United States Patent [19]

Weston et al.

[11] **3,769,478**

[45] **Oct. 30, 1973**

[54] **ISOLATING CIRCUIT BREAKER AND OPERATING MECHANISM THEREFOR**

[76] Inventors: **Donald E. Weston; Raymond F. Kupetis; Demetrius Karathanos,** all of c/o H. K. Porter Company, Inc., 2437 Fulton St., Chicago, Ill. 60612

[22] Filed: **Mar. 1, 1971**

[21] Appl. No.: **119,511**

[52] **U.S. Cl.** ..... **200/146 R,** 200/153 L

[51] **Int. Cl.** **H01h 33/12**

[58] **Field of Search** ..... 200/146, 145, 153 L

[56] **References Cited**

UNITED STATES PATENTS

3,566,055 2/1971 Weston ..... 200/145 X

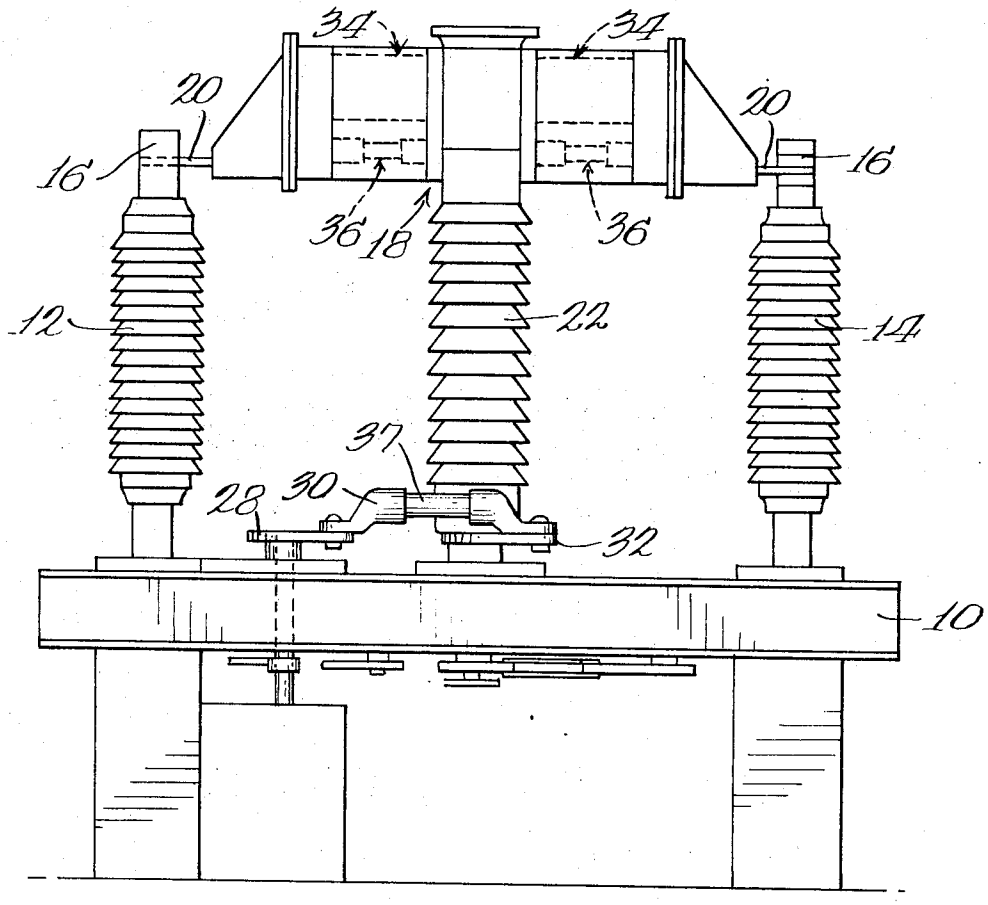
Primary Examiner—Robert S. Macon

Attorney—Gary, Parker, Juettner, Pigott & Cullinan

[57] **ABSTRACT**

A rotary disconnect switch includes separate main contacts and vacuum contacts mounted within the disconnect switch. A remote mechanical operator connected to a power device serves to close and open the disconnect, main and vacuum contacts in a particular ordered sequence. The operator also includes a latched spring driver to assure rapid closing of the contacts in sequence.

16 Claims, 16 Drawing Figures



PATENTED OCT 30 1973

3,769,478

SHEET 1 OF 8

Fig. 1.

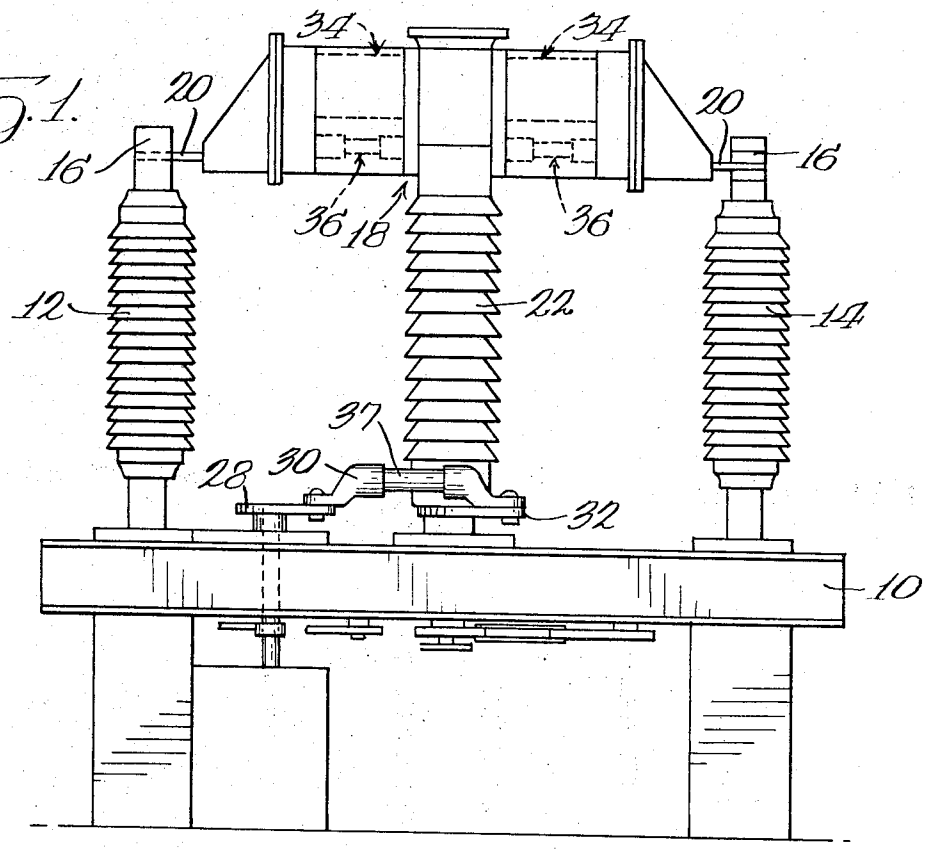
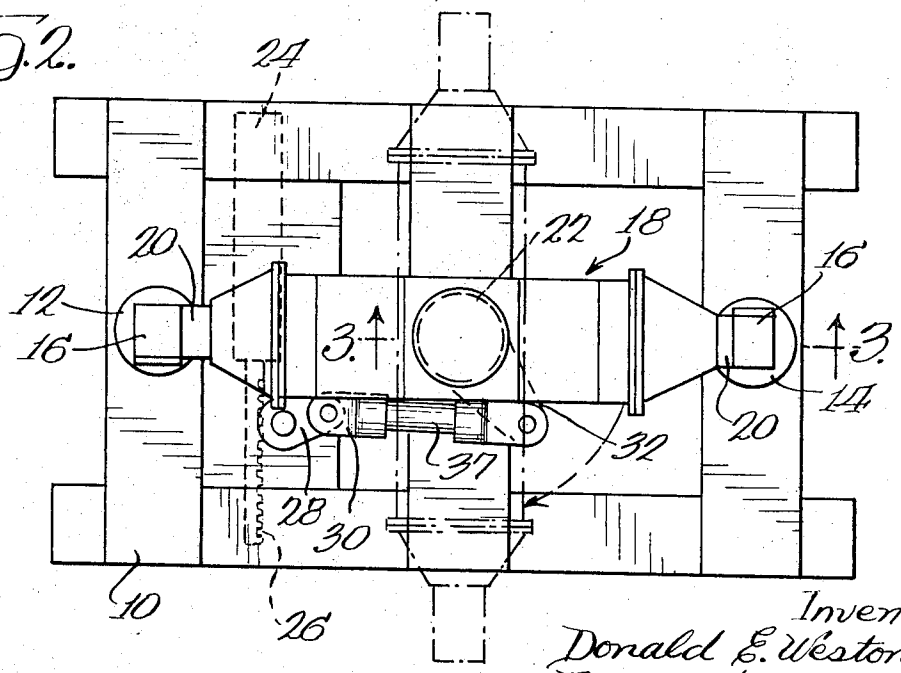


Fig. 2.



Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos

By

Gary, Parker, Juettner, Pigott & Cullinan
Attys

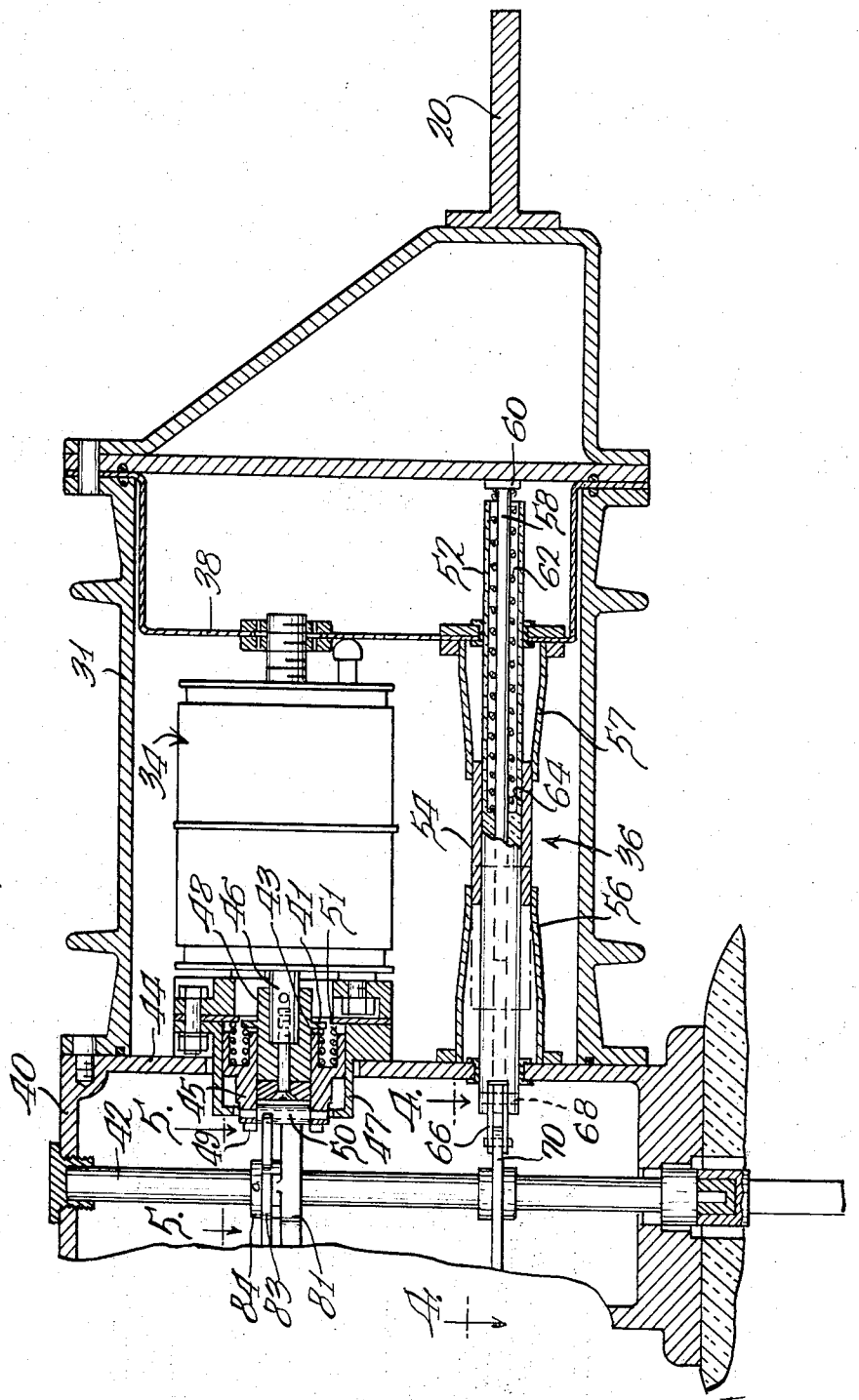


FIG. 3.

Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos

By
Gary, Parker, Juettner, Rigott & Cullinan
Attys

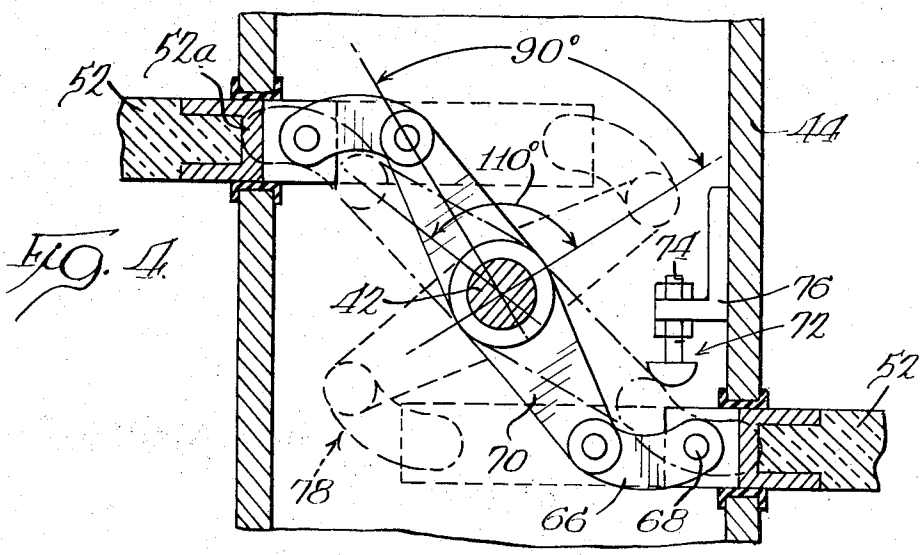


Fig. 4.

Fig. 5.

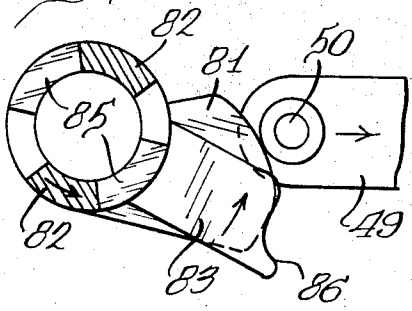


Fig. 7.

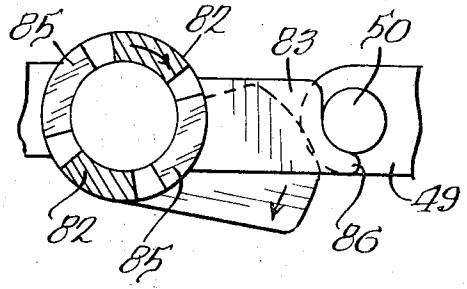


Fig. 6.

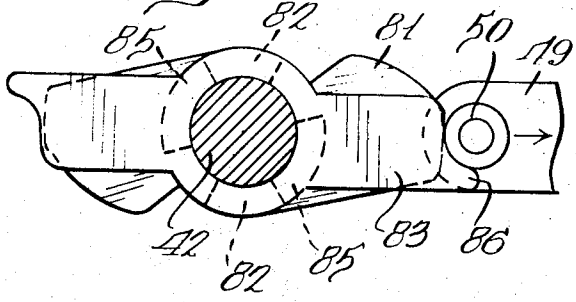
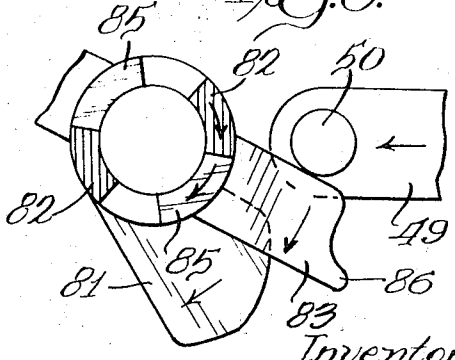


Fig. 8.



Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos

By
Gary, Parker, Juettner, Pigott & Cullinan
Attys

PATENTED OCT 30 1973

3,769,478

SHEET 4 OF 8

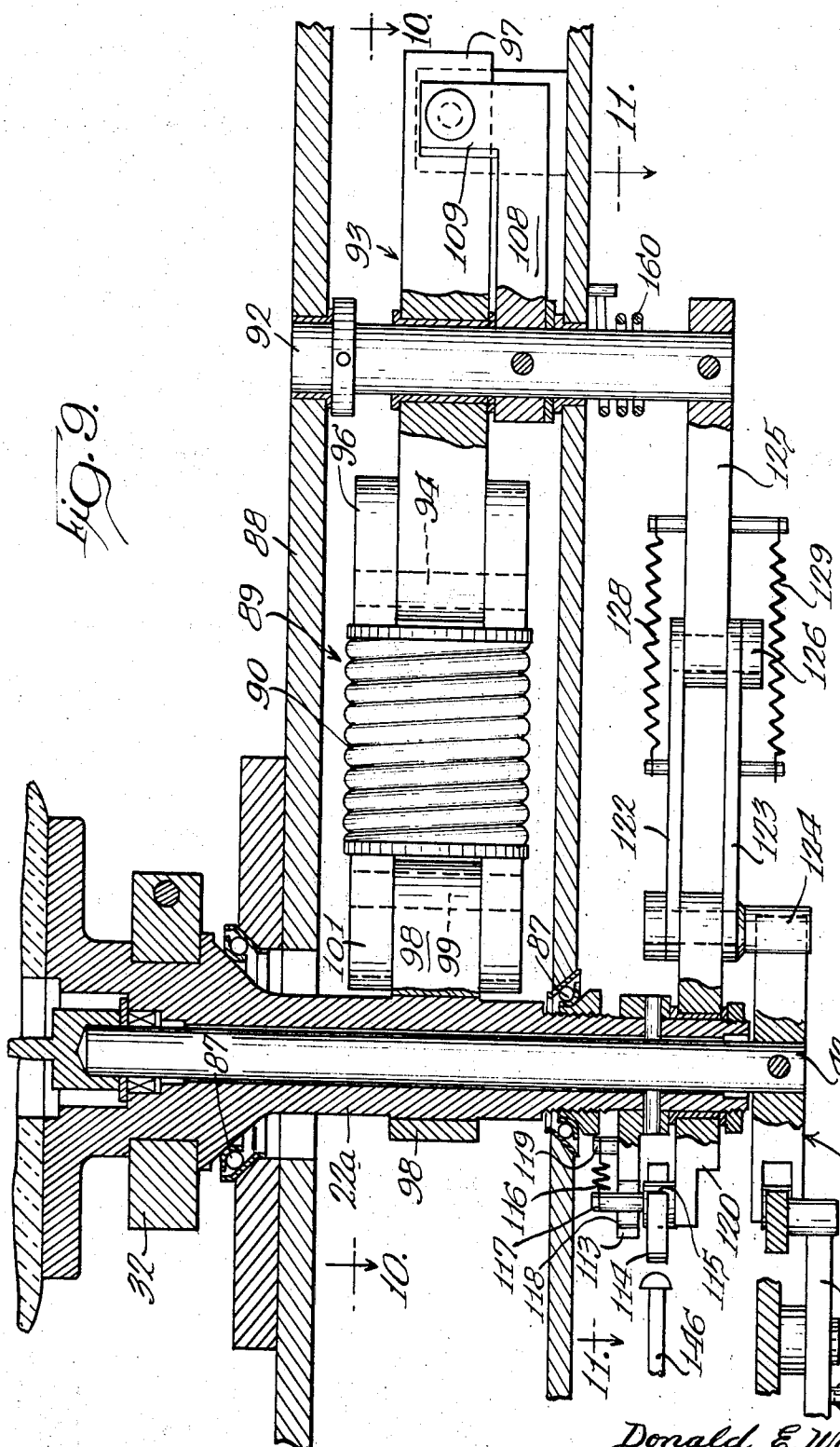


Fig. 9.

Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos

By
Gary, Parker, Juettner, Pigott & Cullinan
Atty's

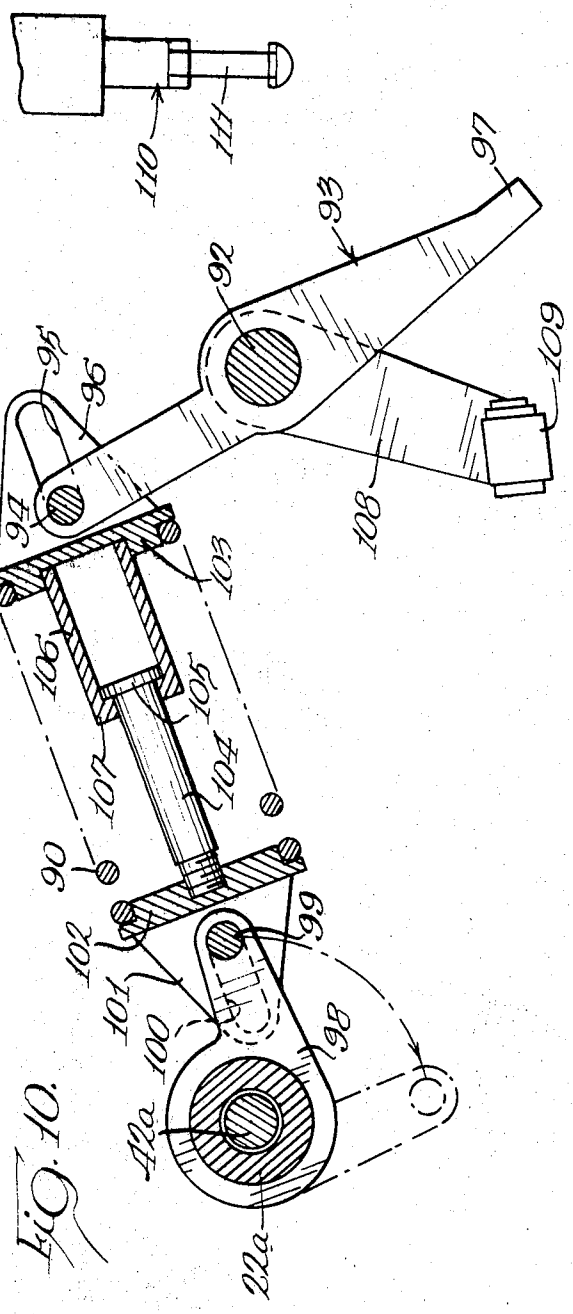


FIG. 10.

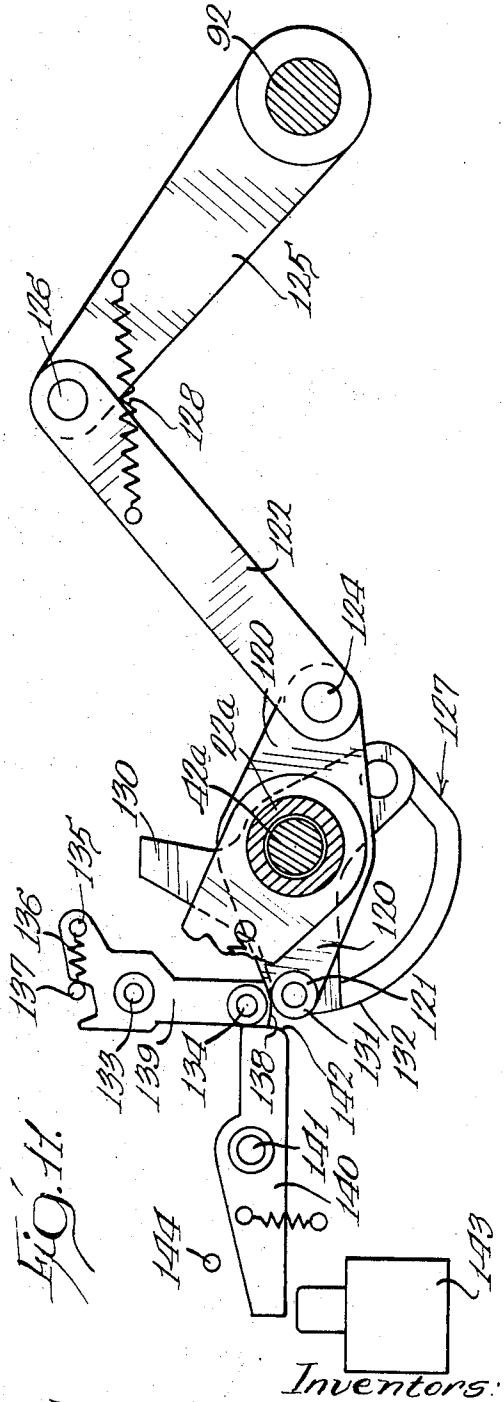


FIG. 11.

Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos
By
Gary, Parker, Juettner, Pigott & Cullinan
Attys

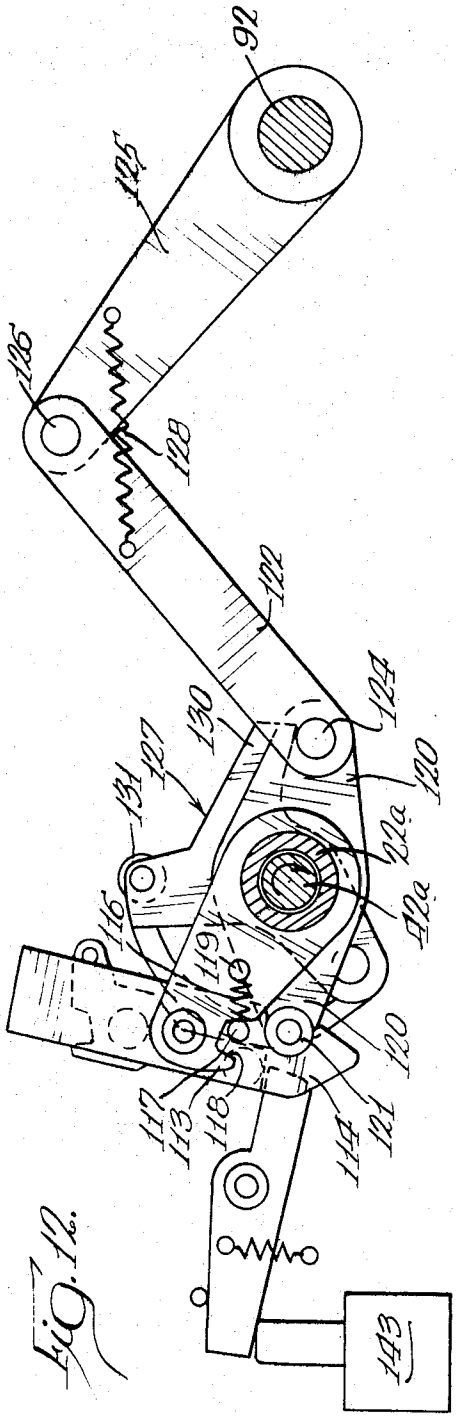


Fig. 12.

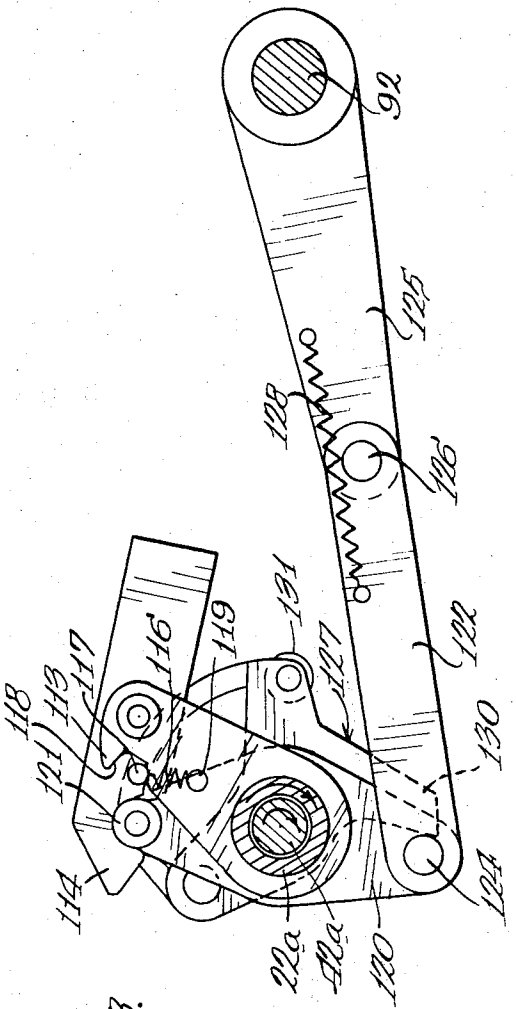


Fig. 13.

Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos
By
Gary, Parker, Juettner, Pigott & Cullinan
Attys

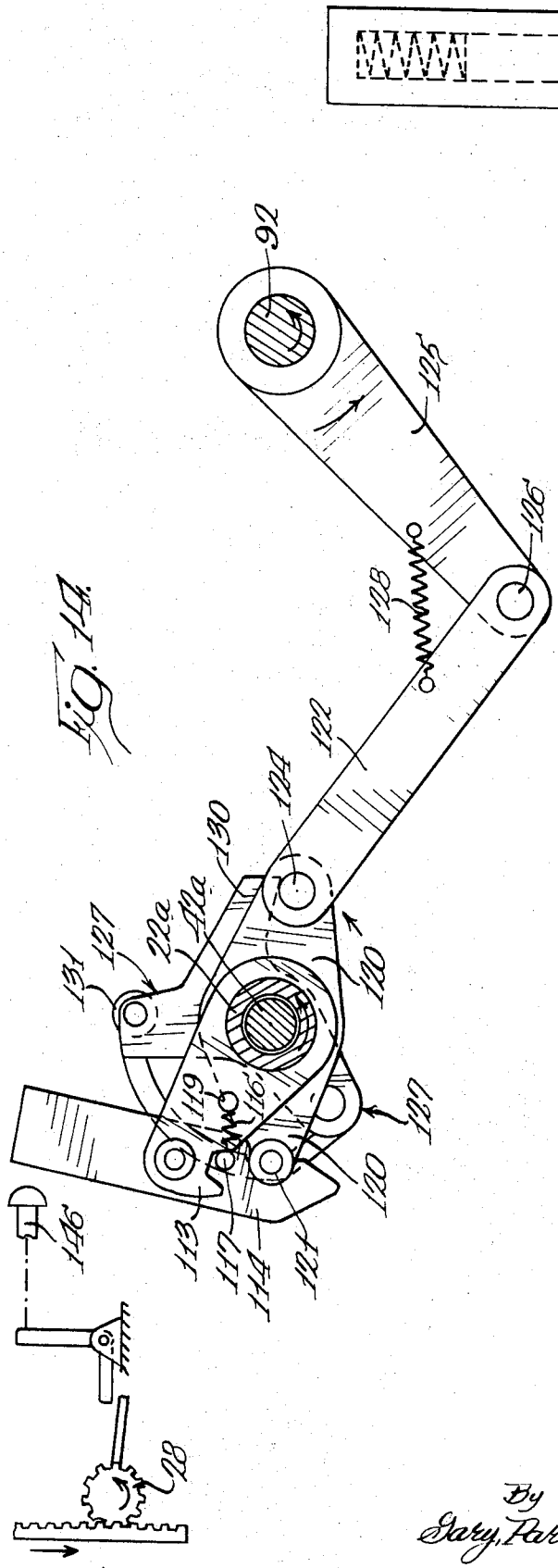


Fig. 14.

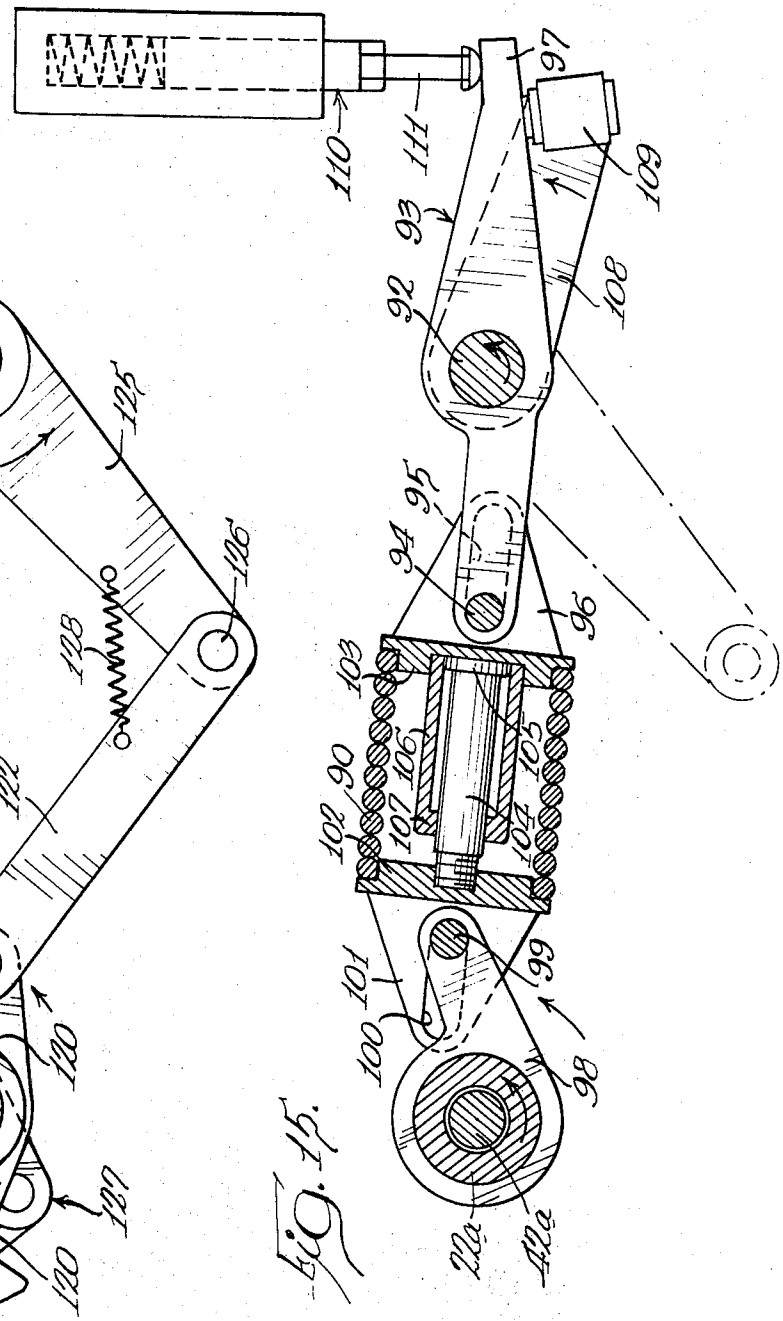


Fig. 15.

Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos
By
Gary, Parker, Juettner, Pigott & Cullinan
Attys

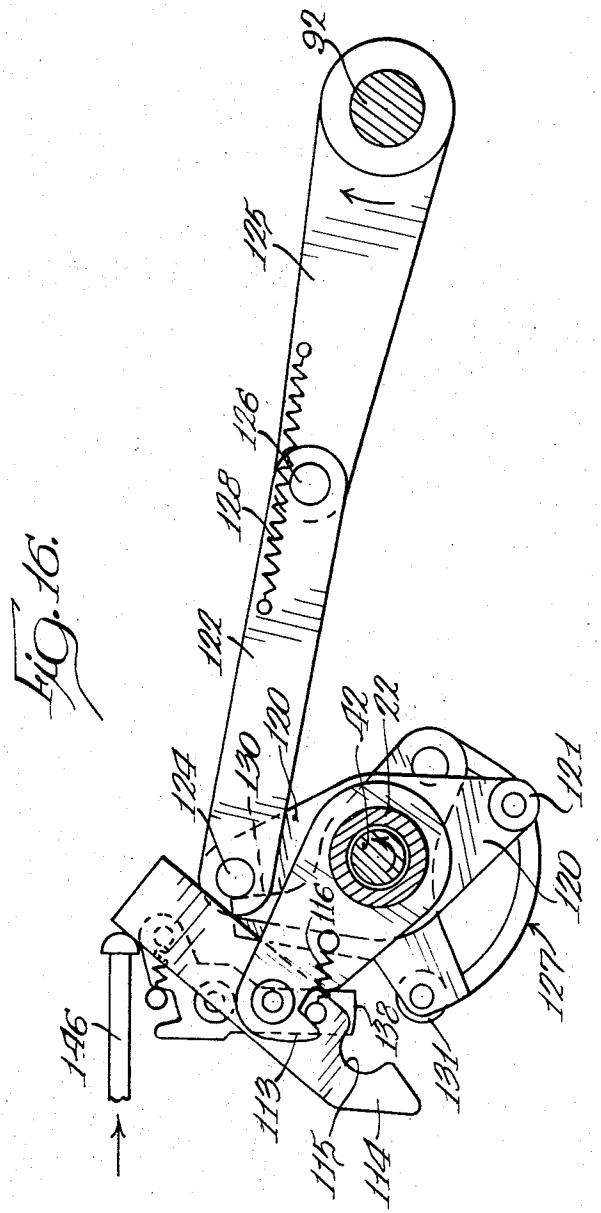


Fig. 16.

Inventors:
Donald E. Weston
Raymond F. Kupetis
Demetrius Karathanos

By
Gary, Parker, Juettner, Pigott & Cullinan
Attys

ISOLATING CIRCUIT BREAKER AND OPERATING MECHANISM THEREFOR

BACKGROUND OF THE INVENTION

This invention relates to high tension switchgear and more particularly to a composite switch having a plurality of components operated in sequence as the circuit is to be broken. The present invention is more particularly directed to improvements in the class of devices described in the Western U.S. Pat. No. 3,566,055, incorporated herein by reference.

The aforesaid Weston patent discloses a disconnect switch having separate main contacts and vacuum contacts mounted in parallel therein and connected between the disconnect contacts. The body of the disconnect switch rotates on an insulated shaft between stationary contacts, which serves to open and close the disconnect switch. The main contacts and vacuum interrupter contacts mounted within the disconnect switch body are remotely operated by means of a linkage operatively connected to a second shaft within the insulated shaft. In opening, the main contacts are first opened, and then the vacuum contacts are rapidly opened to break the circuit. The disconnect switch is then rotated to an open position in order to electrically isolate the circuit components and prevent arc-over. In closing, the disconnect is rotated into a closed position, and is followed by the sequential closing of the main contacts and vacuum contacts.

In performing the foregoing opening and closing sequences, it is important that each sequence be performed rapidly to avoid or minimize electrical stress on the various components of the system. Thus during closing, the main contacts, during the last 1/4 inch of their gap, should move at a speed of not less than about 8 feet per second where fault closing must be accomplished. Since the vacuum contacts do not serve to make the circuit, the speed of the moving vacuum contact should not exceed 2 feet per second when the main contacts are closed. During opening, it has been determined that the main contacts should open to a gap of 2.5 inches in the order of about 1.5 cycles of a 60 cycle circuit, while the vacuum contacts should open to a gap of 3/8 of an inch with a minimum average speed of about 4 to 7 feet per second.

Also in systems of the type herein described, it is desirable that the switch operating mechanism be completely reliable because of the possibility of infrequent usage and include safety features to prevent operation out of sequence. Thus, if a single device is to be used to cause sequential activation of both the opening and closing functions, the device should be capable of automatically setting itself to the first stage of the opening and closing sequence without the need for manual manipulation. The device should also contain locking mechanisms operative in both the open and closed position to prevent accidental movement of switch parts from external influences.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to provide a circuit breaker having a plurality of contacts, together with a remote operating mechanism capable of opening and closing the contacts in a rapid, predetermined sequence.

Another object of the invention is to provide an operating mechanism in connection with a high tension circuit breaker having a plurality of switch components, wherein said mechanism operates said components automatically in sequence from opening to closing free of external influence.

A further object of this invention is the provision of locking means in such an operating mechanism whereby the entire circuit breaker may be locked in open and closed position.

Other objects and features of the invention will become apparent from the following description and appended claims, taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified elevational view of a high tension circuit breaker that incorporates features of the presently described invention;

FIG. **2** is a plan view of the device shown in FIG. **1**, with the disconnect switch shown closed in full lines and open in broken lines;

FIG. **3** is a fragmentary sectional view along section line **3—3** of FIG. **2** and shows details of the main vacuum and disconnect components along with associated actuating mechanisms;

FIG. **4** is a plan view of the linkage connected to the main contacts, taken along line **4—4** of FIG. **3**, and also showing other positions of the linkage in outline;

FIG. **5** is a view taken along line **5—5** of FIG. **3**, showing the cam and latch assembly for operating the vacuum contacts, and FIGS. **6**, **7** and **8** are similar views showing various stages of operation of the assembly;

FIG. **9** is a vertical section of the lower portion of the apparatus shown in FIG. **1**, showing the operating mechanism for performing the desired sequence of steps in opening and closing the contacts;

FIG. **10** is a view taken along line **10—10** of FIG. **9** showing a spring assembly used in conjunction with the operating mechanism;

FIG. **11** is a view taken along line **11—11** of FIG. **9** illustrating the operating mechanism of the present invention;

FIGS. **12**, **13**, **14** and **16** are views similar to FIG. **11** illustrating various operative sequences of the components; and

FIG. **15** is a view similar to FIG. **10** showing the spring assembly in stressed position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. **1** and **2** which show the gross structure of the preferred embodiment, an elevated rectangular base **10** has a pair of upstanding and widely spaced insulator stacks **12** and **14** secured thereon, each of said stacks carrying a stationary disconnect contact **16** adapted to be connected to a transmission line. The contacts **16** are preferably of the structure shown in Weston patent application Ser. No. 47,429 filed June 18, 1970. A T-shaped switch component, generally indicated at **18**, is mounted for rotation between the insulator stacks, with each end of the horizontal member of said component terminating in a contact **20** adapted to mate with or engage a stationary contact **16**. The vertical leg of the switch component **18** comprises an insulator stack **22** adapted to be rotated about its axis through an arc of about 90° between the switch closed position shown in solid lines and the

switch open position shown by broken lines in FIG. 2.

Suitable power means are provided for rotating the T-shaped component between open and closed positions in the disconnect function. A hydraulically operated double acting piston 24 may be used to reciprocate a rack 26 in contact with a pinion 28 to which one end of a lever 30 is secured. One end of a similar lever 32 is secured to the vertical leg or stack 22 of the T-shaped component 18. A rigid link 37 is pivotally connected at its ends to the free ends of the pinion lever 30 and the stack lever 32. The link arrangement is designed for half reduction such that rotation of the pinion 28 through an arc of 180° by the linear action of the rack 26 will cause the T-component to be rotated through the desired arc of about 90° from closed to open position. Reversal of the piston 24 causes linear reciprocation of the rack 26 in the opposite direction, thereby returning the T-component to closed position.

