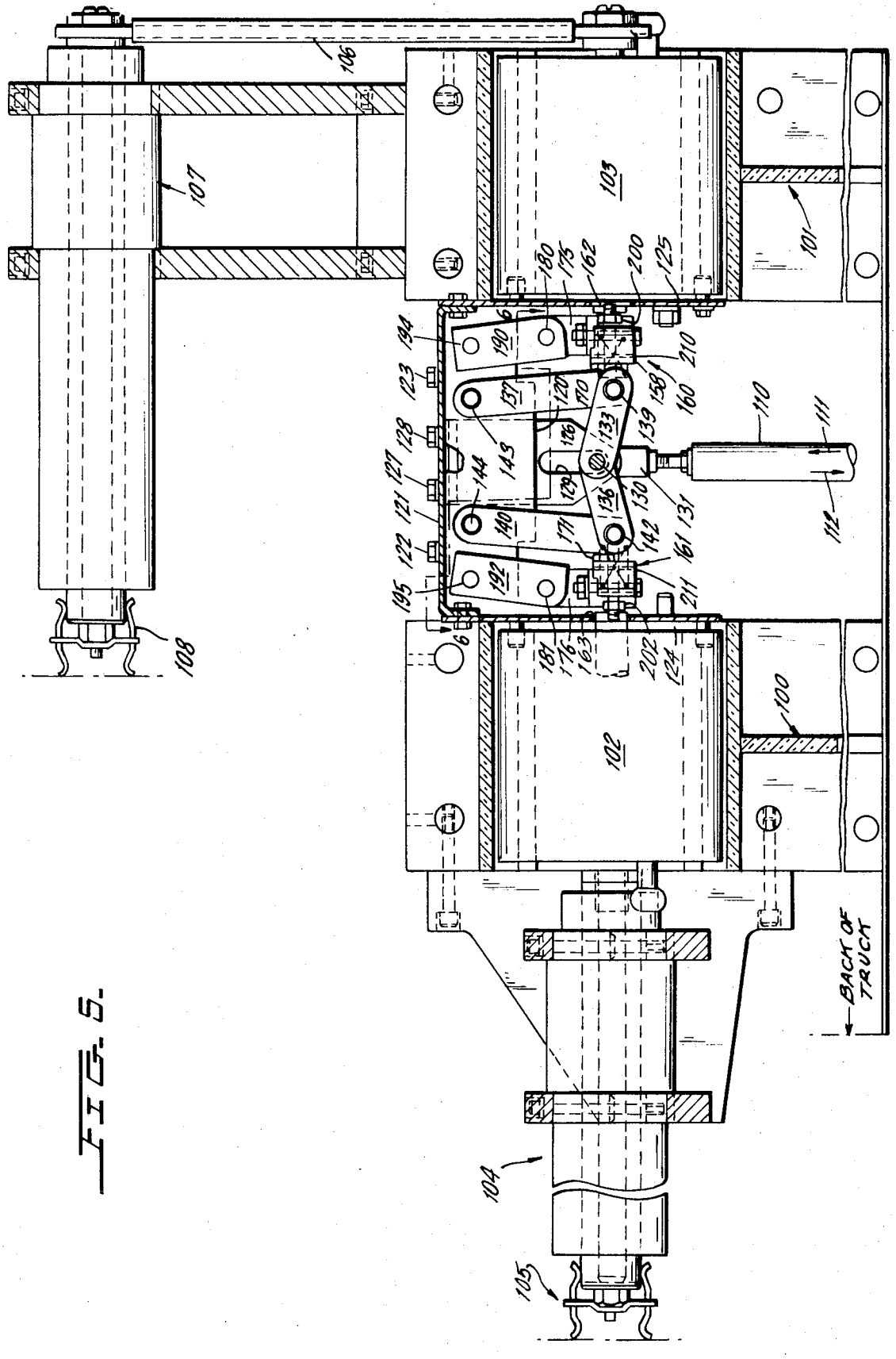

106
107
103
101
180
175
162
200
125
194
190
210
123
137
120
170
158
160
110
111
128
133
139
143
144
127
126
121
129
136
130
131
140
171
142
161
122
192
211
195
181
176
163
202
124
100
102
108
BACK OF TRUCK
104
105

FIG. 5.

