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ELECTRIC DISCHARGE TUBE COMPRISING MEANS FOR PRODUCING AND DEFLECTING AN ELECTRON BEAM

Filed March 31, 1950 2 SHEETS--SHEET 1

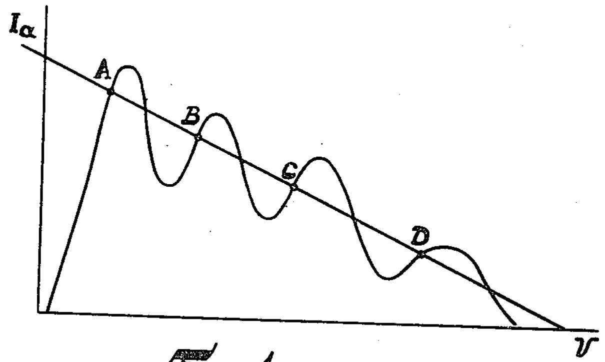


Fig. 1

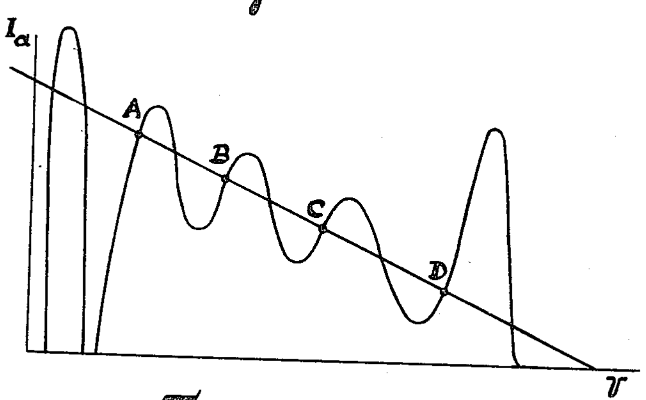


Fig. 2

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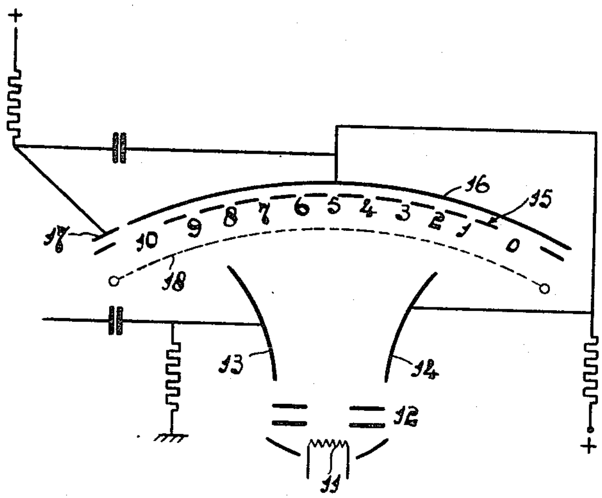


Fig. 3

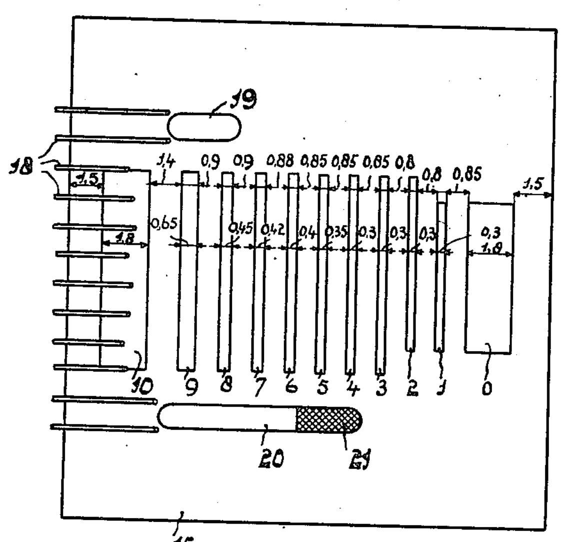


Fig. 4

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## ELECTRIC DISCHARGE TUBE COMPRISING MEANS FOR PRODUCING AND DEFLECTING AN ELECTRON BEAM

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11 Claims. (Cl. 315—21)

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This invention relates to electric discharge tubes comprising means for producing and deflecting an electron beam in which the electron beam is adapted to be held in determined positions by current distribution between two or more collecting electrodes.

