

[54] **MOVABLE CONTACT-STEM OPERATOR
FOR A VACUUM-TYPE
CIRCUIT-INTERRUPTER**

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[51] Int. Cl. **H01h 33/66**

[58] Field of Search **200/144 R, 144 B**

[56] **References Cited**

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3,784,774 1/1974 Wilson 200/144 B

Primary Examiner—Robert S. Macon

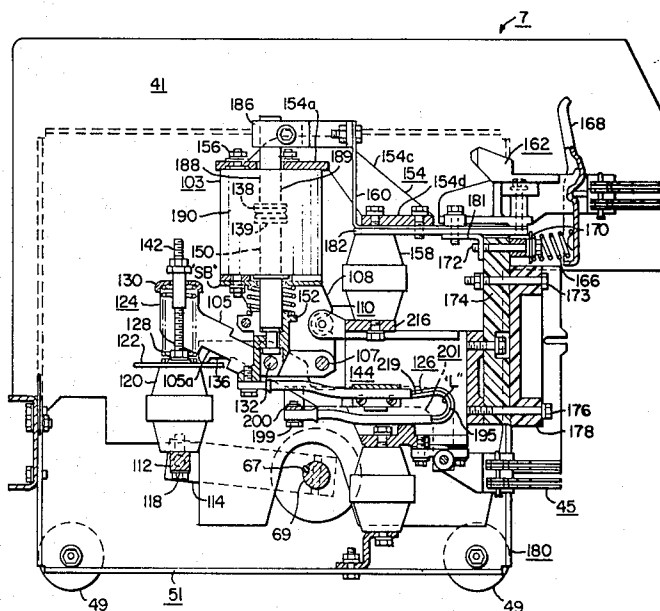
Attorney, Agent, or Firm—W. R. Crout

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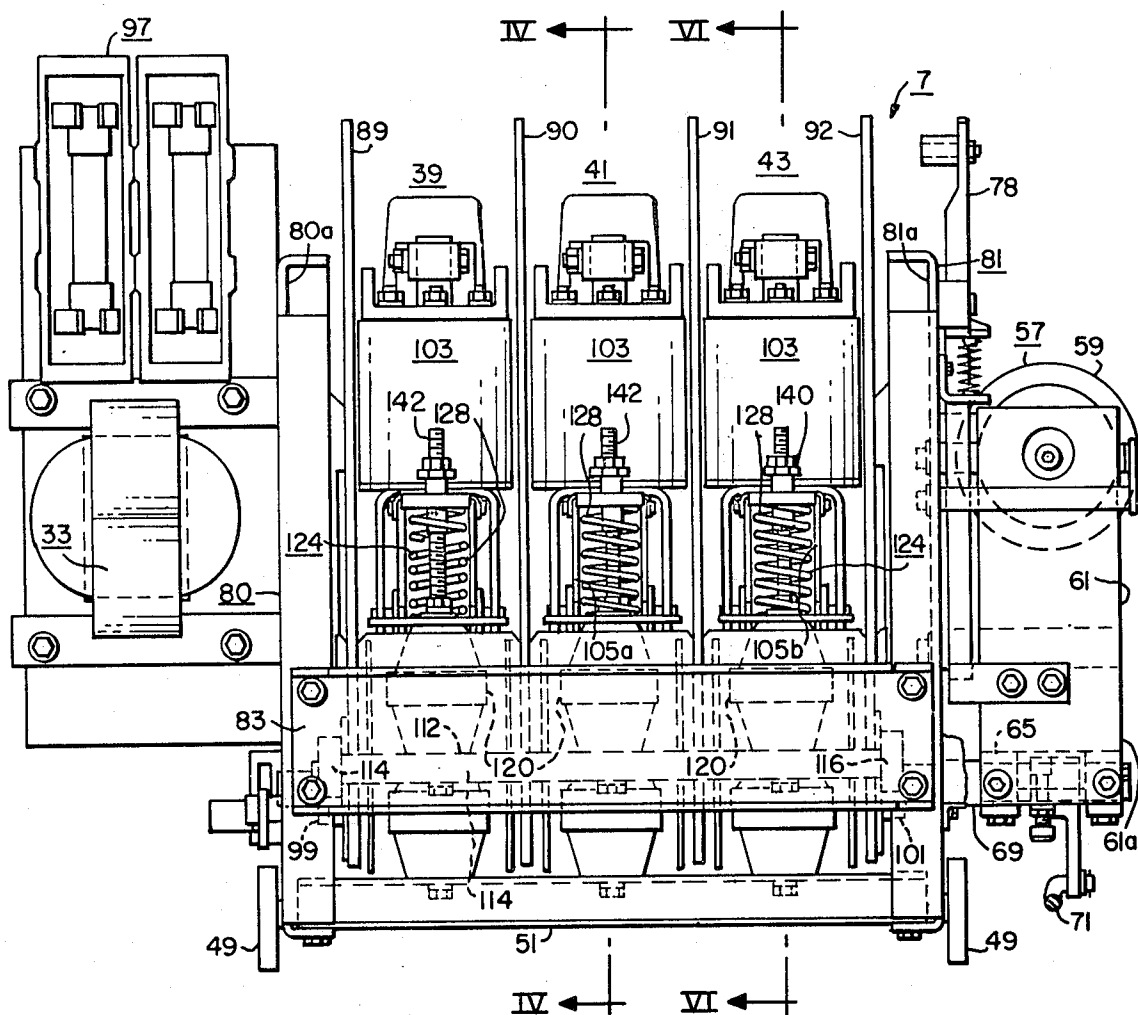
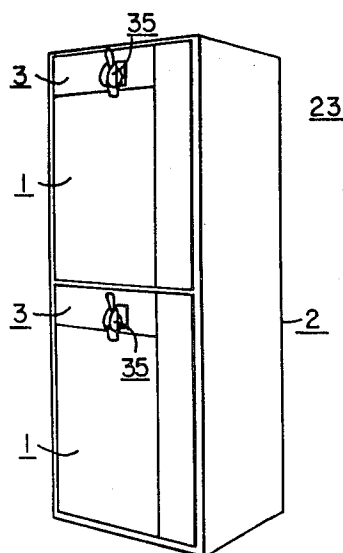
ABSTRACT

An improved movable-contact-stem operator is provided for a vacuum-type circuit-interrupter comprising a loosely fitting clamp-type contact-stem operator, which is retained in place by a suitable means, such as by a shoulder-bolt, for example. The movable-contact-stem operator has at least one pivot-aperture provided therethrough, which accommodates the contact-operator pivot pin, and upon suitable alignment with a pivotally mounted contact-operating lever, may, as a subsequent procedural operation, have the clamping bolt tightened upon the contact-stem operator, so that thereafter the operating motion is transmitted directly between the contact-operator and the movable contact stem without any torque, or rotational motion being transmitted to the usually provided metallic sylphon bellows which maintains the evacuated condition within the vacuum circuit-interrupter envelope.

