Feb. 23, 1943. F. J. POKORNY 2,311,690

ARC QUENCHER

Filed June 10, 1940 3 Sheets-Sheet 1

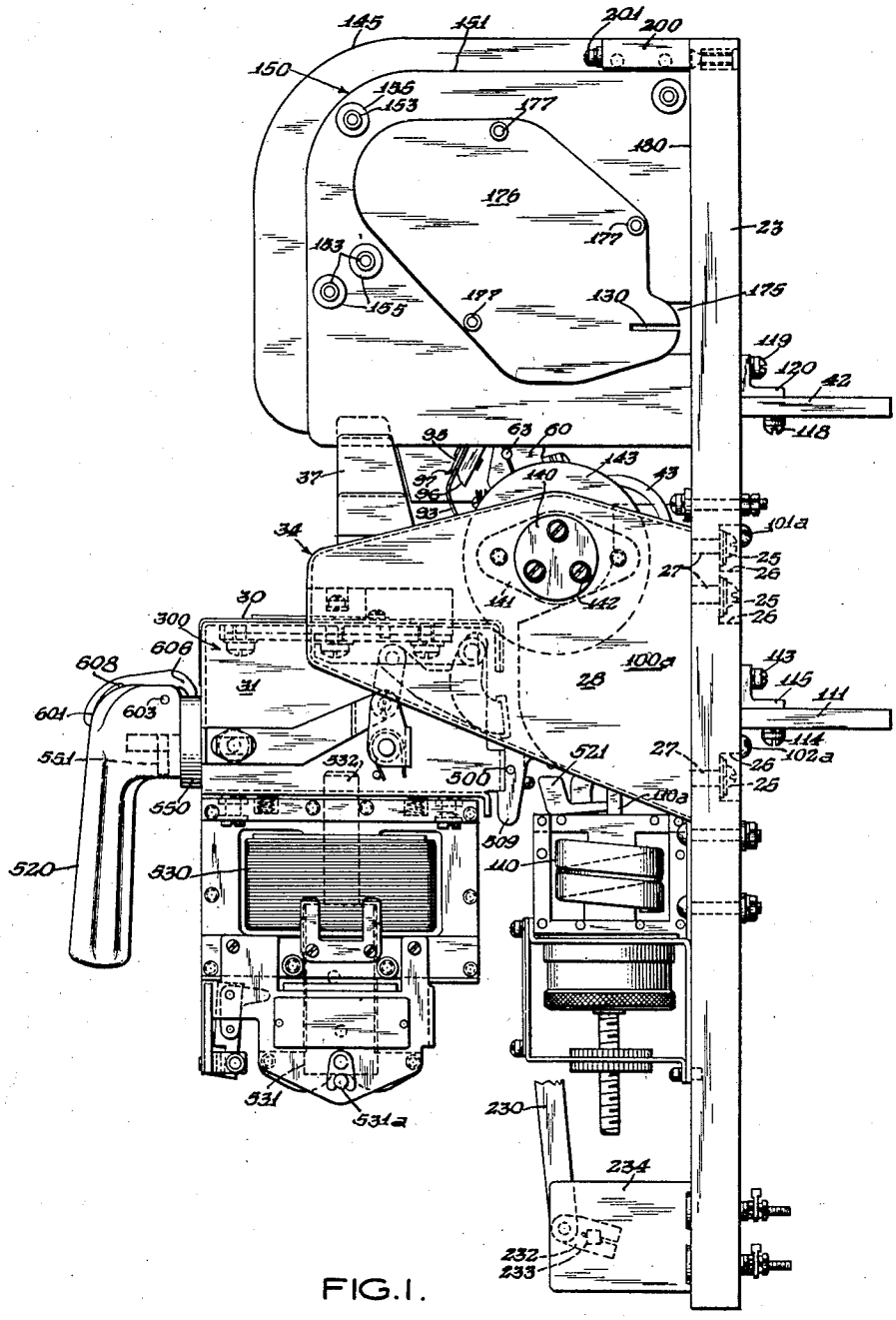


FIG. 1.

INVENTOR.
Frank J. Pokorny.

BY

ATTORNEY

Feb. 23, 1943. F. J. POKORNY 2,311,690

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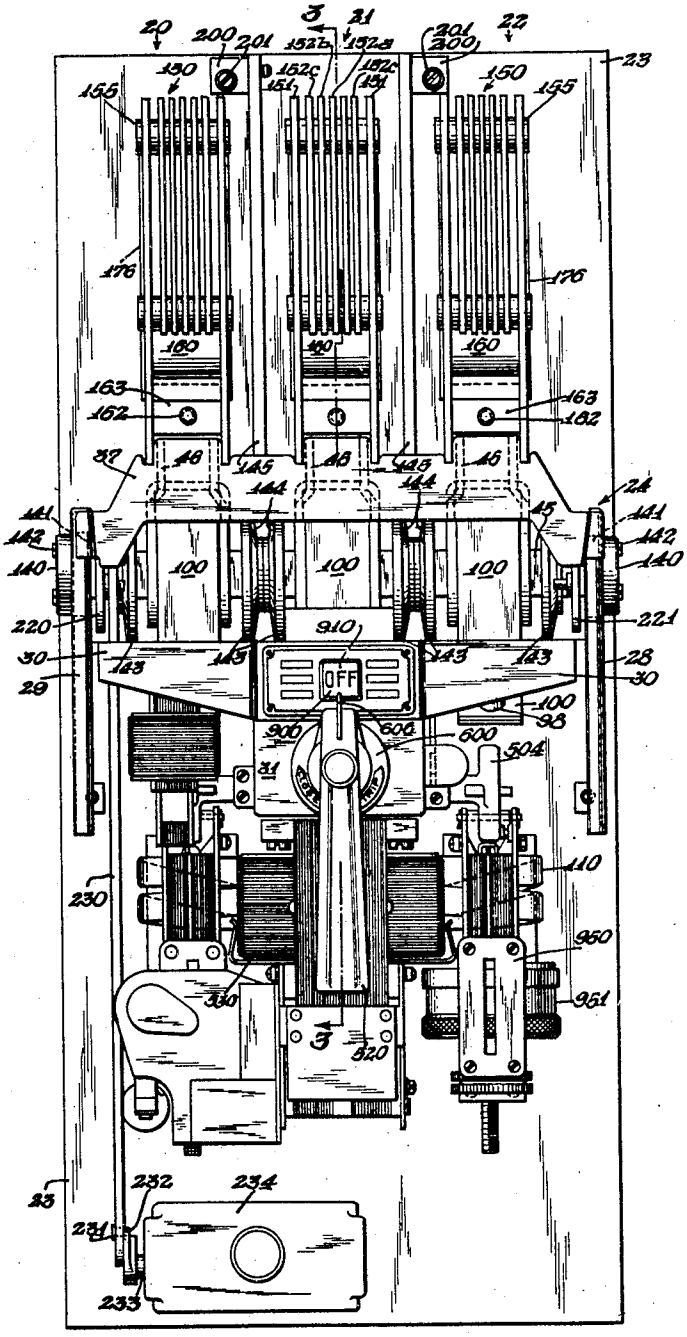


FIG. 2.

