Dec. 26, 1939. J. M. WALLACE 2,184,760

CIRCUIT INTERRUPTER

Filed Nov. 12, 1937

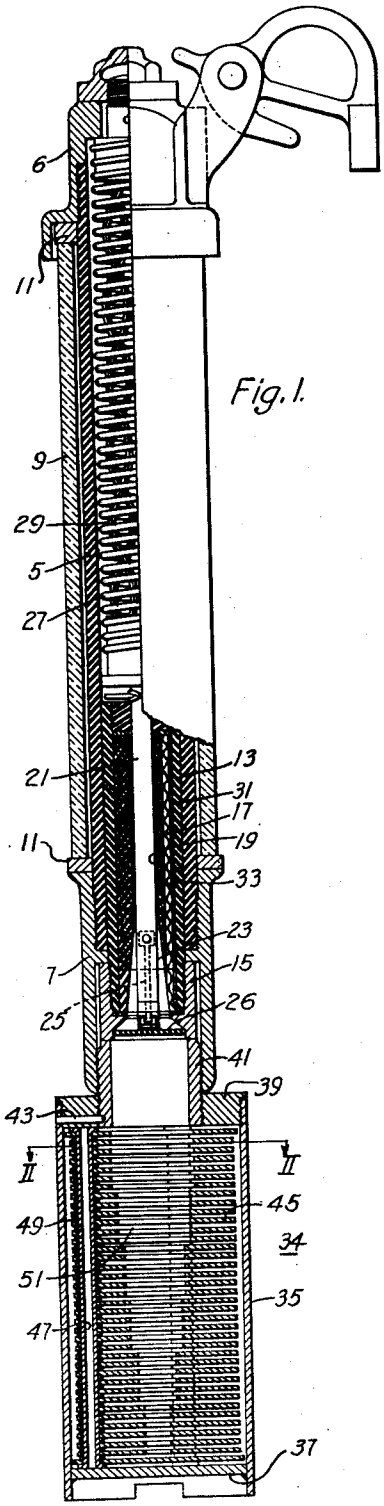


Fig. 1.

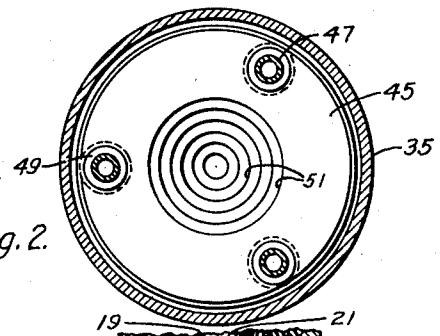


Fig. 2.

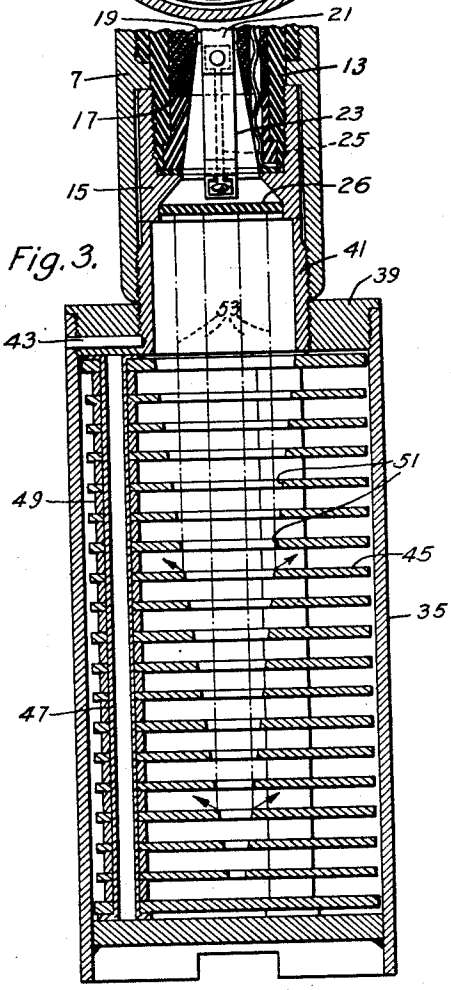


Fig. 3.