FIG. 3 shows the interior of the upper and horizontal leg portions of the T-component. Since only half of the entire component is shown for the sake of brevity, it will be understood that an identical corresponding opposed structure is contained in the other half of the component, and the respective contacts shown are electrically connected in series to identical contacts in the other side, as is fully explained in the aforesaid Weston U.S. Pat. No. 3,566,055. In order to break and make contact between the opposed pairs of disconnect contacts 16 and 20, a conventional vacuum tube switch, generally indicated at 34, and a main contact or shunt switch, generally indicated at 36, are electrically connected across the T-component in parallel, although such components do not operate in parallel but sequentially as hereinafter described. The stationary ends of the respective vacuum and main contacts 34 and 36 are connected by a common conductive partition 38 to the disconnect terminal 20.

The contacts 34 and 36 are enclosed in a housing comprising a central section 40 in which a central shaft 42 is rotatably mounted. The vacuum contacts 34 are secured in a horizontal position between a vertical wall 44 of the central section 40 and the partition 38, and the main contacts are supported in a similar fashion below the vacuum contacts. The contacts are surrounded by a suitable insulated cylindrical housing 31 extending from the central section 40 to the terminal 20.

The internal structure of the vacuum contacts 34 is conventional, and other equivalent forms of circuit interrupters may be employed. For purposes relevant herein, each contact 34 comprises a tube of insulating material evacuated to a finite degree and containing a pair of separable contacts, one of which is movable and adapted to be actuated by means of a rod 46 projecting from one end of the tube. An adjacent interrupter (not shown) is mounted on the other side of the shaft 42 with its rod juxtaposed to the rod 46, and conductive means is provided between the rods to electrically connect the movable contacts. A sleeve 48 secured around the rod 46 carries a collar 41 which is contacted by a compression spring 43 disposed between the collar and a spring housing 45 which is slidably mounted in a tubular guide and stop member 47 that is secured to the vacuum tube or the wall 44. The spring housing 45 is also slidably guided on the inner end of the sleeve 48, and has inwardly extending arms 49 having apertures for receiving a vertical pin 50 therebetween. A driving spring 51 extends between the vacuum tube and the spring housing 45. When closed, the compression spring 43 assures firm contact between the vacuum contacts. Because of the driving spring, however, positive external pressure must be exerted against the rod 46 to retain the contacts in a closed position.

The main contacts 36 comprise an elongated tube 52 on which is secured a cylindrical bridging contact 54. The tube 52 is slidably movable along its axis relative to opposed spring loaded finger contacts 56 and 57 and is urged axially inward by means of a plunger 58 having a head 60 in abutment with the housing and a spring 62 extending between the head 60 and an abutment 64 within the interior of the tube 52. The spring 62 also serves as a shock absorber for rapid outboard movements of the tube, but a separate shock absorber (not shown) may be provided to dampen sudden movements of the tube. During opening, the tube 52 and bridging contact 54 move away from the outer finger contact 57 to break the main circuit which by-passes or shunts the vacuum tube circuit. Again, it will be noted that the tube 52 is constantly urged inward, that is, toward the shaft 42, and must be held in a closed position.

The shaft 42 is insulated below the lower portion of the central housing section 40 and is rotated from below the structure shown in FIG. 3 in order to operate the vacuum contacts 34 and the main contacts 36 is a predetermined sequence. As shown in FIGS. 3 and 4, the main contact tube 52 is horizontally bifurcated at its inner end for receiving one end of a curved toggle link 66 which is pivotally connected to said tube by means of a vertical pin 68 through said tube and said link. The other end of the toggle link 66 is pivotally connected to the end of a crank arm 70 secured to the shaft 42. A similar connection extends from the shaft 42 to the other main contact tube 52*a*, which is diagonally opposed from the first tube 52 (FIG. 4). Thus, the axes of the respective tubes 52 and 52*a* are substantially parallel and are equally spaced on opposite sides of a parallel line through the axis of the shaft 42.

It may be seen that when the crank arm 70 and the links 66 are in a maximum extended position (shown in chain lines in FIG. 4), the toggle link 66 is on toggle, and the end of the crank arm 70 is engageable with an adjustable stop 72 comprising the head of a bolt 74 spring biased in a bracket arm 76 secured to and extending from the wall 44 of the control housing section 40. This is the position attained by the linkage when resetting the vacuum contacts to closed position. After the vacuum contacts have been closed and latched (see FIG. 6), the main contact springs 62 return the linkage clockwise approximately 20° to the solid line position in FIG. 4 (see also FIG. 7) which is the normal switch closed position thereof. The spring biased bolt 74 serves to break the toggle of the linkage toward open position.

Further rotation of the shaft 42 in a clockwise direction through an arc of 90° (overall arcuate movement is about 110°) causes the toggle link 66 to be pulled to a full open position, which is the position indicated by dotted lines in FIG. 4. Upon counterclockwise or switch closing rotation of the shaft 42, at an intermediate position of the linkage, about 30° from its fully extended (chain-line) position, the main contacts 54–5-6–57 are closed but the vacuum contacts are still separated, e.g., by about ⅛ inch. Thus, because of the me-

chanical arrangement employed, the vacuum contacts are not closed until after the shaft **42** has rotated sufficiently to close the main contacts, whereby the circuit is made (the switch closed) through the main contacts, as will hereinafter be more fully explained.

As shown in FIGS. **3** and **5–8**, means are provided to open and close the vacuum contacts **34**, as well as to latch the contacts in a closed position. For this purpose, a cam and latch assembly is provided to urge the vertical pin **50** of the vacuum contacts in an outward direction. A cam arm **81** having an outer cam surface for urging the pin **50** is secured to the shaft **42**. The upper hub portion of the cam arm includes an opposed pair of upstanding lugs **82**. Rotatably mounted on the shaft **42** above the cam arm **81** is a rotary latch **83**, the latch being trapped on the shaft proximate to the cam by a collar **84** secured to the shaft. The lower hub portion of the latch **83** is equipped with an opposed pair of abutments **85** extending toward the cam arm **81** and complemental to the lugs **82** on the cam arm. The circumferential dimensions of the lugs **82** and the abutments **85** are such as to provide a predetermined spacing between opposed lugs and abutments providing a lost motion rotary connection between the cam arm and latch correlated to the degree of shaft rotation desired prior to the tripping of the vacuum contacts.

Both the cam arm **81** and latch extend on opposite sides of the shaft for operation of opposed vacuum contacts, but again the operation of only one side of the arrangement will be described for the sake of brevity. As shown in FIG. **5**, during closing, the shaft **42** is rotated in a counterclockwise direction. The cam arm **81** presents an outer curved surface that bulges axially outward from the shaft **42** in a clockwise direction and engages the pin **50**. Thus, rotation of the cam arm **81** in a counterclockwise direction urges the pin **50** along a linear path away from the shaft to close the contacts, as shown in FIGS. **5** and **6**. During closing, the latch **83** is carried by the cam arm **81** to a position where a curved arm **86** on the end of the latch abuts the pin **50** as shown in FIG. **6**, which position corresponds to the chain line position shown in FIG. **4**. The shaft **42** is then reversely rotated in a clockwise direction to the switch closed position shown in FIG. **7**, wherein the cam surface is cleared away from the pin in preparation for subsequent opening of the switch. At this stage, the latch is not moved and remains in locked position because of the lost motion between the cam lugs **82** and their corresponding latch abutments **85**.

Upon opening movement, as shown in dotted lines in FIG. **4** and in FIG. **8**, the shaft **42** is rotated further clockwise from the position shown in FIG. **7**, and to first open the main contacts **54** and only thereafter to trip the vacuum contacts by virtue of delayed engagement of the cam lugs **82** with the latch abutments **85** to rotate and carry the latch away from the pin **50** whereupon the spring **51** drives the vacuum contacts open (FIG. **8**). As shown in FIG. **6**, the pin **50** may comprise a roller bushing rotatably mounted on an inner pin, in order to reduce friction in the camming and latching operation.

FIGS. **9**, **10** and **11** show the operating mechanism for sequentially rotating the insulator or outer shaft **22** and the inner shaft **42**, which includes means to accelerate rotation of the inner shaft during the closing operation. The hollow insulator **22** is mounted at its lower end on a tubular shaft **22***a* which is rotatably mounted on ball bearings **87** in a housing **88**. The inner shaft **42** similarly includes a lower shaft extension **42***a* which is concentrically and rotatably mounted within the outer or tubular shaft **22***a*. The outer shaft **22***a* is rotated by power means hereinbefore described through the crank arm **32** (FIG. **9**), said power means being also operative at times to rotate the inner shaft through the operating mechanism shown in these Figures.