INVENTOR.
Frank J. Pokorny.
BY Samuel Arkolench
ATTORNEY

Feb. 23, 1943. F. J. POKORNY 2,311,690

ARC QUENCHER

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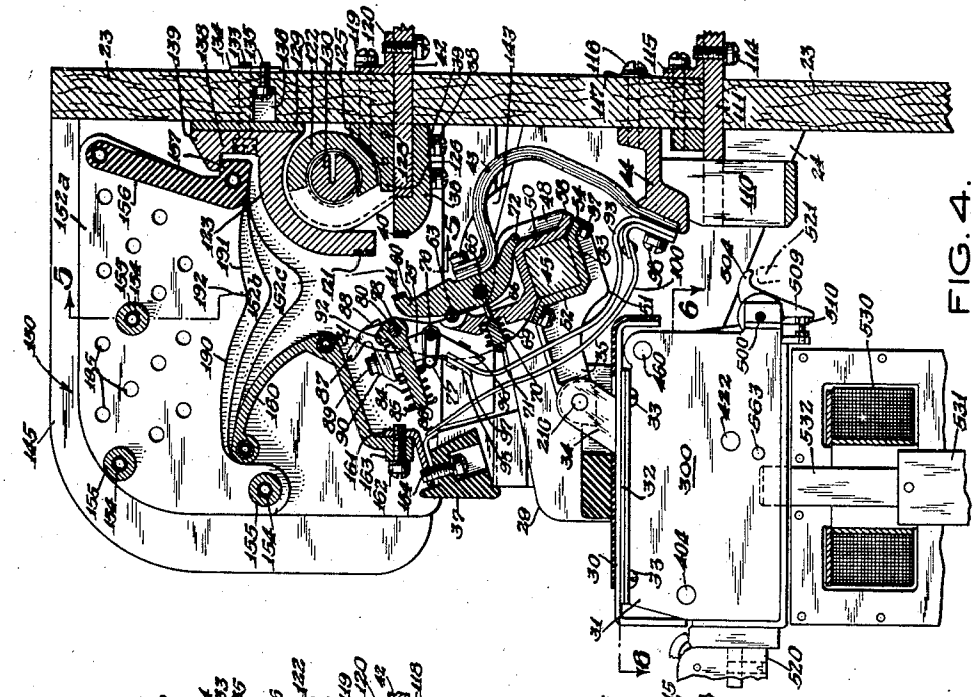


FIG. 4.

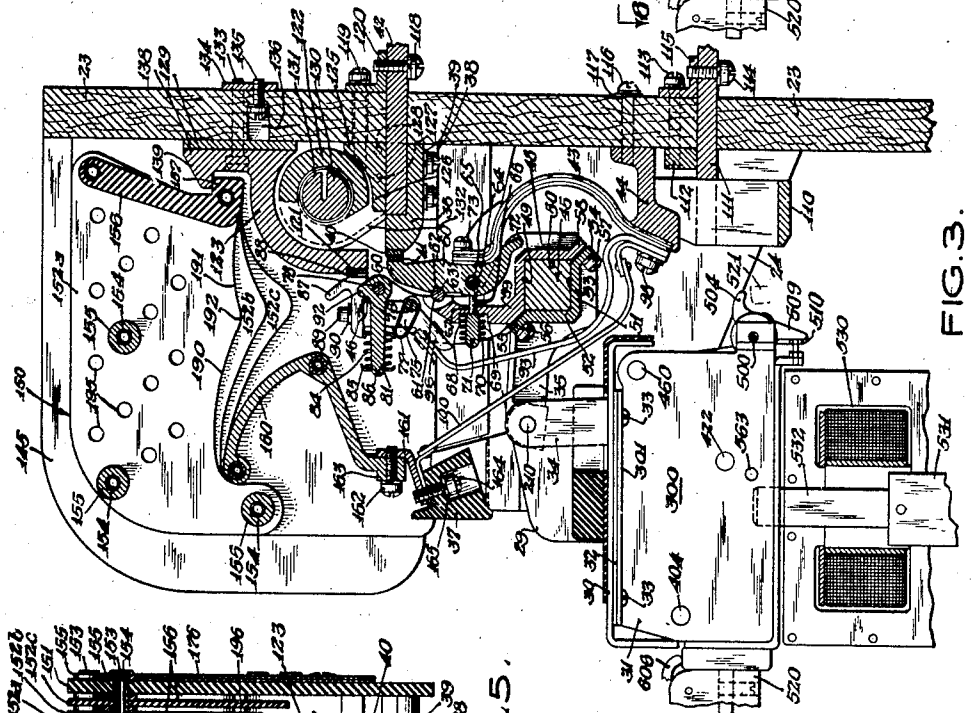


FIG. 3.

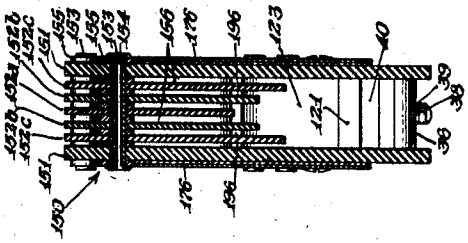


FIG. 5.

INVENTOR.
Frank J. Pokorny.
BY Samuel Ostrolenk
ATTORNEY

Patented Feb. 23, 1943

2,311,690

UNITED STATES PATENT OFFICE

2,311,690

ARC QUENCHER

Frank J. Pokorny, Philadelphia, Pa., assignor to I. T. E. Circuit Breaker Company, Philadelphia, Pa., a corporation of Pennsylvania

Application June 10, 1940, Serial No. 339,683

18 Claims. (Cl. 200—147)

This invention relates to circuit interrupting apparatus and arc quenching means, therefore and more particularly to an arc quencher that is readily mountable and demountable as a unit.

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 into contact. Such parts should be periodically inspected and replaced when necessary. As these parts are enclosed within the arc quencher provision must be made for the easy removal of the extinguishing device and also for securely clamping it in operative position.

