

Nov. 22, 1938.

R. C. DICKINSON ET AL

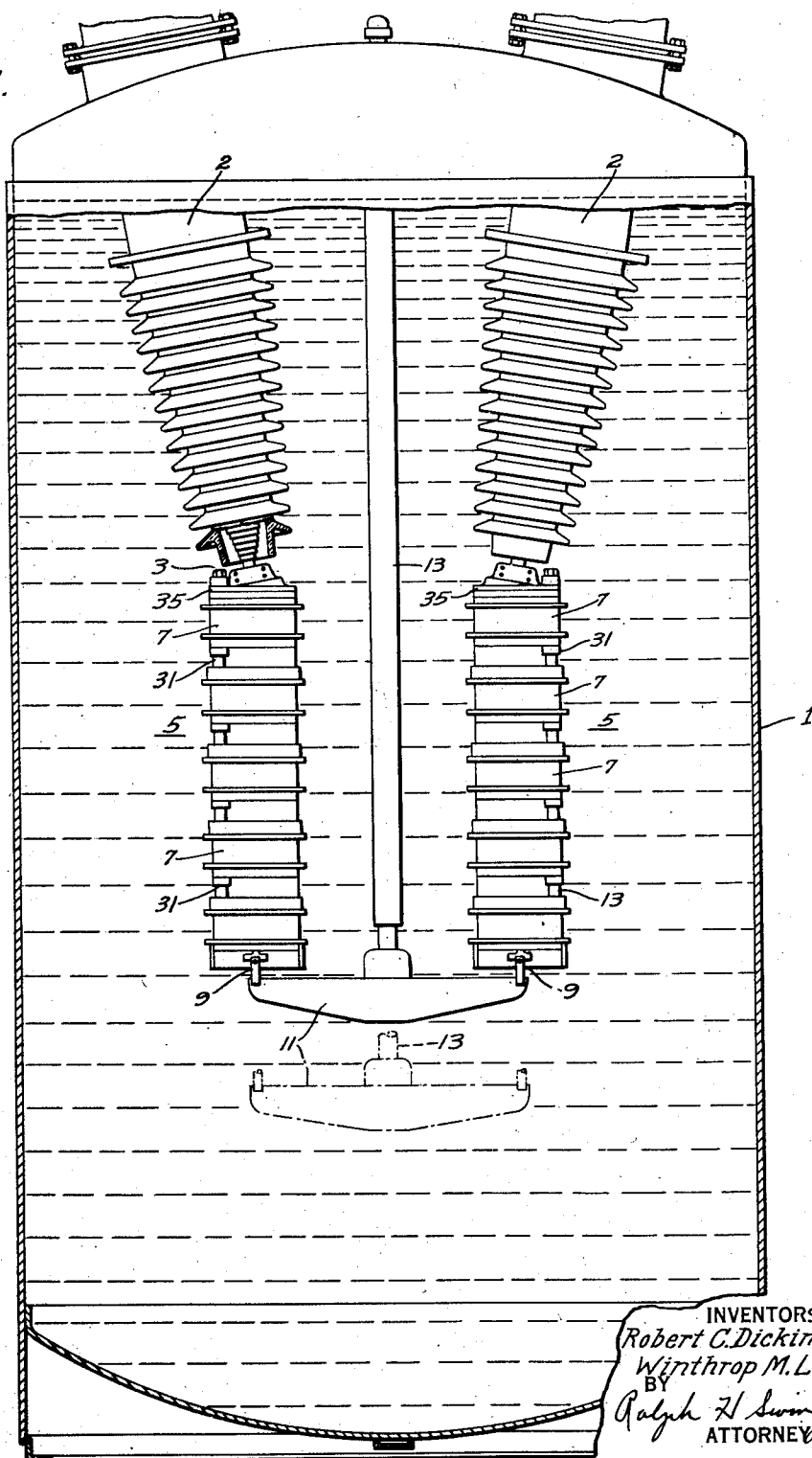
2,137,873

CIRCUIT BREAKER

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5 Sheets-Sheet 1

Fig. 1.



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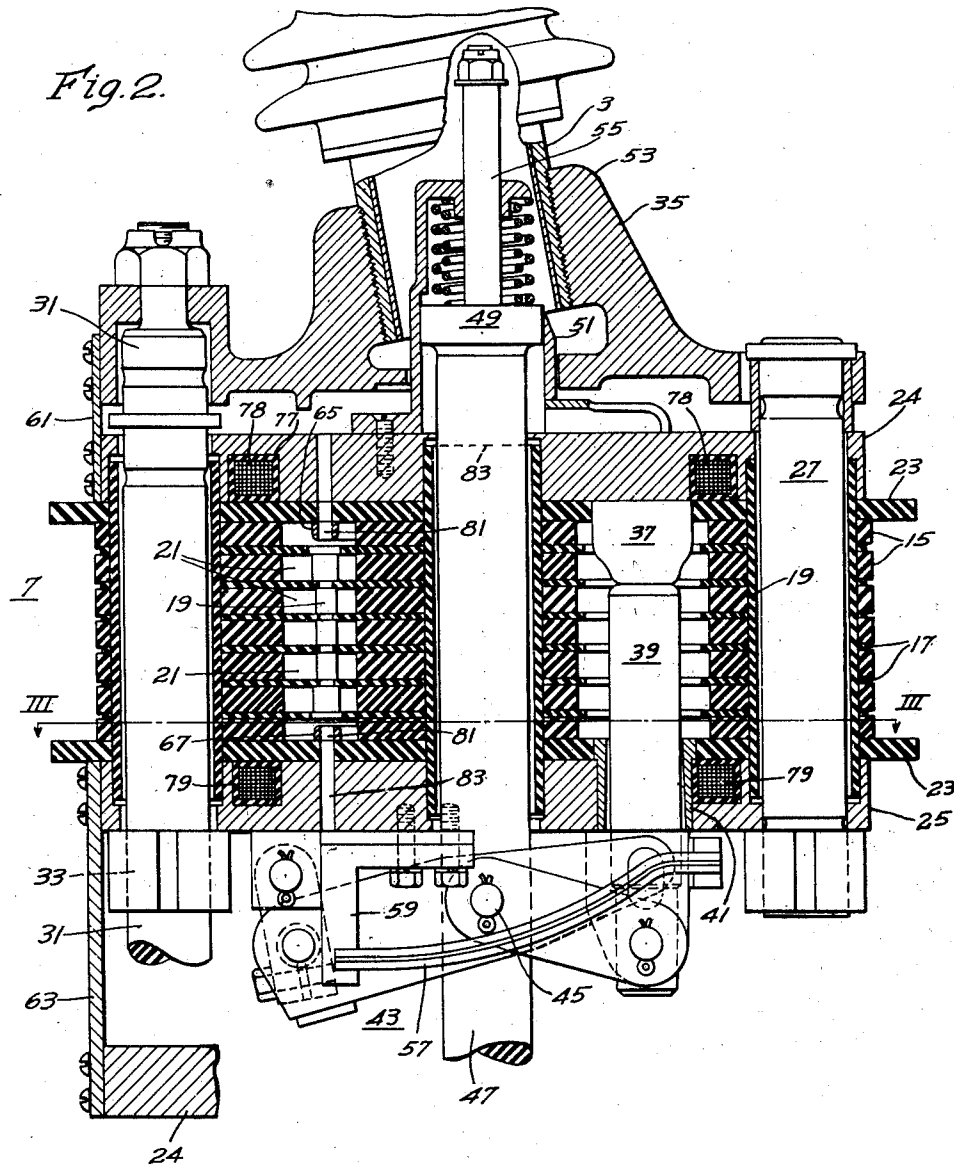
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5 Sheets-Sheet 2



