Nov. 10, 1953 P. B. HOYE 2,658,977

ELECTRICAL LOAD BREAK SWITCH

Filed May 8, 1948 4 Sheets-Sheet 1

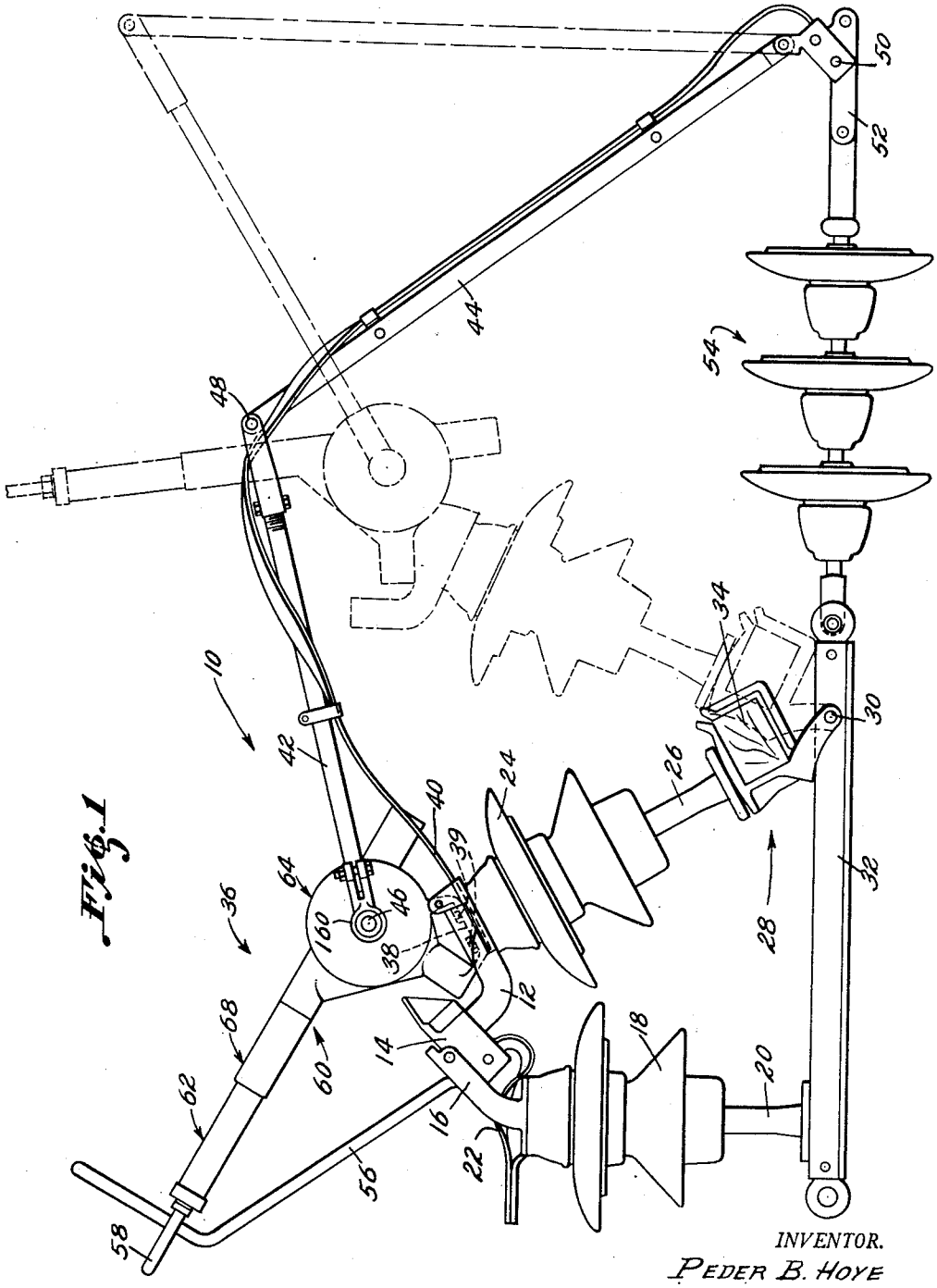


Fig. 1

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Filed May 8, 1948 4 Sheets-Sheet 2

