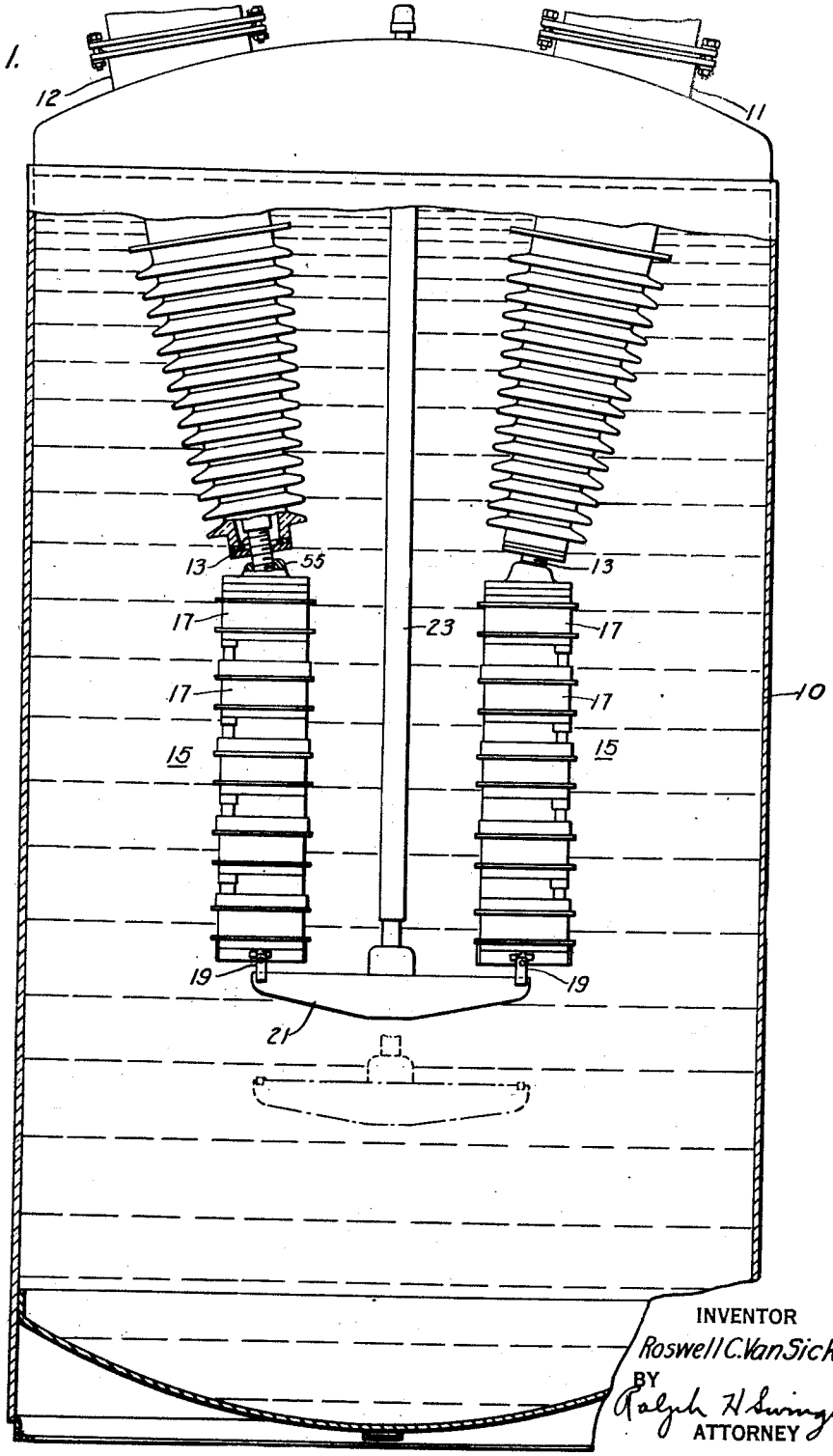
Nov. 29, 1938. R. C. VAN SICKLE 2,138,391

CIRCUIT BREAKER

Filed June 5, 1936 4 Sheets-Sheet 1

Fig. 1.



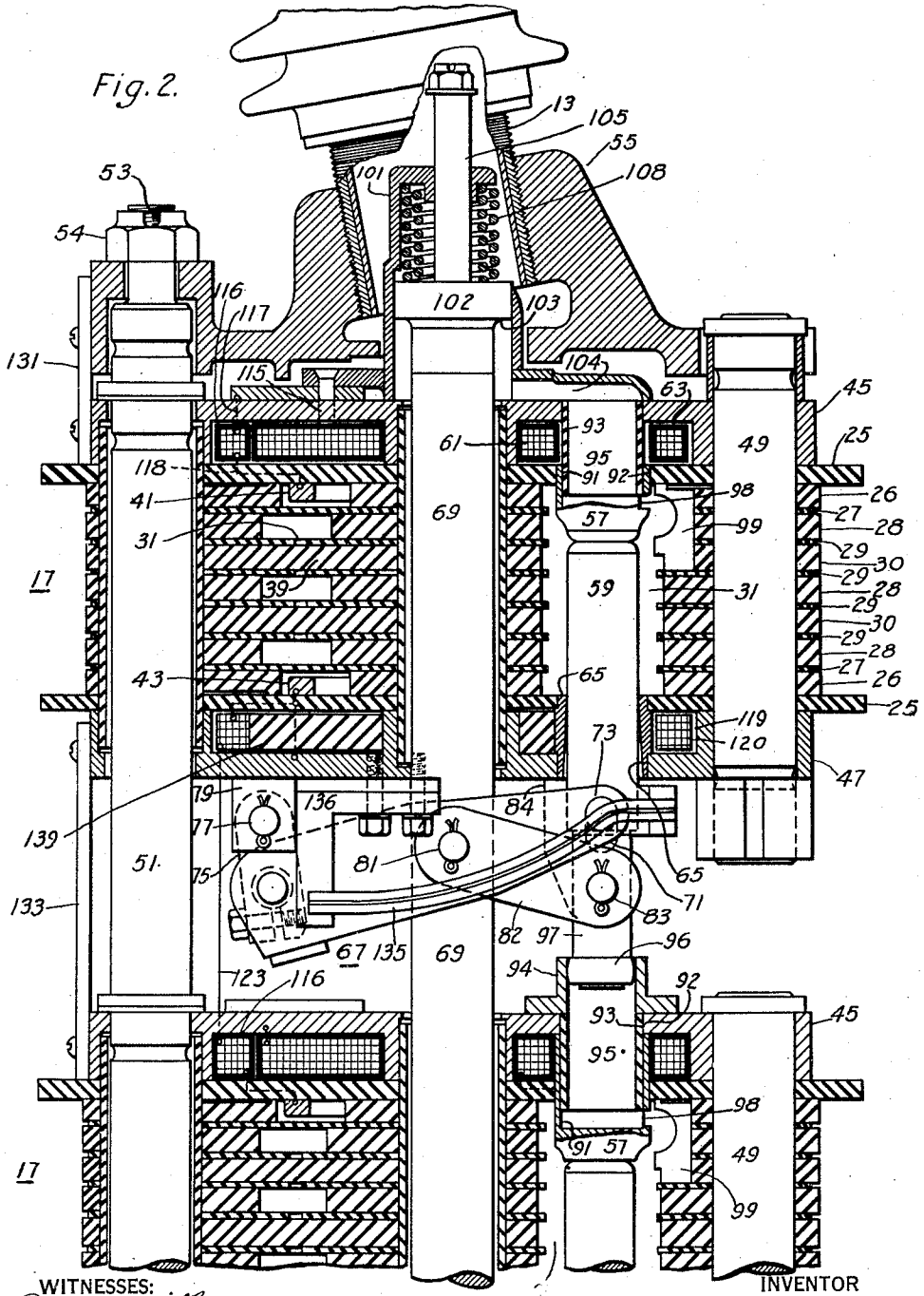
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CIRCUIT BREAKER

Filed June 5, 1936 4 Sheets-Sheet 2

Fig. 2.