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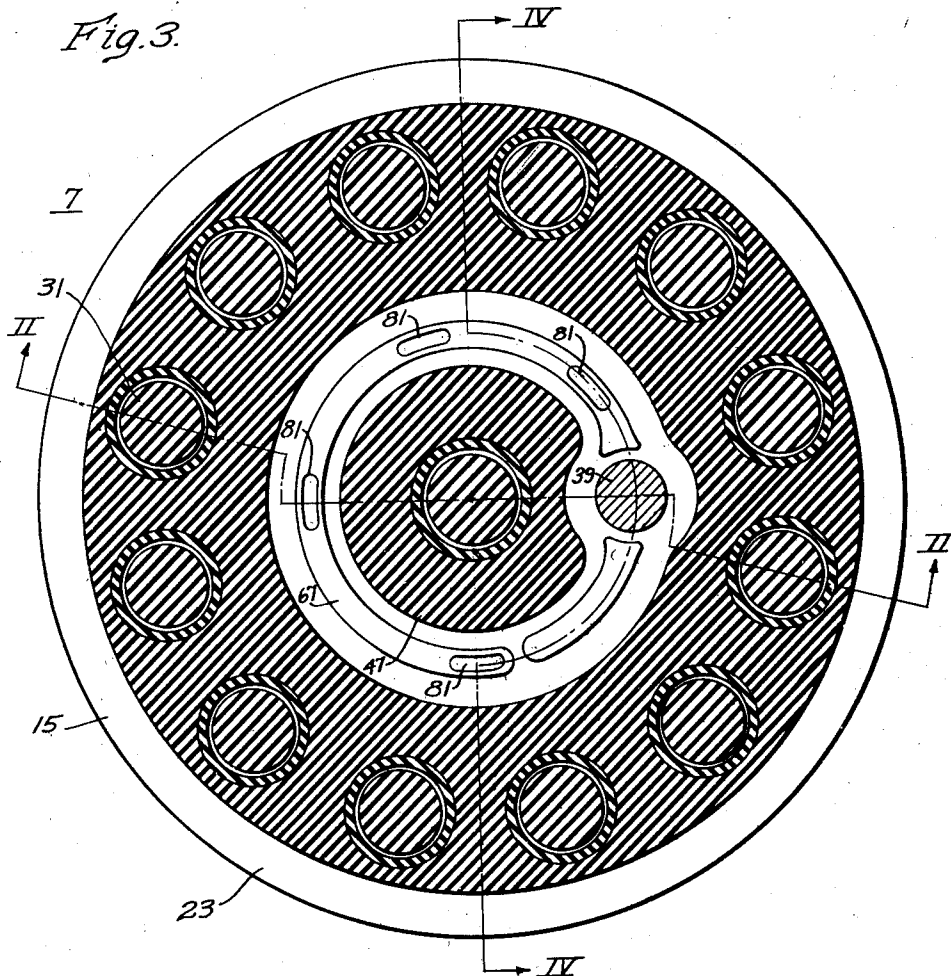
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CIRCUIT BREAKER

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5 Sheets-Sheet 3



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CIRCUIT BREAKER

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5 Sheets-Sheet 4

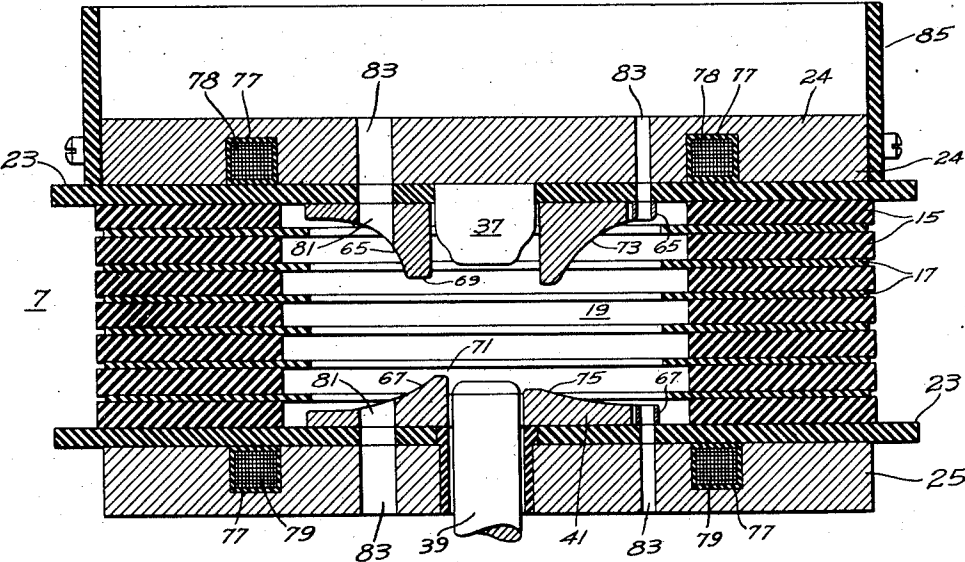


Fig. 4.

