Feb. 28, 1967 J. ARNAUD ETAL 3,307,065

LOW NOISE ELECTRON GUN WITH CROSSED ELECTRIC AND MAGNETIC FIELDS AND AUXILIARY AXIAL ELECTRIC FIELD

Filed Jan. 8, 1963 2 Sheets-Sheet 1

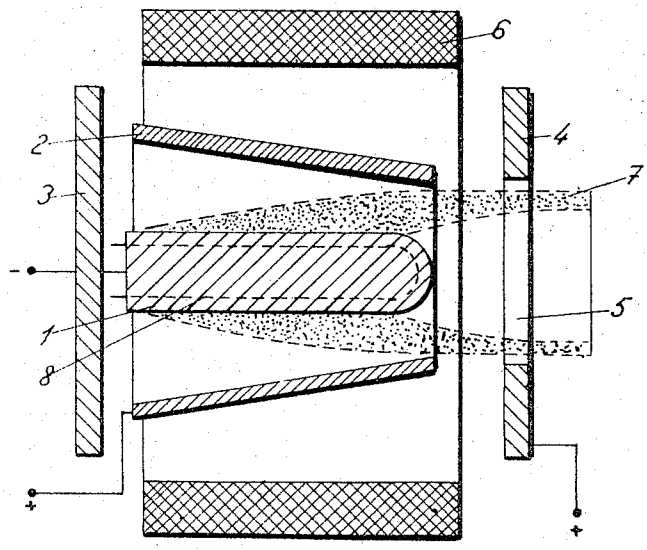


FIG. 1
PRIOR ART

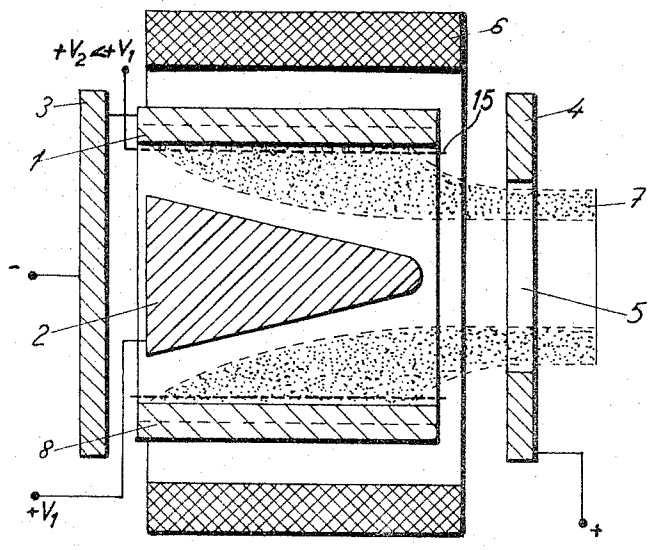


FIG. 2

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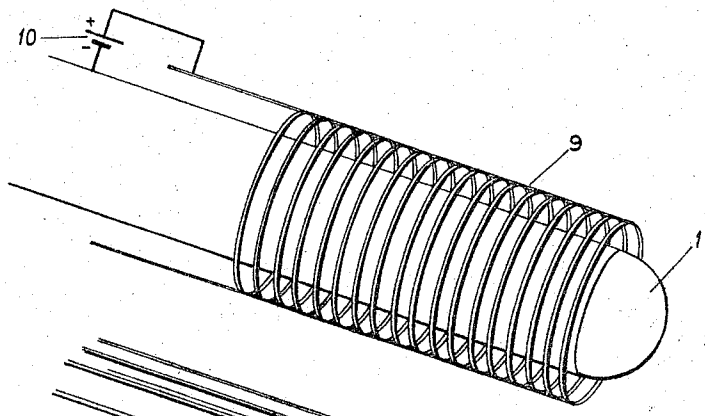


