June 8, 1954 O. DÖHLER ET AL 2,680,823

ELECTRON OPTIC DEVICE FOR A BEAM PROPAGATING PERPENDICULARLY TO CROSSED MAGNETIC AND ELECTRIC FIELDS

Filed July 1, 1950

3 Sheets-Sheet 1

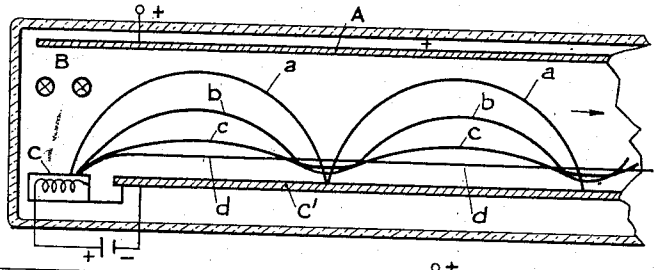


Fig.1

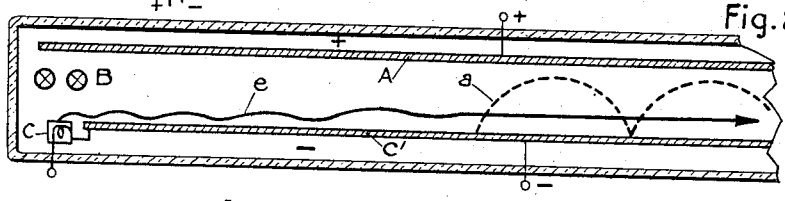


Fig.2

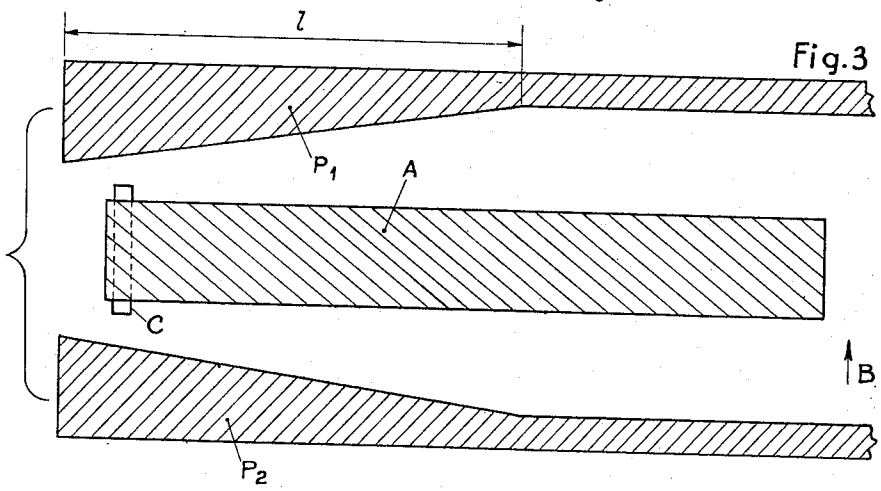


Fig.3

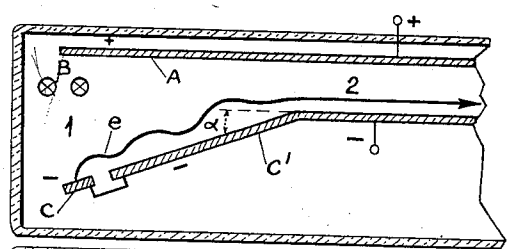


Fig. 4

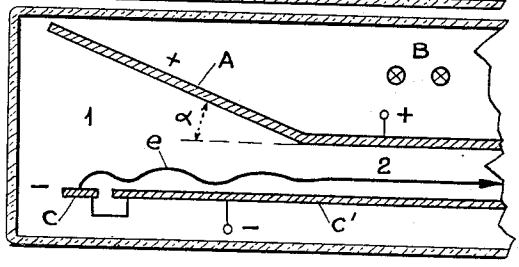


Fig. 5

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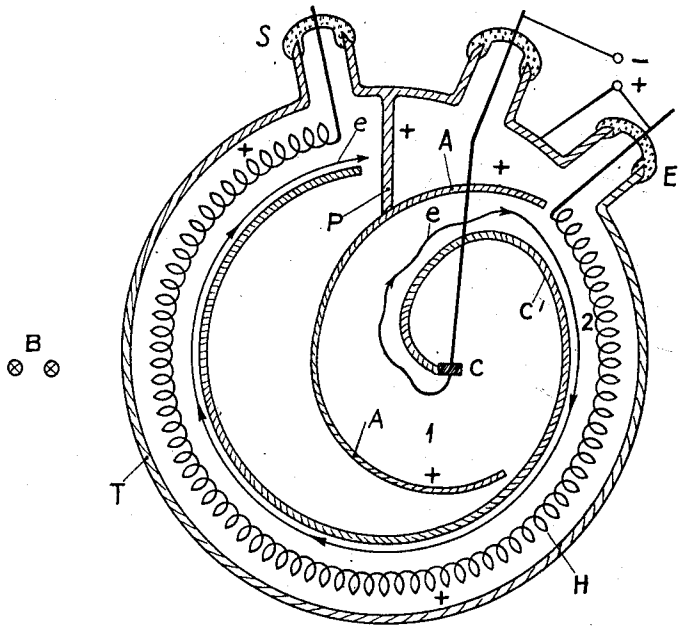


Fig. 6

Fig. 7

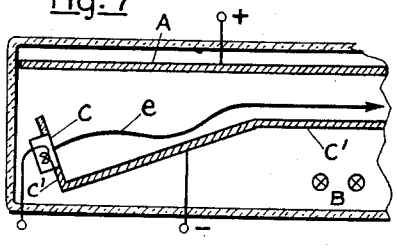
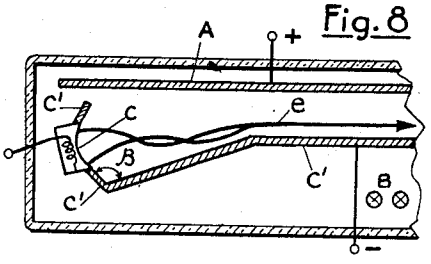


Fig. 8



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ELECTRON OPTIC DEVICE FOR A BEAM PROPAGATING PERPENDICULARLY TO CROSSED MAGNETIC AND ELECTRIC FIELDS

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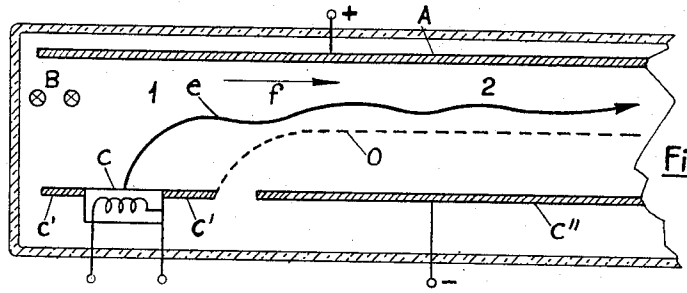


