Aug. 19, 1952

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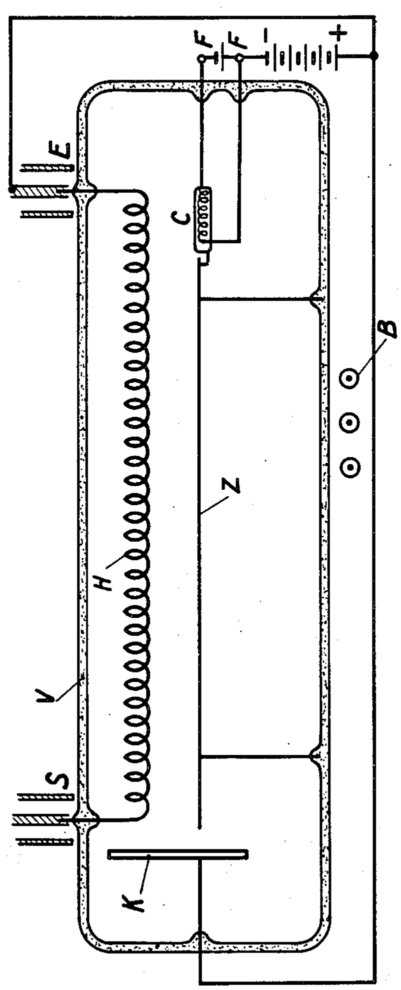
ELECTRON OPTICAL SYSTEM FOR CATHODES OF ELECTRON BEAM TUBES