FIG. 3

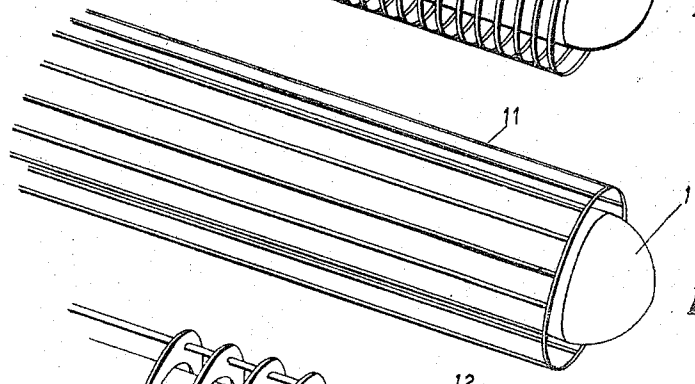


FIG. 4

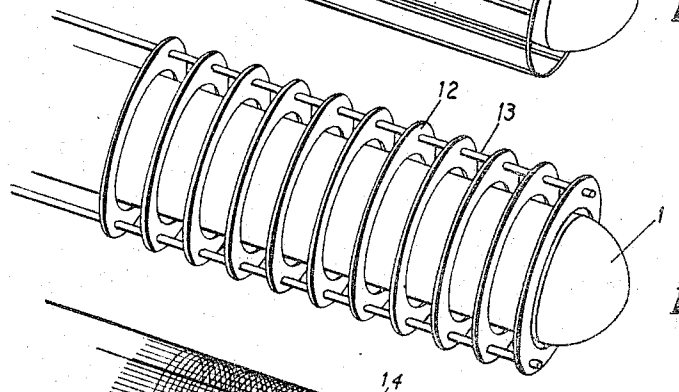


FIG. 5

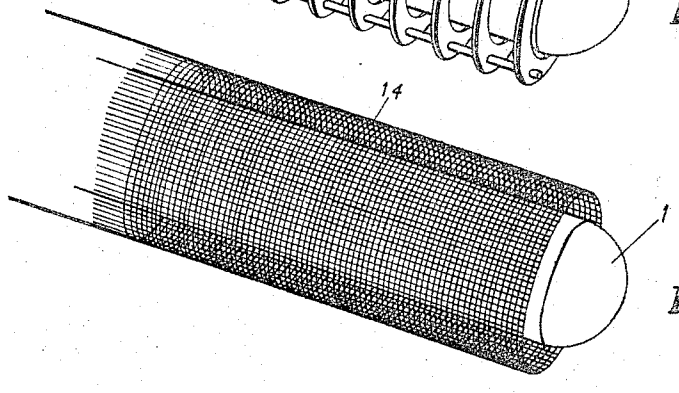


FIG. 6

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United States Patent Office

3,307,065

Patented Feb. 28, 1967

3,307,065

LOW NOISE ELECTRON GUN WITH CROSSED ELECTRIC AND MAGNETIC FIELDS AND AUXILIARY AXIAL ELECTRIC FIELD

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Filed Jan. 8, 1963, Ser. No. 250,051
Claims priority, application France, Jan. 19, 1962, 885,291, Patent 1,319,431
12 Claims. (Cl. 315—15)

The present invention relates to an improvement in electron guns of the type described in the French Patent No. 982,527 of July 12, 1943, and more particularly to improvements in electron guns in which the cathode and the accelerating anode facing the cathode have a shape with symmetry of revolution about an axis parallel to the cathode surface, while the magnetic field is directed in the sense of this axis, and an auxiliary electric field is also provided in the axial direction in such a manner as to concentrate the electrons into a tubular beam which simultaneously turns about itself and propagates in the direction of this axis.

It is therefore an object of the present invention to provide an electron gun structure of the type described hereinabove which offers improved operating characteristics.

It is another object of the present invention to provide an electron gun structure of the type described hereinabove which, when used in operation in an electron discharge device, effectively produces less noise.

A further object of the present invention resides in the provision of an electron gun structure which effectively eliminates instabilities in the space charge of the electron gun and therewith operating deficiencies resulting therefrom.

A still further object of the present invention resides in the provision of an electron gun structure of the type described hereinabove provided with electrode surfaces having the shape of bodies of revolution about an axis and with crossed electric and magnetic fields in which that part of the noise of the tube is significantly reduced, if not completely eliminated, that would otherwise be caused by phenomena attributable to and peculiar to the electron gun structure.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, several embodiments of the present invention as contrasted to the prior art constructions, and wherein

FIGURE 1 is a somewhat schematic cross sectional view of first embodiment of a known prior art electron gun structure of the type described hereinabove,

FIGURE 2 is a somewhat schematic cross sectional view of a second embodiment of a known prior art electron gun structure of the type described hereinabove, however, also indicating therein schematically the improvement in accordance with the present invention, and

FIGURES 3 to 6 are partial perspective views of different embodiments of an electron gun structure in accordance with the present invention and embodying the improvements thereof.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIGURE 1 which illustrates one prior art embodiment of an electron gun structure, reference numeral 1 designates therein a cylindrical cathode with an external emissive surface heated by a filament 8. The anode 2 of the electron gun faces the cathode 1 and has the shape of a body of symmetry of revolution coaxial to the cathode 1. The electron gun

structure further includes two electrodes 3 and 4 in the form of disks perpendicular to the axis of the system while the electrode 4 is provided with an orifice or aperture 5 for the passage of the electron beam. This system of electrodes is, of course, located within an evacuated envelope not illustrated in this figure to simplify the drawing. A winding or coil 6 of conventional construction provides an axial magnetic field necessary for proper operation of the gun. A suitable voltage is applied between the anode 2 and the cathode 1, and a positive voltage is applied to the electrode 4 with respect to the electrode 3, the latter being connected to cathode 1.