Fig. 9

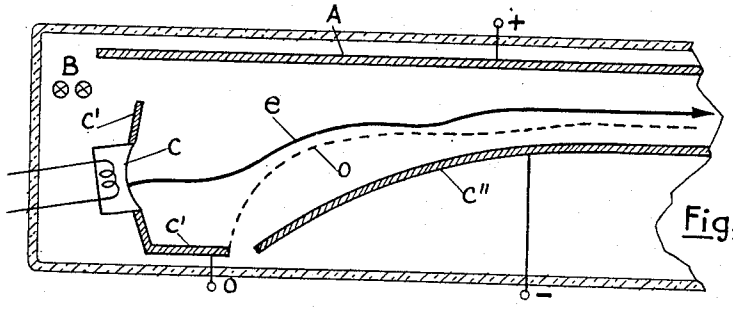


Fig. 10

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ELECTRON OPTIC DEVICE FOR A BEAM PROPAGATING PERPENDICULARLY TO CROSSED MAGNETIC AND ELECTRIC FIELDS

Oscar Döhler and Alfred Lerbs, Paris, France, assignors to Compagnie Generale de Telegraphie Sans Fil, a corporation of France

Application July 1, 1950, Serial No. 171,706

Claims priority, application France July 7, 1949

7 Claims. (Cl. 313—75)

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The present invention relates to an electron optic device interposed between the source of an electronic beam and the space between an anode and a cathode, in which space exists a magnetic and electric field crossed and perpendicular in the direction of the propagation of said beam.