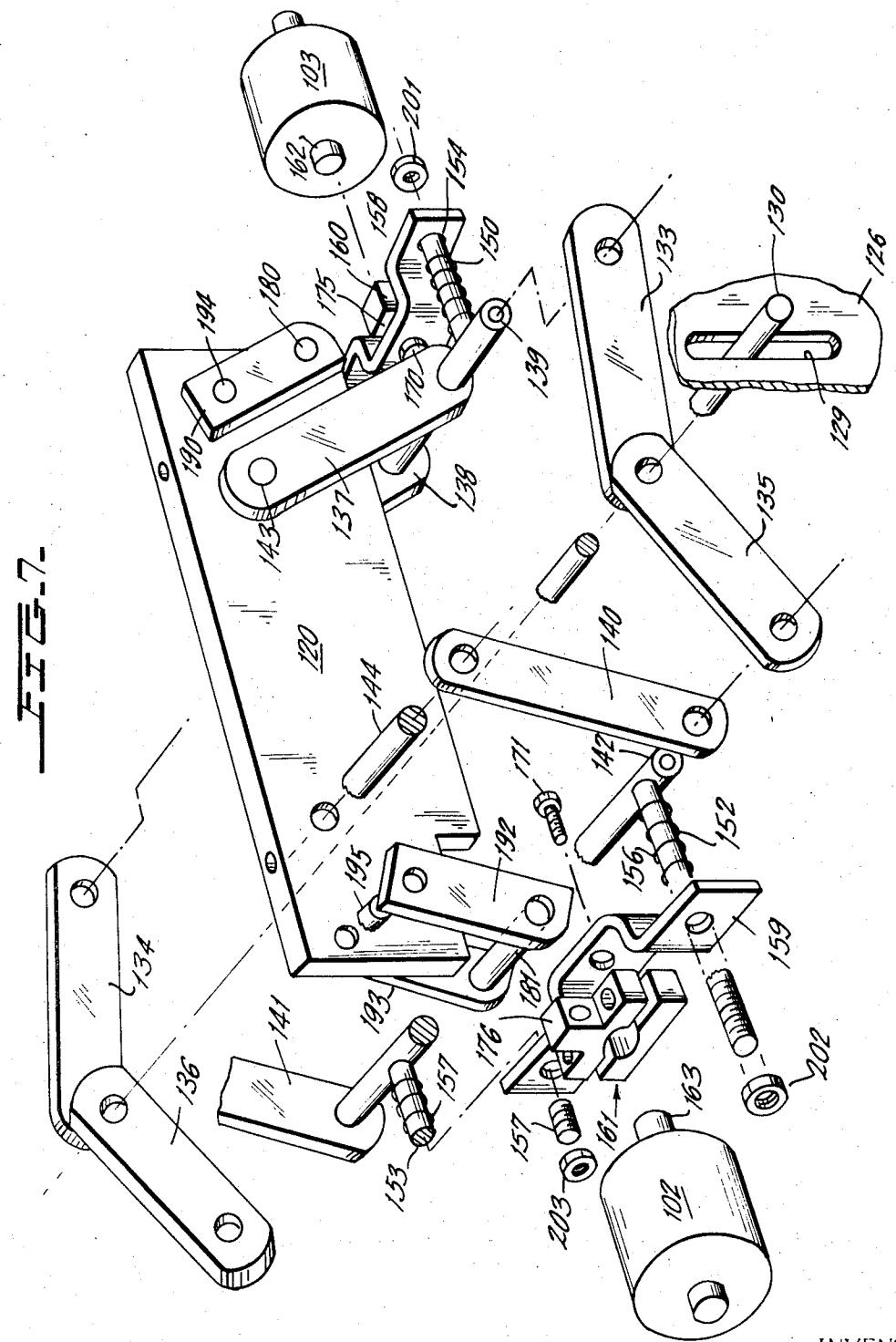


FIG. 7.

INVENTOR.
PHILIP C. NETZEL

BY

Astrolen M, Faber, Gerb & Soffen

ATTORNEYS

OPERATING MECHANISM FOR VACUUM CIRCUIT BREAKER INCLUDING CONTACT PRESSURE SPRINGS

RELATED APPLICATIONS

This application is related to copending application Ser. No. 192,073, filed Oct. 26, 1971, entitled Low Profile Circuit Breaker With Staggered Terminals, in the name of Thomas F. Brandt, Jr., et al. assigned to the assignee of the present invention.

