Dec. 14, 1948. P. B. HOYE 2,455,998

ELECTRICAL LOAD BREAKING DEVICE

Filed Dec. 20, 1943 6 Sheets-Sheet 1

Fig. 1.

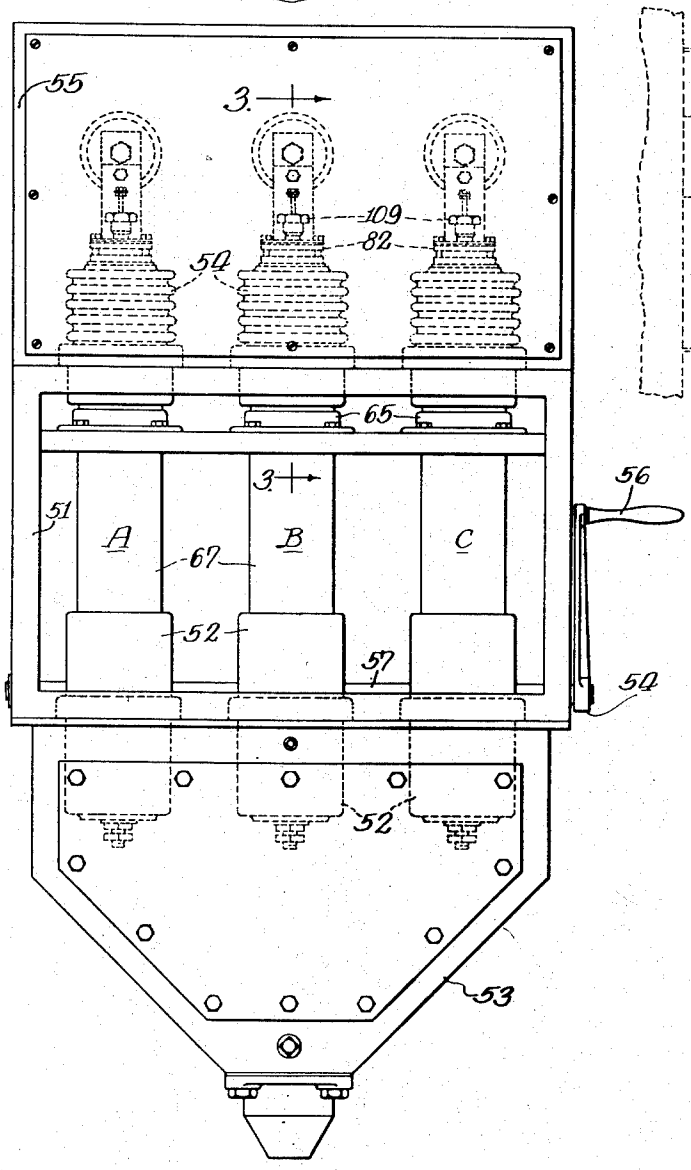
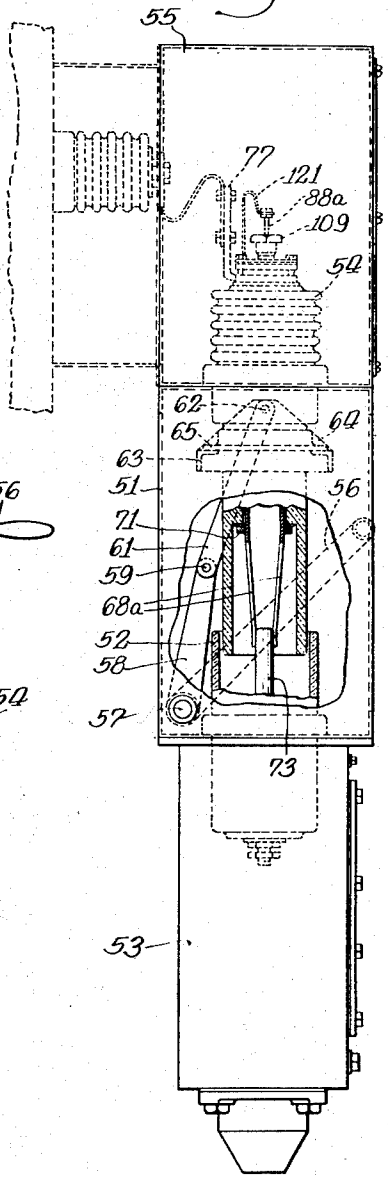


Fig. 2.



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Filed Dec. 20, 1943 6 Sheets-Sheet 2

Fig. 3.

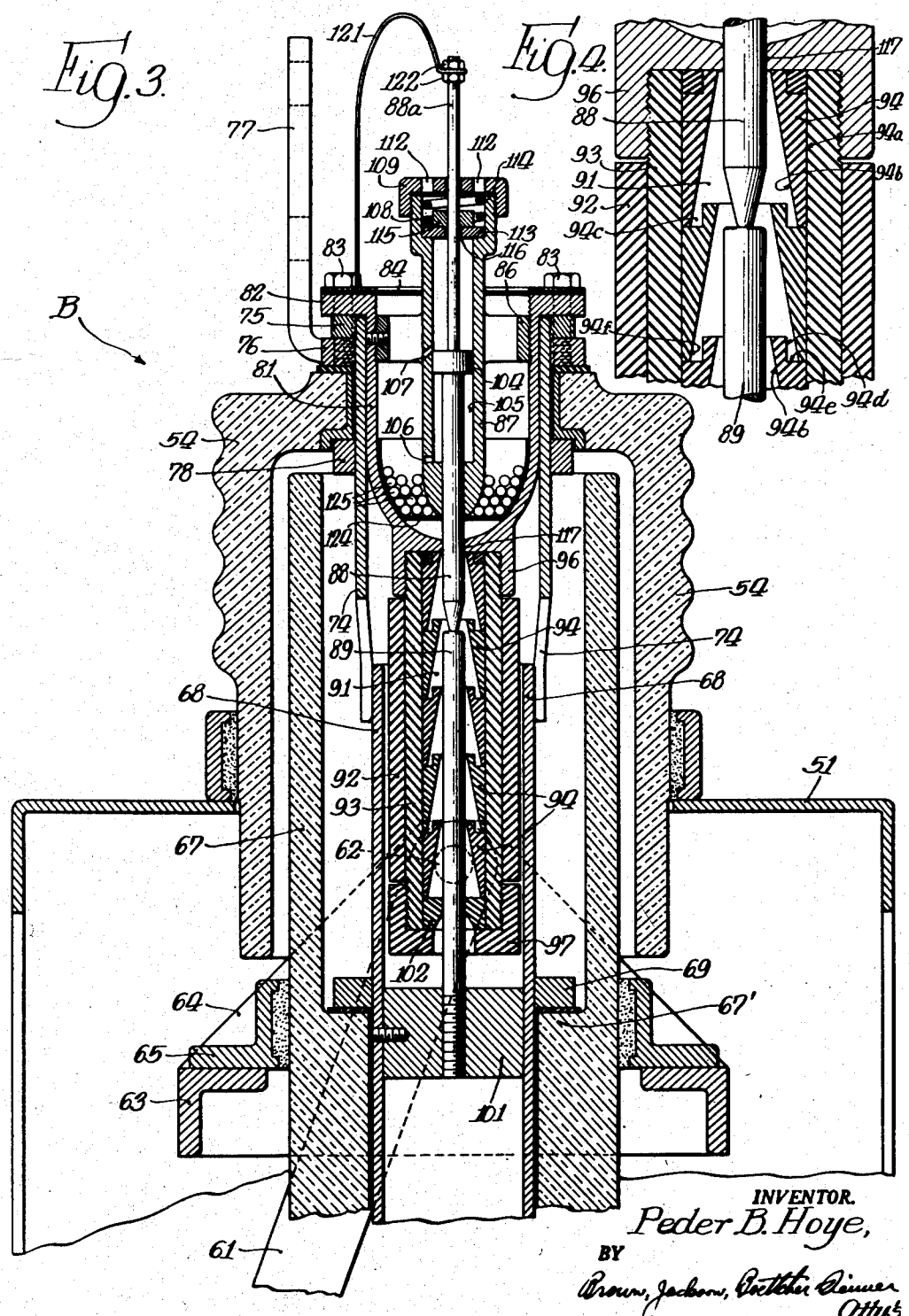


Fig. 4.

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ELECTRICAL LOAD BREAKING DEVICE

Filed Dec. 20, 1943 6 Sheets-Sheet 3

Fig. 5.

