Jan. 11, 1944. H. C. GRAVES, JR 2,338,715

ARC SPLITTING PLATE

Filed March 20, 1941 4 Sheets-Sheet 1

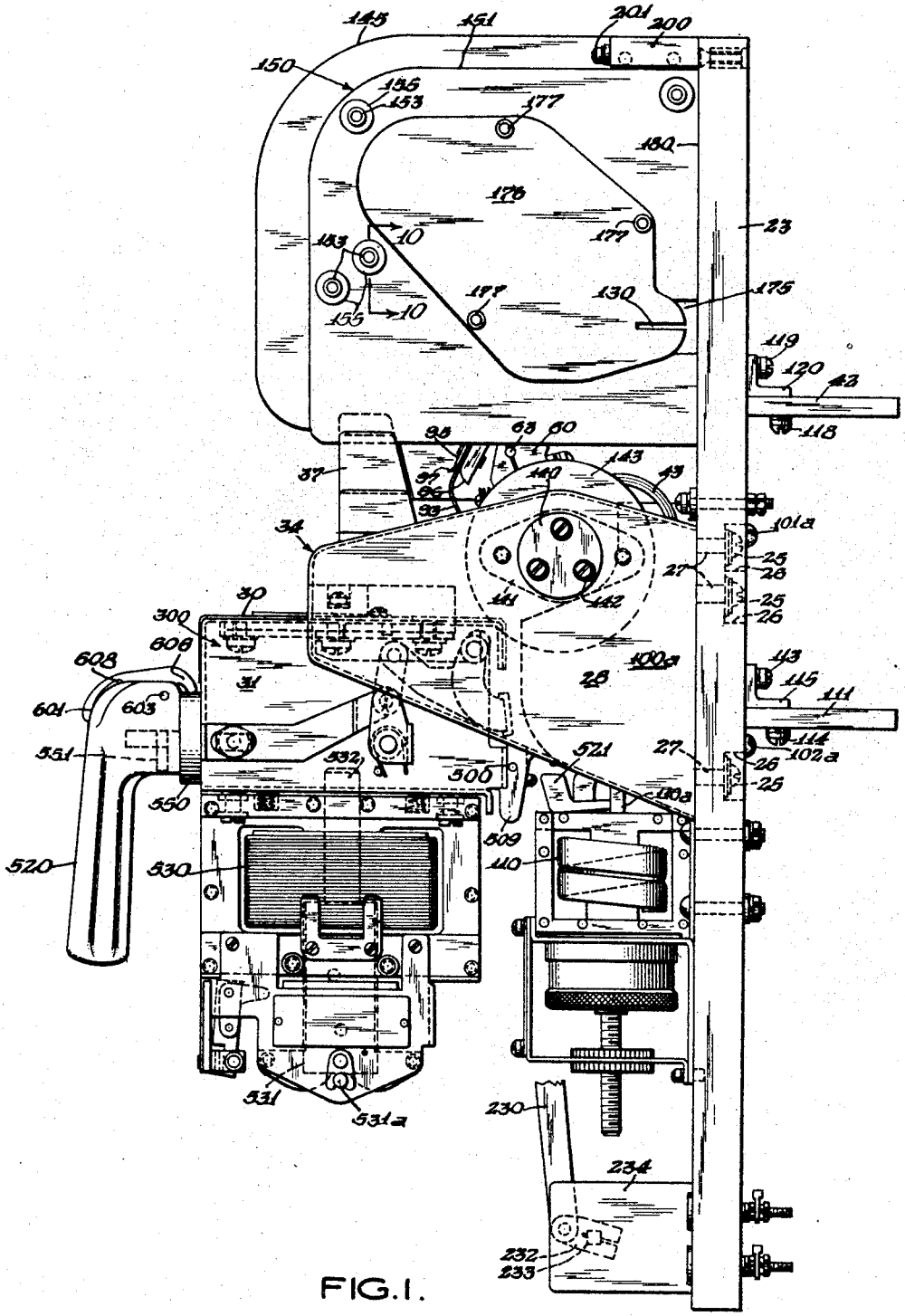


FIG. 1.

