

May 30, 1939.

R. C. VAN SICKLE ET AL

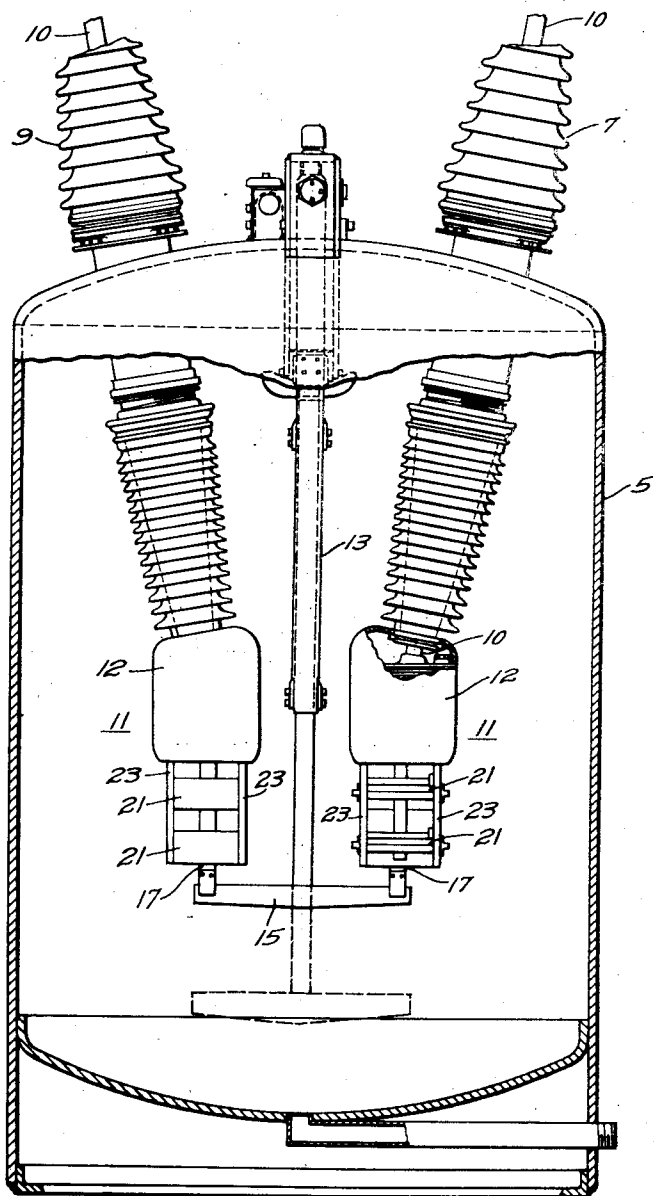
2,160,630

CIRCUIT BREAKER

Filed May 29, 1936

5 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

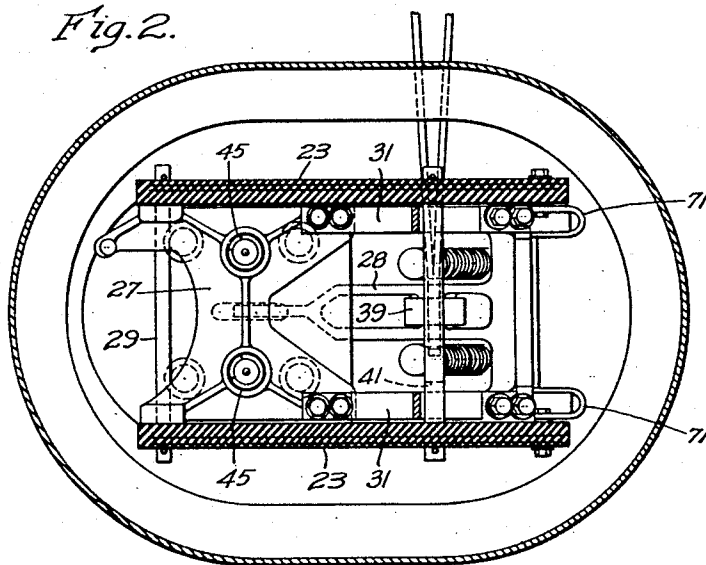


Fig. 3.

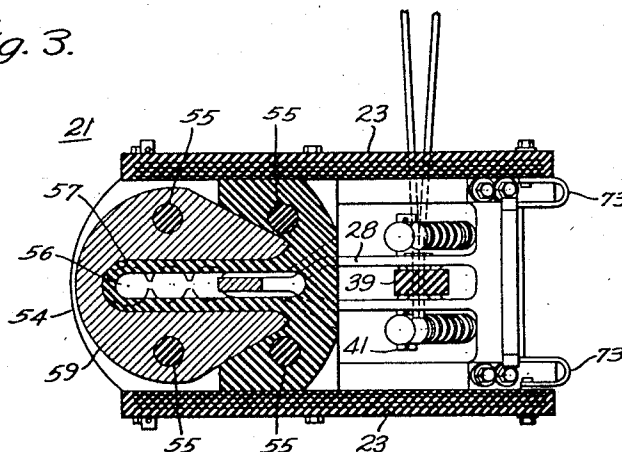
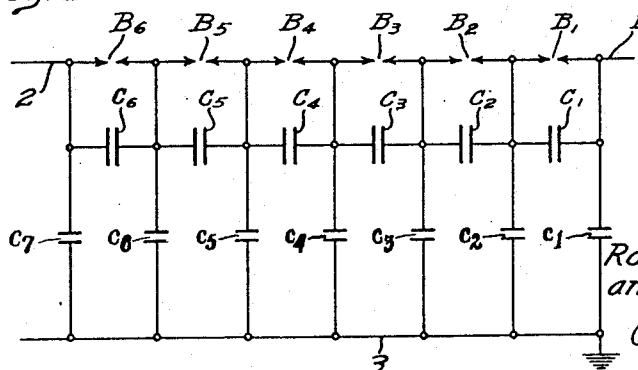


Fig. 8.