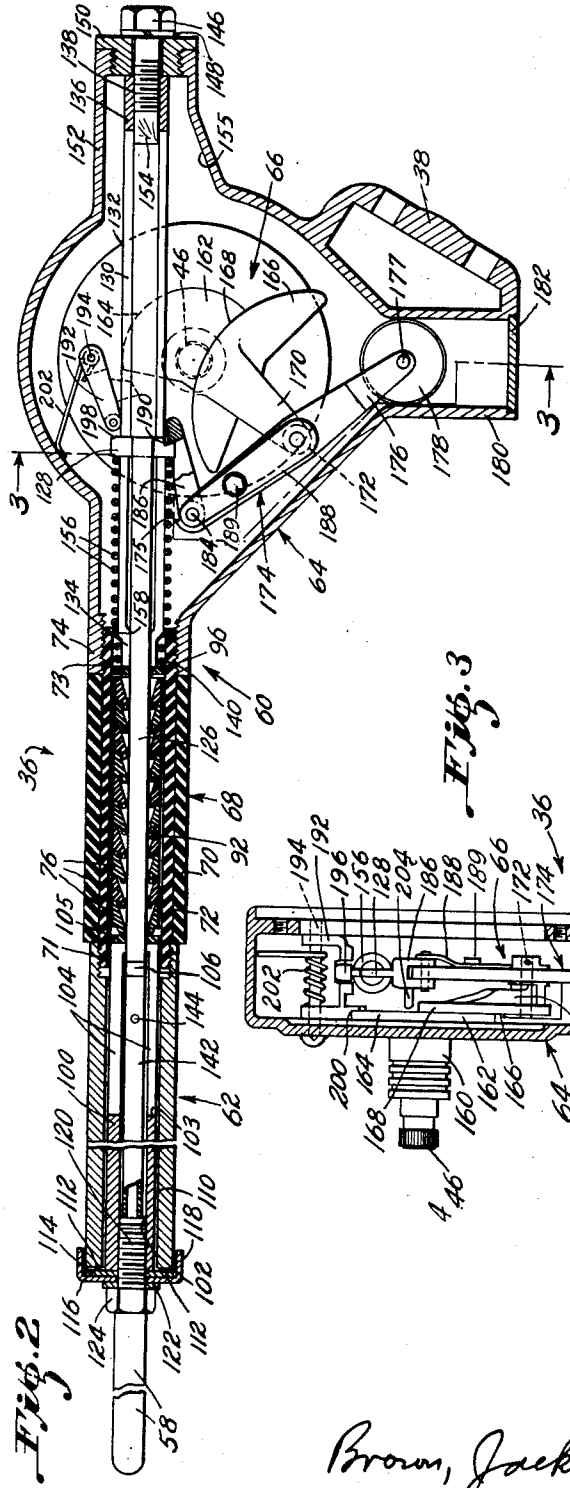


Fig. 2

Fig. 3

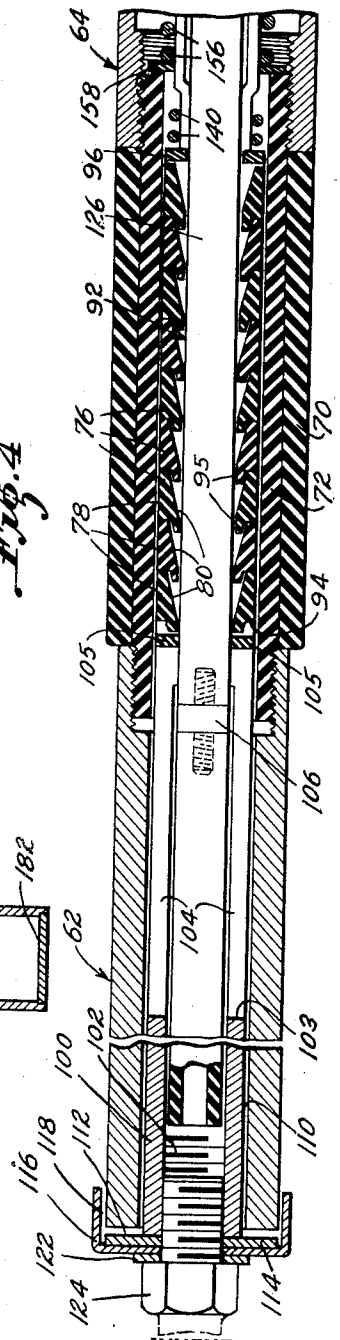


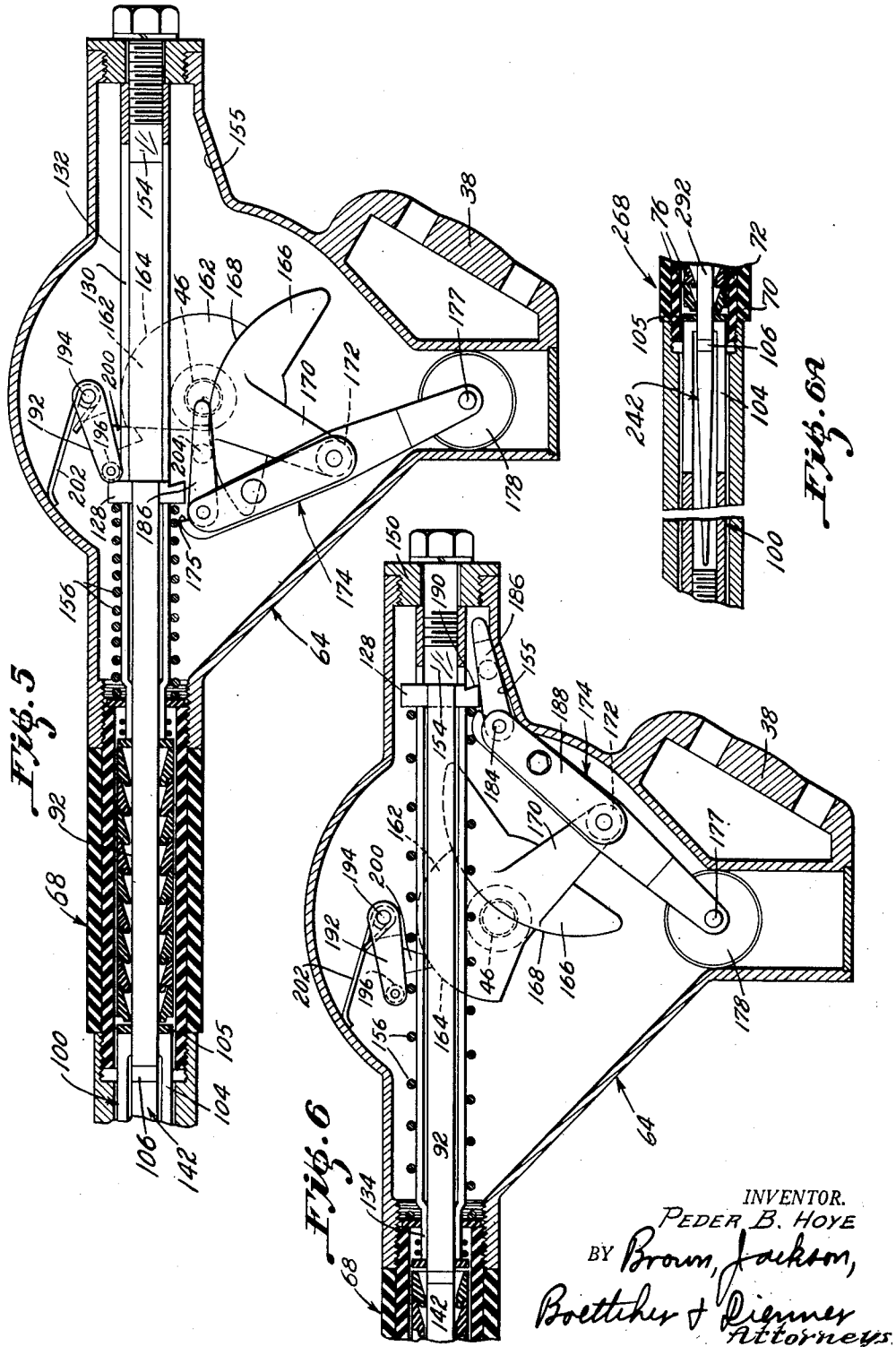
Fig. 4

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ELECTRICAL LOAD BREAK SWITCH

Filed May 8, 1948 4 Sheets-Sheet 3



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Nov. 10, 1953 P. B. HOYE 2,658,977

ELECTRICAL LOAD BREAK SWITCH

Filed May 8, 1948 4 Sheets-Sheet 4

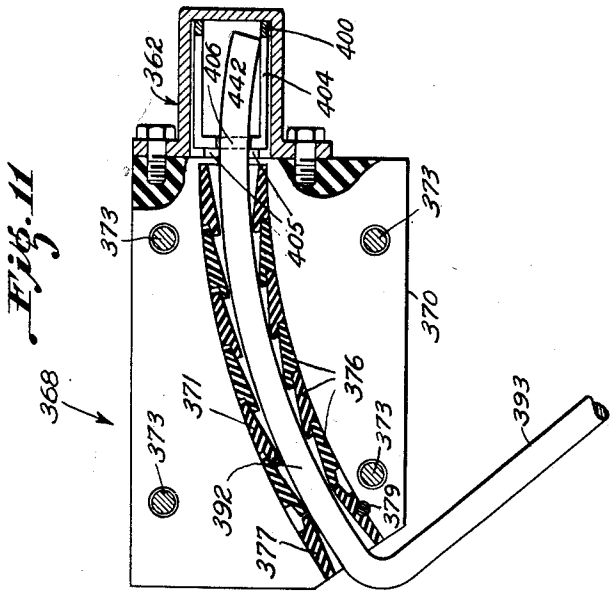


Fig. 11

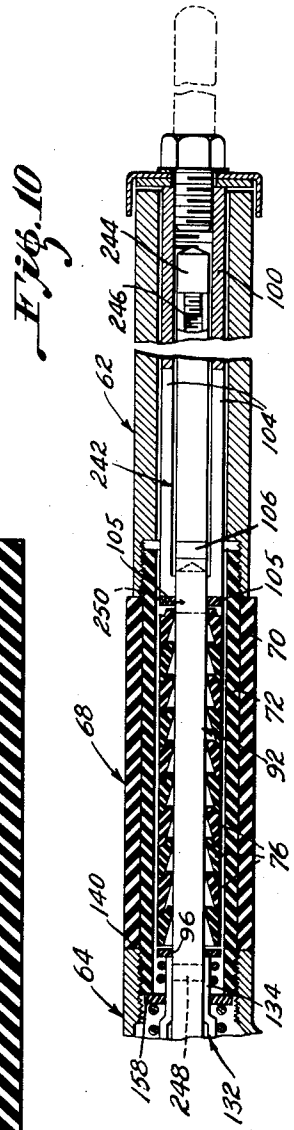


Fig. 10

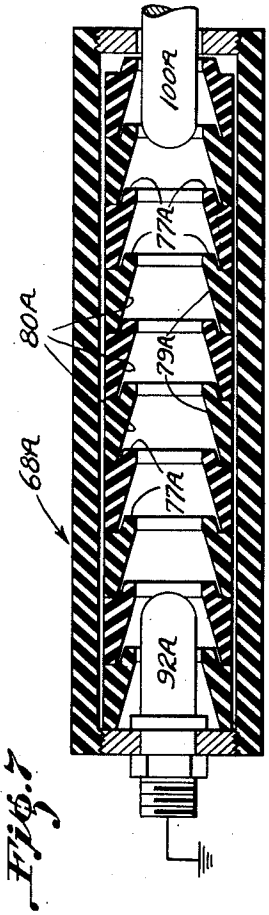


Fig. 7

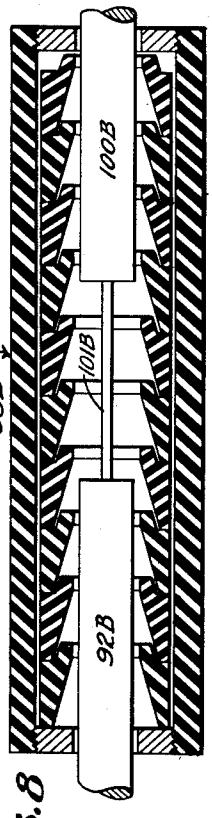


Fig. 8

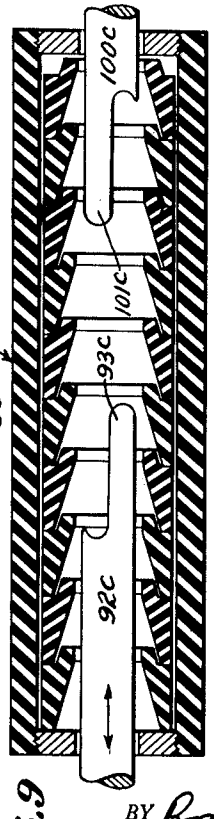


Fig. 9

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UNITED STATES PATENT OFFICE

2,658,977

ELECTRICAL LOAD BREAK SWITCH

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Application May 8, 1948, Serial No. 25,966

32 Claims. (Cl. 200—146)

1

The present invention relates to an electrical load breaking device and, more particularly, to a load breaking device of the air break type.

It is an object of my invention to provide a switch for interrupting an electrical circuit in which switch the contacts may be very rapidly separated, in order to reduce the arcing period and to increase the interrupting capacity of the switch. The mechanism for attaining this object also provides means for reengaging the separated contacts at a slower rate.

It is another object of my invention to provide a circuit interrupting mechanism which is power actuated for opening the contacts in response to a predetermined condition, such, for example, as the position of a pair of main contacts, and which provides mechanism for reengaging the contacts while simultaneously reenergizing the power means. In its preferred form, the contacts and the power means are disconnected from all connecting linkage or actuating mechanism during separation of the contacts, the linkage for reengaging the contacts becoming associated therewith only after the contacts have become completely separated following interruption of the circuit.

It is a further object of my invention to provide in switching apparatus of the foregoing type, a pair of air break contacts and an interrupting unit in series, said interrupter unit being movable for opening the circuit and being adapted to cause its arcing contacts and then the air break contacts to be separated after limited opening movement of the unit, the remainder of its movement being adapted to provide for spacing of the air break contacts.

It is a further object of the invention to provide in the switching apparatus just described mechanism which is adapted to re-energize, throughout substantially the entire closing movement of the interrupter unit, the power means for separating the arcing contacts of the unit.

It is another object of my invention to provide an electrical load breaking device of the air break type having an arc extinguishing chamber which includes throat means arranged to direct the gaseous products resulting from the arc angularly into the path of the arc, at least one of a pair of electrodes being disposed in said chamber. The electrodes may be separated by an air gap, connected by a fusible element, or formed as movable contacts.

It is a further object of my invention to provide switching apparatus which includes a pair of relatively separable contacts and an arc extinguishing chamber having throat means therein, one of the movable contacts having associated with it an insulating member which is drawn into the arc extinguishing chamber during separation of the contacts, in order to constrict the arcing space within said chamber and to reduce the cross sectional area of the chamber. In the preferred form of the invention, the associated surfaces of the insulating member and of the walls of the arcing chamber are so formed and positioned relative to each other that gases generated by the arcing of the contacts are placed under high pressure and turbulently distributed within the chamber, said gases being directed angularly into the path of the arc. A further advantage resulting from employment of the insulating member which is associated with one of the contacts is that upon closing of the contacts the surface on said one contact to which the arc may strike is reduced without reducing the area of engagement between the contacts when in reengaged position.