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ARC SPLITTING PLATE

Filed March 20, 1941 4 Sheets-Sheet 2

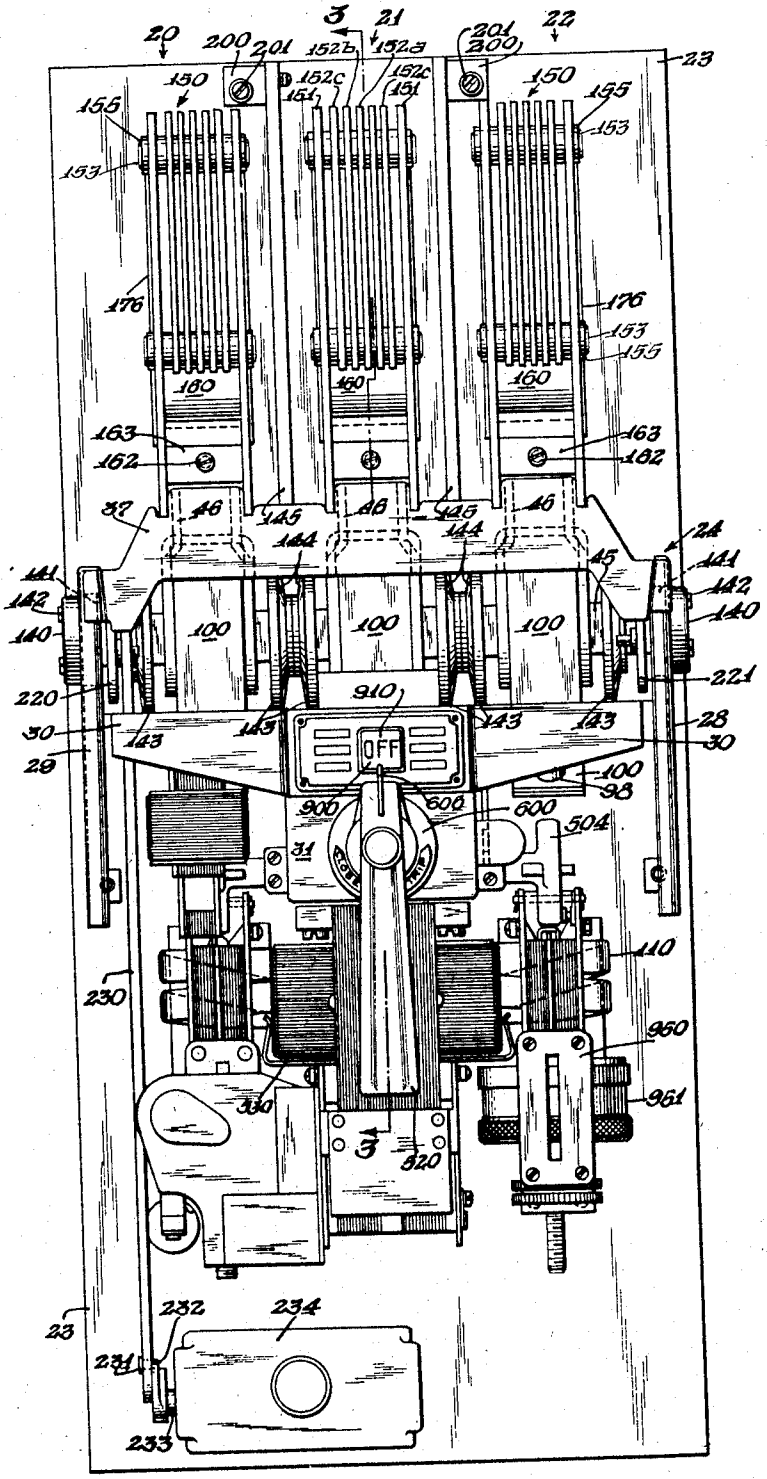


FIG. 2.