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CIRCUIT INTERRUPTER

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11 Claims. (Cl. 200—149)

My invention relates to circuit interrupters and particularly to expulsion type devices wherein the arc is drawn in a restricted passage having a material therealong which gives off gas when acted upon by the arc. This gas flows through the arc and out one end of the passage to carry away the ionized arc products. A closed cooling chamber or condenser is placed over the end of the arc passage to receive the gases given off.

This invention is an improvement in the condenser part of such a circuit interrupter and makes it possible to interrupt higher short-circuit currents than was possible with the prior art devices, such as shown in Slepian Patent No. 2,077,276, issued April 13, 1937, and Rawlins Patent No. 2,082,028, issued June 1, 1937, both assigned to the assignee of this application.

It is an object of my invention to provide an entirely enclosed circuit interrupter which is capable of interrupting heavy short-circuit currents. This is accomplished by providing the cooling means in the closed chamber with a tapered opening therethrough so as to make use of the kinetic energy of the flowing gas to distribute the gas quickly and uniformly throughout the condensing chamber and take full advantage of the cooling capacity of all parts of the condenser.

In one form of a device embodying my invention, the condenser comprises a plurality of spaced metal plates or washers having a central opening therethrough. The holes through the plates vary in size from a large opening in the plates adjacent the end of the arc passage to a small size at the opposite end of the structure. The large opening at the end of the cooling structure adjacent the arc passage permits the gases flowing out of the arc passage to flow freely without substantial obstruction. This makes it possible to take full advantage of the expulsion action to carry away the ionized gas in the arc passage so that the arc is quickly extinguished.

The fact that the opening through the plates is tapered provides a uniform distribution of the gas throughout all parts of the condenser instead of permitting the gas to flow all the way through the stack of plates until it hits the closed end and then be deflected back only into the lowermost plates in the stack. By using plates having openings of various sizes, the edge portions around the openings which project beyond the edges of the plates above serve to catch the outflowing gas and deflect it into the spaces between the plates, thus using the kinetic energy of the gas to distribute it uniformly among the plates.

In the older types of devices with openings of uniform size, the gas diffused between the plates solely because of pressure built up in the chamber. This slowed down the condensing action and is undesirable since the building up of pressure in the condenser retards the expulsive flow of gas through the arc, and, therefore, reduced the arc extinguishing ability of the device.

In a preferred form of my invention, the arc passage is lined with boric acid, which gives off water vapor or superheated steam which is quickly condensed as soon as it comes in contact with the relatively cool surfaces of the metallic plates in the condenser. This relieves the pressure within the device and permits the gas to flow through the arc with an expulsion action so as to quickly extinguish the arc.

Laboratory tests on a circuit interrupter embodying my invention show that it will successfully interrupt a short-circuit current of 67,000 peak amperes at 7500 volts, whereas a circuit interrupter using a condenser of the older design failed under the same circuit conditions at 37,000 peak amperes. By using the condenser of my invention, the interrupting ability of the fuse is raised almost to that obtainable from a fuse without a condenser where the gas may flow freely out the open end of the arc passage. At the same time, all of the advantages of an entirely enclosed fuse are retained. There is no flame or ionized gas emitted from the fuse, which makes it possible to mount the fuse in restricted spaces indoors where the emission of hot ionized gases might cause flashover between the conducting parts of adjacent apparatus. The use of an entirely enclosed condenser also greatly reduces the amount of noise present when heavy short-circuit currents are interrupted.

These and other objects and advantages of my invention will be more fully apparent from the following description of the drawing which illustrates a specific embodiment of the invention. In the drawing:

Figure 1 is a view, partly in cross-section and partly in elevation, of one form of my invention;

Fig. 2 is an enlarged transverse cross-sectional view through the condenser taken on the line II—II of Fig. 1; and

Fig. 3 is an enlarged cross-sectional view through a modified form of my invention.

The circuit interrupter shown in Fig. 1 to illustrate the invention is a high voltage expulsion fuse. The main fuse tube 5 is of fibre or a fibrous material impregnated with a phenolic condensation resin. This insulating tube is

threaded at each end, and is provided at its upper end with a contact ferrule 6, and at its lower end with a contact ferrule 7. The fibrous insulating tube 5 is protected against the weather when used out of doors by an outer tube 9 of refractory weatherproof material, such as glass or porcelain. The outer refractory tube 9 is supported through gaskets 11 between the ends of the tube and the inner ends of the contact ferrules 6 and 7.

