PLURAL BEAM ELECTRON GUN

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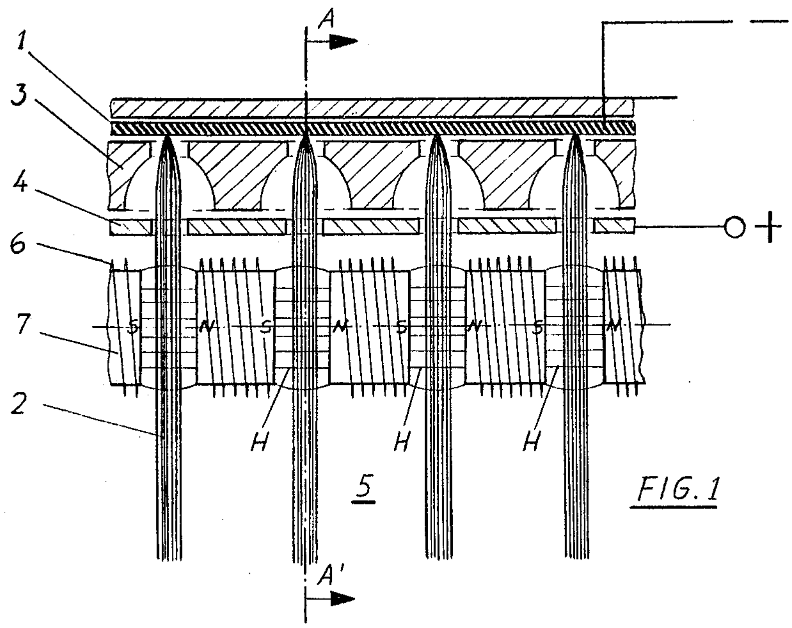

FIG. 1

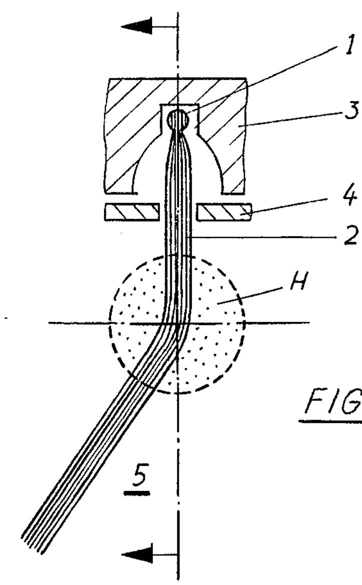

FIG. 2

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PLURAL BEAM ELECTRON GUN

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The present invention relates to an electron gun and more particularly one which essentially comprises a hot cathode of an annular shape which serves as a source of electron beams and is provided with an anode, and preferably also with a focusing electrode.

For heating metals under a high vacuum to the melting point, it is already known to employ electron beams which are produced by an electron source consisting of an annular hot cathode which is provided with a focusing electrode. The metal to be melted is usually grounded and serves as an anode for the electrons which are emitted by the hot cathode and are accelerated by this potential distribution toward the metal. Such an annular beam system has, however, the disadvantage that, for example, at the occurrence of gas eruptions from the metal being melted, gas discharges may easily occur between the metal and the hot cathode which may soon cause a destruction of the hot cathode.

There is also an annular beam system known in which between the hot cathode which is surrounded by a focusing electrode and the metal to be melted an anode is provided which is likewise of an annular shape. The metal is then usually connected to the same electric potential as the anode which is provided along its entire periphery with a continuous slot for the passage of the electrons in the direction toward the metal to be melted. The focusing electrode which surrounds the annular hot cathode is arranged around the latter so that the hot cathode is not visible from the side of the metal, as seen in the direction of the electrons passing through the slotted anode. The electrons emerging from the hot cathode are deflected by a suitable electric potential distribution between the cathode, the focusing electrode and the anode, so that the electrons describe curved paths which start at the hot cathode, extend through the slot of the anode and end on the metal body to be melted and have a curvature which decreases in the direction toward the anode. The slope of this curvature may be varied by a suitable variation of the mentioned potential distribution whereby the angle of impact of the electron rays on the metal body to be melted will also be changed. The change of the slope of the curves which form the paths of the electrons and decrease in curvature in the direction toward the anode is produced by electric fields of different strengths. When using an annular hot cathode, all of the electron rays together form a conical beam the focus of which is located on or near the metal body to be melted. The hot cathode, the focusing electrode and the continuous slot in the anode of such a known electron gun may, however, also be of a different than an annular shape. For example, the hot cathode may consist of a straight wire, in which case the slot in the anode also extends in a straight direction.

