Dec. 15, 1931. J. SLEPIAN 1,836,994

CIRCUIT INTERRUPTER

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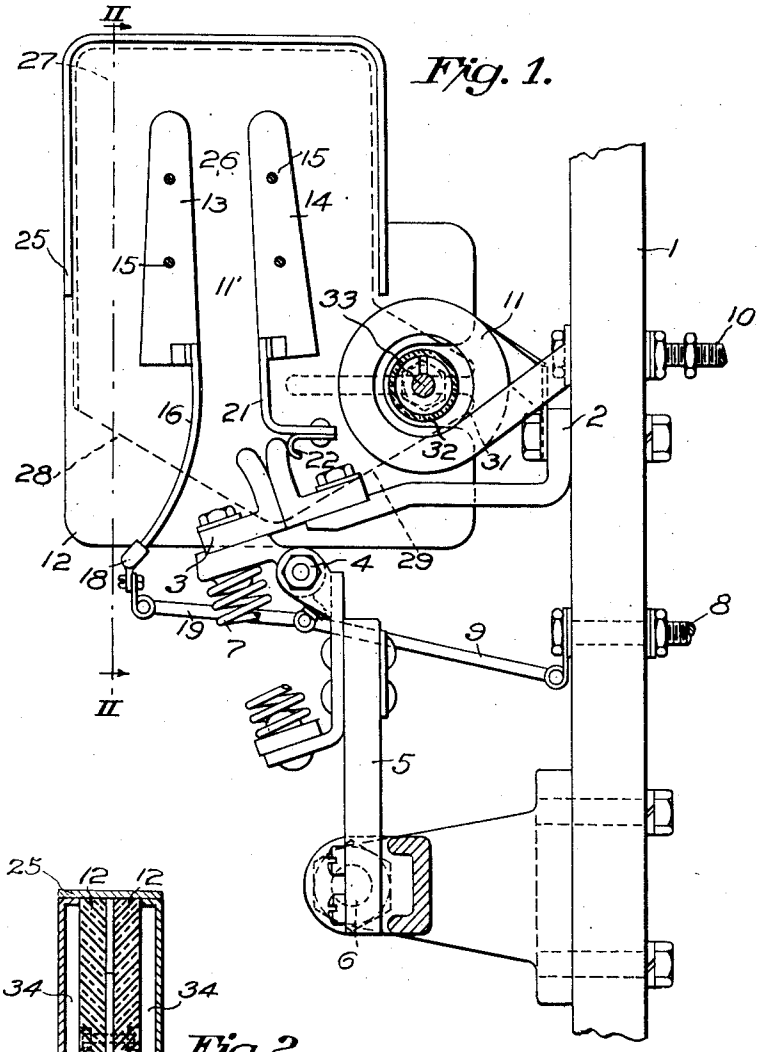


Fig. 1.

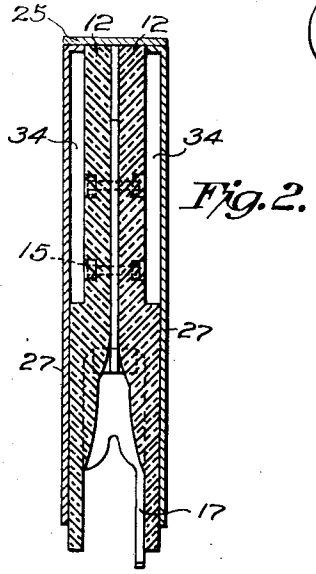


Fig. 2.

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CIRCUIT INTERRUPTER

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My invention relates to interrupting means for electric circuits and particularly to such means for interrupting circuits of high voltages while supplying heavy loads. The general principles of my invention, however, are applicable in connection with devices for interrupting circuits where the voltage and current are of relatively low value; and, in fact, to the interruption of electrical discharges through gases generally.

Among the objects of my invention is the provision of means for interrupting electrical discharges through gases generally.

Another object of my invention is the provision of means for interrupting electrical circuits by means of a pair of separable contacts opening in air or other gaseous media without the need of resorting to the use of oil or similar means for quenching the arc incident to separation of the contacts.

Other objects of my invention will be apparent on reading the following specification in connection with the drawings in which:

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

Fig. 2 shows a detailed view of a deionizing chamber taken along the line II—II of Fig. 1.

