July 10, 1934. J. SLEPIAN 1,966,316

ARC CHUTE

Filed Jan. 10, 1929

Fig. 1.

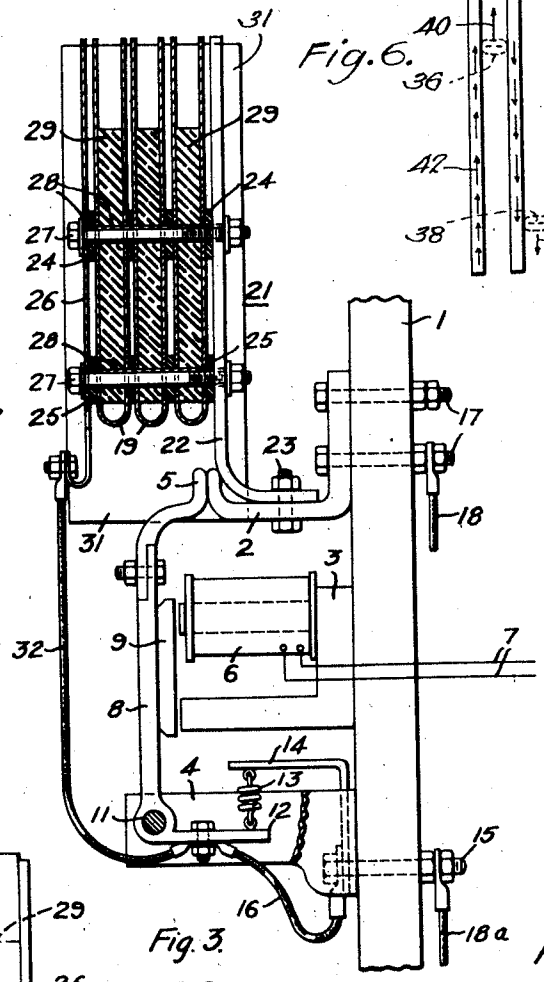



Fig. 6.

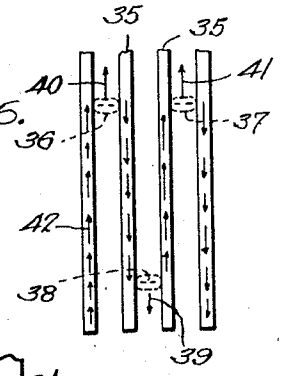



Fig. 5.

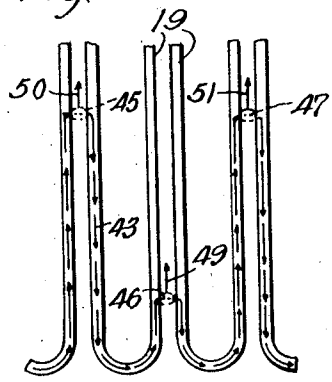



Fig. 2.

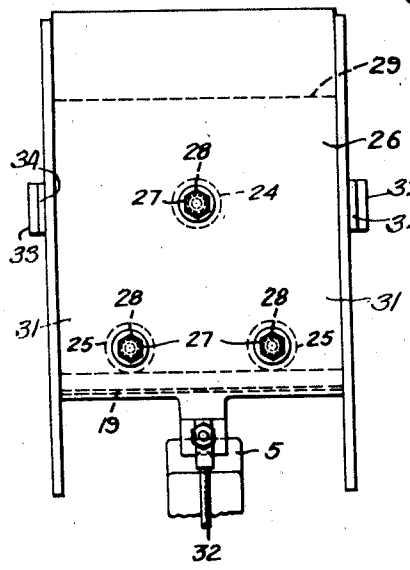



Fig. 3.

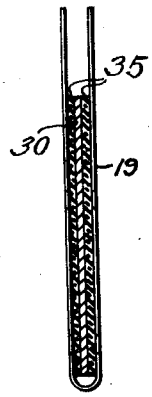
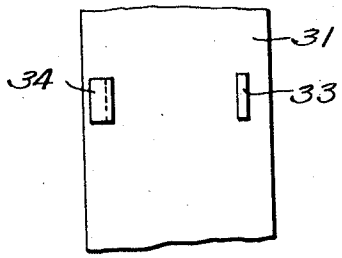



Fig. 4.