2

In a preferred form of the invention, the insulating member is of the same outline as the movable contact with which it is associated in end-to-end relation, said insulating member remaining in engagement with the other contact, even when the contacts are fully separated. Easier reengagement of the contacts is thereby provided. The insulating member may be hollow and have one or more vent holes through the wall and, if desired, arc extinguishing material may be carried within the hollow insulating member.

It is another object of the present invention to provide a pair of relatively separable contacts which overlap when in engaged position. Such arrangement provides several advantages. To be particularly noted is the fact that upon closing of the contacts the hottest surface areas of the approaching contacts will engage and then pass beyond each other, so that the contacts will not become welded upon cooling. During separation of the contacts such construction also permits acceleration of the contacts even before they actually separate from each other. Consequently, very rapid separation is achieved and the arc is destroyed more quickly.

Yet another object of the invention is to provide additional surface areas for cooling and de-ionizing the hot gases resulting from the arcing contacts, a portion of said additional surface being provided by improved construction of one of the arcing contacts itself.

It is another object of the invention to provide switching apparatus which includes a circuit

interrupter unit which is adapted to be movable and, when the circuit is interrupted, to be located on the deenergized side of the switching apparatus, so that the interrupter unit may be safely handled for repair or replacement of its parts, or of the unit itself.

It is yet another object of the invention to provide switching apparatus having a pair of main contacts which are separable and an interrupter unit in parallel with the main contacts and so mounted with respect to them that when the main contacts are separated and the circuit is interrupted, the interrupter unit will be on the deenergized side of the switching apparatus.

Experiments with electrical load breakers of the air break type which employ arc extinguishing chambers having lining material which produces gases during arcing has indicated that for a given voltage (*a*) the greater the current the greater the need for separating the contacts and (*b*) the greater the current the less resistance there should be to the flow of gases which are generated within the arc extinguishing chamber. It is an object of my invention to provide means whereby the resistance against the flow of the gases is varied with the separation of the contacts.

It is a further object of my invention to provide an interrupter unit which is movable for opening a circuit and which is adapted to separate its contacts after a portion of its opening movement, the speed of said separation being independent of the speed of the opening movement of the unit.

It is yet another object of the invention to provide an interrupter unit having a housing in which are disposed separable contacts, an arc extinguishing chamber, power means adapted to separate the contacts, means adapted to restrain such separation and mechanism for rendering ineffective the restraining means and for reengaging the separated contacts while reenergizing the power means. In one form of the invention the contacts and chamber may have their central axes disposed substantially along a straight line and, in another form of the invention, the contacts and chamber may have their central axes disposed along a curved line.

It is still another object of my invention to provide, in an interrupter unit of the type indicated immediately above, positive means for separating the contacts if the power means fails to do so.

Since the passage of current through an ionized gas is facilitated by having the electrodes hot and, since ionized gases and hot electrodes are present in an air break type of electrical load break switch during arcing, it is an object of my invention to provide means for removing heat from one or more of the electrodes of such a switch so that the arc may be more easily extinguished.

Other objects, uses and advantages of the invention will be obvious, or will become apparent, from a consideration of the following description when taken with the accompanying drawings in which:

Figure 1 is a side, elecational view of the electrical load breaking device of my invention;

Figure 2 is a sectional view on enlarged scale, of the interrupter unit of Figure 1;

Figure 3 is a cross-sectional view on the line 3—3 of Figure 2;

Figure 4 is an enlarged, sectional, fragmentary view of the arcing chamber of the interrupter unit;

Figure 5 is an enlarged, sectional, fragmentary view of the operating mechanism of the interrupter unit at an intermediate point during separation of the contacts of the interrupter unit;

Figure 6 is a view similar to Figure 5, but showing the operating mechanism in a position wherein the contacts are in their fully separated or open position;

Figure 6A is a fragmentary view showing a modified form of insulating member;

Figure 7 illustrates diagrammatically an arc extinguishing chamber of the air break type embodying my invention wherein there are a pair of electrodes spaced by an air gap;

Figure 8 is a view similar to that of Figure 7, but showing the electrodes joined by a fusible element;

Figure 9 is a view similar to that of Figure 7, but showing the electrodes formed as movable contacts which may be engaged with each other;

Figure 10 is a view similar to Figure 4 showing structure which is adapted to cool the contacts when the contacts have separated; and

Figure 11 is a sectional view of a modified form of arc extinguishing chamber of the air break type and cooperating contacts.

Referring now to Figures 1 through 5, but particularly to Figure 1, there will be seen an electrical load break switch of the air break type, indicated generally by the reference numeral 10. Switch 10 includes a pair of main contacts, one of which, 12, is movable and the other of which, 14, is relatively stationary, said contacts providing a knife switch. The stationary contact 14 is connected to a bracket 16 which is supported on an insulator 18, the lower end of which insulator, in turn, is connected with a supporting post 20. A flexible braided cable 22 is connected to the stationary contact 14 and bracket 16 and is adapted to be connected in the power line (not shown).

The movable contact 12 is secured at one end to an insulator 24 which, in turn, is connected at its lower end with a post 26. The post 26 is connected with a hinged clamping structure which is indicated generally by the reference numeral 28. The clamping structure 28 comprises a pair of separable clamping arms, one of which is hinged as at 30 to a switch base 32. It will also be observed that post 20 which supports the insulator 18 and stationary contact 14 is also connected to the supporting bracket 32.

The clamping member 28 is adapted to be secured to a cross bar, such as a wooden cross head 34. Although only one load break switch is illustrated in Figure 1, it will be apparent that there may be a group of switch bases 32 in side-by-side relation to which a plurality of load break switches may be respectively hinged, said switches being interconnected by their being clamped to the common cross bar or cross head 34. When so arranged, the plurality of switches may be opened and closed as a unit.

An interrupter unit, indicated generally by the reference numeral 36, is connected by its bracket portion 38 to the insulator 24 and, in conducting relationship, to the movable main contact 12. A flexible braided cable 40 is connected with the movable contact 12 and bracket 38 and is supported from a pair of hinged arms or links 42 and 44. Arm 42 is connected at one end in non-rotatable relationship to a stub shaft 46 and, at its other end, is hinged as at 48 to arm 44. The

latter arm, in turn, is hinged at its other end at 50 to a supporting bracket or base 52. The supporting bases 32 and 52 are spaced apart and are fixed relative to each other, so that the arms or links 42 and 44 provide a pantograph structure. Arms 42 and 44 will assume the dotted line position shown in Figure 1 when the movable contact 12 is shifted to its dotted line position about the hinged connection 30. The supporting brackets 32 and 52 may be separated by a plurality of insulators, as indicated at 54. The flexible conductor or cable 40 leading from the movable contact 12 is secured at its other end to the bracket 52 and is connected with the remainder of the electrical circuit (not shown). The main electrical circuit through the switch 10 is, therefore, as follows: conductor 22, stationary contact 14, movable contact 12, and flexible conductor 40. A shunt circuit for shunting the main contacts 12 and 14 is provided through a horn 56, which is connected to the supporting bracket 16 and, therefore, has electrical connection with the flexible conductor 22, and a horn 58 which has frictional contact with horn 56, and thence through the interrupter unit 36 and its connecting flange 38 to the flexible conductor 40. Within the interrupter unit 36 there is disposed a pair of separable arcing contacts, an arc discharge chamber and associated apparatus which will now be described more fully by reference to Figures 2, 3 and 4.

The interrupter unit 36 comprises a housing, indicated generally by the reference numeral 60, which housing is formed generally of three portions, namely, a tubular, upper housing portion or member 62 and a lower housing portion or casing 64 in which the actuating mechanism, indicated generally by the reference numeral 66, is housed, and an intermediate portion or arc extinguishing chamber 68 which is formed of insulating material and is interposed between and connected with the tubular member 62 and the housing portion 64.

The intermediate insulating portion 68 comprises one or more insulating sleeves, such as the tubes or sleeves 70 and 72, the outermost sleeve 70 preferably being composed of an insulating material of high tensile strength, such as a phenolic condensation product or the like. The inner sleeve 72 is preferably composed of insulating material and has its upper end 71 externally threaded into the adjacent internally threaded end of the tubular housing member 62. The lower end 73 of the sleeve 72 is externally threaded for screwing into the internally threaded boss 74 which is formed on the lower housing portion 64. Within the inner sleeve 72 is positioned a liner of insulating material comprising a plurality of axially aligned ferrules or rings 76, said rings being composed of an insulating material having high ability to withstand the destructive action of an electric arc, while at the same time permitting a certain amount of burning whereby a substantial amount of gas is produced. Such material is typically represented by horn fiber or the like. Each ring has a cylindrical outer surface 78 which has a free fit within the surrounding insulating sleeve 72. Each ring 76 is formed with a relatively long tapering throat 80, the constricted end of which closely surrounds the movable electrode or contact 92, only a relatively small annular space intervening between the constricted end of each throat and the movable electrode 92. That end of each ring 76 which is formed with the constricted portion of the throat

has its end surface cut back or annularly recessed, as indicated at 94, to provide a neck 95. This serves the purpose of increasing the length of the creepage path or area of the arc extinguishing chamber and also provides sheltered or protective surfaces in the chamber which are not reached directly by the arc. The wider portion of the throat at the opposite end of each ring 76 is adapted to have a free fit over the upstanding neck 95 of the adjacent ring. Consequently, the junction between each ring is protected against direct action of the flame produced by the arc. The series of rings 76, by reason of their throats being tapered, tend to direct the gases, which are produced during arcing, angularly into the path of the arc.