Positioned within the fibre tube 5 at its lower end is a removable refill having a fibre tube 13 on one end of which is threaded a terminal ferrule 15. Inside of the fibre tube 13 of the refill, there is a lining 17 of arc extinguishing material which is preferably solid boric acid (H_3BO_3) which when acted upon by an arc is decomposed, giving off water vapor (H_2O), leaving solid boric oxide (B_2O_3). Other materials may be used which give off a large quantity of a gas which is readily condensable at room temperatures. Examples of such other materials are gypsum ($CaSO_4 2H_2O$) and ammonium alum ($Al_2(NH_4)_2(SO_4)_4 24H_2O$).

The opening through the boric acid lining forms an arc passage 19 which has a restricted portion of uniform width at its upper end and an enlarged tapered portion at its lower end. A rigid rod 21 of conducting material extends into the arc passage 19 through its upper end and is of sufficient size to substantially close the upper end of the passage. The lower end of the conducting member 21 is connected to a fusible element 23 which may be provided with a strain wire 25 to relieve the fusible element from tension. The lower end of the fusible element and the strain wire are fastened to the contact ferrule 15 on the end of the refill. A fibre disc 26, which is secured in the end of the refill ferrule 15 with a driven fit, is blown out as soon as a very small pressure has built up in the arc passage 19 and is largely destroyed by the blast of hot gas.

The upper end of the conducting rod 21 is removably connected to a tension spring 27, which is fastened at its other end to the upper contact ferrule 6. A flexible conducting shunt 29 conducts current to the conducting rod 21 from the upper terminal 6. The detailed construction of the removable refill and the spring, together with the means by which it is removably positioned within the outer tube, is similar to the construction shown in Rawlins Patent No. 1,976,634, issued October 9, 1934, to the assignee of this invention, and it is, therefore, not necessary to describe it in detail here.

The refill unit is also provided with an auxiliary arc passage 31 having a secondary fusible element 33 arranged so that heavy current arcs will be finally extinguished in the main arc passage 19 and small current arcs will be finally extinguished in the smaller auxiliary arc passage 31. The details of this structure and its method of operation are also fully described in Rawlins Patent No. 1,976,634.

The lower contact ferrule 7 is internally threaded at its lower end to receive the cooling chamber or condenser 34. This condenser comprises a portion of steel tubing 35 having an end plate 37 welded to close its lower end. The upper end of the tube 35 is threaded to receive a plug 39 which has an opening into which is threaded a connecting collar 41. The upper end of the collar is threaded to be screwed into the lower end of the terminal ferrule 7. A pin 43 locks the tube 35, the plug 39 and the collar 41 together so that the condenser may be unscrewed from the terminal ferrule 7 to permit the refill containing the fusible element to be removed and replaced after each operation of the fuse.

Inside of the chamber formed by the tube 35, there is positioned a mass of cooling material which may be provided in any one of a number of different forms. The cooling material has a multiplicity of interstices providing a large area of surface with which the arc products may contact to be cooled and deionized. It is an important feature of the invention to provide this mass of cooling material with a central opening in alignment with the open end of the arc passage so that the gases flowing expulsively out of the arc passage will not be substantially obstructed and may flow into the center of the mass of cooling material. By making the opening in the mass of cooling material tapered, the smaller free area through which the gas may flow at the smaller end of the opening forces the gas to flow into the interstices in the cooling material and be uniformly distributed therein. The fact that the opening in the mass of cooling material is tapered also has the advantage that a greater mass of material may be provided than where the opening is of a uniform width which must be large at its end adjacent the end of the arc passage in order to not unduly obstruct the expulsive flow of gas.

The drawing shows one preferred form of cooling means in the chamber comprising a stack of washers or plates 45 which are assembled upon three brass tubes 47. The washers are of copper or other material having a high specific heat and a high rate of heat conduction. The washers or plates 45 are spaced apart by small washers 49 between the plates. The ends of the brass tubes 47 are riveted or spun over so that the stack of plates is held together and may be positioned in the chamber as a single unit.

Each of the plates or washers 45 is provided with a central opening 51, which has a large area in the plates at the end of the condenser nearest the end of the arc passage 19. By making the opening through these plates of large area, there is very little obstruction to the gases flowing out of the end of the arc passage. The holes in the upper plates should have an area as large as the major part of the area of the lower enlarged end of the arc passage 19 or several times the cross-sectional area of the upper restricted end of the passage 19. The size of the openings through the plates or washers 45 is restricted at intervals along the stack until there is only a small opening at the closed end of the chamber.