BACKGROUND OF THE INVENTION

This invention relates to an operating mechanism for vacuum circuit breakers, and more specifically relates to a novel spring toggle arrangement for simultaneously operating the movable contacts of two vacuum interrupters which are axially spaced from one another and which are disposed coaxially.

In order to use vacuum interrupters for medium high voltage circuit breakers, for example, circuit breakers rated at 34.5 kilovolts or 38 kilovolts, it is necessary to provide two presently available vacuum interrupters in series with one another. That is, an economical single vacuum interrupter bottle which can operate at these medium voltages is not available. These two vacuum interrupter units may conveniently be located coaxially with respect to one another and spaced from one another so that an operating mechanism can be positioned between the vacuum bottles. By placing the operating mechanism between the vacuum bottles, the contact pressures present in each interrupter when closed will be arranged to oppose one another.

Arrangements of this type are generally disclosed in U.S. Pat. No. 3,597,556 to Sharp, where the operating mechanism of that patent is disposed between two spaced vacuum bottles, but where, however, the mechanism is arranged to cause the contacts in the interrupter to have a wiping action.

BRIEF SUMMARY OF THE INVENTION

The principle of the present invention is to provide a novel and modified operating mechanism for two spaced vacuum interrupters which are connected in series such that contact biasing forces are provided in a direction parallel to the axis of the bottles, with a toggle mechanism automatically preloading the contacts at the time the contacts touch. The mechanism is further provided such that when the contact erosion reaches its half-life, the spring force will be equal to the recommended momentary contact loading force. The toggle mechanism is further arranged so that it cooperates with current-carrying linkages which connect the two interrupters in series with one another and which bypass current around the operating mechanism.

More specifically, and in accordance with the invention, novel contact loading springs are provided for the operating mechanism of a pair of vacuum interrupters which are so arranged that they will hold the interrupter contacts closed against the magnetic forces generated by large momentary fault currents.

The mechanism also provides compensation for contact erosion of the contacts within the interrupter bottles. Thus, the contact loading springs are preloaded to about 75 percent of their required force for full momentary rating at the position where the contacts of the vacuum interrupters meet. As the toggle is further operated, the force on the contacts due to the springs builds up to a maximum of about 112.5 percent when the toggle is in its fully extended position. As the contacts erode due to interruption duty, this maximum force will gradually decrease. At the point where the contacts have reached their half-life (0.0625 inch erosion for a typical commercially available vacuum interrupter), the maximum spring force will be equal to the recommended momentary contact loading.

The contact spring carriage can, at this point, be adjusted by loading shims between the springs and the contact spring carriage to restore the desired contact spring force.

It will be noted that the use of a toggle linkage for operating the contacts permits the circuit breaker operating mechanism to be reduced in size as compared to an arrangement in which the contacts are operated in tandem, since the forces required from the operating mechanism to hold the contacts closed are reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates portions of the mechanism used in accordance with the present invention.

FIG. 2 schematically illustrates the toggle mechanism of FIG. 1 with the mechanism components shown in their open position.

FIG. 3 is similar to FIG. 2, but shows the toggle components in their contact closed position.

FIG. 4 shows a cross-sectional view of a novel arrangement for the opening spring of the operating mechanism of FIG. 1.

FIG. 5 is a plan view, partially in cross-section, of one detailed embodiment of the invention.

FIG. 6 is a cross-sectional view of FIG. 5, taken across the section line 6 — 6 in FIG. 5.

FIG. 7 is a perspective view, partially exploded, illustrating the toggle operating mechanism of FIGS. 5 and 6.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring first to FIGS. 1, 2 and 3, there is schematically illustrated a circuit breaker mounted on a truck 10 which can be racked between various positions in a conventional manner, where the truck 10 carries a main operating mechanism 11 which moves a shaft 12 with vertical motion which is transmitted to a toggle linkage 13. The toggle linkage 13 is then connected at one end to shaft 14 and at its other end to shaft 15, where the shafts 14 and 15 are, in turn, connected to the movable contacts of vacuum interrupters 16 and 17 respectively. Each of vacuum interrupters 16 and 17 and the toggle mechanism 13 are mounted on truck 10 through the insulator posts 18 and 19.

Interrupters 16 and 17 then have outer terminals 20 and 21 respectively, where terminal 20 is connected to a primary disconnect contact 22, while terminal 21 is connected to a conductor bar 23. The conductor bar 23 is then, in turn, connected to a suitably supported primary disconnect contact 24.