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CIRCUIT BREAKER

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Fig. 3.

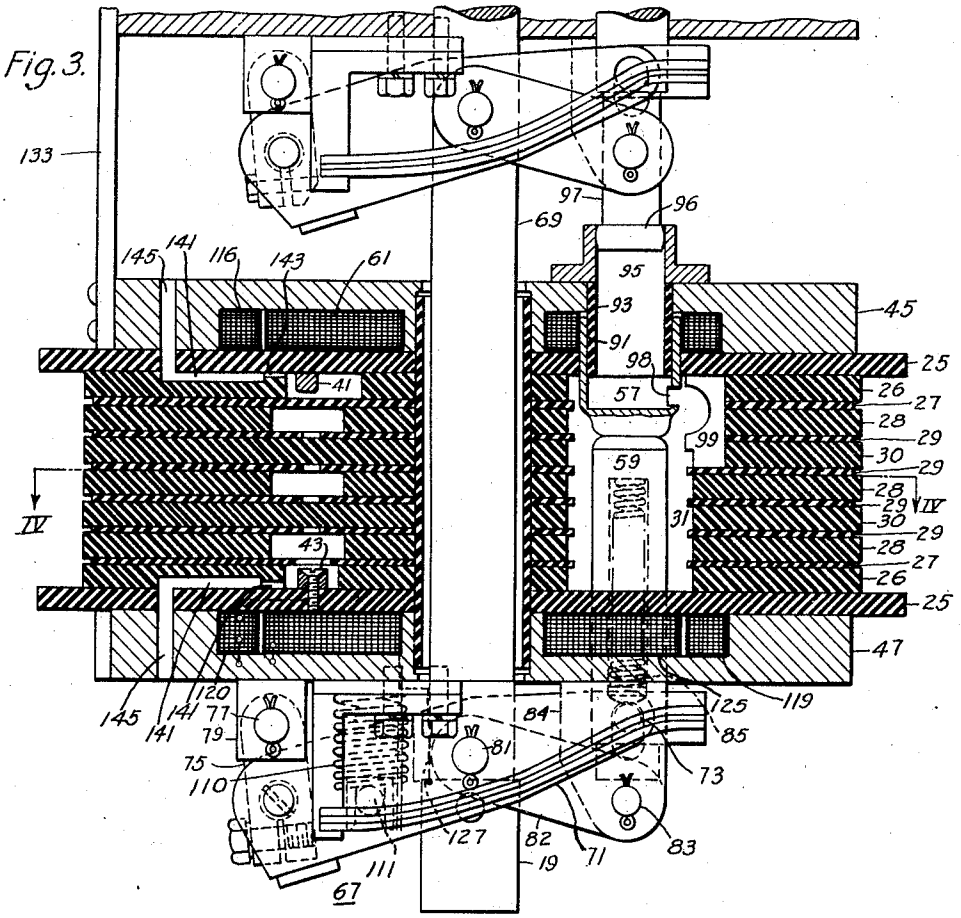
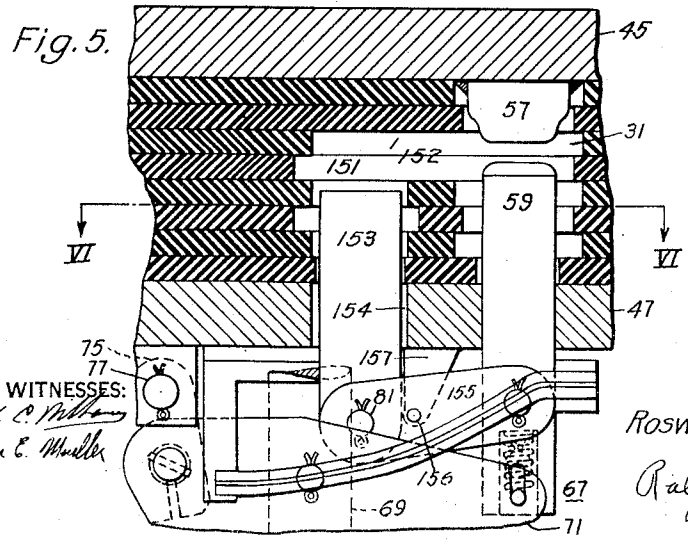


Fig. 5.



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Nov. 29, 1938. R. C. VAN SICKLE 2,138,391

CIRCUIT BREAKER

Filed June 5, 1936 4 Sheets-Sheet 4

Fig. 4.

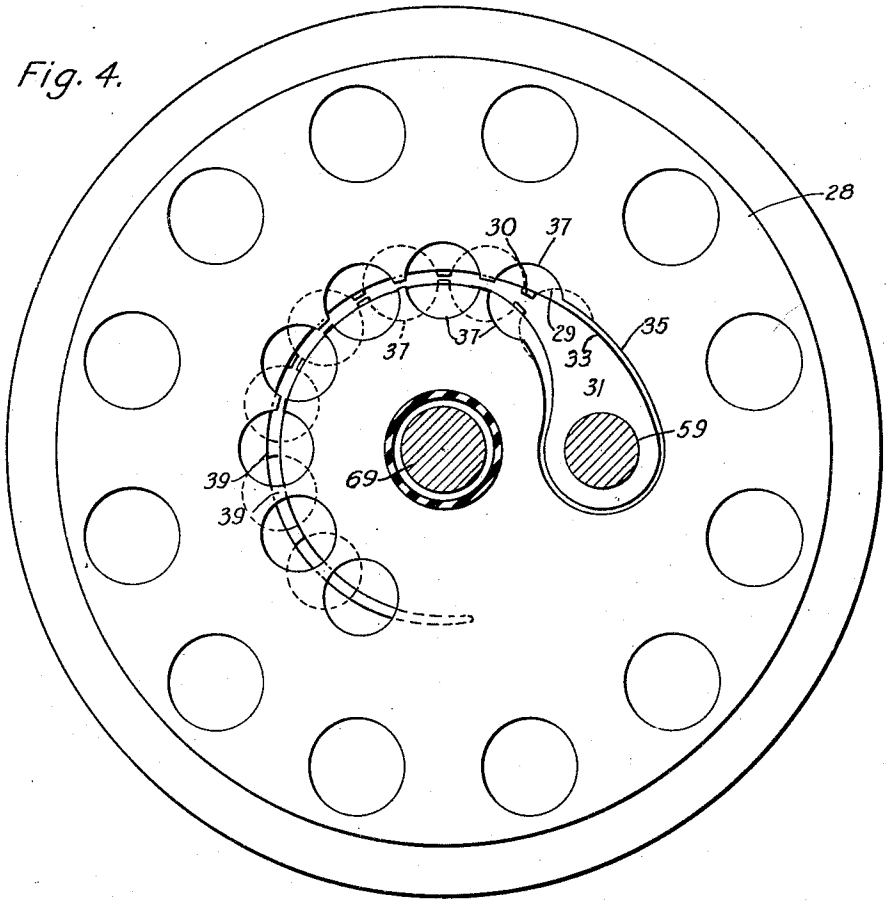
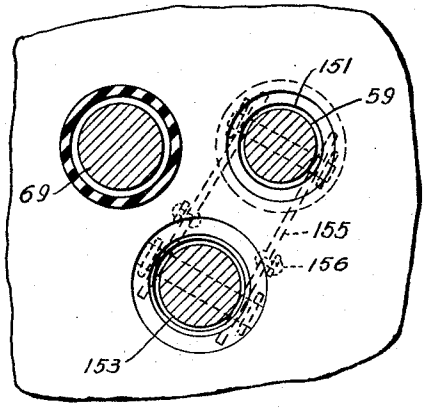


Fig. 6.