2,607,904

Filed Oct. 11, 1949

3 Sheets-Sheet 1



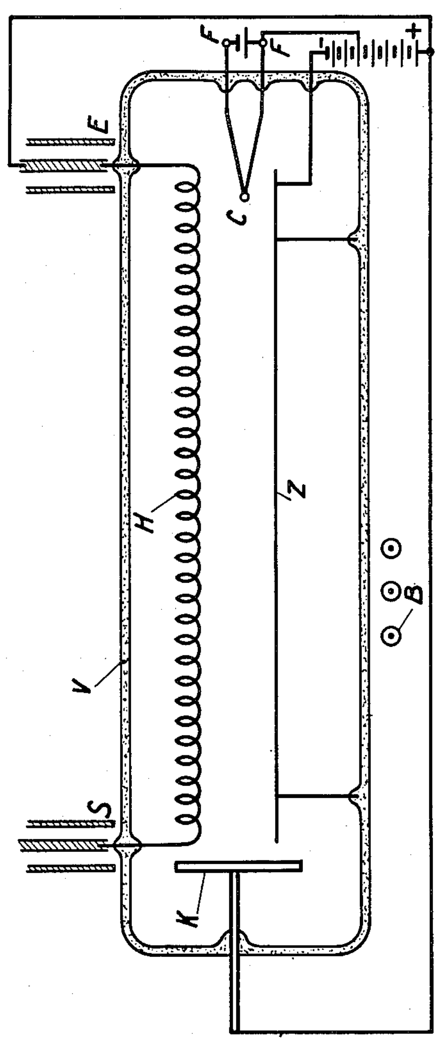


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Fig. 3

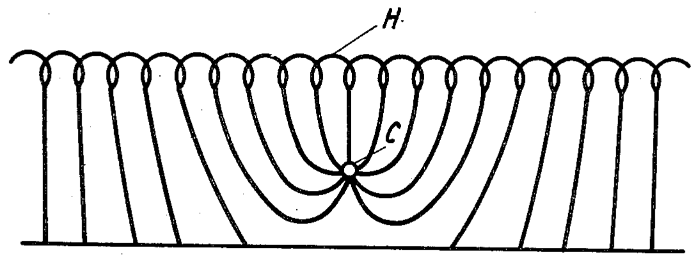

Fig. 5

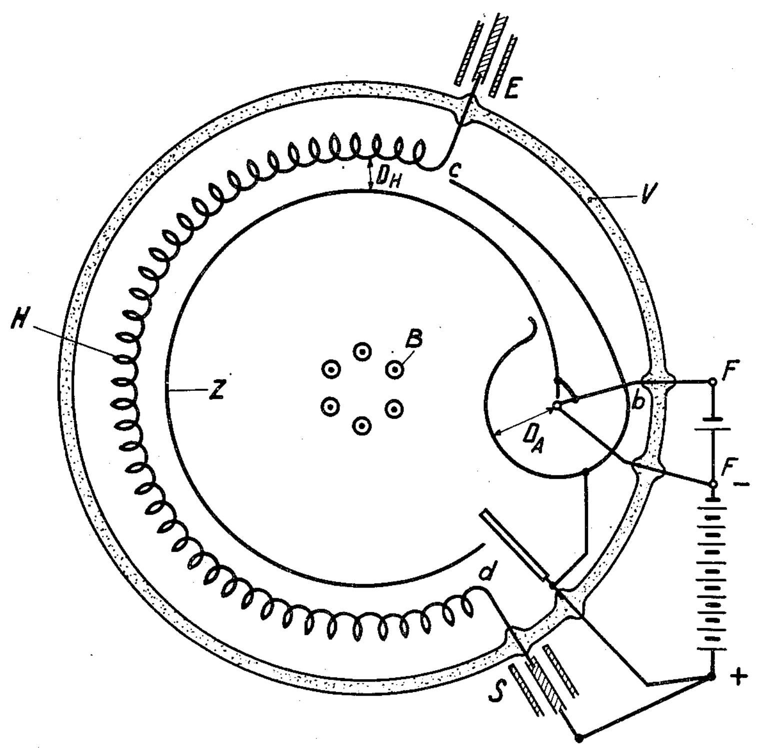

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Fig.4

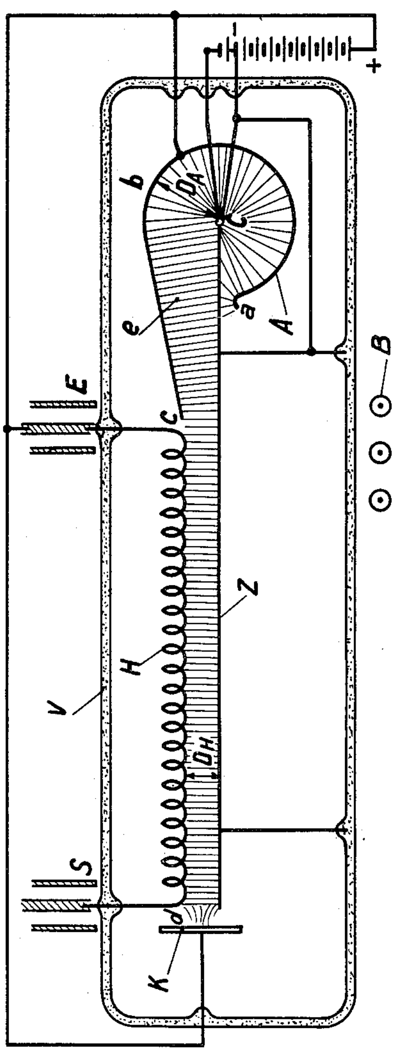
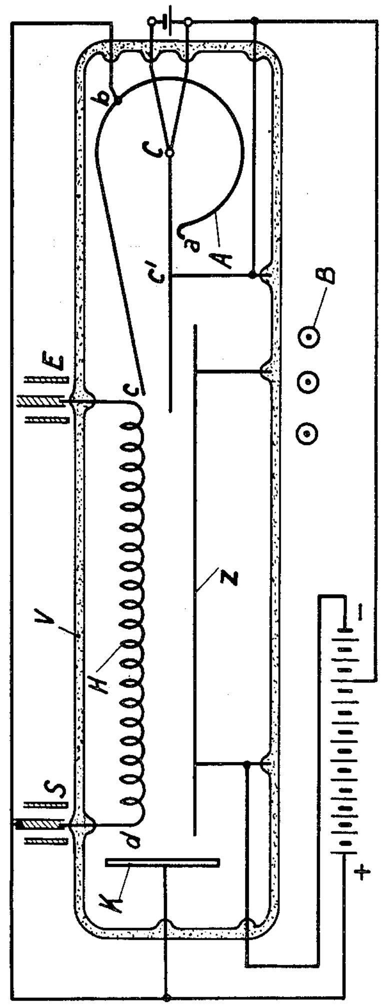