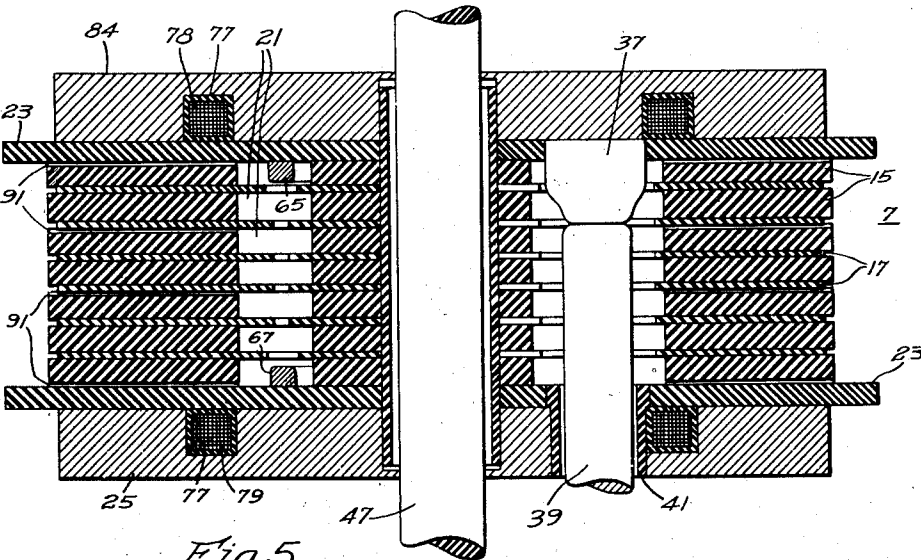


Fig. 5.

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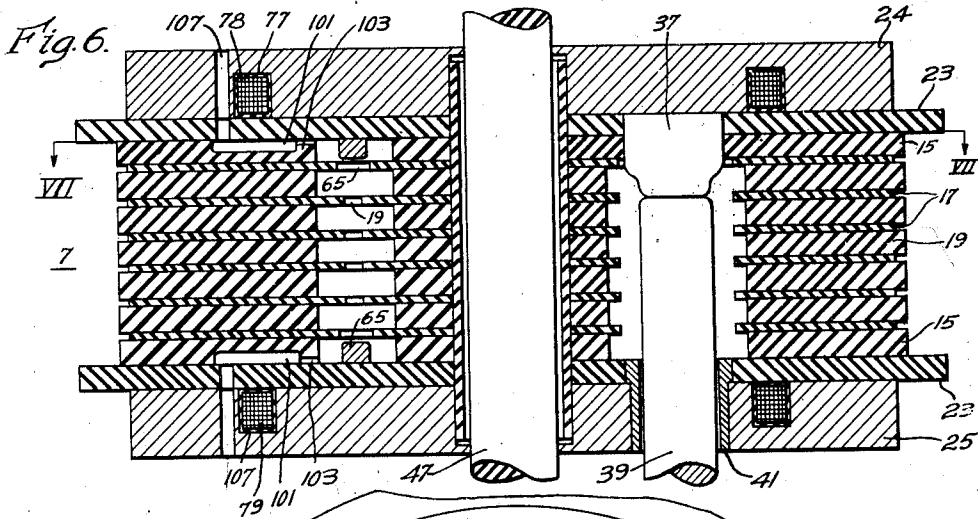
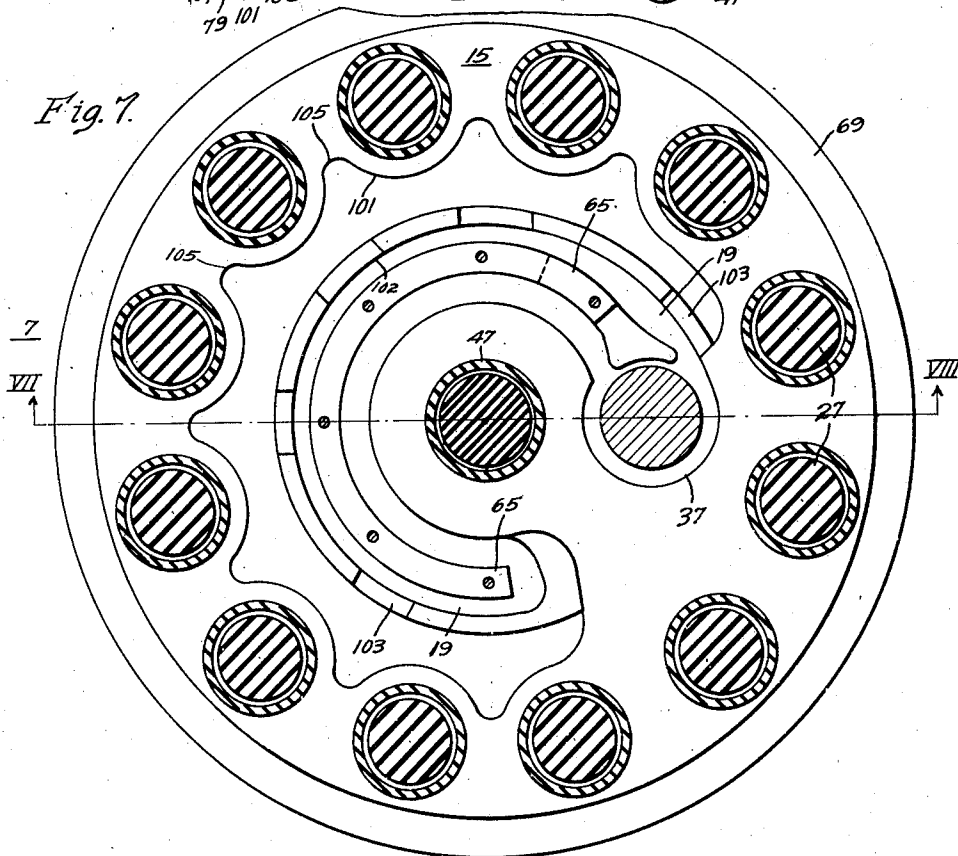
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CIRCUIT BREAKER

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5 Sheets-Sheet 5



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2,137,873

CIRCUIT BREAKER

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Application May 29, 1936, Serial No. 82,594

16 Claims. (Cl. 200—150)

This invention relates to circuit breakers and particularly to improvements in arc extinguishing structures therefor.