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Patented Nov. 29, 1938

2,138,391

UNITED STATES PATENT OFFICE

2,138,391

CIRCUIT BREAKER

Roswell C. Van Sickle, Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application June 5, 1936, Serial No. 83,600

20 Claims. (Cl. 200—150)

This invention relates to circuit breakers, and more particularly to arc extinguishing devices therefor.

More specifically, the invention relates to improvements in an arc extinguishing structure of the type shown and described in the copending application of H. C. Lingal and R. C. Dickinson, Serial No. 743,697, filed September 12, 1934 now Patent No. 2,112,033 issued March 22, 1938 and assigned to the assignee of this application, in which structure an alternating current arc is drawn between a pair of separable contacts positioned in a generally annularly shaped passage defined by a stack of plates of insulating material. The passage has considerable axial length and has an arc terminal at each end thereof to provide a path for the ends of the arc which is adapted to be rotated around the passage by a magnetic field set up radially across the passage. The arc passage is substantially completely enclosed and adapted to be filled with oil or other suitable arc quenching liquid which is readily decomposed when acted upon by an arc to produce a gas which contains a high percentage of relatively cool un-ionized particles. These gas particles are caused to flow through and intermingle with the arc stream so that when it passes through the current zero sufficient deionization will take place to prevent the arc from restriking when the voltage builds up in the opposite direction.

Although one or two reignitions at the current zero is considered good high speed performance for such structures, arc extinguishment at the first current zero is desirable and in fact is possible of attainment. In the copending application of B. P. Baker and W. M. Leeds, Serial No. 82,408, filed May 29, 1936 and assigned to the assignee of this application, a high speed circuit breaker is shown having two arc extinguishing assemblages each comprising a plurality of arc extinguishing units adapted for tandem operation.

The particular arc interrupting structure described in the last named application provides for the production of ten arcs in series with five in each assemblage. The individual arc extinguishing units comprise a generally annularly shaped arc passage in which the separate series related arcs are drawn.

The Baker and Leeds application above referred to deals particularly with magnetic means for moving the arc from the main contacts onto the arcing contacts provided at the ends of the respective arc passages. These magnetic means comprise two sets of coils for each arc extinguishing unit. The first arc moving means comprises a single coil in series with the main and only arc forming contacts which sets up a radial magnetic field across the upper end of the arc passage so as to move the upper end of the arc onto the upper arc horn of each unit.

The second arc moving means comprise a coil adjacent both the upper and lower end of the arc passage, which coils have a larger number of turns and a much smaller thermal capacity than the first mentioned coil. The second coils are adapted to be inserted in the arc circuit upon the transfer of the upper end of the arc of each unit from one of the main contacts onto the arc horn. The second or smaller coils are so arranged and connected that upon the aforesaid transfer of the arc that both of the coils will be energized so that they are jointly operative to produce a strong radial magnetic field for completing the transfer of the arc from the lower main contact onto the lower arc horn and also to rotate the arc along the arc horns at a high velocity.

Inasmuch as the first coil is connected in series with the main current carrying contacts, it must of necessity have a high current carrying capacity and consequently is limited to a small number of turns. The magnetic effect of the coil is, therefore, limited in that the field produced is not of sufficient magnitude to rotate the arc at such velocities as are required for high speed arc extinguishment. The requisite high strength magnetic field is thus provided by the second coil system which gives satisfactory operating results over a wide range of current values.

It has been discovered, however, that particularly on currents of extremely large magnitude that a coil arrangement of this type drives the arc at such a high velocity that it may under certain circumstances reach the end of the arc horns in the passage before it is effectively extinguished.

An improvement in arc extinguishment, particularly for such high current values, has been effected by the particular treatment of the side walls and general shape of the arc passage as more clearly shown and described in the copending application of H. M. Wilcox, Serial No. 83,597, filed concurrently herewith, now Patent No. 2,095,301 issued October 12, 1937 and also assigned to the assignee of this application. In this application, the arc passage has a general shape similar to that disclosed in the aforenamed Baker and Leeds application. However, certain

of the plates providing oil pockets adjacent the arc passage have been constructed with barriers extending transversely of the passage so as to slow up the arc movement prior to its reaching the end of its path of travel, as provided by the arc horns and the arc passage.

Inasmuch as the foregoing improvements deal with an arc extinguishing unit which is substantially enclosed and the extinguishment of an arc therein involves the production of gas by the decomposition of the arc quenching liquid in the passage, attention may advantageously be given to means for permitting the escape of gas thus produced. Each of the foregoing applications covering the several improvements named embody the venting means covered in a copending application of R. C. Dickinson and W. M. Leeds, Serial No. 82,594, filed May 29, 1936, and assigned to the assignee of this application.

Although the features briefly referred to in the aforenamed copending applications when combined provide a highly efficient high speed arc extinguishing structure capable of interrupting loads having a wide range of current magnitude, I have discovered that the operation of such structure may be improved in a number of instances.

It is a known fact that when an attempt is made to close the contacts of a circuit breaker under load, particularly a breaker of the oil type, an arc may be drawn before the contacts engage which vaporizes the oil between the contacts and builds up a pressure which opposes closing. The gas pressure may be high enough to place an additional load upon the levers of the closing mechanism sufficient to cause a resulting deflection of the levers which may permit closing of the mechanism without closing the contacts.

It is, therefore, an object of my invention to provide a circuit breaker of the type above referred to, in which the reactive pressures tending to oppose closing of the contacts under load have been rendered ineffective.

A further object of my invention is to provide means in a circuit breaker of the liquid immersed type in which the pressure created by an arc established between the main contacts during the closing operation under load is utilized to assist in closing the contacts of the breaker.

I have also discovered that inasmuch as the arc passage within the arc extinguishing units of breakers of the type aforesaid are substantially completely enclosed, except for the venting means that the movement of at least one of the main contacts into and out of the arc passage during the opening operation produces a displacement of the oil from the passage. During the opening operation, the high speed withdrawal of the moving contact will leave a space within the passage which may be filled with gas without moving the surrounding oil or raising the gas pressure, thereby somewhat lowering the efficiency of operation of the arc extinguishing device.

A further object, therefore, of my invention is to provide means for avoiding the formation of pockets in the oil which may be produced by high speed movement of the movable contact out of the arc extinguishing passage.

A more specific object of my invention relates to utilizing the last named compensating means during the closing operation of the breaker to supplement the force exerted upon the moving contact by the actuating mechanism in an amount to compensate for the pressure created by the arc tending to oppose the closing of the main movable contact.

An ancillary object of my invention is to provide means within an arc extinguishing structure of the above-named type, in which the movement of the main contact into the arc passage causes the oil to be displaced to a cylindrical chamber provided with a piston operatively associated with the mechanism for moving the main contact member, so that during the opening operation the oil previously displaced during the closing operation will again be returned to the arc passage and fill the space left by the moving contact.