17 Claims, 16 Drawing Figures



SHEET 1



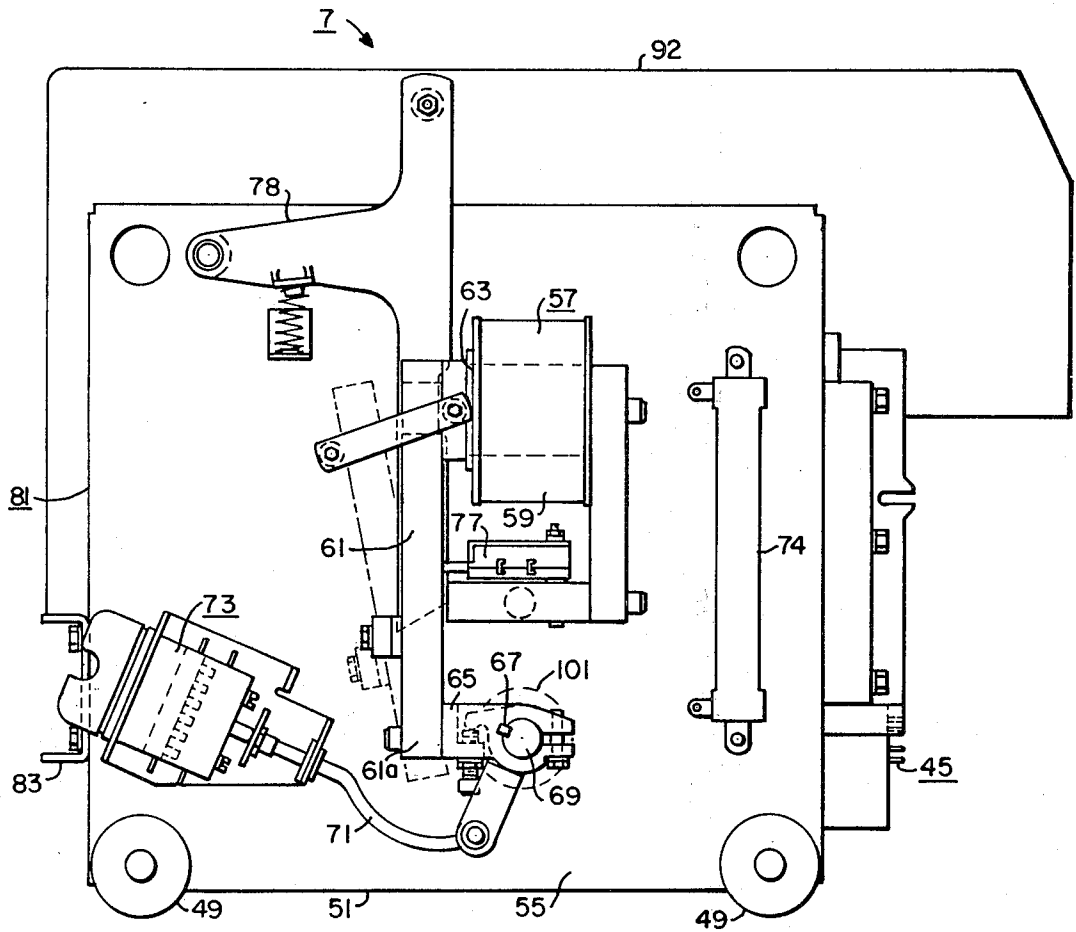


FIG. 2

FIG. 16

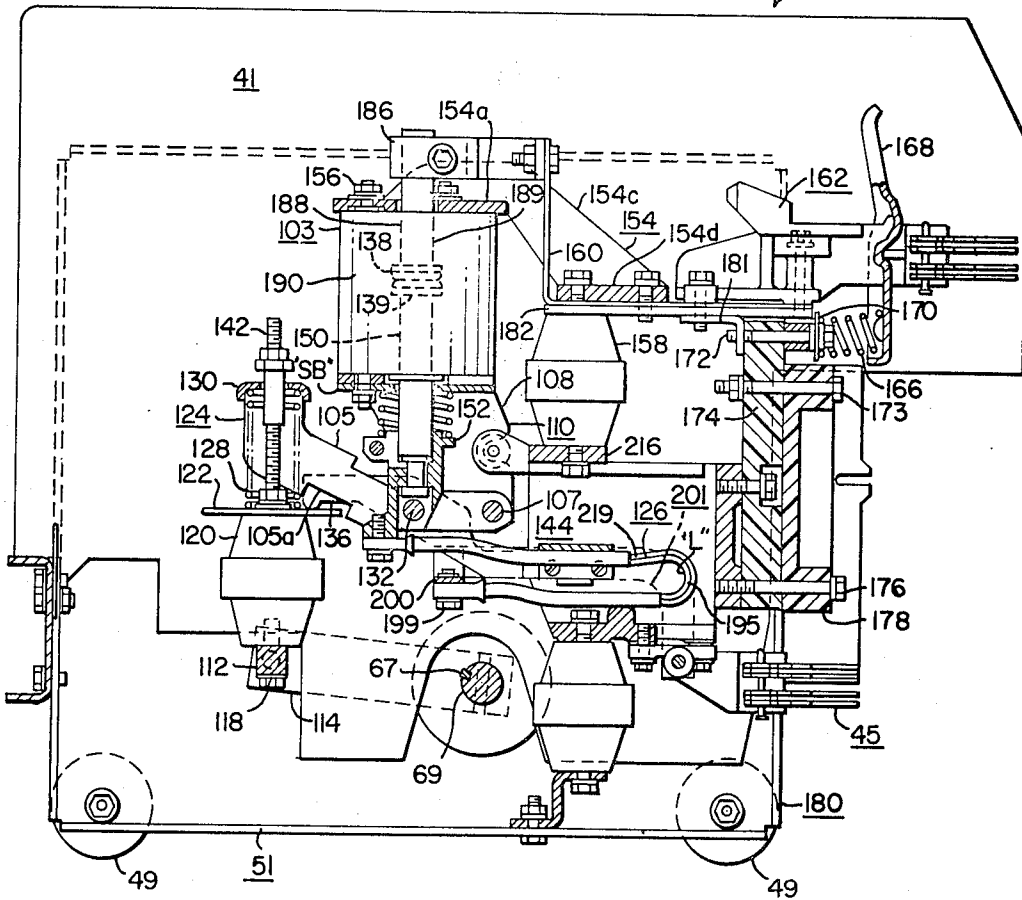
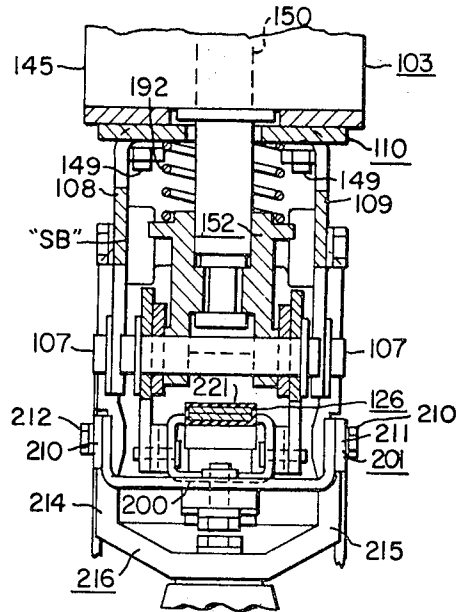
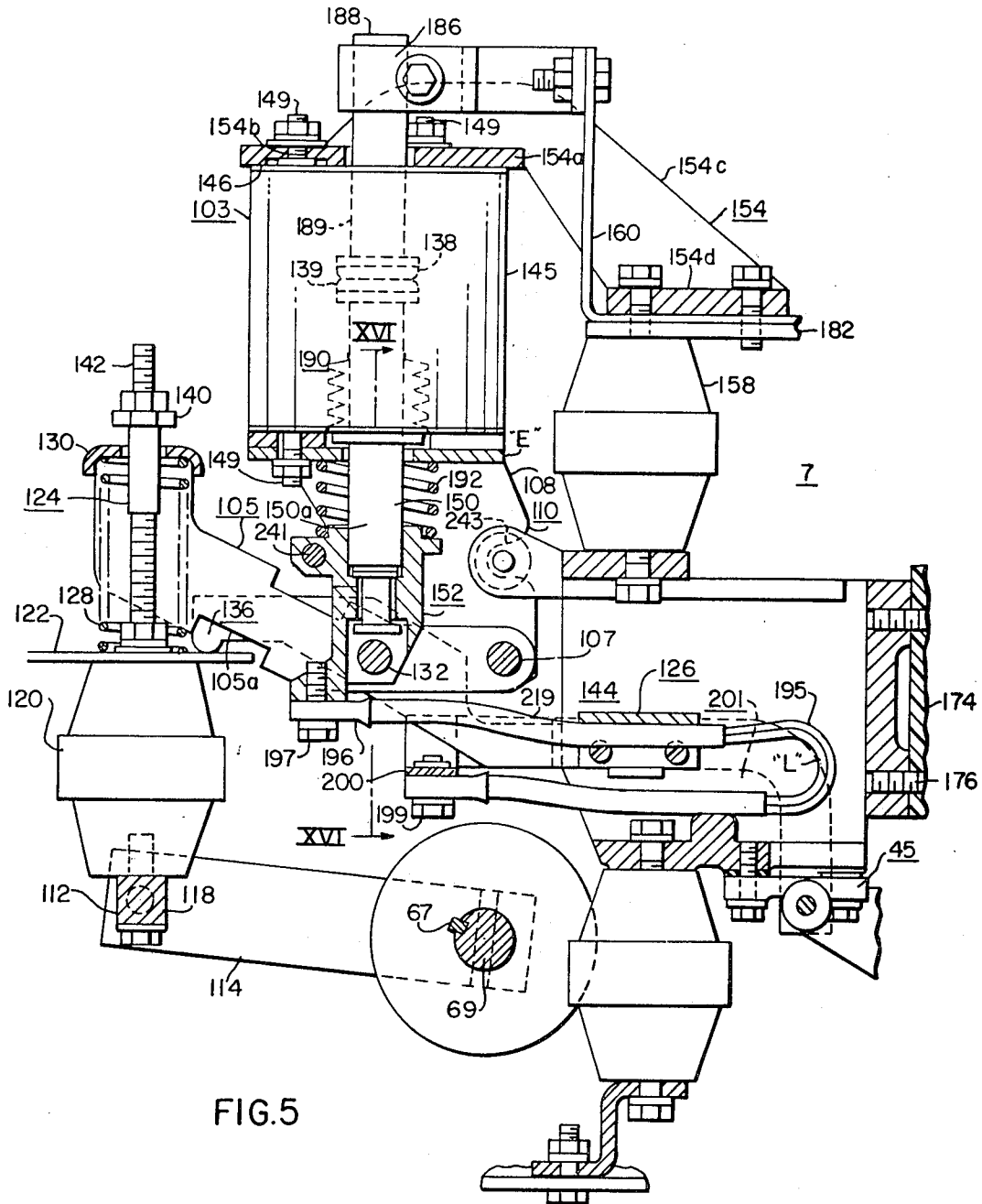