As shown in Figs. 1 and 2, there are six different groups of plates with the openings of the same size in each group, whereas in the modification shown in Fig. 3, the openings through the plates taper uniformly from the end of the condenser adjacent the arc passage to the other end of the condenser. The uniform taper shown in Fig. 3 is theoretically more desirable, but it has been found that the stepped arrangement shown in Fig. 1 gives almost as good results and is more desirable from a manufacturing standpoint, since fewer different parts are required, thus reducing the cost.

The operation of the circuit interrupter of my invention is as follows: When an overload occurs, the fusible element 23 and the strain wire 25 are melted so as to permit the tension spring 27 to pull back the conducting arc drawing member 21, or if my invention is used in a circuit breaker, the conducting rod 21 has a moving contact on its lower end which is drawn away from a fixed con-

tact connected to the ferrule 15. In either case, the arc is initially established in the large tapered portion of the arc passage 19 and is then drawn back into the more restricted portion of the passage. The arc acts upon the arc extinguishing material 17 along the passage which gives off a large quantity of gas. While a solid material such as boric acid is shown for supplying the arc extinguishing gas, the device may also contain a liquid which will give off gas when acted upon by the arc.

The arc drawing rod 21 substantially closes the upper end of the arc passage 19 and thereby causes the gases formed to flow out of the lower end of the passage. The restricted passage causes the gas given off to quickly reach a high pressure and flow expulsively through the arc to carry away the hot ionized arc products.

The fact that the cooling members in the condenser have a large passage at the end of the condenser nearest the arc passage permits the gases to flow freely from the open end of the arc passage without substantial obstruction. This makes it possible to take full advantage of the expulsion action of the flowing gas to quickly extinguish the arc.

The use of plates having openings of decreasing size along the stack permits the edge of each plate which projects beyond the edges of the plates above to act as a deflector which catches the outflowing gas and makes use of the forward motion of the gas to deflect it into the spaces between the plates as indicated by the flow lines 53 in Fig. 3. This gives a uniform distribution of the outflowing gas among all of the plates as soon as the gas begins to flow and greatly increases the rate at which the gas is condensed so that it may be condensed almost as fast as it is formed. This keeps the internal pressure in the condenser to as low a value as possible and makes it possible to increase the efficiency of the arc extinguishing action, since the expulsive flow of gas through the arc passage is not substantially interfered with.

While I have shown and described in detail certain preferred forms of my invention, it is contemplated that various modifications may be made and it is intended that the claims shall cover such modifications. Where it is stated that the arc passage is open or is normally open at one end during the extinguishing of the arc, it is intended to include structures wherein there is a cover over the end of the arc passage which is blown open as soon as a small pressure is built up so that there will be an open end passage through which the gases can flow expulsively, except perhaps during the interruption of the smallest currents which may not require an expulsion action for their interruption. Also, where it is stated that the condenser is substantially enclosed, it is contemplated that some type of safety valve may be provided which would open up when very high pressures are reached to prevent bursting of the chamber. With such an arrangement, the condensing chamber would still be entirely enclosed when operating over the range of currents which the device is normally intended to interrupt.

I claim as my invention:

1. In a circuit interrupter, means for establishing an arc and causing a flow of gas, a chamber for receiving said gas, material in said chamber having a large area of surface with which said gas may contact, means providing a passage into said material in the chamber of sufficient size at the end nearest the point where the arc is established to permit substantially free flow of the gas into said material, and means at intervals along said passage projecting into the passage beyond the part of said material directly ahead thereof for deflecting the gas into said material.

2. In a circuit interrupter, means for establishing an arc and causing a flow of gas, a chamber for receiving said gas, material in said chamber having a large area of surface with which said gas may contact, means providing a passage into said material in the chamber of sufficient size at the end nearest the point where the arc is established to permit substantially free flow of the gas into said material, and said passage being progressively restricted.

3. In a circuit interrupter, a restricted arc passage, means for establishing an arc in said restricted passage, means for causing fluid to flow expulsively through the restricted passage and out one end thereof, a chamber positioned over said end of the arc passage, said chamber being entirely closed when normally interrupting the circuit and having cooling means therein with a multiplicity of interstices providing a large surface area, and a progressively restricted opening extending from said end of the arc passage into the cooling means.