A still further object of the invention consists in means for directing a stream of oil or other arc quenching liquid between the main contacts during the time of separation so as to assist the magnetic field coils in moving the arc from the main contacts on to the arc receiving horns.

Other objects and advantages relate to details of the arc extinguishing structure and will be apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a side elevation view of the circuit breaker of my invention showing the tank thereof partially in cross section,

Fig. 2 is a vertical sectional view taken through the upper portion of one of the arc extinguishing assemblages of the breaker of my invention, showing the uppermost end portion of the next adjacent arc extinguishing unit,

Fig. 3 is a vertical sectional view showing the lowermost arc extinguishing unit of one of the arc extinguishing assemblages of the breaker,

Fig. 4 is a cross sectional view taken along the line IV—IV of Fig. 3, showing the slot-like arc extinguishing passage,

Fig. 5 is a fragmentary vertical sectional view of a modified form of construction of my invention, and

Fig. 6 is a cross sectional view taken along the line VI—VI of Fig. 5.

Referring to the drawings, the reference numeral **10** designates a tank or enclosure in which the arc extinguishing mechanism of my invention is housed. The upper wall of the tank **10** is provided with insulating bushings **11** and **12** for conducting the line terminals **13** interiorly of the tank. To the lower end of each of the line terminals **13** is secured an arc extinguishing assemblage generally indicated at **15**. Each arc extinguishing assemblage **15** comprises a plurality of, in this instance five, arc extinguishing units **17**.

The electrical circuit through each arc assemblage proceeds from the line terminal **13** through a series contact arrangement through each of the units **17** which will be explained more fully hereinafter and terminates with a releasable contact member **19** positioned at the lower end of each of the arc extinguishing assemblages **15**. The two releasable contact members **19** are adapted to be interconnected by a bridging bar **21** which is movable into and out of engagement with the contact members **19** by a lift rod **23**. The lift rod **23** is adapted to be actuated by a suitable mechanism not shown.

Each of the arc extinguishing units **17** is composed of a series of plates of insulating material arranged in contiguous relation to form a stack. This stack comprises plates of various construction indicated in the order from the top down as **25, 26, 27, 28, 29, 30, 29, 28, 29, 30, 29, 28, 27,**

26 and 25. All of the above designated plates with the exception of plates 25 have a curved tapering slot therethrough and the plates are so arranged that the slots are aligned to form an arc passage 31.

The general outline of the arc passage 31 is defined by the thin plates 27 and 29. With particular reference to Fig. 4, the general arrangement of the arc passage 31 can be ascertained in that three of the plates 28, 29 and 30 are shown in superimposed relation. It will be noted that the plate 29 is provided with a wall defining slot 33. Immediately above plate 29 is plate 28, which generally also has a wall defining slot 35. However, the plate 28 is also provided with a plurality of indentures or recesses 37 adjacent each side of the slot 35.

The plate 30 underlying the plate 29 is similar in construction to that of the plate 28 with the exception that the indentures 37 are shifted along the curved slot a distance equal to one-half the width of the indenture. Thus, the passage 31 is provided with pockets formed by the indentures 37 which are arranged in staggered relation along the walls of the passage. Barriers 39 are positioned transversely of the passage 31 for a purpose which will be hereinafter more fully described.

The upper and lower ends of the passage 31 are enclosed by the plates 25. The portions of the upper and lower plates 25 exposed to the passage 31 are adapted to support upper and lower arc horns designated at 41 and 43, respectively. The ends of the stack of insulating plates above described are provided with an upper end plate 45 and a lower end plate 47, each preferably of magnetic material. The end plates 45 and 47 are maintained in clamping engagement with the insulating plates 25 to 30 by means of tie rods 49 of insulating material passing through suitable apertures placed near the circumference of the aforesaid plates.

The units 17 are adapted to be maintained in spaced axial arrangement by means of a plurality of tie rods 51 also passing through suitable apertures adjacent the circumferences of the units. The upper ends of the tie rods 51 are provided with a threaded portion 53 which may be bolted by means of a nut 54, to a contact foot 55 which, in turn, has threaded engagement with the lower end of the line terminal 13. The contact foot 55 provides for suspending the entire arc assemblage 15 from the lower end of the line terminal 13 and in addition provides means for conducting the current from the line terminal to the first or next adjacent arc extinguishing unit 17.

The particular connection will appear more fully in connection with a description of the circuit through the contacts of each arc extinguishing unit 17. The enlarged portion of the passage 31 is adapted to receive a pair of contacts 57 and 59. The contact 57 is fixed and is adapted to be supported from a series coil designated at 61, which, in turn, is embedded in an annular recess 63 provided in the upper magnetic end plate 45. The lower contact 59 is movable through a guide member 65 inserted through the lower insulating plate 25 and the lower magnetic plate 47.

The movable contact 59 is adapted to be coupled by means of a straight line linkage generally indicated at 67 to an operating rod 69 of insulating material which passes centrally through each of the stacks of plates constituting the separate units 17. The straight line linkage mechanism 67 comprises a lever 71 pivoted at one end to the movable contact 59 by means of a pin 73 and pivoted at its other end to a rocking link 75 which, in turn, is pivoted by a pin 77 to a bracket 79 secured to the lower end plate 47.

The lever 71 makes pivotal connection with the operating rod 69 by means of a pin 81. The pin 81 also has pivotal engagement with a stabilizing link 82 which is adapted to rotate about a fixed pivot 83 determined by a bracket 84 secured to the lower edge of the lower end plate 47. It will thus be seen as the operating rod 69 is reciprocated vertically, the movable contact 59 due to its connection through the actuating linkage 67 will be caused to move substantially parallel with the operating rod 69. In order to provide resilient contact pressure between the contacts 57 and 59, a pivotal pin 73 passing through the lower end of the contact 59 is adapted to bear against a spring 85 positioned in a suitable bore, as specifically shown in Fig. 3 within the contact 57. The limited amount of relative movement required between the pin 73 and the contact 59, is obtained by an elongated slot 86 in the contact 59.

It will be understood that each of the contacts 59 in the separate arc extinguishing units 17 are of identical construction and that each of the units 17 may be provided with identical straight line actuating mechanisms 67 which are coupled by pins 81 to the operating rod 69 for simultaneous actuation thereby. Each of the fixed contacts 57 are provided with a cylindrical bore 91, which bore is in registration with a similar bore 92 extending upwardly through the insulating end plate 25 and the metallic end plate 45.

The bore thus provided is lined with an insulating tube 93, the purpose of which will appear hereinafter. The tube 93 provides a cylinder which is co-axial with a guide member 94 secured to the upper metallic end plate 45, to constitute a cylindrical chamber 95. The chamber 95 is adapted to receive a piston 96 secured to an extension 97 mounted on the lower end of the movable contact member 59. The lower end of the cylindrical chamber 95 has an outlet opening 98 provided through the side wall of the fixed contact 57.

It will thus be observed that if the movable contact 59 is moved from the open to the closed position, the piston 96 will be partially withdrawn from the cylindrical chamber 95 and thereby filling the chamber with arc quenching liquid which is contained in the arc passage 31. Also when the movable contact 59 is moved from the closed to the open position, the piston 96 will expel the arc quenching liquid from the chamber 95 through the opening 98 into the arc passage 31.

In order that the liquid ejected from the chamber 95 through the opening 96 may be directed between the contacts 57 and 59, I have provided a deflecting block 99 which may be positioned in suitable notches made in the first five upper plates 26 to 30. It will, of course, be observed that the fixed contact 57 of the uppermost unit 17 has a construction similar to the remaining fixed contacts in that it has been provided with a cylindrical chamber 95. This chamber does not receive a piston 96 in that there is no movable contact 59 immediately above, whereby such piston would be actuated.

