G. H. STEVENSON.

PROTECTIVE DEVICE.

APPLICATION FILED NOV. 20, 1916.

1,271,794.

Patented July 9, 1918.

2 SHEETS—SHEET 1.

Fig. 1.

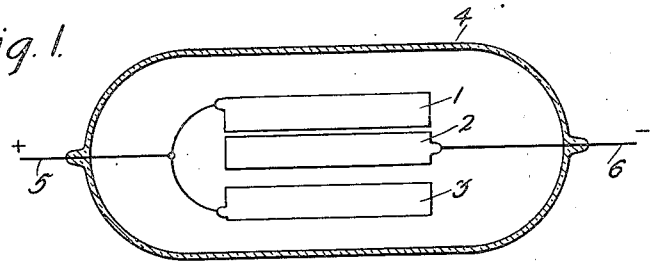


Fig. 2.

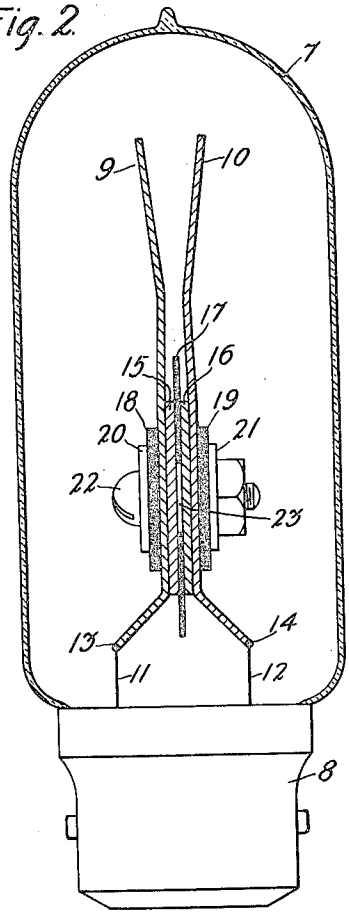
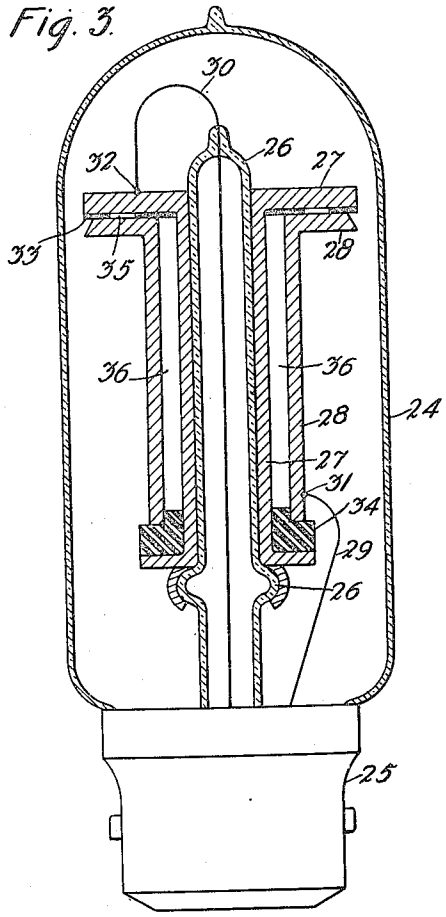


Fig. 3.



Inventor:
George H. Stevenson.
by A. C. Munnel. Att'y.

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2 SHEETS—SHEET 2.

Fig. 4.

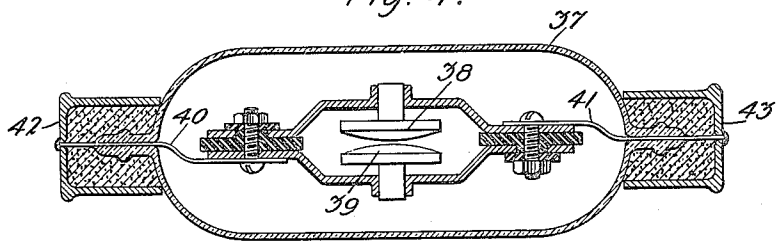


Fig. 5.