Fig.6



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2,607,904

ELECTRON OPTICAL SYSTEM FOR CATHODES OF ELECTRON BEAM TUBES

Alfred Lerbs, Paris, France, assignor to Compagnie Generale de Telegraphie Sans Fil, a corporation of France

Application October 11, 1949, Serial No. 120,717
In France October 18, 1948

14 Claims. (Cl. 315—39)

My invention relates to electron beam tubes and covers an electron optical system adapted to be applied to the cathode of such tubes.

It is an object of this invention to provide an improved electron optical system for an electron beam tube.

A further object is to provide a cathode system capable of producing a large emission current which can be adjusted by controlling the current through the cathode.

These and other objects of the invention will be apparent from the following description, the appended claims, and the drawings, in which

Figs. 1 and 2 show conventional electron beam tubes of the travelling-wave type;

Fig. 3 shows the distribution of the electric field of the cathode structure shown in Fig. 2 under certain operating conditions; and

Figs. 4 through 6 show three embodiments of my improved electron optical system.

The drawbacks of the known cathodes will be explained with reference to Figs. 1 and 2 which illustrate known electron beam tubes belonging to the class of travelling-wave tubes with a transverse magnetic field, to which my invention can be advantageously although not exclusively applied.

In Figs. 1 and 2, a travelling-wave tube, contained in a straight casing V, comprises in a known manner a helical-shaped retardation line H with its input at E and its output at S, a cathode C, an electrode Z which is located opposite the retardation line and which is raised to a suitable potential for producing an electric field between Z and H, and a collector K raised to a positive potential. The whole arrangement is placed in a transverse magnetic field B set up by a suitable coil and core.

The cathodes used in these tubes may be either flat-shaped oxide cathodes, or filament-shaped cathodes made of metal such as tungsten or tantalum. They are usually raised to a potential that corresponds to the distribution of same in the region between H and Z in which they are located, so as not to disturb the shape of the static lines of force.

Fig. 1 shows for example an oxide cathode located at the level of the electrode Z and raised to the same potential as said electrode Z. Fig. 2 also shows by way of example a metal cathode which is located in the space between Z and H and is raised to an intermediate potential between these two electrodes according to the potential drop up to the region occupied by the cathode.

In the first case (oxide cathode) the emission current cannot be adjusted by acting on the heating, and furthermore such cathodes cannot be used if the anode voltage is higher than a certain maximum value. In the second case (metal cathodes) the emitting area is small and the emission current is limited by the space charge. The emission could be increased by deforming the electric field around the cathode in such a manner that a greater portion of the lines of force are directed towards the cathode (in which case the increased field density adjacent the cathode would prevent the formation of a space charge), for example by placing the cathode as in Fig. 2 but raising it to a lower potential than that which corresponds to its position in the field between H and Z. Fig. 3 shows the distribution of the electric field in the case in which the cathode is placed as in Fig. 2 but is raised to the same potential as the electrode Z.

However, this arrangement has the effect of influencing the shape of the static characteristic of the tube, that shows the current in the helix as a function of the field B, since in this case said current gradually decreases as B increases instead of suddenly dropping to zero when a certain critical value B_c is exceeded as is required for the efficiency of the tube.

These difficulties are obviated by my invention which enables a cathode to be constructed that combines the advantages of the flat oxide cathode (internal emission and good static characteristic) with those of the metal cathode (emission that can be adjusted by means of the heating and no limitation of the value of the anode voltage).