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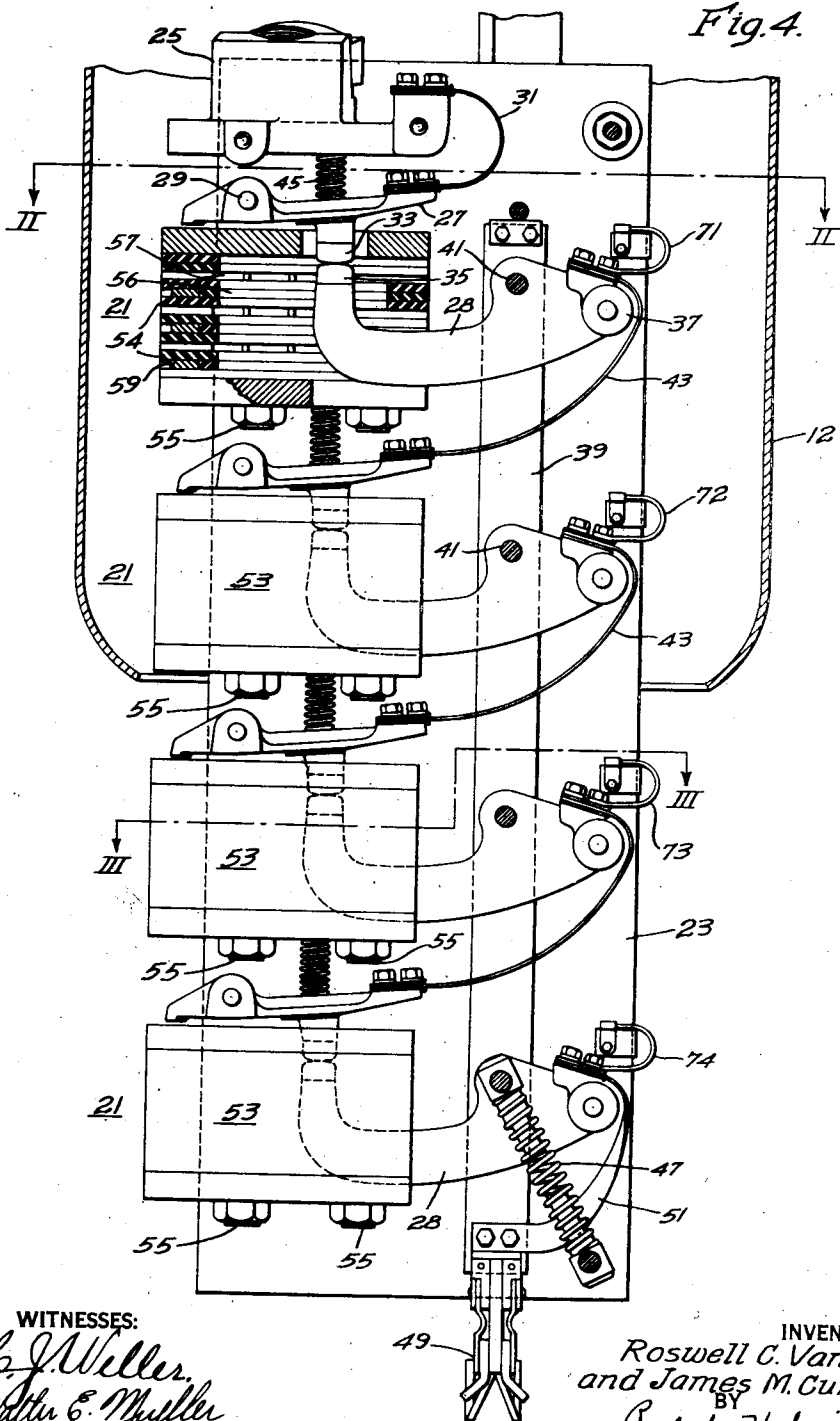
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CIRCUIT BREAKER

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Fig. 5.

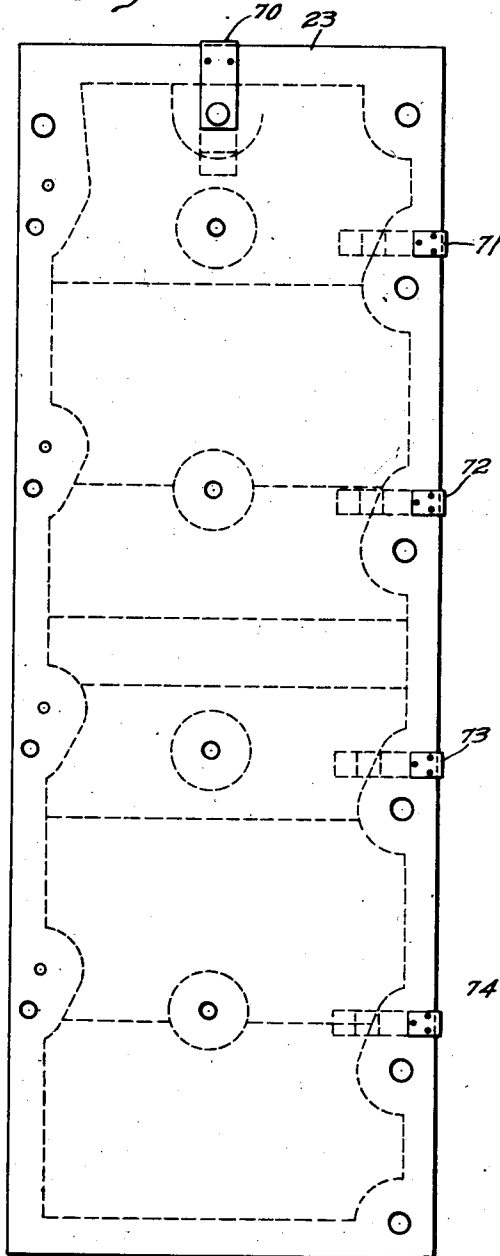
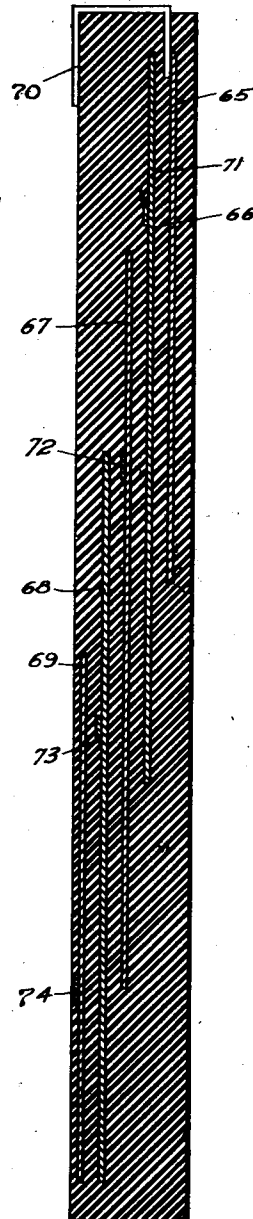