Further the type of power switching apparatus to which this invention may be applied, is frequently enclosed in compact metal cubicles as a protection for the operator and surrounding apparatus. In such an installation, vertical space within the compartment is limited so that it is advantageous to be able to withdraw the arc quencher forward horizontally without any vertical movement being required.

Is is, therefore, an object of this invention to provide an arc quencher that is readily mountable and demountable to and from operative relation with the separable contacts of a circuit interrupter.

It is a further object of this invention to provide an arc quencher that is demountable by a simple horizontal forward movement without any vertical movement being required.

It is another object of this invention to provide an arc quencher that is a rugged unitary structure and that may be securely held in operative position by a single clamping means.

It is an additional object of the present invention to provide an effective compact arc chute that is composed of inexpensive parts and is easily manufactured.

There are many other objects and uses of the present invention and of the combinations and elements herein set forth. Many of them have already been pointed out. Many others will in part be apparent and where not intrinsically apparent will be pointed out in the following description and drawings, in which:

Figure 1 is a side elevation of the circuit breaker of our 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.

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.

Referring now to Figures 1, 2, 3 and 4, I have here shown a three pole circuit breaker comprising the elements of the present invention. The circuit breaker consists of a group of pole units **20**, **21**, **22** (Figure 2) mounted on the face of an ebony, asbestos or slate panel **23** which forms the mounting plate of the entire circuit breaker arrangement.

Main supporting members

The main bracket or housing **24** which supports the operating members is secured to the panel **23** by means of screws **25**, **25** the heads of which are recessed in openings **26**, **26** in the back of the panel **23** and which pass through the perforations **27**, **27** in said panel to engage the main bracket **24** (Figure 1).

As seen in Figures 1 and 2, the main bracket or housing preferably 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 hereinafter described is bolted to the lower side of the shelf **30**, the housing **300** of the said operating mechanism comprising flanges **32**, Figures 3 and 4, through which bolts **33** may be passed to engage the shelf **30**.

Link **34** connects the operating mechanism **31** to the lever **35** which is secured to the contact shaft **45** and is rotatable therewith. As seen more particularly in Figures 3 and 4, the stationary contacts **36** and their back connection stud assembly are mounted on the panel above the housing or supporting bracket **24** and support the inner end of the arc chutes in the manner hereinafter described.

A bridge **37** of insulating material secured to the outer end of the main bracket **24** supports the outer end of the arc chutes in the manner hereinafter described.

Main and arcing contacts—The stationary main contacts

The stationary main contacts **36** are bolted to the connecting stud **42** by means of the bolts **38** and the washers **39**. The connecting stud **42** passes through the back panel **23** and is suit-

ably arranged so that appropriate circuit connections may be made thereto. The path of the main current when the contacts are closed, as seen in Figure 3, is through the connection stud 42, the stationary contact 36, the stationary contact tip 40, the movable contact tip 41, the contact lever 60 carrying the flexible connection 43 which in turn is electrically connected to the member 44.

Movable contacts support

The movable contact shaft 45 is preferably a square steel bar covered with phenolic insulation molded in place and is rotatably supported in appropriate bearings as hereinafter described.

A contact arm for each pole is mounted on this shaft. The contact arm 46 is preferably a bronze casting reinforced by flanges 47 and 48. The lower end of the bronze casting which engages the square steel shaft is preferably formed in a V comprising the members 49 and 50 set at approximately right angles to each other so that they will engage the square sides of the shaft 45 to which they are to be clamped.

The clamping member 51 comprises also a V-shaped member having the sides 52 and 53 which likewise may engage the sides of the square steel shaft and comprising also flanges 54 and 55 through which bolts 56 and 57 may be threaded to engage the flange 58 and the flat portion 59 of the contact arm 46 in order to securely clamp the same to the contact shaft 45.

As will be noted, especially in connection with Figures 2 and 3, each of the main contact arms 46 may be secured to the contact shaft 45 so that rotation of the contact shaft 45 by the lever 35 will result in corresponding movement of the contact arms 46 for the purpose of opening or closing the circuit.

While any necessary number of contact carrying arms may be mounted upon the contact shaft as the specific circuit connections may require only one lever 35 is necessary for the opening and closing operations which result in rotation of the shaft 45 and the operation of the various contacts.

In order to obtain a balanced structure it is preferred that the lever 35 be secured to the shaft 45 substantially at the center so that the mechanism may be properly balanced.

Movable main contacts

Each contact arm 46 carries a pair of contact levers 60 formed and cut from a special copper extruded bar. Each of these two levers 60 carries at its upper end a silver nickel contact block 41 for engaging the stationary main contact tip 40. The back of the contact arm 46 has a part-cylindrical depression 61 and the front of each of the contact levers has a similar depression 62. A bronze pivot pin 63 is placed in these depressions. This pivot pin has flanges at each side and also a flange in the center between the two contact levers 60 in order to prevent any lateral movement of the members with respect to each other.

Each of the contact levers 60 is drilled at 64 so that a pin 65 may be inserted therein. The pin 65 is preferably of dumbbell shape and acts as an equalizing yoke between the two contacts 60—60. A link 66 engages the pin 65 between the two contact levers 60—60 and is extended up through a perforation 67 in the contact arm 46 into the recessed area 68 of said contact arm. A compression spring 69 forms the main contact spring and is retained in position between the base of the recess 68 and the spring cup 70 which is held in place on the spring link 66 by the cotter pin 71.

The spring link 66 in extending between the two main contact levers 60 has an eye 66' which engages a groove 65' in the pin 65 in order to prevent its moving to either side.

When the main contacts are disengaged in the manner shown in Figure 4, the lower ends 72 of the main contact levers 60 press against the contact arm 46 in the manner shown.

For simplified assembly the only element which retains the pin 63 in place is the pressure of the spring 69 upon the main contact lever.

In the closed position the pressure through the contact lever 60 between the spring 69 (bearing on the pin 65) and the contact 41 serves to maintain the adequate pressure necessary to hold the pin 63 in place. In the open position, the pressure of the bottom end 72 of the main contact lever 60 against the contact arm 46 and the pull of the compression spring upon the pin 65 of the lever 60 using the member 72 as a fulcrum serves to maintain the pin 63 in place.

This design of pivot provides long wearing surfaces. The spring link and pressure equalizing pin may be made of hard steel so that their area of engagement may be small. The area of engagement at the pin of the contact levers may be of relatively soft material.

