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Schleimann-Jensen

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[54] **GAS-FILLED DISCHARGE TUBE FOR TRANSIENT PROTECTION PURPOSES**

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[52] **U.S. Cl.** **313/217,** 317/62

[51] **Int. Cl.** **H01j 17/04**

[58] **Field of Search** 317/62; 313/217

[56] **References Cited**

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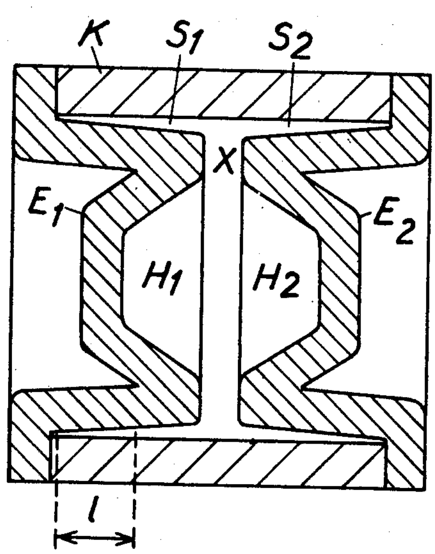
Assistant Examiner—Darwin R. Hostetter
Attorney, Agent, or Firm—Hane, Baxley & Spiecens

[57] **ABSTRACT**

A gas-filled discharge tube for use as transient protection device has at least two electrodes separated by a discharge gap and one insulating body which provides a vacuum sealed housing for the electrodes. Between the electrodes the insulating body defines a narrow gap in the direction from the discharge gap to the junction between one electrode and the insulating body around the whole electrode. This narrow gap has a maximum width of 0.15 mm along a distance which has a length of at least 1 mm.

8 Claims, 9 Drawing Figures



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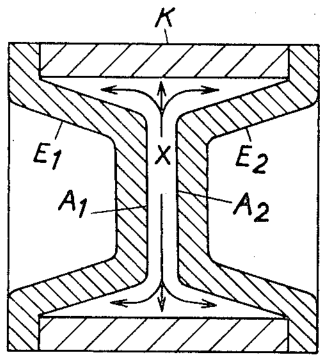


Fig. 1 PRIOR ART

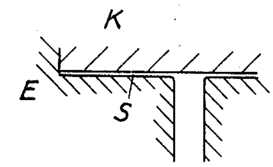


Fig. 2a

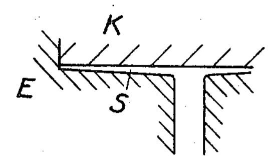


Fig. 2b

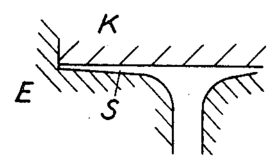


Fig. 2c

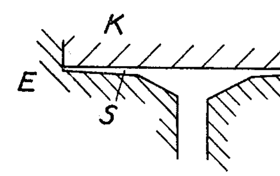


Fig. 2d

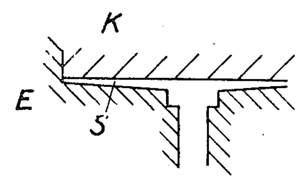


Fig. 2e

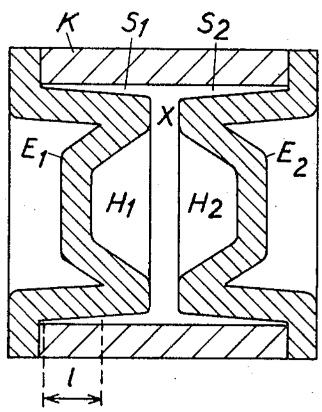
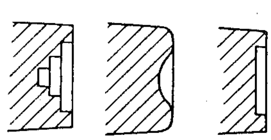


Fig. 3



a b c

Fig. 4

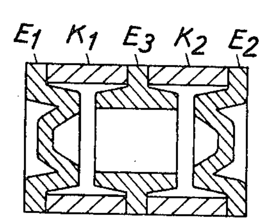


Fig. 5

GAS-FILLED DISCHARGE TUBE FOR TRANSIENT PROTECTION PURPOSES

Gas-filled discharge tubes have found a large range of use as protection devices against overvoltage transients in electronic equipment of very varying kind.

For this special purpose the tubes mostly consist of a several; electrodes which are electrically insulated from each other by a suitable mutual distance and are placed in a vacuum tight housing containing a gas of suitable kind and with suitable pressure. The tubes can, for example, be connected between ground and a line point where transients can occur, or they can be connected between other points, which may be subjected to overvoltage transients. Sometimes three-electrode tubes are preferred. A central electrode is then generally connected to ground while the other two electrodes are connected to points which are to be protected.