It will be understood that FIG. 1 schematically illustrates only a single pole of a circuit breaker which, conventionally, would be a multi-pole unit.

The vacuum interrupters **16** and **17** are so arranged that when the operating shaft **12** is in the upper position shown in FIGS. **1** and **2**, the ends of toggle links **30** and **31** will be moved to their collapsed position, so that the members **14** and **15** will be retracted relative to vacuum interrupters **16** and **17** respectively, and the vacuum interrupter contacts will be open. In order to close the vacuum interrupter contacts, shaft **12** is moved downwardly by the mechanism **11**, which will be later described, so that links **30** and **31** spread away from one another in order to move members **14** and **15** toward their respective interrupters **16** and **17**, thereby to close the vacuum interrupter contacts of each interrupter **16** and **17**.

FIG. **3** shows the toggle links **30** and **31** in their contact closed position after having moved through the closing stroke indicated in FIG. **2**. In one embodiment of the invention, where the vacuum interrupters **16** and **17** are of the type manufactured by the General Electric Company as their type No. PV–03G, this total closing stroke will be 0.75 inch for each vacuum interrupter.

In order to insure an approximate linear motion for members **14** and **15**, connected to toggle links **30** and **31**, guide links **32** and **33** are pivotally mounted to the lower ends of links **30** and **31** respectively, and are further pivotally supported from the upper stationary mounting structure **34**. The pin **35** which connects links **30** and **31** is further guided in a suitable guide slot **36** to insure that the center of the toggle formed by links **30** and **31** moves only vertically and in the direction of movement of shaft **12**.

As shown in FIGS. **2** and **3**, and as will be described more fully hereinafter, the support member **34** may also be a conductive member which is electrically connected to pivot links **40** and **41**, which are, in turn, electrically connected to the terminals of interrupters **16** and **17**, connecting the members **14** and **15** respectively.

In accordance with an important feature of the invention, a contact loading spring, schematically illustrated in FIGS. **1** and **2** as spring **42**, is connected between the end of shaft **12** and the shaft pin **35** of the toggle, including links **30** and **31**. This will then provide the desired contact loading by forces exerted through pivot pin **35** when the contacts are in their closed position.

The operating mechanism **11** of FIG. **1** includes a jackshaft **50** which has a crank **51** extending therefrom for each pole of the breaker. Shaft **51**, shown in FIG. **1**, is connected to the bottom of shaft **12** and is further connected to an opening spring mechanism **52**, which will be shown in more detail in connection with FIG. **4**. When the interrupters are in their closed position (FIG. **3**), the mechanism **11** is latched against motion due to opening spring **52** by the latch system including latch **53**, crank **54** which rotates about fixed pivot **55**, and link **56** connected to crank **51**. Thus, in the closed position, the right hand end of crank **54** will be latched under latch **53**. In order to open the breaker, latch **53** is removed so that crank **54** can rotate counterclockwise about shaft **55**, thereby allowing opening spring **52** to move the shaft **12** upwardly from the position of FIG. **3** to the position of FIG. **2**.

A closing spring **60** is provided to close the breaker contacts and the closing spring **60** is provided with an output shaft **61** pivotally mounted on rotatable latch plate **62**, which has a latching detent which can be latched by the latch **63**. Plate **62** is then provided with a camming surface **62***a* which cams against a roller **64** at the left-hand end of crank arm **54**. Thus, when the latch **63** is moved to an unlatched position, as by the operation of a closing coil, the plate **62** is rotated due to the expanding action of closing spring **60** so that cam surface **62***a*, acting against roller **64**, rapidly rotates crank **54** around shaft **55**, thereby rotating crank **51** clockwise to move shaft **12** downwardly. Note that at the end of this operation, latch **53** reseats itself against the roller **54a** at the right-hand end of crank **54**.

The downward movement of shaft **12** causes the downward motion of pin **35**, and thus the closing of the contacts, as shown in FIG. **3**. Note that in moving to this fully expanded toggle position, that the spring **42** (FIGS. **1** and **2**) will compress, thereby to place a spring loading force on the closed contacts. Thus, even though the contacts may erode, there will be sufficient force remaining in the precompression of the spring **42** to create the necessary contact pressure for the contacts within the interrupters **16** and **17**. Moreover, this force may be easily adjusted, for example, by loading shims between the spring and its carrier, or in the case of FIG. **2**, by threading the nut **65** downwardly on shaft **12**, thereby to move spring containing washer **66** toward shoulder **67**, which contains the lower end of spring **42**.