The pivot pin engaged by the half cylindrical surfaces of the contact arm and the contact levers provides a maximum of area for the softer parts. This area could not be obtained in the same width or pin length by any other method.

If the levers were formed to rock in a groove in the arm, there would be copper and brass bearing surfaces which are far inferior to the steel pin between them.

During the closing movement there is no instant when there is any relaxation of pressure upon the pin 63, for until the main moving contact tip 41 is brought into contact with the stationary contact tip 40, the bottom end 72 of the contact lever 60 engages the contact arm 46 in the manner shown in Figure 4.

Only after the moving contact tip 41 is in engagement with the stationary contact tip 40 is there a transfer of the fulcrum or the base of pressure from the portion 72 to the tip 41. In such case, as has been seen in connection with the closed position of Figure 3, there is again sufficient pressure to maintain the pin 63 in place.

During the opening movement, pressure is maintained upon the pin 63 by reason of the fact that spring 69 by its pressure on the pin 65 forces contacts 40 and 41 against each other until, in the rotation of the contact shaft 45, the end 72 of the contact lever presses against clamping portion 48 of the contact arm 46, whereupon the base of pressure is transferred from contact tip 41 to end portion 72. In this manner, the spring pressure is always exerted to maintain pin 63 in position.

The rotation of the main contact lever 60 about the pin 62 during the closing operation necessarily results in a slight sliding motion of the movable contact tip 41 with respect to the stationary contact tip 40 so that a wiping action occurs tending to clean the contacts.

As seen also in Figures 3 and 4, the back of the contact levers are drilled and tapped for the securing screws 73 in order to attach the flexible conductor 43 thereto.

The upper end of the flexible conductor **43** is slit so that separate screws **73** may attach the separate ends to the two separate contact members **60** to allow independent movement of the contacts. The arrangement of the lever arms above and below the contact pivot is such that during heavy current flow the magnetic forces set up will tend to increase the pressure between the moving and stationary contacts when the flow of current is between the stationary contact tip **40** and the movable contact tip **41**.

By the use of two contact levers of this type for each pole of the circuit breaker, an adequate contact at each pole is ensured.

Movable arcing contacts

The arcing contacts **87** are mounted in the upper part of the contact arm **46**, and are supported by arcing contact levers **75**. The arcing contact levers **75** preferably are each cut from a bar of extruded copper and in this case also we have found it preferable to use a pair of such contacts and levers for a single pole. Each of the arcing contact levers **75** is pivoted on the pin **76** which is grooved between the contacts to take a hair pin spring **77** which serves to keep the pin **76** in center position. A second pin **78** is mounted in the top of the contact arm **46** between two upwardly extending flanges **79** thereof.

An appropriate bushing may be placed between the flanges so that the pin may be securely riveted over them without bending them. The eye **80** of the spring link **81** is placed over the bushing, the said spring link **81** extending beyond the back of the arcing contact levers **75**.

Pins **82** having rounded heads are driven into the upper part of the back of the arcing contact lever **75**.

A spring cup **83** is pressed against these pins by the compression spring **84** which is held in place on the link **81** by the spring cup **85** at the opposite end which in turn is held in position by the cotter pin **86**. The arcing contact **87** is mounted upon the arcing contact lever **75** and is preferably formed or cut from an extruded copper bar and is provided with a contact face **88** preferably of Elkonite silver which is soldered to the copper. Each of the contacts **87** of each of the contact levers **75** is held in place upon its contact lever by a socket head cap screw **89** and lock washer **90**. As will be seen more particularly in Figure 18, the contacts **87** are held against turning or other displacements by the shoulder **91** which engages a corner of the arcing contact lever **75**. The ends of the contact arm flanges bear against the outer sides of the two arcing contacts and the projection **92** of the spring link separates the two arcing contacts **87—87** from each other, thus serving adequately to position them.

As is seen in Figures 3, 4, the lower end of the arcing contact lever **75** is off-set at **93'** to receive the end of a flexible conductor **93**. The conductor **93** like the conductor **43** is also slit, the ends thereof being riveted at the off-set **93'** to the arcing contact lever **75** by means of the rivet **94** passing through the washer plate **95**.

The off-set **93'** is curved away at **96** from the flexible conductor and the washer plate **95** is curved away at **97** therefrom for the purpose of preventing kinking during operation. This flexible conductor **93** is led down to the lower terminal block **44** to which it is connected by the same screws **98** that hold the main contact lead **43**.

The main contact levers, in contact open position, are held against their fulcrums and against a stop on the arm by a compression spring at the back of the arm, acting on a link connected to the two contact levers between the fulcrum and the stop. The contact surface is at the top of the lever above the fulcrum. The flexible conductor is secured to the bottom of the lever below the fulcrum.

When the shaft and arm are moved to contact closed position, the contact ends of the levers are rotated about their fulcrums and pushed back from their advanced position, moving the bottom stop clear of the arm. This compresses the spring and increases the contact pressure. The use of a single spring and link between the two levers permits the pin to act as an equalizing yoke.

The attachment of the flexible conductor below the fulcrum causes the magnetic forces to balance about the fulcrum so that the contact pressure may remain the same or increase during fault current.

The auxiliary or moving arcing contacts are mounted at the top of the arm. In this case the spring is above the fulcrum and below the detachable contact tips. Equalization of pressure is arranged in the same way. Maintained pressure during fault or inrush current is provided in the same manner.

Overcurrent coil connections

It should also be noted that the flexible lead **100** from the arcing horn hereinafter described .s 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 angle of the terminal and of the screw **98** is selected so that a repair man may reach these screws over the back edge of the bracket shelf **30**.

The lower terminal or "pigtail" posts may have connected thereto a coil **110** which may energize an over-current magnet.

This coil may have a cross-section of copper and the requisite number of turns corresponding to the current rating of the circuit breaker, one terminal of the coil being connected to the lower terminal post **44** and the opposite end of the coil being connected to the back connection stud **111** which has the securing block **112** welded to it at the face of the panel **23**.

The back connection stud **111** is held in place in the panel **23** by the screws **113** and **114** which pass through and engage the clip **115**. The terminal post **44** is bolted in place on the panel **23** by means of the bolts **116** and lock washers **117**. In other words, therefore, the current is not led directly to the back connection stud **111** but through the lower terminal post **44** and through the coil **110** of the over current magnet to the back connection stud **111** through which the connection is made to the circuit.

The coil **110** of the over current magnet is therefore connected in series with the contacts.

It might here be noted that the upper back connection stud **42** is likewise connected through the panel **23** by means of screws **118** and **119** engaging and passing through the clip **120** and is therefore held in position in the same manner as the lower back connection stud **111**.

