Aug. 10, 1937. A. W. HULL ET AL 2,089,555

ELECTRICAL DISCHARGE DEVICE

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Fig. 1.

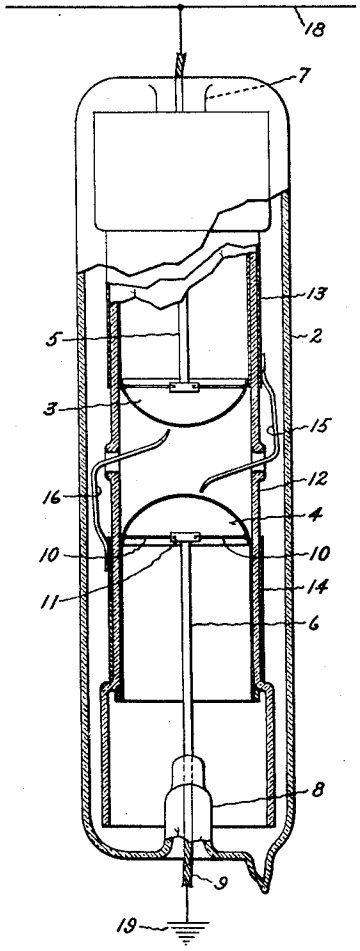


Fig. 2.

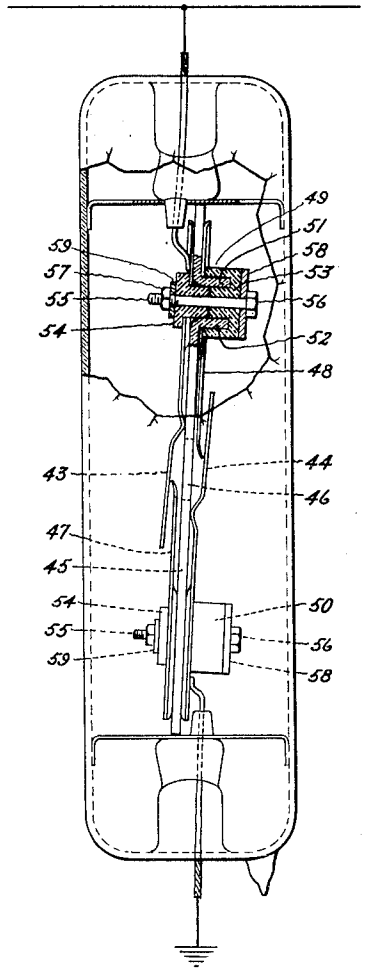
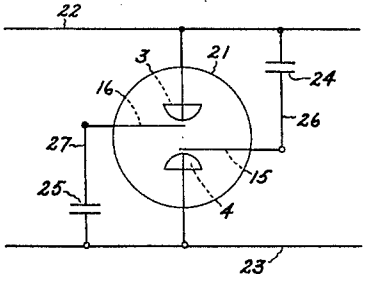


Fig. 3.



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Fig. 4.

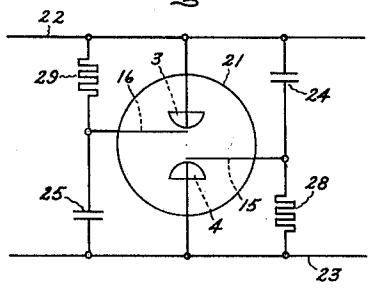


Fig. 5.

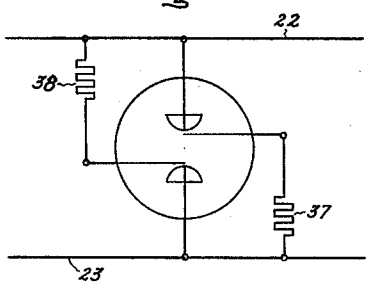


Fig. 6.

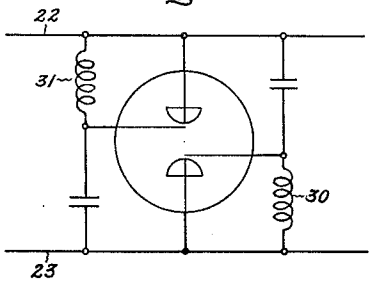


Fig. 7.

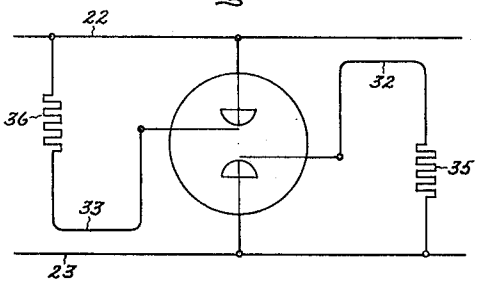


Fig. 8.

