Dec. 6, 1960 R. O. GRAY 2,963,617

OVER-VOLTAGE PROTECTIVE DEVICE

Filed Feb. 4, 1958

Fig. 1

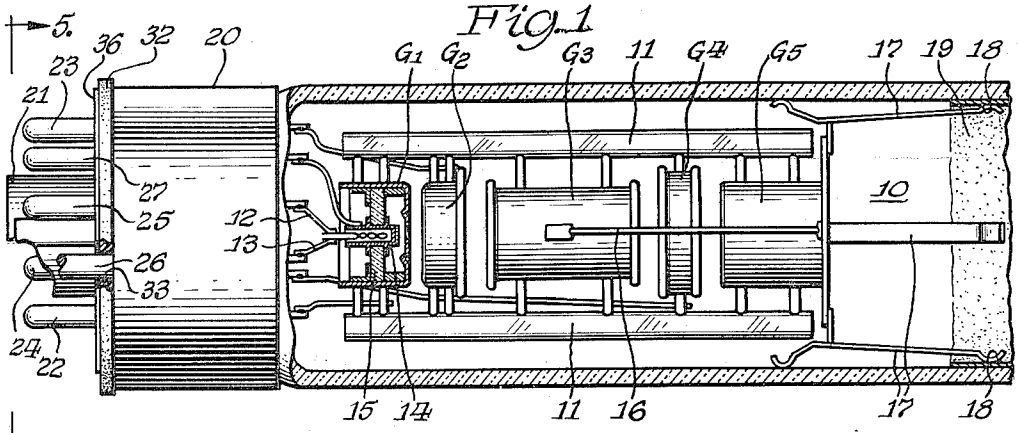


Fig. 5

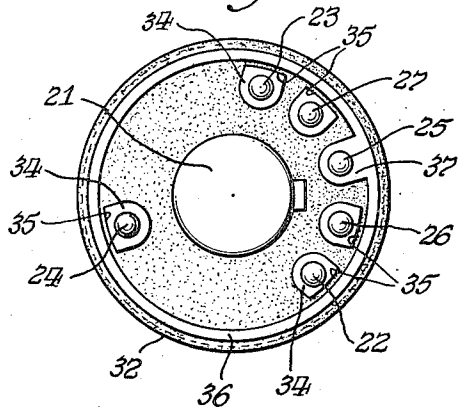


Fig. 4

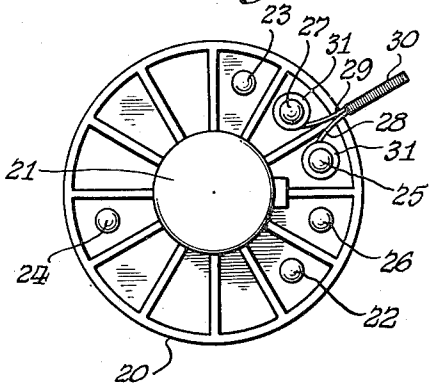


Fig. 2

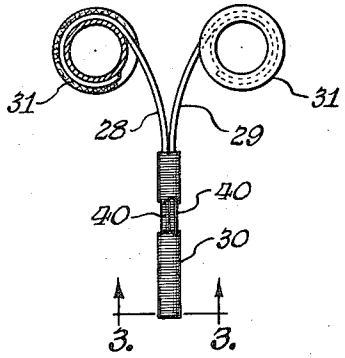
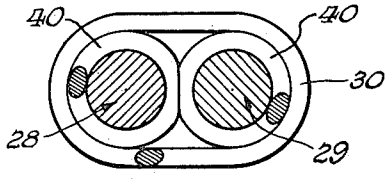


Fig. 3



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OVER-VOLTAGE PROTECTIVE DEVICE

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6 Claims. (Cl. 315—20)

This invention is directed to an over-voltage protective device which has application to electron tubes, in general, but is especially suited for use in cathode-ray tubes.