FIG. 4



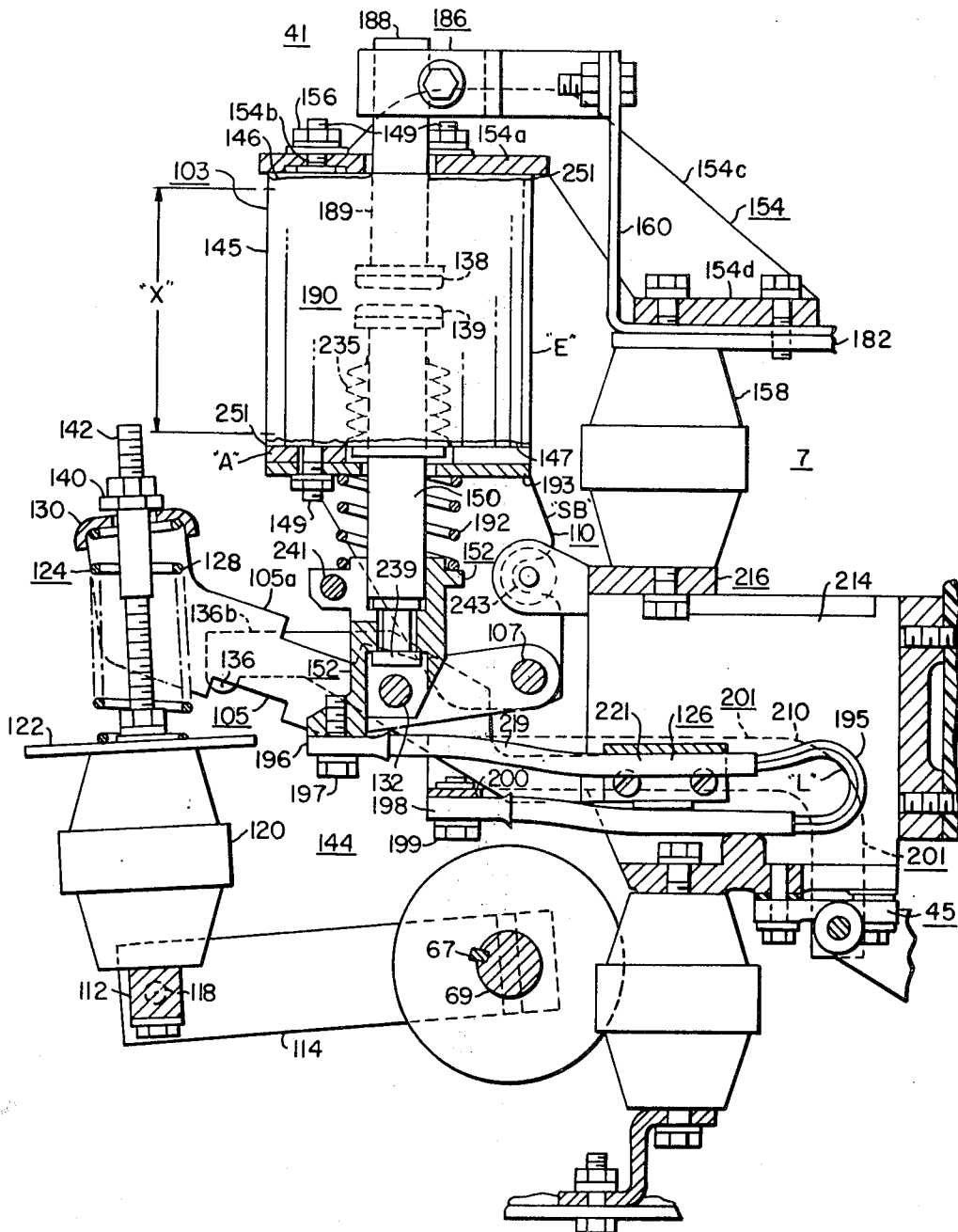


FIG. 6

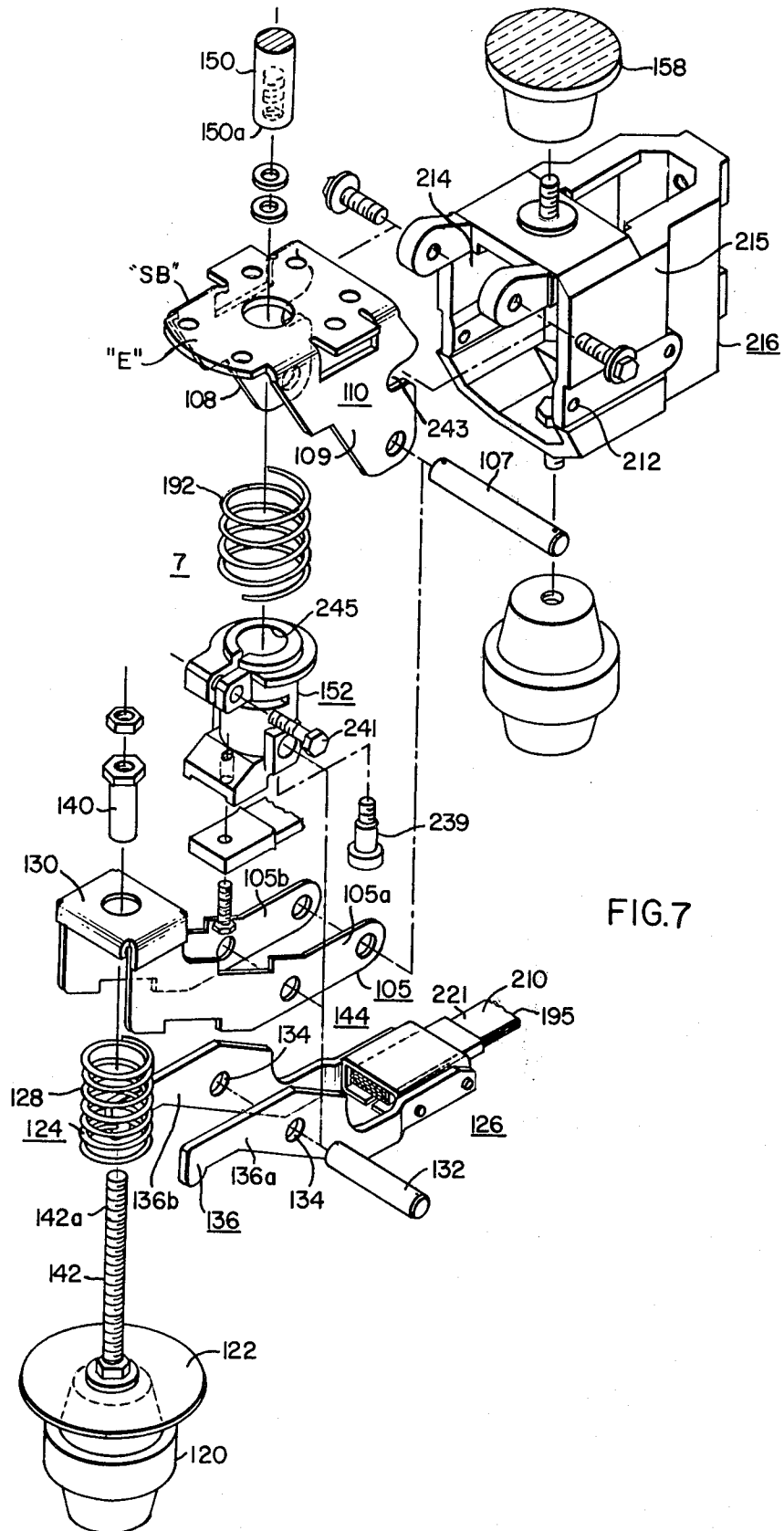


FIG. 7

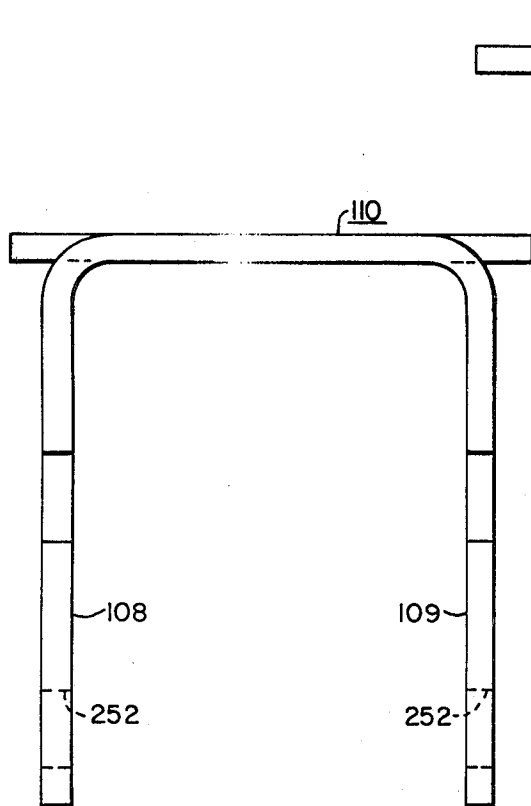


FIG. 9

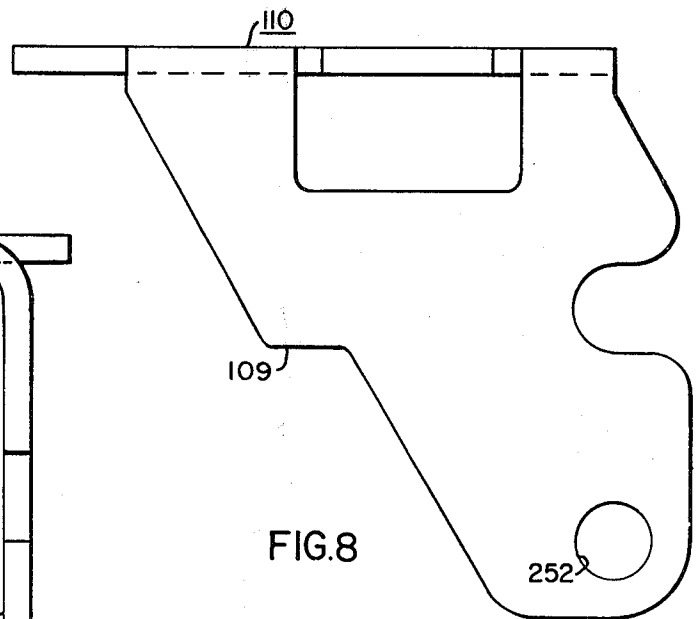


FIG. 8

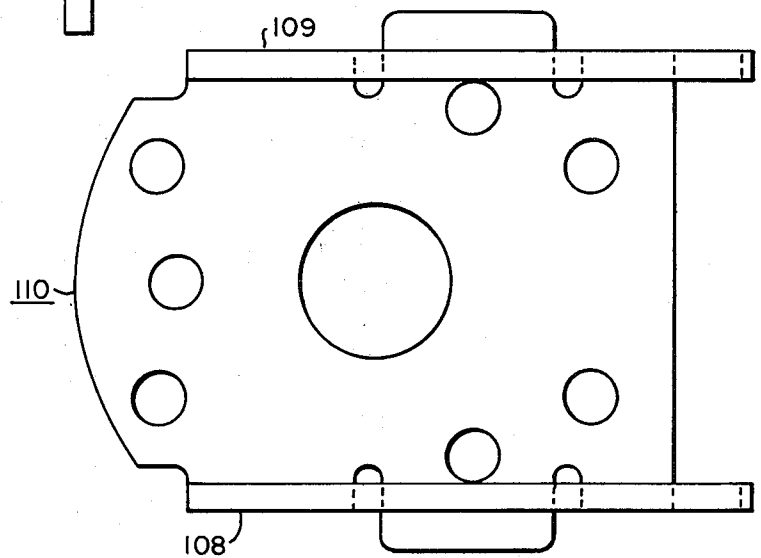
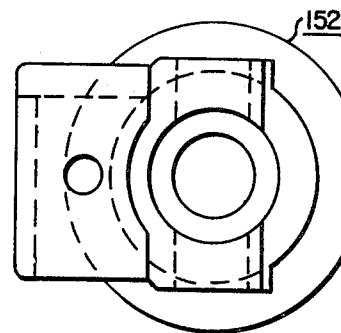
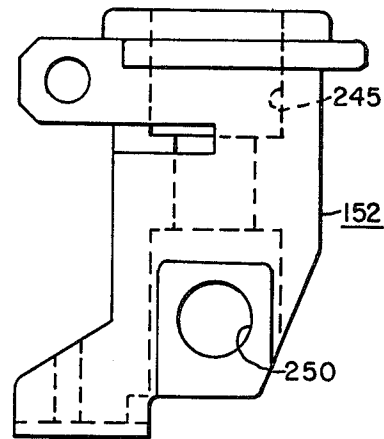
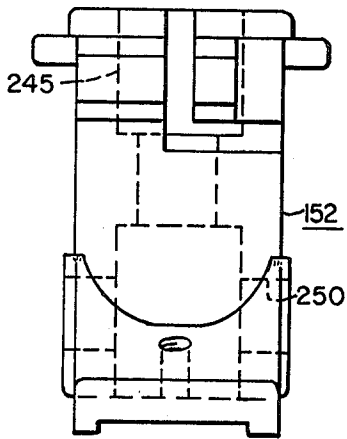
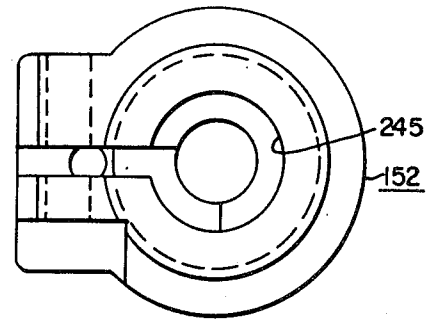
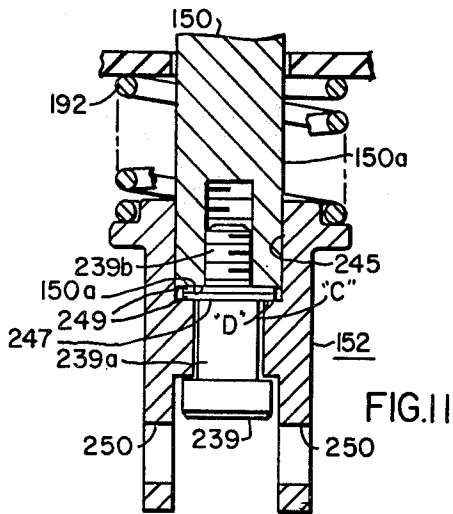


FIG. 10



MOVABLE CONTACT-STEM OPERATOR FOR A VACUUM-TYPE CIRCUIT-INTERRUPTER

The shoulder-bolt, together with a suitable number of washers, accommodates the longitudinal tolerances, which inevitably accompany the manufacture of vacuum "bottles" or vacuum-type circuit-interrupter units. In addition, should the clamping bolt for any reason become loosened, nevertheless the vacuum interrupter unit will be properly operated by the presence of the shoulder-bolt, which maintains through the head portion thereof, a suitable affixment of the operator, which though in this particular instance being loose, nevertheless provides proper operation of the vacuum-type interrupter unit, even though the contact operator has lost its clamping engagement with the lower external end of the movable-contact stem.

Another important feature of the invention is the utilization of an accurately-machined lower support-flange plate member, in this particular instance comprising a generally U-shaped accurately-machined support-plate, with the two leg portions thereof providing aligned pivot-apertures, which accommodate the pivotally-mounted support pin, which serves as a fixed pivotal support for the rotatable movable contact arm of the circuit-interrupter mechanism. As a result, even though tolerances vary in the manufacture of the length of the vacuum bottle, nevertheless for multi-pole contactor assemblies, such manufacturing tolerances may readily be accommodated by the use of such a lower accurately-machined support-flange plate member, which accurately positions and locates the fixed mounting location of the pivot point for the movable-contact lever, the latter, as is customary, being mechanically linked to the operating mechanism for the contactor assembly.

