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(54) Protection of the cathode of an electron beam tube from ion bombardment

(57) An electron gun includes an annular adjustable magnet system 1, 2—which may be that of an integrated ion sputter pump 6—to produce a rotational symmetric magnetic field which diverges from the cathode to the anode, to deflect positive ions away from the cathode.

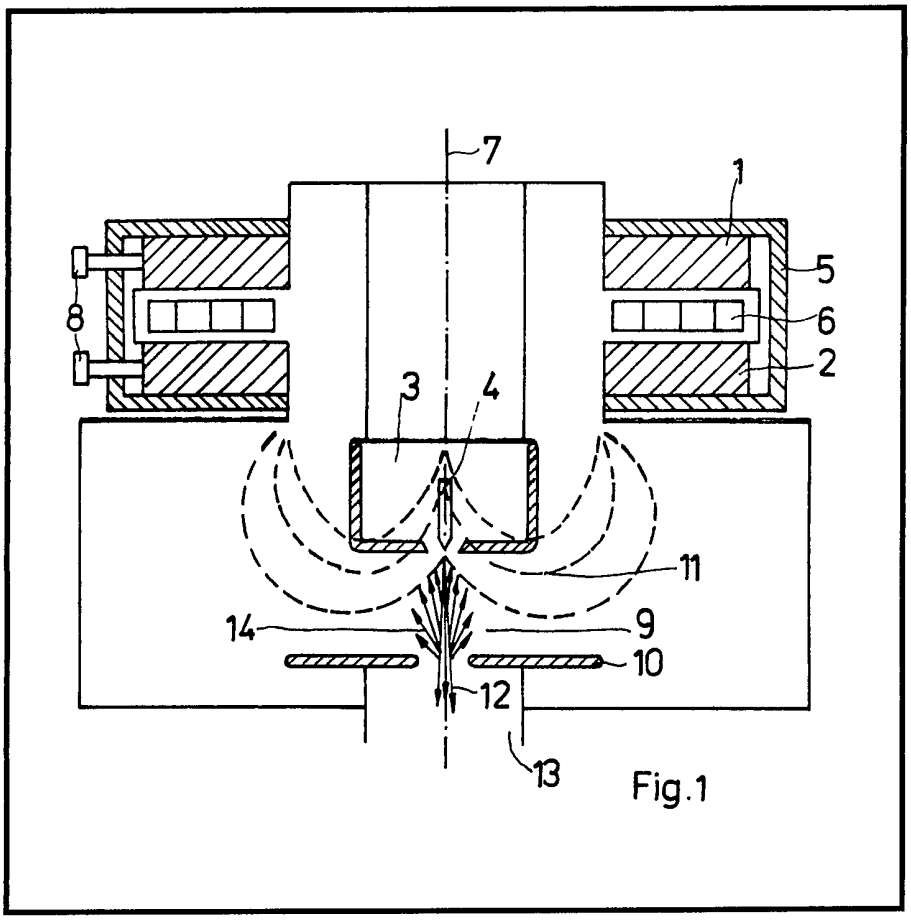

Fig.1

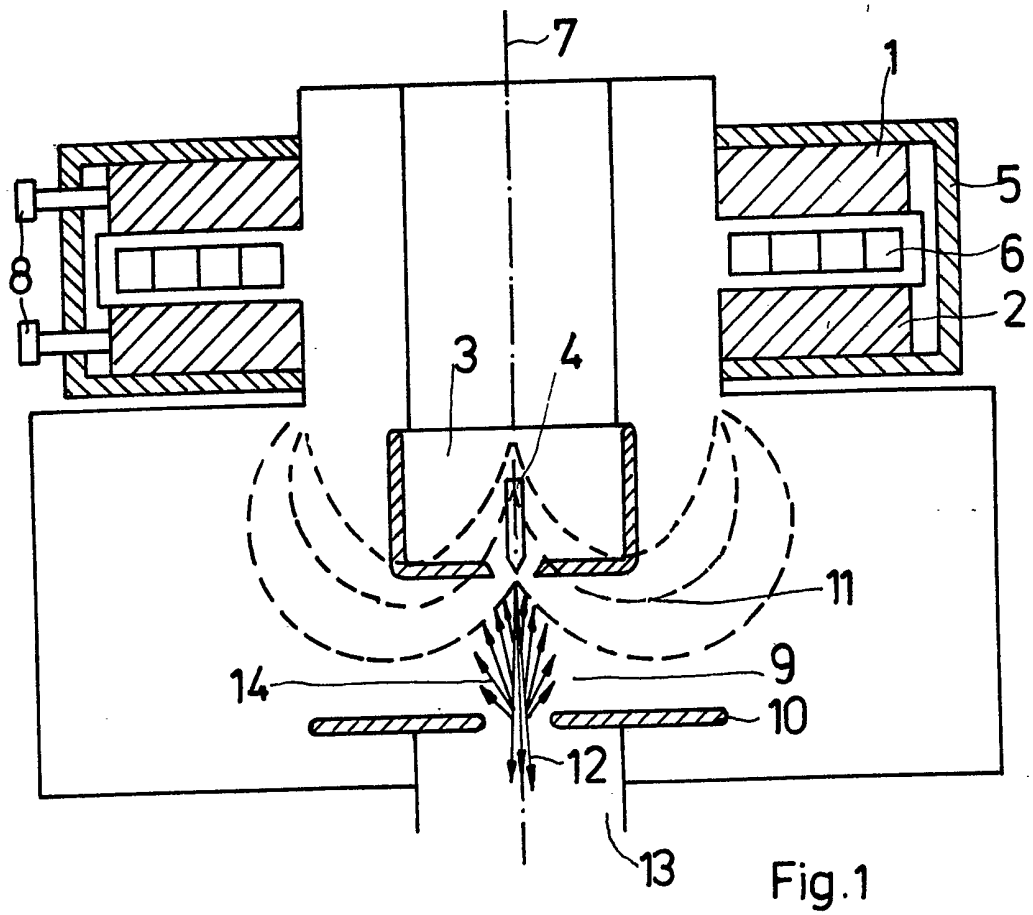

Fig.1

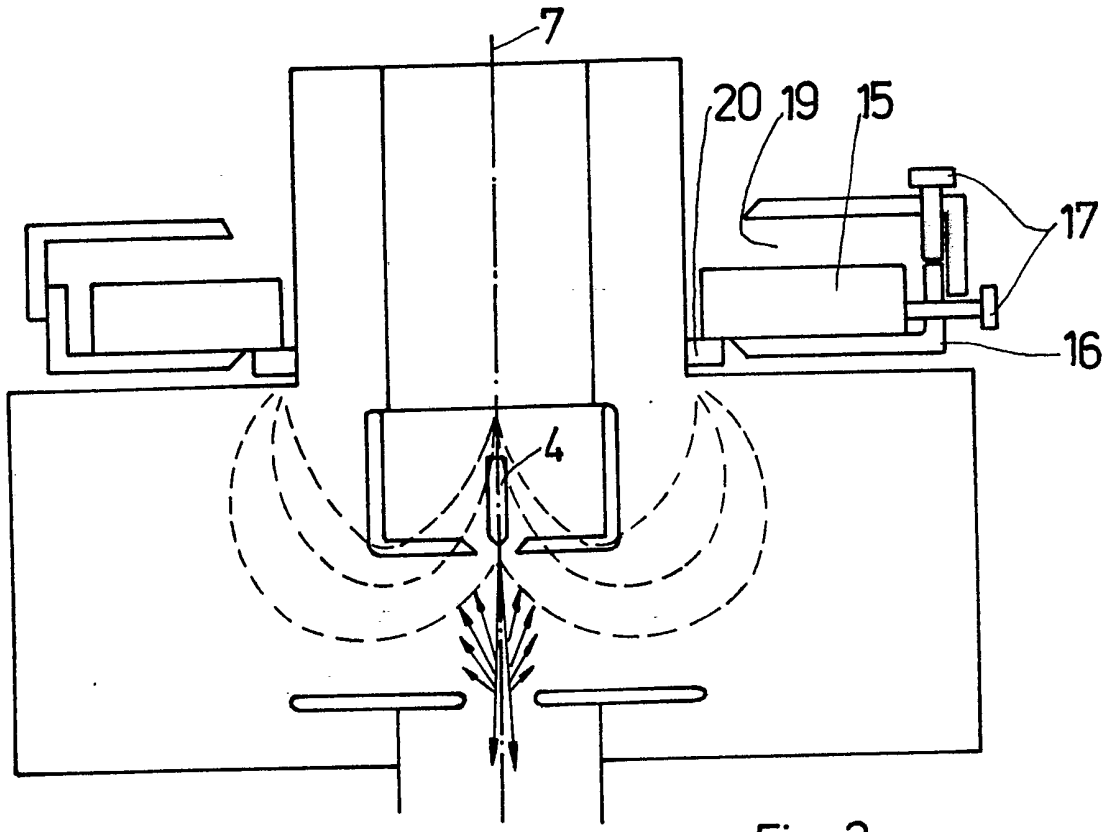

Fig.2

SPECIFICATION

Protection device for a cathode of an electron beam device

The invention relates to a protection device for an electron gun, which deflects the positive ions away from a cathode thus reducing the ion bombardment thereof. It can be used in electron beam devices where an unvarying position of the electron source is required, for example, in electron beam measuring devices and electron beam exposure devices.

Heretofore, ion traps have been used to protect electron guns, in which in an asymmetrical system an electron beam is deflected by magnetic or electric means, as published in E. Bas, Optik 12 (1955) 8. page 377 to 384 and Rint: Handbuch für HF- und Elektrotechniker.