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ARC SPLITTING PLATE

Filed March 20, 1941 4 Sheets-Sheet 3

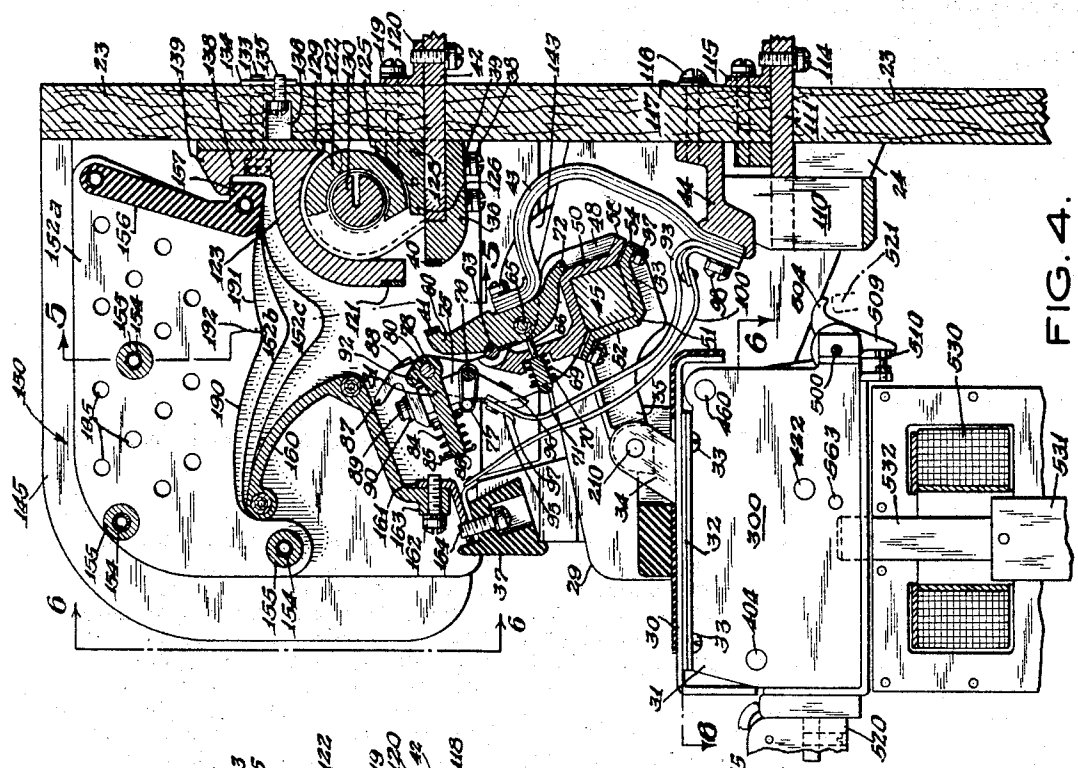


FIG. 4.

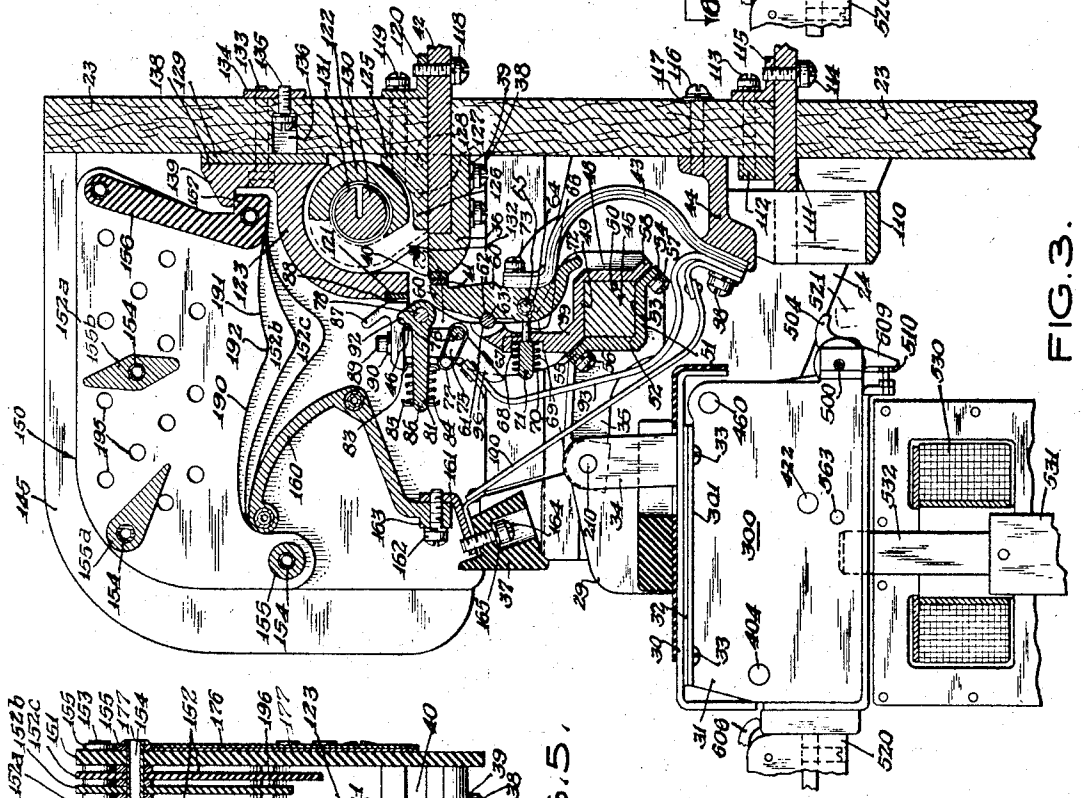


FIG. 3.

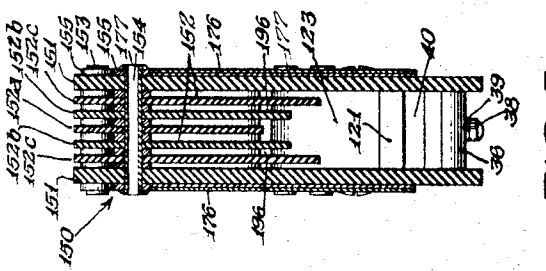


FIG. 5.