In order to create a flow of arc quenching liquid through the upper contact 57 of the uppermost unit, further provisions have been made which consist in providing a cylindrical chamber

101 upon the upper magnetic end plate 45 of the uppermost unit 17. The cylindrical member 101 is coaxial with respect to the operating rod 69 and is adapted to receive a piston 102 secured to the end of the operating rod. The area on the lower side of the piston between the rod 69 and the outer circumference of the piston 102 designated at 103 is effective in forcing oil from within the cylindrical member 101 through a passage 104 to the cylindrical chamber 95 of the upper contact 57. The upper end of the piston 102 is also provided with a guide pin 105 extending through the upper end of the cylindrical member 101 which also serves as a guide member for the operating rod 69.

In order to assist or to accelerate the opening movement of the operating rod 69, that is, a movement in a downward direction, the pair of accelerating springs designated 108 are provided between the end of the cylindrical member 101 and the piston 102. The initial acceleration of the operating mechanism is supplemented by the springs 85 in each movable contact 59. The downward or opening movement of the operating rod 69 and consequently the movable contact 59 is aided, as shown in Fig. 3, by a coil spring 110 having one end in engagement with the lower metallic end plate 47 and its other end engaging a coupling pin 111 passing through the operating lever 71 of the straight line linkage 67. Although this construction, for the sake of simplicity is only illustrated in Fig. 3, it is to be understood that the spring 110 is utilized in each of the straight line operating linkages 67 of each unit. It will also appear that inasmuch as a piston 96 attached by means of the extension 97 to the movable contact member 59 in the arrangement shown would serve no useful purpose in the lowermost unit 17, as shown in Fig. 3, such piston and extension may be omitted.

The magnetic arc moving means whereby the arc is transferred from the contacts 57, 59 onto the upper and lower arc horns 41 and 43 are similar to that described in the aforementioned copending application of B. P. Baker and W. M. Leeds.

The coil 61 which has been previously referred to is preferably one of high current carrying capacity having a few number of turns. One end of the coil 61, as before mentioned, is connected to the upper contact 57, whereas the other end of the coil 61 has connection as by a screw 115 to the upper end plate 45. The annular recess 63 in the upper magnetic end plate 45 also contains a coil designated at 116. The coil 116 has a larger number of turns than the coil 61 and has one end thereof connected, as shown in Figs. 2 and 3, by a dotted connection 117 to the upper end plate 45.

The other end of the coil 116 is connected, as shown by the dotted connection 118 to the arc horn 41. The lower end plate 47 of each unit also has an annular recess 119 which is similar to the recess 63 in the upper end plate 45. The recess 119 houses a coil 120 similar to the coil 116 in the upper end plate 45. One end of the coil 120 is connected to the lower arc horn 43 which, in turn, is connected to the lower end plate 47. The other end of the coil 120 is connected by the conductor 123 to one end of the coil 116 in the upper end plate 45 of the next lower unit 17.

The respective coils 61, 116 and 120 of each of the units 17 are similarly connected with the exception of the coils in the lowermost unit 17. As shown in Fig. 3, two series coils are employed in the lowermost unit 17. The upper coil 61, as well as the upper coil 116, are similar in arrangement and connected as in the preceding units. The annular recess 119 in the lower end plate 47 of the lowermost unit in addition to housing the coil 120 also has a series coil 125 which is similar to the coil 61 in the upper end plate 45, it differing from the coil 61 only in its connections. Since the coil 125 is positioned in the lower end plate 47, means are provided as an aperture to allow the free passage of the movable electrode 59. One end of the coil 125 is connected by the lead 127 to the releasable contact 19 which, in turn, is secured to the lower end of the operating rod 69.

The other end of the coil 125 is connected to the lower end plate 47. One end of the coil 120 is connected by a lead 129 to the lower arc horn 43. The other end of the coil 120 is connected to the end plate 47. In order to make electrical connection from the terminal 13 to the first arc extinguishing unit 17, the connecting strip 131 is provided which bridges the contact foot 55 and the upper end plate 45 of the uppermost unit. Succeeding units are adapted to be electrically connected by a bridging connector 133, respectively joining the lower end plate 47 of one unit with the adjacent upper end plate 45 of the next adjacent unit. The complete electrical circuit through each of the arc extinguishing assemblages 15 for the various positions of the electrode and arc with respect to the electrodes and the arc receiving horns will now be considered.

When the electrodes are in the closed position, as shown in Figs. 2 and 3, the circuit from the incoming line terminal 13 proceeds to the contact foot 55, the bridging connection 131 to the upper magnetic end plate 45 through the connection 115 to the coil 61 from the other end of the coil 61 to the upper fixed contact 57. The movable contact 59 through a flexible shunt 135 connecting the movable contact 59 to the lower end plate 47 through a bracket 136 connected thereto. From the lower end plate 47, the circuit proceeds through the bridging connector 133 to the upper end plate 45 of the next lower unit through which, and also through the succeeding units, the circuit repeats itself until it reaches the lower end plate 47 of the lowermost unit.

From the lower end plate 47 of the lowermost unit 17, the circuit proceeds through the series coil 125 and from thence to the connection 127 to the releasable contact 19. It will, of course, be understood that the circuit through the other arc extinguishing assemblage 15 is the same as that previously described, and that the connection between the two assemblages 15 is obtained by the bridging bar 21 making contact with the two releasable contacts 19.

From the foregoing circuit connection, it will be observed that the current flowing through the series coils 61 will produce a radial magnetic field which is augmented by the upper magnetic end plate 45 and caused to be directed radially across the upper end of the passage 31. The action of the radial magnetic field thus produced in each of the units 17 will cause the upper end of an arc drawn, as a result of the opening of contacts 57 and 59, to be moved onto the upper arc horn 41.

As the upper arc horn 41 is engaged by the arc, the electrical connection through the arc assemblage is as follows. The line terminal 13, contact foot 55, connection 131, upper end plate 45, connection 117, coil 116, connection 118, upper

arc horn 41, movable contact member 59, flexible shunt 135, bracket 136, lower end plate 47, lower coil 120, connection 123, to the upper coil 116 of the next lower unit 17 from whence the circuit repeats for all succeeding units.

It will be observed that as soon as the upper end of the arc produced between each of the contacts 57 and 59 shifts to the upper arc horn 41 the upper coil 116, as well as the lower coil 120 of each unit, will be inserted into the arc circuit since the lower coil 120 and the upper coil 116 of a next lower unit are connected in series. With the exception of the lowermost unit 17, the lower coil 120 is not as yet inserted into the arc circuit. The reason that it is not inserted in the circuit is that in all preceding units the lower coil 120 is connected in series with the upper coil 116 of the next lower unit. Since there is no coil 116 with which the lower coil 120 of the lowermost unit 17 may be connected in series, the energization of such coil 120 must be deferred until complete transfer of the arc onto the lower horn 43. The advantage of having the lower coil 120 energized by the energization of the upper coil 116 of a next lower unit is that the joint action of the two coils is obtained more quickly than if the lower coil were inserted by the transfer of the arc to the lower horn which is in a less favorable position for arc transfer.

It will be noted, however, that the lower end of the arc passage of the lowermost unit 17 is not without a magnetic field since there is provided a series coil 125 which is at all times in series with the arc circuit and hence provides the necessary field to initially move the arc from the moving contact 59 onto the lower arc horn 43.