Fig. 6.



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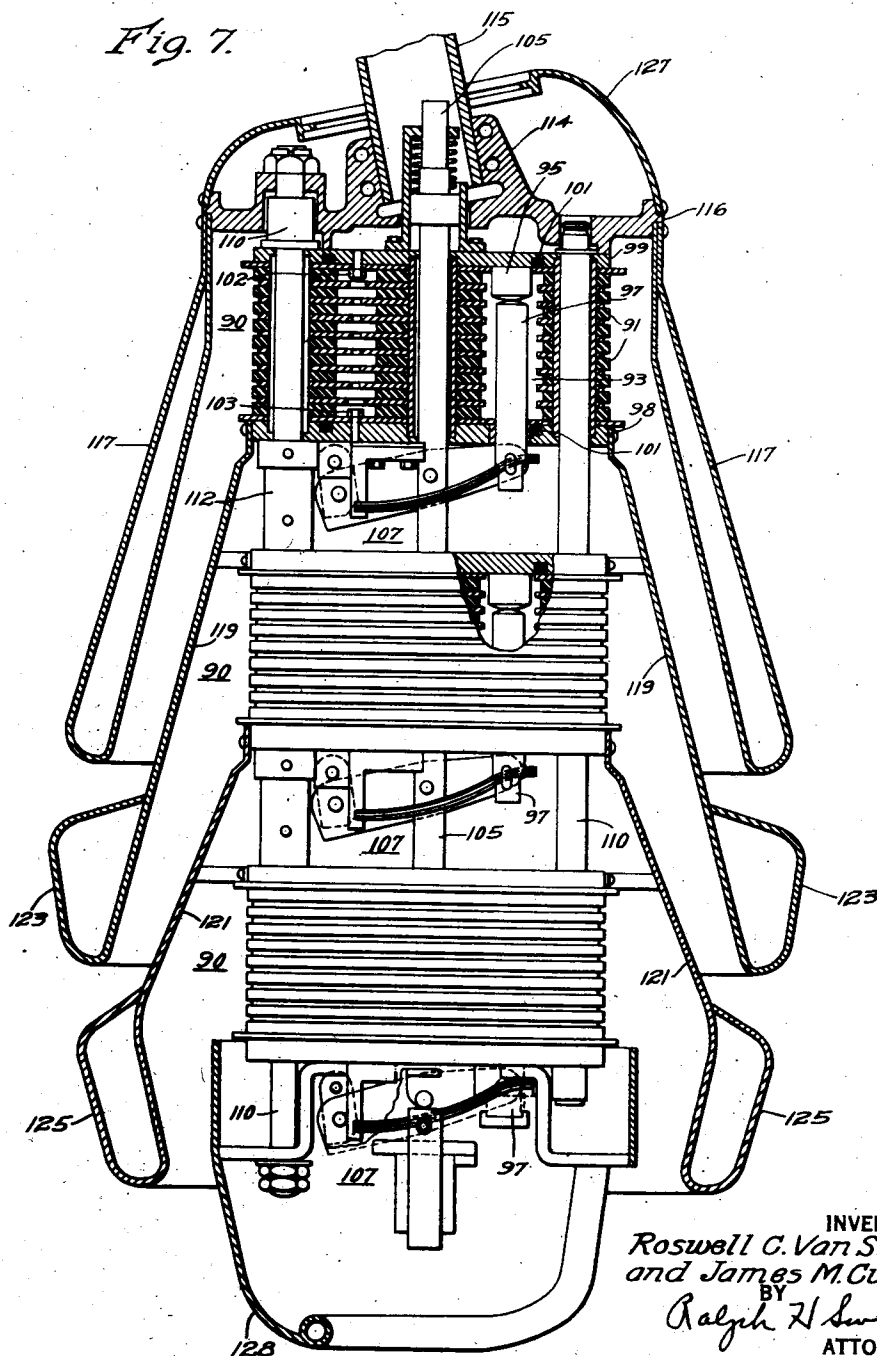
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CIRCUIT BREAKER

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Fig. 7.



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2,160,630

CIRCUIT BREAKER

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Application May 29, 1936, Serial No. 82,576

10 Claims. (Cl. 200—145)

This invention relates to circuit breakers and more particularly to circuit breakers of the high voltage type employing a multi-break contact construction.

5 Heretofore the practice in the circuit breaker art has been almost universal in the adoption of a double break construction in which the two breaks were introduced in series. It is believed that the extreme simplicity of this form of construction was largely responsible for its popularity in spite of the fact that each break must be
10 able to interrupt substantially full voltage. Tests on double break circuit breakers have shown that the voltage appearing across one break may be as high as 85% of the total voltage.