According to the invention, with a cathode of cylindrical shape is associated an electron optical system comprising a likewise cylindrical anode that surrounds the cathode, and a member adapted to connect the field distribution round the cathode to the field distribution between the retardation line and the electrode which is located opposite said line.

The invention will be more clearly understood by referring to Figs. 4 to 6 which show by way of example nonlimitative embodiments thereof.

According to Fig. 4, in which the same elements as in Figs. 1 and 2 are designated by the same reference letters, an electron beam tube, for example of the travelling-wave type with a transverse magnetic field and of straight structure, is provided with a cylindrical cathode C which is located at the level of the electrode Z and which is raised to the same negative potential as said electrode Z. According to the invention, said cathode is surrounded by an anode A which is raised to the same positive potential as the helix H and the collector K and the cross-sectional shape of which comprises a circular portion *ab* concentric to the cathode and a straight portion *bc* which progressively merges the outlet end of the anode cylinder with the inlet of the space between the electrodes Z and H, through which space the beam is adapted to pass. By means of this arrangement an intense field is produced adjacent the cathode, without disturbing the homogeneous distribution of the field in all directions as in Fig. 3, since it can be seen that within the limits of the sector *ab* almost all the lines of force *e* extend radially up to the cathode, so that the density of the field adjacent the cathode surface is high, whereby the magnitude of the space charge is decreased and the cathode current is increased. On the other hand, the homogeneity of the field in almost all directions enables a good static characteristic to be obtained. It is therefore possible to use a metal cathode and take advantage of its inherent advantages, to which are furthermore added the advantages which were heretofore possessed only by oxide cathodes.

But it is also possible to apply the invention in the case in which an oxide cathode is used, which may advantageously be made of cylindrical shape which is easier to fit when mounting the electrodes than a flat cathode and which moreover is the only shape that gives satisfactory results as regards manufacturing technology in the case of a thorium oxide cathode.

The radius D_A of the circular portion is determined by taking into account that the electrons do not touch the anode, such radius being variable and a function of the magnetic field applied, of the anode voltage and of the distance D_H, between the electrodes Z and H, at which the member A is connected to the point *c*. The length *bc* should preferably be equal to several times the distance D_H.

Fig. 5 shows the application of the arrangements of Fig. 4 to a travelling-wave tube with a transverse magnetic field and of circular structure. It does not require further explanations since the reference letters are the same as in Fig. 4.

Fig. 6 shows the application of the principles of the invention to the case in which the cathode is raised to an intermediate potential between Z and H and is arranged as in Fig. 2. In this case, at the level of the cathode C is placed an auxiliary electrode C′ raised to the same potential as C, the member A surrounding the cathode as in Fig. 4, and the dimensioning rules being applied with respect to the electrode C′ as they were previously with respect to the electrode Z. In other respects, the figure does not require further explanations, since the reference letters are the same as in Fig. 4.

The invention is not restricted to the examples which have been described and illustrated, but on the contrary may be subjected to any modification that may be within the scope of the expert, without changing its principle. Thus, for example, it is not necessary for the cathode to be a linear filament. It is also possible to use a wound filament, particularly when it is desired to have a cathode of large area. In that case, account must be taken of the diameter of the cathode in dimensioning the system.

The application of the invention to travelling-wave tubes with a transverse magnetic field has only been described by way of a non-limitative example and it is to be understood that the invention can also be applied to travelling-wave tubes without a transverse field, and more generally to any electron beam tube in which it is required to direct in a desired manner a beam emitted by a cylindrical cathode.

I claim:

1. In an electron tube structure, a cathode for emitting electrons, an electrode connected to said cathode and extending substantially radially therefrom, an electron collector spaced from said cathode, an anode having a cylindrical portion partially surrounding said cathode with the latter positioned at the axis of revolution of said cylindrical portion so that the electric field surrounding said cathode is substantially radial, said anode having a substantially rectilinear extension extending adjacent said electrode, and means producing a magnetic field extending parallel to the axis of revolution of said anode cylindrical portion for causing electrons leaving said cathode to flow in a stream between said anode extension and said electrode toward said collector.