When the circuit breaker therefore is closed, the current flowing into the upper stud **42** enters the main contact block **36**, passes through the

main stationary contact surface 40 to the main movable contact surface 41 and into the main contact lever 60 passing therefrom through the flexible lead 43 to the lower terminal block 44 around and through the coil 110 to the lower back connection stud 111 and thence back to the circuit to which the same is connected.

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; since the leads 43, 93 and 100 each are connected to the pigtail post 44.

The arcing contact circuit is in parallel with the circuit through the main contact tips 40 and 41. The arcing contacts are designed to make before and separate after the main contacts during the closing and opening so that as is hereinbefore described, the arc particularly during the opening may be made between the arcing contacts so that the main contacts which carry the load should not be roughened or distorted to offer any substantial resistance to the passage of current.

Blow out magnet and stationary arcing contact

The current path from the arcing contact tip 88 to the arcing contact lever 75 and through the flexible lead 93 to the lower terminal block 44 has been described. The movable arcing contact tip 88 engages the stationary arcing contact tip 121. Current is led to the stationary arcing contact tip 121 in the following manner:

Current from the upper connection stud 42 flows into the lower terminal 125 of the blow out magnet coil 122 around the coil to its upper terminal 129 and thence to the stationary arcing contact 123. From the stationary arcing contact, the current flows to the stationary arcing contact tip 121, thence to the movable arcing contact tip 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 arcing contacts, particularly the movable arcing tip 87—88, may readily be replaced after the same have become worn. When the circuit breaker is 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 main stationary contact 36 is attached to the back connection stud as is the lower terminal of the blow-out magnet coil 122 by means of screws 38. Screws 119 passing through panel 23 serve to fasten the lower terminal of blow out magnet coil 122 and angle clip 120 to panel. Screws 118 in turn fasten back connection stud 42 to the angle clip 120. The electrical connection between the back connection stud 42 and the lower terminal 125 of the blow out magnet coil 122 is made by direct contact between the angle clip 120 and the screw 119 as well as by the direct pressure of the terminal 125 against the connection stud 42.

The coil consists preferably of a strip of bar copper wound in a helix, the lower end at 126 being sweated and pinned by pins 127 and 128 to the lower coil terminal 125 and the upper end being secured to a flat plate terminal 129 which lies against the panel 123. The coil 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. Insulated side plates 132 are fastened on each side of the coil terminals. The arcing terminals 123 also cut from an extruded brass bar is secured to the upper coil terminal 129 and the panel 23 by screws 133, threaded into the nut plate 134 which is further anchored in position to provide a secure attachment of the members by the screws 135, the heads of which are embedded in the recess 136 so that they may not interfere with the securement of the coil terminal 129 to the panel.

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

The arcing contact 123 curves around the blow out coil as seen in Figures 3 and 4 and forms an arcing horn. The arcing contact is preferably wider than the coil 122 and as seen in Figures 3 and 4, its under surface rests against the edges of the insulating side plates 132. As has been above described, the arcing contact tip 121 is at the lower end of the arcing contact 123 and is preferably a contact surface of Elkonite silver.

As seen in Figure 2, the contact shaft 45 is a square steel bar which as above described is covered with phenolic insulation molded in place. Each end of this shaft is drilled at 140*a* to receive the bearings 140. The shaft itself extends betwen the side plates 28 and 29. The bearings are brass cylinders inserted in holes in the sides plates to which their drilled flanges 141 are secured by screws 142.

When the screws 142 are removed and the two bearings at each end are withdrawn, the shaft and the entire contact assembly may be removed from between the side plates provided of course that the flexible leads have been disconnected and also provided that the connection between the link 34 and the arm 35 of the contact shaft are separated.

Assembly and operation of the contacts

The contact arms 46 are secured to the contact shaft by clamp members 51 which are held in place by a pair of screws 56 and 57 on each side of the shaft.

The outside poles are suitably positioned by the contact arm caps or clamps 51*a* while the middle pole arm is held in position by the cap 51. As is seen more particularly in Figure 3 the clamp or cap 51 is extended to form the shaft actuating arm 35 and is drilled to receive pin 210 in the upper end of the main toggle link 34. A movement of the operating mechanism 31 will raise or lower the pin 210, therefore raising or lowering the shaft actuating arm 35 and so rotate the contact shaft 45 to move the contacts into and/or out of engagement.

As is more clearly seen in Figure 2 secured to either or both ends of the steel contact shaft 45, is a steel arm 220 and 221. Each of these arms carries as will be noted, two studs 223 and 224 which are riveted in place.

Secured to one of the studs of each of the members 220 and 221 is a contact opening spring the lower end of which may be attached to studs riveted to the insides of the bracket side plates. These two springs may bias the shaft towards opening position and assure quick opening.

The second of the studs for instance stud 223 on the arm 220 may be utilized to operate auxiliary switches or other devices by means, for instance, the vertical insulated shaft 230 attached

to this stud and passing through the shelf of the bracket **30** (Fig. 2).

Thus, for instance, the vertical shaft **230** may operate auxiliary switch **234** in any suitable manner for any suitable purpose. The rotation of the contact shaft **45** towards opening position will through the arm **220** and the stud **223** force the vertical link **230** downwardly. The vertical link **230** is connected by pin **231** to the crank **232** on the shaft **233** of the switch **234**. The downward motion of the vertical link **230** will result in rotation of the crank **232** and will therefore result in rotation of the shaft **233** and in the consequent operation of the various contacts and other portions of the switch suitably connected to and actuated by shaft **233**.

Such switch **234** may be used where, for instance, the circuit breaker is to be connected with automatic reclosing circuits when it is open and such relay will obviously be reset to its original position when the solenoid or manual closing mechanism hereinafter described rotates the contact shaft **45** towards closing position thus raising the insulated link **230** and operating the switch.

As has been above pointed out, preferably three contact arms **46** are mounted on this shaft, one for each pole of the circuit breaker as seen in Figure 2. On each side of each arm, there is cemented to the shaft insulation a Bakelite washer **143** which improves the pole to pole and pole to ground insulation.

As will be noted in Figure 2, the inter-pole washers are bevelled and flanged so that the bevelled and flanged portions **144** thereof are spaced apart so that an inter-phase barrier **145** secured to the panel may extend between them. The cooperation of these parts makes it impossible for any flexible conductors of adjacent poles to be drawn together during heavy current flow while at the same time any possibility of arcing over is obviated.