15 In view of the increasing demand for higher transmission voltages and for high speed interrupting operations, the simple double break circuit interrupter no longer is able to meet these requirements. Generally it may be said that for
20 a given method of arc extinguishment the amount of electrode separation necessary for effective interruption varies nearly directly with the voltage. It is therefore conceivable that a simple double
25 break interrupter may be constructed which has the ability of interrupting extremely high voltages. However, such a structure would not meet modern requirements, since the time interval required to separate the movable contacts the
30 requisite distance would be prohibitive. Thus, in order to obtain a large electrode separation within a very short interval of time, the simple double break construction was abandoned for one providing a larger number of serially related breaks.
35 It is apparent that by simultaneously initiating a plurality of breaks the total time of electrode separation is reduced to that required for moving one of a plurality of pairs of separable electrodes a relatively short distance. Theoretically, the
40 amount of the electrode separation necessary for interruption when a plurality of breaks are employed is inversely proportional to the number of breaks. It is thus seen that a plurality in excess of two breaks per pole greatly shortens the
45 time interval required for obtaining the requisite separation for arc extinguishment.

The progress, however, in high voltage high speed multi-break circuit breaker construction has been greatly handicapped due to the difficulties encountered in obtaining a workable distribution of voltage across the several contacts.

50 It is known that the unequal distribution of voltage across the arc interrupting structure of a multi-break circuit interrupter is caused by the capacitance to ground of the arc drawing con-

tacts and their connected metal parts. Particularly in oil or other liquid arc quenching circuit breakers wherein the contacts are surrounded by a tank, at least a substantial portion of which is of metal at ground potential, the disturbing capacity appears even in a more marked degree between the contacts and the metal portion of the
5 breaker tank. This disturbing capacity is troublesome during the opening operation of a multi-break circuit interrupter in that it causes the voltage to be distributed so unevenly across
10 the several breaks that one or a relatively small number of the breaks are required to do substantially the entire work of arc interruption.

The capacity to ground of the arc drawing
15 contact members also manifests itself after the circuit has been opened by causing an unequal distribution of voltage across the several arc extinguishing devices, thereby seriously affecting the insulation of the interrupting structure when
20 the breaker is in the open circuit position. The capacity to ground of the arc drawing contact members also has a disturbing influence upon the voltage distribution across the contact members during the closing operation of the breaker. The
25 disturbing capacity may cause substantially full voltage to appear across a single break from which insulation failure of the particular arc extinguishing device associated with that break may result. Flashover across the insulation is also
30 likely to occur under these abnormally high voltage conditions across a single break, or a breakdown of the gap between the cooperating contact members may occur, thereby making it difficult
35 to bring these contact members into engagement with each other.

We propose to reduce the effect of this capacity to such an extent that any desired distribution of voltage may be obtained across the several
40 breaks of the circuit breaker.

It is, therefore, an object of my invention to provide a multiple break circuit interrupter in which the division of voltage across the interrupting structure is under control during the opening and closing operations of the breaker
45 and also while the breaker is either in the open or closed position.

Another object of my invention is to provide means for reducing the disturbing capacity effect between the arc drawing contacts of a multiple
50 break circuit interrupter and ground, to a minimum, in order to control the voltage distribution across the several contacts of the breaker.

A further and more specific object of my invention is to provide shielding means in the form
55

of capacitors connected across the breaks of a multi-break circuit interrupter whereby improved voltage distribution across the several breaks of the interrupter is obtained.

5 A still further object of my invention is to embody shielding means adjacent the breaks of a multi-break circuit interrupter, which shielding means function to control the voltage distribution across the several breaks and also provides means
10 for supporting the multi-break interrupting structure.

Other objects and advantages relate to details of the breaker structure and the relation of the various parts thereof, and will appear more fully
15 in the following description when taken in connection with the accompanying drawings, in which:

Figure 1 is a side elevation view of the breaker of my invention showing a substantial portion
20 of the breaker tank in section in order to reveal the interrupting structure,

Fig. 2 is a cross sectional view of one of the multiple arc interrupting units taken along line II—II of Fig. 4,

25 Fig. 3 is a cross sectional view of one of the multiple arc interrupting units taken along the line III—III of Fig. 4,

Fig. 4 is a longitudinal sectional view of one of the multiple arc interrupting units of the breaker
30 of my invention,

Fig. 5 is a side elevation view showing one of the shield members used in conjunction with the multiple arc interrupting units of the breaker,

Fig. 6 is a cross sectional view of the shield
35 member shown in Fig. 5,

Fig. 7 is a side elevation view of a multiple breaker-interrupting unit of modified form and in which a shielding means of different form is shown partially in cross section, and

40 Fig. 8 is a circuit diagram showing the capacity relationship between the various parts of the arc interrupting structure.

The general aspect of the method by which we accomplish the foregoing objects will be more
45 fully understood from a consideration of the circuit diagram shown in Fig. 8. In this figure, the reference characters B_1 to B_6 , inclusive, designate the breaks of a multi-break circuit interrupter. The connection designated at 1 is adapted to represent one of the line terminals of the breaker, whereas the connection 2 represents the other line terminal. It is a known fact that the unbalance of voltage across the several
50 breaks of a circuit breaker is caused by the capacity to ground of the contacts and their connected metal parts intermediate the contact members directly connected to the line terminals. The capacity to ground of the contact members connected directly to the breaker terminals designated in Fig. 8 as C_1 and C_7 , does not have a
60 disturbing influence upon the voltage distribution, since the potential of each of these contacts is determined by the potential of the respective terminals to which it is connected. These disturbing capacities are represented in
65 Fig. 8 as condensers c_2 to c_6 , inclusive. The circuit interrupter tank which is maintained at ground potential is designated as a conductor 3. The ideal condition or that condition for which
70 the voltage would be equal across each of the breaks B requires zero capacitance to ground of the floating contact members forming the breaks and equal capacitances between the separate breaks. It is not practical to attempt to reduce
75 the capacity to ground of the floating contact

members between the end breaks B_1 and B_6 to zero, but it is possible to overcome the disturbing effects of this capacity by adding a capacitance across each break B_1 to B_6 , so that the total capacity across each break will be large as compared to the capacities c_2 to c_6 . The total capacitance across the respective breaks, that is the capacitance between a pair of cooperating contact members and the added capacitances are designated as C_1 to C_6 , respectively.