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ARC SPLITTING PLATE

Filed March 20, 1941 4 Sheets-Sheet 4

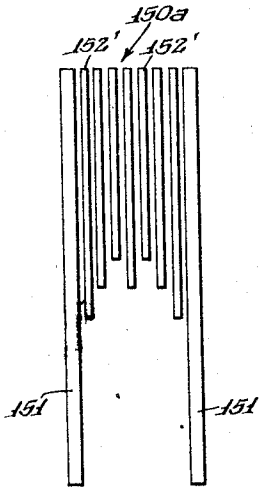


FIG. 7.

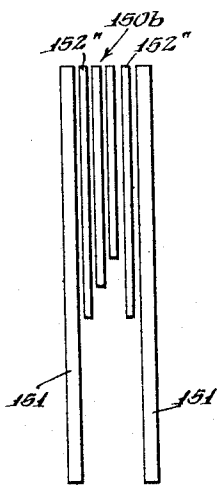


FIG. 8.

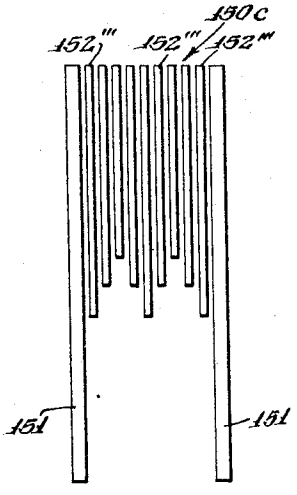


FIG. 9.

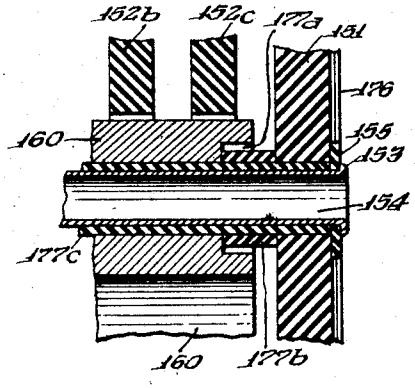


FIG. 10.

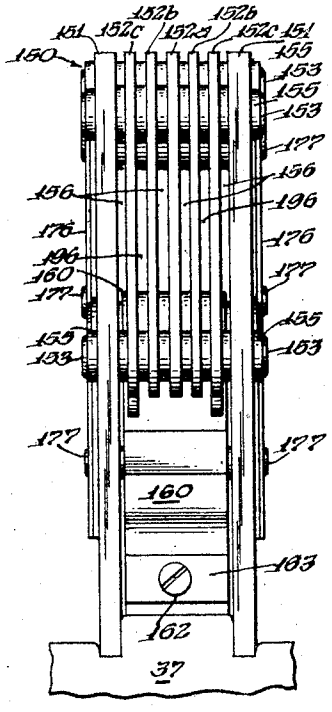


FIG. 6.

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Patented Jan. 11, 1944 2,338,715

UNITED STATES PATENT OFFICE

2,338,715

ARC SPLITTING PLATE

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Application March 20, 1941, Serial No. 384,245

12 Claims. (Cl. 200—147)

This invention relates to circuit interrupting apparatus and arc quenching means therefor, and more particularly to an arc quencher having a series of parallel plates so arranged that the arc may be forced longitudinally between them for extinguishment.

The type of apparatus involved includes power switching equipment that may be required automatically to interrupt fault currents of great magnitude. These arcing currents, unless extinguished quickly, will seriously damage metallic parts with which they come in contact.

Further, the type of power-switching apparatus to which this invention may be applied is frequently enclosed in compact metallic cubicles as a protection for the operator and the surrounding apparatus.

It is important, in connection with apparatus of this type, that the arc, which may be drawn between the contacts when they are open, be rapidly extinguished. Accordingly, my invention provides for an arc quenching device, consisting preferably of plates of insulating material emitting little or no gas or vapor when in contact with an arc, between which the ionized gases forming the arc are squeezed and brought into intimate contact with cooling surfaces which thus serve to de-ionize the gases to extinguish the arc.

An important object of the present invention, therefore, is the arrangement of an arc quencher having a series of parallel plates in such a manner that the arc may be forced longitudinally between them for the de-ionization of the gases and the extinguishment of the arc.

There are other objects and uses of the present invention and of the combinations and elements herein set forth. Many of these will in part be apparent and, where this is not the case, they will be pointed out in the following description and drawings, in which:

Figure 1 is a side elevation of the circuit breaker of my invention.

Figure 2 is a front view of the circuit breaker arrangement of Figure 1.

Figure 3 is a cross-sectional view on line 3—3 of Figure 2 showing the circuit breaker in closed circuit position, and showing slightly modified spacing washers.

Figure 4 is a view corresponding to that of Figure 3 showing the circuit breaker in open circuit position.

Figure 5 is a cross-sectional view on line 5—5 of Figure 4 showing the arrangement of the arc quencher.