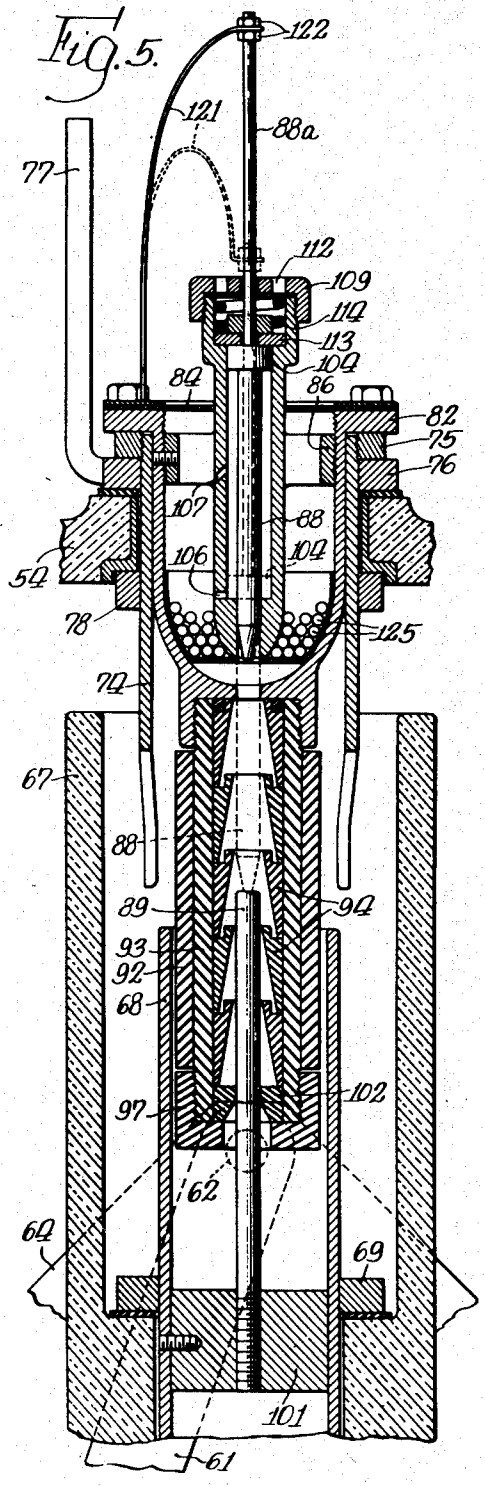
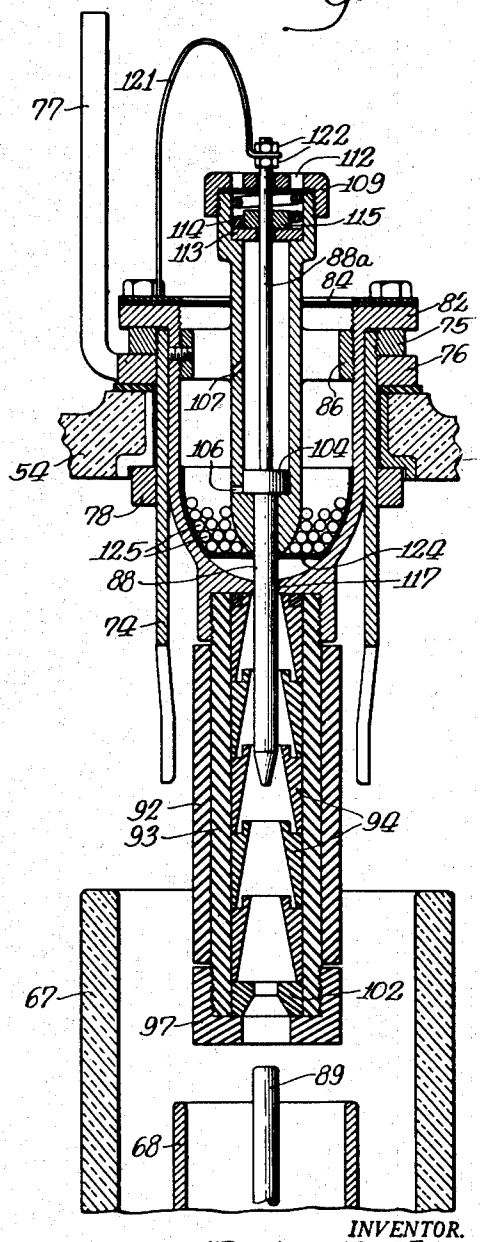


Fig. 6.



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ELECTRICAL LOAD BREAKING DEVICE

Filed Dec. 20, 1943 6 Sheets-Sheet 4

Fig. 7.

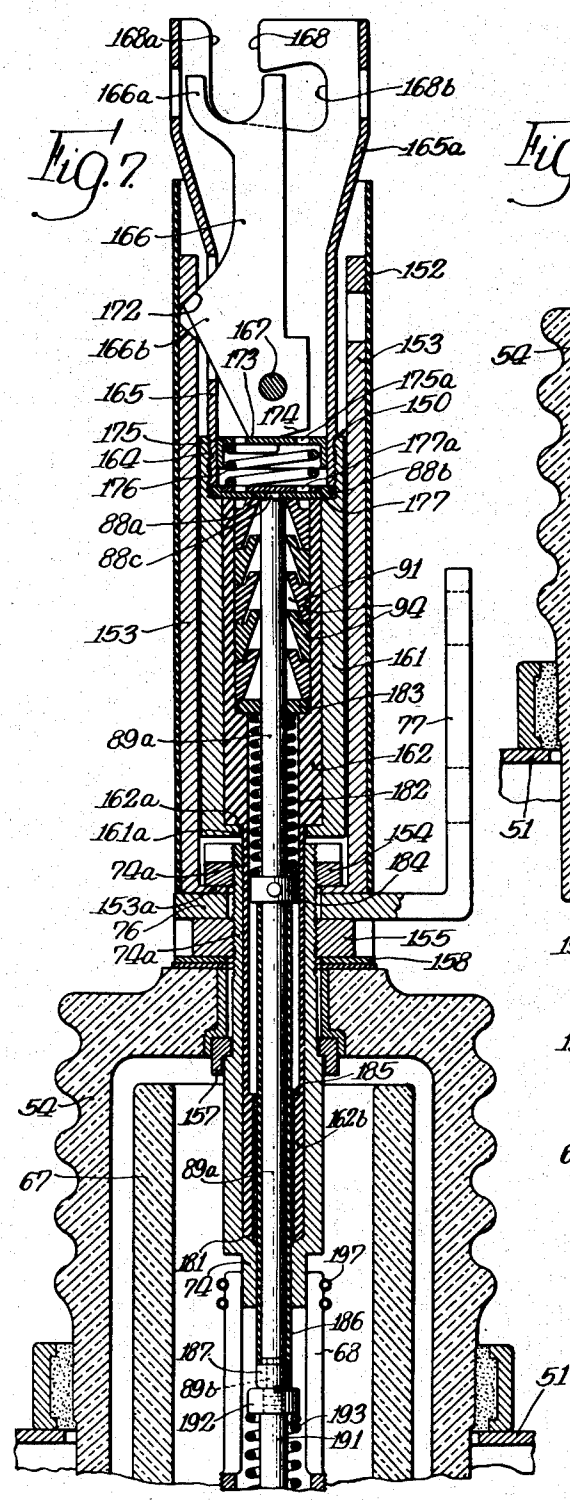
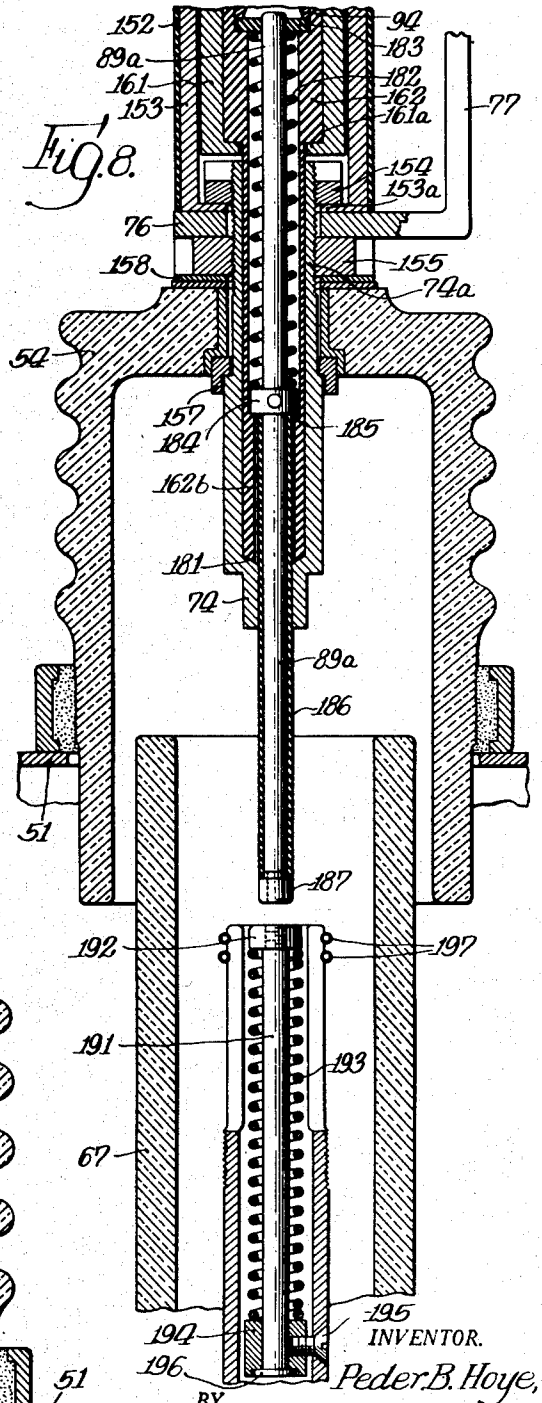


Fig. 8.