In the construction and arrangement of the contacts, the movable main contact is supported by an operating arm on the contact bar or shaft and is connected to the lower stud by a flexible shunt of suitable size.

Pressure on the main contact is obtained through the use of a compression type coil spring, mounted outside the current path, and, consequently, is unaffected by heating.

The pressure on the arcing contacts is also obtained by the same type of compression type coil spring protected from the arc.

The main contacts are protected by the sequence of operation in opening or closing of the device, since the main contacts close after the arcing contacts and open before them.

Although with the construction herein described, replacement of the contacts should not be necessary, the arrangement of the movable main contact lever and the movable arcing contact is such that access to both stationary and movable parts with a minimum amount of labor is possible.

As hereinafter described, accessibility of the main contacts is such that it is necessary only to remove one screw from the arc quencher assembly and lift it off manually so as to reach the contacts. In addition, as is hereinbefore described, the removal of the two bearings **140** of the main contact shaft and pigtails is sufficient to make available all parts of the contact mechanism for replacement, cleaning or repair.

The individual poles of the circuit breaker are each rigidly mounted on a rigid insulating shaft so as to insure the simultaneous opening and closing of all contacts. The use of a single trip free mechanism operating the main contact shaft also insures that all of the poles will operate simultaneously and precludes the possibility of opening individual poles without opening others.

An important feature of the present invention is that the same structure may be used for single pole or multi-pole operation, that is, as seen for instance in the structure of Figure 2, the circuit breaker mechanism is so arranged that three poles are simultaneously operated by a single closing and tripping mechanism. The same type of structure may be so arranged as to take one, two or four poles or more.

Arc chute, arc horns and blow out

In the actual operation of the contact assemblies herein described, when the contacts are fully closed and the latches are then tripped, the contact shaft **45** and the contact arm **46** 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 **46** 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 highly magnetized in proportion to the current flowing.

As seen in Figures 2, 3, 4 and 5 surrounding each pole is an arc chute **150** comprising side plates **151** of insulating material and supporting between them five shorter parallel spaced plates **152** also of fiber.

The entire group is held together preferably by rivets **153**, **153** making as far as possible a rigid assembly. Preferably, the rivets comprise, as seen in Figure 5, a central metal tube-like arrangement **154** and an outer insulating cylinder **155**.

As seen in Figures 5 and 4, near the panel **23**, the inside plates **152** are separated by fiber members **156** which prevent the arc gases from coming in contact with the panel and which also comprise hooks **157** which engage under the hook or lip **139** of the stationary arcing contact member **123** in order to assist in supporting the arc quencher assembly. This is effected by the fact that the fiber hook on the barrier herein described is held snugly between the hook of the arcing horn and the upper current surface of the horn. Near the front of the arc chute is secured an arcing horn **160** which is electrically connected to an angle-clip **161**, being connected thereto by the screw **162** passing through the flange **163** of the arcing horn and a flange of the angle clip.

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 con-

ductor 100 which in turn connects it to the lower terminal 44. At the end of the opening movement of the arcing contact the tip 87 of the movable arcing contact 75 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 current is first transferred from the main contacts to the arcing contacts, and, when the arc is then transferred to the stationary arcing contact or horn 160, the movable arcing contact is shunted out of the circuit.

As seen in Figure 2, the blow out core 130 extends beyond the sides of the blow out coil 122 a distance equal to the thickness of the insulating side plates 151.

The insulating side plates are notched at 175, as seen in Figure 1, so that they may embrace the core 130 while their edges rest against the panel 23. By this arrangement, any possible impediment to the magnetic fluxes induced by the core in the pole pieces hereinafter described is obviated.

Ferrous blow out plates or pole pieces 176, Figures 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, as seen particularly in Figure 1, cover a part of the notch 175 in the insulating 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.

Each of the side plates has its back edge 180 (Figure 1) bevelled on the inner side thereof so that it may be slid in position easily past the notches of the insulated bridge hereinafter described.

The notch 175 around the blow out core 130 (Figure 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 (Figure 3) assist in positioning the back end of the arc chute in proper relation to the panel 23 and the various other portions of the contact assembly.

The front of the arc chute is supported by the metallic clip 161 which is secured to the insulating bridge 37 and in current carrying contact with the conductor 100 by the screws 164 and its lock washer 165. The screw 162 provides a releasable clamping means between the arcing horn 160 and the clip 161 to maintain the arc chute in operative position.

The front end of the arc chute is therefore securely positioned in place by means of the screws 164 and 162. It will be noted that removal of the screw 162 will permit the withdrawal of the entire arc chute from the contact assembly. That is, when the screw 162 is no longer in engagement with the angle clip 161 then (Figure 3) when the entire arc chute 150 is slid towards the left, the hook 157 of the fiber spacer 156 may be disengaged by this simple horizontal movement from the hook 139 of the arcing contact 123 and as seen in Figure 1, the notch 175 of the outer plate 151 may by the same motion slide out of engagement with the blow out core 130. The arc chute therefore is so arranged that a simple unscrewing of the screw 162 will permit removal thereof.

It should be noted that the screw 162 is so arranged that it need not be completely removed but it may be rotated a sufficient number of turns to disengage it from the clip 161 and may remain in the portion 163 of the arcing horn 160 during removal of the arc chute. By this simplified means involving rotation of a single screw, the arc chute may be securely mounted in place or quickly removed by a single motion in a horizontal direction.

The arc splitting plates 152 (five in number in the preferred embodiment) have, as seen in Figures 3 and 4, their lower edges shaped in two arcs 190 and 191 which are concave in a downward direction with the cusp 192 between them rounded. This cusp lies approximately midway between the stationary arcing horn 123 and the front arcing horn 160. The downwardly extending cusps facilitate the entranec 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 Figures 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 Figures 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 (Figure 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 insure contact of the arc gases with the various plates, the holes or perforations 195 of each of the plates are 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 74 to the arcing horn 160.

The current flowing through the coil 122 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. Preferably 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 re-striking thereof. The arc therefore may be quenched with $\frac{1}{120}$ of a second of the formation thereof.

Inter-phase barriers

Sufficient inter-phase barriers are provided by the side plates **151** of the arc chute. However, additional inter-phase barrier plates **145** (Figures 1–4 inclusive) may be used to make it impossible for any flashing over of the arc from one pole to the other. These inter-phase barriers are placed between the arc chutes and carried up so that they are aligned with the top of the panel **23** and may be secured to the panel by suitable blocks **200** of insulating material; the blocks **200** of insulating material are secured to one side of the inter-phase barriers at the top. These blocks are drilled to receive the screw **201** which threads into a plug in the panel to secure the barrier in position.