The electron gun structure of a cathode-ray tube comprises a series of axially spaced electrodes for forming, focusing, and accelerating a beam of electrons. During operation, the gun structure is subjected to high electric potentials, particularly the accelerating or final anode which is operated at voltages upwards of 15,000 volts. A problem of particular significance in respect to the operation of an electron gun structure is the prevention of electric arc discharges between its several electrodes. Such an arc discharge may be experienced and is generally attributable to extraneous high voltages, such as surge voltages in the final anode energizing circuit or accumulated build-up of charges on the gun structure, which effect breakdown between electrodes. Arcing between certain of the electrodes, e.g., the focusing and accelerator electrodes, will not usually result in permanent damage to the gun structure. However, since the external circuits associated with the gun electrodes are of substantially high impedance, arcing initiated between the final anode and an adjacent electrode will frequently progress along the gun structure and result in an arc discharge between the cathode and filament. The filament being inherently a low impedance circuit, a high discharge current flows and the filament usually becomes permanently damaged. Since the filament is sealed within the cathode-ray tube and cannot be replaced without disassembling the tube, the tube is usually scrapped.

While most arc discharges are attributable to temporary voltage surges of considerable magnitude, irregularities e.g., burrs on the electrodes, or inaccurate electrode alignment may also provoke arc discharges in the presence of lesser disturbances. Thus, while a cathode-ray tube having an electron gun with a minor imperfection in its structure may perform satisfactorily under normal operating conditions, the occurrence of a minor voltage surge may induce an arc discharge because of the weakness represented by the imperfection. A partial solution to this problem has been the exercise of extreme caution during the assembly process and maintenance of rigid quality control. It is obvious that such expedients are costly and further do not admit of a positive solution to the problem.

It is, therefore, an object of this invention to provide an over-voltage protective device for preventing damage to the electrode structure of an electron-discharge device.

It is also an object of this invention to provide an over-voltage protective device for controlling electric arc discharge between the conductive elements, such as electrodes, of an electron-discharge device.

It is a further and specific object of this invention to provide an over-voltage protective device which minimizes damage resulting from an arc discharge between the electrodes of a cathode-ray tube.

An over-voltage protective device, in accordance with this invention, is useful in conjunction with an electron-discharge device having a pair of spaced conductive elements which are insulated for potential differences less than a predetermined breakdown voltage, and which are subject during operation to extraneous high potential differences exceeding this breakdown voltage. The over-voltage protective device prevents electric arc discharge between such elements and comprises a pair of closely spaced suppressor terminals which define a spark gap and are adapted to break down at a voltage lower than the aforesaid breakdown voltage. Means are provided for electrically connecting the suppressor terminals to the conductive elements or electrodes.

In one embodiment, the suppressor terminals comprise conductive leads provided with loops for establishing mechanical and electrical connections to the terminal pins associated with the electrodes of the electron-discharge device desired particularly to be protected, such as the cathode and filament elements.

An alternate embodiment utilizes a wafer of insulating material adapted for mounting upon the base of an electron-discharge device. Suppressor terminals comprising conductive tabs are affixed to the wafer and are apertured to engage the terminal pins. They have a close spacing from a grounded conductive ring and, in conjunction therewith, define spark gaps of much less breakdown rating than the breakdown potential between electrodes of the tube.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The organization and manner of operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals identify like elements, and in which:

Figure 1 is a fragmentary view, partly in section, of the neck portion of a cathode-ray tube, showing its electron gun structure;

Figure 2 is a plan view illustrating an arc suppressor arrangement which comprises one embodiment of the invention;

Figure 3 is an enlarged end view of the suppressor arrangement in Figure 2 taken along line 3—3;

Figure 4 is an end view of the base portion of a cathode-ray tube showing the suppressor arrangement of Figure 2 mounted upon the base terminals; and

Figure 5 is an end view of the cathode-ray tube taken along line 5—5 in Figure 1 showing an alternate embodiment of the subject invention positioned upon the tube base terminals.