Where it has been necessary in the prior art to interrupt circuits of relatively high voltage or circuits carrying large currents, it has been the practice to open the circuit at a pair of separable contacts immersed in oil, or some other liquid medium which has the property of quenching arcs incident to such interruption. It has been necessary to use containers for the liquid which are of considerable size and expensive; and the more common arc quenching media are oils which involve a considerable fire hazard in case of accident. I have found that where electric arcs are compelled to operate in narrow channels or slots between walls of refractory insulating material, such walls have the property of strongly deionizing the arc path, and, therefore, of fulfilling much the same arc-quenching function as the liquids of the prior art. Such a deionizing means is particularly effective in aiding the interruption of alternating currents by reason of the fact that when the current in the arc passes through zero in the course of the alternating current cycle, the contiguity of the refractory walls results in rapid destruction of all the free ions which have given conductivity to the previously existing arc. When the alternating voltage across the terminals of the arc path rises on the succeeding half of the alternating wave, the conductivity of the arc path has fallen to such a degree that this voltage is insufficient to re-establish current flow along the path, and the arc therefore remains extinct.

With the foregoing objects and principles in mind, reference may be had for an understanding of my invention to the drawings which show a circuit breaker mounted upon a suitable insulating panel 1 to which is bolted a stationary terminal 2 of a form well known in the art. A movable terminal 3 cooperating therewith is supported upon a hinge 4 on the movable arm 5 which, is in turn hinged to the panel 1 at 6. Flexible contact between the members 2 and 3 is assured by the use of the spring 7 between the contacts 3 and the movable arm 5. Stud 8 provides a connection for one line terminal and a flexible conductor 9 carries current therefrom to the movable contact 3. Stud 10 provides connection for the other line terminal and conducts current through a blow-out magnet 11, which will be described in more detail later, and thence to the stationary terminal 2. When the circuit interrupter is closed, therefore, current enters through stud 8, passes through flexible conductor 9 to contact 3, thence to contact 2 and through blow-out magnet 11 and stud 10 into the other side of the line.

When contacts 2 and 3 are separated, while current is flowing in the circuit an arc is drawn therebetween. The arrangement which is provided, in accordance with my invention, to quench this arc comprises the structure 11′ which is constituted by a pair of opposed spaced plates 12 of some refractory insulating material. I have found soapstone to be one suitable material. As shown in Fig. 2 the plates 12 are spaced apart by a distance which is small compared with the

length and breadth of their opposed surfaces. As a specific example, I have used soapstone slabs approximately four inches by six inches by ½ inch thick spaced apart about $\frac{1}{16}$ of an inch over the major part of the surface. The lower portion of the space between the slate is enlarged in section as indicated in Fig. 2 so as to provide a cavity in which the contacts 2 and 3 may move.

Between the slate slabs are positioned two conducting arc horns 13 and 14 which may be held in position by suitable bolts 15 passing through the slabs 12. The arc horns 13 and 14 are positioned directly above the path occupied by the arc incident to the opening of contacts 2 and 3. The lower end of the horn 13 is extended by a projecting copper strap 16 which broadens sufficiently to fill the entire width of the cavity in which contact 3 moves and which extends to a point just above the path traveled by contact 3 in opening. One side of the strap 16 extends downward at 17 and is provided with a terminal 18 to which is connected a flexible conductor 19, the other end of which makes contact with the movable contact 3, as shown in Fig. 1.

From the lower end of the arc horn 14, a strap 21, filling the cavity between the slabs 12, extends downward and makes contact at 22 with the stationary contact member 2.

The top and a portion of the ends of the slot between the slabs 12 is closed by a wall 25. The arc horns 13 and 14 may be proportioned as shown in Fig. 1 being approximately parallel and having their inner faces separated by the gap 26, the length of which will depend upon the voltage and current which the circuit breaker is intended to interrupt. On a circuit breaker designed to interrupt currents up to 1,000 amperes on alternating current circuits of approximately 500 volts, I have found that a spacing of about one inch gave satisfactory results. The arc horns 13 and 14 terminate somewhat below the top of the slot between the slabs 12, the intervening distance being approximately equal to the length of the gap 26. The outer edges of the arc horns 13 and 14 are separated from the end wall 25 by approximately the same distance. The arc horns may, therefore, be said to divide the chamber into three approximately equal vertical areas.