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1,966,316

# UNITED STATES PATENT OFFICE

1,966,316

## ARC CHUTE

Joseph Slepian, Pittsburgh, Pa., assignor to Westinghouse Electric & Manufacturing Company, a corporation of Pennsylvania

Application January 10, 1929, Serial No. 331,469

8 Claims. (Cl. 200—144)

My invention relates to circuit interrupters and particularly to circuit interrupters of the air-break type wherein the arc incident to the separation of the contacts is led into a space occupied by a plurality of metal plates or grids and is broken up into a series of arcs that are rapidly deionized and extinguished as they move between the grids.

As a particular feature of my invention here described, an arc, consequent upon the opening of the circuit, moves into an arc-extinguishing means adapted to divide it into a plurality of short arcs between grids of such form that a magnetic flux is induced by current flow in the grids themselves which moves the arc rapidly over the grid surfaces.

The rapid movement of the arc within the extinguishing means prevents the burning and vaporizing of metal which occurs if arc terminals move slowly or stand still for any appreciable time.

I have found that, in circuit breakers of the prior art, vaporized metal combines chemically with the oxygen of the air for a considerable time after the electric arc proper is extinguished; and that the ionized products of this combustion are a frequent cause of restriking or re-ignition of the arc. By preventing the formation of such vapors, re-ignition of the arc is prevented.

In the particular embodiment here shown, the deionizing means comprises an aggregate of spaced plates of U-shape, the adjacent surfaces between the spaced plates being traversed by the termini of the short arcs into which the original arc is broken. The flow of current from the one to the other branch of each U-shaped plate sets up a magnetic field which causes the short arcs to move rapidly across the surfaces of the plates.

With these and other objects in view, the invention comprises the novel structure and combination and arrangement of parts that will be fully set forth in the following description, taken in conjunction with the drawing, in which:

Figure 1 is a side view, partly in section and partly in elevation, of a circuit interrupter embodying my invention;

Figs. 2 and 3 are, respectively, views, in side elevation and in end or edge elevation, of one of the U-shaped plates embodying a modified form of my invention.

Fig. 4 is a fragmentary view, in side elevation, of the assembly shown in Fig. 2.

Figs. 5 and 6 are schematic diagrams used in explaining my invention.

My invention comprises, in general, an insulating base 1, upon which is mounted a stationary contact member 2, a magnetic core 3 and a bracket 4 that supports the movable elements of the breaker 5. The foregoing elements may be of any type well known in the art to be suitable, their precise structure not being claimed herein.

The magnetic core 3 has a winding 6 mounted thereon that may be energized, through leads 7, from any desired control circuit. A movable contact member 5 is carried by a pivoted arm 8 having an armature 9 to be attracted by the magnetic core 3 when the coil 6 is energized. The arm 8 is supported upon a pivot 11 and has a lateral extension 12 that is attached, by means of a spring 13, to a stationary bracket 14.

Line current is conducted to the extension 12 from a terminal bolt 15 through a flexible conductor 16. The contact member 2 is fastened to the base 1 by volts 17, to one of which is attached the terminal piece of a conductor 18. A similar terminal piece for a conductor $18^a$ is attached to the bolt 15.

The mode of operation in moving the mechanism just described to open-circuit position from the closed position shown in Fig. 1 is as follows.

Assuming the contact member 5 and the member 2 to be in engagement, as shown in Fig. 1, a circuit is completed, through the conductor 18, bolt 17, contact member 2, contact member 5, arm 8, conductor 16 and bolt 15, to the other conductor $18^a$.