Referring now more particularly to Figure 1, the neck portion of the cathode-ray tube there shown includes an electron gun structure **10** comprising a number of axially spaced electrodes, conventionally designated G1, G2, G3, G4, and G5, which are mutually insulated for operating potentials less than predetermined breakdown voltages. That is to say, their spacing provides an insulation such that there is no breakdown in the presence of potentials normally applied to the gun structure in creating, focusing and accelerating an electron beam. Electrodes G1—G5 are rigidly secured by the parallel glass rods **11**. A filament arrangement, comprising lead-ins **12** and **13**, is disposed within a cylindrical cathode electrode **14**. Filament lead-in **12** is maintained at D.C. ground potential through its associated energizing network (not shown). Cathode **14** is mounted within electrode G1 and is insulated therefrom by a ceramic washer **15**. Electrode G3 is conductively connected to G5 by a rod **16**. Electrode G5 in turn mounts the resilient fingers **17** which axially center and support one end of electron gun structure **10**. Fingers **17** include the offset portions **18** which

contact an aquadag coating 19 disposed upon the inner surface of the cathode-ray tube neck. Coating 19 is connected to a source of high electric potential (not shown). The cathode-ray tube neck is terminated by a base portion 20 which includes a keyed base plug 21 and a plurality of terminal pins which are electrically connected to assigned ones of the electron gun electrodes. More particularly, the terminal pins 22, 23, and 24 are connected to electrodes G1, G2, and G4 respectively, while terminal pins 25, 26 are connected to respective filament lead-ins 12, 13. Terminal pin 27 is electrically connected to cathode electrode 14.

Figure 2 discloses an over-voltage protective device comprising a pair of suppressor terminals. More specifically, it includes the conductive leads 28 and 29 having an insulating coat of varnish and individually wrapped with an insulating thread 40, best shown in Figure 3. The leads are adjacently disposed and held in a closely spaced relationship by an outer thread 30 or other suitable binder. Leads 28, 29 are conductively terminated by the eyelets 31 adapted to engage an adjacent pair of terminal pins in the tube base. Figure 3 illustrates the extremities of leads 28, 29 remote from eyelets 31. They are devoid of insulating varnish and are maintained in a non-conductive relationship by the thickness of threads 40 so as to define a spark gap across the ends thereof as shown in Figure 3. This gap is characterized by a breakdown potential that is materially lower than the gun elements to be protected and this is accomplished by a close spacing of the bared ends of conductors 28 and 29. Figure 4 shows the eyelets 31 of suppressor leads 28, 29 in conductive engagement with cathode terminal pin 27 and filament terminal pin 25.

In typical operation, the electrodes of electron gun 10 are energized and develop an electron beam which is accelerated and focused in conventional manner upon a screen (not shown). For the most part, the circuits coupled to the electrodes have a high impedance except for the filament circuit connected to lead-ins 12 and 13 which is a low impedance network.

A high potential is, of course, applied to final anode G5 via aquadag coating 19 so that electrodes G3, G5 are continually operated at a high electric potential. Upon the occurrence of an extraneous voltage of sufficient intensity to exceed the electrode breakdown voltage, an arc discharge occurs between grid G3 connected to the final anode and grid G2. It will flash across the intervening gun electrodes and subsequently appear between cathode 14 and the filament. Ordinarily, a high current surge resulting from an arc discharge from the cathode to the filament destroys the filament structure. This undesirable result is effectively precluded by the subject invention. The voltage breakdown rating of the bared extremities of suppressor leads 28 and 29 is typically between 800 and 1200 volts which is substantially below the breakdown voltage of conventional cathode-ray tube cathode-filament structures, the most critical of the gun elements. Any desired rating for suppressor leads 28 and 29 can of course be obtained by varying the thickness of threads 40.