2. An electron tube structure as defined in claim 1 wherein means is provided for setting up an electric field extending between said electrode and said anode extension and substantially transversely of both said electron stream and said magnetic field.

3. An electron tube structure comprising a cathode, a substantially cylindrical anode substantially surrounding said cathode and positioned with the latter at its axis of revolution for urging electrons radially therefrom in substantially all directions, said anode serving to produce a dense electric field adjacent the cathode whereby the magnitude of the space charge is maintained low and the cathode current is relatively substantial, an electron collector, and an electrode connected with and extending substantially radially from said cathode and maintained at cathode potential, said anode having an extension located adjacent to but spaced from said electrode for confining the electrons between the extension and said electrode.

4. A tube structure as defined in claim 3 wherein means are provided for setting up a transverse magnetic field for causing the electrons to form a stream flowing from said cathode and longitudinally through the space between said electrode and said anode extension toward said collector.

5. Electron tube structure comprising a cathode, an electrode extending radially from said cathode, a substantially cylindrical hollow anode surrounding said cathode and extending into the proximity of said electrode, said cathode being positioned along the axis of revolution of said anode whereby electrons are caused to diverge from said cathode in substantially all directions, an electron collector spaced from said cathode, a retardation line located between said cathode and said electron collector adjacent the flight path of electrons moving toward said collector, said electrode also extending between said cathode and said collector adjacent the flight path of the electrons, said electrode being maintained at substantially cathode potential while said retardation line is maintained at substantially anode potential, means for establishing a magnetic field transversely of the flight path of said electrons,

the potential difference existing between said electrode and said retardation line cooperating with said magnetic field to cause said electrons to flow from the cathode to the collector without collecting either upon the electrode or the said retardation line.

6. Electron tube structure as defined in claim 5 wherein said anode is provided with a substantially straight portion positioned for directing the electrons into the space between said electrode and said retardation line.

7. In combination, a cathode, a cylindrical anode substantially surrounding said cathode with the latter positioned along the anode axis of revolution for producing a substantially uniform radial electric field around said cathode, said anode having an opening therein, and an electrode extending from said cathode through the opening in said anode, said anode being provided with an extension a flattened surface somewhat spaced from and opposed to one surface of said electrode for cooperating with said electrode to guide electrons therebetween.

8. An electron tube structure comprising a cathode, an anode having a cylindrical portion substantially surrounding said cathode with the latter positioned along the axis of revolution of said anode cylindrical portion for producing a substantially uniform radial electric field around said cathode, said anode having an opening therein, an electrode extending from the region of said cathode through the opening in said anode, an electron collector, a retardation line located between said cathode and said electron collector adjacent the flight path of electrons moving from said cathode to said collector, said retardation line having one end adjacent to the opening in said anode, said tube structure having a magnetic field extending substantially transversely of the flight path of electrons and means for providing an additional electric field substantially perpendicular to the axis of said retardation line and coextensive therewith.

9. The apparatus of claim 8, wherein said electric field providing means comprises an extension of said electrode and a source of potential connected between said electrode and said retardation line.

10. The apparatus of claim 8, wherein said electric field providing means comprises an auxiliary electrode and a source of potential connected between said auxiliary electrode and said retardation line, and wherein the electrode which extends from said cathode is maintained at a potential intermediate the potential of said auxiliary electrode and the potential of said retardation line.

11. The apparatus of claim 8, wherein said anode is provided with a flattened extension having a surface spaced from and opposed to one surface of said electrode.

12. The apparatus of claim 11, wherein the portion of said additional electric field adjacent said electrode and said anode extension is substantially parallel to the electric field produced between said electrode and said anode extension by said anode and said cathode.

13. The apparatus of claim 8, wherein said retardation line is in the form of a partial annulus.

14. The apparatus of claim 8, wherein said retardation line extends in a substantially straight line.

ALFRED LERBS.

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