It is a known fact that in actual operation either terminal of the breaker 1 or 2 may be grounded and that the breaks toward the grounded side have a tendency to take less than their share of the voltage. It would be impossible
15 to provide means for obtaining an absolute equal distribution of voltage over all breaks for all conditions of operation. However, by making the values of the capacitances C_1 to C_6 large with respect to the capacitances c_2 to c_6 , the best average working condition is obtained. The particular structure whereby these results are obtained is more particularly shown in Figs. 1 to 6, inclusive.

Referring now to Fig. 1, the reference character 5 designates the circuit breaker tank having insulating terminal bushings 7 and 9 through which line terminals 10 are conducted interiorly of the tank. The lower portion of each line terminal 10 is provided with a multiple break arc
30 extinguishing assemblage generally indicated at 11.

Each of the arc extinguishing assemblages 11 comprises a plurality of pairs of separable contacts which are adapted to be simultaneously actuated to open and closed positions by an operating mechanism including a lift rod 13 and a horizontal bridging bar 15. The horizontal bridging bar 15 is adapted to make releasable engagement with the actuating rods 17 through
40 which each of the arc extinguishing assemblages 11 are actuated.

Each of the arc extinguishing assemblages 11 comprises a plurality of arc extinguishing units 21. The arc extinguishing assemblages 11 are more particularly of a type shown and described in an application of John B. MacNeill, Serial No. 42,183, filed September 26, 1935, and assigned to the assignee of this application.

As described in the aforementioned application, 50 the arc interrupting assemblages 11 constitute a pair of insulating plate members 23 between which the arc extinguishing units 21 are mounted in spaced relation with respect to each other. To the upper portion of the support plate members 23 is secured a foot member 25 (Fig. 4) adapted to be threaded to the lower portion of the contact terminal 10 extending through the terminal bushings 7. The foot member 25 provides a support and also makes electrical
60 connection between the incoming terminal member 10 of the circuit breaker and the arc interrupting assemblage.

Each of the arc interrupting units 21 includes a pair of separable contacts designated at 27 and 28, respectively. The contact member 27, as shown in Fig. 2, has an X-shaped configuration and is adapted to be pivotally mounted upon a cross rod 29 extending between the support plates 23.

The contact member 27 is connected by means of a flexible shunt 31 to the contact foot 25. The contact proper between the contact members 27 and 28 is maintained by means of contact tips 33 and 35, respectively, secured to the co- 75

acting ends of these members. Contact member 28 is pivoted at one end upon a cross rod 37 extending between the support plates 23. It will be noted that, as shown in Fig. 4, four interrupting units 21 are illustrated. The four moving contact members 28 are adapted to be moved simultaneously either into or out of engagement with the respective fixed contact members 27 by means of a common actuating rod 39 preferably of insulating material.

The rod 39 makes pivotal engagement with each of the contact arms 28 intermediate the ends of the contact arm by means of cross pins 41. The uppermost contact arm 28 is electrically connected by means of a flexible shunt 43 to the next adjacent relatively fixed contact member 27. In like manner, the succeeding movable contact members 28 are connected to the next adjacent fixed contact members. It is thus seen that the four pairs of contacts shown are electrically connected in series.

The relatively fixed contact members 27 are biased toward the closed position by a pair of springs 45. During the closing operation of the respective pairs of contacts, the actuating rod 39 is moved upwardly, which movement simultaneously causes each contact tip 35 to engage its cooperating contact tip 33 which is movable upwardly against the bias of springs 45 to thereby insure an equalized spring pressure contact on all interrupting units. The contact members 28 are normally biased toward the open position by means of a pair of springs 47 coupled between the support members 23 and the pivotal pins 41.

The lowermost portion of the operating rod 39 as also shown and described in the aforesaid application of John B. MacNeill, Serial No. 42,183, filed September 26, 1935, is provided with a releasable contact 49 which, in turn, is connected electrically through a flexible shunt 51 to the lowermost contact arm 28. The releasable contact 49 is adapted to engage the bridging contact member 15 to complete the electrical circuit between the two arc interrupting assemblies 11 when the breaker is in the closed circuit position and also during the initial opening movement of the contact arms 28. During the opening movement of the breaker the releasable contact 49 on the operating rod 39 moves only a relatively short distance as compared with the movement of the lift rod 13 and the bridging bar 15. When the contact 49 has moved to the limit of its travel, the bridging bar 15 disengages and continues its movement to the full open position, as shown by the dotted lines in Fig. 1. The provision of two additional breaks of considerable length in a body of insulating liquid which has not been subjected to an arc insures against insulation failure when the breaker is in the open circuit position.

Each of the arc interrupting units 21 also comprises an arc extinguishing device generally indicated at 53. Each arc extinguishing device 53 is associated with a pair of the contact members 27 and 28 and comprise a stack of plates 54 of insulating material maintained in clamping engagement by four bolts 55 also of insulating material, as more clearly shown in Fig. 3 and in the partial cross sectional view of the upper unit 53 of Fig. 4.

Each of the plates 54 comprising an arc extinguishing device 53 are slotted so as to provide an aligned opening or passage 56 there-through having a length several times its maximum width, and in which passage the contact

tips 33 and 35 of the contact members 27 and 28 are adapted to extend.

Alternate plates forming the arc extinguishing device 53 are provided with arcuate indentures 57 adjacent the passage 55 so as to form pockets along the walls of the passage for retaining a quantity of arc extinguishing liquid in which the entire arc interrupting assemblies 11 are immersed. At least three of the slotted plates of insulating material forming the stack 53 are provided with a U-shaped cutout portion for the reception of a similarly shaped iron plate 59.

