March 15, 1938. M. KNOLL ET AL 2,110,911

ELECTRON TUBE

Filed July 27, 1934

Fig. 1

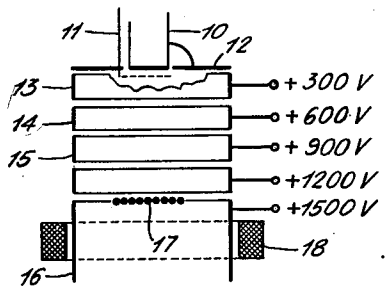


Fig. 2

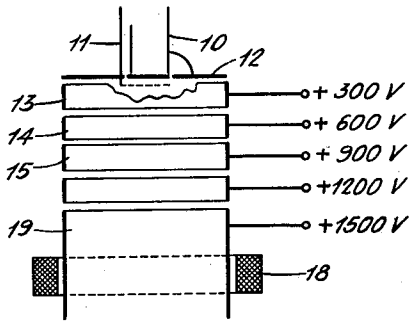


Fig. 3

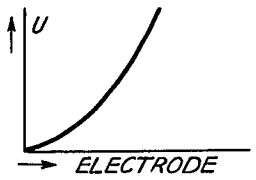


Fig. 4

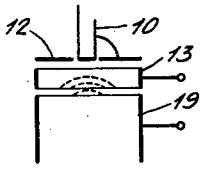


Fig. 6

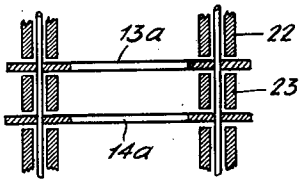


Fig. 5

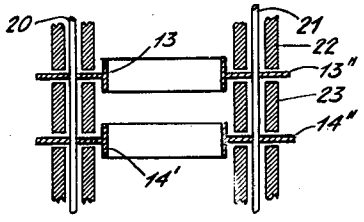


Fig. 7

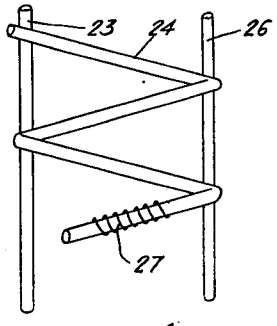


Fig. 8

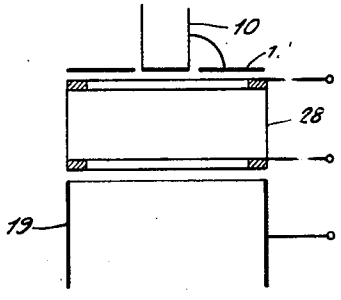
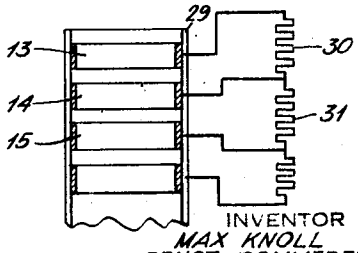


Fig. 9



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2,110,911

ELECTRON TUBE

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Application July 27, 1934, Serial No. 737,185
In Germany July 31, 1933

10 Claims. (Cl. 250—27.5)

The invention relates to an arrangement by means of which a small fluorescent spot can be produced on a luminous screen of a cathode ray tube. To this end, and in accordance with the invention, the electron rays after leaving the cathode are to pass through one or several electrodes whose opening is large as compared with the cross section of the electron ray beam, and the electrodes are to have a positive potential applied relative to the cathode which is the higher the farther the respective electrode is apart from the cathode. An electrode opening is to be considered "large" in this connection relative to the cross section of the beam if the equi-potential surfaces of the field produced by the electrodes are practically parallel to each other within the entire cross section of the ray.

The invention will be described in the following on hand of several embodiments given by way of example and schematically represented in the drawing in which Fig. 1 shows one embodiment of applicants' invention;

Fig. 2 shows a modification of the embodiment shown in Fig. 1;

Fig. 3 shows graphically the potential distribution illustrative of that used in connection with applicants' invention; and

Figs. 4 through 9 show other embodiments and modifications of applicants' invention.

In Fig. 1, 10 designates the cathode, 11 the lead-in for the control grid, which in cathode ray tubes serving for the reception of television transmissions, can be used for the modulation of the brilliancy of the luminous spot. The cathode 10 is conductingly connected to a disk 12, serving for rendering homogeneous the field of the electrodes. These cylindrical electrodes are designated by 13, 14, 15, and they have a positive potential applied to which increases with an increasing distance from the cathode 10. In these values of the potentials as well as in the examples of embodiments to follow, the cathode potential is assumed to be zero. Furthermore an additional cylindrical electrode 16 is provided covered at the top by a mesh 17 forming the anode of the tube. A magnetic field concentrating coil is designated by 18.

The arrangement shown in Fig. 1 operates in the manner that in the axis of the cathode ray tube, the equi-potential surfaces assigned to the electrical field produced by the electrodes 13 to 15 are practically parallel and at right angles to the tube axis, and that therefore the beam of electron rays whose axis coincides with the axis of the tube, and whose cross section is small as compared with the opening of the electrode, consists of practically parallel electron rays. In the concentrating arrangement 18 the beam of rays is rendered convergent so that on the luminous screen of the tube (not shown in Fig. 1) a small fluorescent spot is produced.