When a beam is thus directed the focus quality is reduced due to the asymmetrical deflection and lens aberrations, and hence the image quality of the electron probe device. The US Patent specification No. 3,452241 discloses an axial ion trap which obviates the disadvantages of the asymmetrical systems.

An axial symmetrical beam directing means is employed controlled by electrostatic means which are arranged about an ion trap in the optical axis.

Said system is disadvantageous due to the high requirements to be met by the electrodes and to the corresponding power supplies, in particular, when the requirements as to the quality of the electron beam are high. In the event of electron beam devices having no shielding means for the electron gun, in particular ion deflection means, the wear time of the cathode tip, for example, through cathode bombardment is given by the producer. The deteriorating effect of cathode wear resulting in a reduction of the solid angle value has to be compensated for by readjustment of the cathode which has to be carried out by the user.

For this purpose the electron beam device has to be taken out of use and the electron gun has to be dismounted.

This technique is expensive, may lead to brittle fracture of the cathode parts and more or less reduces the operation time depending on the stability required from the electron beam device. The original directional radiation value is not accurately re-attained by readjustment of the cathode.

It is an object of the invention to obviate the above disadvantages.

It is a further object of the invention to provide a means for prolonging the operation time of cathodes in electron beam devices in that the cathode tip is protected against positive ions, without any interference of the electron beam itself.

The invention provides a device for protecting the cathode of an electron beam device against ion bombardment in deflecting the positive ions off the cathode of an electron gun wherein the cathode is surrounded by a magnet system for producing a magnet field rotation symmetrical about the electron optical axis and diverging from the cathode to the anode of the electron gun.

Advantageously, an annular magnetic system is constituted of two permanent magnets, between which a variable airgap is provided and producing an annular magnetic return path. Furthermore, it is advantageous when the annular magnetic system is embodied as an axially magnetised permanent ring magnet which is arranged in an annular pole shoe.

It is still a further advantage to produce the rotation symmetrical field by a magnet system of a sputter ion pump integral with the electron gun.

The effect of the device of the invention consists in that the rotation symmetrical magnetic field of flux diverges towards the anode and thus causes a defocussing of the positive ions and reduces the intensity of the ion bombardment of the cathode tip.