The rings 76 are disposed between a washer 96, which is adapted to rest against the free end of the lower contact member 132, and the free end of the upper contact member, hereinafter generally referred to as the stationary or, relatively stationary, contact 100.

The stationary contact 100 is a hollow tubular element which is internally threaded as at 102 at its upper end and which is slotted, as by cutting, along its longitudinal axis in two or more planes, one of said slots being indicated at 103. At the lower end of contact 100 adjacent the movable contact 92, the slots provide spring fingers 104 which have their lowermost ends inwardly directed toward the movable contact 92 and which are adapted to have resilient engagement therewith. The lowermost ends of the fingers 104 have tips 105 of arc resisting material, such as a tungsten-silver alloy, and the end or tip 106 of the movable contact 92 is also formed with an arc resisting material, such as a tungsten-silver alloy. The two contacts are provided with such tips because of the high melting point of such material, said tips tending to prevent melting during arcing when the contacts are separated or are re-engaged.

The movable contact 92, which is shown in the form of a male contact member, is adapted, when in closed position, to overlap the relatively stationary contact 100, which is shown in the form of a female contact member. It will be observed that the tip of the male contact is positioned beyond the inwardly directed ends of the spring fingers 104 of the female contact 100, which fingers engage the movable male contact at surfaces spaced from its free end. Such arrangement provides a double advantage. These advantages will be better appreciated when it is understood that closing of the contacts 92 and 100 will cause arcing between the approaching contacts which will tend to melt those surfaces of the contacts between which the arc strikes. If such contacts were merely brought into abutment, they would, upon engagement and cooling, tend to weld and thereby become inseparable. However, in the construction which is shown, any surfaces which would tend to melt are driven past each other and assume a position not in engagement with each other, the engagement of the hot tips of the contacts being primarily with surfaces which are much cooler. Furthermore, when the contacts 92 and 100 are to be separated for interrupting the circuit, overlapping of the contacts permits them to be accelerated to a certain velocity before they are entirely disengaged. As a result, the contacts may be more rapidly separated and the arc more quickly extinguished.

The stationary, or female, contact 100 is

secured within the tubular housing portion 62 of the housing 60 and is of such a diameter that clearance is provided between its outer surface and the inner surface of the tube 62. This clearance provides a vent passageway 110 for hot gases which result during arcing of the contacts. The tubular housing portion 62 has recesses 112 cut into its end and there is secured over the end a washer 114 which may, for example, be welded to the tubular portion 62 at locations intermediate the recesses 112. The washer and recesses thereby define passageways for the flow of gases. A cup-shaped member 116 fits over the washer 114 and encircles the end of tubular housing portion 62 with sufficient clearance to provide an annular continuation of the passageways 112, as shown at 118. It will be observed that the gases will be discharged longitudinally of the tubular member 62 and, therefore, in a direction away from the horn 58. Horn 58 which is threaded, as at 120, is adapted to be secured to the internal threads at the end of the stationary contact 100 by passing through a washer 122 and central apertures in the cup-shaped member 116 and the washer 114. A nut 124, when threaded on the horn 58 on the outer side of washer 122, secures the cup-shaped member 116 in place and positions the stationary contact 100 and horn 58 relative to the tubular housing portion 62.

Referring now to the movable contact member 92, it will be seen that it constitutes a rod 126 of electrically conductive metal which is slotted at its lowermost end to receive a flat cross member or latch bar 128 which is welded in place in the slot. The latch bar 128 serves a number of purposes, to be described more fully hereinafter, and it rides in the central longitudinally extending slot 130 of a lower contact 132. As may be seen in Figure 2, the lower contact 132 constitutes a tubulatr member having its upper split end 134 inwardly directed for frictional engagement with the contact rod 126, which constitutes the movable contact 92, said lower contact 132 being slotted substantially its full length, except at the lower end 136, which is internally threaded as at 138. It will be readily seen that the contact rod 126 will be guided in the lower contact 132 and will be in electrically conductive engagement at all times therewith, regardless of the position of said rod . The split end 134 is encompassed by garter springs 140 which urge the split portions of end 134 into contact with rod 126. There is thus provided a plurality of resilient frictionally engaging spring fingers through which the movable contact rod 126 may slide, the number of fingers depending upon the number of slots formed in the end 134 of lower contact 132.

At the opposite end of the movable contact rod 126 there is secured an insulating member or filler member 142 which is of substantially the same external diameter as the movable contact 92 and is secured in end-to-end relation with the tungsten-silver tip 106 of the movable contact. The insulating member 142 may be solid but, in its preferred form, is hollow in order that it may be lighter in weight and may provide additional contact area for hot gases. The insulating member 142 may have one or more vent holes, such as the vent hole 144 which extends through the wall of the insulating member 142, and within said hollow filler member 142 there may be disposed arc extinguishing material (not shown).

The lower contact 132 is secured in position within the lower housing portion 64 for the operating mechanism 66 by means of a bolt 146 which is threaded into the internally threaded end 138 of said lower contact, the head of said bolt bearing against a lock washer 148 which rests upon a threaded closure plug 150 which is threaded into the extension 152 of the lower housing portion 64. A bumper 154 is positioned within the lower contact 132 against the end of the threaded bolt 146, said bumper being formed of wood or other material and being adapted to absorb the blow of the movable contact when said contact is separated from the stationary contact 100 by power means which will now be described.

Although the separation of the arcing contacts 92 and 100 of the interrupter unit 36 could be manually performed, the employment of power means is preferable, since it will result in more rapid separation of the contacts and therefore a more prompt extinguishment of the arc. A helical spring 156 encircles the lower tubular contact 132 and bears at its upper end against a washer 158, which, in turn, bears against the lower end of the insulating tube 72 and the other end of spring 156 bears against the latch bar or cross member 128. When the contacts 92 and 100 are engaged, as shown in Figure 2, the spring 156 is compressed and tends to move the movable contact 92 from engagement with the stationary contact 100 by reacting against the cross member or latch bar 128. The movable contact 92, however, is restrained against separating movement by restraining means which will now be described.

In order to better understand the restraining means for the movable contact 92, attention is called to the fact that the position of the contacts 92 and 100, as shown in Figure 2, corresponds to the position of the interrupter unit 36 and main contacts 12 and 14, as shown in Figure 1, wherein the main contacts 12 and 14 are closed and contact between the horns 56 and 58 exists. It will be recalled that when the main contacts 12 and 14 are opened by movement, either manually or by power means, toward the dotted-line position of Figure 1, arm or link 42, which is connected to the stub shaft 46 of the interrupter unit, is rotated in a counter-clockwise direction, as viewed in Figure 1. The stud shaft will, therefore, be rotated in a counter-clockwise direction.

Stub shaft 46, as may be most readily seen in Figure 3, is supported for rotation in a boss 160 which is formed integrally with the housing portion 64 of the housing 60 of interrupter unit 36. Within the housing portion 64, the stub shaft 46 is secured to an actuating mechanism, which is identified generally by the reference numeral 68, said actuating mechanism rotating with the stub shaft 46. The actuating mechanism 68 comprises a plate member 162 which has a curved cam surface 164. Secured to the plate 162, either integrally or by welding or other means, is an arcuate member 166 which has a cam surface 168. An arm 170 on the arcuate member 166 has a hinged connection 172 at its end with the central portion of a double armed release lever 174. A clevis 176 formed at one end of the double armed lever 174 is adapted to carry a roller 178 which is guided in a hollow extension 180 of the housing portion 64, said hollow extension being closed by a disc or plug 182. At the other end of the double armed lever 174 there is a hinged connection 184 with a U-shaped latch 186. A generally flat spring 188, secured to the double armed

lever 174 by a bolt 189 and having one end apertured and fitting over the hinged connection at 172, has its other end out-turned and pressed against an arm of the U-shaped latch 186 in order to provide a friction bearing between said arm of the latch 186 and the double armed lever 174, so that the latch will not freely rotate about the hinged connection 184.

Although element 186 will generally be identified as a "latch," it will on occasion be referred to as "restraining means," "contact re-engaging means" or the like, which terms indicate functions of the element 186.

The latch bar or cross member 128, which is secure in the end of rod 126 which constitutes the movable contact 92, has an angular notch 190 which is adapted to engage the central portion of the U-shaped latch 186. Latch 186 serves as a restraining means for the movable contact 92 which is urged out of engagement with the stationary contact 100 by the spring 156 which is compressed. By reason of the inclination of the angular notch 190 and the frictional bearing between the U-shaped latch 186 and the double armed lever 174 and the force exerted by spring 156, the latch bar 128 and latch 186 remain in engagement in the position illustrated in Figure 2.

Disposed in the path of movement of the latch bar 128 of movable contact 92 is a spring loaded latch or detent means 192 which comprises a U-shaped member pivoted on its arms about the pin 194, said pin being mounted in the housing portion 64. Opposite to the pivoted end of the detent means 192 there is disposed a roller 196 against which the beveled corner 198 of the latch bar 128 is adapted to bear when the movable contact 92 is permitted to move downwardly toward the detent means 192. One of the arms of the detent means 192 carries an extension 200 against which the cam surface 164 of the plate 162 is adapted to bear for releasing the detent means against the action of its spring 202 which tends to maintain the detent means 192 in the path of the movable contact 92.