As mentioned previously, it is desirable to close the main and vacuum contacts as quickly as possible, and for this purpose, an accelerating mechanism, generally indicated at **89** is provided. A compressible helical spring **90** with its axis in a horizontal plane is located between the shaft **22***a* and an auxiliary vertical shaft **92** spaced from the shaft **22***a* and mounted for rotation in the housing **88** (see especially FIGS. **10** and **15**). A lever **93** is rotatably mounted on the auxiliary shaft **92** and extends to both sides thereof, one end of said lever being pivotally connected by a pin **94** in an axial slot **95** of a bifurcated extension of a spring mounting head **96**, the other end of said lever terminating in a vertical abutment **97**. A crank arm **98** is secured to the shaft **22***a* and is pivotally connected at its outer end by a pin **99** in an axial slot **100** of a bifurcated extension of a second spring mounting head **101**. The spring mounting heads **96** and **101** have respective internal collars **102** and **103** around which the ends of the spring **90** are carried, with the ends of the spring contacting and urging the spring mounting heads apart. Guide means are also provided between the heads **96** and **101** to assure linear movement of one head relative to the other and to limit maximum separation between the heads. For this purpose, a rod **104** is secured at one end to the second spring head **101** and extends within the enclosure of the spring **90** to an enlarged cylindrical terminus **105**. One end of a sleeve **106** is secured to the first spring head **96** and extends around the rod **104** to an end **107** of reduced diameter adapted to slide over the rod. The terminus **105** has a diameter approximately equal to the sleeve; the telescoping relationship therefore serving to guide the travel of one spring mounting head relative to the other. Maximum separation is limited by abutment between opposing shoulders of the terminus **105** and the sleeve end **107**.

As best shown in FIGS. **9**, **10** and **15**, a drive arm **108** is secured to the auxiliary shaft **92** and has an abutment **109** engageable with the abutment **97** on the lever **93**. Rotation of the auxiliary shaft in a counterclockwise direction when viewed from the top causes the drive arm **108** to rotate the lever **93** in a counterclockwise direction to a position shown in FIG. **15**, wherein the spring **90** is compressed. The accelerating mechanism is charged only upon closing rotation of the shaft **22** in the closing of the disconnect contacts, at which time the lever **93** will have been moved into the position shown in FIG. **15**. During the other sequential operations, including the opening of the disconnect contacts, the lever **93** is in the position shown in FIG. **10**, and no compression can occur. This is true despite rotation of the shaft **22***a* and crank arm **98** in the opening operation (rotation of the shaft in a clockwise direction when viewing FIG. **10**), because the axial slots **95** and **100** permit rotation of the crank **98** when the lever **93** is not in its compression position.

Also included in the accelerating mechanism is a kick-off mechanism, generally indicated at **110**, which comprises a driven plunger **111** slidably mounted in an

associated housing 112 and engageable with the abutment 97 of the lever 93 on the side of the abutment opposite the side engaged by the drive arm 108. The plunger 111 may be actuated by any convenient means, such as a spring, or may be held in a fixed position to insure that the accelerating mechanism does not become locked on toggle and will release its energy when required.

The operating mechanism will now be described with reference to FIGS. 9, 11–14 and 16. This mechanism is located below the accelerating mechanism and includes means to rotate the inner shaft 42*a* in proper sequence and to derive rotary power from the outer shaft 22*a* as the shaft is rotated to a closed position. A crank arm 113 is secured to the lower end of the shaft 22*a*, and a dog latch 114 is pivotally mounted on the outer end of said arm. The dog latch, which has a recess 115 on one side, is urged in a counterclockwise or latching direction by a tension spring 116 extending between a first pin 117 extending upward from the latch and a second upstanding pin 119 secured to the crank arm.

A lever 120 is mounted for rotation at its midpoint around the shaft 22*a* below the dog latch 114, one end of said lever having an upstanding pin 121 which may be engaged by the recess 115 of the dog latch 114. The other end of the lever 120 is pivotally connected into one side of a toggle linkage which includes upper and lower bars 122 and 123 connected at one end to the lever 120 by a pin 124, which extends downward below the linkage. The other side of the toggle linkage comprises a third bar 125 secured to the auxiliary shaft 92 and pivotally connected at its outer end between the other ends of the bars 122 and 123 by a pin 126. A pair of tension springs 128 and 129 extend between the bars 122–123 and the link or bar 125.

The inner shaft 42*a* extends beyond the bottom of the shaft 22*a* and has a bottom crank 127 secured thereto, said crank presenting an outwardly extending leg 130 on one side engageable with the pin 124, and a latching leg carrying a roller 131 spaced at about 90° from the leg 130. On its other side, the bottom crank presents a cam surface 132 extending circularly between the latching leg and a third leg on the crank.

In order to latch against the latching roller 131 and thereby prevent rotation of the inner shaft 42 in the opening direction under the bias of the main contact springs 62, quickly releasable latching means are secured to the frame. An inner latch 139 is pivoted about a pin 133 and extends from both sides thereof, one end thereof terminating in a biased latching surface 138 adapted to engage the latching roller 131 and having an adjacent roller 134. The other end of the inner latch 139 carries a pin 135 to which is connected a tension spring 136, the other end of said spring being connected to a second pin 137 secured on the frame.

The spring 136 constantly urges the inner latch 139 toward a latched position with the latching roller 131, and the inner latch is retained in latch position by an outer latch 140 pivotally mounted on a pin 141 and extending on both sides thereof, one side presenting a latching surface 142 adapted to bear against the roller 134 of the inner latch 139. The other end of the outer latch 140 is connected to a trip mechanism 143, such as a solenoid or hydraulic operator, which operates to rotate the outer latch into unlatched position as defined by an opposed stop 144.

The locked position of the latches is shown in FIG. 11 and the unlatched position is shown in FIG. 12. When viewed from the top, energizing of trip mechanism 143 causes the outer latch 140 to be rotated in a clockwise direction, thereby releasing the inner latch 139, which thereupon rotates clockwise under the influence of the roller 131. The bottom crank 127 is now released, enabling the bottom crank 127 to rotate in a clockwise direction under the bias of the main contact springs 62.

The operation of the entire unit will now be described. When the disconnect contacts, main contacts, and vacuum contacts are all closed, the mechanism is in the position shown in FIGS. 4 (solid lines), 7, 10 and 11. In order to open, the piston (FIG. 2) is activated to initiate rotation of the T-member 18 in the clockwise direction. Before the member 18 is rotated at all, or at least within the very initiation of its movement, the trip mechanism 143 is actuated to trip the outer latch 140 (FIGS. 9 and 11) causing the inner latch 139 to be tripped, thereby releasing the bottom crank 127 for rotation with the inner shaft 42. Upon release of the bottom crank 127, the spring 62 of the main contact (FIG. 3) causes instantaneous inward driving of the tube 52, thereby rotating the shafts 42 and 42*a* through the linkage members 66 and 70 to open first the main contacts 36 and then the vacuum tube 34. As explained before, the main contacts 36 are opened just prior to the opening of the vacuum contacts 34, and both are fully open before the opening of the disconnect 20. During opening of the contacts 34 and 36, the bottom crank 127 is rotated with the inner shaft 42–42*a* to the position shown in FIG. 12, wherein the arm 130 now engages the pin 124 on the toggle linkage and rotatable lever 120.

The outer shaft 22–22*a* continues to rotate under the influence of its power means, whereupon the dog latch 114 engages the upstanding pin 121 on the rotatable crank 120, and whereupon the entire T-member 18, including the shafts 22–22*a* and 42–42*a*, is rotated through 90° to the switch open or isolating position shown in dotted lines in FIG. 2. During this movement, the crank 120 causes the toggle linkage members 123 and 129 to move to on toggle position whereupon the springs 128 and 129 carry the linkage slightly over toggle as shown in FIG. 13. The switch full open position of the mechanism is shown in FIGS. 4 (dotted lines), 8 and 13.

It will be noted that during switch opening movement the auxiliary shaft 92 has not been rotated sufficiently to cause compression of the accelerating mechanism 89 because of the free travel allowed by the axial slots 95 and 100, despite rotation of the shaft 22–22*a* and associated crank arm 98 (FIG. 10).

During the closing sequence, the above operations occur essentially in reverse order, with the exception that the accelerating mechanism is brought into play. In closing, the T-component 18 is rotated in the opposite direction for about 85° by the power means described above. In so doing, as shown in FIG. 14, the dog latch 114 carries the rotatable lever 120, which pushes the bottom crank 127, until the toggle linkage reaches an over toggle position opposite the over toggle closed position. As this occurs, the shaft 92 and drive arm 108 are rotated to drive the lever 93 in the counterclockwise direction, and at the same time, rotation of the outer shaft 22*a* moves the crank 98 toward closed posi-

tion. Thus, the crank **98** and lever **93** are swung toward each other by the power drive mechanism to the position shown in FIG. **15** to compress the spring **90** and thereby cause the accelerator mechanism **89** to become charged.