In the presently known devices of this kind, the ratio between electric field E and magnetic field B is maintained constant, and it is known that in such conditions the paths of electrons are cycloidal, that is to say that said electrons return periodically to the potential of the cathode as in the static case of the magnetron.

It is known that the efficiency and gain of a tube functioning with such a beam are proportionally as much greater as the amplitude of the cycloidal movement is weaker, and the present invention is directed towards the means of reducing said amplitude in such a manner that the movement of the electrons becomes as rectilinear as possible.

A means considered in the present invention consists of a progressive variation along the beam, of the relation between the electric and magnetic field, by operating on either one or the other of said fields, or on both.

A further object of the present invention is to reduce as much as possible the length of the transitory space occupied by the electron optics in which the movement of the electrons loses progressively its cycloidal characteristic, and consists of an adequate arrangement at the source of the electronic beam.

The present invention will be better understood by means of the annexed drawings:

Fig. 1, diagram showing the electronic paths.

Figs. 2 and 3, a system employing the means conforming to the present invention.

Figs. 4 and 5, two other embodiments of a second system.

Fig. 6, a form of cylindrical construction.

Figs. 7, 8, 9 and 10, four systems relative to the arrangement of the cathode, employing further means conforming to the present invention.

Fig. 1 represents schematically a system comprising anode A and cathode C′ between which is applied an electric field, a magnetic field B being applied perpendicularly relative to the plan of the drawing. A power source C, situated at the level of cathode C′ and connected to the potential of said cathode, produces a beam of electrons which travel perpendicularly between A and C′ in the electric and magnetic field. In the known devices, where the distance between A and C′ is constant, the electrons follow cycloidal paths as

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shown by *a*. It is of advantage for the efficiency and gain that the electrons follow the rectilinear path *d*. The means conforming to the present invention assure that the electrons follow, if not the ideal path *d*, at least the intermediary paths *b* or *c*, or that the form of said paths approach gradually towards *d*, on passing progressively by *b* and *c*.

The present invention is based on the fact that the form of the paths of electrons is influenced by the ratio E/B and that the amplitude of cycloidal movement becomes reduced in proportion to the increase of said ratio. According to the present invention there is therefore provided an electron optics device in which said ratio increases progressively in the direction of the beam propagation.

A system represented in Fig. 2 in cross section, and in Fig. 3, plan view comprises means for diminishing progressively the magnetic field in the direction of the propagation of the beam the electric field remaining constant said diminution is effected by providing polar elements P_1 and P_2 with an appropriate profile along the portion *l* on which is effected the progressive transformation of the cycloidal path *e* into a rectilinear path. The remaining references shown in Figs. 2 and 3 have the same signification as in Fig. 1. For purposes of comparison there is indicated in dotted lines the cycloid followed by the electrons with the same constant fields in the homogeneous space between electrodes A and C.

In practice it is easier to increase the electric field rather then to decrease the magnetic field in the direction of the propagation of the beam. Figs. 4 and 5 show simple forms of an electron optics effecting said increase. The same references designating the same elements as in the preceding figures there is obtained, on bending to an angle α the negative electrode in Fig. 4 or the anode in Fig. 5. If the distance between cathode C and space 2 where the fields E and B are homogeneous is great enough, the beam will be sufficiently linear on entering into space 2 even if the amplitude of the cycloidal movement at the beginning of space 1 is relatively great. Any type of cathode can therefore be utilised, either plane oxide cathodes or directly heated or a filament the initial direction of the electrons, determining the beginning of the path being unimportant since whatever the initial path may be it has sufficient time to become linear before entering the homogeneous space.

The linear arrangements according to Figs. 4 and 5 have often the disadvantage of being too

long. A means of avoiding this disadvantage consists of constructing the device in cylinder form, as shown in Fig. 6.

Fig. 6 shows delay line H incoming at E and outgoing at S. Said delay line is at the same potential as anode A of the heretofore described electron optics device which comprised the same elements A, C, C', excepting that the electrodes are suitably incurved in order to inject the beam into the circular space between H and C', at the same time retaining the basic arrangement of Fig. 4. Collector P receives the electrons which are not absorbed by H. A power source C, and a negative electrode C' are of the same potential. The distance between C and A decreasing towards the constant distance between H and C' the electric field increased in space 1. The electron optic corresponding to said space is therefore in the non utilised space of the interior of housing T, of which latter no dimension need be changed.