CROSS-REFERENCE TO RELATED APPLICATIONS

A related patent application by A. W. Hodgson Ser. No. 481,562 filed June 20, 1974 and assigned to the assignee of the instant application, discloses an improved operating mechanism for the circuit-interrupter assembly of the instant patent application.

BACKGROUND OF THE INVENTION

Vacuum-type circuit-interrupters have been extensively utilized in industrial switchgear for controlling feeder circuits, and for controlling, for example, electrical motors of various ratings. In the case where the air-break interrupter units control electrical motors, reference may be made to the following patents for background information: U.S. Pat. No. 3,602,680, issued Aug. 31, 1971 to Alfred W. Hodgson; U.S. Pat. No. 3,639,873, issued Feb. 1, 1972 to Alfred W. Hodgson; U.S. Pat. No. 3,621,339, issued Nov. 16, 1971, to Alfred W. Hodgson; U.S. Pat. No. 3,264,431, issued Aug. 2, 1966 to A. W. Hodgson; U.S. Pat. No. 3,264,432, issued Aug. 2, 1966 to A. W. Hodgson et al.; U.S. Pat. No. 3,264,433 issued Aug. 2 1966 to R. D. Clark, Jr. et al.; and U.S. Pat. No. 3,290,468 issued Dec. 6, 1966 to R. D. Clark Jr. et al.

When vacuum-type circuit-interrupter units are utilized in place of air-break interrupting units, invariably a metallic sylphon bellows is utilized to hermetically maintain the evacuated condition within the vacuum-type circuit-interrupter envelope. It is desirable not to impose any torsional, or rotational stress upon this syl-

phon bellows, which is manufactured for strictly linear straight-line motion. Also, the operational life of such a vacuum-type circuit-interrupter unit may approach one million operations, for example, so that it is necessary to prevent the imposition of torsional, or rotational stress upon the metallic bellows associated with the movable-contact stem of the vacuum circuit-interrupter unit. Also, as will be well known by those skilled in the art, in the manufacture of vacuum circuit-interrupters, or vacuum bottles, manufacturing tolerances are somewhat wide, and vary over a considerable range of dimensional values. It is, therefore, desirable to accommodate these widely different manufacturing tolerances, particularly in the case where a number of vacuum bottles are utilized in multi-pole circuit-interrupting, or contactor apparatus, so that a single operating mechanism may be employed, with facility, to actuate a number of individual pole-units without imposing any torsional stress upon an individual vacuum unit other than a longitudinal linear motion, and also to accommodate considerable variance in the tolerances of the individual vacuum bottles themselves.

SUMMARY OF THE INVENTION

In the improved actuating means for actuating the movable-contact stem of the movable contact of a vacuum-type circuit-interrupter, according to the present invention, a loosely fitting movable-stem operator is provided, being associated with a suitable affixment means, such as a shoulder-bolt, for example. As a result, the rotatable contact-actuating levers may be placed into the proper operating position, with the contact-operator loosely fitting upon the contact stem, and, consequently, not imposing any torsional stress upon the stem, or ultimately upon the metallic sylphon bellows of the vacuum circuit-interrupter unit.

Only as a final operation is a clamping bolt tightened, to thereby fixably secure the movable-contact operator upon the lower external end of the contact stem, clamping the two members fixedly together to thereby subsequently actuate the movable-contact stem, and, consequently, the movable contact of the vacuum circuit-interrupter, thus causing direct actuation between the operator and the movable-contact stem, as initiated by the movable-contact-operating lever.

To accommodate variant manufacturing tolerances, say, for example, the length of the vacuum interrupter units, an accurately-machined lower support-flange plate is provided, the latter having accurately-located pivot apertures for the pivot pin to support, in a pivotal manner, the contacting-actuating lever. As well known by those skilled in the art, the contact-actuating lever is mechanically linked to a suitable operating mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of motor-starter equipment including two motor starters disposed in superimposed relation together with their disconnecting-switch structures;

FIG. 2 is a side-elevational view of the right side of the truck-mounted contactor, or interrupter assembly of the instant invention;

FIG. 3 is a front elevational view looking at the front of the truck-mounted vacuum-type circuit-interrupter assembly of the present invention;

FIG. 4 is a vertical sectional view taken substantially along the line IV—IV of FIG. 3 with the separable-contact structure closed;

FIG. 5 is an enlarged detailed view of the operating linkage and mechanism structure of FIG. 4, again the separable contacts of the vacuum-type circuit-interrupter assembly being illustrated in the closed-circuit position with the operating magnet energized;

FIG. 6 is a fragmentary vertical section view taken substantially along line VI—IV of FIG. 3, again the contact structure being shown in the open-circuit position;

FIG. 7 is an exploded perspective view of the several parts employed in conjunction with the improved operating mechanism of the instant invention;

FIG. 8 illustrates, in side elevation, the accurately machined lower interrupter support-plate utilized in the present invention;

FIG. 9 is front-elevational view of the improved accurately machined interrupter support of FIG. 8;

FIG. 10 is an inverted plan view of the accurately machined interrupter support structure of FIG. 8;

FIG. 11 illustrates a sectional view taken through the improved shoulder-bolt and movable-contact operator connection for actuating the movable-contact stem of the vacuum-type circuit-interrupter of the present invention;

FIG. 12 is an enlarged side-elevational view of the improved movable-contact operator utilized;

FIG. 13 is a top-plan view of the improved movable-contact operator of FIG. 12;

FIG. 14 is a front-elevational view of the improved movable-contact operator of FIG. 12;

FIG. 15 is an inverse plan view of the improved movable-contact operator of FIG. 12; and

FIG. 16 is a fragmentary vertical sectional view taken along the lines XVI—XVI of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention has particular applicability to high-voltage motor starters 1 designed for starting and controlling alternating-current motors. Generally, these starters 1 are supplied in a steel floor-mounted enclosure 2, such as set forth in FIG. 1. The steel floor-mounted enclosure 2 may, for example, accommodate two motor starters 1, as actually shown in FIG. 1 disposed in superimposed relation.

The contactor assembly 17 comprises electrically isolated contactor poles 39, 41 and 43 which represents commercially available components, such as the Westinghouse Electric Corporation contactor Type LF-50V430 contactor. Contactor electrical terminal 45, as illustrated in FIG. 4, engages an electrical terminal assembly to supply voltage through cables to a remote load, which may be a motor installation.

The isolation switch assembly 3 is slidably positioned within the cabinet housing 2 by outwardly protruding flanges which engage horizontal guide tracks.

Due to the weight of the contactor assembly, 7 it is generally located in the bottom section of the cabinet housing 2. The positioning of the contactor assembly 7 within the cabinet housing 2 is accomplished by inserting the wheels 49, which are affixed at the four corners of the base 51 of the assembly 7, into guide tracks and rolling the assembly 7 into the cabinet housing 2 until

electrical engagement with the electrical terminal assembly occurs.

The vacuum-type contactor 7 is designed for starting and controlling three phase, 50-60 cycle alternating-current motors. The voltage may, for example, be 6,600 and the contactor-closed continuous rating in amperes 360.

FIG. 2 illustrates, in side elevation, the right-hand side 55 of the truck-mounted vacuum-type contactor assembly 7. As illustrated in FIG. 2, it will be observed that there is provided a direct-current operating magnet 57 having a direct-current magnet coil, or operating coil 59. Associated with the magnet structure 57 is a rotatable magnet armature 61 which makes abutting engagement when the operating magnet 57 is energized with the magnetic poleface 63. The lower end 61a of the rotatable magnet armature 61 is affixed by a clamp casting 65 and a key 67 to the external end of an operating shaft 69, as shown. Also affixed to the operating shaft 69 is an electrical interlock pushrod 71 which operates an electrical interlock 73. In addition, FIG. 2 shows a protective resistor 74 which is inserted into the series magnet coil circuit 57 when the armature 61 has reached its fully-closed position against the pole face 63, as illustrated by the full lines in FIG. 2. Additionally, there is illustrated in FIG. 2 another interlock 77. Also FIG. 2 illustrates an isolating-switch mechanical interlock arm 78, which is operable by a downwardly-extending interlock rod (not shown) extending downwardly and operable by the isolating-switch assembly 3.