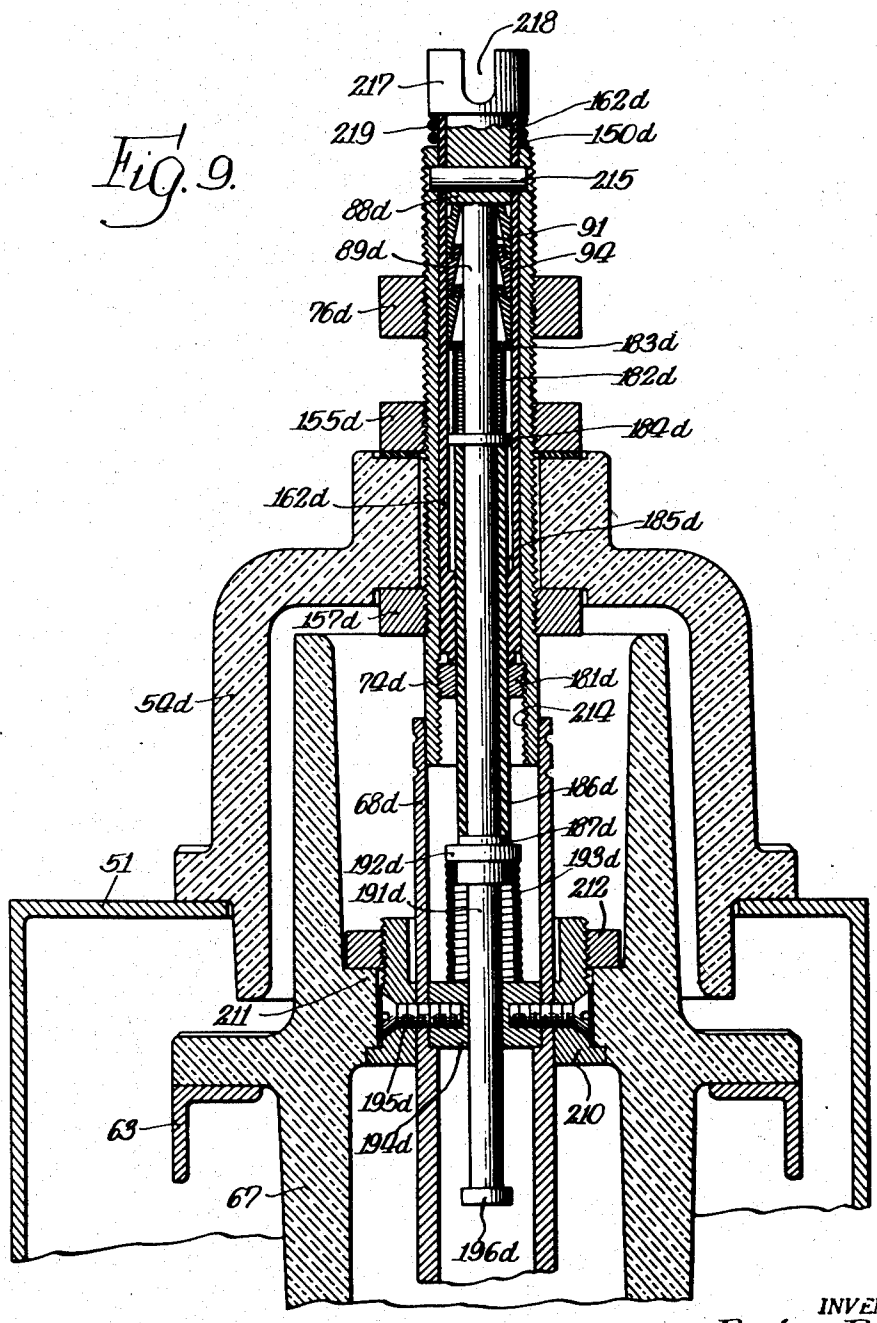
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ELECTRICAL LOAD BREAKING DEVICE

Filed Dec. 20, 1943 6 Sheets-Sheet 5

Fig. 9.



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ELECTRICAL LOAD BREAKING DEVICE

Filed Dec. 20, 1943 6 Sheets-Sheet 6

Fig. 11.

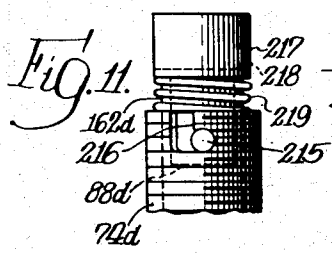


Fig. 10.

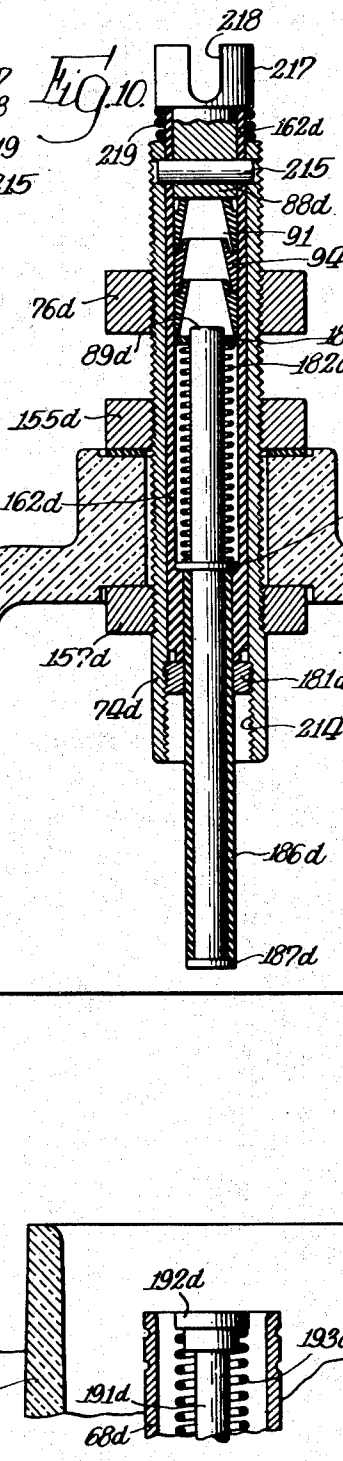
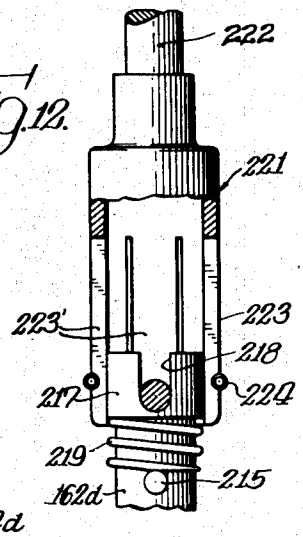


Fig. 12.



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Patented Dec. 14, 1948 2,455,998

UNITED STATES PATENT OFFICE

2,455,998

ELECTRICAL LOAD BREAKING DEVICE

Peder B. Hoye, Maywood, Ill., assignor to Electrical Engineers Equipment Co., Melrose Park, Ill., a corporation of Illinois

Application December 20, 1943, Serial No. 514,944

25 Claims. (Cl. 200—146)

1

The present invention relates to an electrical load breaking device of the air break type.

One of the features of the invention resides in an improved construction and arrangement of arcing contacts and arc extinguishing chamber in which the arc extinguishing action is performed primarily by causing the gaseous products of the arc to be projected at a relatively high pressure and a relatively high velocity directly into the arc itself. More particularly, this arc extinguishing chamber comprises an improved arrangement of aligned tapered throats which direct the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle counter to the direction of travel of the movable arcing contact. The high velocity, high pressure discharge of the gaseous product of the arc, and of the air in said gaseous products, diagonally into the path of travel of the arc has been proven to have a very effective arc extinguishing action.

Another feature of the invention resides in a load breaking switch of the above general description in which one or both of the arcing contacts is gas impelled so that the relatively high pressures of the gaseous products are effective to produce a greatly accelerated separating motion between the two arcing contacts.

Another feature of the invention resides in a load breaking switch of the above general type in which the arc extinguishing contacts and arc extinguishing chamber operate in conjunction with main load carrying contacts, and wherein these main load carrying contacts and the arc extinguishing contacts are arranged concentrically in a compact tubular nesting or assembly.