The iron plates 59 are uniformly spaced along the passage 56 and so alter the magnetic field produced by the arc drawn in the passage 56 upon the separation of the contacts 33 and 35 that the arc is moved from the contact tips 33 and 35 laterally toward the closed end of the passage 56.

As the arc is thus moved, the arc extinguishing liquid within the passage 56 and also that partly entrapped in the pockets formed by the recesses 57 will be partially volatilized. The gases thus produced will create sufficient pressure within the passage to start a flow of un-ionized oil particles to be directed against the arc stream, thereby causing its extinguishment.

In order that the voltage shall be distributed in accordance with a predetermined gradient across the several pairs of contacts 27 and 28, we provide particular shielding means in the form of conducting plates such as metal foil imbedded in each of the insulating support members 23. The construction of the shielding means as applied to one of the support members is more particularly shown in Figs. 5 and 6.

Referring to the cross section of Fig. 6, which has been somewhat exaggerated in order to more clearly show the arrangement of the shielding plates, the shield means comprises five conducting plates 65 to 69, inclusive. The plates 65 to 69 are spaced from each other and displaced endwise in stepped overlapping arrangement as shown. The plates 65 to 69 are also arranged in the order named with the plate 65 on the outside or adjacent the inner wall of the breaker tank.

It will be noted that each of the plates 23 are symmetrical in construction and are provided with suitable conductors making connection between the shielding plates 65 to 69 and their respective contact members. More specifically, the conducting plate 65 is connected by a connection 70 to the contact foot 25. The plate 66 makes contact with the uppermost contact arm 28 by means of connection 71. In like manner, the remaining conducting plates 67 to 69 make electrical connection through the respective connecting leads 72 to 74 to their respective contact arms 28.

From the foregoing, it will be apparent that the leads 70 and 71 are connected across the upper pair of contacts 33 and 35, thereby connecting the capacity between the plates 65 and 66 in parallel with these contacts. Similarly, the capacity between succeeding pairs of plates as 66-67, 67-68 and 68-69 are by means of conductors 71-72, 72-73 and 73-74, respectively, connected across a corresponding pair of separable contacts.

By positioning the shield plates 65 outermost with respect to the other plates or adjacent the inner wall of the breaker tank and connecting it to the terminal 10 by means of the conductor 70, the capacitance to the tank of the breaker of

the inner shields 66 to 69 is greatly reduced. A similar effect is also produced by a shield member 12 surrounding each arc assemblage 11 in part and making electrical contact with the breaker terminal 10.

As previously pointed out in connection with the schematic diagram of Fig. 8, the capacity between each pair of contact members 27 and 28 including the added capacity of their respective shielding plates, is made large with respect to the capacity of the cooperating contact members 27 and 28 to ground. If such condition exists, the capacity thus connected across the individual pairs of cooperating contacts will determine the voltage distribution across these contacts rather than the capacity between the contacts and ground. The addition of the shield plates 65 to 69 may introduce additional capacitance to ground, but this increase is relatively less than the increase of the capacitance across the gaps.

From the foregoing description, it will be apparent that this method of voltage distribution control may be employed in obtaining a predetermined voltage distribution across the several serially related breaks in a multi-break circuit interrupter. In some instances, it may be desirable to produce a substantially uniform distribution of voltage so as to make each break interrupt an equal portion of the voltage. It may also be desirable to produce a predetermined unbalance of voltages across the several breaks so as to make certain of the arc interrupting units interrupt a greater portion of the total voltage than other of the units in the series of breaks. This may be accomplished by proportioning the individual capacitances between the shielding plates 65 and 69 in each of the arc extinguishing assemblages 11 so as to produce the voltage gradient desired across these serially related breaks. It will be apparent that the change in capacity may be obtained by varying the spacing between the respective plates 65 to 69 or by varying the amount of overlap of one plate with respect to adjacent plates.

The capacitance shielding structure above described also controls the distribution of potential between each arc-extinguishing assembly 11 and the bridging bar 15 as well as controlling the distribution of potential across the individual assemblages 11. The addition of capacitance in parallel with the respective pairs of contacts 33 and 35 provides a relatively low impedance path between each line terminal 10 and its respective releasable contact 49, as compared with the impedance between each contact 49 and the bridging bar 15 when the latter is in the full open position. This difference in impedance will cause substantially the potential stress impressed across the line terminals of the interrupter to appear across the gaps between the contact 49 and the bridging bar 15. Thus, the arc-extinguishing assemblies which are most subject to insulation failure are relieved of high potential stresses since these stresses are made to appear across two relatively long gaps between the releasable contacts 49 and the bridging bar 15, which gaps are filled with insulating liquid capable of withstanding high voltage.

The shielding plates 65 to 69 also function to effect voltage control during the final period of the arc-extinguishing operation. The arc-extinguishing units 53 associated with each pair of separable contacts 33 and 35 produce a strong deionizing action upon the respective serially re-

lated arcs drawn between these contacts. The arc-extinguishing units 53 are capable, under certain conditions, to force a current zero when appreciable current, say 5 to 10 amperes, is still flowing. The forcing of current zero in one unit while appreciable current is flowing represents a rapid transition of the arc path within that unit from a conducting state to one having infinite resistance.

When the current has thus been forced to zero in one unit the arc paths in the other units remain conducting for a relatively long time before becoming non-conductive. During this period of conductivity, the applied voltage across the conducting arc paths collapses and appears across the arc path of the unit in which the current was forced to zero. Thus, the interrupter that extinguishes its arc first in point of time must withstand quickly a high voltage which is in the same direction as the arc voltage. This sudden increase in voltage may be of sufficient magnitude to cause the arc to restrike and be carried over to a subsequent current zero more favorable to arc extinction. By the addition of capacitance across the respective pairs of contacts 33 and 35 as afforded by the shield plates 65 to 69, the rate of voltage decrease or collapse across the conducting arc paths is reduced and consequently, the rise in voltage across the unit in which the current was forced to zero will also be decreased. The net result is a synchronization of the deionizing action of the arc paths within the respective interrupting units 53, so as to make more uniform the distribution of voltage across the respective pairs of contacts and thereby insure interruption of the circuit at the first current zero.