In the copending application of H. J. 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, is shown and described an arc extinguishing structure particularly adapted for operation on high voltage, high power electrical systems. The arc extinguishing structure disclosed in the said application comprises a plurality of plates of insulating material arranged in a stack and having a narrow aligned slot in each of the plates so as to form a narrow channel or passage of considerable length in which an arc is adapted to be drawn longitudinally thereof by the separation of suitable contact members.

The slot-like passage is filled with oil or other suitable arc quenching material which gives off a gas when acted upon by an arc. The gas produced by the arc is known to contain finely divided relatively cool unionized particles which are carried through and are intermingled with the arc stream. Thus as an alternating current arc passes through a current zero, there is a strong tendency to deionize the space occupied by the arc stream to such an extent that the arc will not restrike when the voltage builds up in the opposite direction. Heretofore, one or two reignitions at the current zero has been considered usual performance, prior to arc extinguishing.

The present day demands for high speed circuit interruption, however, makes arc extinguishment at the first current zero very desirable. A study of the theory of arc extinguishment by means of structures of the type above described has revealed that an increase in the rate of gas liberation greatly accelerates the deionizing action. Movement of the arc laterally through the oil or other gas producing material subjects the heat of the arc successively to fresh layers of oil, the rapid decomposition of which thereby provides unionized gas particles in greater quantities.

In order to provide the high rate of gas liberation necessary for arc extinguishment of extremely large currents, arc velocities have been increased which necessarily demands a longer path of arc travel through the gas producing material. By giving the arc passage a generally annular shape, as described in the aforesaid application, an increased length of arc travel can be obtained

without causing the arc interrupting structure to assume unreasonable proportions. From a practical consideration, the requirement for high speed, high power circuit interruption which makes the adoption of curved arc passages particularly desirable has, accordingly, complicated the problems of dissipating the gas necessary for arc extinguishment. In order to retain the deionizing effect, the arc must be confined in a relatively narrow passage so that the gas produced by the action of the arc upon the oil or other gas producing material will be directed through the arc stream. It will be apparent that particularly in extinguishing structures capable of interrupting a large amount of power, fairly large quantities of gas are generated, accompanied by pressures which, if not relieved, may be destructive to the arc confining structure. It is, therefore, necessary to provide means for proper venting of the arc passage, so that the gas produced during arc extinguishment may escape after performing its deionizing function.

The main object of our invention is directed to the provision of an arc extinguishing structure for circuit breakers of the type above described in which proper provision is made for enabling the gas produced by the decomposition action of the oil or other gas producing material to escape from the arc extinguishing structure. In order to further meet the demands of high-voltage and high speed arc extinguishment, circuit breakers have been provided in which the work of interruption has been apportioned to a plurality of serially related breaks in which more than two breaks are employed in contradistinction to common practice. A convenient arrangement for a multiple unit construction may consist in mounting the arc extinguishing units end to end for tandem operation. This arrangement, however, requires special consideration of the venting problems of the individual arc extinguishing units, since during arc interruption the products of combustion of the arc expelled from the arc chamber are apt to cause a flash-over across the ends of each unit.

It is, therefore, a further object of our invention to provide venting means for a multiple unit arc extinguishing structure which reduces the flashover hazard, across the units, to a minimum.

Other objects and advantages relate to details of the extinguishing structure and will appear more fully in the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a side elevation partially in section of a multiple break circuit breaker embodying our invention.

Fig. 2 is a vertical sectional view taken along the line II—II of Fig. 3 showing one of the upper arc extinguishing units of the breaker arc extinguishing assemblage.

Fig. 3 is a cross sectional view of the upper arc extinguishing unit shown in Fig. 2 and taken along the line III—III of that figure.

Fig. 4 is a fragmentary sectional view of the arc extinguishing unit of Fig. 2 and taken along the line IV—IV of Fig. 3.

Fig. 5 is a fragmentary sectional view of an arc extinguishing unit showing a modified form of venting means.

Fig. 6 is a fragmentary sectional view of an arc extinguishing unit showing a further arrangement of venting means, and

Fig. 7 is a cross sectional view of the arc extinguisher shown in Fig. 6 taken along lines VII—VII of that figure.

Referring to the drawings, the reference numeral 1 designates a tank or enclosure adapted to be filled with oil or some other suitable arc quenching medium, and is provided at the upper end thereof with a pair of insulating bushings 2 through which the line terminals 3 of the circuit breaker are conducted interiorly of the tank. To the lower end of each of the terminal members 3 is secured an arc extinguishing assemblage generally indicated at 5. Each of the arc extinguishing assemblages comprises a series of arc extinguishing units 7 which are arranged end to end in spaced relation, as shown. Each of the units 7, as will appear more fully hereinafter, is provided with a pair of separable contacts which are connected in series so as to provide an arc circuit from the incoming terminal 3 through the arc extinguishing assemblage 5 to a releasable contact member 9 at the lower end of each assemblage 5.

The releasable contact members 9 are adapted to be electrically connected to each other by means of a bridging bar 11, in this instance moved into and out of engagement with the contact members 9 by a lift rod 13 which is actuated by a suitable operating mechanism not shown.

Each of the units 7, as more particularly shown in Fig. 2, comprises a plurality of plates of insulating material designated as 15 and 17 respectively. Each of the plates 15 and 17 have relatively narrow circular slots extending there-through, which slots are adapted to be aligned when the plates are arranged in a stack so as to form an annularly shaped narrow passage designated at 19.

The plates 15 are provided with indentures or recesses adjacent the sides of the slot, so as to provide pockets 21 along the sides of the slot for entrapping oil or other suitable arc quenching liquids. The ends of the passage 19 are enclosed by plates 23 also of insulating material. To each end of the stack is also applied end plates 24 and 25 of magnetic material. The entire stack assemblage is adapted to be held together by a plurality of tie rods 27, preferably of insulating material and passing axially through the stack adjacent the peripheral edge thereof, as shown. The individual units 7 comprising an arc extinguishing assemblage 5 may be held in spaced relation with respect to each other by means of tie rods 31 also passing axially through each of the units 7 and through suitable spacing members 33 interposed between the adjacent units 7.