When the coil 6 is de-energized, the spring 13 actuates the arm 8 in a contra-clockwise direction, thereby moving the contact member 5 away from the member 2, thus producing an arc therebetween that moves upward because propelled either by the force inherent in the arc itself or by an additional blowout magnet that may be provided. The arc will be broken into a plurality of short arcs by the members of the arc-extinguishing device 21, shown in Fig. 1, and the circuit will be established from the member 2 to a plate 22 and thence, through the plurality of short arcs and U-shaped members 19, to an end plate 26 and a flexible conductor 32 leading to the bolt 15. The series of short arcs just described will move rapidly in the spaces between the members 19, as heretofore mentioned, and will thereby be deionized and quickly extinguished.

It is clearly apparent to any one familiar with the contactor art that any other suitable means for effecting engagement and separation of con-

tact members might be employed, and, therefore, I do not wish to limit the application of my invention to any particular contactor.

Referring to Fig. 1 of the drawing, a plurality of U-shaped metal plates 19 of the form shown in detail in Figs. 2 and 3 is assembled to constitute the arc-quenching device 21, the lower ends of the U-shaped members 19 being positioned slightly above the contacts 2 and 5.

In the assembly of the elements of arc-extinguishing device 21, a supporting plate 22 is provided with a lateral extension which may be attached to the terminal 2 by a bolt 23.

Insulating members 24 and 25 are employed to space the plates apart, the width of each space which has been found to be suitable for most purposes being one-sixteenth of an inch. By making the spaces between the plates in which the arc plays very narrow, the flux is concentrated providing a strong field along this whole length of the short arc to move it rapidly without substantially bowing it out. By making the spaces in which the arcs play very narrow, a high reluctance path for the flux is provided between the plates. Another method of making the reluctance of the flux paths between the legs of the U less than the reluctance in the arc spaces between the plates by the use of iron is described below in connection with Fig. 3. For commercial-frequency alternating-current circuits, a sufficient number of U-shaped plates should be assembled to provide one intervening gap for each 140 volts of the circuit to be interrupted.

When the required number of U-shaped members 19 have been assembled, an end plate 26 is spaced from the last U-shaped member by insulating members 24 and 25, the entire assembly being clamped together by the bolts 27 having insulating sleeves 28.

Between the legs of each U-shaped member 19, insulating members 29 are provided to maintain the legs in their parallel relation when the bolts 27 are tightened.

As shown in Fig. 1, the insulating members 29 are of substantially the same length as the legs of the U-shaped members 19 and, when so provided, the parallel legs of the members may be in closer proximity to each other than otherwise, as the insulation therebetween reduces the possibility of arcing between the legs of the same member, thereby ensuring that the path of the current will follow the U-shaped portion of the member.

The sides of the assembly 21 are enclosed by insulating plates 31 that extend below, and adjacent to, the sides of the movable contact 5 and the terminal 2, thereby confining the arc within the width of the arc-extinguishing device 21. The plates 31 are provided with openings through which the lugs 33 and 34 on the end plates 26 and 22, respectively, extend in order to retain the plates on the sides of the structure 21 as illustrated in Fig. 4. A flexible conductor 32 may connect end plate 26 to the bolt 15 through conductor 16.

The plates 19 of the device 21 may be made of non-magnetic conducting material and, if so, will, under many conditions, insure extinction of the arc. Under other conditions, however, it is advisable to supply a magnetic means of one form or another to assist in transferring the arc to the plates 19 and in moving it in the spaces provided therebetween.

For example, the desired magnetic effect may simply and readily be obtained by forming the plates 19 from magnetic material. Alternatively, the insulating members 29, heretofore referred to, may be replaced by a magnetic member 30 that is covered with insulation 35 but is located between the legs in a position similar to that of the members 29 as shown in Fig. 3. In most cases, in which the iron is provided between the legs of the plates or when the plates themselves are constructed of magnetic material, an additional arc-moving force, such as a separate blowout magnet, need not be provided, although it will be understood that the provision of such blowout magnets as are known in the circuit-interrupter art is within the purview of my invention.

Enough details of the structure embodying my invention having been set forth to enable its general characteristics to be understood, certain principles underlying its operation will now be explained.