Another feature of the invention resides in a load breaking switch of the above general type in which the arc extinguishing contacts and the arc extinguishing chamber can be readily removed as a complete interrupter unit for inspection, repair or substitution through the use of a switch stick actuated from a remote point, and without the necessity of opening the main contacts or disconnecting these main contacts from the line. This enables the interrupter unit to be readily examined for possible repair or replacement without opening the line through the main contacts.

Other objects, features, and advantages of the invention will appear from the following detailed description of certain preferred embodiments of the invention.

In the accompanying drawings illustrating such embodiments:

2

Figure 1 is a fragmentary front elevational view showing a load breaking isolator switch embodying the invention;

Figure 2 is a fragmentary side elevational view thereof;

Figure 3 is a fragmentary vertical axial sectional view through one of the arc extinguishing chambers, showing the cooperation of the two arcing contacts therein;

Figure 4 is a fragmentary sectional view showing the lining rings of the arc extinguishing chamber on a larger scale;

Figure 5 is a fragmentary view similar to Figure 3, showing the relation of the arcing contacts at different stages of the switch opening operation;

Figure 6 is a similar fragmentary view showing the positions of the main contacts and arcing contacts in a still further stage of the switch opening operation;

Figure 7 is a fragmentary vertical axial section similar to Figure 3 showing a modified construction in which the controlled or relatively movable arcing contact is gas impelled, this view showing the switch closed;

Figure 8 is a similar fragmentary view taken lower down on the switch assembly, this view showing the switch in the act of opening;

Figure 9 is a fragmentary section, similar to Figures 3 and 7, showing another modified construction;

Figure 10 is a view similar to Figure 9, showing the latter embodiment of switch in open circuit position;

Figure 11 is a detail elevational view showing the arrangement for detachably locking the removable interrupter unit in the switch assembly; and

Figure 12 is a fragmentary detail view showing how the removing tool engages over the upper end of the interrupter unit preparatory to removing the latter.

In the embodiment of my invention illustrated in Figures 1 to 6, inclusive, I have shown the invention incorporated in an isolator switch, but it will be understood that the invention is not limited thereto. Referring to Figures 1 and 2, this isolator switch is shown as being of the three phase type, having the three disconnecting switch units A, B, and C enclosed within a main housing 51. Each switch unit comprises a lower insulating shell 52 which extends down into a bell-shaped or pot-head form of lower housing 53, from the lower end of which the three circuit conductors are led. Each switch unit also com-

prises an upper insulating shell 54 extending up into an upper terminal housing 55 for making any suitable connection with transformer terminals or any other circuit connections. Disposed at one side of the main housing or frame 51 is an operating handle 56 which is mounted on an operating shaft 57. The shaft 57 extends across the back of the main housing or frame 51 in rear of the switch units A, B, and C.

Mounted on the operating shaft 57 just inside each side wall of the main housing 51 is a pair of actuating arms 58 (Figure 2), which are pivotally connected at their upper ends at 59 with a pair of links 61 which extend up for pivotal connection at 62 with the ends of a lifter frame 63. This lifter frame extends across the entire width of the isolator switch assembly so that it can function as a common actuating element for all three switch units A, B, and C. Pivot ears or lugs 64, extending upwardly from the ends of this lifter frame, receive the pivot pins 62 at the upper ends of the links 61. If desired, the vertical motion of the lifter frame may be guided by guideways on the end or side walls of the stationary frame 51.

The lifter frame has operative connection with each switch unit A, B, and C through attachment rings 65 which are bolted to the lifter frame at each switch unit. Each attachment ring is cemented or otherwise secured to the outside of a long insulating sleeve 67 which carries and houses the relatively movable main contact of its respective switch unit. This movable main contact is in the form of a long metallic sleeve 68 which is rigidly anchored in an inwardly extending annular boss 67' of the insulating sleeve 67, as by an upper ring 69 pinned or otherwise secured to sleeve 68 and bearing on the upper end of the boss 67', and a lower ring 71 threaded over the contact sleeve and bearing against the lower end of the boss. As shown in Figure 2, the lower portion of the movable contact sleeve 68 is slotted to form fingers 68*a*, and these converge for sliding contact up and down along the sides of the stationary terminal post 73 which is rigidly mounted in the lower insulating shell 52.

The upper end of the movable main contact 68 is adapted to have sliding engagement up into the lower end of the tubular main stationary contact 74. The latter contact is in the form of a sleeve having a slotted end establishing contact fingers which are converged inwardly for firm frictional engagement with the outer surface of the movable contact sleeve 68. The upper end of the stationary main contact 74 is threaded into an anchoring ring 75 which seats on top of the terminal ring 76, the latter being secured to the top of the upper insulating shell 54, and having an upwardly extending terminal lug 77 for establishing connection with a transformer terminal or other circuit connection. A ring 78, secured around the outside of the terminal sleeve 74 seats within the upper portion of the tubular insulator 54 and holds the stationary contact 74 against upward movement. It will be observed from the foregoing that when the operating handle 56 occupies the upper position illustrated in the drawings, the movable main contact sleeve 68 occupies the upper position illustrated in Figure 3, at which time it is completing a circuit down through the switching unit by virtue of its engagement with the slotted lower portion of the stationary main contact 74. When the operating handle 56 is swung downwardly through substantially 90 degrees of

movement, the reciprocable insulating sleeve 67 of each switching unit is carried downwardly, thereby causing the movable main contact 68 to move down out of engagement with the stationary main contact 74.

Referring now to the improved arcing chamber and arcing contacts which I have embodied in this isolator switch unit, a cup-shaped casting 81 is extended down into the upper end of the stationary main contact sleeve 74, this cup-shaped casting having an outwardly extending flange 82 at its upper end which seats on the anchoring ring 75 of the contact sleeve 74. Passing down through apertured corners of the flange 82 are cap screws 83 which tap into threaded holes in the terminal ring 76. The screws 83 also serve to secure a perforated plate or metal screen 84 across the open top of the cup-shaped casting 81. Secured within the cup-shaped casting is a spider ring 86 which is formed integral with a long dash-pot cylinder 87 extending axially of the cup-shaped casting 81. Guided for vertical sliding movement in this cylinder 87 is the relatively stationary arcing contact 88 which is in the form of a rod extending down through the lower end of the guide cylinder 87. This relatively stationary arcing contact 88 is adapted to have endwise abutment against the upper end of the relatively movable arcing contact 89, the latter also being in the form of a rod which is carried by the movable main contact 68 to move therewith. The two arcing contacts 88 and 89 have cooperative engagement with each other within the improved arc extinguishing chamber indicated generally at 91. This arc extinguishing chamber is defined within one or more insulating sleeves, such as the sleeves 92 and 93, the innermost of which carries a series of arc extinguishing rings 94. The outer sleeve 92 is preferably composed of an insulating material of high tensile strength, such as a phenolic condensation product or the like. The inner sleeve 93 is preferably composed of fiber, and has its upper end threaded for screwing into an internally threaded boss 96 extending downwardly from the cup-shaped casting 81. An internally threaded cap 97, composed of fiber or like material, screws over the threaded lower end of the inner sleeve 93, this cap serving to hold the outer sleeve 92 confined between the boss 96 and cap 97, and also serving to hold the the arc extinguishing rings 94 in place within the inner sleeve.

These lining rings 94 are preferably 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 a material is typically represented by horn fibre or the like. Each ring has a cylindrical outer surface 94*a* which has a relatively snug push fit within the surrounding insulating sleeve 93. Each ring is formed with a relatively long tapering throat 94*b*, the constricted end of which closely surrounds the arcing electrodes 88 and 89, only a relatively small annular space intervening between the constricted end of the throat and the arcing electrode. That end of each ring formed with the constricted portion of the throat has its end surface cut back or annularly recessed, as indicated at 94*c*. This serves the two-fold purpose of increasing the length of the creepage path or area of the arc extinguishing chamber, and also of providing sheltered or protected surfaces in

the chamber which are not reached directly by the arc. Such will be obvious from the fact that the cut-back or recessed area 94c is defined by three walls 94d, 94e, and 94f which increase the total length of the creepage path considerably at each ring, and which recessed walls are out of the normal path of the arc flame and hence are protected against being burned by the direct action of the flame.

The relatively movable arcing contact 89 has its lower end threaded into a circular metallic mounting block 101 which is pinned or screwed to the relatively movable main contact 68. Thus, the relatively movable arcing contact remains permanently electrically connected with the relatively movable main contact, and moves directly therewith in all circuit opening and closing operations. This lower arcing contact enters the arc extinguishing chamber through a closely fitting lower guide ring 102 composed of insulation. This lower guide ring together with all of the tapered throat lining rings 94 can be readily removed for inspection and renewal by unscrewing the cap 97 from sleeve 93, or by unscrewing sleeve 93 from boss 96.