One important feature of the present invention is in the construction of the opening spring **52**, which provides a buffering dashpot to absorb the excess energy during the opening operation of the interrupters. Thus, in FIG. **4**, the crank arm **51** connected to shaft **12**, rotates counterclockwise in order to open the breaker. The opening springs shown as concentric springs **70** and **71** are contained within opening spring housing **72**, which contains a movable plate on piston **73** which is secured to a link **74**, which is connected to shaft **12** and crank arm **51**. In addition, the link **74** is further connected to a shaft **75** having an enlarged head **76**, which moves within a cavity **77** of the spring housing. Thus, during the opening operation, shaft **12** can move rapidly under the expanded force of springs **70** and **71**, until the piston **73** passes port **78**, at which time the increase in pressure on the right-hand surface of piston **73** is raised, thereby providing a strong restraining action against the continued opening movement of shaft **12**. At the same time, the movement of enlarged head **76** into the chamber **77** exerts a controlled restraining force against too rapid movement of shaft **12** in the opening direction.

FIGS. **5**, **6** and **7** illustrate one specific embodiment of one pole of a 34.5 kilovolt circuit breaker which uses the toggle mechanism of the present invention.

The overall breaker is best seen from FIG. **5**, which shows support molding structures **100** and **101**, which serve to support vacuum interrupter bottles **102** and **103** respectively. A terminal bushing **104**, having a primary disconnect contact **105** at the end thereof, is connected to the fixed contact terminal of vacuum bottle **102**.

An electrical conductor bar **106** is connected to the fixed contact terminal of vacuum bottle **103**, and the conductor bar **106** is appropriately connected to a suitably supported bushing **107**, having the second primary disconnect contact **108** at the end thereof. Note that the primary disconnect contacts **105** and **108** are not disposed above one another, but are staggered in position in order to permit a low profile for the breaker. That is, a given dielectric spacing is obtained between terminals **105** and **108**, where this spacing is not a complete vertical spacing, as was the case in the prior art. Consequently, the breaker can be mounted in an outdoor cubicle having a height less than about 6 feet, which can conveniently be shielded or hidden by common shrubbery to produce an unimposing appearance for the substation using the switchgear.

Thus, the overall breaker will have a shorter profile than it would have had if the breaker terminals were disposed above one another in the conventional manner. This is the subject matter of the invention claimed in copending application Ser. No. 192,073.

FIGS. **5** and **6** also show the operating shaft **110** which corresponds to the operating shaft **12** of FIGS. **1** to **4**, where the operating shaft **110** moves in the direction of arrow **111** to open the contacts of vacuum interrupters **102** and **103**, and moves in the direction of arrow **112** to close the interrupter contacts.

The operating mechanism for operating the interrupters **102** and **103** is driven from shaft **110** and is generally supported and sub-assembled on the conductive block **120** (FIGS. **5** and **7**). The block **120** is, in turn, secured on a top cover plate **121** by bolts **122** and **123** in FIG. **5**, which thread into the top of conductive member **120**. The cover plate is not shown fully in detail, but is made sufficiently wide to cover the top of the operating mechanism.

The top cover **121** is then connected to suitable side plates **124** and **125**, which are, in turn, connected to the support moldings **100** and **101**, and are disposed adjacent the vacuum interrupter bottles **102** and **103**.

A generally L-shaped slide guide plate **126** has a flange at its upper end bolted to the top cover **121** by the bolts **127** and **128** (FIG. **5**). Guide plate **126** then has an elongated guide opening **129** therein (FIGS. **5** and **7**) which opening receives and guides the motion of pivot shaft **130**.

The upper end of a shaft portion **131** (FIGS. **5** and **6**) which is adjustably connected to the main operating shaft **112**, has a cylindrical bushing **132** connected to the end thereof which slidably receives the pivot pin or shaft **130**. The pivot pin **130** is then connected to the toggle link pairs **133–134** and **135–136** respectively. These toggle link pairs correspond generally to the toggle links **31** and **30** respectively in FIGS. **1** to **4**. Note that these links are separated from one another by the bushing **132** on the pin **130**, and further note in FIG. **6**, that these links may be bent to accommodate themselves to a relatively small volume.