4. In a circuit interrupter, a restricted arc passage, means for establishing an arc in said restricted passage, means for causing fluid to flow expulsively through the restricted passage and out one end thereof, a chamber positioned over said end of the arc passage, said chamber being entirely closed when normally interrupting the circuit and having cooling means therein with a multiplicity of interstices providing a large surface area, a progressively restricted opening extending from said end of the arc passage into the cooling means, and said progressively restricted opening having an area through which the fluid may flow at its end adjacent said restricted passage not less than one-half of the area of said end of the restricted passage.

5. In a circuit interrupter, means for establishing an arc and causing a flow of gas, a chamber for receiving said gas, material in said chamber having a large area of surface with which said gas may contact, said material having a central opening therethrough of sufficient area to accommodate substantially the full flow of said gas at the end of the chamber next to the means for establishing the arc and having portions along its length projecting into the opening a distance beyond the corresponding portions nearer to the means for establishing the arc for receiving said flow of gas and directing it laterally into the material.

6. In a circuit interrupter, means for establishing an arc and causing a flow of gas, a chamber for receiving said gas, said chamber being substantially entirely enclosed during normal operations of the interrupter to open the circuit, a plurality of spaced metallic plates in said chamber, said plates nearest the means for establishing the arc having openings therethrough of sufficient area to accommodate the full flow of said gas, and said plates at more remote points having openings of smaller area.

7. In a circuit interrupter, a passage for the arc, means for establishing an arc in said passage, means providing fluid to flow expulsively through the passage and out one end thereof, a normally closed chamber positioned over said

end of the arc passage, a mass of cooling material in said chamber having a multiplicity of small interstices, said mass of cooling material having a large central opening therein in alignment with said passage for the arc to permit said fluid to flow into the center of the mass of cooling material without substantial obstruction and said large central opening being tapered toward the end of the chamber opposite the end of the arc passage for causing the fluid to be forced to flow into the small interstices in the mass of cooling material.

8. In a circuit interrupter, means between which an arc may play, means along the path of the arc which when acted upon by the arc gives off a large quantity of gas which is condensable at room temperatures, a condenser for receiving said gas, said condenser having a mass of cooling material with a passage therein which is large at the end where said gas is first received and which is reduced in size at a plurality of points toward the other end.

9. In a circuit interrupter, means for establishing an arc, a restricted passage for the arc which is open at one end, a material along the passage which gives off a readily condensable gas when acted upon by the arc to flow through the passage and out its open end with an expulsion action, a closed condenser positioned over the open end of said passage, said condenser including a mass of material having an opening extending thereinto from its end nearest the open end of said passage, said opening having a sufficiently large cross-sectional area at its end nearest the open end of said passage to permit the gas to flow thereinto without substantial obstruction, and means at intervals along the opening for causing the gas to be deflected into the mass of material.

10. In a circuit interrupter, a movable conducting rod for drawing the arc, a restricted passage into which said rod extends and in which the arc is drawn, said passage being open at one end at least during part of the time that the arc is being extinguished and during at least a part of the same time being substantially closed at the other end by said conducting rod, material along said passage for giving off gas when acted upon by the arc, a chamber on the open end of said passage for receiving said gas, said chamber having means therein providing a large area of surface with which the gas may come in contact, a passage for the gas in said means in the chamber, said passage for the gas having a cross-sectional area at its end nearest the arc passage at least several times the cross-sectional area of the portion of the arc passage which is substantially closed by the conducting rod, and said passage for the gas decreasing in cross-sectional area as its other end is approached.

11. In a circuit interrupter, a movable conducting rod for drawing the arc, a restricted passage into which said rod extends and in which the arc is drawn, said passage being open at one end at least during part of the time that the arc is being extinguished and during at least a part of the same time being substantially closed at the other end by said conducting rod, material along said passage which when acted upon by the arc gives off gas substantially all of which is condensable at room temperatures, a substantially closed condenser over the open end of said passage and into which the gas may flow with an expulsion action, said condenser having therein a mass of metallic material having a multiplicity of interstices providing a large area of surface for cooling and condensing the gas, said mass of metallic material having an opening extending thereinto for receiving the gas, said opening having a cross-sectional area at its end nearest the arc passage which is several times the cross-sectional area of the portion of the arc passage which is substantially closed by the conducting rod, and the cross-sectional area of said opening being progressively restricted toward its other end.

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