Aug. 9, 1938. K. SCHLESINGER 2,126,287

TELEVISION TUBE

Filed Nov. 15, 1935 2 Sheets-Sheet 1

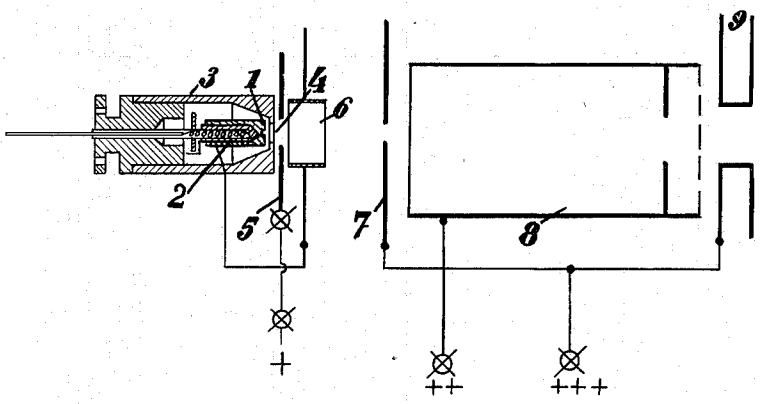

Fig. 1

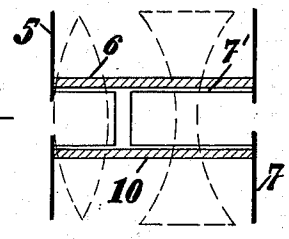

Fig. 3

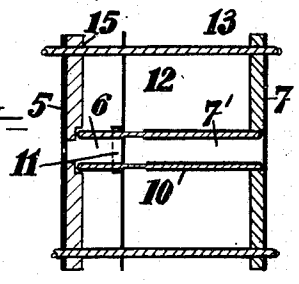

Fig. 4

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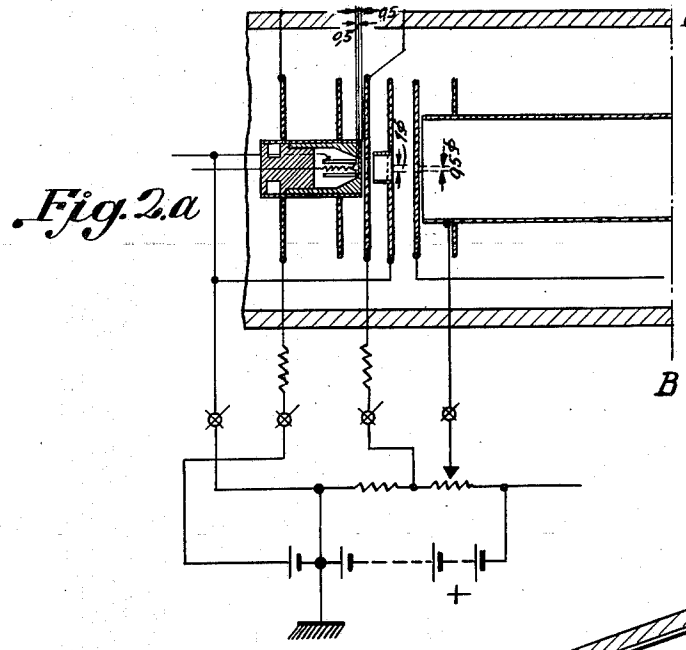