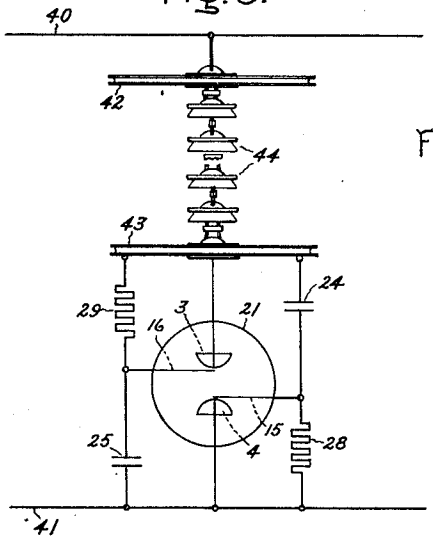
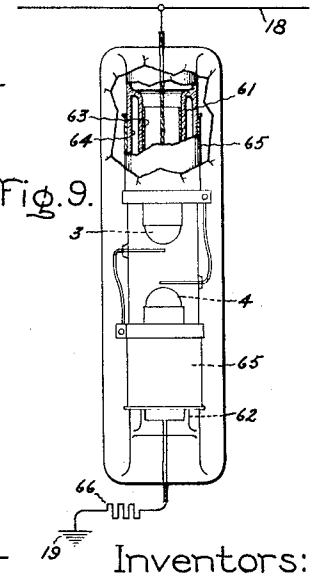


Fig. 9.



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UNITED STATES PATENT OFFICE

2,089,555

ELECTRICAL DISCHARGE DEVICE

Albert W. Hull and Leland B. Snoddy, Schenectady, N. Y., assignors to General Electric Company, a corporation of New York

Application May 17, 1932, Serial No. 611,831

5 Claims. (Cl. 250—27.5)

The present invention relates to electrical discharge devices which operate by the ionization of vaporized normally solid material in a vacuous space and which are characterized by their quick response to abnormal potentials, low discharge impedance during operation, and quick recovery after the excess voltage disturbance has been discharged. Its object is to provide for the selective discharge of transient disturbances in an electric device or system as distinguished from normal frequency impressed voltages.

The term transient as applied to a disturbance or discharge has been used herein to designate any electrical disturbance characterized by high rate of change of voltage, whether of atmospheric origin, such as lightning, or in the form of a surge within the system to be protected.

It is desirable that over-voltage discharge devices, commonly termed lightning arresters, should not discharge electric energy when the voltage of a line or electrical apparatus to which they are connected rises, within safe limits, above its normal voltage, but should readily discharge a transient discharge before it can harm the line or apparatus which such discharge device is intended to protect.

In accordance with our invention we have provided lightning arresters (meaning thereby over-voltage discharge devices of any character) which have the characteristics of readily discharging transients even when the voltage of these transients is materially below the normal voltage of the system, while remaining non-conductive to impressed voltages double the normal voltage or even higher when of normal frequency or rate of change.

These apparently incompatible characteristics of our improved device are the consequence of a construction whereby the lightning or abnormal frequency produces a local ionization at one of the electrodes which acts as a trigger to initiate the main discharge. Our invention includes also a new method and other novel features as pointed out with greater particularity in the appended claims. A more complete understanding of our invention may be gained from the following description taken in connection with the accompanying drawings.

Fig. 1 of the drawings is a side elevation partly in section of a preferred form of our invention shown connected between a conductor to be protected and ground; Figs. 2 and 9 are side elevations partly in section of modifications; and Figs. 3 to 8 are diagrammatic representations of various forms of circuit connections suitable for use in connection with our improved discharge device.

The device shown in Fig. 1 comprises an elongated envelope 2 of glass, fused silica or other suitable material. It contains non-thermionic electrodes 3, 4 which are mounted upon conductors 5, 6 and have closed rounded ends facing one another. The conductors 5, 6 are sealed into reentrant stems 7, 8 in the usual manner. A suitable connection between the electrodes 3, 4 which consists of hollow sheet metal, such as copper or nickel, and their terminal conductors is shown at 9 for the electrode 4. The branches 10 of the supports 11 are fastened by welding or otherwise to the conductor 6 and to electrode 4. In the example shown in Fig. 1 the electrodes 3, 4 are spaced apart a distance within the range of about .5 to 2.5 centimeters, the particular distance chosen depending on the conditions of service.

