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Komoda

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[54] ELECTRON GUN DEVICE OF FIELD EMISSION TYPE

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[52] **U.S. Cl.** .....**250/49.5 A,** 250/49.5 R, 313/82

[51] **Int. Cl.**.....**H01j 37/26**

[58] **Field of Search**.....313/82, 83, 206, 313/240, 80; 250/49.5 A, 49.5 R

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[57] **ABSTRACT**

In an electron gun device of the field emission type, a shield electrode whose potential is the same as that of a cathode-tip of needle shape is disposed in surrounding relationship to a first anode so as to shield said first anode from ground potential portions of the device, such as the envelope, so that discharge between the anode and the ground potential portions is prevented, whereby the needle tip of the cathode is protected from destruction due to said discharge.

10 Claims, 2 Drawing Figures

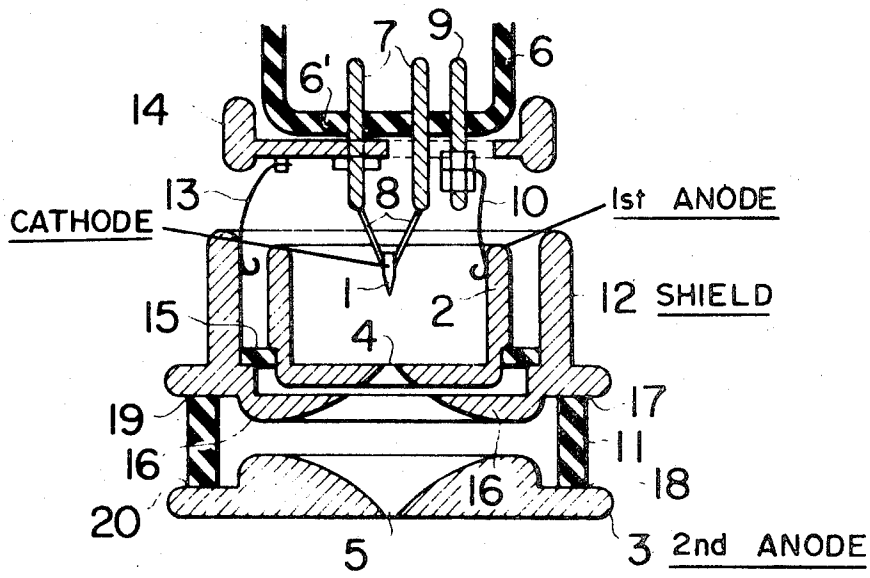


FIG. 1

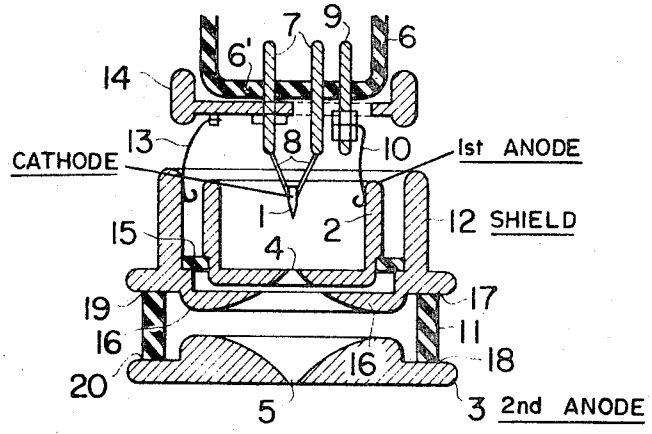
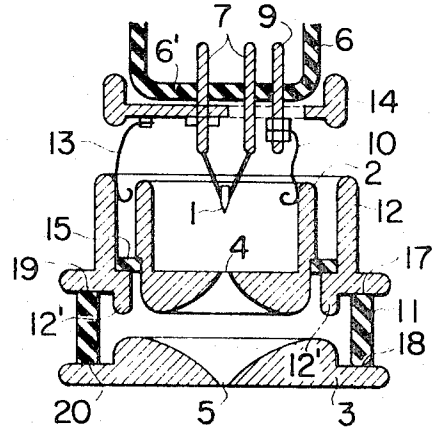


FIG. 2



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ELECTRON GUN DEVICE OF FIELD EMISSION TYPE

BACKGROUND OF THE INVENTION

This invention relates to an electron gun device of the field emission type, which is particularly suitable as a source of an electron beam in an electron microscope, and the like.