Figure 6 is an end view taken along line 6—6 of Figure 4 showing a slight modification of the structure of the arc quencher.

Figures 7, 8 and 9 are cross-sectional views, each corresponding to the cross-sectional view of Figure 5 but showing variations in the number of parallel spaced plates in the arc quencher and in the arrangement thereof.

Figure 10 is a cross-sectional view of the arc quencher showing the slightly modified form of Figure 6 and taken along line 10—10 of Figure 1.

Referring now to the figures, I have here shown a three-pole circuit interrupter having a plurality of arc chutes 150, each comprising side plates 151 which support a plurality of shorter spaced parallel plates 152; the lower edges of each of which are curved to form the downwardly depending cusps 192.

Since the function of the arc chute is the rapid extinguishment of an arc drawn between the contacts of a circuit interrupter, the structure and operation thereof can best be understood from a preliminary description of the relevant portions of a type of interrupter in connection with which the same may be used.

In Figures 1 to 4, I have shown a circuit interrupter having the pole units 20, 21 and 22 mounted on the face of an insulating panel 23.

The bracket which supports the operating members is secured to the panel 23 by means of screws 25 and comprises two flanged side plates 28 and 29 which extend on each side of a horizontal shelf 30 to which they are welded. The operating mechanism 31, comprising the toggles and other elements, is bolted to the lower side of the shelf 30. Link 34 connects the operating mechanism 31 to the lever 35 which is secured to the shaft 45 and is rotatable therewith.

The stationary contacts 36 and their back connection stud assembly are mounted on the panel above the bracket 24 and support the inner ends of the arc chutes in the manner hereinafter described. A bridge 37 of insulating material secured to the outer end of the bracket 24 supports the outer end of the arc chutes.

The stationary main contacts 36 are bolted to the connecting stud 42 which passes through the panel 23. The path of the main current when the contacts are closed (Figure 3) is through the connection stud 42, the stationary contact 36, the stationary contact tip 40, the movable contact tip 41 mounted on the contact lever 60 which carries the flexible connection 43, the opposite end of which is connected to the member 44.

The movable contact lever 60 is pivotal about

the pin 63 on the contact carrying arm 48 which is secured by the clamp 51 to the rotatable shaft 45. The lever 60 is resiliently secured to the arm 48 by the link 66 extending through the perforation 67 of the arm, and by the spring 69 mounted on the link and compressed between the recess 68 of the arm and the cup 70 on the end of the link.

When the main contacts are disengaged (Figure 4) the lower end 72 of the main contact lever 60 presses against the contact arm 48 in the manner shown. As the contacts are engaged, then end 72 of the lever is forced away from the arm 48 (Figure 3) and contact pressure is obtained by compression of spring 69.

The arcing contact members 87 are mounted in the upper part of the contact arm 48 and are supported by arcing contact levers 75 which pivot on pin 76. A second pin 78 is mounted in the top of the contact arm 48 between two upwardly extending flanges 79 thereof. Link 81 is connected to pin 78 and extends beyond the back of the arcing contact levers 75. Spring 84 is compressed between spring cup 85 on the free end of the link 81 and sliding spring cup 83 which is pressed against the back of the lever.

The lower end of the arcing contact lever 75 is off-set to receive the end of a flexible conductor 93 which is connected to the terminal block 44.

The flexible lead 100 from the arcing horn 160 herinafter described is also connected to the terminal block 44. It will thus be seen that the three flexible conductors 100, 93 and 43 are all led from the contact structure to the lower terminal 44 to which all three are or may be secured by the same screws and lock washers.

The lower terminal or "pigtail" posts may have connected thereto a terminal of coil 110 which may energize an over-current magnet, the opposite end of the coil being connected at 112 to the back connection stud 111.

Since the leads 43, 93 and 100 are each thus connected to the pigtail post 44, the over-current coil 110 will thus be in series with the main contacts; and, after these are opened, with the arcing contacts; and finally with the arcing horns.

When the circuit breaker is fully closed, the resistance of the circuit through the main contacts 36 and 60 is low as compared with the resistance through the arcing circuit so that a relatively small current flows through the latter.

The movable arcing contact 88 (when the arcing contacts are engaged and the main contacts are not engaged) engages the stationary arcing contact 121. Current is led to the stationary arcing contact 121 through the blow-out coil in the following manner:

Current from the upper connection stud 42 flows into the lower terminal block 125 of the blow out magnet coil 122 around the coil to its upper terminal 129 and thence to the stationary arcing horn 123 which is secured thereto. From the stationary arcing horn, the current flows to the stationary arcing contact 121, thence to the movable arcing contact 88, thence through the arcing contact lever 75, flexible lead 93, the terminal block 44, the coil 110, and the connection stud 111 in the manner hereinbefore described.