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 as has been before pointed out, the back end bears against the panel and extends down between the shaft insulation disks **143—143**.

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

The lower back corner of the upper inter-phase barrier is supported by a strip of insulating material secured to the panel just above the top of the housing brackets. The lower inter-phase barriers align with the upper ones and are secured to the panel by screws threaded into their edge. These lower barriers are notched to surround the shaft. They prevent the flexible conductors from being drawn together during fault current.

Various other elements may, of course, be utilized in connection with the circuit breaker mechanism. Thus, for instance, as seen in Figure 2, a suitable time delay element **950** may be provided in connection with the over current coil **110** to permit the breaker to carry normal load above its trip setting for short periods of time. The specific details of the time delay elements are not herein discussed since they constitute no part of the present invention.

The operation and function of each of the parts of the arc chute of the present invention and the cooperation thereof with the elements of the circuit breaker have been set forth in connection with the specific description of each of said parts.

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.

Accordingly, I prefer to be bound, not by the specific disclosures herein, but only by the appended claims.

This application embodies portions of the structures of the application of Frank J. Pokorny, for Circuit breaker operating mechanism, Serial No. 339,682, the application of William Maxwell Scott, Jr., for Circuit breaker, Serial No. 339,687, the application of William Maxwell Scott, Jr., for Stationary contact structure, Serial No. 339,688, and the application of William Maxwell Scott, Jr., for Circuit breaker-movable contacts, Serial No. 339,689, all filed June 10, 1940. In this application I have claimed those inventions and portions of the structure devised by me.

I claim:

1. An arc extinguisher comprising a plurality of spaced parallel barrier plates insulatedly mounted between a pair of side plates, said plates extending in planes parallel to the axis of the arc, ferrous plates mounted on the outer sides of said side plates forming a path for magnetic blow-out fluxes, said ferrous plates being registerable with the ends of the magnetic core of a blow-out coil, said barrier plates, side plates and ferrous plates forming a single integral unit mountable and removable as a unit upon a circuit breaker, said unit carrying a hook at the rear end engageable with coacting means on the circuit breaker panel and a single releasable screw threaded means at the front end engageable with cooperating means on the circuit breaker for securing the front of the arc extinguisher in position.

2. An arc extinguisher for extinguishing an arc drawn between opposed contacts, said arc extinguisher comprising a plurality of spaced parallel barrier plates insulatedly mounted between a pair of side plates, said plates extending in planes parallel to the axis of the arc, ferrous plates mounted on the outer sides of said side plates forming a path for magnetic blow-out fluxes, said ferrous plates being registerable with the ends of the magnetic core of a blow-out coil, said barrier plates, side plates and ferrous plates forming a single integral unit mountable and removable as a unit upon a circuit breaker, said unit carrying a hook at the rear end engageable with coacting means on the circuit breaker panel and means at the front end engageable with cooperating means on the circuit breaker, said coacting means on the circuit breaker panel comprising an extension of an arcing horn, said unit carrying an arcing horn at the front end, and means for connecting said latter arcing horn in the arcing circuit, said unit being removable from said circuit breaker panel by a movement substantially parallel to the movement of the contacts.

3. An arc extinguisher comprising a plurality of spaced parallel barrier plates insulatedly mounted between a pair of side plates, said plates extending in planes parallel to the axis of the arc, ferrous plates mounted on the outer sides of said side plates forming a path for magnetic blow-out fluxes, said ferrous plates being registerable with the ends of a magnetic core of a blow-out coil, said barrier plates, side plates and ferrous plates forming a single integral unit mountable and removable as a unit upon a circuit breaker, an insulating supporting bridge at the front of the circuit breaker, the forward bottom edges of the side plates engageable with said bridge for supporting the forward end

thereof, and means at the rear end of the unit engageable by horizontal movement of the unit with coacting means on the circuit breaker for supporting the rear end thereof.

4. In a circuit breaker mounted on a panel, an insulating supporting bridge supported at a distance from the panel; a blow-out coil including an arcing horn secured to said panel and an arcing contact structure secured to said panel and partially encasing said blow-out coil, a hooked extension on said arcing contact, said blow out coil having a core extending beyond the ends of said coil, an arc extinguisher having side plates of insulating material provided with notches engageable with said extensions of said core, said side plates carrying ferrous plates registerable with the ends of said core, and a hooked member in said arc extinguisher engageable with said hooked extension on said arcing contact by horizontal movement of said arc extinguisher, an insulating bridge supported by and spaced from said panel the other end of said arc extinguisher being supportable on said insulating bridge, an arcing horn supported in said arc extinguisher at said other end.

5. In a circuit breaker mounted on a panel, an insulating supporting bridge supported at a distance from the panel; a blow-out coil secured to said panel and an arcing contact structure secured to said panel and partially encasing said blow-out coil, a hooked extension on said arcing contact and a removable arc extinguisher, said blow out coil having a core extending beyond the ends of said coil, said arc extinguisher engageable with said extensions of said core, said side plates carrying ferrous plates registerable with the ends of said core, and a hooked member in said arc extinguisher engageable with said hooked extension on said arcing contact, the other end of said arc extinguisher being supportable on said insulating bridge, an arcing horn supported in said arc extinguisher at said other end; said arcing contact structure also comprising an arcing horn, a metallic member on said insulating bridge and means for connecting said first arcing horn to said metallic member, said member being connected to a terminal of the circuit, said second mentioned arcing horn being connected through the blow-out coil to another terminal of the current supply.

6. In a circuit breaker mounted on a panel, an insulating supporting bridge supported at a distance from the panel; a blow-out coil secured to said panel and an arcing contact structure secured to said panel and partially encasing said blow-out coil, a hooked extension on said arcing contact and a removable arc extinguisher, said blow out coil having a core extending beyond the ends of said coil, said arc extinguisher engageable with said extensions of said core, said side plates carrying ferrous plates registerable with the ends of said core, and a hooked member in said arc extinguisher engageable with said hooked extension on said arcing contact, the other end of said arc extinguisher being supportable on said insulating bridge, an arcing horn supported in said arc extinguisher at said other end; said arcing contact structure also comprising an arcing horn, a metallic member on said insulating bridge, and means for connecting said first arcing horn to said metallic member, said connecting means comprising a releasable member engageable with said metallic member and an end of said first arcing horn, said arc extinguisher being removable from the circuit breaker assembly upon release of said releasable member.