Although the disclosure has been directed to a specific shielding structure embodied in the form of condenser plates disposed within the insulating support plates 23, it will be apparent that the same results may be obtained by embodying the shield in the form of a cylinder which may comprise alternate layers of insulation and metal foil. In a structure of this kind, it is contemplated that electrical taps may be brought out from the separate layers of conducting material and connected across the cooperating contact members 27 and 28 in a manner similar to the connections provided by the taps 70 to 74 shown in Figs. 5 and 6.

In Fig. 7, we have shown a modified form of shielding means which is particularly adapted for a different form of arc interrupting assemblage. As shown in this figure, the three arc interrupting units generally indicated at 90 are circular in form and are composed of a plurality of insulating plates 91 having a tubular arc passage 93 contained therein.

Extending within the arc passage 93 of each unit 90 is a fixed contact 95 adapted to cooperate with the moving contact 97, the latter extending through a suitable aperture in the lower end plate 98 of the arc extinguishing unit. The lower end plate 98 is preferably constructed of magnetic material and is provided with an annular recess for the reception of a lower field coil 101. The upper end plate 99 of the unit 90 is also of magnetic material and is provided with an annular recess similar to that within the lower plate 98 in which is positioned an upper field coil 101, one end of which is adapted to be connected to the upper plate 99 and the other end to an arc horn 102 lying in the upper end of the tubular arc passage 93. The lower coil 101 has one end con-

5 nected to a similar arc horn 103 lying in the lower end of the arc passage 93 and has its other end connected to the lower metallic end plate 98. It will thus be seen that when the contacts 95 and 97 separate and the arc is transferred to the arc horns 102 and 103, the arc current will flow in series with the upper and lower coils 101, thereby producing a radial magnetic field across the tubular arc passage 93 so as to rotate the arc laterally between the arc horns within the arc passage until it is extinguished.

10 The circular form of arc interrupting units 90 readily lend themselves to a compact arrangement providing for an actuating rod 105 extending co-axially through the centers of the respective units. The actuating rod 105 is constructed of insulating material and is coupled by suitable linkage mechanisms, generally indicated at 107, to the respective movable contact members 97 by which mechanisms the respective movable contacts are simultaneously actuated.

20 The separate units 90 are adapted to be retained in superimposed spaced relation with respect to each other by means of tie rods 110 extending the length of the entire arc interrupting assemblage. Suitable spacing members 112 are provided to maintain the proper spacing between the units 90. To the upper end of the tie rods 110 is secured a contact foot 114 which, in turn, is adapted to be connected to the lower portion of the breaker terminal 115.

25 The contact foot 114 is provided with an outwardly extending flange 116 to which may be secured a flared metallic shield 117. This shield extends downwardly and flares outwardly and may overlap a considerable portion of the intermediate unit 90. A second shield member 119 also of circular cross-section and having a general frusto-conical shape, is secured at its upper end to the lower metallic end plate 98 of the unit 90 and also to the upper metallic end plate 99 of the middle unit 90, and may partially overlap the lowermost arc interrupting device 90.

30 A third shield member similar in shape to the member 119, is designated at 121. This member makes electrical contact at its upper ends to the lower plate 99 of the intermediate unit 90 and the upper plate 99 of the lowermost unit 90. The lowermost portions of the shields 119 and 121 are provided with enlarged annular portions 123 and 125, respectively, in order to avoid any abrupt edges so as to produce a substantially continuously rounded shield structure.

35 The continuity of the exterior envelope is preserved at the upper portion of the unit by means of an end bell 127 having mechanical and electrical contact with the flange 116 of the contact foot 114. Continuity of the external shielding structure is maintained at the lower end of the arc interrupting assemblage by means of a lower bell-shaped shield 128 mounted as shown to the lower ends of the tie bolts 110.

40 It will be apparent from the foregoing description that the capacitance between the shield members 117 and 119 is directly connected across the cooperating contact members 95 and 97 of the uppermost arc extinguishing unit 90. Likewise, the capacitance between the shield members 119 and 121 is connected across the cooperating pair of contacts in the intermediate unit 90 and the capacitance between the shield 121 and the end bell 128 is connected across the cooperating pair of contacts in the lowermost unit 90. By varying the shape of the respective shield members and the spacing thereof with respect to

each other and the cooperating contact members 95 and 97, it will be apparent that the respective capacitances imposed across these several pairs of contacts may be varied in accordance with predetermined values so as to obtain a desired distribution of voltage across the several pairs of contacts.

45 From the foregoing description, it will now be apparent that by the application of capacitance shielding means to a multiple break circuit interrupter, we have been able to control the voltage distribution in accordance with a predetermined voltage gradient across the several breaks of the circuit interrupter. It has been shown that the desired results may be obtained by reducing the disturbing capacity effects between the floating contact members and ground. By providing capacitance across each of the breaks of the circuit interrupter which is large as compared with the capacitance from the floating contact members forming the breaks to ground, we have also shown that a desirable distribution of voltage can be obtained by the proper arrangement of conducting plates within the supporting structure for the arc extinguishing units.

50 Although we have shown specific contact arrangements within certain arc extinguishing assemblages and particular capacitive shielding arrangements therefor, it is to be understood that the same is for illustrative purposes and changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. In a circuit breaker, a plurality of pairs of separable serially connected contacts, a common actuating member for simultaneously opening said pairs of contacts to produce a plurality of serially connected arcs, a metallic shield member at least partially surrounding each pair of said contacts to shield said contacts from capacity to ground, means for electrically connecting one of the contacts of each pair to its corresponding shield member, the capacity between adjacent shield members being greater than the capacity between any pair of contacts and ground for producing a substantial uniform division of voltage between the several pairs of contacts during at least part of the arc-extinguishing operation and following arc extinction when the breaker is in open circuit position.