FIG. 3 shows that, in general, the truck-mounted contactor assembly 7 comprises two side metallic support plates 80 and 81 interconnected by a front U-shaped metallic support channel member 83, which is more clearly illustrated in FIG. 3 of the drawings. Also FIG. 4 shows the lower stab assembly 45 which interconnects the contactor assembly 7 with stationary load terminals for operating an external piece of equipment, such as an electrical motor, for example.

FIG. 3 illustrates a view looking into the front of the truck-mounted vacuum-type circuit-interrupter assembly, or contactor assembly 7. It will be observed that the armature 61 of the operating magnet 57 is affixed to the external end of the operating shaft 69 and effects the rotatable operating motion thereof. The operating shaft 69 is, of course, journaled in suitable bearings 99, 101 provided on the inner sides 80a, 81a of the two metallic side support plates 80 and 81.

It is, of course, desirable to provide contact-closing spring pressure for each of the individual pole-units 39, 41 and 43 in the closed-circuit position of the contactor assembly 7, as illustrated in FIG. 4 of the drawings. Each pole-unit 39, 41 or 43 is provided with its own individual vacuum-interrupter unit 103 and a pivotally mounted rotatable contact-operating arm 105, which is pivoted upon a stationary pivot pin 107 extending between the two downwardly extending flange portions 108, 109 of a U-shaped lower interrupter support 110, the configuration of which is more readily apparent from a study of FIGS. 4 and 5 of the drawings.

The rotation of the rotatable contact arm 105 is effected by a laterally extending cross-bar 112 which is moved in generally a vertical direction by two spaced crank-arms 114, 116 the latter being affixed to and rotatable with the operating shaft 69. FIG. 3, taken in conjunction with FIG. 4, more clearly shows the structure of the laterally-extending cross-bar 112. As illus-

trated in FIG. 4, it will be observed that the crossbar 112 is preferably of metal, and in this particular instance has a square cross-section, as shown, having end pivot-pins 118, the latter being apparent from a study of FIG. 3 of the drawings.

The cross-bar 112 is fixedly secured to an insulator support 120 individual to each of the three pole-units 39, 41, and 43 as more clearly illustrated in FIG. 3. The insulator support 120, in turn, supports an abutment member or in this particular instance a plate 122, for example, having a configuration more clearly apparent from a study of FIG. 7 of the drawings. FIG. 7 illustrates an exploded view of the contact-pressure spring assembly 124 and the relationship between the abutment member or plate 122 and a rotatable reverse-current loop-arm assembly 126, again the configuration of which is more clearly apparent from a study of FIG. 5 of the drawings.

As well known by those skilled in the art, it is desirable to supply contact-spring pressure between the separable contacts in the closed-circuit position of the interrupter 103. This spring pressure, which is provided in the instant invention, is afforded by a compression spring 128 illustrated in FIGS. 3 and 5, and interposed between the abutment plate 122 and an upper movable spring seat 130, which straddles the two contact-actuating arms 105a, 105b, which collectively constitute the movable contact-actuating arm 105 of the interrupter assembly 7.

It will be observed, in connection with FIGS. 4, 5 and 7 of the drawings, that a contact drive pin 132 passes through the two leg portions 105a, 105b of the movable contact-actuating arm 105 and, additionally, passes through a pair of apertures 134 provided in the rotatable reverse-current actuating arm 136. In other words, the same pivot pin 132 passes through the two leg portions 105a, 105b of the contact-actuating arm 105 and also through the leg portions 136a, 136b constituting the reverse-current arm-assembly 136, thereby enabling a fulcrum point to be exerted at the pivot pin 107 in the contact-welded condition of the separable contacts 138, 139 under certain conditions, as more fully described hereinafter.

With reference to FIGS. 4, 5 and 6 of the drawings, it will be observed that there is provided an overtravel adjusting nut 140, which is threaded upon the upper end 142a of a contact-pressure stud 142, the lower end of which is secured into the upper end of the insulator support 120. Thus, in the closed-circuit position of the vacuum-interrupter assembly 7, as illustrated in FIG. 4, the contact compression spring 128 is compressed, thereby applying contact-closing pressure between the separable contacts 138 and 139, the overtravel adjusting nut 140 accommodating the "wipe" travel distance by continued closing travel of the contact-actuating arm 114. Thus, FIG. 4 illustrates the closed-circuit position of the interrupter device 7 with the operating magnet 57 energized and the compression spring 128 providing the desired contact pressure in the closed-circuit position of the device.

It will be obvious that during the opening operation, the operating shaft 69 will rotate in a counterclockwise direction, as viewed in FIG. 4, carrying downwardly with it the two operating arms 114 and 116 together with the cross-bar 112 and the three insulator supports 120. Also carried downwardly will be the abutment plates 122 and the contact pressure studs 142 until the

overtravel adjusting nuts 140 engage the yoke portions 130 of the contact actuating arms 105, as illustrated in FIG. 6 of the drawings. Assuming that there does not exist a welded condition at the separable contacts 138, 139, the operating mechanism 144 will continue its counterclockwise opening movement carrying the separable contacts 138, 139 to their fully-open circuit position, as illustrated in FIG. 6 of the drawings.

The interrupter unit 103 may be of any suitable type manufactured commercially by a number of companies, and, in general, comprises an evacuated envelope 145 having end metallic plates 146, 147 hermetically sealed to the ends of the insulating envelope 145, such as a ceramic sleeve, for example. The vacuum bottle 103 is provided having supporting stud portions 149, say three in number, for example, extending upwardly and downwardly as illustrated in FIGS. 5 and 6, and also having the movable contact stem 150 extending externally, as illustrated in FIGS. 6 and 7. In its manufactured component assembly form, it is, therefore, provided in a form enabling its ready mounting by the six mounting studs 149 and the movable contact 139 may be opened and closed by an actuating clamping portion 152 secured to the extending end 150a of the movable contact stem 150. The present equipment utilizes preferably, one of these manufactured bottles 103 for each pole-unit 39, 41, 43. As illustrated in FIG. 5, there is provided an upper interrupter support casting 154, cast, in this particular instance, of aluminum, which has a horizontally-extending apertured support-flange portion 154a having mounting holes 154b therein to accommodate the three upwardly extending mounting studs 149, the latter, as mentioned, constituting a part of the manufactured bottle 103.

Mounting nuts, not shown, threadedly secure the support-flange portion 154a of the casting 154 to the vacuum bottle 103 and maintain it fixedly in a proper position. The casting 154, in addition, has a pair of downwardly-slanting support arms 154c, which are interconnected by a second support flange portion, or yoke portion 154d, the latter being affixed to an upper insulator support 158 (FIG. 5) and to a metallic conductor support strap 160, the latter being securely mounted to an upper fusefinger terminal assembly, generally designated by the reference numeral 162, and illustrated more clearly in FIG. 4 of the drawings. A fuse-finger contact-pressure spring 166 is utilized, as illustrated in FIG. 4, supported between the pivotal fuse-finger portion 168 of the terminal assembly 162 and a spring seat 170 associated with a mounting bolt 172, the latter extending through a vertically-disposed insulating spacer block 174, the latter being secured by mounting bolts 172, 176 to a laterally-extending insulating support plate 178 of the frame 180. In addition, a metallic angle 181 is provided to rigidly interconnect the horizontally-extending line-connection strap 160 with the horizontally-extending conductor strap 182, FIG. 4 again showing this construction more clearly. A mounting bolt, not shown, extends vertically through the several component parts, as also shown in FIG. 4.

Fixedly secured to the upper extremity of a line-connection strap 160 is a terminal clamp 186 having a clamping portion 186a which encircles the upper extending end 188 of the stationary contact stem 189, as more clearly shown in FIG. 6. Due to the inherent flexibility provided by the line-connection strap 160 (FIG. 4), there is not exerted any stress nor torquing action

upon the stationary contact stem 188. However, with reference to FIG. 4, it will be observed that the bottle structure 103 itself is rigidly supported by the relatively massive and heavy upper interrupting casting support 154.

To counteract the inward closing force exerted because of the evacuated environment 190 within the evacuated enclosure 145, a kickout spring 192 is provided to compensate for the atmospheric pressure, the latter, of course, tending to force the separable contacts 138, 139 into the closed-circuit position, as illustrated in FIG. 5. The kickout spring 192 is interposed between a lower metallic washer 193 and the upper end of contact operator 152.