The opposite ends of links **133** and **134** are then pivotally connected to toggle links **137** and **138** through the pin **139**, while the outer ends of links **135** and **136** are similarly connected to toggle links **140** and **141**, which are carried on pin **142**. The upper end of the pairs of links **137** and **138** are pivotally connected to the conductive support **120** by the pin **143** (FIGS. **5** and **7**), while the upper ends of links **140** and **141** are pivotally connected to support **120** by the pin **144**.

Each of pins **139** and **142** are surrounded by bushing members which have extensions **150–151** and **152–153** extending therefrom. These extensions are spring guide pins which respectively receive contact pressure springs **154** to **157** respectively. The opposite ends of contact pressure springs **154** and **155** then bear against a spring carrier plate **158** and, similarly, springs **156** and **157** press against a spring carrier plate **159**. The spring carrier plates **158** and **159** then receive contact clamps **160** and **161** which clamp onto the movable contact terminals **162** and **163** respectively of vacuum interrupters **103** and **102** respectively, Note that the clamps **160** and **161** are conventional split member clamps which are tightened on the cylindrical contact terminals **162** and **163** respectively by tightening the clamping bolts. The spring carriers **158** and **159** are then firmly secured to the terminals **162** and **163** respectively, by the bolts **170** and **171** respectively, which extend through the center of the spring carriers **158** and **159** respectively, and into the ends of terminals **162** and **163** respectively.

The upper ends of clamp members **160** and **161** then have extending tongues **175** and **176**, which tongues contain openings which receive suitable pins such as pins **180** and **181**, which are used to form an electrical connection permitting mechanical rotation between the clamps **160** and **161** and the electrical connecting links **190–191** and **192–193**. The upper ends of links **190** to **193** are also in rotatable pressure contact with the main conductive support body **120** by a suitable pressure connection which includes shafts **194** and **195** respectively (FIGS. **5** and **7**). Thus, the links **190** and **191** form an electrical connection from the terminal **162** of vacuum interrupter **103** to the conductive support **120**. The links **192** and **193** then continue this electrical connection from the body **120** to the terminal **163** of interrupter **102**.

It should be noted that links **190–193** take all of the electrical conducting duty involved in the series connection of interrupters **102** and **103**, and remove the need for electrical conduction through portions of the main operating mechanism. It will further be noted that these links also act to force movement of members **162** and **163** of interrupters **103** and **102** respectively to be constrained to a straight line so that pure butt contacting action is obtained within the vacuum interrupter units.

It will finally be observed that there is intentional free play between the end cap nuts **200–201** and **202–203**, which are secured to the ends of posts **150–153** respectively, and serve as a stop for the movement of the spring brackets **158** and **159**. As will be seen more fully hereinafter, this intentional free play improves the operation of the unit during opening, since it permits the application of an impact force to the closed contacts.

The operating mechanism of FIGS. **5**, **6** and **7** is shown with the interrupter contacts in their closed position. It will be noted that the forces of springs **154** through **157** (which serve the purpose of spring **42** in FIGS. **1**, **2** and **3**) press the spring carriers **158** and **159** outwardly and away from one another, thereby to press the movable contact terminals **162** and **163** of interrup-

ters 103 and 102 respectively toward their contact engaged position. Note further that the contact biasing force is axially directed in the same direction in which the contacts would normally move. It will also be seen that the breaker can be held in its closed position through the toggle mechanism with the application of relatively small forces to the shaft 110.

The operating mechanism is so adjusted that when the toggle is in its fully extended position, as shown in FIGS. 5 and 6, the force on the contacts is about 112.5 percent of the rated force. Thus, when the contacts erode due to interruption, so that the spring carriers 158 and 159 will be further apart when the breaker contacts are closed, the reduction in spring force will be to the 100 percent figure after the contacts have eroded by their half-life, which would conventionally be about 0.0625 inch. This force can then be easily adjusted by the location of shims in the toggle mechanism. Thus, in FIGS. 5 and 6, there are shown shims 210 and 211 disposed between spring carriers 158 and 159 and the terminal members 162 and 163 respectively.

It is important to note that the use of these shims does not affect the stroke of the operating mechanism, but merely change the end position of the movable contacts.