In Fig. 2 another embodiment is shown in which the parts corresponding with those in Fig. 1 are designated by the same reference characters. Besides the electrodes 13 to 15 a further electrode 19 is provided which can be designated as anode of the cathode ray tube.

The functioning of the arrangement shown in Fig. 2 as regards the parallel course of the rays is the same below cathode 10 as in the arrangement according to Fig. 1. The concentrating coil 18 acts in identical manner as described in connection with Fig. 1.

It must be expressly pointed out that the height of the electrodes 13 to 15, their relative distance and the potential differences existing therebetween need not have the same values as those indicated in Figs. 1 and 2. In particular it might be desirable to make the electrodes unequally high and/or to choose the potential differences unequally great, so as to compensate possible irregularities in the course of the field, for instance in the vicinity of the cathode, and to thereby insure a substantially parallel course of the electron rays at the entrance into the collector arrangement 18.

In rendering the electrode distances and the potential differences thereof unequal it can furthermore be achieved that the equi-potential surfaces between cathode and anode will have a very large and accurately defined radius of curvature. In selecting the latter equal to the distance between anode or cathode respectively, and luminous screen, a sharp fluorescent spot can also be obtained without the use of a concentrating coil. To this end, for instance, in case of equally high electrodes 13 to 16 and 19 respectively, the voltage at two successive electrodes must be higher than between the two preceding ones. The voltage U therefore must have a course approximately as that shown in Fig. 3.

An embodiment containing only a single electrode in the sense of the electrodes 13 to 15, is shown in Fig. 4. The axial height of electrode 13, as well as the voltage between the electrode and anode 19, is so dimensioned that the equi-potential lines, several thereof are shown in dotted lines in Fig. 4, have such a curvature over the cross section of the beam, that they produce an accelerating and collecting action upon the elec-

trons. Likewise, in such an arrangement a special concentrating coil is therefore not required. The electrode 13 may eventually likewise have the cathode potential applied.

In Figs. 5 and 6 the construction and mounting of the electrodes 13 to 15 is shown and also the mode of supplying the potentials thereto. In Fig. 5 the electrodes consist of cylinders 13', 14' having disk-like flanges provided thereon. These flanges are drilled through and are placed over bolts 20, 21 of insulating material. The prescribed distance of the electrodes is insured by means of spacers 22, 23. The spacers are to consist of resistance material. The uppermost and the lowest of the electrodes must be imagined to be connected at two sealed places through which an auxiliary current is supplied. In certain conditions a subdivision of the voltage supply is suitable in such manner that more than two sealed-in places are employed. The auxiliary current produces at the resistances 22, 23, etc., a voltage drop in such manner that the individual electrodes reach the desired potential. The arrangement shown in Fig. 6 differs from that in Fig. 5 only by the use of disk-like electrodes 13*a* and 14*a* in place of cylindrical electrodes. The mounting of these electrodes and the mode of supplying the voltage is carried out in the same manner as is described in connection with Fig. 5.

The arrangement shown in Figs. 5 and 6 has the great advantage in that it is not necessary to pass the voltage for each electrode through the wall of the tube, instead for the supply of the voltage for n electrodes only two, or at any rate considerably less than n, sealed-in places are required. The resistances between the individual electrodes may, even if resistance tubes of only a few sizes are available, within certain limits still be regulated in that resistances as spacers are not employed on all bolts 20, 21 or on bolts otherwise also used, but glass or porcelain tubes are provided on one or several bolts. In connecting resistance tubes of various sizes in parallel a further stepping of the total resistance between two electrodes is possible. It needs not be further explained that it is within the scope of the invention to also provide between the electrodes 13, 14 small resistances of other than tube shape, for instance wire or carbon resistances.

Another embodiment which can be used in place of the electrodes 13 to 15 of Figs. 1 and 2 is also shown in Fig. 7. It is namely possible to replace the electrodes by means of helices 24 of resistance wire which at the upper and lower end are connected by means of sealing as explained in connection with Fig. 5. An auxiliary current is passed through the helical wire corresponding to the current through the resistances 22, 23, etc. (Fig. 5), and whose voltage drop along the helical wire produces equi-potential surfaces in the tube axis as described on hand of Fig. 1. The helical wire 24 can be supported by a larger number of bolts 25, 26 of insulating material. The helically shaped body may likewise be composed of insulating material preferably of glass, whereby the bolts 25, 26 can be dispensed with, and the resistance proper may itself be provided in the form of a helix on the windings of the helix of insulating material. The last mentioned mode of execution is shown in Fig. 7 in which the resistance wire arranged on the helical body is designated 27.

Furthermore, the electrode can be constructed in the sense of a helix passed by current in accordance with Fig. 7 also in such manner that an insulating tube of large diameter preferably of porcelain is provided at the inside with a coating of resistance material preferably of carbon in the form of a helix.