As is well known, a conventional electron gun device for an electron microscope has a cathode tip of needle shape, means for heating said tip and an anode for causing electrons to be emitted from aid tip by applying an electric field between said tip and said anode.

In such an electron gun device, undesirable discharge occurs frequently in the operation and at this time, the tip portion of said cathode is destroyed so that the field emission of electrons therefrom stops.

Since the useful life of the cathode tip in the conventional electron gun device is very short for the reasons described above, it is necessary to exchange said tip frequently.

In the electron gun device, ultra high vacuum conditions must be maintained and once this condition is broken for exchange of said tip, it is necessary to evacuate the electron gun device once again. However, this requires complicated procedures and very long time to effect such evacuation.

SUMMARY OF THE INVENTION

An object of the invention is to provide an electron gun device having a very long useful life.

Another object of the invention is to provide an electron gun device having the advantage that the number of times wherein exchange of the cathode tip is required, and thus the number of times wherein evacuation of the microscope is necessary, has been greatly reduced.

A further object of the invention is to provide an electron gun device suitable as the source of an electron beam for use in an electron microscope and the like.

The electron gun device of this invention is characterized in that a shield electrode, being at the same voltage as that of the anode, is disposed in said device to surround an accelerating anode for shielding said anode from parts at ground potential.

These and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic diagram showing an embodiment of the invention; and

FIG. 2 is a schematic diagram showing another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, an electron gun for an electron microscope includes a cathode tip 1 of needle shape, a first anode 2, a second anode 3, the respective anodes being provided with holes 4 and 5 through which an electron beam passes. Insulators 6 and 11 serve as supports and spacers, the insulator 6 carrying terminal electrodes 7 supporting a tungsten filament 8 of hair-pin shape, and a terminal electrode 9 carrying a contact spring 10.

These are well known elements which constitute a conventional electron gun structure. However, in addition, a first shield electrode 12 is provided which is a characteristic element according to the present invention.

In a conventional electron gun structure, a negative high voltage, for example −30 KV, is applied to the cathode tip 1 through the terminal electrodes 7, and another negative high voltage of about −27 KV is applied to the first anode through the contact spring 10 and the terminal electrode 9. Moreover, the second anode 3 is grounded.

In the electron gun device of conventional structure, since the intensity of the electric field adjacent to the top portion of the cathode tip 1 becomes 10^7–10^8 v/cm due to potential difference between said tip 1 and the first anode 2, electrons are caused to emit from said tip 1 by means of the electric current flowing through the filament 8 so as to make it clean by heating it. These electrons passing through hole 4 are focused by an electric field produced between the first and second anodes 2 and 3 which act as an electron lens so that an electron beam having a fine spot of high density is obtained from the hole 5.

Since the cathode tip 1 is surrounded by the first anode 2, discharge almost never occurs between said tip 1 and parts which are not at ground potential, such as the envelope of the electron gun device (not shown), even when the negative high voltage is applied to the cathode tip 1 as described above.

However, it is possible that discharge occurs between the first anode 2 and the parts at ground potential. When such discharge occurs, the potential of the first anode 2 is reduced to ground potential at once, and the potential difference between the tip 1 and the first anode 2 becomes very high so that the quantity of electrons emitted from the tip 1 increases rapidly and to a great extent.

Generally, the tip portion of the cathode 1 is very sharp so as to allow electrons to be emitted therefrom by means of electric field effects. For example, a tungsten line, having a diameter of 0.1–0.2 mm whose radius of curvature at the tip portion is formed in a needle shape to have the very small value of 500 A, is used as the tip. Therefore, as a result of the rapid increase of electrons upon occurrence of the above-mentioned discharge, the tip portion of the cathode is extraordinarily heated and thereby destroyed, so that emission of electrons therefrom stops since the intensity of the electric field adjacent to the tip portion of the cathode 1 decreases to almost zero value, under which conditions the field is unable to cause electrons to be emitted therefrom.