The upper ends of the tie rods 31 are bolted to a contact foot 35 which, in turn, has threaded engagement with the lower end of the incoming terminal 3. Each of the arc extinguishing units 7 is provided with a pair of separable contacts, a fixed one 37 which is adapted to be electrically connected to the upper magnetic end plate 24 and a movable one 39 which is adapted to be moved into and out of engagement with the fixed contact 37 through a suitable guide member 41 positioned in the lower magnetic end plate 25. The movable contact 39 is adapted to be actuated by a straight line actuating mechanism, generally indicated at 43, and which mechanism makes pivotal connection by means of a pin 45 to an actuating rod 47 passing through the central portion of the stack of plates constituting the unit 7.

The upper end of the operating rod 47 is provided with a guide member 49 adapted to operatively engage the walls of a cylindrical cap member 51. A coil spring 53 surrounding a guide rod 55 projecting from the end of the member 49 is interposed between the end of the cylindrical cap member 51 and the member 49, and serves to actuate the rod 47 to the open circuit position.

Although only the uppermost unit 7 is shown in Fig. 2, it will be understood that the remaining or the subsequent units are similar in construction, each having a separable pair of contacts 37 and 39 of which the movable contact is actuated by a mechanism 43. Each of the mechanisms 43 of each assemblage 5 are operatively coupled to the single actuating rod 47 which extends the full length of the arc extinguishing assemblage. The releasable contact members 9 are respectively mounted upon the lower ends of the two operating rods 47.

As the lift rod 13 is moved into the closed position, the bridging bar 11 engages the releasable contacts 9 and moves the two operating rods 47 to the uppermost or closed position against the biasing action of the spring 53. Thus when the breaker is tripped, the holding mechanism associated with the lift rod 13 is released, thereby allowing the spring 53 to move the operating rod 47 of each arc extinguishing assemblage 5 downwardly so as to simultaneously separate the contacts 39 from the fixed contacts 37.

Each of the movable contacts 39 are connected by a flexible shunt 57 to a bracket 59 mechanically and electrically connected to the lower magnetic end plate 25. Thus, the electrical circuit from one of the line terminals 3 through one of the arc extinguishing assemblages 5 continues through the contact foot 35, a bridging strip 61 connecting the contact foot 35 with the upper end plate 24, a fixed contact 37, movable contact 39, flexible shunt 57, bracket 59, the lower end plate 25, bridging connector 63 which connects the lower end plate 25 of the uppermost unit 7 with the upper end plate 24 of the next adjacent unit 7.

It will be apparent that the circuit through the succeeding units 7 will be the same as that described in connection with the first or uppermost unit. Connection from the lowermost end plate 25 of the lower unit 7 is made by a flexible shunt, not shown, to the respective releasable contact 9 mounted upon the end of the operating rod 47. From one of the contact members 9 the circuit continues through the bridging bar 11, the other contact member 9 and then through the other arc extinguishing assemblage 5 and to the other line terminal 3.

The arc which has been established as a result of the movement of the contact member 39 toward the open position will be transferred to a pair of arcing horns 65 and 67, the former lying in the upper end of the passage 19 and being supported by the upper end plate 23 of insulating material. The latter horn 67 is disposed in the lower end of the passage 19 and is preferably mounted upon the lower insulating end plate 25. The arc horns 65 and 67, respectively, are provided with arc receiving tips 69 and 71. The horns generally have a circular shape and extend throughout a substantial portion of the circumference of the passage 19. The remaining portion of the passage 19, that is, the spacing between the end of the respective horns 65 and 67 and the contact members 37 and 39, is provided with insulating barriers or deflectors designated at 73 and 75, respectively, the purpose of which will appear more fully hereinafter.

It will be noted that the arc receiving tip 69 of the arc horn 65 extends downwardly into the passage 19 some distance beyond the lower edge of the fixed contact 37. Thus as the movable contact 39 separates from the fixed contact 37, an arc will be drawn therebetween, but since the movable contact 39 travels closely adjacent to the arc receiving tip 69, the arc will transfer from the main contact 37 to the arc horn 65.

The magnetic end plates 24 and 25 are each provided with an annular recess 77 in which coils 78 and 79, having low resistance and a relatively small number of turns, are embedded. One end of the upper coil 78 is connected to the upper end plate 24, whereas the other end of the upper coil 78 is connected to the upper arc horn 65. The lower coil 79 is similarly connected in that it has one end connected to the lower plate 25, and its other end connected to the lower arc horn 67. The specific connections of the coils 78 and 79 are not shown since they may be effected in any conventional manner. Thus, as the moving contact 39 is drawn past the lower edge of the arc receiving tip 69, the arc from the fixed contact 37 will transfer thereto and since the voltage drop across the upper coil 78 and the arc horn 65 is not sufficient to maintain the arc between the fixed contact 37 and the moving contact 39, that portion of the arc will be extinguished.

As soon as the arc transfers from the fixed contact 37 to the arc horn 65, the upper coil 78 is inserted into the arc circuit. The energization of the upper coil 78 immediately sets up the radial magnetic field across the upper end of the passage 19 which assists in moving the lower end of the arc from the movable contact 37 onto the lower arc horn 67. Upon the transfer of the lower end of the arc to the lower arc horn 67, the lower coil 79 is also inserted in the arc circuit and the arc current circuit for each unit then is from the upper end plate 24 through the upper coil 78, arc horn 65, arc horn 67, the lower coil 79 and the lower end plate 25. The magnetic field produced by the lower coil 79 operates jointly with that produced by the upper coil 78 to create a strong radial magnetic field across the greater portion of the passage 19.

The radial magnetic field thus produced causes the arc to rotate along the passage 19 in a counter-clockwise direction as viewed in Fig. 3 with its ends in engagement with the arc horns 65 and 67. Immediately upon the initiation of the arc between the contacts 37 and 39 part of the

oil or other arc quenching media within the passage 19 is decomposed and the arc is soon surrounded by a gas bubble. As soon as the magnetic field operates upon the arc, it is believed that the arc is driven to one side of the gas bubble surrounding it, thereby engaging a fresh wall of oil which, in turn, creates more gas and large quantities of relatively cool unionized particles which of necessity must flow back through the arc stream.

When the arc current passes through current zero, the effect of the relatively cool unionized gas particles is to build up the dielectric strength of the space formerly occupied by the arc stream to such an extent that the arc will not restrike upon the voltage building up in the opposite direction. The rapid movement of the arc by means of a strong radial field as is capable of being produced by the upper and lower coils 78 and 79, causes an ample quantity of relatively cool gas to be produced for deionizing purposes. If the arc is moved at a sufficiently high rate of speed and enough gas is produced by decomposition of the oil when acted upon by the heat of the arc, arc extinguishment may take place at the first current zero.