The invention will be described with reference to the appended drawing forming part of the specification and in which:

Figs. 1 and 2 show characteristic curves of electric discharge tubes of the type to which the invention is directed

Fig. 3 is a schematic showing of an electric discharge tube system in accordance with the invention, and

Fig. 4 is a schematic showing of a frontal view of a portion of an electric discharge tube in accordance with the invention.

Circuit arrangements for operating deflection tubes of the type under consideration have been described in U. S. A. patent application Ser. No. 790,874 and relate to circuits and means by which an electron beam may be held in determined positions by current distribution between at least two collecting electrodes, the variation of current through at least one of these electrodes with beam position having a number of maxima and minima. The average value of the current in the direction of deflection of the beam may vary continuously and in the same sense. Such a variation is shown in Figs. 1 and 2 of the accompanying drawing and may be achieved with the use of the circuit-arrangement indicated in Fig. 3 of the accompanying drawing. The points A to D (Figs. 1 and 2) are points at which the beam can be held in a determined position. A detailed description of the operation of this circuit-arrangement is given in the aforesaid U. S. A. patent application Ser. No. 790,874.

It has been found that the variation of the anode current $I_a$, as a function of the voltage V of the deflection plate **14** (Fig. 3), which voltage is also the anode voltage of the anode **16**, can in practice be obtained only with difficulty with the construction of the electrodes as described in U. S. A. patent application Ser. No. 790,874, since such constructions have a limitation in that at a given width of beam a comparatively high deflection voltage is required to displace the beam in accordance with the required characteristic curve, since the width of the beam may, at the most, be a small portion of the spacing between two maxima of the anode current curve. Thus, with definite dimensions of the tube, only a comparatively low beam current is obtainable, whereas the spacing between two maxima must be comparatively great as compared with the width of the beam, so that the beam to pass from one determined position to the next must be deflected through a comparatively great distance for passing from one maximum to the next. Appreciable deviations may furthermore occur, if the beam exhibits slight divergences from its path. This leads to difficulties in mass production. It is furthermore difficult to obtain, if desired, an ascending variation of the mean anode current.

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The object of the invention is to mitigate these difficulties.

According to the invention, an electric discharge tube comprising a cathode, one or more collecting electrodes and several auxiliary electrodes together with means for beaming the electrons, and suitable for use in a circuit-arrangement in which the beam is held in determined positions by current distribution between at least two collecting electrodes and by at least one circuit connected to these electrodes, and in which the variation of the current flowing to at least one collecting electrode as a function of the deflection voltage has a number of maxima and minima, is characterized in that one collecting electrode has a number of apertures provided side by side in the direction of deflection of the beam, the dimensions of these apertures in the direction of deflection of the beam being smaller than the corresponding dimensions of the sectional area of the beam.

Thus, the width of the beam may be approximately half or more of the spacing between two maxima of the anode current variations, so that with tube dimensions and voltages which are otherwise the same, the beam current may be increased considerably. The width of beam is to be understood to refer to that part of the cross-section of the beam in which the electron density is more than 10% of the maximum density.

In order that the invention may be more clearly understood and readily carried into effect, it will now be described more fully by reference to the accompanying drawing, given by way of example.

Referring now to Figure 3, the dimensions of the apertures arranged in a row are matched to the sectional area of the beam, since, when the beam approaches the deflection plate **14** (at D, Fig. 1 or 2), the current flowing to the collecting electrode or anode **16** in Fig. 3 decreases so that the anode voltage is higher than if the beam is at A (Fig. 1 or 2) in the proximity of the deflection plate **13**. Consequently, the apertures from **1** to **9** (Fig. 4) are chosen to be gradually larger.