The upper or relatively stationary arcing contact 88 has a free sliding fit in the tubular guide 87, and carries a piston 104 which slides in a cylinder 105 in said tubular guide. The piston 104 serves both as a stop device and as a one-way retarding device for the upper arcing contact 88. In the normal closed position of the switch unit (Figure 3) when the main contacts 68 and 74 are in engagement, the lower arcing contact 89 is in abutment with the upper arcing contact 88, having forced the upper contact 88 to the raised position illustrated. At this time the piston 104 stands at an intermediate position in the cylinder 105, as illustrated in Figure 3. When the movable main contact 68 and movable arcing contact 89 start down together in a switch opening operation, the upper arcing contact 88 follows the lower arcing contact 89 down. These two arcing contacts are in engagement at the instant that the main contacts start to separate, and hence the two arcing contacts become transposed from a shunt relation to a series relation. Therefore they momentarily take over the entire load so that substantially no arc is drawn between the main contacts 68 and 74 in the separation of these main contacts. The arcing contacts remain in engagement until the main contacts have become well separated, whereupon the piston 104 strikes the bottom of the cylinder 105 and stops further descent of the upper arcing contact 88. Immediately therewith the arc is drawn as the lower arcing contact continues to move downwardly, and the creation of the arc generates high pressure gases in the arc extinguishing chamber 91 which immediately drive the upper arcing contact 88 back in an upward direction so as to accelerate the separation of the arcing contacts.

Referring again to the cylinder 105, it will be seen that leading from the bottom of the chamber 105 are one or more venting ports 106, and leading from approximately the mid point of the cylinder is another venting passageway 107. The upper end of the guide member 87 is formed with a counterbore 108 over which screws a cap 109 having venting apertures 112 therein. A yieldable abutment disc 113 seats in the bottom of the counterbore, with a spring 114 confined between it and the cap 109. An extension rod 88a extends upwardly from the piston 104 and passes freely

through the yieldable abutment ring 113 and cap 109. Surrounding this rod, with a rather snug sliding fit, is a valve ring 115 which normally seats on the abutment disc 113 and closes a valve port 116 formed centrally in this disc. The lower portion of the arcing rod 88 passes through a relatively snug opening 117 formed in the bottom of the cup-shaped casting 81. When the rapidly expanding gases of the arc force the contact rod 88 upwardly the piston 104 is free to move unimpeded by any damping action because the ports 106 and 107 admit atmosphere below the piston and because the air confined above the piston is freely vented out through valve port 116 and past upwardly displaced valve disc 115 and out through vents 112. However, on the return motion of the arcing contact, a very pronounced delaying or impeding action occurs in the downward motion of the piston 104. During the first part of this downward motion the check valve 115, seating on the valve port 116, prevents inflow of atmosphere into the chamber area above the piston; also, outflow of air from the lower portion of the chamber area is restricted by the ports 106 and 107, and particularly so after the lower edge of the piston cuts off the port 107 so that the venting is confined to the restricted outflow through the smaller port 106. By virtue of the above operating relationship, the arcing contact 88 is made responsive to pressure so that it is free to move upwardly with a very rapid motion as soon as the arc is drawn, and is impeded against return motion so that an adequate time interval is established to quench the arc, and also so that there will be so oscillation of the upper arcing contact 88. The restriction through port 106 is not so small, however, that the upper arcing contact might be prevented from following down directly with the lower arcing contact in the manual switch opening operation. A very supple form of pigtail or like flexible conductor 121 has its lower end anchored under one of the cap screws 83 and has its upper end secured to the upper rod portion 88a by the nuts 122, whereby the relatively stationary arcing contact 88 remains permanently electrically connected to the relatively stationary main contact 74, although being movable relatively thereto.

Mounted in the lower portion of the cup-shaped casting 81 is a thin cup 124 composed either of perforated sheet metal, wire gauze or the like. Reposing in this perforated cup are a large number of small balls 125, such as small steel balls of the type used in ball bearings. When the expanding gases of the arc drive the upper arcing contact 88 upwardly through the opening 117, they remove all obstruction from this opening so that they can freely discharge upwardly through the perforated cup 124 and balls 125. The top perforated plate or screen 84 prevents the balls from being blown completely out of the assembly. The balls exert a pronounced cooling and screening action on the discharging gases. The mode of operation of the switch should be apparent from the preceding description, but may be briefly summarized as follows:

When the movable main contact 68 and movable arcing contact 89 start down together in a switch opening operation, the upper arcing contact 88 follows the lower arcing contact 89 downwardly. These two arcing contacts are in engagement at the instant the main contacts 68 and 74 start to separate, and hence the two arcing contacts become transposed from a shunt relation to a series relation with respect to the main con-

tacts. Therefore, they momentarily take over the entire load so that substantially no arc is drawn between the main contacts 68 and 74 in the separation of these main contacts. The arcing contacts 88 and 89 continue to remain in engagement until the main contacts have become well separated (Figure 5), whereupon the piston 104 strikes the bottom of cylinder 105 and stops further descent of the upper arcing contact 88. This lower position of the upper arcing contact 88 is illustrated in dotted lines in Figure 5. Thereupon the lower arcing contact starts drawing away from the upper arcing contact so that an arc is drawn between these two contacts. The creation of the arc generates high pressure gases in the arcing chamber 91, which immediately, or after the gas pressure has reached a predetermined value, drives the upper arcing contact 88 in an upward direction so as to accelerate the separation of the arcing contacts. This upper position of the upper arcing contact is illustrated in full lines in Figure 5. Thereafter, the downward return motion of the upper arcing contact is so delayed or retarded by the action of the piston 104 in the retarding chamber 105 that the lower arcing contact 89 has ample opportunity to reach the lower end of its movement before the upper arcing contact can drop down again to a striking position. Figure 6 illustrates the switch parts approaching the fully open position, the final degree of separation being somewhat more than is shown in this figure.

Referring again to the arc extinguishing action occurring within the chamber 91, the construction of the lining rings 94 out of horn fiber or other suitable insulating material having high tensile strength gives these lining rings the ability to withstand the large expansion pressure from the arc. The strength of these lining rings strengthens the entire assembly. It should also be noted that the tapering throat 94*b* in each lining ring controls and directs the motion of the expanding gases so as to create a pronounced turbulent action in close proximity to the arc. Also, the very high pressure developed in the relatively small arc extinguishing chamber 91 greatly assists in interrupting the arc. The burning action on the lining rings coacts chemically with the fiber composition of these rings so as to liberate a substantial quantity of carbon dioxide, which has a higher dielectric strength than air. These chemical products are created at the point of highest turbulence or highest rate of flow of the gas. Also, as previously remarked, the cutback or recessed area 94*c* at the reduced throat end of each lining ring enables the lining rings to telescope or overlap, and also results in a longer creepage path, lengthened by the three walls 94*d*, 94*e*, and 94*f*, which longer creepage path is moreover protected against the effect of the arc so that there is a reduced deposition of metallic particles on this creepage path owing to the protection of the path from the arc. Still further, it should be noted that these lining rings 94 can be easily replaced at relatively small expense, so that there is no necessity of discarding the entire arc interrupting assembly. The arc extinguishing chamber 91 and upper arcing electrode 88 can be removed from the assembly by removing the screws 83 and lifting the cup-shaped casting 81 upwardly out of the main contacts 68 and 74, this casting 81 carrying the upper arcing terminal 88 and arc extinguishing chamber 91 with it, but leaving the lower arcing electrode 89 remaining in permanent attachment to the lower main contact 68.

Referring now to the modified construction illustrated in Figures 7 and 8, in such modified embodiment the upper arcing contact, the lower arcing contact, and the arc extinguishing chamber are constructed and arranged in the form of a completely removable interrupter unit, designated 150 in its entirety, which interrupter unit can be quickly and easily removed and replaced through the simple manipulation of a switch hook or the like. This removal and replacement of the interrupter unit can be performed while the main switch contacts are in engagement, or after the main switch contacts have been moved to the switch open position. In this modified embodiment the assembly of the arc extinguishing chamber 91 and associated parts is mounted above the tubular porcelain insulator 54 instead of within this insulator, as was true of the preceding embodiment. This upper assembly comprises an outer tube 152 composed of insulating material, such as "Bakelite" or the like, which is lined with a stationary metallic tube 153, preferably composed of copper. The metallic tube 153 has electrical connection with the stationary main contact 74 through the medium of a threaded upper sleeve extension 74*a* of said main contact, this sleeve extension passing up through the tubular supporting insulator 54 and receiving upper and lower clamping nuts 154 and 155. The metallic sleeve 153 has an inwardly extending lower flange 153*a* which seats on the terminal ring 76 of the terminal lug 77, these parts being rigidly clamped together on the threaded extension 74*a* of the main contact 74 by the nuts 154 and 155. The stationary main contact 74 carries a shouldered abutment ring 157 which is held against a shoulder formed in the under side of the supporting insulator 54, the parts being clamped in this relation by the nut 155 screwing down against the washer 158 bearing against the top of the insulator.