Surrounding the cylindrical electrodes 3, 4 and mounted thereon is a cylinder 12 consisting of glass, silica or other suitable dielectric material. Adjacent the respective electrodes upon the exterior of the cylinder 12 are metallic conductors or films 13, 14 forming with the electrodes 3, 4 and the intervening dielectric the elements of capacitors. Mounted upon these respective plates 13, 14 and extending through apertures in the cylinder 12 are respectively auxiliary electrodes 15, 16. These auxiliary electrodes assume the form of wires, preferably pointed as shown, which terminate closely adjacent the electrode opposite the one with which the respective auxiliary electrodes are coupled by the respective capacities.

The electrodes, conductors, envelope wall and other parts of our device are denuded of gas by suitable degassing methods and the space within the envelope is evacuated to a pressure so low that ionization of residual gas is of no account during the passage of an electrical discharge between the electrodes 3, 4, this condition of the device for the sake of brevity being referred to simply as evacuated. During the functioning of the device a discharge starts momentarily as a pure electron discharge and immediately changes to an arc discharge by the ionization of vaporized electrode metal. This feature of the present device is described and claimed in U. S. Patent No. 1,906,602, May 2, 1933, issued to Albert W. Hull. The main electrodes 3, 4 are connected between an electrical device to be protected (represented pictorially by the conductor 18) and ground, as indicated at 19.

For the sake of clearness the operation of the device will be explained with reference to one

pair of electrodes but it is to be understood that the action is the same with respect to the other pair of electrodes, the potential being reversed. When a surge, or other transient discharge, travels along the conductor 18 and raises the potential of the main electrode 3, the pilot electrode 16 closely adjacent to it remains for a short time at its original potential because of the capacity between it and the electrode 4. The voltage between the main electrode and the pilot electrode 16 therefore rises to a value sufficiently high to cause a discharge to take place between these two electrodes. This discharge or spark has very little power, but is sufficient to serve as a trigger to lower the discharge impedance of the gap between the main electrodes 3 and 4. As a specific illustration the following example may be given involving a device similar to the one described in which the main gap between the electrodes was about 1 centimeter and the auxiliary gaps between each of the pilot electrodes and its respective main electrode was about ½ millimeter. The electrical capacitors whereby the pilot electrodes were respectively coupled to one of the main electrodes, as above explained, had an electrical capacity respectively of about 20 micro-microfarads. The breakdown voltage between the main gaps was about 70,000 volts or more for steady potentials or alternating potentials of normal frequency. However, by the action of the pilot electrodes, a surge of 20,000 volts caused the breakdown of the main gap, giving a low voltage metal vapor arc which completely discharged the surge.

The advantage of the described construction over the simpler form of discharge device unprovided with auxiliary electrodes as herein shown, is that the main electrodes can be placed much farther apart with a given voltage rating, thus allowing a much greater safety factor for the normal frequency power voltage; while at the same time the sensitivity of the device to surges, which depends on the spacing between the auxiliary electrodes and the associated main electrodes, may be greatly increased. It is possible, therefore, to provide a lightning arrester which can be safely connected directly between a high voltage transmission line and ground and can be depended upon not to pass current even when the line voltage goes to double normal value but will operate to discharge lightning or a surge on the line of only one half the normal line voltage.

The spacing between the main electrodes is preferably so chosen, with respect to the voltage and inductance of the line and devices to be protected, that the arc goes out after discharging the surge, before any appreciable power current from these devices flows through it. But it is also practical and satisfactory to operate with a gap spacing such that power current flows through the arrester for the remainder of the half cycle in which the surge occurs, but is extinguished at the end of this half cycle.

In Fig. 3 a discharge device embodying our invention is diagrammatically represented at 21 as being connected between two conductors 22 and 23. Instead of having a capacity provided within the device this figure shows capacitors 24 and 25 connected in external circuits 26 and 27 respectively between the auxiliary electrode 15 and the main electrode 4 and the auxiliary electrodes 16 and the main electrode 3.

In some cases it is advantageous to provide also a high resistance whereby the potential of the capacitors 24 and 25 may be equalized. Such resistances have been shown in Fig. 4 at 28 and 29. Inductive resistances may be employed as indicated at 30 and 31 in Fig. 6.