Fig. 2a

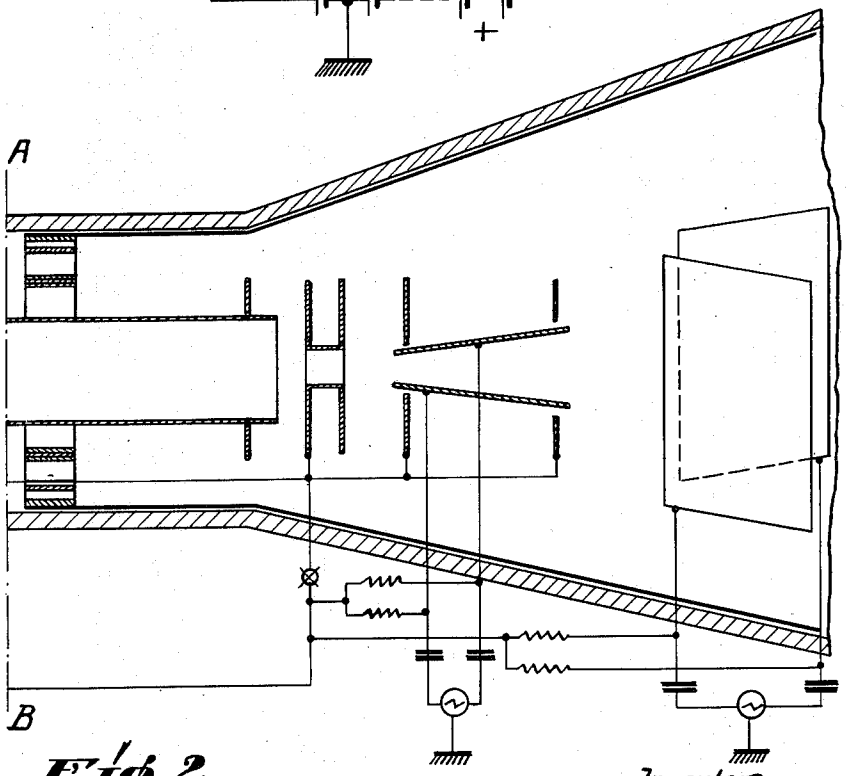

Fig. 2

Inventor:

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UNITED STATES PATENT OFFICE

2,126,287

TELEVISION TUBE

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Application November 15, 1935, Serial No. 49,953
In Germany November 20, 1934

19 Claims. (Cl. 250—27)

The subject matter of the co-pending patent application Ser. No. 19,817/35, filed May 4, 1935, is a high-vacuum television tube, in which the reproduction and the deflection are performed by electrostatic means, and in which all electrodes serving to generate the field are arranged within the tube, so that the tube is immediately operable without additional externally disposed auxiliary means, such as coils and the like.

The subject matter of the present invention is an improvement on the tube described in the co-pending patent application, and relates to the illumination of the diaphragm aperture to be reproduced with cathode rays by means of a special condensing system located between the cathode and the diaphragm the aperture of which represents the object of electron optical reproduction. The invention relates to the arrangement of the electrodes, to the adjustment of the concentrative effect by special auxiliary potentials, and to the mechanical production of a condensing system of this kind, which is of particular importance in view of the small size of the diaphragm aperture and of the intermediate electron-optical image reproduced on the diaphragm by means of the said condensing system.

The invention is illustrated in the accompanying drawings,

Fig. 1 of which is a diagrammatic longitudinal section through the essential parts of the electrode system of a cathode ray tube according to the invention, whereas

Fig. 2, which is, for reasons of space, divided into two parts along the line A/B, shows a dimensional longitudinal section through the portion of the cathode ray tube which contains the electrode system, in conjunction with a diagrammatic showing of the essential parts of the operating circuits, the second pair of deflecting plates being indicated in a perspective view.

Figs. 3 and 4 show the structural details of two modifications of the preliminary condensing system according to the invention.

In Fig. 1, 2 is the cathode, which is identical with the systems previously described by the applicant. The same possesses a spot of oxide 1 of the approximate size of the aperture in the intermediate diaphragm. For normal purposes an emissive surface is sufficient of .5 mm. in diameter, which is capable of supplying currents of up to 6 mA. and more. In the immediate vicinity of the spot of oxide there is provided the control electrode 3. It is only by reason of the small spacing of the aperture 4 in the control grid 3 from the oxide surface, and wholly independently of all electrodes and potentials provided otherwise in the tube, that the sensitivity of the tube is attained. According to the invention, the applicant makes use of spacings of such a smallness as is reconcilable with the required reliability of the mechanical construction. In practice, even in the case of large scale series production, it is quite readily possible to employ a grid aperture 4 of 1 mm. diameter spaced ½ mm. from the surface of the cathode. It is true that it is necessary for this purpose to assemble the grid and the cathode member on the same metallic base S, which ensures the centering of the grid and the cathode in relation to each other.

The very narrow control grid aperture 4 represents an effective screening of the cathode against external fields even against those desirable for freeing a sufficient emission from the cathode. It is, therefore, essential to provide behind the control cylinder 3 a suctional anode 5, to obtain an emission at all. In order not to have to apply unnecessarily high potentials to the anode, the spacing of this anode from the cathode will be made as small as permissible. This leads to the provision of a narrow boring and a spacing of the order of 1 mm. from the control grid 3. The biases at the anode 5 are wholly without effect on the sensitivity of the control. They determine merely the position of the working point and the required bias of the grid 3 in relation to the cathode 1. In this way the possibility is provided of regulating, by varying the bias of the anode 5, any other optical functions of the condenser, without at the same time variations taking place in the characteristic curve of the tube and in the control operation. According to the invention, this is made use of for adjusting the preliminary condensing system, as follows: the focussing electrode of the condensing system consists of a cylinder 6, which is maintained at a fixed bias. The diameter of this cylinder amounts to 5 mm., its length to 3 mm. This cylinder is directly connected with the cathode.