The deionizing structure thus constituted is held between pole plates 27 of a blowout magnet which is energized by the winding 11 previously referred to. The plates 27 cover practically the entire upper portion of the side walls of the deionizing chamber 11, but their lower ends are cut away as indicated at 28 and 29 in Fig. 1. They also are provided with a projection 31 which extends backwards to join a core 32 surrounded by the winding 11. A through bolt 33 clamps the core 32, the slabs 12 and the plates 27 firmly together and forms a rigid structure thereof.

The upper half of the slabs 12 may be recessed as shown at 34 in Fig. 2 thus providing slots separating the face plates 27 from the face of the slabs 12.

The mode of operation of the circuit breaker constructed in the foregoing way will now be readily apparent. When the main contacts 2 and 3 begin to separate at the opening of the circuit breaker, the arc formed between them is driven upward to the effect of the blowout magnet and forced into the narrow portion of the slot between the slab 12. The voltage gradient of an arc operating in such a confined space is relatively high and in consequence the arc termini transfer from the contacts 2 and 3 to the members 16 and 21, which are immediately adjacent thereto and provide a shorter path of operation for the arc. The blowout magnet then forces the arc upward between the arc horns 13 and 14 into the narrowest portion of the slot 26. The field of the blowout magnet continually drives the two termini of the arc along the edges of the arc horns 13 and 14, and will, if the arc is not previously extinguished, force them around the upper ends of the arc horns and cause the arc to run with its termini on the outer faces of the arc horns 13 and 14. The arc will, therefore, curve around in a long bow between the outer edges of horns 13 and 14 and become greatly lengthened in the confined space at the sides and top of the chamber 11. The voltage per inch of an arc in such a confined space becomes extremely high and even on direct current circuits unless the current or voltage is extremely large, this will result in a rupture of the arc. On alternating current circuits, however, the effect of such a long confined path is even more marked; the current sinks in the course of the alternating current cycle to zero at which time the rate of production of new ions in the arc path has practically also fallen to zero. Such ions as remain in existence as a result of the previous large currents in the arc path fly about and quickly come in contact with one or the other of the insulating walls. When this occurs they are caused to lose their charge and to recombine with the ions of opposite sign. As a consequence the free ions rapidly disappear in the arc path. When the alternating voltage between the arc horns 13 and 14 rises again in the course of its cycle, the number of free ions left in the arc path is extremely small. As a consequence the path has a very low electrical conductivity and the electrical gradient is insufficient to re-establish the rapid production of ions which is necessary to continued current flow in the arc. The arc thereafter remains extinct accordingly.

It will thus be seen that I have provided means by which arc of considerable current

and voltage value may be extinguished without the use of liquid medium for quenching the arc and that the structure which is utilized in effecting this result is relatively small and cheap to manufacture.

It will be evident that while I have described this arc extinguishing structure in connection with the operation of a circuit interrupter, that its general principles may be applied on numerous other purposes not connected with that type of apparatus. It will also be evident that while I have shown it as embodied in a relatively small circuit interrupter, that by increasing its dimensions and providing it with accessories well known in the art, it may be applied to circuit interrupters of considerably larger voltage and current.

It will also be evident that while I have described the device as provided with a blow-out magnet, there may be fields of service in which the means for such a magnet is not sufficient to warrant the expense of providing it and that the principles of arc deionization utilized in the present apparatus may be applied in structures which utilize other means, such as natural draft, to cause the arc to transverse the deionizing chamber. In the case of such structures, it may be desirable to embody the closing wall 25 over the top of the chamber.

While I have described one particular embodiment of my invention, it will be evident to those skilled in the art that the principles thereof may be applied to many different structures. I, therefore, desire that the language of the following claims shall be given its broadest reasonable interpretation and limited only as expressed in its terms, or in accordance with what the prior art imposes.

I claim as my invention:

1. In combination with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart a distance less than one-fourth of an inch, arc horns between said walls adapted to act as termini of said arc and means to impel said arc along said arc horns.

2. In combination with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart and two arc horns positioned to divide the space between said walls into three substantially equal subdivisions.

3. In combination with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart to form a slot, a closure for the top and sides of said slot, two arc horns positioned to divide the space between said walls into three substantially equal subdivisions.