It is likewise advantageous in some cases to employ instead of capacitors as shown in connection with Figs. 1, 3, 4, and 6 an auxiliary line which is spaced parallel with the main line so as to provide sufficient distributed capacity and inductance as indicated at 32 and 33 of Fig. 7. In this case also high resistances 35 and 36 may be provided in series respectively with the auxiliary conductors 32 and 33. In some cases the capacity device may be entirely omitted, the auxiliary electrodes being connected through high resistances with the opposite main electrodes as indicated at 37 and 38 in Fig. 5. These resistances are preferably of the type known as thyrite, described in United States Patent No. 1,822,742, K. B. McEachron, dated September 8, 1931.

While in most cases it is entirely practicable to connect the improved discharge device constituting our invention directly between line and ground, as shown in Fig. 1, a series air gap may be provided in some cases for additional protection. Such an arrangement is shown in Fig. 8 in which the discharge device 21 is connected between the conductors 40, 41 in series with an air gap between arcing rings 42, 43 which are separated by suspension insulators 44. A surge between the lines 40 and 41 will cause the air gap between the rings 42 and 43 to break down, thereupon causing the building up of potential between the main electrodes and the auxiliary electrodes and a discharge of energy through the device 21 as already described above.

The main electrodes, while preferably blunt and rounded as shown in Fig. 1, may assume various forms within the scope of our invention. In Fig. 2 is shown an alternative structure in which the main electrodes 43 and 44 are plate-shaped and supported on opposite sides of a plate or sheet of dielectric material 45 which may consist of glass, fused quartz, or other suitable non-conductor. An orifice is provided at 46 through the dielectric material 45 for the passage of the main discharge. The main electrodes 43 and 44 and the auxiliary electrodes 47 and 48 may be secured to the plate 45 by bolts and suitable insulating bushings 49, 50.

The structure of the bushing and the attached parts will be apparent from the sectional view of the bushing 49. The glass plate 45 has bosses 51, 52 extending at right angles therefrom and fitting into recesses of one member 53 of the bushing which consists of suitable insulation, as, for example, lavite or fused alumina. The cooperating member 54 of the bushing is pressed against the member 53 by a bolt 55 which pins the two portions together with the assistance of nuts 56 and 57 and suitable plates 58 and 59. The electrodes 43 and 48 are held in position against the glass plate 45 by the two members of the bushing when urged against each other by the tightening of the nuts 56 and 57.

In some cases it is advantageous to separate the plates of the internal capacitor by a vacuum space. A construction suitable for this purpose is shown in Fig. 9. The main electrodes 3, 4 are supported by re-entrant tubular supports 61 and 62. Within these tubular supports is placed the conducting coating or sheet material forming one plate of the capacitor as indicated at 63. Surrounding the supports 61, 62 is a tube 64, upon

which are supported or deposited, respectively, the cooperating electrodes of the internal capacitors, one of which is shown at 65. It will be observed that a vacuum space as well as layers of solid dielectric material intervenes between the plates of the internal capacitors. The discharge device in this figure is shown also as connected between a line 18 and ground 19 but in this instance a resistance 66 is provided in the ground circuit. This resistance may consist of thyrite, which was identified above.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. A vacuum electric discharge device comprising an envelope having main electrodes and an auxiliary electrode adjacent to and spaced from one of said main electrodes and a capacitor within said envelope connected to said auxiliary electrode and another of said main electrodes for causing an initial difference of potential between said auxiliary electrode and the main electrode to which it is adjacent when a transient voltage is impressed on said main electrodes.

2. An electric discharge device comprising an evacuated envelope containing main electrodes and an auxiliary electrode located adjacent to one of said main electrodes, and a capacitor within said envelope comprising the other of said main electrodes and a member directly connected with said auxiliary electrode.

3. A lightning arrester comprising an evacuated envelope, main electrodes of solid material mounted therein, an auxiliary electrode having a point adjacent one of said main electrodes and a means within said envelope providing an impedance connection between said auxiliary electrode and another more distant main electrode.

4. A lightning arrester comprising a sealed evacuated envelope, main non-thermionic electrodes therein having blunt ends juxtaposed and spaced apart, a sheath of dielectric material partially surrounding said main electrodes and leaving said blunt electrode ends unobstructed, a conductive plate mounted on the exterior of said sheath opposite each electrode and a pilot electrode connected with each plate and extending in close proximity to the other plate.

5. A lightning arrester comprising an evacuated sealed envelope, main non-thermionic electrodes therein having blunt ends spaced apart a distance within the range of about .5 to 2.5 centimeters, sharp-pointed pilot electrodes respectively adjacent to said main electrodes and being spaced apart therefrom a distance of about one half millimeter and impedance elements in said envelope respectively connected with each of said main electrodes and connected with a pilot electrode of another main electrode.

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LELAND B. SNODDY.