Referring now more particularly to Figures 1 through 6, the operation of my improved electrical load breaking device will be described. The full line position of the mechanism illustrated in Figure 1 shows the circuit uninterrupted, the main contacts 12 and 14 being fully engaged and the current passing from the energized side of the switch through braided cable 22 to contact 14 and thence to contact 12 and cable 40. The load break switch (or a group of switches in side-by-side relation) mounted on the switch base 32 and connected to the cross bar 34, may then be moved toward the dotted line position of Figure 1, in order to interrupt the circuit. In interrupting the circuit, all of the mechanism which is supported for rotational movement about the hinged connection 30 moves clockwise, as viewed in Figure 1, and this clockwise movement may be actuated manually or by power means associated with the cross bar 34. It is contemplated that the mechanism mounted for movement about the hinge 30 will be rotated to the dotted line position of the parts in order to fully open the switch.

In the opening movement, only a small angular distance of rotation is required to cause the main contacts 12 and 14 to separate. As soon as said contacts are separated, the entire current flows through the parallel or shunt circuit which leads from the cable 22 through the bracket 16 and horn 56 to the horn 58 of the interrupter unit 36. The circuit continues from horn 58 to the stationary contact 100 and through the spring fingers 104 of said contact to the movable contact 92 which is gripped by said fingers. The path of the current continues through the movable contact 92 to the spring fingers at the upper end 134 of the lower contact 132 and thence to the lower housing portion 64 of the housing 60 of the interrupter unit 36 by means of bolt 146 and closure cap 150. The current is then transmitted through the integral flange 38 of the housing portion 64 to the braided cable 40, said flange and cable being secured, along with the movable contact 12, to the insulator 24 by means of studs or bolts 39. As the opening movement of the switch causes the main contacts 12 and 14 to separate, the pantograph structure which includes the arms or links 42 and 44 begins to pivot at the pivot points 46, 48 and 50 and the rod or link 42 rotates in a counter-clockwise direction, as viewed in Figure 1.

Since rod 42 is connected non-rotatably with the stub shaft 46, which is borne in the boss 160 of the lower housing portion 64 of the interrupter unit 36, said stub shaft also rotates in a counter-clockwise direction. This causes the plates 162 and 166 which are connected to the shaft 46 to rotate in a counter-clockwise direction, as viewed in Figures 1 and 2. Rotation of the plate 166 in a counter-clockwise direction causes its arm 170 to be rotated in the same direction, and, through the pivotal connection 172 with the double armed lever 174, to cause said double armed lever to pivot in a clockwise direction about the pivot point 172 and pivot point 177 of the roller 178 which recedes into the hollow extension 180 of housing portion 64. As a result, the U-shaped bracket 186 rotates in a clockwise direction, but does not release from the latch bar or cross member 128, since the latch bar follows and maintains frictional engagement with the U-shaped latch 186, due to the compression spring 156 urging the latch bar and movable contact 92 toward a disengaged position.

Opening movement of the load break switch 10 will, therefore, permit the movable arcing contact 92 to be moved slightly toward disengaged position until the beveled edge of the latch bar 128 rests on the roller 196 of the spring loaded detent means 192. Such movement of the movable contact 92 into engagement with the detent means or latch 192 does not cause separation of the arcing contacts 92 and 100, since said contacts were overlapped in their engaged, or closed, position.

Further opening movement of the switch 10 continues to cause the arm 42 of the pantograph structure to rotate in a counter-clockwise direction and, consequently, to cause the plate 162 and the plate 166 to rotate in a counter-clockwise direction while the double armed lever rotates in a clockwise direction about the pivot point 172. Consequently, as soon as the latch bar 128 comes to rest upon the roller 196 of the detent means 192, the U-shaped bracket 186, which restrained movement of the movable contact 192, disengages from the angular notch 190 of said latch bar and moves, not only longitudinally away from the latch bar, but also laterally away therefrom at an angle with respect to the path of movement of the latch bar and movable contacts 92. At the same time, the cam surface 164 of plate 162 approaches and comes into engagement with the extension 200 on the spring loaded detent means 192 and begins to disengage it from the latch bar 128 and movable contact

92. When the U-shaped latch 186 has moved out of the path of the latch bar 128 and movable contact 92, the cam surface 164 has moved to a position which releases or trips the detent means 192 which has been serving to restrain separation of the contacts, and the movable contact 92 is then very rapidly propelled out of engagement with the stationary contact 100 by reason of the compression spring 156. It will be appreciated that other power means than the spring 156 may be employed, but that any such power means, when permitted to act, must be adapted to separate the contacts 92 and 100 very rapidly. Although the contacts 92 and 100 might be separated by manual actuation, they could not be satisfactorily separated as rapidly as is desired in that way.

If, for any reason, the actuating means, such as spring 156, fails to move the movable contact 92 out of engagement with the stationary contact 100, following release of the detent means 192, then the contact 92 is positively forced out of engagement with the contact 100 by the shoulder 175 provided adjacent pivot point 184 on the double armed lever 174 of the actuating mechanism 66. Shoulder 175 will engage the latch bar 128 and will force it and movable contact 92 downwardly by reason of continued movement in a counterclockwise direction of arm 42 of the pantograph structure. Consequently, if the spring 156 should be rendered ineffective or if the contacts 92 and 100 should be frozen, yet there is provided means for automatically and positively causing a separation of the arcing contacts 92 and 100 when the switch 10 is moved to open position.

It will be observed that when the detent means 192 is released or tripped the movable contact 92 is entirely disconnected from all detents, latching mechanism, or other mechanism, including the spring, and therefore is not required to draw any such mechanism along with it in separating from the stationary contact 100, even though some of the same mechanism is subsequently employed to cause re-engagement of the contacts and re-energization of the spring 156. This arrangement permits more rapid separation of the contacts and quicker extinguishment of the arc which will result from the separation. Furthermore, by reason of having the movable contact and stationary contact overlapping, the movable contact is adapted to be accelerated prior to the time when it actually separates from the stationary contact. This too permits more rapid separation of the contacts and quicker extinguishment of the arc.

It will be observed that the speed with which the arcing contacts 92 and 100 are separated is entirely independent of the speed with which the interrupter unit itself is movable about the pivot point 30.

The arcing contacts 92 and 100 are adapted to be separated at such time as the main contacts 12 and 14 have become separated a safe distance, in order to prevent restriking, the horns 56 and 58, however, still being in conducting relationship until after the arcing contacts have been separated and the arc extinguished. From the foregoing, it will be apparent that only a small portion of the opening movement of the switch is necessary to disengage the main contacts and to disengage the arcing contacts. As a result, the remainder of the opening stroke of the switch is adapted to provide separation of the horns 56 and 58 and also of the main contacts 12 and 14. This permits necessary separation of the horns and main contacts.

When the arcing contacts 92 and 100 separate, an arc will be drawn between them, and the liner rings 76 will be burned sufficiently to produce gases which will be useful in extinguishing the arc. Since the arcing chamber 68 has a plurality of tapered rings which provide throats, the gases will tend to be directed diagonally into the path of the arc. Because the filler rod or insulator member 142 which is connected to the movable contact 92 is drawn down into the arc extinguishing chamber when the contact 92 is separated from the stationary contact 100, the filler tube will tend to constrict the cross-sectional area and the arcing space within the arcing chamber, so that the gases which are formed as a result of the arcing are confined sufficiently to provide high pressure and turbulence within the arcing chamber. This is desirable to assist in the rapid extinguishment of the arc.

In the fully open position of the arcing contacts 92 and 100, the filler rod or tube 142 will fill most of the arcing chamber in a longitudinal direction, only the end of the movable contact 92 remaining in said chamber. The upper or free end of the insulating member 142 will continue to remain between the inwardly directed ends of the spring fingers 104 of the stationary contact 100. The gases generated by the arcing of the contacts 92 and 100 will pass toward the upper end of the interrupted unit 36, that is, the end at which the horn 58 is located, and will pass from the arc extinguishing chamber through the passageways defined by the slots 103 in the lower end of stationary contact 100. The slots 103 not only provide additional surface for cooling and deionizing the gases but also make possible the formation of the spring fingers of stationary contact 100. The gases will then flow to and through the vent passageway 110 defined between the inner surface of tubular housing portion 62 and the outer surface of the stationary contact 100 until they reach the passageways 112 at which time the gases will pass outwardly and then be directed back toward the lower end of the housing by reason of the cup-shaped member 116. The clearance between the insulating member or filler tube 142 and the rings 76 and the size of the passageways or slots 103 at the lower end of the stationary contact 100, together with the dimensions of the vent passageway 110 and passageways 112 and 118, will be such as to prevent too rapid issuance of the gases from the interrupter unit, since it is desirable to employ the gases to extinguish the arc and it is also desirable to cool and deionize the gases before releasing them to atmosphere.

Although the insulating member 142 of Figure 2 is shown as being a hollow tube and having one or more apertures or openings, such as the opening 144, through its wall portion, it will be appreciated that the insulating member 142 may also be a solid member or rod. However, with the insulating member 142 being hollow there is provided additional surface for cooling of the hot gases resulting from the arcing of the contacts and there is the additional advantage that the weight of the insulating member is reduced so that the mass of the movable contact 92 is less than it would be if the insulating member 142 were solid. Decreasing the weight of the insulating member 142 by forming it as a tubular member is an advantage when it is important to separate the arcing contacts rapidly. If aper-

tures or openings 144 are disposed within the insulating member's wall, gases will be permitted to flow substantially over the entire inner surface of the insulating member 142. Also, arc extinguishing material may be positioned within the hollow member whereas that is not possible in a solid insulating member.

Experiments have shown that in breaking a circuit, with the voltage remaining constant, the greater the current the greater the distance required between the arcing contacts before the arc will be interrupted. Experiments have also established that when employing an arc extinguishing chamber in which gaseous products are produced during arcing, that, for constant voltage, the greater the current the more desirable it is to lessen the resistance to the flow of gases through the arc and out of the interrupter unit. From the foregoing it will be seen that it would be desirable to provide a circuit interrupting device having an arc extinguishing chamber, which device would increase the amount of the arcing space within the chamber as the distance between the arcing contacts is increased.