In a further embodiment shown in Fig. 8, likewise a single electrode is to be used between cathode 10, i. e. the disk 12 connected thereto and electrode 19 to be considered as the anode. This electrode is designated by 28 in Fig. 8, and may suitably consist of a cylindrical metal layer 28 provided on the glass wall of the tube, for instance, by means of evaporation in the vacuum. At the upper and low end of the electrode a reinforced ring is provided also connected to the sealed-in places as described on hand of Figs. 5 and 6. The auxiliary current passes through electrode 28 in such manner that the lower ring thereof has a positive potential relative to the upper ring. Hence within the electrode 28, a course of equi-potential lines is produced causing an electron ray beam of constant cross section.

On hand of Fig. 9 a further construction of electrodes is to be explained which is of particular importance to the electrodes 13 to 15 and 19 of the form represented in Figs. 1 and 2. The electrodes 13 to 15 and 19 are namely intended to be produced by evaporation of metal in vacuum onto a glass or porcelain tube 29 which itself will be inserted in the cathode ray tube. The resistances 30, 31 etc., are passed by an auxiliary current as for instance explained on hand of Fig. 5 and causes a distribution of the voltage on the electrodes 13 to 15 and 19.

The above explanation regarding the height of the electrodes and the potential differences therebetween (acceleration and concentrating action) is also correspondingly applicable to the distance of the disk-like electrodes 13*a*, 14*a* in Fig. 6 and to the size of the resistances 22, 23 in Figs. 5 and 6. Also the pitch of the helix 24 in Fig. 7 and/or the specific resistance of the electrode wire or wire 27 can be correspondingly selected. Finally also the thickness of the metal layer 28 in Fig. 8 along the height of the cylinder can be varied.

Besides the cathode ray tubes serving for the reception of television transmission, the invention is also applicable to oscillograph tubes, furthermore to Roentgen tubes and the like.

Having thus described the invention, what we claim is:

1. An electrical lens system comprising a plurality of cylindrical annular electrodes positioned coaxially and in register and adapted to have linearly increasing positive potentials with respect to a predetermined point applied thereto, and a magnetic coil disposed concentrically about the electrode adapted to have the maximum value of the positive potentials applied thereto.

2. An electrical lens system comprising a plurality of similar cylindrical annular electrodes disposed coaxially and in register, a dissimilar electrode of greater axial length than any of the aforesaid electrodes, said last mentioned electrode being placed coaxially and in register with said other electrodes, and a magnetic coil disposed concentrically about said dissimilar electrode.

3. An electrical lens system comprising a plurality of similar cylindrical annular electrodes disposed coaxially and in register, a cylindrical annular electrode of greater length than the aforesaid electrodes and axially aligned with said first named electrodes, a mesh-like closure ele-

ment supported on the end portion of said cylindrical electrode nearest said first named series of electrodes, and a magnetic coil disposed concentrically about said cylindrical electrode.

4. An electron beam structure comprising an electron emitting cathode, an electrostatic guard disc connected thereto, a plurality of thin annular cylindrical electrodes disposed coaxially and in register with said cathode, and a magnetic coil surrounding the electrode positioned furthest away from said cathode.

5. In combination an electron emitting cathode, a guard disc connected thereto, a plurality of similar cylindrical annular electrodes positioned coaxially with said cathode and progressively spaced therefrom, a single cylindrical annular electrode of greater length than the aforesaid electrodes, positioned coaxially and in register with the aforesaid electrodes, and more remote from the cathode than said first named series of electrodes, and a magnetic coil disposed concentrically about the last of said electrodes.

6. In combination, an electron emitting cathode, a guard disc connected thereto, a plurality of similar cylindrical annular electrodes positioned coaxially and in register with said cathode, a single cylindrical annular electrode of greater length than the aforesaid electrodes, positioned coaxially and in register with the aforesaid electrodes, a magnetic coil disposed concentrically about the last mentioned electrode, and a series of electrical contact means to which suitable voltages may be applied for subjecting said electrodes to linearly increasing potentials with the maximum potential placed upon the last mentioned electrode.

7. An electrical lens system comprising a plurality of cylindrical annular electrodes positioned coaxially and in register and adapted to have increasing potentials with respect to a predetermined point applied thereto, the increase in potentials following a nonlinear law, and a magnetic coil disposed concentrically about the electrode adapted to have the maximum potential applied thereto.

8. In combination, an electron emitting cathode, a guard disc connected thereto, a plurality of similar annular electrode elements positioned coaxially and in register with said cathode, an elongated annular electrode positioned coaxially and in register with the first named electrodes, a magnetic coil disposed concentrically about the last of said electrodes, and a series of electrical contact means to which suitable voltages following a nonlinear law are applied to said electrodes with the maximum voltage placed upon the last of said electrodes.

9. The tube structure claimed in claim 8 wherein said plurality of annular electrodes comprises a series of electrically independent conducting annular areas upon the tube wall.

10. The tube structure claimed in claim 6 wherein said plurality of annular electrodes comprises a series of electrically independent conducting annular areas upon the tube wall.

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