With reference to FIGS. 4, 5 and 6 of the drawings, it will be observed that there is provided at the lower end of the contactor-assembly 7 a reverse-current connector-assembly 126 comprising a generally loop-shaped flexible connector 195 having an upper terminal 196 fixedly secured by a connector bolt 197 to the lower end of the movable contact operator 152. The flexible connector 195 extends rightwardly, as viewed in FIG. 5, into a loop portion "L", and then extends toward the left, as viewed in FIG. 5, to be secured by a connector bolt 199 to the mid-portion 200 of a stationary U-shaped current-feeding member, generally designated by the reference numeral 201 and having a configuration more readily apparent from a study of FIG. 6 of the drawings.

As indicated in FIG. 6 of the drawings, the current-feed structure 201 comprises a pair of stationary L-shaped leg members 210, 211 bolted, as at 212, to the side walls 214, 215 of the lower interrupter casting support 216, and having a bight portion at the front thereof, designated by the reference numeral 200. The bight portion 200 is electrically connected to the lower terminal 198 of the loop-shaped reverse-current loop assembly 126, as indicated more clearly in FIG. 5, which has the desirable advantage, namely an augmentation of the upper movable flexible strap portion 221 by the magnetic field around the leg portions 210, 211 of the L-shaped reverse-current feed structure 126.

To obtain the higher mechanical forces only during an occasional system fault, without increasing the mechanical forces in effect in normal operation, the novel reverse current loop is provided as shown in FIG. 5.

This reverse-current loop 126 provides an increase in contact force and also weld-breaking force which is in proportion to the square of the current "I" flowing through the reverse current loop.

By properly proportioning the reverse-current loop 126, it is possible to provide a substantial increase in the contact and weld breaking forces under high-current conditions while only slightly increasing these forces under normal operating conditions.

The reverse-current loop 126 consists of upper and lower shunt legs, not shown, plus parallel load connection bus bars 210, 211 as shown in FIGS. 4 and 5.

When current flows through the reverse current loop conductors 221, 222, the magnetic fields surrounding these conductors 221, 222 react with each other to develop mechanical forces on the various conductors.

The lower horizontal leg 222 of the shunt and the parallel load connection bus bars 210, 211 are restrained by non-movable parts of the support structure 180, while the upper shunt leg 221 is free to move up-

ward until it strikes the right-hand end of the reverse-current loop-arm 136.

When the contactor 7 is subjected to a power system fault, of high current magnitude, the reverse current loop 126 will apply a force upward on the right-hand end of the reverse-current loop-arm 136 which will in turn pry the interrupter contacts 138, 139 closed assuming the contactor magnet 57 remains closed.

A second reaction of the reverse-current loop-arm 136 is to apply a downward force on the contact spring support plate 122 which will in turn increase the opening velocity of the magnet and cross-bar assembly 112 once the magnet 57 is de-energized.

When the magnet 57 is released, the moving assembly is accelerated by the combined forces of the contact springs 128 and reverse current loop 126 until there is no gap at the contact overtravel adjusting nut as shown in FIG. 6.

At this point, the kinetic energy of the moving system imparts a hammer blow to the contact actuating arm 105 which acts to break any contact welds which might exist.

When the overtravel adjusting nut 140 makes contact with the upper contact spring seat 130, as shown in FIG. 6, the function of the reverse current loop 126 automatically takes a complete reversal to apply an additional contact opening force to the interrupter 7 rather than a contact closing, as it previously had done when the magnet 57 was closed.

In this design the connection from the contactor load terminal 45 to the lower leg 222 of the shunt 195 is divided into two parallel legs 210, 211 which straddle and are mounted at the same elevation as the upper leg 221 of the shunt.

A kickout spring 192 is mounted directly on the contact shaft 150 of the interrupter 103 to take up the play between the contact actuating mechanism 144 and the interrupter contacts 138, 139. Without a kickout spring 192 in this location, the contacts 138, 139 could touch momentarily under low contact force conditions while play is being taken up in the operating mechanism 144. Play between the contacts and operating mechanism 144 would aggravate the contact erosion and welding problems both on the opening and closing operations.

The kickout springs 192 also minimize armature bounce on opening and in addition are proportional to apply sufficient load on the magnet 57 at open gap position to prevent the magnet 57 from picking up unless its operating voltage is sufficient for the magnet 57 to seal-in from the contact-touch position.

Each pole 39, 41 and 43 of the contactor may be installed or removed from the contactor as an individual sub-assembly, so that it may be efficiently assembled or maintained at a work-bench rather than in the contactor 7.

The interrupter unit itself may also be installed or removed from the contactor as a smaller sub-assembly consisting of the interrupter 103, its support 154, moving contact actuating arm 105, and reverse current loop details 126 as shown in the exploded view of FIG. 7.

In order to obtain maximum mechanical life of the interrupter bellows 235 and also avoid friction between the interrupter contact shaft 150 and its bushing, it is important that the relationship between the contact

drive pin 132 and the pivot pin 107 for the contact actuating arm 105 be accurately maintained.

To accomplish this, the interrupter 103 and the contact actuating arm 105 are both mounted on a single rigid mechanical detail 110 which can be accurately manufactured. This detail 110 is the lower interrupter mounting bracket shown in FIG. 7.

In connection with the above alignment of parts, it is also desirable that the contacts 138, 139 touch when the contact drive pin 132 is on the same horizontal centerline, not shown, as the pivot pin 107 for the contact-actuating arm 105.

When the interrupter sub-assembly is being assembled, the kickout spring 192 is placed over the contact shaft 150 and then compressed by the contact operator 152 which in turn is held in place by the shoulder bolt 239. The shoulder bolt 239 is only tightened finger tight so as not to apply excessive torque to the interrupter shaft 150 and bellows 235.

The contact operator 152 and shoulder bolt 239 design is coordinated in a manner that the shoulder bolt 239 cannot clamp the contact operator 152 to the contact shaft 150, but instead permits the contact operator 152 to rotate freely on the contact shaft 150 without applying torque to the contact shaft 150 when the contact operator 152 is being lined up with the contact-actuating arm 105.

After the contact drive pin 132 is installed, the contact actuating arm 105 is depressed to take up the play between the contact drive pin 132 and contact shaft 150 following which the contact operator 152 is clamped to the contact shaft 150 by tightening the clamping bolt 241.

In normal service, the contact shaft 150 will be actuated through the clamped joint between it and the contact operator 152, but should this joint fail the contacts 138, 139 will then be closed by compression of the parts between the drive pin 132 and the end 150a of the contact shaft 150, and opened by the shoulder bolt 239.

One of the objects of the present invention is to prevent excessive torque from being applied to the shaft 150 of the interrupter 103 during maintenance and/or assembly since torque may destroy or shorten the mechanical life of the interrupter bellows 235.

The shoulder bolt 239 acts as an assembly fixture to compress the kickout spring 192 during assembly while still allowing the contact operator 152 to be rotated as required to install the contact drive pin 132. In operation the shoulder bolt 239 in addition acts as a safety device to insure opening of the contacts in the event the contact operator 152 is not securely clamped to the interrupter contact shaft 150.

The interrupter 103 is rigidly supported at its upper end, which contains the interrupter stationary contact 138 so as to avoid transmitting contact forces through the walls 145 of the interrupter 103. The moving contact end 150 of the interrupter 103 in addition is clamped to the stationary portion of the pole assembly to provide lateral stability. Clamping of the lower end of the interrupter sub-assembly "SB" is accomplished by means of an oversized open slot 243 which compensates for the manufacturing tolerances of the interrupter 103 and also simplifies installation and removal of the interrupter sub-assembly "SB".

Manufacturing tolerances on the interrupter length dimension "X" are rather large, so the vertical loca-

tions of the lower ends of the interrupter 103 may vary considerably from contactor 7 to contactor 7 and from pole to pole. Since the operating mechanism 144 for each pole is mounted on the moving contact end "E" of the individual interrupters 103, rather than on some fixed portion of the pole assembly, this is of little consequence.

In the event the interrupter length "X" is found to be other than its nominal value, the final lengths of the contact springs 128 will also vary from their nominal value resulting in either high or low contact forces.

The average contact force in the case of a multiple-pole contactor, as shown in the drawings, can, however, be corrected by adjusting the angular position of the magnet armature 61 on the operating shaft 69 so that the correct average contact spring length and force 128 is obtained when the magnet 57 is sealed-in.

Angular position adjustment of the magnet armature 61 is a standard feature of an existing air-break contactor magnet 57 applied to the disclosed vacuum contactor 7.

Variations in contact forces between poles existing after the magnet adjustment 61 has been made will fall within allowable limits if the contact springs 128 are designed to have a low spring rate.