Aperture 10 is materially larger, since in this position a great part of the beam must be allowed to pass, in order to produce a high current pulse across the auxiliary anode 17, this pulse being utilized for the fly-back of the beam to aperture 0. The collecting electrode or anode 16 may, for example, be plate-shaped or be made of electrically interconnected rods.

In order that the anode current may be independent of the anode voltage, a suppressor grid may be provided, for example at 18. In order to prevent the beam from being interrupted when passing by the suppressor-grid wires, these wires are arranged parallel to the direction of deflection. If necessary, a plurality of such suppressor grids may be provided.

It has been found that with the use of a beam of circular sectional area it is difficult to obtain high current strengths, more particularly since it is of great importance to minimize the size of the tube. Consequently, use is preferably made of a ribbon-like beam. It is then possible to ensure a comparatively high current strength at low voltages and a small width of beam, whilst retaining sensitivity of deflection, since the beam width may be more than half the spacing between the maxima of the anode current variations corresponding with the maxima of the anode surface struck by the beam, so that the spacing between the maxima may be small as compared with the width of beam which itself is then smaller. The apertures in the collecting electrode 15 are then shaped in the form of slits. Such an electrode is shown in Fig. 4. The slits 1, 2, 3 and 4 are here 0.3 mm. wide. Since it may technically be difficult to make the slits still narrower, the slits 1 and 2 are in this case shorter than the other slits. Owing to the dispersion of the beam according as the deflection takes place towards the aperture 10, the apertures and the intermediate spaces become wider and wider towards slit 10. Thus, the slit 9 has a width of 0.65 mm. Rods 18 constitute a suppressor grid arranged at the cathode-side of the electrode 15. The height of the beam is preferably chosen to be greater than the height of the apertures.

The gradual increase of the direct current component of the anode current may then be obtained, for example, by providing a key-shaped aperture, which becomes wider towards slit 10, above the row of slits. However, owing to the shadow effect of the suppressor-grid wires 18, irregularities are liable to occur if the beam shifts slightly upwards or downwards. Consequently, instead of a key-shaped aperture a short slit 19 and a long slit 20, are provided, which slits 19 and 20 extend parallel to the direction of deflection. The apertures 19 and 20 are arranged, respectively, above and below the rows of slits 0 to 10, whilst the position of the suppressor-grid wires is chosen to be exactly such that the shadows of the wires viewed in the direction of the beam constitute the boundaries of the upper and lower sides of the slits 19 and 20. Thus, slight upward shifts of the beam have no effect upon the anode-current variation. In order to facilitate the gradual increase in anode current, a gauze 21 provided at the beginning of the slit 20 ensuring that only approximately half of the electrons falling through this part of the aperture 20 can reach the anode located behind it. Thus, abrupt increase in anode current when the beam strikes this slot is prevented.

That the sectional area of the beam must be larger than that of the apertures 1 to 9 follows from the fact that otherwise the maxima of the current flowing through the collecting electrode concerned would be restricted to a determined value, since the beam is in this case capable of passing completely through the slits, so that the variation shown in Figs. 1 and 2 would not be obtained. The strips between the slits are also preferably made narrower than the width of the beam, in order to ensure a smooth variation of the minima. Otherwise an angular variation of the anode-current characteristic curve would result, which is generally undesirable. It is furthermore advantageous if the width of the strips between the slits of the perforated collecting electrode 15 exceeds the width of the adjacent slits. This ensures a smaller dispersion in the depths of the minima, which results in a uniform curve as shown in Figs. 1 and 2. The greater width of the aperture 0 as compared with that of the apertures 1 to 9 is intended to ensure a high current maximum at D (Fig. 2). The beam, upon flying back from 10 to 0, is thus prevented from passing beyond 0, which is undesirable particularly if on this side a further fly-back anode were provided. In the latter case, oscillation of the beam might ensue. Uniform control of deflection is assisted, more particularly in the extreme positions of the beam, by the curved shape of the deflection plates 13 and 14. It is furthermore advantageous if the fly-back anode 17 is narrower (as shown in Fig. 3) or arranged in part behind a portion of the screen 15. This results in a narrower current peak on the left-hand side of A (Fig. 2), so that a higher fly-back voltage pulse is produced. Since this fly-back voltage pulse may also serve to operate subsequent tubes, it is of advantage if it has a high value.