In order to open the interrupter, shaft 110 moves upwardly in the direction of arrow 111, with the shaft being guided for linear movement by the guide slot 129, which receives pin 130. The upward movement of pin 130 causes toggle links 133–134 and 135–136 to move inwardly. Once they have reached a given position, the nuts 200 to 203 on the spring guide pins 150–153 respectively, strike their respective spring carriers 158 and 159. This impact force is then applied to the contacts of interrupters 102 and 103 in order to break any welds that may have been formed between these contacts, and the continued movement of pin 130 upwardly causes the continued relative inward movement of the interrupter contacts, moving them to their disengaged positions.

During this movement, guide links 137 and 138, and 140–141 move respectively clockwise and counterclockwise, and similarly, the links 190–191 and 192–193 execute the same movement. Thus, these various pairs of links form two parallelograms causing the brackets 160 and 161 to move generally linearly, without rotation. Thus, good straight-line action is obtained for the movement of the movable contacts of interrupters 102 and 103. Note further that this novel action is obtained by incorporating the links 190-193, which are used primarily to form the electrical conducting path through the series connected interrupters, in the mechanical toggle mechanism.

In order to reclose the interrupters, the operating shaft 110 is moved downwardly in the direction of arrow 112 and the toggle mechanism responds accordingly by extending between the pins 139 and 142. The mechanism is so adjusted that at the instant the contacts touch, the contact loading springs are preloaded to about 75 percent of the required force for full momentary rating. As the toggle is further operated, this force on the contacts builds up to its predescribed maximum of 112.5 percent when the toggle has been fully extended.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to 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. An operating mechanism for first and second vacuum interrupters; said first and second vacuum interrupters each including generally cylindrical housings having axially disposed and axially movable contact terminal members extending from one end surface thereof; and means for supporting said first and second vacuum interrupters in spaced coaxial relation with said one end surfaces facing one another; said operating mechanism comprising, in combination:

an axially movable operating shaft movable generally perpendicular to the axes of said first and second interrupters;

first and second toggle link means, each having first and second ends, and pivotally connected at their said first ends to one another and to said operating shaft;

first and second guide link means for guiding the motion of said second ends of said first and second toggle link means; said first and second guide link means each having first and second ends;

a stationary support means; said first ends of said first and second guide link means being pivotally mounted to said stationary support means; said second ends of said first and second guide link means being pivotally connected to said second ends of said first and second toggle link means respectively;

first and second pivotal means pivotally connecting together said second ends of said first and second guide link means respectively, and said second ends of said first and second toggle link means respectively to said contact terminal members of said first and second interrupters respectively;

a spring biasing means having first and second end portions connected to said operating shaft and said stationary support means respectively; said operating shaft being movable to move said first and second toggle link means from an interrupter closed position in which said first and second toggle link means are extended to an interrupter open position in which said first and second toggle link means are collapsed from their extended position;

and first and second conductive links for connecting said first and second vacuum interrupters in series with one another; said first and second conductive links each having a first end mechanically and electrically pivotally connected to said stationary support means, and each having a second end mechanically and electrically pivotally connected to said contact terminal members of said first and second interrupters respectively; said first and second conductive links generally forming parallelogram mechanisms with said first and second guide link means respectively for guiding the motion of said contact terminal members in a straight line; said stationary support means consisting of electrically conductive material.

2. The operating mechanism of claim 1 which further includes a guide means having an elongated slot extending parallel to the direction of movement of said shaft; said operating shaft and said first and second toggle link means having a common pivot pin extending therefrom and disposed within said elongated slot for movement therein.

3. The operating mechanism of claim 1 which further includes first and second spring bracket means connected to said contact terminal members of said first and second vacuum interrupters respectively, and wherein said spring biasing means includes compression springs disposed between said first and second spring bracket means and said first and second pivotal means.

4. The operating mechanism of claim 3 wherein said first and second pivotal means connected to said first and second spring bracket means respectively, includes lost motion means whereby the toggle formed by said first and second toggle link means can collapse for a given distance from their fully extended position before said contact terminal members are directly mechanically engaged by impact force from said operating shaft.

5. The operating mechanism of claim 4 which further includes position adjustment shim means disposed between said first and second spring bracket means and said contact terminal members of said first and second vacuum interrupters respectively.

6. The operating mechanism of claim 1 which further includes accelerating spring means connected to said operating shaft for biasing said operating shaft toward an interrupter opening position; and time-delay dashpot means connected to said accelerating spring means for damping the opening movement of said first and second toggle link means as they reach the end of their movement to a collapsed position.

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