It will be apparent that the production of a sufficient quantity of gas to effectively extinguish the arc in such a short time interval may create so high a pressure within the passage 19 as to cause mechanical failure of the structure. It is, therefore, necessary to provide suitable vent openings to enable the gas thus produced to escape from the chamber for passage 19.

As shown in Figs. 2, 3 and 4, the arc horns 65 and 67 are provided with slot-like passages 81 spaced, as particularly shown in Fig. 3, throughout the length of the horns. These passages or conduits 81 are adapted to be aligned with similar passages 83 extending axially through the end plates 23, 24 and 25. It will thus be seen that the passages 81 and 83 will provide adequate means for the escape of gas and also oil or any other product of decomposition resulting from the formation and extinguishment of an arc within the passage 19.

It will be noted that as the arc is moved along the horns 65 and 67, the gas produced as a result of the advancing portion of the arc contacting the oil contained within the passage 19 will flow back through the arc stream and hence out of the openings created by the passages 81 and 83. Inasmuch as the vent openings 81 and 83 are located through the arc horns respectively at the upper and lower ends of the passage 19, considerable longitudinal flow of gas in the arc in addition to the transverse flow takes place, thereby increasing the turbulence of the gas in the arc stream which further aids in extinguishing the arc.

It will be noted that the insulating end plates 23 are extended beyond the insulating plates 15 and 17 forming the main body portion of the arc extinguishing units and the metallic end plates 24 and 25. The projecting portions of the end plates 23 provide baffles between the metallic end plates 24 and 25 of each unit 7 so as to increase the creepage distance between these plates, particularly during the discharge of large quantities of gas or perhaps other products of decomposition of the arc which are to a certain extent conducting. Considerable danger of flashover between the end plates 24 and 25 is present. Thus the projecting edges of the plates 23 materially decrease the flashover hazard.

In order to further lessen the danger of flash-over, the upper end plate 24 may be surrounded with a relatively short cylindrical baffle 85 of insulating material (Fig. 4). The baffle 85 not only deflects the gas upward after being expelled from the vents, but also increases the creepage distance from the end plates 24 to the lower end plate 25. The baffle 85 also prevents any foreign matter which may be expelled through the vent openings 83 of the upper plate 24 from being washed over the sides of the unit 7, thereby further decreasing the flashover hazard.

The insulating deflectors 73 and 75 positioned between the terminating ends of the arc horns 65 and 67 and the contact members 37 and 39 previously referred to, are utilized to deflect the oil in the passage 19 which is caused to be placed into circulation by the rotating movement of the arc in the passage. The introduction of the deflectors 73 and 75 causes a gradual diminution of passage length on one side of the contacts 37 and 39 whereas the arc receiving tips 69 and 71 have a similar effect on the opposite side of the contacts. Inasmuch as the passage is materially shortened in the region of the contacts 37 and 39, and also at the arc receiving tips 69 and 71, the velocity of the oil will be materially increased due to Venturi action. This increase in velocity is helpful in replacing gas with fresh oil at the place of least separation between the arc horns 65 and 67, thereby further insuring that when the arc has been extinguished that it will not restrike at that point.

Although the arrangement of a number of vent openings 81 and 83 distributed along the arc horns 65 and 67 provides a more ready egress for the gas from the arc passage 19, it does so at the expense of a greater loss of oil from the arc passage than would result if a single vent slot of appropriate dimensions were placed through the arc horns adjacent the contacts. In the latter form of construction the gas produced by the arc acting upon the oil as it advances along the arc horns 65 and 67 in a counter-clockwise direction, as viewed in Fig. 3, will flow back through the arc stream causing deionization and then escape through the vent opening adjacent the contacts 37 and 39. The oil in the passage will, due to the rotation of the arc and assisted by the gas pressure produced by the arc acting thereon, be caused to circulate in a counter-clockwise direction and be in part forced out of the vent openings. However, if the vents are located through the arc horns adjacent the contacts 37 and 39, the oil must flow across the contacts and arc receiving tips 69 and 71 before it reaches the vent openings.

In Fig. 5, a modified means of venting the passage 19 has been shown. Instead of carrying the venting passages axially through the end plates of each unit 7, a number of radial passages 91 uniformly distributed lengthwise of the passage are provided.

Although this particular method of venting may not be as effective as the venting means shown in the previously discussed figures, it has the advantage of cheaper construction, and perhaps subjects the arc to a more violent cross-flow of gas at intervals when the arc is immediately adjacent one of the passages 91. As described in the previous figures, the projections of the insulating end plates 23 also provide baffles for preventing flashover as a result of the gas being discharged between the metallic end plates 24 and 25.

In Figs. 6 and 7, a slightly modified form of arc extinguishing structure is shown. In these figures the arc passage 19 is not continuous or recurrent, as shown in the previous figures, but extends substantially through an arc of 270° more or less. The general outline of the side walls of the passage 19, however, is similar to that previously described. The arc horns 65 and 67 have the same general conformation as those previously described and are supported by the insulating end plates 23.

The venting means in this instance comprise a generally annularly shaped chamber 101 concentric with the passage 19 and formed in the upper and lowermost insulating plate 15. The annular shaped chamber 101 is connected by means of radial ports 103 to the arc passage 19. The ports 103 are spaced angularly from each other throughout the length of the arc travel, so as to provide substantially uniform access of the gas produced in the passage 19 to the annular chamber 101. Chamber 101 has outwardly projecting nodes 105, each of which are adapted to communicate with an axially directed passage 107 extending through both the insulating and magnetic end plates 23, 24 and 25.

It will thus be seen that both the upper and lower ends of the arc passage 19 are freely vented into the space between adjacent units 7, which space is bounded by the metallic end plates 24 and 25 of two adjacent units, which plates are maintained at the same electrical potential. In the modified form, as shown in Figs. 6 and 7, the projecting baffle portions of the insulating end plates 23 also decrease the flashover hazard across end plates 24 and 25 in the manner previously described.