Referring now to the removable interrupter unit designated 150, which is adapted to drop down into the stationary metallic tube 153, this interrupter unit comprises a relatively heavy outer metal sleeve 161 within which is mounted an insulating tube 162, composed of "Bakelite" or the like. The arc extinguishing chamber 91 is formed within this insulating tube 162, the extinguishing chamber being formed with the series of liner rings 94 of substantially the same construction described above. The upper end of the removable metallic tube 161 is counterbored and internally threaded, as indicated at 164, for receiving the threaded lower end of an upper metallic sleeve 165. Mounted in said upper sleeve is a swinging latch 166 which is pivoted on a cross pin 167 extending transversely through the tube 165. The upper portion of the tube 165 is belled outwardly at 165*a* to accommodate the lateral swinging motion of the forked upper end 166*a* of the latch 166. Opposite sides of this bell-shaped portion are pinched towards each other to form flattened side walls. Formed in these opposite side walls are L-shaped slots 168 each comprising the vertical passageway 168*a* and the horizontal passageway 168*b*. These slots are adapted to receive the pin of a switch stick. The end of the switch stick preferably has fork arms between which extends a transverse pin, or the stick may merely have a laterally projecting pin, possibly formed with an enlarged head at the outer end of the pin. In the normal position of the forked

upper end 166a of the latch it is aligned with the vertical passageways 168a so that the transverse pin on the switch hook can be passed down through the vertical portion of the L-shaped slots into engagement with the yoke extremity of the latch, whereupon the switch hook can be moved laterally for swinging the yoke shaped extremity over into registration with the horizontal end of the slots. Projecting from one side of the latch or pawl 166 is the latching nose 166b which is adapted to engage in a latching pocket 172 formed in the stationary metallic sleeve 153. The latch 166 is resiliently held in both its engaged and released positions, thereby locking the interrupting unit to the switch stick until the interrupting unit is latched to the stationary socket. and particularly until after the latching nose 166b is engaging in the latching pocket 172. This interlocking function is obtained by the action of two flat surfaces 173 and 174 formed on the lower edge of the latch and against which is pressed a spring urged disc or ring 175. This ring is freely slidable within the metallic tube 165 and is urged upwardly by a compression spring 176 confined below the ring. The lower end of the spring 176 bears against a disc-shaped release valve 177 which normally seats on a stationary disc 88a which serves as the upper arcing contact. This contact disc 88a has a raised peripheral flange 88b against which the lower end of the metallic sleeve 165 abuts for anchoring the contact disc 88a in place. A central aperture 88c in the disc 88a serves to vent gases from the arc extinguishing chamber 91 when such gases create a pressure adequate to force the release valve disc 177 upwardly, at which time the gases pass upwardly through outwardly disposed ports 177a in the disc 177, and through ports 175a in the detent ring 175. The lower end of the metallic sleeve 161 is formed with an inwardly extending flange 161a against which the shoulder 162a of the insulating sleeve 162 is held by the upper arcing contact disc 88a.

The insulating sleeve 162 is formed with a reduced extension 162b extending downwardly from the shoulder 162a, and the lower beveled end of this reduced extension abuts against a beveled shoulder 181 formed within the tubular main contact 74. Mounted for vertical sliding movement within this insulating sleeve extension 162b is the lower arcing contact 89a which is normally urged in a downward direction by a compression spring 182. The upper end of this spring bears against a stationary collar 183, which also guides the upper end of the arcing contact, and the lower end of the spring bears against a movable collar 184 which is pinned to an intermediate part of the contact rod 89a. In the open position of the switch the collar 184 rests against a shoulder 185 formed in the reduced extension 162b of the insulating sleeve 162. That portion of the contact rod 89a extending downwardly below the collar 184 is sheathed within an insulating tube 186 which has a free sliding fit within the tubular main contact 74 and insulating sleeve extension 162b. A metallic cap 187 screws over a reduced threaded end 89b of the contact rod and serves to hold the insulating tube 186 in place on the rod. It will be observed that when a switch hook is inserted in the slots 168 and the latch 166 released, the interrupter unit 150 can be removed in its entirety, such unit comprising the sleeves 161, 165, insulating tube 162, 162b, upper arcing contact 88a, arc extinguishing chamber 91, lower arcing contact 89a, and lower insulating sleeve 186.

In the operation of closing the switch the spring pressed arcing contact 89a is pushed upwardly to its circuit closing position, against the pressure of the spring 182, by the action of a spring pressed follow-up rod 191 which is carried within the movable main contact 68. As best shown in Figure 8, it will be seen that the upper end of the follow-up rod 191 carries a collar 192 which serves as a guide for guiding the motion of the upper end of the follow-up rod within the tubular contact 68, and which also serves as an abutment against which bears the upper end of a compression spring 193 surrounding the rod. The lower end of the follow-up rod is slidably guided within a guide collar 194 which is fixedly anchored within the tubular contact 68 by set screws 195 or the like. The lower end of the compression spring 193 bears against this guide collar 194, and a stop head 196 at the lower end of the rod 191 limits the upward movement of the follow-up rod to the upper position illustrated in Figure 8. The spring 193 is substantially stiffer in deflection strength than the spring 182 which normally urges the lower arcing contact 89a downwardly. Hence it will be seen that in the operation of closing the switch, when the upper end of the follow-up rod 191 strikes the lower end of the contact rod 89a the upper spring 182 yields in deference to the lower spring 193, and hence the arcing rod 89a is pushed upwardly to closed circuit position in engagement with the upper arcing contact 88a. After the lower arcing contact abuts the upper arcing contact, continued further movement of the movable main contact 68 is absorbed by the lower compression spring 193. In the completely closed position of the switch the movable main contact 68 is in resilient engagement over the reduced lower portion of the stationary main contact 74. The upper portion of the movable main contact 68 is slotted to provide a plurality of longitudinal contact fingers, and these are urged inwardly into firm engagement with the stationary main contact 74 by circular garter springs 197 which encircle these contact fingers.

In the operation of opening this embodiment of switch, the movable main contact 68 starts downwardly and quickly moves out of engagement with the lower end of the stationary main contact 74, during which time the arcing contacts 88a and 89a remain in firm spring-pressed engagement by virtue of the action of the follow-up spring 193 holding the lower arcing contact 89a pressed upwardly against the upper arcing contact 88a. Hence, the arcing contacts, which were previously in shunting relation to the main contacts 68 and 74, are now transposed to series relation with respect to these main contacts for momentarily carrying the entire load. This avoids any arcing at the instant of separation between the main contacts 68 and 74. With continued downward movement of the movable main contact the stop head or collar 196 finally abuts the bottom of the guide block 194 and starts moving the follow-up rod 191 downwardly directly with the movable main contact 68. Instantly therewith the lower arcing contact 89a starts to separate from the upper arcing contact 88a under the action of the spring 182, with the result that an arc is drawn between the two contacts. The creation of the arc immediately develops high gaseous pressures in the arc extinguishing chamber 91, which pressures act

upwardly against the release valve 177 and also act downwardly against the lower arcing contact 89a. This gas pressure acting downwardly on the lower arcing contact drives or impels this lower contact in a downward direction so as to quickly accelerate the relative separating movement between the two arcing contacts. This downward gas impelled motion of the lower arcing contact 89a is permitted by the spring 193 which readily yields under the substantial pressures which the gas exerts on the lower arcing contact. Hence, even though the movable main contact 68 may be moving down with a relatively slow motion in the switch opening operation, once the arc is drawn between the arcing contacts 88a and 89a these two contacts separate with a very rapid motion which is independent of the slower motion of the movable main contact 68. In consequence thereof the arc is quickly extinguished within the arc extinguishing chamber 91, such action being aided and abetted by the throttling and gas directing functions of the liner rings 94, as previously described.

With regard to the removability of the interrupter unit 150, attention is directed to the fact that this unit can be completely removed from the switch assembly when the switch is either in its open position or in its closed position. It will be obvious that in the open position no circuit relations are disturbed, and hence there is no problem of extinguishing any arc. When the switch is in its closed position, the arcing contacts are in shunt relation to the main contacts, with the latter carrying the major portion of the load, and when the interrupter unit is removed from the switch assembly there is no breaking of the circuit because the continuity of the circuit is maintained through the main contacts 68 and 74. Hence, there is no appreciable arcing between any of the parts when the interrupting unit 150 is removed at this time. Any repairs or replacements can be made in the interrupter unit, and the unit then restored to its normal operative position in the switch assembly, without disturbing the relation between the main contacts 68 and 74.

Figures 9 to 12, inclusive, illustrate a relatively simplified embodiment having several points of similarity to the construction shown in Figures 7 and 8. Many of the reference numerals employed in the preceding figures have also been employed to designate similar parts in these later figures, with the suffix "d" added to the numeral.