With suppressor 28, 29 in position, as shown in Figure 4, the occurrence of such a voltage surge of high intensity, culminating in an electric arc discharge upon cathode 14, causes the spark gap defined by the bared extremities of suppressor leads 28, 29 to break down and dissipate the arc. The high surge current induced by the arc discharge is shunted to ground via filament terminal pin 25, preventing damage to the filament structure. Of course, this disposition of the arc disturbance results directly from the fact that the breakdown potential of the suppressor is much less than the breakdown potential of cathode-to-filament so that the arc discharge is channeled from cathode 14, to pin 27, suppressor 28, 29 to ground filament pin 25. In this manner, the filament itself is protected.

In the alternate embodiment shown in Figure 5 the arc suppressor arrangement comprises a wafer 32 of insulating material which is adapted to be mounted upon base 20 by providing the wafer with a central opening to accommodate the keyed base plug 21 and a pluarity of apertures 33 (only one shown, Figure 1) for receiving the base terminal pins. A number of conductive tabs 34, apertured to receive and conductively engage terminal pins 22—24, 26, and 27, are affixed to wafer 32 and include the arc portions 35. The suppressor tab arrangement further employs a conductive ring 36, likewise fixed to wafer 32, having an integral tab 37 which engages grounded filament terminal pin 25. Conductive ring 36 is circumferentially disposed adjacent to and in a closely spaced relationship to arc portions 35 of tabs 34 so as to define a series of spark gaps which break down at voltages much less than the breakdown voltages of the electron gun electrodes.

Conductive tabs 34 and ring 36 may be printed upon wafer 32 by conventional means or may comprise conductive foil suitably bonded to the wafer. Although tabs 34 are shown as completely surrounding terminal pins and in conductive contact therewith, it is not necessary that the tabs be in physical contact with the several terminal pins in order to permit proper functioning of this arc suppressor arrangement. It is sufficient that the spacing between tabs 34 and their associated terminal pins be equal to or preferably less than the spacing between ring 36 and arc portions 35 of the several tabs.

The operation of the embodiment of Figure 5 is substantially identical to that described in conjunction with the embodiment of Figure 4, that is, an arc discharge from any of electrodes, G1—G5, is dissipated by the spark gap defined by the conductive tab associated with the terminal pin connected to that electrode and conductive ring 36. Since tab 37 extending from ring 36 is connected to terminal pin 25, which is returned to a plane of reference potential, the induced surge current is harmlessly shunted to ground. The breakdown rating for the spark gaps has been found to be somewhat higher than that of the suppressor lead arrangement of Figure 2 but well below the breakdown voltage of the cathode filament structure.

An added advantage of the embodiment shown in Figure 5 is that an arc appearing on any of electrodes G1, G2, G4, or cathode 14, is instantly dissipated between its associated suppressor tab 34 and ring 36. This feature reduces progressive arcing between the electrodes by dissipating the arc discharge almost upon its inception. Although the spacing between tabs 34 and ring 36 is shown in Figure 5 as uniform, it is recognized that different spark gap spacings can be provided in order to accommodate the different breakdown voltages of the several electrodes.

In summary, this invention provides a simple and inexpensive spark gap arrangement for preventing damage to an electron gun structure occasioned by electric arc discharges. The use of this invention with conventional cathode-ray tubes further permits a measurable relaxation in the stringent techniques required in the manufacturing processes and thus effects a substantial saving in shrinkage.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. In combination: an electron-discharge device comprising a first conductive element and a second conductive element spaced from said first element and insulated with respect thereto for potential differences less than a predetermined breakdown voltage, and including a base portion

comprising respective first and second terminal pins connected to said elements, said first and second elements being adapted to be maintained at different potentials and being subject to extraneous high potential differences in operation of said device; and an over-voltage protective device for preventing electric arc discharge between said elements attributable to said extraneous high potential differences, said protective device comprising a wafer of insulating material adapted for mounting upon said base portion, a first conductive suppressor tab affixed to said wafer and apertured to engage said first terminal pin, a second conductive suppressor tab, likewise affixed to said wafer, apertured to engage said second terminal pin and disposed adjacent to and in closely spaced relation to said first suppressor tab for defining therewith a spark gap adapted to break down at a voltage lower than said breakdown voltage, whereby said extraneous high potential differences of a magnitude greater than said breakdown voltage are prevented from appearing between said first and second elements.