It is apparent from the foregoing description that the positive potential difference between the cathode tip and the first anode can be prevented from becoming excessive by preventing discharges between the first anode and the ground potential parts of the electron gun assembly and thereby destruction of the tip portion of the cathode can be prevented.

Thus, the electron gun device of the present invention is designed to have a first shield electrode 12 surrounding the first anode 2. The same voltage that is applied to the tip 1 is applied to the first shield electrode 12 through the contact spring 13 connected to the terminal electrode 7.

Moreover, an insulator 15 capable of withstanding voltage of at least 5 KV is disposed between the first anode 2 and the first shield electrode 12, and if necessary, a second shield electrode 14 may be disposed to surround the end portion 6' of the insulator 6 so as to prevent a discharge therefrom.

The first shield electrode 12 has a bottom portion 16 which shields the first anode 2 from the second anode 3 as well as from said ground potential portions, but since the bottom portion 16 of the shield electrode 12 has a curved smooth surface which is fully polished so as not to cause any large variation in the distribution of an electric field between said anodes, almost no discharge may occur therebetween.

On the contrary, discharge may occur easily between contact portions 17 and 18, or between contact portions 19 and 20 along the insulator 11 between the two anodes. Therefore, the first shield electrode can be modified to practically omit the bottom portion 16 and to dispose in its place a projected portion 12'.

According to this invention, since the top portion of the tip is protected from destruction due to said discharge, the life time of the tip greatly increases. This invention can be applied to all electronic gun devices of the field emission type having at least a cathode tip of needle shape and an anode for producing the electric field between it and the tip so as to cause electrons to be emitted from the tip.

While I have shown and described two embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to a person skilled in the art, and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are obvious to one of ordinary skill in the art.

What is claimed is:

1. In an electron gun device of the field emission type for generating an electron beam having a cathode tip of needle shape, means for heating said cathode tip, a first anode, a second anode, and means for applying an electric voltage between said cathode tip and said first anode so as to produce an electric field therebetween which causes electrons to be emitted from said tip, the improvement which comprises a shield electrode disposed to surround said first anode between said first and second anode and means for applying to said shield electrode the same voltage as that applied to said anode, whereby said shield electrode shields said anode from ground potential portions of said device.

2. An electron gun device as defined in claim 1, wherein said anode and said shield electrode are substantially concentric cup-shaped elements.

3. An electron gun device as defined in claim 1, wherein said means for heating said cathode tip includes a pair of terminals connected to said cathode tip for applying a heating current thereto and an insulator for supporting said pair of terminals, and further including an additional shield electrode disposed between said insulator and said anode and being connected to one of said pair of terminals.

4. An electron gun device as defined in claim 3, wherein said means for applying a voltage to said shield electrode includes an electrical connection between said shield electrode and said additional shield electrode.

5. An electron gun device as defined in claim 1, wherein said shield electrode is a substantially cylindrical element disposed concentrically to said anode.

6. An electron gun device of the field emission type comprising:

a cathode tip of needle shape capable of being heated and having a large negative electric potential with respect to ground potential portions of said gun device;

an anode applied with an accelerating voltage with respect to said tip so as to produce therebetween an electric field which causes field emission of electrons from said tip; and

a shield electrode disposed to surround said anode and interposed between said anode and said ground potential portions of the gun device, said shield electrode being rendered in the same potential as that of said tip, whereby said shield electrode shields said anode from the ground potential portions to thereby prevent undesired discharge therebetween.

7. An electron gun device as defined in claim 6, wherein said anode and said shield electrode are substantially concentric cup-shaped elements.

8. An electron gun device as defined in claim 6, wherein said shield electrode is a substantially cylindrical element disposed concentrically to said anode.

9. An electronic gun device as defined in claim 6, further including means for heating said cathode tip including a pair of terminals connected to said cathode tip for applying a heating current thereto and an insulator for supporting said pair of terminals, and an additional shield electrode disposed between said insulator and said anode and being connected to one of said pair of terminals.

10. An electron gun device as defined in claim 9, wherein said means for applying a voltage to said shield electrode includes an electrical connection between said shield electrode and said additional shield electrode.

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