The stationary main contact 74d has its upper portion externally threaded for receiving the upper and lower nuts 155d and 157d which clamp this main contact stationarily in the top of the insulator 54d. An upper terminal lug or ring 76d screws down over the threaded upper end of the contact sleeve 74d for establishing connection with a transformer terminal or other circuit connection. As an alternative arrangement, the transformer or other outlet terminal might be clamped between the two threaded members 76d and 155d.

The movable main contact 68d is secured by screws 195d to a retaining ring 210 which is clamped to the internal flange 211 of the insulator 67 by a nut 212. The lower end of the movable main contact 68d has resilient contact fingers, similar to the contact fingers 68a of Figure 3, which slide up and down the stationary terminal post 73. The screws 195d also anchor the guide block 194d through which slides the spring follow-up rod 191d. The compression spring 193d tends to thrust this rod upwardly until the stop collar 196d at the lower end of the rod strikes the under side of the guide block 194d. The cap 192d at the upper end of the follow-up rod is adapted to bear against the lower end of the relatively movable arcing rod 89d. An insulating sleeve 186d surrounds the lower portion of the arcing rod 89d, extending upwardly from the end cap 187d to the under side of the collar 184d, this sleeve possibly serving as a shoulder for holding the collar 184d in its correct position on the arcing rod. The lighter upper spring 182d is confined between the movable collar 184d and a stationary upper collar 183d which abuts the bottom liner ring 94 of the arc extinguishing chamber 91. The liner rings 94 are held within an insulating sleeve 162d which has its lower end anchored against an abutment ring 181d that screws up an internal thread 214 formed in the lower end of the main stationary contact 74d.

The upper arcing contact 88d is mounted within the upper end of the insulating sleeve 162d, which upper end projects from the upper end of the stationary upper contact sleeve 74d. The fit of this arcing contact 88d in the sleeve 162d may be slightly loose, if desired, to allow some of the gas to vent from the upper end of the arc extinguishing chamber. A transverse pin 215 passes through the insulating sleeve 162d and upper arcing contact 88d and secures the two together. The opposite ends of this pin project beyond the insulating sleeve for quick detachable cooperation with L shaped bayonet slots 216 (Fig. 11) formed at diametrically opposite sides of the metal sleeve 74d. Formed integral with the upper end of the upper arcing contact 88d is a shouldered head 217 which abuts against the upper end of the insulating sleeve 162d. A transverse slot 218 extends across the top of the head 217 for establishing operative connection with a removing tool, such as shown in Figure 12. A compression spring 219 abutting against the under side of the head 217 is adapted to be compressed against the upper end of the metallic sleeve 74d when the removable interrupter unit 150d is in place in the assembly, this spring keeping the ends of the pin 215 pressed firmly upwardly against the upper sides of the lateral ends of the bayonet slots 216. The electrical connection from the sleeve 74d to the upper arcing contact 88d occurs through the pin 215 and spring 219.

Referring to Figure 12, the removing tool 221 comprises an insulating stick portion 222 and the lower socket portion 223. This socket portion is slotted longitudinally to form the spring fingers 223 which are adapted to be forced down resiliently over the outside of the head 217, an outer garter spring 224 adding to the resiliency of these fingers. A transverse pin 225 extends diametrically through opposite fingers 223', this pin being adapted to engage down in the slot 218 in the head 217.

The operation of this embodiment will be apparent from the description of the preceding embodiment. Figure 9 illustrates the switch in its closed position and Figure 10 illustrates the switch in its open position.

When it is desired to remove the removable interrupter unit 150d from the switch assembly, the removing tool 221 is engaged over the interrupter head 217, with the pin 225 engaging in the slot 218. Rotation of the removing tool now releases the ends of the pin 215 from the lateral ends of the bayonet slots 216, so that the entire inter-

rupter unit 150*d* can be pulled directly out of the switch assembly through the friction grip of the resilient socket fingers 223'. The interrupter unit can be removed and replaced either while the switch is in the closed circuit position (Figure 9) or in the open circuit position (Figure 10) without interfering in any way with the main switch contacts or drawing any arc.

My invention also contemplates using the interrupter unit alone as a complete switching unit without embodying it in an isolator switch or without employing main contacts in conjunction with it. For example, such use of the interrupter unit alone may be diagrammatically represented by considering it in a switch assembly such as shown in Figures 9 and 10 but with the cooperating main contacts removed from that assembly. In such an arrangement the lower sleeve 68*d* could have its upper end terminating in the retaining ring 210, so that there would be no upper contacting portion of this sleeve; and the upper sleeve 74*d* could have its lower end terminating substantially at the lower edge of the internal nut or ring 181*d*, so that there would be no lower contacting portion of this sleeve. Hence, there would be no main contacts but the entire switching operation would be performed solely by the arcing contacts 88*d* and 89*d*.

My invention also contemplates a construction in which the upper arcing contact would be gas impelled, like the arcing contact 88 in Figures 3, 4, and 5, and the lowering arcing contact would also be gas impelled, like the arcing contact 89*a* or 89*d* of Figures 7 and 8 or 9 and 10. In such an arrangement, the simultaneous gas impelled movement of the two arcing contacts in opposite directions would increase still further the rate of separation of the two arcing contacts. Such arcing contacts might be arranged to have direct contact with each other in their closed circuit positions, or they might be arranged to have contact with opposite ends of an intermediate contact constructed in the form of a hollow metallic ring anchored in the arc extinguishing chamber 91 in place of one of the insulating lining rings 94. The two arcing contacts would then be gas impelled in opposite directions away from this intermediate contact ring, whereby two arcs would be drawn in series, one from each of the two arcing contacts to the intermediate contact.

While I have illustrated and described what I regard to be the preferred embodiments of my invention, nevertheless it will be understood that such are merely exemplary and that numerous modifications and rearrangements may be made therein without departing from the essence of the invention.

I claim:

1. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of chamber for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a series of lining rings of insulating material through which at least one of said contacts is adapted to travel, said lining rings being formed with tapering throats to direct the gaseous products of the arc in a predetermined direction with respect to the direction of travel of said latter contact, and recessed areas at the points of junction between said lining rings to increase the length of the creepage path in said arc extinguishing chamber.

2. In switching apparatus, the combination of a first contact, a second contact movable into and out of engagement with said first contact, and an air-break type of arc extinguishing chamber through which said second contact is adapted to travel in separating from said first contact, said chamber comprising a series of lining rings of fiber or like insulating material, said lining rings being formed with tapering throats to direct the gaseous products of the arc in a directtion toward said first contact, and recessed areas formed in those ends of said lining rings corresponding to the constricted throat ends thereof, said recessed areas increasing the length of the creepage path through said chamber.

3. In circuit interrupting apparatus, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of chamber for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a series of rings of insulating material, and shielding formations on said rings for protecting the creepage path through the chamber from the effect of the arc drawn between said contacts.

4. In a switch of the class described, the combination of a pair of cooperating main contacts capable of relative movement into and out of engagement with each other, a pair of cooperating arcing contacts connected with said main contacts and also movable into and out of engagement with each other, an arc extinguishing chamber surrounding said arcing contacts and isolating the latter from said main contacts, a series of lining rings of insulating material in said chamber through which at least one of said arcing contacts is compelled to travel in the separating motion between said arcing contacts, said lining rings being formed with tapering throats to direct the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle relatively to the direction of travel of said latter contact, said lining rings having their ends substantially in contact with each other and cooperating with said arcing contacts to form a constricted chamber area for causing the gases of the arc to rise to relatively high pressures in said chamber area, means operative during the switch opening operation for causing said arcing contacts to remain in engagement until after said main contacts have separated and for thereafter causing said arcing contacts to separate so as to draw the arc therebetween in said arc extinguishing chamber, and means responsive to said relatively high pressures in said chamber area for accelerating the relative separating motion between said arcing contacts.

5. In switching apparatus of the class described, the combination of a pair of cooperating main contacts capable of relative movement into and out of engagement with each other, a socket associated with said main contacts, a removable interrupter unit mounted for rotative releasing movement within said socket, said interrupter unit comprising a pair of cooperating arcing contacts electrically connected with said main contacts and also movable into and out of engagement with each other, means operative during the switch opening operation for causing said arcing contacts to remain in engagement until after said main contacts have separated and for thereafter causing said arcing contacts to separate so as to draw the arc therebetween, bayonet slot holding means for holding said interrupter unit in said socket, and releasing means operative to axially rotate said interrupter unit and thereby release said bayonet slot holding means and to then remove said interrupter unit from said socket.

6. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative 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.

7. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a plurality of throats directing the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said contact.

8. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising an aligned series of tapered throats directing air in the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said contact.

9. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a series of throats having closed outer ends and having open inner ends diagonally inclined to direct air and the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said contact.

10. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a series of removable rings of insulating material formed with aligned tapering throats having closed outer ends and having open inner ends which direct the air and gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said contact, said tapering throats with their closed outer ends cooperating with said contacts to define a constricted chamber area for causing the gaseous products of the arc to rise to relatively high pressures.