In connection with the particular arrangement of venting means shown in Figs. 6 and 7, it may be pointed out that this arrangement provides highly satisfactory arc extinguishing operations over a wide range of current values. However, the extinguishment of relatively low current arcs and relatively high current arcs can be considerably improved by separate treatment of the arrangement of the arc passage venting means. We have found that for low currents improved operation can be obtained by concentrating relatively small vent openings at the ends of the passage near the contacts. The low current arc, due to its relatively weaker radial field strength in the arc passage 19, tends to move only a very short distance along the passage before it is extinguished. Also, since the low current arc decomposes very little of the arc quenching liquid in the passage, the gas pressure may not reach a value which is favorable to arc extinction. Therefore, by placing the vent openings near the contacts the movement of the arc is assisted by the motion of the liquid toward the vent openings, and also by keeping the vent openings small, the pressure will rise sufficiently to maintain adequate dielectric between the contacts.

On the other hand, we have found that the concentration of larger vent openings at the ends of the arc passage adjacent the ends of the arc horns 65 and 67 farthest from the contacts is more effective for the extinguishment of currents of greater magnitude. The reason for expecting a more efficient operation under these conditions is as follows: Arcs of high current magnitude, although under the influence of a proportionately higher strength radial magnetic field produced by the coils 79, may not move at a much higher velocity than arcs of low current magnitude due

to the high resistance to motion of arcs of large cross section in a restricted slot. However, by providing vents at the ends of the arc horns farthest from the contacts a considerable portion of the arc quenching liquid in the passage 19 will be expelled through the vent openings, and more rapid motion of the arc relative to the slot facilitated. This allows the arc extinguishing gas in back of the arc stream to be scattered over a greater distance, and a continuous ionized path for breakdown made less likely. After arc extinguishment, the trapped gas may escape from the arc passage 19 through the vents provided therefor, thereby allowing the passage to refill with arc quenching liquid.

It will be apparent that any of the foregoing types of vent openings leading from the arc passage may be employed in the particular arrangements last described for obtaining more efficient operation for the extinguishment of arcs of low and high current magnitude.

From the foregoing description, it will be apparent that we have provided an arc extinguishing structure which is particularly adapted for high voltage and high speed arc interruption service. We have also provided an arc extinguishing unit having an arc passage therein which is adequately vented, thereby making high power, high speed extinction possible without increasing the hazard of failure of the arc extinguishing unit due to flashover which may result from the discharge of the products of decomposition of the arc from within the unit. Furthermore, we have provided a particular arc extinguishing unit and venting means therefor peculiarly adapting the unit for multiple arrangement in a multiple-break circuit interrupter.

Although we have shown and described particular structural arrangements for carrying out the objects of our invention, it is to be understood that the same is for illustrative purposes and that 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 an arc extinguisher, means of insulating material for defining the walls of a generally annularly shaped narrow arc passage, means for establishing an arc at a predetermined position within said passage, stationary arc terminal means of generally circular shape at each end of said arc passage for receiving the ends of said arc, a coil for setting up a magnetic field radially across said passage for moving said arc along said passage with its ends in engagement with said arc terminal means, a material along said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, said arc passage being closed at its end adjacent both the inside and outside of said circular arc terminal means, and a plurality of openings through said arc extinguishing structure to cause the gas produced by the arc to pass laterally and longitudinally through said arc and escape through said openings.

2. In an arc extinguisher, a stack of plates of insulating material, each of said plates having a narrow generally circular slot therethrough, said slots being aligned to form a generally annularly shaped arc passage of considerable length, means for enclosing the ends of said passage, means for establishing an arc of considerable length within said passage, arc terminal means within said passage for receiving said arc, means

for setting up a radial magnetic field across said passage for moving said arc laterally in one long section therealong in engagement with said arc terminal means, a material along said passage which produces a gas when acted upon by an arc to aid in extinguishing the arc and vent means comprising a plurality of openings disposed at spaced intervals circumferentially of and adjacent to said arc terminal means and leading radially from said passage exteriorly of said stack of plates to enable the gas to escape from said passage.

3. In an arc extinguisher, a stack of plates of insulating material, each of said plates having a narrow generally circular slot therethrough, said slots being aligned to form a generally annularly shaped arc passage of considerable length, means for enclosing the ends of said passage, means for establishing an arc of considerable length within said passage, an arc terminal at each end of said passage for receiving the ends of said arc, a coil for establishing a radial magnetic field across said passage for rotating the arc laterally in one long section therein between said arc terminals, a material along said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and venting means at each end of said passage comprising a duct having a portion leading radially from said passage adjacent an arc terminal and a second portion positioned for discharging gas axially of said passage.

4. In an arc extinguisher, a plurality of plates of insulating material each of which is provided with a curved narrow slot therethrough, said plates being arranged in a stack with their slots in alignment to form a generally annular passage, end plates of insulating material for enclosing the ends of said passage, means for establishing an arc within said passage, means for rotating said arc in said passage, and venting means adjacent at least one end of said stack for the gases produced by the action of said arc comprising a duct leading from the end of said passage and terminating in an axial direction with respect to said passage.

5. In an arc extinguisher, a plurality of plates of insulating material each of which is provided with a curved narrow slot therethrough, said plates being arranged in a stack with their slots in alignment to form a generally annular passage, end plates of insulating material for enclosing the ends of said passage, means for establishing an arc within said passage, means for rotating said arc in said passage, and venting means for at least one end of said passage comprising an annularly shaped chamber within said stack adjacent the end of said passage, ports connecting the end of said passage and said chamber and ducts leading from said chamber axially through the end of said stack.

6. In an arc extinguisher, a plurality of plates of insulating material, each of which is provided with generally circular narrow slots therethrough, said plates being arranged in a stack with their slots in alignment to form a generally annular passage and plates of insulating material for enclosing the ends of said passage, means for establishing an arc within said passage, an arc horn at each end of said passage for receiving the ends of said arc, a coil for setting up a radial magnetic field across said passage for moving the arc between said arc horns, a fluid in said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and venting means adjacent at least one end of

said passage comprising an annularly shaped chamber within said stack adjacent the end of said passage and concentric therewith, a plurality of radially extending ports joining said passage and said chamber and a plurality of ducts leading axially from said chamber through the end of the stack.

7. In a circuit breaker, an arc interrupting assemblage comprising a plurality of arc extinguishing units, each of said units having means of insulating material for defining the walls of an arc passage, said units being arranged end to end in spaced relation, means for simultaneously establishing a series arc within each of said passages, each of said passages having a material therealong which gives off a gas when acted upon by an arc to aid in extinguishing the arc, vent means for each unit adjacent the ends thereof only to enable gas to escape from the passage within each of said units, the passage of each unit being completely enclosed except for said vent means, and means associated with each unit for confining the discharge gases to prevent flashover exteriorly of the units during or immediately following a circuit interruption.