It will be noted that the series connection of the lower coil 120 of one unit with the upper coil 116 of the next adjacent unit 17 eliminates the necessity of providing a series coil similar to coil 125 in the lower end plates 47 of the four units 17 preceding the lowermost unit. The final circuit through the arc extinguishing assemblage 15, that is, when the arc is completely transferred to the arc horns 41 and 43, is as follows. Terminal 13, contact foot 55, bridging connection 131, the upper end plate 45, connection 117, coil 116, connection 118, arc horn 41, arc horn 43, coil 120, connection 123 and to the coil 116 of the next unit 17 from whence the circuit precedes through succeeding units until it reaches the lower arc horn 43 of the lowermost unit 17.

From this arc horn the circuit proceeds through the coil 120 the coil 125, the connection 127 which terminates at the releasable contact 19. In order to maintain the magnetic characteristics of both end plates 45 and 47 the same, the annular recess 119 in the lower end plate 47 is constructed to the same dimensions as the upper annular recess 63. The space which would ordinarily be occupied by a lower series coil 125 in the first four units of the arc extinguishing assemblage in the annular recess 119 is filled in with an annular plate of insulating material designated at 139.

The foregoing arrangement of coil connections for producing the radial magnetic field for arc movement from the main contacts 57 and 59 onto the arc horns 41 and 43 is particularly adapted for the transfer of arcs of varying current magnitude. The continuous energization of the series coils 61 and 125 during the time that the contacts 57 and 59 are closed, supply a ready field so that as soon as these contacts open at least the upper end of the arc in all of the units 17 will be transferred onto the upper arc horn.

Although a comparatively low magnetic field is required for moving arcs of high current magnitude onto the arc horns, some difficulty may be experienced in obtaining movement of arcs onto the arc horns of arcs having extremely low current values. By arranging the fixed contacts 57 with a cylindrical chamber 95 and providing pistons 96 made operative therein by the movement of an immediately adjacent movable contact 59, then directing fluid contained in the cylindrical chamber 95 through the openings 98 during the opening movement of the contacts and directing the stream of liquid thus ejected by means of a deflecting member 99 between the fixed and moving contacts, arc movement from these contacts onto the arc horns is rendered more positive.

The prime function, however, of the hollow fixed contacts 57 and the pistons 96 contained therein is to provide means for balancing the force exerted upon the movable contacts 59 due to pressure created within the passage 31 caused by an arc during the closing operation of the movable contacts 59 under load. From Figs. 2 and 3 it will be apparent that the pressure in passage 31 created by an arc during the closing operation of the movable contacts 59 will react through the passage 98 into the cylindrical chamber 95 and exert a force upon the lower surface of each piston 96.

Thus if the lower areas of each of the pistons 96 are equal to the upper contact area of the contacts 59, and since there are only four cylindrical chambers 95 with pistons 96 therein without further provision for balancing the pressure in the uppermost passage 31, complete balance of the force at the contacts preventing closure would not be obtained. In order to obtain a complete balance of these forces, the pressure in the uppermost unit 17 is permitted to react through the passage 104 against the lower or effective area 103 of the piston 102 secured to the end of the operating rod 69.

It will be apparent that by properly proportioning the area 103, the difference in the moment arm may be accounted for so as to give the entire system of contacts absolute balance during the closing operation under conditions of load. However, in the event that it would not be desirable to provide for balancing means exteriorly of the upper grid unit 17, the balance of the entire system could be obtained by changing the ratio of the areas of the pistons 96 with respect to the areas of the contacts 59. Since five arc extinguishing units 17 are shown, and assuming that the pressure in each of the passages 31 of each unit is the same, the ratio of area of the pistons 96 to the area of the contacts 59 would have have to be

$$\frac{N}{N-1}$$

where N is the total number of arc extinguishing units.

From the foregoing description, it will readily be seen that the hollow fixed contact arrangement provided with a piston 96 also avoids the formation of pockets or void spaces in the arc extinguishing liquid during the opening operation of the fixed contacts 59. As the movable contact 59 moves into the passage 31 and the piston 96 of the corresponding contact 57 moves upwardly, the quantity of liquid displaced by the contact 59 will be caused to flow into the cylindrical chamber 95.

During the opening operation, as the movable

contact 59 recedes from the passage 31, the space formerly occupied by it will be filled with oil forced from the chamber 95, thereby tending to maintain the arc space between the contacts filled at the outset of the arc extinguishing operation. It will also be remembered that the expulsion of the oil from the chamber 95 by the piston 96 assists in moving the arc from off the electrodes 57 and 59 onto the arc horns 41 and 43.

The gas formed during arc extinguishment within the passage 31 is permitted to escape through suitable vent passages provided at the upper and lower ends of the passage adjacent the arc horns. The vent means, as shown more clearly in Fig. 3, and more fully shown and described in a copending application of R. C. Dickinson and W. M. Leeds, Serial No. 82,594, filed May 29, 1936, and assigned to the assignee of this application, comprises an annularly shaped chamber 141 substantially concentric with the passage 31 and positioned in the upper end of the upper plate 26 and the lower end of the lower plate 26, which chamber communicates with the passage 31 by means of ports 143. The chamber 141 is connected with an opening 145 passing axially through the end plates 45 and 25 at the upper end of the unit, and also through the plates 47 and 25 at the lower end of the unit.

In Figs. 5 and 6, a modified arrangement is shown wherein compensation for the force exerted upon the movable contact may be had during the closing thereof under load. As illustrated in these figures, the arc passage 31 is enlarged in that it includes a cylindrical passage 151 adjacent the movable contact 59. The chamber 151 communicates with the passage 31 by a passage 152. A piston 153 is adapted to extend into the chamber 151 through an aperture 154 in the lower end plate 47. The piston 153 is coupled by a link 155 pivoted intermediate its end at 156 to a bracket 157 secured to the lower end plate 47. A suitable operating mechanism similar to that shown at 67 in the previous figures, may also be employed to actuate the movable contact 59. It will be observed from these figures that any pressure created within the chamber 31 caused by an arc due to the closure of the contacts 57 and 59 will react upon the piston 153 through the connecting link 155 and tend to assist the closing of the contact 59. By apportioning the area of the piston 153 and the contact 59 inversely with respect to the moment arms about their pivotal connection 156, exact balance can be obtained.

It will also be observed that as the contact 59 moves into the passage 31 into contacting engagement with the fixed contact 57, the piston 153 will be withdrawn from the passage 31, thereby preventing the liquid within the passage 31 from being forced therefrom. Also when the contact 59 is withdrawn from the passage, the plunger 153 will be forced farther into the passage, therefore, preventing the formation of pockets or void spaces in arc extinguishing liquid within the passage 31 between the electrodes.

The arrangement shown in Figs. 5 and 6 is also useful in providing the flow of oil between the contacts 57 and 59 as a result of the piston 153 during the opening operation in order to assist the magnetic field coils in moving the arc from the contacts onto the arc horns.

It will be observed that the modifications shown in Figs. 5 and 6 may be particularly adapted to a circuit breaker embodying two arc extinguishing units singly. That is, a construction in which each line terminal 13 supports but one arc extinguishing unit. It is also apparent that the construction of Figs. 5 and 6 when embodied in a multiple unit, as shown in the preceding figures, may be arranged for completely balanced conditions in each unit independently of the other units.