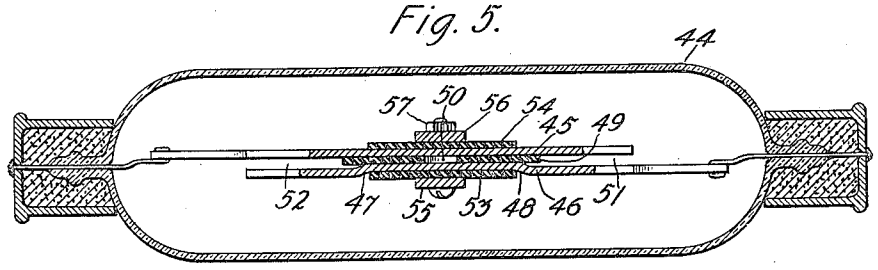
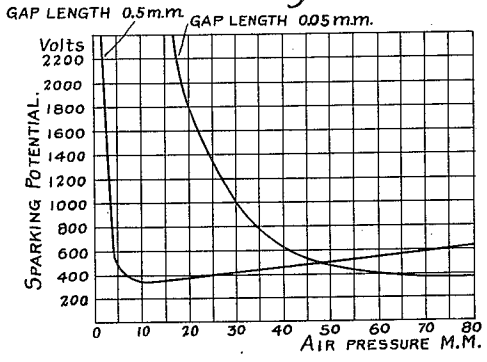


Fig. 6.



Inventor:
George H. Stevenson.
by S. Thurnell Att'y.

UNITED STATES PATENT OFFICE.

GEORGE H. STEVENSON, OF MOUNT VERNON, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

PROTECTIVE DEVICE.

1,271,794. Specification of Letters Patent. Patented July 9, 1918.

Application filed November 20, 1916. Serial No. 132,446.

To all whom it may concern:

Be it known that I, GEORGE H. STEVENSON, a subject of the King of Great Britain, residing at Mount Vernon, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Protective Devices, of which the following is a full, clear, concise, and exact description.

This invention relates to devices for protecting electric circuits from lightning and other abnormal voltages, and more particularly to protective devices of the vacuum type.

The present protective devices of the vacuum type used for telephone circuits comprise essentially two electrodes separated by a short gap. It has been found that, within certain limits of the length of the gap, the maintenance cost of these devices decreases as the gap is enlarged, for the reason that there will be less tendency to short-circuit by pitting and burning of the electrodes. However, a gap which is large enough to give low maintenance cost has had the disadvantage of not providing for the protection of the circuit if the gas pressure is increased beyond a certain value.

The general object of this invention is to provide a protective device which will have low maintenance cost and which, in the event of the pressure being increased, will still protect the circuit.

This result is accomplished, according to the present invention, by providing a comparatively large principal or primary gap between two electrodes which, as explained above, will give low maintenance cost, and a smaller secondary or auxiliary gap between the same two or different electrodes which will protect the circuit if the pressure is increased.

The invention will be readily understood from the following description taken in connection with the accompanying drawings which show some of the various forms in which the invention may be embodied; and in which—

Figure 1 is an elevation partly in section showing the invention in its elementary form; Figs. 2, 3, 4 and 5 are elevations partly in section of different embodiments of the invention characterized respectively by diverging electrodes, concentric electrodes, spherical faced electrodes and flat electrodes; and Fig. 6 is a graphical representation of the relation existing between pressure, sparking potential and the spark-gap of a protective device.

Paschen's law, upon the application of which the operation of the present protective device depends, states that the pressure corresponding to the minimum potential which will cause an arc to be struck between electrodes surrounded by a certain gas, usually called the "critical pressure," is very nearly inversely proportional to the distance between the electrodes.