2. In combination: an electron-discharge device comprising a plurality of spaced conductive elements, including one to be maintained at a reference D.C. potential, and including a base portion comprising a plurality of terminal pins connected to assigned ones of said elements, said elements being maintained at different operating potentials and being subject to extraneous high potential differences in the operation of said device; and an over-voltage protective device for preventing electric arc discharge between said elements attributable to said undesired extraneous high potential differences, said protective device having means for mounting it upon said base portion and including a conductive portion for engaging the one of said terminal pins which connects to said one element of said electron-discharge device, and a plurality of conductive components, likewise included in said protective device for engaging the remaining terminal pins and disposed adjacent to said conductive portion for defining therewith a plurality of spark gaps having breakdown voltage rating lower than the breakdown voltages between said elements of said electron-discharge device.

3. A protective device for dissipating a voltage transient comprising: two sections of insulatingly covered conductor disposed in substantially parallel relation and fixed against relative movement, each of said sections having an exposed portion at one end thereof serving as an electrode and said exposed portions being physically disposed relative to one another to define a spark gap having a voltage breakdown threshold less than the voltage transient to be protected against, and each of said sections further having a terminal portion at the opposite end thereof for connecting said spark gap across a component to be protected.

4. In combination: an electron-discharge device comprising a first conductive element and a second conductive element spaced from said first element and insulated with respect thereto for potential differences less than a predetermined breakdown voltage, and including a base portion comprising respective first and second terminal pins connected to said elements, said first and second elements being adapted to be maintained at different potentials and being subject to extraneous high potential differences in operation of said device; and a removable over-voltage protective device for preventing an electric discharge between said elements attributable to said extraneous high potential differences, said protective device comprising a support member having a first aperture for receiving said first terminal pin, a second aperture for receiving said second pin, and a conductive portion extending from said apertures and providing an arc discharge path between said first and second pins adapted to break down at a voltage lower than said breakdown voltage, and said support member further having an indexing provision for orienting said apertures in respect of said first and second terminal pins as said protective device is applied to said base portion.

5. In combination: an electron-discharge device comprising a first conductive element having a lead-in and a second conductive element having a lead-in, spaced from said first element and insulated with respect thereto for potential differences less than a predetermined breakdown voltage, said first and second elements being adapted to be maintained at different potentials and being subject to extraneous high potential differences in operation of said device, and an over-voltage protective device for suppressing an electric arc discharge between said elements attributable to said extraneous high potential differences, said protective device comprising a first suppressor electrode having a terminal portion at one end for encircling said lead-in of said first element to establish mechanical and electrical connections therewith, and a second suppressor electrode likewise having a terminal portion at one end for encircling said lead-in of said second element to establish mechanical and electrical connections therewith, said electrodes having their opposite ends disposed adjacent to and in closely spaced relation to one another to define a spark gap adapted to break down at a voltage lower than said breakdown voltage, whereby extraneous high potential differences of a magnitude greater than said breakdown voltage are prevented from appearing between said first and second elements.

6. An over-voltage protective device for use with an electron-discharge device which has a first conductive element having a lead-in and a second conductive element having a lead-in, spaced from said first element and insulated with respect thereto for potential differences less than a predetermined breakdown voltage, said first and second elements being adapted to be maintained at different potentials and being subject to extraneous high potential differences in operation of said device, said protective device comprising: a first suppressor electrode having a terminal portion at one end for encircling said lead-in of said first element to establish mechanical and electrical connections therewith; and a second suppressor electrode likewise having a terminal portion at one end for encircling said lead-in of said second element to establish mechanical and electrical connections therewith, said electrodes having their opposite ends disposed adjacent to and in closely spaced relation one to another to define a spark gap adapted to break down at a voltage lower than said breakdown voltage, whereby extraneous high potential differences of a magnitude greater than said breakdown voltage are prevented from appearing between said first and second elements.

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