In operation, provided that the magnetic field of the coil 6 is superior to the critical field which blocks the passage of current toward the anode 2, and in the absence of the axial electric field, the electrons emitted by the cathode 1 turn about the latter as in a magnetron. As the axial electric field is applied between the electrodes 3 and 4, these electrons receive additionally a component of axial speed which causes the same to be displaced in the axial direction, while concentrating the same into a tubular beam 7 turning about itself.

The electron gun structure of FIGURE 2 differs from that of FIGURE 1 by the reversed position of the cathode 1 and the anode 2, the cathode being in this embodiment a hollow cylinder of which the internal surface is emissive, and the anode 2 being in the form of a cylinder or conical body occupying the axial position. Furthermore, the same reference numerals as used in FIGURE 1 designate the analogous elements in the embodiment of FIGURE 2, and the operation thereof is the same, a tubular beam 7 being also supplied by this electron gun structure.

Tests have indicated that the tubes provided with such electron gun structure are afflicted with a significant noise of the beam current.

It being understood that the validity of the present invention does not depend on the accuracy of the theories elaborated herein on this subject, one may explain this phenomena by the hypothesis that the noise results from an instability of space charge within the gun structure: an excess of space charge within the emitted beam diminishes the emission of the cathode; it follows therefrom a positive reaction which may entrain, in the case of beams propagating within crossed fields, an oscillation of the space charge.

In support of this hypothesis, one may refer to the fact that the noise is reduced in a very important manner if one saturates the cathode emission by underheating the cathode in such a manner that the emitted current no longer depends on the space charge of the beam.

The present invention aims at realizing a gun structure for tubes as defined hereinabove with which the noise of the tube would be strongly reduced if not eliminated altogether.

The present invention consists in a modification of the gun structure described hereinabove in such a manner that the emitted current no longer depends on the space charge of the beam.

According to the present invention, this modification consists in the addition of a grid structure carried at a potential intermediate between the potential of the cathode and that of the anode, the order of magnitude of the dimension between the conductor elements of this grid, or the dimensions of its meshes being only a fraction, for example, one-fifth to one-third of the grid-cathode distance.

FIGURES 3 to 6 illustrate in perspective view and in a non-limitative manner, four embodiments in accordance with the present invention.

In FIGURE 3, the cathode 1, intended for example, for the gun structure of FIGURE 1, is surrounded by a grid structure 9 in the form of a helix. This grid structure

9 is carried at a potential slightly positive with respect to the cathode 1 by a suitable voltage source 10.

In FIGURE 4, the grid structure 11 is in the form of a cage with bars parallel to the generatrix of the cathode cylinder 1.

In FIGURE 5, the grid structure 12 is in the form of annular members aligned on supports 13.

In FIGURE 6, the grid structure 14 is made of woven lattice work.

In all the embodiments, the dimension and the potential of the grid structure are in conformity to the conditions indicated hereinabove.

The grid structure may be realized of any material known for this usage, but is preferably made of a material having a slight secondary emission, for example, of gold or covered with gold.

The dimensions of the conductors of the grid structure as well as the distance thereof from the cathode are chosen in a manner known in the theory of triodes to obtain a compromise between optimum shielding of the cathode and the transparency of the grid such that the dissipated power in the grid structure is limited. For example, if the grid structure is at a distance of 0.3 millimeters from the cathode, the meshes of the grid may have a dimension less than 100 microns.

Analogous grid structures could also be disposed in front of the internal surface of the hollow cylinder constituting the cathode 1 of FIGURE 2, as indicated schematically in FIGURE 2 at 15, the grid structure 15 being here connected to a positive potential V_2 which is lower than the anode potential V_1.

While we have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited to the details shown and described herein, but is susceptible of numerous changes and modifications as known to a person skilled in the art. More particularly, the present invention may be modified without departing from the spirit and scope thereof so as to adapt the same to particular application of the gun structure, to the particular shape of the anode and to the particular value of the magnetic field. Furthermore, the applications of the gun structures in accordance with the present invention are numerous, however one may mention, in particular, the klystrons, and the traveling wave tubes of the O-type and certain types of the M-type.

Thus, while we have shown and described several embodiments in accordance with the present invention, it is obvious that the same is not limited thereto, but is susceptible of numerous changes and modifications within the spirit and scope thereof, and we 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 encompassed by the scope of the appended claims.