11. In apparatus of the class described, the combination of a first contact, a second contact movable into and out of engagement with said first contact, and an air-break type of arc extinguishing chamber through which said second contact is adapted to travel in separating from said first contact, said chamber comprising a series of diagonally inclined throats directing the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle counter to the direction of travel of said second contact.

12. In apparatus of the class described, the combination of a pair of cooperating contacts capable of relative separation, and an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a series of throats having closed outer ends and having open inner ends diagonally inclined to direct the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said movable contact, spring means normally tending to move said movable contact away from other contact, and control means for holding said movable contact in engagement with said other contact in opposition to the action of said spring means.

13. In apparatus of the class described, the combination of a first contact, a second contact movable into and out of engagement with said first contact along a rectilinear path of travel, an air-break type of arc extinguishing chamber through which said movable contact is adapted to travel for extinguishing the arc drawn between said contacts in their relative separation, said chamber comprising a series of tapered throats directing the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the rectilinear line of travel of said movable contact, the outer ends of said throats being closed and the inner ends having a relatively close fit with said movable contact whereby to define a constricted chamber area for causing the gases of the arc to rise to relatively high pressures, a helical spring mounted concentrically of said movable contact and normally tending to move said movable contact away from said first contact, and control means for holding said movable contact in engagement with said first contact in opposition to the action of said helical spring.

14. In apparatus of the class described, the combination of pair of cooperating contacts capable of relative separation, an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a plurality of throats directing the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said movable contact, the outer ends of said throats being closed and the inner ends having a relatively close fit with said movable contacts whereby to define a constricted chamber area for causing the gases of the arc to rise to relatively high pressures, and means enabling one of said contacts to be gas impelled in a direction away from its circuit closing position by the pressures of the gases within said chamber area.

15. In apparatus of the class described, the combination of a relatively stationary contact, a relatively movable contact movable into and out of engagement with said relatively stationary contact along a substantially rectilinear line of travel, an air-break type of arc extinguishing chamber through which said relatively movable contact travels in separating from said relatively stationary contact, said chamber comprising a series of aligned tapering throats directing the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the rectilinear line of travel of said movable contact, actuating means for moving said movable con-

tact out of engagement with said relatively stationary contact, and spring means associated with said movable contact enabling said latter contact to be gas impelled in a direction away from said relatively stationary contact by the pressures of the gases within said chamber area.

16. In apparatus of the class described, the combination of a relatively stationary contact, a relatively movable contact movable into and out of engagement with said relatively stationary contact, an air-break type of arc extinguishing chamber through which said relatively movable contact is adapted to travel for extinguishing the arc drawn between said contacts in their relative separation, said chamber comprising a series of tapered throats directing air and gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle pointing toward said relatively stationary contact, the outer ends of said throats being closed and the inner ends having a relatively close fit with said movable contacts whereby to define a constricted chamber area for causing the gases of the arc to rise to relatively high pressures.

17. In apparatus of the class described, the combination of cooperating arcing contacts capable of relative separation, an air-break type of arc extinguishing chamber through which at least one of said contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative 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, cooperating main load carrying contacts connected with said arcing contacts, and means for causing said arcing contacts to remain in engagement until after said main contacts have separated and for thereafter causing said arcing contacts to separate so as to draw the arc therebetween in said arc extinguishing chamber.

18. In apparatus of the class described, the combination of a pair of cooperating arcing contacts capable of relative separation, an air-break type of arc extinguishing chamber through which at least one of said arcing contacts is adapted to travel for extinguishing the arc drawn between said contacts in such relative separation, said chamber comprising a plurality of throats directing the gaseous products of the arc diagonally inwardly into the path of the arc at an oblique angle to the line of travel of said latter contacts, cooperating relatively separable main contacts grouped substantially concentrically of said arcing contacts and arc extinguishing chamber and electrically connected with said arcing contacts to carry the main part of the line load through said apparatus, and means operative during the opening of the circuit for causing said arcing contacts to remain in engagement until after said main contacts have separated.

19. In switching apparatus of the class described, the combination of a pair of cooperating main contacts capable of relative movement into and out of engagement with each other, a readily removable interrupter unit adapted to be associated with said main contacts, said interrupter unit comprising a pair of relatively separable arcing contacts and an air-break type of arc extinguishing chamber through which at least one of said arcing contacts is adapted to travel for extinguishing the arc drawn between said arcing contacts in such relative 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, said arcing contacts being electrically connected with said main contacts, means operative during the switch opening operation for causing said arcing contacts to remain in engagement until after said main contacts have separated and for thereafter causing said arcing contacts to separate so as to draw the arc therebetween, and readily releasable holding means normally holding said interrupter unit in said switching apparatus but capable of being released by a switch stick from a relatively remote point without opening said main contacts nor disconnecting them from the line.

20. In apparatus of the class described, the combination of a pair of cooperating main contacts capable of relative movement into and out of engagement with each other, said main contacts being of substantially circular outline, a pair of cooperating arcing contacts capable of relative movement into and out of engagement with each other, said arcing contacts also being of substantially circular outline and being aligned substantially concentrically of said main contacts, said arcing contacts being electrically connected with said main contacts, means operative during the opening of the circuit for causing said arcing contacts to remain in engagement until after said main contacts have separated, and an air-break type of arc extinguishing chamber disposed substantially concentrically of said main contacts and of said arcing contacts and through which at least one of said arcing contacts is adapted to travel for extinguishing the arc drawn between said arcing contacts in such relative 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.

21. In apparatus of the class described, the combination of a first contact, a second contact movable into and out of engagement with said first contact, and an air-break type of arc extinguishing chamber through which said second contact is adapted to travel in separating from said first contact, said chamber comprising a series of throats directing the gaseous products of the arc into the path of the arc in a direction counter to the direction of travel of said second contact.

22. In switching apparatus of the class described, the combination of a pair of cooperating main contacts capable of relative movement into and out of engagement with each other, a readily removable interrupter unit adapted to be associated with said main contacts, said interrupter unit comprising a pair of relatively separable arcing contacts and an air-break type of arc extinguishing chamber through which at least one of said arcing contacts is adapted to travel for extinguishing the arc drawn between said arcing contacts in such relative separation, said arcing contacts being electrically connected with said main contacts, means operative during the switch opening operation for causing said arcing contacts to remain in engagement until after said main contacts have separated and for thereafter causing said arcing contacts to separate so as to draw the arc therebetween, and readily releasable latching means normally holding said interrupter unit in said switching apparatus but capable of being released by an insulated removing tool from a relatively remote point without opening said main contacts nor disconnecting them from the line, said latching

means comprising a pivoted latch pivotally carried by said removable interrupter unit and adapted to engage a relatively stationary latching shoulder on said switching apparatus, and combined guiding and retaining means carried by said removable interrupter unit operable to guide said removing tool into cooperative releasing engagement with said pivoted latch and to retain said removable interrupter unit on said removing tool in the operation of removing said unit from the switching apparatus after release of said pivoted latch.

23. In switching apparatus of the class described, the combination of a pair of cooperating main contacts capable of relative movement into and out of engagement with each other, a readily removable interrupter unit adapted to be associated with said main contacts, said interrupter unit comprising a pair of relatively separable arcing contacts and an air-break type of arc extinguishing chamber through which at least one of said arcing contacts is adapted to travel for extinguishing the arc drawn between said arcing contacts in such relative separation, said arcing contacts being electrically connected with said main contacts, means operative during the switch opening operation for causing said arcing contacts to remain in engagement until after said main contacts have separated and for thereafter causing said arcing contacts to separate so as to draw the arc therebetween, and readily releasable latching means normally holding said interrupter unit in said switching apparatus but capable of being released by an insulated removing tool from a relatively remote point without opening said main contacts nor disconnecting them from the line, said latching means comprising a movable latch part and a relatively stationary latch part cooperating between said removable interrupter unit and a relatively stationary portion of said switching apparatus for normally latching said interrupter unit in place in said switching apparatus, and means carried by said removable interrupter unit adapted to be engaged by said removing tool for releasing said movable latch part from said relatively stationary latch part and for retaining said removable interrupter unit on said removing tool in the operation of removing said unit from the switching apparatus after release of said latching means.

24. An electric circuit interrupter comprising in combination, conductor means between which an arc is formed on interruption of the circuit, and an air-break type of arc extinguishing chamber through which said arc is drawn in such interruption of the circuit, said chamber comprising throat means constructed and arranged to direct the gaseous products of the arc diagonally inwardly into the path of the arc.

25. An electric circuit interrupter comprising in combination, conductor means between which an arc is formed on interruption of the circuit, and an arc extinguishing and confining chamber along the past of the arc from which an arc extinguishing medium can be evolved due to the heat of the arc for extinguishing the same, said chamber comprising throat means constructed and arranged to direct said arc extinguishing medium diagonally inwardly into the path of the arc.

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