A further means of reducing the length of space 1 in Figs. 4 and 5 consists of providing the cathode with a form and position in such a manner that the initial directions of the emission of electrons are favorable to the rapid transformation of their paths into a straight line, the amplitude of the cycloidal movement being greatly reduced at the point of departure from said cathode.

Fig. 7, representing the arrangement and references of Fig. 4, shows the emitting surface of cathode C practically perpendicular in relation to path *e*. Nevertheless, if the surface of said cathode is plane and large enough (in the case where a strong emitting current is required), the paths will be approximately linear according to the point of emission of said cathode. To avoid this effect, the surface of said cathode is provided curved, as shown in Fig. 8, said curve being determined experimentally in such a manner that the paths rapidly assume a linear form independent of the point of emission. This effect can also be lessened by choosing a suitable angle β which forms said cathode surface with negative electrode C'.

A further means of obtaining a distribution of the electric field flavorising the formation of a linear beam is shown in Fig. 9. Negative electrode C' is divided into two electrodes C' and C'', of which C' is connected to power source C, whereas C'' is at negative potential in relation to C'. The intensity of the electric field increases in the direction of arrow *f*. Said field distribution is therefore not determined by the form of the electrodes as in Figs. 4 to 8, but by the distribution of the tension between the electrodes. The advantage of this arrangement is that it allows the choice of a desired position of the beam in space 2 and the possibility of influencing, in a certain degree, the shape of the focusing field and consequently the focusing of the beam.

It is obvious that the form and arrangements of the cathode in Figs. 7 and 8 can be applied to Fig. 9. The arrangements shown in Figs. 7 and 8 can also be combined with the arrangements shown in Fig. 4, thus obtaining the arrangement shown in Fig. 10, said Fig. 10 being understood without any further description, the reference utilised being the same as in the preceding figures.

The present invention is applicable to all tubes where the electronic beam moves perpendicularly to crossed electric and magnetic fields and particularly to those where at least one of the electric field electrodes is in the form of a delay line in which is propagated, parallel to said beam, an electromagnetic wave intended to be amplified. The different forms of application and embodiment of the present invention as represented in the annexed drawings are not limitative but on the contrary allow all the variations accessible to anyone skilled in the relevant art, particularly relative to the design and arrangement of the cathode and the means to be utilised to focus the emission of said cathode in a predetermined direction.

What we claim is:

1. An electronic tube comprising a pair of electrodes extending substantially parallel over a part of the tube length and provided with connections to a potential source to establish an electric field between said electrodes, an electronic gun situated close to the beginning of the space between said electrodes and comprising means for injecting into said space an electronic beam essentially perpendicular to said electric field, means comprising a magnetic circuit for causing a substantially time-constant magnetic field to traverse said space in a direction perpendicular to said electric field and to said beam, and means to cause the ratio between the intensities of said electric and said magnetic field to increase in said direction of propagation, the intensity of the magnetic field and the difference of potentials between said electrodes remaining constant over the other part of the length of said space.

2. Electronic tube according to claim 1, in which the magnetic circuit comprises a gap which increases in the direction of the propagation of the beam.

3. Electronic tube according to claim 1, in which the distance between the electrodes decreases in the direction of the propagation of the beam, at least in the vicinity of the entry of said beam into the space between said electrodes.

4. Electronic tube according to claim 1, in which one of the electrodes, in the vicinity of the entry of the beam into the space between said electrodes is divided into several portions connected to different potentials relating to the second electrode.

5. Electronic tube according to claim 1, in which at least one of the electrodes, in the vicinity of the entry of the beam into the space between the electrodes, is bent at a certain angle in relation to the second electrode.

6. Electronic tube according to claim 5, in which the electronic gun is situated at a certain part of the bent electrode, said part being bent at a right angle in relation to the part of the same electrode delimiting the entrance of the space traversed by the beam.

7. Electronic tube according to claim 6, in which the part of the electrode containing the electronic gun is concave in the direction of the beam.

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