The coil 122 is wound so that current flowing from the lower coil terminal to the upper coil terminal flows around the slotted cylindrical iron core 130 in a clockwise direction in the views of Figures 3 and 4. A fiber tube 131 insulates the core 130 from the coil 122.

The upper part 138 of the arcing horn 123 is extended along the panel and forms a hook 139 for anchoring the arc chute in the manner hereinafter described.

The arcing horn 123 curves around the blow-out coil as seen in Figures 3 and 4, and forms a path for one of the arc terminals. The arcing horn is preferably wider than the coil 122 and as seen in Figures 3 and 4, its under surface rests against the edges of insulating side plates 132 which extend on either side of the coil 122.

In the actual operation of the contact assemblies, when the contacts are fully closed and the breaker is then tripped, the contact shaft 45 and the contact arm 48 rotate in a counterclockwise direction in the views of Figures 3 and 4. As the arm and the contact pivot pins 76 and 63 move away from the stationary contacts, the springs 69 and 85 maintain the moving contacts in engagement with the stationary contacts until in the rotation of the contact levers, these levers 75 and 60 strike their respective stops.

During this movement, the lower end 72 of the contact lever 60 strikes the part of the contact arm 48 which surrounds the shaft 45. At this point in the movement, the main contacts separate while the arcing contacts are still engaged. It is thus seen that the circuit through the main contacts is interrupted and all the current is transferred to the circuit of the blow-out coil 122 and the arcing contacts. The core 130 therefore and its associated pole pieces are magnetized in proportion to the current flowing.

When the arcing contacts are fully opened, the end of the arc is transferred from the movable arcing contact to the arcing horn and the arc is drawn between the horn 160 and the terminal 123.

The arc chute

The arc chute 150 comprises side plates 151 and five shorter parallel spaced arc splitting plates 152. Both the side plates and the arc splitters are of arc resistant insulating material. The entire group is held together preferably by rivets 153, 153, 177, 177 making a rigid assembly. Preferably, the rivets comprise, as seen in Figure 5, a central metal tube-like part 154 and carry insulating spacing washers 155 which space the arc splitting plates.

The portions of the inside plates 152 near the panel 23 (Figures 4 and 5) are separated by members 156 of insulating material which prevent the arc gases from coming in contact with the panel and which also comprise hooks 157 engaging under the hook or lip 139 of the stationary arcing horn 123 in order to assist in supporting the arc quencher assembly. Near the front of the arc chute is secured a metal arcing horn 160 which is connected to metal angle clip 161, by the screw 162 passing through the flange 163 of the arcing horn.

As seen in Figures 6 and 10 the mounting hole 177*a* of arcing horn 160 may be counterbored over size and additional insulating bushings 177*b* may be used for spacing the arc horn from the side walls of the arc quencher. This serves to increase the leakage distance between the arcing horns.

As is seen in the slightly modified form of Fig. 3, instead of using spacing washers 155 to space the plates of the arc quencher of Fig. 3, from each other, a series of strips 155*a* or 155*b* of insulating material extending out radially from the rivets may be used. These strips may be

streamlined as shown to afford minimum resistance to the flow of arc gases, and serve as cross-barriers to restrict the movements of spaced parts of any arc that may have been moved this distance from the arcing horns.

The metallic clip 161 is secured by the screw 164 and lock washer 165 to the bridge 37 of molded insulating material. This metallic clip 161 is electrically connected to the flexible conductor 100 which in turn connects it to the lower pigtail terminal 44. At the end of the opening movement of the arcing contact the tip 87 of the movable arcing contact 87 moves under the stationary arcing horn 160 in the manner shown in Figure 4 so that the arc terminal is transferred to the stationary arcing horn 160 and the current flows through the conductor 100 to the lower terminal block 44.

The blow-out core 130 extends beyond the sides of the blow-out coil 122 a distance equal to the thickness of the side plates 151.

The side plates are notched at 175 (Figure 1) so that they may embrace the core 130 while their edges rest against the panel 23. The inner surfaces of the magnetic poles 176 bear against the ends of the core. By this arrangement, any possible impediment to the flow of magnetic fluxes from the core into the pole pieces hereinafter described is obviated.

Ferrous blow-out plates or pole pieces 176 (Figs. 1, 2 and 5) are secured to the outer surfaces of the side plates 151 of the arc chute by means of rivets or other suitable attaching means 177. These blow-out plates or pole pieces (see Fig. 1) cover a part of the notch 175 in the plates 151 so that when the arc chutes are in position against the panel 23 and in proper relation to the contact assembly, the surface of each end of the core 130 is in contact with a corresponding iron blow-out plate or pole piece 176. The rivets for securing the iron plates to the arc chute are relatively remote from the blow-out core so that a slight spring of the plates may be used to assure intimate contact. The edges of the iron are flared slightly to provide for easy engagement.