If an arc deionizing and extinguishing device be made as shown in Fig. 6 consisting of a plurality of flat plates 35 in spaced relation to each other, it is found that, under certain conditions, a portion only of the arcs, as at 36 and 37, are rapidly moved in the spaces intervening between the plates, the other arcs such as at 38 moving very slowly or even remaining stationary. This is probably caused by the magnetic effects resulting from the flow of the current from one plate through the arc and down through the adjacent plate to an adjoining arc. A simple analysis shows that current flow between arcs irregularly distributed over the faces of successive plates sets up magnetic fields which drive the arc downward as indicated by arrow 39 if it is at the lower end of a plate, but tend to move the arc upward as indicated by the arrows 40 and 41 if it is at the upper end of a plate due to the reaction between the magnetic flux set up by the current flowing toward and away from the arcs as indicated by the arrows 42, and the current flowing in the arcs 39, 40, and 41. This effect may be opposed by a sufficiently strong impressed magnetic field, but this impressed magnetic field needs to be much stronger than would be required if this loop effect did not occur.

It is necessary to the successful operation of my arc deionizing device to have all the short arcs move with sufficient rapidity to prevent the termini thereof, when passing over the surfaces of the plates, from evolving metal vapors. In order to prevent such segregation of the arcs at the upper and lower ends of the plates and to obtain a similar movement of the arcs in all of the spaces, I have substituted for the simple flat plates 35 just described, the plurality of U-shaped plates 19 hereinbefore described. It can be shown that the magnetic effect of current flow that conducts from each arc to the adjacent one through the U-shaped portion of the member is to cause the arcs to take up similar positions in the different spaces since the current indicated by the arrows 43 flows upwardly to each arc 45, 46, and 47 and downwardly away from each arc, irrespective of the position of the arc between the plates 19 and its relation to the other arcs. Thus, the magnetic fields set up by the currents flowing in the U-shaped portion of metal between successive short arcs produce a driving force upon these arcs, moving them upward, as indicated by arrows 49, 50, and 51, in the spaces between the members with substantially equal forces and like speeds of movement.

As the speed at which the arcs are moved depends upon the extent and magnitude of the magnetic field set up by the arc current and the spacing of the members 19, quantities should be taken into consideration when constructing arc interrupters of this type in order to make certain that the legs of the U-shaped members 19 and the end plates 22 and 26 are of such lengths that the arcs will have sufficient lengths of surfaces over which to travel without reaching the ends of plates 19 during the half period of the alternating-current cycle which may elapse before the line current passes through zero and then becomes extinct.

It will thus be seen that I have provided a deionizing device for an arc established by a circuit interrupter that moves the arc very rapidly across the cool surfaces of a plurality of metallic plates. The said plates may, if desired, be of non-magnetic material, and they may have associated with them magnetic means for assisting in moving the arc. The plates themselves may be constructed of magnetic material, thus strengthening the field about the current flowing therethrough.

The plates are preferably made of U-shape in order that the spaces provided between adjacent members shall form similar current paths with the arc, and that all of the arcs shall be acted upon in the same manner and with the same speed of movement. The number of plates, the widths of the spaces and the lengths of the plates will all depend upon the circuit in which my interrupting device is to be employed. Under all conditions, such dimensions should be so chosen that the speed of the arc movement shall always be great enough to prevent the arc from burning the plates, under which condition, the arc will be deionized and extinguished within a half cycle of alternating current.

An important feature of the invention is the close spacing of the plates. The passage of the current up one of the plates, across the arc and down the adjacent plate will create a magnetic field that has lines of force in the space between the plates. With the widely spaced plates of the prior art, these lines of force will only affect the edge of the arc where it joins the plates, and the body of the arc will lag behind the edges. In the present invention, however, these lines of force act on the whole body of the short arc and drive it quickly upward so that it does not burn the plates. Due to the fast driving action of the field, it is not necessary to provide the usual blow-out coil required with the widely spaced plates of the prior art.

By "closely spaced" in the claims is meant such close spacing that the magnetic field created by the current in the plates affects the whole body of the short arc.

The use of magnetic material for or between the plates has an additional advantage besides strengthening the magnetic field acting on the arc. The lines of force acting on the arc complete their circuit through the magnetic material and hence do not travel into the space between adjacent plates to conflict with the lines of force acting on the adjacent arcs. Accordingly, the use of magnetic material prevents conflict between adjacent magnetic fields and permits the plates to be spaced more closely together.