If reference will now be made to Figure 6A a structure for providing such results will be shown. The device constitutes a tapered insulating member or filler rod 242 which is adapted to be secured in end-to-end relationship with a movable contact 292, said tapered insulating member having substantially the same outline or outside diameter for approximately a quarter of the distance adjacent the movable contact 292 and then diminishing in cross-section toward that end which will be the last to enter the arc extinguishing chamber 268.

If the current is small, it will be desirable to constrict the size of the arcing space within the arcing chamber when the arcing contacts are separated. That position of the insulating member 242 which is of substantially the same diameter as the movable contact is adapted to do just that, since it will constrict the chamber 268 during separation of the contacts a small amount.

If the current is larger, for the same voltage, it is necessary to separate the contacts a greater amount, and it is desirable to provide larger arcing space within the arc extinguishing chamber. The tapered portion of the insulator member 242 provides such increase in the space within the arc extinguishing chamber. Although the insulating member 242 is shown as being a tapered rod over substantially the greater part of its length, it will be appreciated that it may be formed as a hollow member and its shape may be varied in numerous respects while yet providing the same function.

When the switch 10 has been moved to fully open position, as indicated by the dotted line position of Figure 1, the arm 42 will have cranked the stub shaft 46 through a substantial arc. In doing so, the U-shaped latch 186 will have been rotated by the double armed lever 174 in a direction which is also away from the relatively stationary contact 100. The latch will tend to follow an arcuate path by reason of the pivotal connection 184 which is spring-loaded to form a frictional bearing between the latch and the double armed lever. However, as may be more easily seen in Figure 5, an outstanding boss 204 on the latch 186 will come into contact with the curved cam surface 168 of the plate 166, which is rotating in a counter-clockwise direction. The shape of the cam surface 168 is such that as the latch 186 moves toward the hollow extension 152 of the housing portion 64, it will be guided substantially parallel to the path of movement of the movable contact 92. This will be made possible by the fact that the lever arrangement comprising the arm 170 of plate 166, the double armed lever 174 and the roller 178 in the guide of the follow extension 180 constitutes a straight-line-motion mechanism which will cause the pivot point 184 to follow a substantially rectilinear path, said path being substantially parallel to the path of movement of the movable contact 92. As the latch 186 reaches the hollow extension 152, it engages a cam surface 155 on the inside of housing portion 64, and is thereby directed inwardly toward the movable contact 92, and beneath the latch bar or cross member 128. At that time, the latch 186 is so positioned that upon movement of the actuating mechanism 66 to cause reengagement of the arcing contact 92 with the contact 100, the latch 186 will move upwardly and reengage the angular notch 190 of the latch bar 128 and thereby raise the movable contact 92 against the opposing action of the spring 156. It will therefore be seen that the latch 186, which serves as a restraining means prior to opening of the contacts, also serves as a contact reengaging, or resetting, means when the actuating mechanism is moved in the opposite direction.

Assuming now that the switch 10 is in fully open position, as indicated by its dotted line position in Figure 1, the switch may be closed by movement of the interrupter unit 36 and movable contact 12 about the pivot point 30 in a counter-clockwise direction, as viewed in Figure 1. Such movement will cause the arm, or link 42 to rotate in a clockwise direction, whereupon the U-shaped latch 186 will gradually raise the movable contact 92 by its latch bar 128, against the action of the spring 156. Since the latch 186 will be associated with the latch bar 128, the projection on the latch 186 will pass by the cam surface 168 of the arcuate plate 166 without contact or conflict therewith. Simultaneously, the cam surface 168 will be moving to a position out of engagement with the detent means 192. As the horn 58 of the interrupter unit 36 closely approaches the horn 56, which is associated with the stationary contact 14, there will be no arcing, since the circuit is not closed through the interrupter unit and since the contact 12 is sufficiently spaced from the stationary contact 14. Before the horns 58 and 56 reengage, arm 42 will have rotated the stub shaft 46 and the mechanism connected therewith sufficiently in a clockwise direction to have raised the latch bar 128 past the spring loaded detent means 192 and to have caused reengagement of the movable contact 92 with the relatively stationary contact 100.

Since, when the movable contact 92 is fully separated from stationary contact 100, the insulating member or filler tube 142 still has its free end between the spring fingers of the stationary contact 100, and since the outline of said insulating member 142 is substantially identical at the gripped portion with the outline of the movable contact 92 an easy sliding fit of the movable contact into reengagement with the stationary contact is permitted without any abutting action between the ends of the respective contacts. Furthermore, since the insulating member 142 covers the free end of the movable contact 92 on that surface to which an arc is most likely to be drawn, there is less oppor-

tunity for the movable contact to be softened or melted as the result of arcing between the contacts when they close. Furthermore, since the surfaces of the two contacts which are most closely adjacent each other during the closing of said contact, are formed of arc resisting material, such as a tungsten-silver alloy, the heat resistant qualities of such alloy tend to prevent any melting of the ends of said contacts.

It is to be remembered also that in fully closed position of the switch 10, the movable contact 92 will have its tip 106 passed through the contacting surfaces of the spring fingers 104 of the stationary contact 100 until the movable contact 92 is in overlapping position with respect to the stationary contact 100. This means that any softened surfaces of the respective contacts caused during reengagement of said contacts will ultimately be positioned out of contact with each other and the contacting surfaces of the contacts 92 and 100 will be against cooler metal. By causing the contacts to overlap, they will be unable to freeze in closed position. It will be appreciated that the contacts could be overlapped in other fashions than that illustrated, such, for example, as side-by-side or crossed frictional engagement when the two contacts are not formed as male and female members.

Following the closing of the arcing contacts 92 and 100, continued movement of the interrupter unit and movable contact 12 in a counterclockwise direction, as view in Figure 1, will result in reengagement of horns 56 and 58 and then of the movable main contact 12 with the relatively stationary main contact 14. The main circuit will then be established through the braided cable 22, stationary contact 14, and movable contact 12 and braided cable 40.

It will be observed that in reengaging the arcing contacts, the U-shaped latch 136 will simultaneously reenergize the spring 156 which tends to separate the arcing contacts. Reenergization of the spring takes place through substantially the entire closing movement of the interrupter unit 36, with the result that said spring may be more easily compressed than if it had to be reenergized during only a short portion of the closing movement of the interrupter unit and movable contact 12. If, for example, it were necessary to compress the spring very quickly toward the end of the closing stroke, there would be a tendency to resist closing of the arcing contacts during the time that they would be drawing an arc between them and, as a result, the period during which the arc is formed might be extended.

Although the arc extinguishing chamber of the interrupter unit 36 is shown as being used in conjunction with a pair of movable contacts, it will be appreciated that such a chamber is also adapted for use in a lightning arrester structure, such as that illustrated in Figure 7. As is shown diagrammatically in Figure 7, the arc extinguishing chamber 68A may have throat means 80A adapted to direct the gaseous products resulting from arcing between the electrodes 92A and 100A. Said electrodes are relatively fixed with respect to each other with an air gap in between them, the electrode 92A being connected to ground. The throat means 80A, as in the case of the device of Figures 1 through 6, is formed of insulating liner means comprising a plurality of liner rings 76A which are adapted to provide a plurality of shoulders 77A, which are disposed substantially at right angles to the longitudinal axis of the chamber 68A, and a plurality of wall portions 79A which taper inwardly toward said axis. Each wall portion is tapered in the same direction and the shoulders extend radially inwardly from the wider ends of the wall portions. A device such as that shown in Figure 7 may be employed in connection with a power line, in order to reduce the voltage of a lightning surge, since it is capable of interrupting follow current by reason of gases being discharged into the path of the arc.

An arc extinguishing chamber 68B, such as that diagrammatically illustrated in Figure 7, is shown in Figure 8, except that the electrodes 92B and 100B are connected by fusible element 101B which is adapted to be destroyed by passage of overcurrent through it. Heating which is sufficient to destroy the fusible element 101B will cause the release of gases from the insulating liner, said gases being directed into the path of any arc which may tend to form when the fusible element is destroyed.

In Figure 9 is diagrammatically illustrated an arc extinguishing chamber 68C similar to that illustrated in Figure 7, the electrodes 92C and 100C, however, being relatively movable with respect to each other. The electrode 92C is indicated as being movable in either direction through the arc extinguishing chamber 68C and having a reduced end portion 93C which is adapted to frictionally engage the reduced end 101C of the other electrode 100C.

Although in structures illustrated in Figures 7, 8 and 9, it is desirable to have both of the electrodes disposed within the arc extinguishing chamber, it is possible to employ such chamber wherein one of the electrodes only is situated within the chamber.

In Figure 10 is shown a modified structure in which is incorporated means for cooling the arcing contacts when they become separated in order more quickly to extinguish the arc. In any structure wherein a flow of current is passed through ionized gases the amount of flow will depend in part upon the temperature of the electrodes, hotter electrodes providing better current flow. However, since it is the purpose of a circuit interrupting device to interrupt the flow of current and to keep it interrupted, anything which will limit ionization and which will cool the electrodes (the arcing contacts) will be of assistance in extinguishing the arc drawn between the separating electrodes. In the device of Figures 1 through 6, I have shown and described a switch embodying structural features which assist in deionization of the gases formed during arcing. Now I shall describe structure which will assist in removing heat from the contacts (electrodes) which are heated by the arc during separation of the contacts.

Referring now to Figure 10, there will be seen an arc extinguishing chamber 68 which is similar to that of the device illustrated in Figures 1 through 6, and also an upper housing portion 62 and a lower housing portion 64. There will also be seen a relatively stationary female contact 100 having spring fingers 104, the inwardly directed tips 105 of which have frictional engagement with a movable contact 92. Just as in the case of the movable contact illustrated in Figures 2 through 6, movable contact 92 has conductive engagement with a lower contact 132, the split end 134 of which is adapted to have resilient frictional engagement with the movable contact 92 by reason of the garter spring 140.