The electrode material, the distance between the electrodes and the type and pressure of the gas are important factors for determining the striking or firing voltage of the discharge tube. The striking voltage ought to be somewhat higher than the voltage which normally exists between the protection points so that if, in consequence of a transient, the voltage exceeds a value which involves a risk for the equipment, the tube shall ignite. The discharge at first takes place as a glow discharge and the voltage through the tube — and thus through the protected equipment — is limited to the glow voltage of the discharge tube. For larger energy loads in the transient the current through the discharge tube can be so large that the glow current is transformed into an arc discharge. This often occurs for currents of about the value 0.5 ampere. The voltage through the tube and the equipment then decreases to a value which is considerably lower than the glow voltage. Dependent on among other things the electrode material and the surface quality of this material the arc voltage can lie at such low values as about 10 volts or at somewhat higher values, however, in general with a maximum of about 45 volts. At decreasing current — that is when the energy of the transient is carried off through the tube — the arc discharge is transformed back into a glow discharge and ceases, when the voltage of the transient is no longer sufficient to keep the glow current of the discharge tube alive. The extinction voltage can differ from the striking voltage, but it should be higher than the voltage which normally exists between the protection points so that the tube will be extinguished when the transient ceases.

On the whole there are two different categories of discharge tubes for protection against overvoltage transients, namely tubes with electrodes of pure metals and tubes with electrodes, in which the gap between the electrodes has been provided with a layer of material having electron emission promoting characteristics. In both cases discharages cause sputtering of the electrode material, which later condenses on the colder parts within the tube, for example on the insulating part of the cover of the tube or on for the time being relatively cold parts of the electrodes of the tube. This often results in a great reduction of the capacity of the tubes so that they cease to serve their purposes. Reduced insulation and changed striking voltage are the most important reasons for this lowering of capacity and great, often very complicated, efforts have been made to master especially the insulation problems. Thus the tubes have been provided with screens which are to reduce the possibility that sputtering material can reach the insulating part of the tube, or the dimensions of the tube have been increased for example to be able to use housings with a longer insulation section or to have the possibility of placing the electrode gap at one end of the tube and the insulation part at the other end. In discharge tubes according to the invention the insulation difficulties have been overcome without introducing extra elements or other more expensive measures. Simultaneously improvements in the striking voltage characteristics have been attained.

The characteristics for a discharge tube constructed according to the invention appear from the appended claims.

The invention is explained more fully in detail by means of the following detailed description when read with FIGS. 1–5, where

FIG. 1 shows a now common embodiment for a transient protection device;

FIG. 2a to 2e illustrate an examples of insulator-electrode-gaps according to the invention;

FIG. 3 gives an example of a two-electrode tube according to the invention;

FIG. 4 shows different types of electrodes to be used in discharge tubes according to the invention; and

FIG. 5 shows the application of the invention to a three-electrode tube.

In FIG. 1 showing an earlier known protection device the electrodes E_1 and E_2 are vacuum tightly joined with the insulator body K. The joining process can take place by vitrification or by means of a suitable soldering process. In both cases the process often takes place in an atmosphere of the intended filling gas. Sometimes soldering and pumping and gas-filling take place as two operations. The arrangement has then generally been provided with a pump pipe, for example, in the one electrode, whereby the tube can be evacuated and gas filled after the soldering. The pump pipe is sealed after the gas dosage. Quite often the electrodes have been provided with electron emission promoting material A_1 and A_2 in the gap surfaces, but in recent years pure metal-electrodes seem to gaining ground because they have a quicker striking process — and thereby a better protection effect — than what is usual, if activated electrodes are used.

The discharge causes — as mentioned above — material sputtering whether pure or activated electrodes are used. This will be most dominant in the arc region of the discharge. The arc discharge also causes a highly increased gas pressure in the discharge itself and in its immediate vicinity. The pressure is often of such a magnitude that it may become explosive. In FIG. 1 the letter X indicates an arc discharge, which has been caused by a transient. As long as the arc discharge exists, the electrical and magnetic forces existing in the discharge can, to a certain extent, keep the arc material together so that this preferably moves in the longitudinal direction of the arc discharge. The arc discharge causes then, in the first place, a material transport between the electrodes, but when the arc discharge ceases, the material assembling effect of the discharge also ceases and the result will be that with great power sputtered or vaporized material will be thrown out of the gap and towards the insulator K and the electrode sides as is indicated by the arrows. A certain condensation of electrode material on the part of the insulator K, which is situated immediately outside the gap, can be favourable when pure metal electrodes are used, as this condensation material by its field emission characteristics can contribute to a very quick priming mechanism, but the part of the sputtering material, which is thrown up between the electrode sides and the insulator and which is condensed there, quite soon results in limiting the useful life of the tube.

According to the invention the gap between the electrode sides and the insulator is so narrow that only a small quantity of the sputtering material can be thrown into the such gap and the throwing, which possibly takes place, causes a local counter pressure and thereby prevents or considerably reduces the depth of the throwing in the gap range.

The result will be a considerably increased life and load resistance. It has been shown that a gap of maximum 0.15 mm between the insulator and the electrode sides are necessary to ensure the function of the tube according to the invention. Besides the gap should have a minimum depth of 1 mm. In certain cases a better result is attained, if the width of the gap is maximum 0.1 mm.