An annular electron beam system as above described which has a hot cathode, a focusing electrode, and an anode has, however, considerable disadvantages in electronoptical and melting respects. The annular shape of the hot cathode merely permits the emitted electron rays to be electrically influenced in the radial direction thereof, whereas the electrons which are emitted from a single point of the hot cathode are scattered very con-

siderably in the tangential direction. This annular beam system also does not permit the electric fields for focusing the electron rays upon the metal body to be melted to be replaced by magnetic fields which are much more suitable from an electronoptical standpoint and also permit electron beams of a much greater aperture size to be focused. Furthermore, the continuously slotted anode does not permit the electron gun to be evacuated independently of the melting chamber.

It is an object of the present invention to provide an electron gun which overcomes the above-mentioned disadvantages and consists of a hot cathode of any desired shape and preferably an annular shape, an anode, and preferably a focusing electrode. According to the invention, the anode is provided with a plurality of adjacent apertures. In addition, magnetic electronoptical means may be provided for influencing the focusing and/or changing the direction of the electron beams. By employing an anode with a plurality of adjacent apertures, the important advantage is attained over an anode with a continuous slot that the electrons which are emitted from the hot cathode by passing through the separate apertures are concentrated to form separate electron beams whereby the tangential scattering losses which are very considerable in an anode with a continuous slot are reduced to a size which is of no consequence. The anode arrangement according to the invention when made of an annular shape permits the electron beams to be focused in a radial direction and/or to be deflected by conventional magnetic electronoptical means. The electron gun according to the invention does not require any electric deflecting means in the accelerating chamber and therefore it also does not require the very complicated and senistive means which easily get out of adjustment for forming the very critical electrical deflecting fields. In the electron gun according to the invention it has been found to be of advantage to provide between the hot cathode and anode a focusing electrode which is associated with the apertures in the anode and is preferably likewise provided with apertures in axial alignment with those of the anode. This focusing electrode is supplied with an electric potential which is equal to or more negative than that of the hot cathode. The flow resistance of the apertures in the anode of the new electron gun to gas molecules which are contained in the evacuated melting chamber may be made so small that the electron gun may be evacuated independently of the evacuation of the melting chamber so that a certain difference in pressure may be maintained between the melting chamber and the electron gun. The magnetic deflecting means also serve as an effective ion trap for preventing ions which are formed in the melting chamber and are flying in the direction toward the hot cathode from entering the electron gun.

The features and advantages of the present invention will become more clearly apparent from the following detailed description of one preferred embodiment thereof as illustrated diagrammatically in the accompanying drawings, in which:

FIGURE 1 shows a cross section of a part of an electron gun according to the invention which is provided with an annular hot cathode, while

FIGURE 2 shows a cross section which is taken along line A–A' in the radial direction of the electron gun according to FIGURE 1.

In the drawings, in which only the essential parts of the electron gun according to the invention are shown, this gun comprises a hot cathode **1** which is provided with a negative electric potential. The electrons which are emitted from this hot cathode pass from the latter through the perforated focusing electrode **3** and the apertures in the anode **4** into the melting chamber **5**. The focusing electrode **3** is provided with an electric potential which is approximately equal to or more negative than the potential on the hot cathode **1**, preferably the ground potential. The hot cathode **1** may be of a type which emits electrons uniformly from its entire surface or it may be designed so that electrons are emitted only from those parts thereof which are located directly above the apertures in the focusing electrode. This may be attained in a simple manner, for example, by making the hot cathode of an alternately thicker and thinner cross section or by differently activating the different parts of the surface of the hot cathode. Underneath the anode **4** electromagnetic means are secured thereto which consist of coils **6** with ferromagnetic cores **7**. All of these coils **6** preferably have an equal number of windings and are energized by a current of a constant strength. Of course, some of the coils may also be provided with a larger number of ampere turns so that some of the electron beams **2** may be more strongly deflected than the others. The cross-sectional size of the magnetic field H which is formed between the opposite ends of two adjacent cores **7** is determined by the shape of these ends which may be designed in accordance with the particular requirements to be fulfilled by the electron gun. It is also possible to provide suitable cooling means of a conventional type for cooling the focusing electrode **3**, the anode **4**, and the electromagnetic means.