The relation existing between these various factors will be readily understood by reference to the curves shown in Fig. 6. The data from which these curves are plotted is based upon the values taken from Townsend's "*Electricity in Gases*," page 361 (published by the Oxford University Press, 1915), which represents a summary of the experimental work by W. R. Carr on the sparking potential of gases at low pressures and in uniform electric fields. The values given for the sparking potential in air between parallel planes at various pressures, have been recomputed according to Paschen's law for two gaps of lengths of 0.5 mm. and 0.05 mm., respectively. The curves shown are for air-gaps of these lengths. It will be seen that at a pressure of about 50 mm. of mercury, the sparking potential of the two gaps is approximately the same. As the air pressure is decreased from this value, the sparking potential of the shorter gap increases quite rapidly. In the case of the longer gap, however, as the pressure is decreased the sparking potential decreases gradually until the "critical pressure" of about 10 mm. of mercury is reached, whereupon further decrease in pressure causes the sparking potential of that gap to increase very rapidly.

Now if a device is provided in which the electrodes are so arranged that there will be both a long and a short spark-gap, (for example, of the lengths for which the curves shown in Fig. 6 are plotted), it is evident that the pressure in the container can be adjusted to a value, say 10 mm. of mercury, at which the discharge will select the longer gap. It will also be evident that if the pressure within the container increases, due to leakage or other causes, the discharge will continue to take place across the longer gap,

although at a gradually increasing sparking potential, until the pressure has increased to approximately 50 mm. of mercury, whereupon the discharge will also take place across the shorter gap and with further increase of pressure will prefer that gap and will take place at a gradually decreasing sparking potential. With a secondary or auxiliary gap of the short length above mentioned, 0.05 mm., the arc will continue for only a very short time before the pitting of the electrodes will cause bridging of the gap, thereby protecting the apparatus on the line from any further disastrous effects due to abnormal voltages, and indicating that the arrester should be renewed.

The embodiments of the invention hereinafter described are so arranged as to operate upon the principle just explained. These devices are particularly adapted for the protection of telephone, telegraph and signal circuits, and in practice the length of the primary or principal gaps should be from 0.5 mm. to 1.5 mm., and the length of the secondary or auxiliary gaps should be from 0.05 mm. to 0.1 mm., while the pressure to which the container should be exhausted should be approximately the critical pressure of the primary or principal (that is the longer) gap, say from 5 mm. to 20 mm. of mercury.

In the elementary form, the device as shown in Fig. 1 consists of three flat metallic electrodes 1, 2 and 3 arranged parallel to one another within a container 4, which has been evacuated to the desired pressure in any well-known manner. Leading-in wire 5 is connected to electrodes 1 and 3, and leading-in wire 6 is connected to electrode 2. The three electrodes are spaced apart from each other so as to form the larger gap between electrodes 2 and 3 and the smaller gap between electrodes 1 and 2.

Figs. 2, 3, 4 and 5 show how the different length spark gaps may be secured in various forms of vacuum protective devices.

Fig. 2 shows the invention embodied in a structure characterized by diverging electrodes. The evacuated container 7, within which the electrodes are mounted, may be of glass formed and evacuated in the usual manner and cemented to a suitable base 8. The electrodes 9 and 10 are two flat pieces of metal bent in the manner shown, so as to slightly diverge at their upper ends. The lower ends are also bent so that the leading-in wires 11 and 12 can easily be soldered to them at 13 and 14 respectively. The electrodes are held in proper relation to each other by two metallic disks 15 and 16, and an insulating disk 17, which is somewhat larger than the metallic disks and has an opening at its center. Two insulating disks 18 and 19 are placed respectively on the outside of electrodes 9 and 10. Over all and binding the whole assembly together are two metallic bars 20 and 21, crossing the electrodes and engaged at each end by a bolt. One of these bolts is shown at 22. The primary or principal gaps are between the upper ends of the electrodes 9 and 10, and the secondary or auxiliary gap is shown at 23. In evacuating the container, it is difficult to adjust the pressure to the exact critical value for a certain length gap. These diverging electrodes 9 and 10, in effect, furnish a plurality of gaps which make it easy to secure a pressure which is at or near the critical pressure for one of the gaps.