It has been mentioned above that usual transient protections with increasing condensation on insulator and electrode sides has a tendency towards a rise of arc discharges in the gap range between the insulator and the electrodes. This tendency can be accentuated if the transient protection is placed in a holder with parallel adapters, as electromagnetic blowing then can force the arc discharge out in the gap range. In such cases the tube is destroyed rather quickly. In tubes according to the invention this risk is practically completely eliminated. On one hand — as mentioned above — the risk for condensation in the gap range has practically been eliminated and on the other hand a gap of the size, to which the invention refers, causes such a large electron-ion-recombination possibility that a possible arc discharge in the range will be quickly extinguished.

A gap according to the invention can of course be varied in many ways by adaptation between insulator — and electrode form. The gap can have an equidistant width, FIG. **2***a*, or it can be gradually reduced towards the electrode-insulator-junction. The latter embodiment means a possibility to center slightly cone-shaped electrodes correctly in a cylindric insulator body, see FIG. **2***b*. The passage between electrode side and electrode gap surface can be varied in many ways without departing from the idea of the invention. FIG. **2***c–e* give such examples, where FIG. **2***c* shows a rounded form, FIG. **2***d* shows a diagonal cut-off corner part while FIG. **2***e* shows a step formed passage.

According to the invention a further advantage can be obtained considering the insulation qualities and the loading capacity, if the narrow gaps between the electrodes and the insulating body are combined with cavities in the gap surfaces of the electrodes, compare FIG. **3**, which shows an example of such a tube. The electrodes E_1 and E_2 have been formed so that when used together with an insulating body K they give narrow gaps S_1 and S_2 according to the invention. In the gap surfaces of the electrodes, the cavities H_1 and H_2 have been formed. Because of the relatively large volume, which the cavities H_1 and H_2 cause, the sputtering products from an arc discharge have, for example, at X a

tendency to be thrown into the region of the cavity, where the counter pressure will be relatively low. As the material of the arc discharge mostly has electric charge, the possibility is increased that quickly following transients cause arc discharges within the cavity part of the electrodes to further reduce risks for insulation and striking voltage difficulties even if the charge is increased beyond values which can be tolerated, when the gap according to the invention is used together with plane electrodes. In FIG. **3** the letter reference charge **1** indicates the length of the gap. The gap has a length of 1 mm and a maximum width of 0.10 mm.

The form of the cavities can of course be varied within wide limits. Even forms of cavities known per se can be used without departing from the scope of the invention. FIG. **4** shows some examples of possible forms of cavities, FIG. **4***a* showing a step formed cavity, FIG. **4***b* an arcuate cavity and FIG. **4***c* a cylindric cavity.

In well-known manner the gap surfaces of the electrodes — plane or formed with cavities — can be activated by electron emission promoting material or they can be pure metal surfaces, or possibly a combination of both. The surfaces can be even, roughen or in another way uneven.

In FIG. **5**, finally, is shown an example of a three-electrode tube according to the invention. The outer electrodes E_1 and E_2 are shown as cavity electrodes, compare FIG. **3**, while the central electrode E_3 is open so that all three electrodes are in a chamber in common. The gaps between all three electrodes and the two insulator bodies K_1 and K_2 are made according to the invention. Because of drawing technical reasons the tubes have been shown in a greatly enlarged scale. As an example of a size of a tube, it can be mentioned that a tube formed as is shown in FIG. **3** can have a diameter of 5 mm and a length of 6 mm.

We claim:

1. A gas-filled discharge device for transient protection comprising, at least two symmetrical electrodes having face surfaces, an insulation housing mechanically connected to said electrodes for supporting said electrodes in a vacuum-tight housing such that the face surfaces of said electrodes are opposite each other across a discharge gap in plane perpendicular to the symmetry axis of the electrodes, said housing and said electrodes being so dimensioned that an annular gap exists between each said electrode and said housing in the region of their mechanical connection, said annular gap having a length of at least 1 mm and a thickness of less than 0.15 mm, and an ionizable gas within said housing.

2. The discharge device of claim **1** wherein the thickness of said annular gap is less than 0.1 mm.

3. The discharge gap of claim **1** wherein the thickness of said annular gap gradually increases in the direction away from said junction.

4. A gas-filled discharge device for transitent protection comprising, at least two symmetrical electrodes having face surfaces, an insulation housing mechanically connected to said electrodes for supporting said electrodes in a vacuum-tight housing such that the face surfaces of said electrodes are opposite each other across a discharge gap in plane perpendicular to the symmetry axis of the electrodes, said housing and said electrodes being so dimensioned that an annular gap exists between each said electrode and said housing in the region of their mechanical connection, said annular gap having a length of at least 1 mm and a thickness of less than 0.15 mm, the face surface of at least one of said electrodes being provided with a cavity, and an ionizable gas within said housing.

5. The discharge device of claim **4** wherein said cavity is cylindrical in shape.

6. The discharge device of claim **4** wherein said cavity is partially spherical in shape.

7. The discharge device of claim **4** wherein said cavity is generally conical in shape.

8. The discharge device of claim **4** wherein said cavity is stepped conical in shape.

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