From the foregoing description, it will be apparent that I have provided a circuit breaker embodying a multiple break arc extinguishing structure in which provision has been made to compensate for the reactive forces exerted upon the moving contacts caused by pressure due to the formation of an arc during closure of the contacts under load which forces oppose the closing of the contacts. I have shown how such compensation may effectively be obtained for both multiple and single arc extinguishing unit structures. The foregoing also discloses wherein the compensating arrangement is made to function as a means to assist arc transfer from the main electrodes to suitable arc receiving terminals. A further function of such arrangement is directed to the prevention of void spaces between the fixed and movable contacts upon the rapid separation of these contacts thereby increasing the arc extinguishing efficiency of the structure.

Although a number of specific arc extinguishing structures have been particularly described as for instance arc extinguishing units having annularly shaped arc passages therein, it is to be understood that the same is for purposes of illustration and that the pressure balancing arrangement herein disclosed may be used with equal effect in arc extinguishers of different form. I, therefore, do not wish to be limited by the foregoing as many changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. In a circuit breaker, an arc extinguishing device comprising means for defining an arc passage, an arc extinguishing liquid within said passage, a pair of contacts having engageable contact surfaces within said passage, at least one of said contacts having a portion projecting exteriorly of said passage, means associated with said exteriorly projecting portion and moving the said one contact into and out of engagement with the other contact, a movable member having a portion within and a portion without said passage, and a linkage connecting said movable member with said movable contact arranged to operate the member in a direction opposite to the movement of said movable contact to compensate for the displacement of liquid within said passage caused by the movement of said movable contact.

2. In a circuit breaker, an arc extinguishing device comprising means for defining an arc chamber, an arc extinguishing liquid within said chamber, a pair of contacts having engageable contact surfaces within said chamber, at least one of said contacts having a portion projecting exteriorly of said chamber, actuating means operatively connected to said contact portion exteriorly of said chamber for moving said one contact into and out of engagement with the other contact and means responsive to the pressure within said arc chamber produced by an arc between the contacts during the closing operation thereof under conditions of load and operatively coupled to said actuating means for exerting a force on the latter which opposes the force exerted thereon by the

pressure within said arc chamber acting upon said movable contact.

3. In a circuit breaker, an arc extinguishing device comprising means for defining an arc passage, an arc extinguishing liquid within said passage which gives off a gas when acted upon by an arc, a pair of contacts having engageable contact surfaces within said passage, at least one of said contacts being movable into and out of engagement with the other of said contacts, said movable contact member being subjected to a force caused by the gas pressure produced by an arc between the contacts during the operation thereof under conditions of load, said force acting in a direction to move said movable contact to the open position, a movable member within said passage also subjected to a force caused by said gas pressure, and means for operatively connecting said movable member with said movable contact, said connecting means being arranged to cause the force exerted upon said movable member to compensate the force exerted upon said movable contact.

4. In a circuit breaker, a plurality of arc extinguishing units arranged end to end, each unit comprising means of insulating material for defining a substantially closed arc passage, arc quenching liquid in each of said passages, a pair of separable contacts in each passage, common actuating means for simultaneously actuating said pairs of contacts either to open or closed positions, and means associated with each unit operatively coupled to said actuating means and responsive to the pressure within each of said passages to balance the reactive forces resulting from the action of said pressure in each of said passages upon said contacts.

5. In a circuit breaker, a plurality of arc extinguishing units arranged end to end, each unit comprising means of insulating material for defining a substantially closed arc passage, arc quenching liquid in each of said passages, which gives off a gas when acted upon by an arc, a pair of contacts in each of said passages, common actuating means connecting one of said contacts of each pair in tandem for simultaneous operation of the contacts so connected to open and closed positions, said movable contacts being subjected to a force caused by the gas pressure produced within each passage by an arc between the contacts during the closing operation thereof under load, said force opposing the force applied to said actuating means for closing said contacts, and means utilizing the pressure within each passage to exert a force upon said movable contacts in the direction of that applied by said actuating means to offset the force tending to prevent contact closure.

6. In a circuit breaker, a plurality of arc extinguishing units arranged end to end in spaced relation, each of said units comprising means of insulating material for defining a substantially enclosed arc passage, a fixed contact member in each of said passages, a movable contact member extending into each of said passages, said fixed and said movable contact members being arranged end to end in axial alignment, one end of said movable contact member being adapted to make contacting engagement with its cooperating fixed contact member, the other end of each of said movable contact members serving as a piston, said fixed contact members having a cylindrical bore therein open at one end for operatively receiving the piston of a movable contact member of a unit next adjacent, the other end of the bore in each of said fixed contacts having an opening leading into the arc passage of its respective unit, an arc quenching liquid within each of said passages, and actuating means for operatively connecting said movable contact members in tandem for simultaneously operating said members to open and closed positions to cause an alternate flow of liquid between said passages and their corresponding fixed contacts.

7. In a circuit breaker, a plurality of arc extinguishing units arranged end to end in spaced relation, each of said units comprising means of insulating material for defining a substantially enclosed arc passage, a fixed contact member in each of said passages, a movable contact member extending into each of said passages, said fixed and said movable contact members being arranged end to end in axial alignment, one end of said movable contact member being adapted to make contacting engagement with its cooperating fixed contact member, the other end of each of said movable contact members serving as a piston, said fixed contact members having a cylindrical bore therein open at one end for operatively receiving the piston of a movable contact member of a unit next adjacent, the other end of the bore in each of said fixed contacts having an opening leading into the arc passage of its respective unit, an arc quenching liquid within each of said passages, and actuating means for operatively connecting said movable contact members in tandem for simultaneously operating said members to open and closed positions to cause an alternate flow of liquid between said passages and their corresponding fixed contacts, and means for directing the liquid displaced from said fixed contact members during the opening operation of said movable contact members between said fixed and movable contact members.

8. In a circuit breaker, an arc extinguishing assemblage comprising a plurality of arc extinguishing units arranged end to end in spaced relation, each of said units comprising means of insulating material for defining the walls of a narrow arc passage, a fixed contact in the upper end of each unit, a movable cooperating contact for each unit movable through the lower ends of said units, said contacts being arranged end to end in axial alignment, actuating means coupling said movable contacts together for tandem operation, at least one of said fixed contacts of an intermediate unit having a cylindrical bore therein open at its outer end for operatively receiving a piston, said fixed contact having an opening adjacent its other end connecting the cylindrical bore and the arc passage, a liquid in said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, said piston being adapted to be actuated by and simultaneously with a movable contact of a unit next adjacent for drawing liquid from said passage into the fixed contact during the closing operation of the movable contact and for expelling the liquid from the fixed contact between the fixed and movable contacts during the opening operation thereof, said piston being adapted to utilize the pressure created within said passage caused by an arc due to closing the contacts under load to produce a force to oppose the force produced by said pressure acting upon the movable contact.

9. In a circuit breaker, means of insulating material defining the walls of a generally annularly shaped arc passage, a fixed and a movable contact member for drawing an arc longitudinally of said passage, means for setting up a radial magnetic

field for rotating said arc around said passage, a liquid within said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and means operatively coupled to said movable contact utilizing the pressure created by an arc upon closing the electrodes under load for assisting the closing of said movable contact against said pressure, said last named means being operative during the opening operation of said movable contact to cause a flow of liquid against the arc to assist said magnetic field in moving the arc.