2. A circuit breaker comprising a metallic enclosure adapted to be maintained at ground potential, arc interrupting means within said enclosure comprising a plurality of arc interrupting units, each unit including a pair of separable contacts and an arc extinguishing device capable of rapidly deionizing the arc stream, means for connecting said pairs of contacts in series, means for simultaneously separating each pair of contacts to produce a plurality of serially related arcs, and shielding means disposed exteriorly of said arc-interrupting units, said shielding means including a capacitance connected across each pair of contacts, said capacitance being greater in value than the capacitance between each pair of contacts and said enclosure for maintaining uniform the rates of deionization of the arc streams in the respective arc-extinguishing devices.

3. In a circuit breaker, a pair of opposed insulating members, a plurality of pairs of separable contacts supported in spaced relation between said members, means for connecting said contacts in series, a common actuating member

for simultaneously causing the separation of the said pairs of contacts to produce a plurality of serially related arcs, a plurality of conducting members imbedded within each of said insulating members, said conducting members being disposed in capacity relation with respect to each other, and means for connecting two adjacent conducting members within each insulating member across each pair of contacts for controlling the voltage distribution across said pairs of contacts.

4. In a circuit breaker, arc extinguishing means comprising a plurality of arc extinguishing units, each unit including a pair of separable contacts, means for supporting said units in spaced relation with respect to each other, said pairs of contacts being connected in series, means for causing the simultaneous separation of said pairs of contacts to produce a plurality of serially related arcs, and a plurality of metallic shield members surrounding said units and supported thereby in spaced relation with respect to each other, at least two adjacent shield members having an electrical connection to a common connection adjoining adjacent pairs of contacts to provide a capacitance across each pair of contacts for controlling the voltage distribution across said pairs of contacts.

5. In a circuit interrupter, a metallic enclosure, a pair of support members of insulating material mounted within said enclosure, a stack of axially aligned arc extinguishing structures disposed between said support members, each of said structures including a pair of cooperating relatively movable contacts for establishing an arc therein, an operating rod adjacent said stack and movable axially thereof for simultaneously actuating said pairs of contacts, a plurality of conducting members disposed in spaced partially overlapping relation within each of said support members and means for connecting two adjacent conducting members of each support across a pair of cooperating contacts, the capacitance between adjacent conducting members being materially greater than the capacitance between said pairs of contacts and said metallic enclosure.

6. In a circuit interrupter, a metallic enclosure, a stack of axially aligned circular arc extinguishing structures within said enclosure, a pair of relatively movable contacts within each of said structures for establishing an arc therein, each of said structures having an axially aligned opening therethrough, an operating rod movable axially through said opening for actuating said pairs of contacts to open and closed positions, and a plurality of circular metallic shield members surrounding said stack, a plurality of said shield members being flared outwardly at their lower ends and disposed in spaced overlapping relation with respect to each other, at least two adjacent shield members having an electrical connection to a common connection joining adjacent pairs of contacts to provide a capacitance across said pairs of contacts for controlling the voltage distribution thereacross.

7. In a circuit interrupter, a plurality of pairs of separable contacts, means for connecting said contacts in series, common actuating means for simultaneously separating all of said pairs of contacts except one a predetermined distance to form a plurality of serially related arcs and for subsequently separating the remaining pair of contacts a greater distance to provide an insulat-

ing gap capable of withstanding high voltage, and impedance means for controlling the division of voltage between said pairs of separable contacts, said impedance means being connected only across said first-named pairs of contacts to cause a higher potential to appear across said insulating gap formed by said remaining pair of contacts than across any gap formed by said first-named pairs of contacts.

8. In a circuit interrupter, a plurality of pairs of separable arc drawing contacts, means for connecting said contacts in series, common actuating means for simultaneously separating said pairs of arc drawing contacts a predetermined distance to form a plurality of serially related arcs, capacitance means connected across said plurality of pairs of arc drawing contacts for controlling the division of voltage there between, and an additional pair of separable contacts connected in series with said plurality of pairs of simultaneously separable arc drawing contacts, adapted to be separated a distance greater than the separation of said simultaneous separable pairs of arc drawing contacts by said common actuating means subsequent to the opening of said simultaneously actuated arc drawing contacts, said capacitance means causing the greater portion of the total impressed voltage across all of said pairs of contacts to appear across said additional pair of separable contacts when the interrupter is in the open circuit position.

9. In a circuit interrupter, a plurality of pairs of serially connected separable arc drawing contacts, actuating means for simultaneously separating said arc drawing contacts to initiate a plurality of serially connected breaks in the connected circuit, arc-extinguishing means for each of said breaks, an additional pair of contacts in series with said plurality of pairs of arc drawing contacts adapted to be separated subsequent to said plurality of pairs of arc drawing contacts to form an additional break in the connected circuit, and impedance means for controlling the distribution of voltage across all of said breaks, said impedance means being connected across said plurality of pairs of arc drawing contacts for causing a higher voltage to appear across said additional break than across said serially connected breaks.

10. In a circuit interrupter, a plurality of pairs of arc drawing contacts, means connecting said pairs of arc drawing contacts in series, actuating means for simultaneously separating said pairs of arc drawing contacts to establish a plurality of serially related long arcs, an arc-extinguishing unit for each pair of contacts for extinguishing said arcs, an additional pair of contacts connected in series with said arc drawing contacts, said additional pair of contacts being adapted to be separated by said actuating means subsequent to the separation of said arc drawing contacts, and capacitance shielding means surrounding said arc-extinguishing units for controlling the distribution of voltage across all of said pairs of contacts, said capacitance shielding means being connected across said arc drawing contacts to provide a low impedance path as compared with the impedance path between said additional pair of contacts when the interrupter is in the open circuit position.

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