Secured in end-to-end relationship with the movable contact 92 is an insulating member 242, which carries at its free end a heat conducting or absorbing means 244 in the form of an extension which is threaded into a socket 246 in the insulating member 242. The extension 244 has the same circular outline as does the insulating member 242 and the movable contact 92. It will be understood that the extension 244 may be longer or shorter than that shown, it only being necessary that the housing 62 be of sufficient length to accommodate such extension 244 and the insulating member 242 when the movable contact 92 is in engagement with the stationary contact 100, as shown in Figure 10.

When the contacts 92 and 100 have become completely separated and assume a position comparable to that illustrated in Figure 6, the insulating member or filler rod 242 will be drawn into the chamber and the movable contact will assume the dotted line position, as indicated at 248, wherein the contact is completely withdrawn from the arc extinguishing chamber 68 and into engagement with the upper end 134 of the lower contact 132. Lower contact 132 being formed of metal is adapted rapidly to carry off the heat transmitted to the movable contact 92 by the arc while the contacts 92 and 100 were separating. With the movable contact in the position indicated at 248, the insulating member or filler rod 242 will be positioned in the arc extinguishing chamber 68 and will extend therethrough from end-to-end. The extension 244 carried by the insulating member 242 will at this time assume the dotted line position, as indicated at 250, wherein said extension is gripped by the tips 105 of the spring fingers 104 of the stationary contact 100. Since the extension 244 is formed of metal or other heat conducting material it will conduct some of the heat from the stationary contact 100. Consequently, when the contacts 92 and 100 are separated, the heat transmitted to them by the arc will be carried off by conducting means, so that the arcing contacts will be quickly cooled and thereby reduce the tendency of current to flow through the ionized gases in the arc extinguishing chamber between said contacts.

It will be further noted from Figure 10 that when the movable contact 92 is in the fully open position, as indicated at 248, the end 134 of the lower contact 132 shields it and is closer to the stationary contact 100. Consequently, as the movable contact 92 nears the end of its travel, during opening movement, and its tip 106 passes into the end 134 of the lower contact 132, any arcing which may continue will tend to strike to the end 134 instead of the tip 106, since the electrical path will then be shorter between the stationary contact 100 and end 134 than it will be between contact 100 and tip 106 of the movable contact. Hence, the length of time during which the tip 106 is heated by the arc is reduced by so shielding it by the end 134 of the lower contact. The stationary contact 100 also is shielded by the extension 244 which is carried on the insulating member 242. Since extension 244 is preferably formed of metal which will conduct electricity and since the extension is drawn into the position indicated at 250 when movable contact 92 is in its fully open position, the extension 244 will shield the tips 105 of the stationary contact 100 because the electrical path between contact 92, or end 134 of lower contact 132, and the adjacent end of extension 244 is shorter than the path between contact 92, or end 134, and stationary contact 100. Any arc which exists when extension 244 begins to act as a shield will strike to the extension and consequently the time during which tips 105 of contact 100 are heated by arcing is reduced. It will be observed that the contacts 92 and 100 are shielded during the last portion of the opening movement of movable contact 92 and also when the contact 92 is in fully open position.

Referring now to Figure 11, there will be seen a modified structure in which the arc extinguishing chamber 368 is curved and, preferably, has its central axis disposed on an arc of a circle. The chamber may be formed of a pair of insulating blocks, such as the block 370, in each of which blocks is formed one half of a circular passageway 371, said blocks being secured together by a plurality of fastening means, such as the bolts 373. Within the curved passageway 371 are disposed a plurality of insulating rings or ferrules 376 which are formed in a manner substantially the same as the rings 76 of the device illustrated in Figures 1 through 6. The blocks and rings define the arc extinguishing chamber 368. Secured to the blocks, such as the insulating block 370, and in alignment with the chamber 368, is a housing 362 in which is disposed the stationary contact 400 which has spring fingers 404, the inwardly directed ends 405 of which are formed of an arc resisting material, such as a tungsten-silver alloy, and are adapted to be resiliently engaged with the movable contact 392 which has a tungsten silver tip 406. Secured in end-to-end relation with the tip 406 of the movable contact 392, is an insulating member or filler rod 442 which is adapted to move with the movable contact 392 when it travels in a curved path from out of engagement with the stationary contact 400 and through the arc extinguishing chamber 368. Movable contact 392 has an integral arm 393 which is adapted to be hingedly connected to supporting structure (not shown), so that contact 392 may have movement through the curved arc extinguishing chamber 368 into and out of engagement with the stationary contact 400. It will be observed that the liner rings 376 are held in place between the stationary contact 400 and the outermost ring 377 which is held in the passageway 371 by a pin or key 379. Ring 377 is reversed in its position relative to the other rings 376 in order to present the widest portion of its throat at the opening to the chamber 368. It will be appreciated that the rings 376 and the ring 377 could be reversed in their relative positions so that the ring 377 would be adjacent the housing 362 and the rings 376 could extend inwardly from the opening of chamber 368, preferably with the wider portion of their throats at the left side, instead of as shown.

It will be seen that the central axes of the chamber 368 and movable contact 392 lie on a common line which is curved, said line also lying substantially centrally of the tips 405 of the spring fingers 404 of stationary contact 400.

Although I have illustrated in the various figures of the drawings a pair of separable arcing contacts, one of which is movable and the other of which is relatively stationary, it will be understood that the contacts could both be movable toward and away from each other and my invention embraces such structure as well. Consequently, while I have illustrated preferred em-

bodiments of my invention, I do not intend to be limited thereto, except in so far as the appended claims are so limited, since various modifications or changes will suggest themselves to those skilled in the art by reason of my disclosure.

I claim:

1. In switching apparatus, the combination of a pair of cooperating contacts capable of relative separation, and an arc extinguishing chamber for said contacts for extinguishing the arc formed between the contacts during their separation, said chamber comprising throat means constructed and arranged to direct the gaseous products of the arc diagonally inwardly into the path of the arc, and an insulating member carried by one of said contacts and movable into said chamber during separation of said contacts, said insulating member being secured in end to end relation on said one of said contacts and being hollow and having one or more ports through its side wall portion leading to its hollow interior to provide a passageway for gas discharge through said hollow member.

2. In switching apparatus, in combination, a pair of cooperating contacts capable of relative separation, and an arc extinguishing chamber for said contacts for extinguishing the arc formed between the contacts during their separation, and a hollow insulating member carried by one of said contacts and movable into said chamber during separation of said contacts, said insulating member having one or more ports through its side wall portion leading to its hollow interior to provide a passageway for gas discharge through said hollow member.

3. The combination of claim 2, together with arc extinguishing material disposed in the hollow insulating member.

4. An air-break interrupter unit comprising, a pair of relatively separable contacts, resilient means for separating said contacts, means other than said resilient means for restraining separation of said contacts by said resilient means, and operating means adapted to render ineffective said restraining means to permit said resilient means to separate said contacts, said operating means including a member for forcing separation of said contacts if said resilient means fails, said member being adapted to force separation of said contacts after only a small part of the total movement of said operating means.

5. An air-break interrupter unit comprising, a pair of relatively separable contacts, resilient means movable longitudinally of its own axis for separating said contacts, latch means for restraining separation of said contacts by said resilient means, and operating means adapted to render ineffective said restraining latch means to permit said resilient means to separate said contacts, said operating means including a member for forcing separation of said contacts if said resilient means fails, and said operating means being adapted to re-engage said contacts following separation thereof.

6. In switching apparatus, in combination, a movable contact and a relatively stationary contact, spring means acting directly against the movable contact and adapted to separate the movable contact from the relatively stationary contact, means directly engageable with the movable contact and when so engaged being adapted to restrain said contact separating means, means adapted to disengage said restraining means from said movable contact whereby the contact separating means acts to separate said contacts, and guide means adapted to guide the restraining means into reengagement with the movable contact following separation of said movable contact from the relatively stationary contact.

7. In switching apparatus, in combination, a movable contact and a relatively stationary contact, means tending to separate said contacts, means engageable with the movable contact and adapted to move said contact into engagement with said relatively stationary contact and simultaneously to energize said contact separating means, detent means separate from said contact engaging means and adapted to prevent separation of said contacts, and a movable member adapted to disengage the contact engaging means and subsequently to render ineffective said detent means.

8. The combination of claim 7 wherein the contact engaging means is actuated by said movable member for reengaging the contacts by movement of said member in one direction and the contact engaging means is disengaged from and subsequently reengaged with the movable contact by movement of said movable member in the other direction.

9. In switching apparatus, in combination, a movable contact and a relatively stationary contact, means tending to separate said contacts by movement of said movable contact along a path, means adapted to prevent separation of said contacts, said latter means including an element engageable with the movable contact by movement in a direction at an angle with respect to the path of opening movement of the movable contact, a housing for the aforementioned means, means carried by the housing and adapted to move said element out of engagement with said movable contact, said element also being adapted to move in the direction of movement of the movable contact during separation of said contacts, and a cam surface on an inner wall of the housing adapted to move said element of the second mentioned means into engagement with said movable contact following separation of the contacts.

10. In switching apparatus, in combination, a movable contact and a relatively stationary contact, spring means tending to separate said contacts, means adapted to move the movable contact into engagement with the relatively stationary contact and simultaneously to energize the spring means, detent means adapted to be disposed in the path of movement of said movable contact, actuating means for said contact engaging means, movement of said actuating means in one direction permitting movement of the movable contact into engagement with the detent means, whereupon the contact engaging means is disengaged, said actuating means upon further movement in the same direction releasing said detent means, whereby the movable contact is quickly separated from the relatively stationary contact, further movement of said actuating means directing said contact engaging means into reengagement with said movable contact, prior to reclosing of said contacts by movement of the actuating means in the opposite direction.