Immediately after the disconnect engages firmly in its stationary contacts, the dog latch **114** is tripped by a pusher **146** energized by the pinion **28** on the power means (FIG. **14**) which releases the spring force in the accelerating mechanism **89**. That is, tripping of the dog latch **114** releases the previously restrained rotatable lever **120**, which enables the accelerating mechanism **89** to rotate the auxiliary shaft **92** with great speed from the positions of FIGS. **14** and **15** to the positions shown in FIGS. **10** and **16**. As shown in FIG. **16**, rotation of the auxiliary shaft **92** causes the toggle linkage to rapidly extend to the on toggle position, causing the bottom crank **127** and hence, the inner shaft **42–42***a* to be rotated to close first the main Contacts **36** and then the vacuum contacts **34** in rapid sequence. Specifically, the main contacts are driven closed against the force of the spring **62** directly through their linkage members **66** and **70**, and the vacuum contacts are thereafter driven closed by the cam **81** and are positively latched in a closed position by the latch **83**.

In terms of the latter rotation of the inner shaft **42**, the following events happen in the following order after the disconnect makes contact: At 0° rotation, the main contacts begin to close; at 68°, the main contacts close on one side of the T-component; at 74.5°, the main contacts close on the other side to make the main circuit, whereupon the circuit is closed through the switch; at 82°, the vacuum circuit is made, and the contact pressure springs **43** begin to compress; at 110°, the vacuum contacts are latched closed; and the three-bar linkage **120, 122–123, 125** toggles out (FIG. **16**) and the main contact tube **52** attains its maximum travel.

At this time, the cam surface **132** on the bottom crank **127** has passed the prop latch **139–140**, whereupon the springs **136–143** return said latch members to a position to latch the roll **131** on the crank **127**.

The three-bar linkage **120, 122, 125** then over toggles to the closed position indicated in FIG. **11** whereupon the dog latch **114** again latches the lever **120**. A torsional spring **160** (FIG. **9**) between the housing **88** and the auxiliary shaft **92** may be utilized to cause the toggle linkage to move over center, whereupon the springs **128–129** pull the toggle linkage to the full over-center position of FIG. **11**. As this occurs, the bottom crank **127** is permitted to return about 20° or so (as previously explained in connection with FIGS. **4** and **7**) whereupon the latch **139–140** retains the same in switch closed position. Thereafter, the toggle linkage moves to its FIG. **11** position, wherein the dog latch is re-engaged with the lever **120** and the entire mechanism has been returned to its starting or switch-closed condition.

There has thus been shown a convenient, economical and practical operating mechanism for switches of the type disclosed in Weston U.S. Pat. No. 3,566,055 wherein the switch is opened and the circuit broken by first opening the main contacts which are in parallel with the vacuum tube contacts whereby the circuit is maintained solely through the vacuum contacts, very quickly thereafter opening the vacuum contacts at high speed to break the circuit, and within a few cycles thereafter opening the disconnect switch to isolate the switching components from the circuit; and wherein the switch is closed and the circuit made by first closing the disconnect switch, second closing the main contacts at very high speed to make the circuit and thereafter closing the vacuum contacts. In this way, the vacuum tubes are electrically stressed solely at the moment of breaking the circuit for attainment of all of the advantages described in U.S. Pat. No. 3,566,055.

While we have shown and described what we regard to be the preferred embodiment of our invention, it is to be appreciated that various changes, modifications and rearrangements may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. In a circuit breaker having a T-component with a terminal at each end of the horizontal portion thereof, said T-component being rotatable about its vertical axis to make and break a circuit thereacross between spaced stationary contacts, the combination of first switch means connected between said terminals, second switch means connected between said terminals in parallel with said first switch means, a shaft operatively connected to said first switch means and said second switch means for closing said switch means, cam means between said shaft and said first switch means for sequentially closing said first switch means after closure of said second switch means, and accelerator means connected to said shaft for rapidly closing said first and second switch means in sequence, said accelerator means comprising a second shaft spaced from said first shaft and parallel thereto, spring means for imparting instantaneous rotary motion to said second shaft, a toggle linkage operatively connected between said first and second shafts, and latch means for preventing release of said spring until after closure between said terminals and stationary contacts.

2. An operating mechanism for a pair of shafts, said shafts including an outer shaft mounted for rotation about its axis and an inner shaft rotatably mounted within said outer shaft, said mechanism comprising spring means associated with the inner shaft for rotating the shaft in one direction, power means for rotating the outer shaft in both directions, a first crank secured at the other end of the inner shaft and having an arm and a latching surface extending therefrom, a second crank secured above said first crank on said outer shaft and having latch means pivotally carried on the underside thereof, a lever pivotally mounted on said outer shaft, said lever having a first projection engageable with said latch means and a second projection engageable with the arm of the first crank, and means for urging said first crank through engagement with said lever, said means comprising releasable energy means operatively connected to said lever to rotate said lever, first crank and inner shaft in a direction opposite to said one direction.

3. The operating mechanism according to claim **2** wherein said latch means engages said first projection to contain said releasable energy means.

4. The operating mechanism according to claim **2** wherein a second shaft is disposed parallel to and spaced from said inner and outer shafts, a toggle linkage is disposed between said second shaft and said outer shaft such that one end of said linkage is pivotally connected at the second projection of said lever and the other end of said linkage is secured to said second

shaft, and said releasable energy means is operatively connected to the second shaft to rotate said shaft.

5. The operating mechanism according to claim **2** wherein second latch means is provided adjacent said first crank and is engageable with said latching surface, said second latch means, when engaged, operative to restrain motion of the inner shaft in said one direction thereof.

6. The operating mechanism according to claim **5** wherein said second latch means comprises a first latch arm pivotally mounted along substantially a tangential line relative to the arc of travel of the latching surface of said bottom crank so as to be movable into and out of engagement of said latching surface, and a second latch arm pivotally mounted substantially radially with respect to said first crank and engageable with said first latch arm to retain the latter in latching position.

7. In an operating mechanism for controlling the rotation of an inner shaft around which is rotatably mounted an outer shaft, the combination of a first crank arm secured to the outer shaft and terminating in a first spring retaining head, a second shaft spaced from and parallel to said outer shaft, an arm pivotally mounted on said second shaft and having a spring retaining head on one end, compressible spring means connected between said spring mounting heads, a crank secured to said second shaft and having an abutment engageable with the other end of said arm throughout a portion of its arc of travel, and means between said second shaft and said inner shaft for transmitting motion therebetween.

8. The operating mechanism according to claim **7** wherein rotation of the first crank arm and the arm to axially opposed positions causes compression of said spring means.

9. In a circuit breaker, a first and second pair of contacts, each pair having one contact movable into open and closed position, a shaft mounted for rotation adjacent the movable contacts of said first and second pair, a cam secured to said shaft and presenting a cam surface for urging the movable contact of said first pair into closed position, first latch means on said shaft for latching said first movable contact into closed position upon closure thereof by said cam surface, linkage means connected between said shaft and the movable contact of said second pair and operative upon rotation of said shaft in one direction to close said contacts, spring means for urging the movable contact of said first pair toward open position, spring means for urging the movable contact of said second pair toward open position to cause rotation of said shaft in the other direction, and second latch means associated with said shaft for restraining rotation of said shaft in said other direction.

10. The circuit breaker of claim **9** wherein said cam and said first latch means have engageable abutments comprising opposed surfaces enabling conjoint movement, said opposing surfaces having space therebetween permitting a degree of lost motion between said cam and said first latch means, said cam being movable away from its contact before said opposed surfaces engage to disengage said first latch means.

11. The circuit breaker of claim **10** wherein said second latch means restrains motion of said shaft in a position where said cam means has moved away from its contact and the first latch means is in latching position on said contact.

12. A circuit breaker and control therefor comprising a pair of spaced terminals swingable between open and closed position on a first shaft, vacuum enclosed contacts connected between said terminals, main contacts connected between said terminals, spring means for opening said vacuum and main contacts, second shaft means rotatably mounted adjacent said vacuum and main contacts for closing first the main contacts and then the vacuum contacts in sequence against the force of said spring means upon rotation of said shaft means in one direction, means for latching said shaft means against rotation in the other direction upon closure of said main and vacuum contacts, and accelerator means connected to said second shaft for rapidly rotating said shaft in said one direction, said accelerator means comprising spring means compressed in response to rotation of said terminals to closed position.

13. The circuit breaker of claim **12** wherein said accelerator means further comprises a third shaft spaced from said first shaft and parallel thereto, means for mounting said spring means between said first and third shafts such that said spring means is compressible, and translation means for translating force from said spring to said second shaft means for rotation thereof in said one direction.

14. The circuit breaker of claim **13** wherein said translation means further comprised a toggle linkage connected between said second shaft means and said third shaft.

15. The circuit breaker of claim **14** wherein latch means is associated with said toggle linkage to prevent rotation of said shaft by said spring means.

16. The invention according to claim **12** wherein power means are connected to said first shaft for rotation thereof in both directions, said power means comprising a double-acting power cylinder having a piston, means for supplying hydraulic fluid pressure to said cylinder, valve means for controlling fluid supply to either side of said cylinder, a rack connected to said piston, a pinion engaged with said rack to be rotated thereby, a shaft extending from said pinion, a crank arm extending from said pinion shaft, a second crank arm secured to said first shaft, and a link pivotally connected at its free ends to respective first and second cranks.

* * * * *