4. In combination, with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart a distance less than one-fourth of an inch and a closure for the top and sides of the slot between said walls that ensures that the arc and the arc gases move into and out of the space between the walls from the bottom thereof.

5. In combination, with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart a distance less than one-fourth of an inch, a closure for the top and sides of the slot between said walls, and arc horns adapted to act as termini for said arc between said walls, and extending from adjacent the bottom of said slot in spaced relation to the closure for the sides of said slot to points spaced from the closure for the top of said slot, and said slot being open at the bottom between said arc horns and said closure for the sides.

6. In combination, with means to establish an arc, deionizing means for the path of said arc comprising vertical walls of insulating material spaced apart to form a slot, a closure for the top and sides of said slot, two vertical arc horns positioned to divide the space between said walls into three substantially equal subdivisions.

7. In combination, with means to establish an arc, deionizing means for the path of said arc comprising two vertical walls of insulating material spaced apart a distance less than one-fourth of an inch to form a slot, a closure for the top and sides of said slot, two vertical arc horns extending only part of the height of said slot and adapted to effect passages for the arc gas on both sides of said horns.

8. In combination, with means to establish an arc, deionizing means for the path of said arc comprising two vertical walls of insulating material spaced apart, a closure for the top and sides of said slot, two vertical arc horns positioned to divide the space between said walls into three substantially equal subdivisions, said arc horns extending only part of the height of said slots and means to impel said arc towards said arc horns.

9. In combination, with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart by a distance less than one-fourth of an inch to form a slot, a closure for the top and sides of said slot and means to impel the whole length of said arc along a path between said walls.

10. In combination, with means to establish an arc, deionizing means for the path of said arc comprising two vertical walls of insulating material spaced apart to form a slot, a closure for the top and sides of said slot, two vertical arc horns positioned to divide the space between said walls into three substantially equal areas, said arc horns extend-

ing only part of the height of said slots and means to impel said arc towards said arc horns.

11. In combination, with means to establish an arc, deionizing means for the path of said arc comprising two vertical walls of insulating material spaced apart a distance less than one-fourth of an inch to form a slot, a closure for the top and sides of said slot, two vertical arc horns positioned in said slot to act as termini of said arc and forming transverse partitions from one of said walls to the other but extending only part way to the top of said slot, and means to impel the arc along said arc horns.

12. In combination, with a source of alternating voltage and means to establish an arc supplied thereby, insulating walls spaced apart to form a narrow slot, arc horns in said slot adapted to act as termini of said arc, means to impel said arc along said arc horns, the distance between said walls being so related with the distance between said arc horns and to the magnitude and frequency of said voltage that the latter is unable to re-establish appreciable current flow through the arc after the current therein passes through zero.

13. In combination, with a source of alternating voltage, and means to establish an arc supplied thereby, insulating walls spaced apart to form a narrow slot, a closure for the top and sides of said slot, two vertical arc horns in said slot extending only part way to the top thereof and means to impel the arc along said arc horns, the distance between said walls being so related to the distance between said arc horns and to the magnitude and frequency of said voltage that the latter is unable to re-establish appreciable current flow through said arc after the current therein passes through zero.

14. In combination with means to establish an arc, deionizing means for the path of said arc comprising walls of insulating material spaced apart a distance less than one-fourth of an inch, arc horns on which the ends of the arc play with the whole length of the arc between said walls, and means to impel said arc along said arc horns.

15. In a circuit interrupter, means to establish an arc, deionizing means for said arc, a pair of arc horns, each of which is provided with an arcing surface on opposite sides thereof, and means for moving the arc in one direction along one pair of said surfaces and in the opposite direction along the other pair of said surfaces.

16. In a circuit interrupter, means to establish an arc, deionizing means for said arc comprising spaced walls of insulating material, a pair of arc horns between said walls and spaced from the edges thereof along three sides, each of said arc horns having an arcing surface on opposite sides thereof, and a magnetizing coil having pole pieces extending across said pair of arc horns and beyond the outer edges thereof for causing a magnetic field in the same direction in the space between said arc horns and to each side thereof.

In testimony whereof, I have hereunto subscribed my name this 10th day of November, 1927.

JOSEPH SLEPIAN.