11. The combination of claim 10, together with a housing in which said contacts and spring means are carried, said detent means and said actuating mechanism for the contact engaging means being supported by said housing.

12. The combination of claim 10 wherein the actuating means for the contact engaging means

comprises a straight-line-movement mechanism adapted to have a pivotal connection with said contact engaging means and adapted to move the same in a path substantially parallel to the path of movement of the movable contact.

13. The combination of claim 10 together with a housing in which said spring means and contacts are carried, and wherein said actuating means for the contact engaging means has a pivotal connection with the contact engaging means and constitutes a straight-line-motion mechanism for carrying said pivot point in a straight line parallel to the direction of movement of the movable contact, means on said mechanism adapted to release the detent means, guide means associated with said mechanism for maintaining the free end of said contact engaging means substantially parallel to the line of movement of the movable contact, and a cam surface on the housing adapted to direct said contact engaging means into reengagement with the movable contact, following separation of said contacts.

14. In a circuit breaker, in combination, a pair of relatively movable main contacts, a movable arcing contact and a relatively stationary arcing contact, spring means adapted to separate the movable arcing contact from the relatively stationary contact, means adapted to prevent separation of the arcing contacts by said spring means, said second-named means including a resetting element and a releasable detent, actuating mechanism for said resetting element and detent, said actuating mechanism being responsive to opening and closing movement of said main contacts, said resetting element being adapted, upon closing of said main contacts, to move the movable arcing contact into engagement with said relatively stationary contact and to energize said spring means and being adapted upon a predetermined separation of said main contact to be disengaged from said movable arcing contact whereby the movable arcing contact is held against movement by said releasable detent, and cam means on said actuating mechanism adapted to release the detent on further predetermined separation of said main contacts.

15. In switching apparatus, in combination, a pair of axially separable contacts, means adapted to separate said contacts, means engageable with, and in the path of movement of, one of said contacts to prevent the separation of said contacts by said first-named means, and means adapted to disengage said second-named means from, and to move it out of the path of, said one of said contacts, said disengaging means also being adapted to cause separation of said contacts if they fail to separate following disengagement of the second named means.

16. In switching apparatus, in combination, a movable contact and a relatively stationary contact, means adapted to separate the movable contact from the relatively stationary contact but being disconnected therefrom, means adapted to prevent separation of said contacts by said contact separating means, and means adapted to disconnect from the movable contact said second named means, whereby the movable contact is disconnected from any actuating or restraining means when the contacts are being separated by said contact separating means, said third named means also being adapted positively to force the contacts apart if they do not separate when the second named means is disconnected from the movable contacts.

17. In switching apparatus, in combination, a pair of relatively separable contacts, an arc extinguishing chamber through which one of said contacts is adapted to travel during separation of said contacts, an insulating member carried by said one of said contacts, and heat conducting means carried by said insulating member, said insulating member being drawn into said chamber and said heat conducting means being substituted in contact with the other of said contacts upon separation of said contacts.

18. The combination of claim 17, together with second heat conducting means which is adapted to be in heat conducting relationship with said one of said contacts when said latter contact is in the open position.

19. In switching apparatus, in combination, a pair of relatively separable contacts, an arc extinguishing chamber through which one of said contacts is adapted to travel during separation of said contacts, an insulating member carried by said one of said contacts, heat conducting means carried by said insulating member, second heat conducting means associated with said one of said contacts when said contact is in open position, said insulating member being adapted to be drawn into said chamber and said first heat conducting means being drawn into heat conducting relationship with the other of said contacts upon separation of said contacts, both heat conducting means being located outside of said chamber.

20. In switching apparatus, in combination, a pair of relatively separable contacts, an arc extinguishing chamber through which one of said contacts is adapted to travel during separation of the contacts and conductive means for shielding one of the arcing contacts after one of said contacts has completed a certain portion of its opening movement.

21. In switching apparatus, in combination, a pair of separable arcing contacts including a relatively stationary contact and a movable contact, an arc extinguishing chamber through which said movable contact is adapted to travel during separation of the contacts, an insulating member carried by the movable contact, and conductive means carried by said insulating member, said conductive means being adapted to be drawn into shielding position relative to the stationary contact after said movable contact has completed a certain portion of its opening movement.

22. In switching apparatus, in combination, a pair of separable arcing contacts including a relatively stationary contact and a movable contact, an arc extinguishing chamber through which said movable contact is adapted to travel during separation of the contacts, an insulating member carried by the movable contact, conductive means carried by said insulating member, said conductive means being adapted to be drawn into shielding position relative to the stationary contact after said movable contact has completed a certain portion of its opening movement, and conductive means for shielding said movable contact after it has completed a portion of its opening movement.

23. An air-break interrupter unit comprising a pair of relatively separable contacts, an arc extinguishing chamber through which at least one of said contacts is movable during separation of said contacts, a hollow insulating member car-

ried by one of said contacts and movable into said chamber during separation of said contacts, said hollow member having a passageway through its side wall leading to its hollow interior to permit the passage through said hollow member of gases resulting from arcing, power means for separating said contacts, means for restraining separation of said contacts by said power means, and operating means adapted to render ineffective said restraining means, and a housing in which are disposed said contacts, chamber and each of said means.

24. In switching apparatus, in combination, a pair of main contacts one of which is movable and the other of which is fixed, said fixed contact being adapted to be carried on an insulating support, a circuit shunting said main contacts and including an interrupter unit and a pair of arcing horns in series, one of which horns is fixed and is adapted to be carried on the support for the fixed main contact, and non-conductive movable means on which said movable main contact is carried, said interrupter unit also being carried on said movable means and carrying the other of said arcing horns, the electrical circuit being both broken and made internally of the interrupter unit during opening and closing movement, respectively, of the movable means.

25. In switching apparatus, in combination, a pair of main contacts one of which is movable and the other of which is fixed, a circuit shunting said main contact and including an interrupter unit having relatively separable arcing contacts, non-conductive movable means on which said movable main contact and said interrupter unit are carried, said non-conductive movable means having pivotal movement, actuating mechanism for a movable arcing contact, said actuating mechanism including a rotatable member having an axis of rotation parallel to the pivotal axis of said non-conductive movable means, said rotatable member and said movable means being operated by a pantograph mechanism, one of the arms of which includes said movable means and one of the other arms of which is connected with the rotatable member to rotate the same.

26. In switching apparatus, in combination, a pair of relatively separable contacts comprising a male contact and a female contact, said female contact being longitudinally slotted adjacent its contacting end, a housing surrounding said female contact, a gas passageway between said female contact and the wall of said housing, a vent passageway disposed between said gas passageway and the exterior of the housing, the slotted ends of the female contact providing resilent gripping fingers and additional surface area for cooling the heated gases which result from arcing of the contacts during their relative separation, and said slots serving as passageways leading to said gas passageway and vent passageway.

27. In switching apparatus, in combination, a pair of main contacts one of which is movable and the other of which is fixed, a circuit shunting said main contact and including an interrupter unit, said interrupter unit having arcing contacts separable by straight-line movement, non-conductive movable means on which the movable main contact and said interrupter unit are carried, and an actuating mechanism for moving one of the arcing contacts, said actuating mechanism including a rotatable member carried by the non-conductive movable means for causing separation of said arcing contacts following predetermined movement of said non-conductive movable means.

28. In combination, a pair of separable contacts, an arc extinguishing chamber through which at least one of said contacts is movable during separation of said contacts, said chamber having a plurality of liner rings of insulating material adapted to provide a plurality of wall portions tapering inwardly towards said axis and a plurality of shoulders extending inwardly substantially at right angles to said axis from the wider ends of said wall portions, means for varying the arcing space within said chamber, increasingly greater space being provided the farther the contacts become separated, said means comprising an insulating member carried by one of said contacts and being adapted to be moved into said chamber during separation of said contacts and being tapered along a substantial portion of its length with the taper being opposite to that of the liner rings, the end of said insulating member having the smaller cross section being moved into the chamber last.

29. In switching apparatus, in combination, a movable contact and a relatively stationary contact; means adapted to separate the movable contact from the relatively stationary contact but being disconnected therefrom; contact engaging means and detent means both adapted to restrain separation of said contacts by the contact separating means; and means adapted to move both said contact engaging means and said detent means from restraining engagement with the movable contact, whereby said contact separating means is required to move only the movable contact.

30. In switching apparatus, in combination, a movable contact and a relatively stationary contact; means adapted to separate the movable contact from the relatively stationary contact but being disconnected therefrom; contact engaging means adapted to restrain separation of said contacts by the contact separating means; and means adapted to move said contact restraining means from restraining engagement with said movable contact, whereby said contact separating means is required to move only the movable contact; said contact engaging means following its disengagement from said movable contact and following separation of said contacts, being moved by the moving means into position for reengaging the movable contact for subsequently moving it to closed position.

31. In switching apparatus, in combination, a pair of main contacts one of which is movable and the other of which is fixed, a circuit shunting said main contacts and including an interrupter unit, and movable means on which said movable main contact and said interrupter unit is carried, the electrical circuit being both broken and made internally of the interrupter unit during opening and closing movement, respectively, of the movable means.

32. In switching apparatus, in combination, a pair of main contacts one of which is movable and the other of which is fixed, a circuit shunting said main contacts and including an interrupter unit, movable means on which said movable main contact and said interrupter unit is carried, relatively movable arcing contacts in said interrupter unit, and quick break means for causing rapid separation of said arcing contacts, the electrical circuit being both broken and made internally of the interrupter unit during open-

ing and closing movement, respectively, of the movable means.

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