Fig. 3 represents a vacuum protective device with a container 24 which is cemented to a suitable base 25. Within the container 24 is a hollow glass stem 26 upon which concentric cylindrical electrodes 27 and 28 are supported. Leading-in wires 29 and 30 are connected to the electrodes at 31 and 32. The electrodes are separated from each other and held in operable position by insulating disks 33 and 34. Insulating disk 33 has openings in it which provide for the secondary gap 35. The primary gap is between the electrodes 27 and 28 at 36.

Fig. 4 represents a vacuum protective device, comprising a container 37 in which are electrodes 38 and 39 having opposing spherical faces. The electrodes are held in a proper position by means of a framework, substantially as shown in the drawing, which is supported within the tube by two metal members 40 and 41 projecting, respectively, through an end of the tube, and being soldered to terminal caps 42 and 43 which are suitably cemented to the container. The electrodes thus provide a plurality of parallel spark-gaps of gradually varying lengths and make it easy to secure a pressure which is approximately the critical pressure for one of the longer gaps.

Fig. 5 represents an embodiment of the invention comprising a container 44 in which are supported, in a manner similar to that previously explained in connection with Fig. 4, two flat metal electrodes 45 and 46. Electrode 46 is bent at 47 and 48 so as to form a raised or bulging section near its center. Between the electrodes at their center is placed a disk of insulating material 49 which has a hole in its center, thus forming the secondary or auxiliary gap 50. The ends of the electrodes are spaced apart, thus providing the primary or larger gaps at 51 and 52. On the outside of each electrode are placed pieces of insulating material 53 and 54. Over all and binding the whole assembly together are two metallic bars 55 and 56 crossing the electrodes and engaged at each end by a bolt. One of these bolts is shown at 57.

The invention may be embodied in many other forms of protective devices than those

described and is, therefore, not limited to the forms herein disclosed.

What is claimed is:

1. In a protective device, a container, and electrodes therein providing a plurality of spark gaps of different lengths, said electrodes being surrounded by gas at substantially the critical pressure of one of the longer gaps.

2. In a protective device, a container, and electrodes therein providing a plurality of spark gaps of lengths varying from 0.05 mm. to 1.5 mm., said electrodes being surrounded by gas at substantially the critical pressure of one of the longer gaps.

3. In a protective device, a container, and electrodes therein providing a plurality of spark gaps of lengths varying from 0.05 mm. to 1.5 mm., said electrodes being surrounded by gas at a pressure from 5 mm. to 20 mm. of mercury.

4. In a protective device, a container, and electrodes therein providing primary or principal gaps having a length from 0.5 mm. to 1.5 mm. and secondary or auxiliary gaps having a length of from 0.05 mm. to 0.1 mm., said electrodes being surrounded by gas at a pressure of from 5 mm. to 20 mm. of mercury.

5. In a protective device, a container, and electrodes therein providing longer primary or principal gaps and shorter secondary or auxiliary gaps, said primary gaps being of length such that with a certain gas pressure in said container abnormal voltage discharges will take place across said primary gaps, and said secondary gaps being of lengths such that when the gas pressure is increased beyond a certain value abnormal voltage discharges will take place across said secondary gaps.

6. In a protective device comprising a partially evacuated container, in which is arranged a spark gap having a minimum sparking potential at substantially the pressure in said container, means providing an auxiliary spark gap in parallel with said principal gap and having its minimum sparking potential at a higher gas pressure than said principal gap, said minimum sparking potential of the auxiliary gap being less than the sparking potential of said principal gap at the same pressure.

In witness whereof I hereunto subscribe my name this 18th day of November, A. D., 1916.

GEORGE H. STEVENSON.