8. In a circuit breaker, an arc interrupting assemblage comprising a plurality of arc extinguishing units, each of said units having means of insulating material for defining the walls of a generally annularly shaped arc passage, said units being arranged end to end in spaced relation with their respective arc passages in axial alignment, means for simultaneously establishing a series arc within each of said passages, means for producing a magnetic field radially across each of said passages for rotating each arc along its respective passage, each of said passages having a material therealong which gives off a gas when acted upon by an arc to aid in extinguishing the arc, venting means for each unit leading from the passage within the unit and discharging into the space between adjacent units, and baffle means of insulating material positioned adjacent the ends of each unit for increasing the leakage path across each unit to prevent flashover exteriorly of each unit.

9. In a circuit breaker, an arc interrupting assemblage comprising a plurality of arc extinguishing units, each of said units having means of insulating material for defining the walls of a generally annularly shaped arc passage, said units being arranged end to end in spaced relation with their respective arc passages in axial alignment, means for simultaneously establishing a series arc within each of said passages, means for producing a magnetic field radially across each of said passages for rotating each arc along its respective passage, each of said passages having a material therealong which gives off a gas when acted upon by an arc to aid in extinguishing the arc, vent means for each unit comprising at least one duct leading from said passage through at least one end of each unit, and baffle means positioned adjacent the ends of said units for preventing the gases discharged from said vent means from causing a flashover across each unit during or immediately following a circuit interruption.

10. In a circuit breaker, an arc interrupting assemblage comprising a plurality of arc extinguishing units, each of said units comprising a plurality of circular plates of insulating material each plate being provided with a generally circular narrow slot therethrough, said plates being arranged in a stack with their slots in align-

ment to form a generally annularly shaped passage, end plates of insulating material for enclosing the ends of said passage, end plates of magnetic material adjacent said end plates of insulating material, said units being arranged end to end in spaced relation with their arc passages in axial alignment, means for simultaneously establishing a series arc within each of said passages, a coil operatively associated with each of said end plates of magnetic material for setting up a magnetic field across said passages to rotate the arc established in each passage therein, a material along each passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, venting means comprising a plurality of ducts leading from the ends of each passage through the respective end plates of each unit and discharging into the space between said units, said end plates of insulating material having a diameter greater than the diameter of said slotted plates and said end plates of magnetic material to increase the creepage distance between the magnetic end plates of each unit, and an annular member of insulating material surrounding the upper magnetic end plate of each unit to deflect the gas expelled through said venting means in a direction away from the lower magnetic end plate of the same unit.

11. In an arc extinguisher, a plurality of plates of insulating material each of which is provided with a curved slot therethrough, said plates being arranged in a stack with their slots in alignment to form a generally annularly shaped passage of considerable length, end plates of insulating material for enclosing the ends of said passage, a pair of separable contacts within said passage for establishing an arc of considerable length therein, means for rotating said arc in one long section in said passage, and venting means adjacent at least one end of said stack comprising an opening through the insulating material leading from said passage at a point adjacent said electrodes to the exterior of said stack.

12. In an arc extinguisher, a plurality of plates of insulating material each of which is provided with a curved slot therethrough, said plates being arranged in a stack with their slots in alignment to form a generally annularly shaped passage of considerable length, end plates of insulating material for enclosing the ends of said passage, a pair of separable contacts within said passage for establishing an arc of considerable length therein, an arc horn at each end of said passage having one end lying adjacent said separable contacts, means for moving said arc in one long section with its ends in engagement with said arc horns along said passage, and venting means adjacent at least one end of said stack comprising an opening leading from said passage at a point adjacent the other end of one of said arc horns to the exterior of said stack.

13. In a circuit interrupter, an arc-extinguishing structure comprising means of insulating material defining a narrow generally annularly shaped arc passage, a pair of contacts within said arc passage, means for causing a predetermined separation of said contacts to establish an arc solely within said arc passage at a predetermined position, an arc terminal member of arcuate shape disposed in fixed relation at each end of said passage, each of said arc terminal members having one of their ends positioned

adjacent one of said contacts for receiving the ends of the arc drawn between said contacts, means along said arc passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, means for moving the arc laterally in one section between said arc terminal members, and vent openings for the products of decomposition of the arc leading from at least one end of said arc passage to the exterior of said arc-extinguishing structure, said vent openings being disposed adjacent to and circumferentially of said arc terminal members to subject the arc during its movement along said arc terminal members to a longitudinal flow of the products of decomposition during the escape of said products from the arc passage.

14. In a circuit interrupter, an arc-extinguishing structure comprising means of insulating material defining a narrow generally annularly shaped arc passage of considerable length, means for establishing an arc of considerable length within said passage, an arc terminal at each end of said passage for receiving the ends of said arc, a coil for establishing a radial magnetic field across said passage for rotating the arc laterally in one long section between said arc terminals, a material along said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and venting means at each end of said passage comprising a duct having a portion leading radially from said passage adjacent an arc terminal, and a second portion positioned for discharging the products of decomposition of said arc axially of said passage.

15. In a circuit interrupter, an arc-extinguish-

ing structure comprising means of insulating material defining a narrow generally annularly shaped arc passage, means for enclosing the ends of said passage, means for establishing an arc within said passage, means for rotating said arc in said passage and venting means for at least one end of said passage comprising an annularly shaped chamber within said means of insulating material adjacent the end of said passage, ports connecting the end of said passage and said chamber, and ducts leading from said chamber axially through the end of said arc-extinguishing structure.

16. In an arc extinguisher, means of insulating material defining the walls of a narrow generally annularly shaped arc passage in which an arc of considerable length may be established, said arc passage being closed at its ends, an arc horn at each end of said arc passage for receiving the ends of an arc and between which the arc is adapted to be moved, a coil for setting up a radial magnetic field across said passage for moving the arc between said arc horns, a fluid in said passage which gives off a gas when acted upon by an arc to aid in extinguishing the arc, and venting means adjacent at least one end of said passage comprising an annularly shaped chamber within said means of insulating material adjacent the end of said passage and concentric therewith, a plurality of radially extending ports joining said passage and said chamber and a plurality of ducts leading axially from said chamber through the end of the arc-extinguishing structure.

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