10. In a circuit breaker, an arc extinguishing assemblage comprising a plurality of arc extinguishing units arranged end to end in spaced relation, each unit comprising means of insulating material for defining the walls of a generally annularly shaped arc passage, a liquid in each of said passages which gives off a gas when acted upon by an arc to aid in extinguishing the arc, a hollow fixed contact in each unit having an opening leading from within the contact to said passage to conduct liquid from said passage to said contact, a piston operative in said hollow contact, a movable contact adapted for contacting engagement with said hollow contact for establishing an arc within each of said passages, arc terminals within each passage for receiving the ends of the arc established therein, means for setting up a radial magnetic field across each passage to rotate each arc therearound, actuating means coupling said movable contacts for tandem operation, means operatively coupling said pistons for simultaneous operation with said movable contacts, said pistons being adapted to squirt liquid between the fixed and movable contacts against the arcs during the opening operation of said movable contacts to assist in moving the arcs onto said arc terminals, said pistons being adapted to utilize the pressure created by arcs within each passage upon closing the electrodes under load for assisting the closing of said movable contacts against the pressures created in each of said passages.

11. In a circuit breaker, means of insulating material defining the walls of a generally annularly shaped substantially enclosed arc chamber, a fixed and a movable contact member for drawing an arc longitudinally of said passage, means for setting up a radial magnetic field for rotating said arc around said passage, a liquid within said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, actuating means for operating said movable contact to open and closed positions, a passage communicating with said arc chamber, a piston in said passage operatively coupled to said actuating means and responsive to the pressure in the arc chamber to balance the reactive force resulting from the action of said pressure upon said movable contact, said piston being positively actuated by said actuating means during the opening movement of said movable contact to cause a flow of liquid against the arc to assist the magnetic field in moving the arc.

12. In a circuit breaker, means of insulating material for defining the walls of a generally annularly shaped substantially enclosed arc passage, a liquid in said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, a hollow fixed contact within said passage having an opening communicating with said passage, a piston operating in said hollow contact, a movable contact adapted to cooperate with said fixed contact for establishing an arc within said passage, means for setting up a radial magnetic field across said passage for moving the arc therealong, a linkage for simultaneously actuating said piston and said movable contact, said piston causing a stream of arc-extinguishing liquid to be injected into said passage during the opening movement of said movable contact, and means for directing said stream of liquid between said contacts to aid the magnetic field in moving the arc, said piston being operable through said linkage in response to pressure within said arc passage to balance the reactive force due to said pressure upon said movable contact.

13. In a circuit breaker, an arc-extinguishing unit comprising means of insulating material for defining a substantially enclosed arc passage, a fixed contact member in said passage, a movable contact member extending into said passage, said fixed and said movable contact members being arranged end to end in axial alignment, one end of said movable contact member being adapted to make contacting engagement with a cooperating portion of said fixed contact member, said fixed contact member having a cylindrical bore therein open at one end, a piston operative in said bore, the other end of said bore having an opening leading into said passage, an arc-quenching liquid within said passage and actuating means for operatively connecting said movable contact and said piston in tandem for operating said movable contact to open and closed positions and to simultaneously cause an alternate flow of liquid between said passage and the bore of said fixed contact.

14. In a circuit breaker, an arc-extinguishing unit comprising means of insulating material for defining a substantially enclosed arc passage, a fixed contact member in said passage, a movable contact member extending into said passage, said fixed and said movable contact members being arranged end to end in axial alignment, one end of said movable contact member being adapted to make contacting engagement with a cooperating portion of said fixed contact member, said fixed contact member having a cylindrical bore therein open at one end, a piston operative in said bore, the other end of said bore having an opening leading into said passage, an arc-quenching liquid within said passage and actuating means for operatively connecting said movable contact and said piston in tandem for operating said movable contact to open and closed positions and to simultaneously cause an alternate flow of liquid between said passage and the bore of said fixed contact, and means for directing the liquid displaced from said fixed contact member during the opening operation of said movable contact member between said contact members.

15. In a circuit breaker, an arc-extinguishing unit comprising means of insulating material for defining the walls of a narrow arc passage, a fixed contact in the upper end of said unit, a movable cooperating contact for said unit movable through the lower end thereof, said contacts being arranged end to end in axial alignment, actuating means for moving said movable contact to open and closed positions, said fixed contact having a cylindrical bore therein open at its outer end for operatively receiving a piston, said fixed contact having an opening adjacent its other end for connecting the cylindrical bore and the arc passage, a liquid in said passage which gives off a gas when acted upon by an arc to aid

in extinguishing the arc, said piston being adapted to be actuated by said actuating means and simultaneously with said movable contact for drawing liquid from said passage into the fixed contact during the closing operation of the movable contact and for expelling the liquid from the fixed contact between the fixed and movable contacts, during the opening operation thereof, said piston being adapted to utilize the pressure created within said passage caused by an arc due to closing the contacts under load to produce a force to oppose the force produced by said pressure acting upon the movable contact.

16. In a circuit breaker, an arc-extinguishing unit comprising means of insulating material for defining the walls of a generally annularly shaped arc passage, a liquid in said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, a hollow fixed contact in said unit having an opening leading from within the contact to said passage to conduct liquid from the passage to within said contact, a piston operative in said hollow contact, a movable contact adapted for contacting engagement with said hollow contact for establishing an arc within said passage, arc terminals within said passage for receiving the ends of the arc established therein, means for setting up a radial magnetic field across said passage to rotate the arc therearound, actuating means coupling said movable contact and said piston for simultaneous operation, said piston being adapted to squirt liquid between the fixed and movable contacts against the arc during the opening operation of said movable contact to assist in moving the arc onto said arc terminals, said piston being adapted to utilize the pressure created by an arc within said passage upon closing the contacts under load for assisting the closing movement of said movable contact against the pressure created in said arc passage.

17. In a circuit breaker, means of insulating material defining the walls of a generally annularly shaped arc passage, a pair of separable contacts for drawing an arc longitudinally of said passage, actuating means for at least one of said contacts, means for setting up a radial magnetic field for rotating said arc around said passage, a liquid within said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and means actuated by said actuating means for moving an additional quantity of liquid between said contacts to assist said magnetic field in moving the arc laterally along said passage.

18. In a circuit breaker, means of insulating material defining the walls of a generally annularly shaped arc passage, an arc horn of generally annular shape disposed at each end of said arc passage, a pair of separable contacts for establishing an arc longitudinally of said passage, actuating means for at least one of said contacts, means for setting up a radial magnetic field for moving said arc laterally along said passage between said arc horns, a liquid within said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and means actuated by said contact actuating means during the opening movement of said contacts for producing a flow of liquid against the arc to assist said magnetic field in moving the arc from between said contacts onto said arc horns.

19. In a circuit breaker, means of insulating material defining the walls of a generally annularly shaped arc passage, a pair of separable contacts for drawing an arc longitudinally of said passage, at least one of said contacts being movable axially through one wall of said arc passage, actuating means for said one contact, means for setting up a radial magnetic field for rotating said arc around said passage, a liquid within said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, means actuated by said contact actuating means during the opening movement of said contacts for injecting an additional quantity of liquid into said passage to restrict the gas pocket between said contacts, and vent means disposed along said passage for the escape of gas therefrom, the initial gas flow through said vent means and said liquid flow assisting said magnetic field to move the arc along said passage.

20. In a circuit breaker, a plurality of arc extinguishing units, each unit comprising means of insulating material for defining a substantially closed arc passage, arc quenching liquid in each of said passages, a pair of separable contacts in each passage, common actuating means for simultaneously actuating said pairs of contacts either to open or closed positions and means associated with at least one of said units operatively coupled to said actuating means and responsive to the pressure within the arc passage of said one unit to counteract the reactive forces resulting from action of the pressure within each of said passages upon said contacts.

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