The notch 175 which engages the blow-out coil core 130 (Fig. 1) and the lip 139 on the stationary arcing contact 123 which engages the hook 157 of the fiber spacer 156 of the arc chute 150 (Fig. 3) cooperate to position the back end of the arc chute in proper relation to the panel 23 and to the various other portions of the contact assembly.

The front end of the arc quencher is supported and locked in place by means of the screw 162 which passes through the angle clip 161 and the end 163 of the arcing horn 160. The angle clip 161 is secured to the insulating bridge 37 by screw 164.

Rotation of the screw 162 will permit the withdrawal of the entire arc chute from the contact assembly without requiring the disassembly of any other portion of the circuit breaker. The movement of withdrawal is entirely horizontal, no vertical motion being required.

The arc splitting plates 152 (five in number in the preferred embodiment) have, as seen in Figs. 3 and 4, their lower edges shaped in two concave arcs 190 and 191, with the rounded cusp 192 between them. This cusp lies between the stationary arcing horn 123 and the front arcing horn 160. The downwardly extending cusps facilitate the entrance of the arc into the slots between the plates and are so arranged that a relatively small longitudinal length of the arc is first forced between the plates and so that as the arc is blown upwardly, progressively greater lengths of the arc are forced between the plates.

As is also seen in Figs. 3, 4 and 5, the lower edges of the plates 152 are of different heights, the middle one 152*a* being the highest and the outer plates 152*c* being the lowest, that is, extending downwardly a greater distance. The intermediate plates 152*b* are of a height so that the lower edges extend in planes substantially between the position of the edges of the middle and outer members.

As is also seen in Figs. 3 and 4, the five plates here shown have perforations 195 of suitable size and shape, spaced and arranged to permit the flow of arc gases from the slot 196 (Fig. 5) between one pair of plates to the slot between another. In order to provide a more turbulent condition of the arc gases and in order to ensure contact of the arc gases with the various plates, the holes or perforations 195 of each of the plates may be in staggered relation with respect to those in adjacent plates.

Upon opening of the main contacts and formation of the arc between the arcing contacts 74 and 123, the arc is immediately transferred from the arcing tip 87 to the arcing horn 160.

The current flowing through the coil 133 energizes the magnet comprising core 130 and ferrous plates 176 producing a flux across the arc space. This flux forces the arc upwards towards and into the arc chute 150. When the arc reaches the lower edges of the arc splitters or plates 152, it is squeezed or flattened to be forced between the two outer plates 152*c* and 152*c*. Further movement forces the arc between the intermediate plates 152*b*—152*b* further reducing its horizontal width.

As the arc is pushed further, it may enter one of the slots 196 or it may be divided longitudinally in two or more slots. In either case, the arc gases have an opportunity to expand through the holes 195 in the plates 152. This provision for permitting the arc gases to expand from slot to slot reduces the back pressure and hence permits the blow-out magnet to force the arc upward at full speed.

The tendency of the ionized gases discharged from one slot to enter another through the perforations 195 permits parallel arcs to exist over sections of the arc. This causes greater instability and increased tendency to speed the extinguishing of the arc.

By this means also a large cooling area is provided which further contributes to shorten the arcing time. The arc gases are sufficiently cooled and deionized by the arc quencher so that when, in the case of alternating current, the current passes through zero in the cycle immediately following the formation of the arc, the gases will be sufficiently deionized to provide an extremely difficult path for an arc and thus prevent the restriking thereof. The arc therefore may be quenched within 1/120 of a second of the formation thereof.

The construction and operation of the arc quencher is not limited to the particular form of arc quencher shown in Figures 1 to 5 inclusive, or to the particular number of plates therein shown, but as is seen in Figures 7, 8 and 9, any number of plates may be used. Thus the arc quencher 150*a* of Figure 7 has seven spaced plates 152', each of which vary in height in the manner therein shown. This provides for a progressive

squeezing of the arc and a probable separation thereof into at least two parallel arcs. Or, as is seen in Figure 8, the arc quencher 150b therein shown may have as little as four or fewer spaced parallel plates 152'' which will operate in the manner hereinabove described. Or as is seen in Figure 9, the arc quencher 150c therein shown may have nine spaced parallel plates 152''', consisting of two sets each of which is arranged and function in the same manner as the single set of plates as shown in Figure 5.

This arrangement ensures the breaking up of the arc into at least a pair of parallel arcs and probably into a greater number of unstable parallel arcs.

Sufficient interphase barriers are provided by the side plates 151 of the arc chute. However, additional interphase barrier plates 145 (Figures 1 to 4 inclusive) may be placed between the arc chutes and carried up so that they are aligned with the top of the panel 23.

As will also be seen in Figure 1, the inter-phase barrier 145 extends beyond the arc chute both at the top and the front. The front lower corner rests on the insulation bridge 37 while the back end bears against the panel and extends down between the shaft insulation disks 143—143.