7. In a circuit breaker mounted on a panel, an insulating supporting bridge supported at a distance from the panel; a blow-out coil secured to said panel and an arcing contact structure secured to said panel and partially encasing said blow-out coil, a hooked extension on said arcing contact and a removable arc extinguisher, said blow-out coil having a core extending beyond the ends of said coil, said arc extinguisher engageable with said extensions of said core, said side plates carrying ferrous plates registerable with the ends of the core, and a hooked member in said arc extinguisher engageable with said hooked extension on said arcing contact, the other end of said arc extinguisher being supportable on said insulating bridge, an arcing horn supported in said arc extinguisher at said other end; said arcing contact structure also comprising an arcing horn, a metallic member on said insulating bridge, and means for connecting said first arcing horn to said metallic member, said connecting means comprising a screw engageable with openings in said metallic member, and an end of said first arcing horn, said arc extinguisher being removable from the circuit breaker assembly upon rotation of said screw.

8. In a circuit breaker mounted on a panel, a removable arc extinguisher, means for positioning said extinguisher comprising means on said panel engageable with cooperating elements on one end of said extinguisher and an insulating member supported in spaced relation to said panel engageable with the other end of said extinguisher, said other end of said arc extinguisher carrying an arcing horn, and a single means for securing said end of said arcing horn to said insulating member and connecting said arcing horn in an arcing circuit.

9. In a circuit breaker mounted on a panel, a blow-out coil secured to said panel, and an arcing contact structure secured to said panel and partially encasing said blow-out coil, a hooked extension on said arcing contact and a removable arc extinguisher, said blow-out coil having a core extending beyond the ends of said coil, said arc extinguisher engageable with said extensions of said core, said side plates carrying ferrous plates registerable with the ends of said core, said arc extinguisher comprising a series of barrier plates with hooked shaped members therebetween, said hook members being engageable with said hooked extension on said arcing contact.

10. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, magnetic plates positioned on the outside of said insulating plates, spacing means between said insulating plates, means securing said magnetic plates, insulating plates and spacing means together, insulating supporting means, a pair of contact structures on said supporting means for connection in an electric circuit, one of said structures comprising a conducting coil and a magnetic core therefore extending axially beyond the dimensions of said coil, notches in said insulating plates adapted to embrace the ends of said core when said arc chute is in operative position, said magnetitc plates covering said notches to engage the ends of said core, an arcing horn associated with said coil and secured to said supporting means, a horizontal groove in said arcing horn, one of said spacing means for said plates cooperating with said groove for positioning one end of said arc chute, a bracket mounted

on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said arc chute.

11. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, magnetic plates positioned on the outside of said insulating plates, spacing means between said insulating plates, means securing said magnetic plates, insulating plates and spacing means together, insulating supporting means, a pair of contact structures on said supporting means for connection in an electric circuit, one of said structures comprising a conducting coil and a magnetic core therefor extending axially beyond the dimensions of said coil, notches in said insulating plates adapted to embrace the ends of said core when said arc chute is in operative position, said magnetic plates covering said notches to engage the ends of said core, an arcing horn associated with said coil and secured to said supporting means, a horizontal groove in said arcing horn, one of said spacing means for said plates cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said arc chute, said additional spacing means comprising clamping means cooperating with said bracket to preclude movement of said arc chute relative to said insulating supporting means until after release of said clamping means.

12. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, a plurality of spacing means between said plates and means for securing said insulating plates and spacing means together, insulating supporting means, a contact structure mounted on said supporting means, said contact structure comprising a groove having its opposed surfaces in horizontal planes, one of said spacing means cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said chute.

13. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, a plurality of spacing means between said plates and means for securing said insulating plates and spacing means together insulating supporting means, a contact structure mounted on said supporting means, said contact structure comprising a groove having its opposed surfaces in horizontal planes, one of said spacing means cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said chute, said additional spacing means comprising a metallic arcing horn.

14. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, a plurality of spacing means between said plates and means for securing said insulating plates and spacing means together, insulating supporting means, a contact structure mounted on said supporting means, said contact structure comprising a groove having its opposed surfaces in horizontal planes, one of said spacing means cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said chute, said additional spacing means comprising a metallic arcing horn; a second contact structure mounted on said insulating supporting means and conducting means connecting said additional spacing means and said second contact structure.

15. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, a plurality of spacing means between said plates and means for securing said insulating plates and spacing means together, insulating supporting means, a contact structure mounted on said supporting means, said contact structure comprising a groove having its opposed surfaces in horizontal planes, one of said spacing means cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said chute, said additional spacing means comprising a metallic arcing horn; a second contact structure mounted on said insulating supporting means and conducting means connecting said additional spacing means and said second contact structure, one end of said conducting means being insulatedly secured to said bracket, for cooperation with said additional spacing means and the other end of said conducting means being secured to said second contact structure.

16. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, a plurality of spacing means between said plates and means for securing said insulating plates and spacing means together, insulating supporting means, a contact structure mounted on said supporting means, said contact structure comprising a groove having its opposed surfaces in horizontal planes, one of said spacing means cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said bracket for positioning the other end of said chute, and detachable clamping means between said additional spacing means and said conducting means for precluding movement of said arc chute relative to said insulating supporting means until after release of said clamping means.

17. In a circuit interrupter an arc chute comprising a pair of spaced side plates of insulating material, magnetic plates positioned on the outside of said insulating plates, spacing means between said insulating plates, means securing said magnetic plates, insulating plates and spacing means together, insulating supporting means, a pair of contact structures on said supporting means for connection in an electric circuit, one of said structures comprising a conducting coil and a magnetic core therefor extending axially beyond the dimensions of said coil, notches in said insulating plates adapted to embrace the ends of said core when said arc chute is in operative position, said magnetic plates covering said notches to engage the ends of said core, an arcing horn associated with said coil and secured to said supporting means, a horizontal groove in said arcing horn, one of said spacing means for said plates cooperating with said groove for positioning one end of said arc chute, a bracket mounted on said insulating supporting means and additional spacing means cooperating with said

bracket for positioning the other end of said arc chute, said arc chute comprising a plurality of plates of insulating material between said side plates and parallel thereto and spaced from each other and from said side plates.

18. In multipole circuit interrupter, a support, stationary contact structure mounted upon said support, a metallic bracket mounted upon said support, said bracket carrying complementary movable contact structure and operating mechanism therefor, a member of insulating material secured to said bracket and a plurality of arc extinguishers each having one end supported by the respective stationary contact structure and the other end releasably secured to said member; and an arcing horn carried in said other end of each arc extinguisher; the means for securing said other end to said member also connecting said arcing horn in the arcing circuit.

FRANK J. POKORNY.