It will be understood that, while I have described the plates 19 as U-shaped, any other arrangement in which current is forced to pursue an outgoing and return path normal to the direction of current flow in the arcs will be effective of the desired results. In general, all arrangements by which the current path between successive arcs is of such form as to set up magnetic fields tending to produce axial alinement of successive arcs are within the scope of my invention.

While I have shown and described but a single embodiment of my invention, I do not wish to be limited to this particular structure, as many changes, substitutions and omissions may be made from the embodiment illustrated, without departing from the spirit of my invention. I desire, therefore, that the language of the appended claims shall be construed broadly to cover all modifications and arrangements within the scope of my invention.

I claim as my invention:

1. The combination with a circuit-interrupting device having separable contact members, of a plurality of members of sheet material folded upon themselves in such manner that the folds are spaced from each other, insulating means spacing each said sheet member from an adjacent sheet member and a member of magnetic material between the folds of each of said members.

2. In a circuit interrupter, means for causing an arc, means for extinguishing said arc including a plurality of current conducting members folded upon themselves with the folds of each current conducting member spaced apart, and each of said folded current conducting members, being spaced from the adjacent current conducting members, and each of the folds of said current conducting members having a flux path thereabout of lower reluctance between the folds of each member than between adjacent members.

3. The combination with a circuit-interrupting device having separable contact members, of arc extinguishing means comprising a plurality of plates arranged in substantially parallel order, the end members of said plates being connected to the circuit to be interrupted and the plates between said end members being electrically connected in pairs, and each of said plates having flux paths therearound of low reluctance in the spaces between the plates forming each pair and of high reluctance in the spaces between adjacent pairs.

4. The combination with a circuit-interrupting device having separable contact members, of arc extinguishing means comprising a plurality of plates arranged in substantially parallel order, the end members of said plates being connected to the circuit to be interrupted and the plates between said end members being electrically connected in pairs and a member of magnetic material between the plates forming each of said pairs.

5. The combination with a circuit-interrupting device having separable contact members, of arc extinguishing means comprising a plurality of plates arranged in substantially parallel order, the end members of said plates being connected to the circuit to be interrupted and the plates between said end members being electrically connected in pairs closely spaced together, a member of magnetic material between the plates forming each of said pairs, and a member of insulating material on each side of said member of magnetic material insulating it from the plates adjacent thereto.

6. In a circuit interrupter, means for causing an arc, means for extinguishing said arc including a plurality of plates of good conducting material positioned in spaced planes and electrically connected together in pairs at their edges adja-

cent said means for causing the arc, said electrically connected pairs having open spaces therebetween in which the arc is split up into short arcs and providing continuous U-shaped conducting paths of good conducting material connecting the ends of said short arcs, and said U-shaped conducting paths having flux paths thereabout of lower reluctance between the legs of the U than in the spaces between the plates in which the short arcs play.

7. In a circuit interrupter, means for causing an arc, means for extinguishing said arc including a plurality of plates of good conducting material positioned in spaced planes and electrically connected together in pairs at their edges adjacent said means for causing the arc, said electrically connected pairs having open spaces therebetween in which the arc is split up into short arcs and providing continuous U-shaped conducting paths of good conducting material connecting the ends of said short arcs, and a plate of magnetic material positioned between the plates forming each of said electrically connected pairs, said magnetic plate being insulated from at least one of the two plates between which it is positioned.

8. In a circuit interrupter, means for causing an arc, means for extinguishing said arc including a plurality of plates of good conducting material positioned in spaced substantially parallel planes and electrically connected together in pairs at their edges adjacent said means for causing the arc, said electrically connected pairs having open spaces therebetween in which the arc is split up into short arcs and providing continuous U-shaped conducting paths of good conducting material connecting the ends of said short arcs, and the width of said open spaces between the electrically connected pairs in which the arc plays being of the order of one-sixteenth of an inch.

JOSEPH SLEPIAN.