We claim:

1. A microwave electron discharge device, comprising:
electron gun means for producing an electron beam including cathode means having a cylindrical surface about a predetermined axis and accelerating anode means substantially coaxial with said cathode means and facing the cylindrical surface thereof,
said cathode and anode means defining an electron gun space therebetween,
means for producing within said space a substantially radial electric field and a substantially axial magnetic field,
means for additionally producing within the space a further axial electric field component,
means for effectively heating said cathode means to produce cathode emission therefrom,
grid means extending close to the surface of said cathode means and having conducting elements thereof separated from each other by a distance comprised between 1/3 and 1/5 of the distance between said cathode and grid means,
and means for carrying said grid means at a potential intermediate the potentials of said anode and cathode means.

2. A microwave electron discharge device as defined in claim 1 wherein said grid means is in the form of a helix.

3. A microwave electron discharge device as defined in claim 1 wherein said grid means is in the form of a cage having bars parallel to said axis.

4. A microwave electron discharge device as defined in claim 1 wherein said grid means has at least a pair of longitudinal rods in a series of rings supported by said rods.

5. A microwave electron discharge device as defined in claim 1 wherein said grid means is made of a woven meshwork.

6. A microwave electron discharge device as defined in claim 1 wherein said grid means is made of a material having a relatively small secondary emission factor.

7. A microwave electron discharge device as defined in claim 6 wherein said grid means has at least a superficial layer of gold.

8. A microwave electron discharge device, comprising:
electron gun means for producing an electron beam including cathode means having a cylindrical surface about a predetermined axis and accelerating anode means substantially coaxial with said cathode means and facing the cylindrical surface thereof,
said cathode and anode means defining an electron gun space therebetween,
means for producing within said space a substantially radial electric field and a substantially axial magnetic field,
means for additionally producing within the space a further axial electric field component,
means for effectively heating said cathode means to produce cathode emission therefrom,
grid means extending close to the surface of said cathode means and having conducting elements thereof separated from each other by a distance equal to a fraction of the distance between said cathode and grid means,
and grid means for carrying said grid means at a potential intermediate the potentials of said anode and cathode means,
the cylindrical surface of said cathode means being the outer surface of a cylindrical body positioned along said axis, and said anode means being a hollow body surrounding the cylindrical cathode body.

9. A microwave electron discharge device, comprising:
electron gun means for producing an electron beam including cathode means having a cylindrical surface about a predetermined axis and accelerating anode means substantially coaxial with said cathode means and facing the cylindrical surface thereof,
said cathode and anode means defining an electron gun space therebetween,
means for producing within said space a substantially radial electric field and a substantially axial magnetic field,
means for additionally producing within the space a further axial electric field component,
means for effectively heating said cathode means to produce cathode emission therefrom,
grid means extending close to the surface of said cathode means and having conducting elements thereof separated from each other by a distance equal to a fraction of the distance between said cathode and grid means,
and means for carrying said grid means at a potential intermediate the potentials of said anode and cathode means,
the cylindrical surface of said cathode means being the inner surface of a cylindrical body positioned

along said axis, and said anode means being a body of revolution positioned along said axis within said hollow cylinder.

10. In an electron gun structure for use in electron discharge tubes having substantially coaxially arranged cathode and anode means defining therebetween an electron gun space, means for producing crossed electric and magnetic fields within said space and means for producing an auxiliary electric field having at least a component in the axial direction, and means for effecting emission from said cathode means,

the improvement essentially consisting of grid means associated with said cathode means to stabilize the space charge,

and means to enable application of a potential to said grid means to carry the grid means at a potential between the potentials of said anode and cathode means.

11. In an electron gun structure for use in electron discharge tubes having substantially coaxially arranged cathode and anode means defining therebetween an electron gun space, means for producing crossed electric and magnetic fields within said space and means for producing an auxiliary electric field having at least a component in the axial direction, and means for effecting emission from said cathode means,

the improvement essentially consisting of grid means associated with said cathode means to stabilize the space charge, said grid means extending close to the surface of said cathode means and including a plurality of conducting elements, said elements being separated by a distance comprised between ⅓ and ⅕ of the distance between said cathode and grid means,

and means to enable application of a potential to said grid means to carry the grid means at a potential between the potentials of said anode and cathode means.

12. A microwave electron discharge device, comprising:

electron gun means for producing an electron beam including cathode means having an emissive surface and accelerating anode means substantially coaxial with said cathode means and facing the emissive surface thereof,

said cathode and anode means defining an electron gun space therebetween,

means for producing within said space crossed electric and magnetic fields for imparting to the electrons emitted from said surface rotary movements about said axis,

means for imparting to the electrons a velocity component in the direction of an axis,

and grid means extending close to the surface of said cathode means and including grid elements separated from each other by a distance comprised between ⅓ and ⅕ of the distance between said cathode and grid means.

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