The tube according to the invention ensures reliable operation with a simple tube construction of small size, which does not require any critical adjustment.

What I claim is:

1. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned spaced apertures intersecting said given path, said apertures having a cross-sectional dimension smaller than the corresponding cross-sectional dimension of said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

2. An electron tube for an impulse counting system comprising means to generate a ribbon-shaped beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned slit-shaped spaced apertures intersecting said given path, said apertures having a dimension parallel to said given path smaller than the width dimension of said beam, and means to couple one of said electrodes to said deflecting means to

thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

3. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means, a suppressor system interposed between said apertured electrode and said generating means, and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned spaced apertures intersecting said given path, said apertures having a cross-sectional dimension smaller than the corresponding cross-sectional dimension of said beam, said suppressor system comprising a plurality of wire elements arranged substantially parallel to said given path, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

4. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned spaced apertures intersecting said given path, said apertures having a cross-sectional dimension smaller than the corresponding cross-sectional dimension of said beam and the spacing between said apertures being greater than the width of said apertures, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

5. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned spaced apertures intersecting said given path, said apertures having width and breadth dimensions smaller than the corresponding dimensions of said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

6. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of spaced apertures aligned in a row and a further aperture arranged at one side of said row, said apertures intersecting said given path and the apertures in said row having a cross-sectional dimension smaller than the corresponding cross-sectional dimension of said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

7. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of spaced apertures aligned in a row and further apertures arranged one at each side of said row, said apertures intersecting said given path and the apertures in said row having a cross-sectional dimension smaller than the corresponding cross-sectional dimension of the said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

8. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned slit shaped spaced apertures arranged with their longitudinal axis normal to the direction of movement of said beam and further slot shaped apertures arranged one at each side of said row and with their longitudinal axis parallel to the direction of movement of said beam, said apertures intersecting said given path and the said slit-shaped apertures having a width dimension smaller than the corresponding dimension of said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

9. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned slit shaped spaced apertures arranged with their longitudinal axis normal to the direction of movement of said beam and further slot shaped apertures arranged one at each side of said row and with their longitudinal axis parallel to the direction of movement of said beam, one of said slots having a portion thereof provided with a metal gauze coating, said slit-shaped apertures having a dimension smaller than the corresponding dimension of said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to

positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

10. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned slit shaped spaced apertures arranged in a row with their longitudinal axis normal to the direction of movement of said beam, the apertures at the extremes of said row having a greater width than the intermediate apertures, said apertures intersecting said given path and having a width dimension smaller than the corresponding dimension of said beam, and means to couple one of said electrodes to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode.

11. An electron tube for an impulse counting system comprising means to generate a beam of electrons of given cross-sectional dimensions and to direct the said beam in a given direction, a collector electrode system arranged in the path of the beam, an apertured electrode interposed between said collector electrode and said generating means and means to deflect said beam along a given path, said apertured electrode being provided with a plurality of aligned slit-shaped



spaced apertures arranged in a row with the longitudinal axis normal to the direction of movement of said beam, said collector electrode system comprising a first portion adjacent to one extreme of said row of apertures and a second portion adjacent to apertures intermediate to said extremes of said row, said apertures having a width dimension smaller than the corresponding dimension of said beam, and means to couple said collector electrode portions to said deflecting means to thereby deflect said beam to positions of maximum and minimum current distribution between said apertured electrode and said collector electrode system.

ADRIANUS JOHANNES WILHELMUS MARIE VAN OVERBEEK.

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