Although the invention has been illustrated and described with reference to the preferred embodiment thereof, it should be understood that it is in no way limited to the details of such embodiment, but is capable of numerous modifications within the scope of the appended claims. Thus, for example, the hot cathode, anode, and focusing electrode do not have to be of an annular shape, but these elements may also be made of a different shape to suit the particular purpose for which the electron gun is to be used. The hot cathode may be made, for example, in the form of a straight wire and the focusing electrode and anode also be provided with apertures which extend in a straight line. The apertures in the focusing electrode and anode may also be made of any desired shape and some of the adjacent apertures may also differ from each other both in size and shape. Furthermore, the associated apertures in the focusing electrode and in the anode may also differ from each other in size and shape.

Having thus fully disclosed the invention, what I claim is:

1. In an electron gun comprising a hot cathode, an anode having a plurality of apertures laterally adjacent but spaced from each other at one side of said hot cathode, a focusing electrode interposed between said hot cathode and said anode, said electrode having a plurality of apertures substantially in axial alignment with the corresponding apertures in said anode for passing separate electron beams from said hot cathode through the different aligned apertures, and a plurality of electromagnets at the other side of said anode each having a coil and a ferromagnetic core, the opposite ends of adjacent cores being spaced from each other to form gaps substantially in alignment with said apertures for forming magnetic fields for independently deflecting each of said electron beams passing through said apertures in said focusing electrode and anode and then through said gaps.

2. In an electron gun comprising a hot cathode, an anode having a plurality of apertures laterally adjacent but spaced from each other at one side of said hot cathode, a focusing electrode interposed between said hot cathode and said anode, said electrode having a plurality of apertures substantially in axial alignment with the corresponding apertures in said anode for passing separate electron beams from said hot cathode through the different aligned apertures, and a plurality of electromagnets at the other side of said anode each having a coil and a ferromagnetic core, said coils having an equal number of windings and adapted to be energized by a current of the same strength, the opposite ends of adjacent cores being spaced from each other to form gaps substantially in alignment with said apertures for forming magnetic fields for individually deflecting each of said electron beams passing through said apertures in said focusing electrode and anode and then through said gaps.

3. In an electron gun comprising a hot cathode, an anode having a plurality of apertures laterally adjacent but spaced from each other at one side of said hot cathode, a focusing electrode interposed between said hot cathode and said anode and, said electrode having a plurality of apertures substantially in axial alignment with the corresponding apertures in said anode for passing separate electron beams from said hot cathode through the different aligned apertures, and a plurality of electromagnets at the other side of said anode, each of said electromagnets having a coil and a ferromagnetic core, at least one of said coils having a number of windings different from the number of windings of the other coils and adapted to be energized by a current of a different strength than the current for energizing the other coils, the opposite ends of adjacent cores being spaced from each other to form gaps substantially in alignment with said apertures for forming magnetic fields for individually deflecting each of said electron beams passing through said apertures in said focusing electrode and anode and then through said gaps.

4. In an electron gun comprising a hot cathode, an anode having a plurality of apertures laterally adjacent but spaced from each other at one side of said hot cathode, a focusing electrode interposed between said hot cathode and said anode and, said electrode having a plurality of apertures substantially in axial alignment with the corresponding apertures in said anode for passing separate electron beams from said hot cathode through the different aligned apertures, and a plurality of electromagnets at the other side of said anode, each of said electromagnets having a coil and a ferromagnetic core, at least one of said coils having a number of windings different from the number of windings of the other coils and adapted to be energized by a current of a different strength that the current for energizing the other coils, the opposite ends of adjacent cores being spaced from each other to form gaps substantially in alignment with said apertures for forming magnetic fields for individually deflecting each of said electron beams passing through said apertures in said focusing electrode and anode and then through said gaps, said opposite ends of said adjacent cores having surfaces of a particular shape adapted to determine the cross-sectional shape of said magnetic fields.

References Cited by the Examiner

UNITED STATES PATENTS

2,083,203	6/1937	Schlesinger	313—82.1 X
2,660,612	11/1953	Wood	315—13 X
2,690,517	9/1954	Nicoll et al.	313—82.1 X
2,743,389	4/1956	Giuffrida	315—13
2,757,313	7/1956	Miller	315—13
2,758,234	8/1956	Hensel	313—82.1 X
3,040,112	6/1962	Smith	313—82 X
3,068,309	12/1962	Hanks.	

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