NON-TORQUE ACTION EXERTED BY SHOULDER-BOLT 239

To avoid imposing torque action upon the movable contact stem 150 and thereby exerting corresponding torque action upon the bellows 235, the utilization of a novel shoulder-bolt 239 is provided. The construction of the shoulder-bolt is set forth in FIGS. 11-12 of the drawings. It will be observed that the bore 245 of the contact-shaft operator 152 has a relatively loose fit on the contact stem 150 as shown in FIG. 11; the shank 239a of the shoulder-bolt 239 has a loose fit at "C" with the movable contact operator 152. The shoulder-bolt 239, for example, may have an Allen head with an enlarged portion 239a and a reduced portion 239b with a shoulder 247 therebetween, so that the shoulder-bolt, when tightened, will force washers 249 (FIG. 11) against the lower extremity 150a of the moving-contact shaft 150 of the vacuum-type interrupter 103. This is shown in FIG. 11. The number of washers 249 is arranged to accommodate the tolerances provided between the different movable contact shafts 150 of the several pole-units 39, 41 and 43. Once the shoulder-bolt 239 is tightened, the contact-shaft operator 152 is moved manually upwardly, so that there is no clearance at the point "D" in FIG. 11. Then the clamping bolt 241 of FIG. 7 is tightened, so that the movable contact shaft 150 is operated by the contact-shaft operator 152, the latter having the apertures 250 provided therein to accommodate the center-line of the contact-drive pin 132. As a result, there is no torque action exerted either upon the movable contact shaft 150, or the bellows 235 located interiorly of the vacuum envelope 103. There may, of course, be relatively wide tolerances provided in the vacuum-bottle manufacture, and the foregoing arrangement permits a desirable accommodation of these tolerances.

VACUUM-BOTTLE TOLERANCES

Despite the wide latitude of the tolerances provided in the manufacture of the vacuum bottles 103, it is desired not to impose any stress upon the ceramic enve-

lope 145, or to effect the breakage of any of the hermetic seals 251. To effect this end, an accurately-machined lower-interrupter support-plate 110 having the pivot apertures 252 provided therein is supplied. These pivot apertures 252 may be accurately machined, and once the vacuum bottle 103 is fixedly secured by the upper interrupter casting 154, as a first operation, subsequently, as a separate operation, the U-shaped accurately machined support plate 110 is secured into place by the lower three mounting bolts 149. The pivot-pin 132 may then be accurately located with respect to the lower interrupter support 110 because of the accurate machining of the pivot apertures 252 therein.

This will accurately locate the contact-actuating lever 105 and, additionally, accurately locate the contact-stem driving pin 132. As mentioned previously, the contact-shaft clamp bolt 241 is tightened as a final operation after previous assemblage of the contact-pivot pin 132 and tightening of the shoulder bolt 239.

From the foregoing description, it will be apparent that there has been provided an improved movable contact operator for the separable contacts of a circuit-interrupter, particularly applicable to one of the vacuum-type.

Also, it will be observed that with the improved operation mechanism, and the reverse-current loop system, the function of the reverse-current loop-system changes in dependence upon whether or not the operating magnet 57 is energized, or is not energized. In the energized state of the operating magnet 57, an additional force is provided to maintain the contacts 138, 139 closed during the existence of heavy-fault-current conditions. When the magnet 57 is not energized, the fulcrum point changes, or is relocated to thereby provide, instead of a closing force, in this instance an opening force, which assists and augments the accelerating opening springs.

Although there has been illustrated and described specific embodiments of the invention, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein, by those skilled in the art, without departing from the spirit and scope of the invention.

What is claimed is:

1. A circuit-interrupting structure including a vacuum-type interrupting unit having a relatively-stationary contact and a cooperable movable contact, metallic bellows means for hermetically sealing the movable contact to the envelope of said unit, a movable-contact stem for supporting and for moving the movable contact, a movable-contact operator having a relatively-loose fit upon the exterior end of the movable-contact stem, said movable-contact operator having at least one supporting pivot aperture provided therein, a rotatable contact-operating lever having a fixed pivot adjacent one end thereof and a contact-actuating pin extending therethrough which, additionally, extends through said one pivot aperture provided in the movable-contact operator, a bolt for captively securing said movable-contact operator to the external end of the movable-contact stem, and clamping means for clamping the movable-contact operator to the external end of the movable-contact stem after insertion of the contact-actuating pin through the contact-

operating lever and also through the movable-contact operator.

2. The combination according to claim 1, wherein the bolt is a shoulder-bolt having an enlarged diameter portion and an end relatively-small-diameter portion, the relatively-small-diameter portion being threadedly secured into a tapped bore provided in the external extremity of the movable-contact stem.

3. The combination according to claim 1, wherein the movable-contact operator has two-pivot-pin supporting apertures, and the rotatable contact lever comprises a pair of coacting rotatable lever-arms movable together and located externally of the movable-contact operator.

4. The combination according to claim 1, wherein the rotatable-contact lever has at least one contact-compression spring associated with one external end thereof.

5. The combination according to claim 2, wherein one or more washers are provided at the shoulder-portion of the shoulder-bolt for accommodating manufacturing tolerances associated with the vacuum-interrupting unit.

6. The combination according to claim 1, wherein the movable-contact operator generally comprises a cylindrically shaped metallic member having one end bore loosely surrounding the extremity of the movable-contact stem, an intermediate relatively reduced portion for accommodating a shank portion of the bolt, and an enlarged end portion for accommodating the head of the bolt.

7. The combination according to claim 6, wherein the movable-contact operator has a pair of pin-supporting apertures disposed adjacent the head-portion of the bolt.

8. The combination according to claim 1, wherein a U-shaped flange-support plate member is affixed to the movable-contact end of the vacuum-type interrupting unit, and has fixed pivot-pin supporting apertures provided through the leg portions thereof.

9. The combination according to claim 8, wherein the legs of the U-shaped flange support member have notches provided therein for accommodating tolerances of the vacuum-type interrupting units.

10. In combination, a vacuum-type circuit interrupting unit including a relatively stationary contact and a cooperable movable contact, a movable-contact stem supporting said movable contact and effecting the opening and closing motions thereof, a metallic syphon bellows having one end hermetically sealed to the movable-contact stem and the other end hermetically sealed adjacent one end of the circuit-interrupting unit, one end of the movable-contact stem protruding externally of the evacuated envelope of the circuit-interrupting unit, a movable-contact operator having a loose removable yet available manual clamping engagement with the external protruding extremity of the movable-contact operator and additionally having a pivot-supporting aperture provided therein, a rotatable contact-operating lever, means pivotally supporting said contact-operating lever adjacent one end thereof on a fixed pivot, said contact-operating lever having a movable pivot-aperture located intermediate the ends thereof, a movable pivot-pin inserted through the movable pivot-aperture of the contact-operating lever and also through the pivot-aperture of the movable contact-operator, and manual clamping means for selectively

13

clamping at times the movable contact-operator to said movable-contact stem.

11. The combination of claim 10, wherein a bolt removably secures the movable-contact operator to the end-protruding extremity of the movable-contact stem.

12. The combination according to claim 11, wherein the bolt is a shoulder-bolt having an enlarged-diameter portion and an end relatively-small-diameter portion, the relatively-small-diameter portion being threadedly secured into a tapped bore provided in the external extremity of the movable-contact stem.

13. The combination according to claim 10, wherein the movable-contact operator has two pivot-pin supporting apertures located therein, and the rotatable contact lever comprises a pair of coaxing rotatable lever-arms movable conjointly together and disposed externally of the movable-contact operator.

14. The combination according to claim 10, wherein the rotatable contact-operating lever has a contact-compression spring associated with the other end thereof.

15. The combination according to claim 14, wherein

14

operating-lever means carries said contact-compression spring and has additionally a stud passing through the contact-compression spring and also passing through an aperture provided at the said other end of the rotatable contact-operating lever for providing contact compression in the closed-circuit position of the interrupter.

16. The combination according to claim 11, wherein the movable-contact operator generally comprises a cylindrically shaped metallic member having one end bore loosely surrounding the extremity of the movable-contact stem, an intermediate relatively reduced portion for accommodating a shank portion of the bolt, and an enlarged end portion for accommodating the head of said bolt.

17. The combination according to claim 16, wherein said bolt is a shoulder bolt having an enlarged-diameter portion and an end relatively-small-diameter portion, the relatively-small-diameter portion being threadedly secured into a tapped bore provided in the external extremity of the movable-contact stem.

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