Lower interphase barriers 100a (Figure 1) may be aligned with the upper interphase barriers and secured to the panel 23 by screws 101a and 102a thus preventing any tendency of the flexible leads to approach each other or any current at that point from arcing over.

The arrangement of all of the parts of the circuit breaker is such that the assembly thereof is extremely simple:

The entire arc quencher 150 including the arcing horn 160 may be removed from the circuit breaker assembly by a single movement after the rotation of a single screw 162.

The removal of screw 201 permits the interphase barrier to be withdrawn. These operations expose the whole contact structure for inspection.

Assembly replacement and repair are thus greatly facilitated. Separation of the various parts for any purpose whatever is made easy and simple and the general arrangement of the members on the panel 23 facilitates the mounting of this panel in a switch board with other similar circuit breakers or other switch devices.

In the foregoing, I have described only those parts of the circuit breaker necessary to fully understand the operation of the arc quencher and the arc-splitting plates. The various constructions herein described may be modified in many ways which will now be obvious to those skilled in the art.

I claim:

1. In an electrical switching apparatus, a fixed and cooperating movable contact; a stationary arcing horn; a front arcing horn; a plurality of arc extinguishing plates mounted between said arcing horns, the lower edges of said plates forming two concave arcs with a rounded cusp between the ends, said cusp lying between said arcing horns.

2. In an electrical switching apparatus, a fixed and cooperating movable contact; a stationary arcing horn; a front arcing horn; a plurality of arc extinguishing plates mounted between said arcing horns, the lower edges of said plates forming edges curved upwardly from the center toward the arcing horns to form a central cusp therebetween.

3. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plate of insulating material supported between said sheets parallel thereto, the boundary of said plate toward said arcing horns having a form approximating that of said arcing horns.

4. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plate of insulating material supported between said sheets parallel thereto, the boundary of said plate toward said arcing horns having a form approximating that of said arcing horns, the distance between said boundary and said horns being greater near said contacts and at any point remote from said contacts.

5. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plurality of spaced plates of insulating material supported between said sheets parallel thereto, the boundary of each of said plates toward said arcing horns having a form approximating that of said arcing horns.

6. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plurality of spaced plates of insulating material supported between said sheets parallel thereto, the boundary of each of said plates toward said arcing horns having a form approximating that of said arcing horns, the boundaries of said plates toward said arcing horns being at different distances therefrom.

7. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn asso-

ciated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, an odd number of spaced plates of insulating material supported between said sheets parallel thereto, the boundary of each of said plates toward said arcing horns having a form approximating that of said arcing horns, the plates adjacent said enclosing sheets having their boundaries at a lesser distance from said arcing horns than said middle plate.

8. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plurality of spaced plates of insulating material supported between said sheets parallel thereto, the boundary of each of said plates toward said arcing horns having a form approximating that of said arcing horns, said plates extending in planes parallel to the axis of the arc, the free edges of said plates being stepped with relation to each other, the edges of the outermost plates being closest to the arc path, the edges of the remaining plates being progressively raised from the arc path, and the edge of the central plate being furthest removed from the arc path.

9. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial position, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plurality of groups of spaced plates of insulating material supported between said sheets parallel thereto, the boundary of each of said plates toward said arcing horns having a form approximating that of said arcing horns.

10. In a circuit interrupter, a stationary contact and a movable contact, magnetic means for moving an arc drawn between said contacts away from its initial positon, an arcing horn associated with said stationary contact and in electrical communication therewith, a stationary arcing horn associated with said movable contact and in electrical communication therewith, means for transferring an arc terminal from said moving contact to said associated arcing horn, an arc chute comprising two sheets of insulating material enclosing said contacts and said arcing horns, a plurality of spaced plates of insulating material supported between said sheets parallel thereto, the boundary of each of said plates toward said arcing horns having a form approximating that of said arcing horns, said stationary arcing horn being in electrical communication with said movable contact and rigidly supported between said enclosing sheets in spaced relation thereto.

11. In electrical switching apparatus, a pair of contacts, a plurality of spaced plates of insulating material in parallel planes, said plates being at least three in number, the lower edges of each of said plates being in stepped relation at progressively greater distances from the contacts; means for drawing an arc between the contacts, means for moving said arc in a plane parallel to those of the plates and causing said arc to enter the space between adjacent plates.

12. In electrical switching apparatus, a pair of contacts, a plurality of spaced plates of insulating material in parallel planes, said plates being at least three in number, the lower edges of each of said plates being in stepped relation at progressively greater distances from the contacts; and an additional plate adjacent the plate most remote from the contacts and having its lower edge less remote therefrom, means for drawing an arc between the contacts, means for moving said arc in a plane parallel to those of the plates and causing said arc to enter the space between adjacent plates.

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