In order that the invention will be more readily understood reference is made to the accompanying drawing which illustrates diagrammatically and by way of example two embodiments thereof and where:–

Figure 1 is a sectional view of an annular magnet system constituted of two magnets, and

Figure 2 a sectional view of an annular magnet system comprising only one annular magnet and pole shoe.

The device shown in Fig. 1 is constituted of two annular magnets 1 and 2 coaxially arranged about an electron beam axis 7. An electron gun mount 3 is provided in a cavity formed by said annular magnets 1 and 2 with a cathode 4 centrally arranged about the axis 7.

A discharge system 6 of an integrated ion sputter pump is disposed in an air gap between the annular magnets 1 and 2, which are surrounded by a magnetic return path 5.

Two adjustment screws 8 are provided for adjusting the electron gun relative to the electron-optical axis 7 of the electron beam device, by aid of said screws the annular magnets 1 and 2 of the magnetic ring system are radially displaced.

The performance of the device is based upon a diverging magnetic field 11 indicated by its field of flux extending in a cavity 9 between the cathode 4 and an anode 10, which field scarcely affects the near axial charge carrying beams 12 due to the neutralising effect of the radial portions of the magnetic field 11.

Hence, the magnetic field 11 has no negative influence upon the electrons of the charge carrier beams 12 which move comparatively

near to the axis 7.

In the vicinity of the anode 10 the electrons are so highly accelerated that also the diverging negative elements of the charge carrier radiation 12 are scarcely affected by the transverse component of the comparatively feeble magnetic field there.

The positive ions are emitted according to the cosine distribution from a cavity 13 under the anode 10 of the electron gun, which exhibits a higher pressure than the cavity 9, through an anode hole into the gun space and are accelerated towards the cathode 4. The comparatively feeble magnetic field is scarcely of a collective effect upon the near-axial ions due to their large mass. Oblique incident positive ions, represented as beams 14 are further dispersed through the magnetic field 11 diverging outside of the axis 7, in particular directly above the anode 10 in the cavity 9 where the electrons are not yet accelerated so that at the place of the tip of the cathode 4 the ion density is reduced.

Thus damage to the cathode is substantially eliminated.

Fig. 2 shows a device which is constituted of an axially magnetised annular permanent magnet 15, surrounded by an annular pole shoe system arranged about the cathode 4.

The system is constituted of a non-displaceable annular pole shoe 16 and four adjustment screws 17 which serve to displace the annular magnet 15 and for adjusting the electron beam relative to the axis of the electron beam device as well as to an adjustable annular pole shoe 18 by means of which the annular gap 19 and hence the stray field in the cathode 4 range can be adjusted.

An adjustment ring 20 permits an axial adjustment of the annular magnet 15 relative to the cathode 4. The performance of the device according to Fig. 2 is in analogy to that of Fig. 1, it is also based upon a defocussing of the positive ions due to the rotation symmetrical field of flux diverging towards the anode and upon a reduction of the ion density at the cathode tip.

CLAIMS

1. Device for protecting the cathode of an electron beam device against ion bombardment in deflecting the positive ions off the cathode of an electron gun, wherein the cathode is surrounded by a magnet system for producing a magnetic field rotation symmetrical about the electron optical axis and diverging from the cathode to the anode of the electron gun.

2. Device according to claim 1, wherein the magnet system is constituted of two annular permanent magnets, surrounded by an annular magnetic return path and between which a variable air-gap is provided.

3. Device according to claim 1, wherein the annular magnetic system is constituted of an axially magnetised annular permanent magnet which is contained in an annular pole shoe.

4. Device as claimed in claim 1, wherein the rotation symmetrical field is produced by a magnet system of an ion sputtering pump integral with the electron gun.

5. Device as claimed in claim 1, wherein the annular magnetic system is adjustable relative to the electron-optical axis.

6. Device for protecting the cathode of an electron beam device, substantially as hereinbefore described with reference to the accompanying drawings.

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