It is now possible, merely by variation of the potential at the preliminary anode 5 alone, to adjust the degree of focussing of the concentrating element 6 without, apart from the bias of the control grid 3, altering the control data of the television tube. According to the invention, therefore, the anode 5 is led out of the tube separately. This anode 5, in accordance with the invention, may also be employed as a blocking

electrode, as in the case of certain television systems which operate with white impulse signals for synchronizing the scannings at the transmitting and receiving ends it is necessary to be able to perform a blocking of the ray even if the main control grid 3 is positive with respect to the cathode, and it is a great technical advantage if the blocking potentials act on a special grid which has no electrical connection with the picture shading control grid. The "object diaphragm", i. e. the diaphragm having the aperture which is to be electron-optically reproduced on the picture receiving screen, is a piece of sheet metal 7. As in the case of the earlier tubes of the applicant, it is raised to the full main anode potential. The distances between the edge of the condensing cylinder 6 facing away from the cathode and the diaphragm 7 and between the same edge and the anode 5 are equal to each other.

It is possible with an arrangement of this kind to obtain an electron optical reproduction of the cathode spot on the intermediate diaphragm in the scale of 1:1. It is also possible by suitable adjustment of the potential 5 to regulate the reproduction within wide limits and to control to a large extent the angle of divergence of the electrons passing out behind the diaphragm 7. In particular it is possible, even when the control grid has a potential resulting in maximum emission, to make the intermediate image on the diaphragm 7 so small that practically all electrons pass through this diaphragm. The maximum light intensity of tubes of this kind is, therefore, increased to almost six times the amount as compared with tubes lacking the preliminary concentration employed by the applicant.

After the diaphragm 7 there follows unaltered as compared with the construction set forth in the mentioned co-pending patent application, a reproducing system comprising the tubular member 8 with an apertured plate 8' inserted therein and the tubular anode 9, the latter being in fixed conductive connection with the intermediate diaphragm 7. The bias of the tubular member 8 regulates the sharpness of the spot. As experimentally ascertained by the applicant by introducing fluorescent strips, which traversed the bundle of rays in longitudinal section, the greatest width of the bundle of rays at the aperture of the anode 9 mounted at a distance of 110 mm. from the diaphragm 7, amounts to approximately 3 to 5 mm. only, whilst the same without the condensing device amounted to 20 mm. The result is an improved sharpness of reproduction by the electronic lens 8/9, which is now only required to focus axial rays, but not marginal rays. A further result is the elimination of losses due to the stopping of electrons. The different potentials are approximately as follows:

Potential of anode 9 and diaphragm 7	2000 volts
Potential of the tubular members 8	500 to 800 volts
Potential of the preliminary anode 5	About 200 volts
Bias of the inner grid 3	About —10 volts
Tube is completely modulated with	About 20–30 volts
Maximum emissive current	About 500 mA.
Yield obtained in the case of maximum brightness	About 60–70%

In Fig. 2, like references are applied to like elements, as in Fig. 1. In addition, 12 are disc shaped members associated with some of the electrodes and having no electrical but only a structural function in that the electrodes are secured to the supporting members, e. g. glass rods attached to a pinch at the cathode side end of the tube and extending in parallel to the tube axis, by means of said disc shaped members which are provided with holes fitting over said supporting members. 16 and 17 are the deflecting system supplied with deflecting voltages from the generators 18 and 19, 16' are screening means the provision of which the applicant has found expedient for obtaining undistorted line screens of a uniform definition throughout. The high tension anode voltage supply is indicated by a battery 20, though it may of course be of any suitable kind, e. g. preferably an alternating current mains operated apparatus. The anode 9 and the diaphragm 7 are connected to the positive end of the voltage supply, the cathode 2 to a point near the negative end. If the shading control electrode is connected to the negative end of the supply, it is thus negatively biased in relation to the cathode. The shading modulations are introduced over the terminal 27 and produce alternating voltages across the grid leak resistance 25. Whereas now the concentrating cylinder is maintained at a constant potential, which may be, as shown, the cathode potential, the potential of the suctional anode 5 is according to the invention, made adjustable for the purpose of adjusting the degree of preliminary concentration. The drawings show the suctional anode 5 connected to an adjustable tap 23 at a potentiometer 21, 22. A grid-leak resistance 26 and a terminal 28 may be associated with the suctional anode 5 for the purpose of applying blocking impulses to that electrode. A further adjustable tap 24 is connected with the tubular member 8, by variation of the potential of which the refractive power of the main lens 8/9 may be varied. 29 is the envelope of the cathode ray tube.

Fig. 3 shows a form of condensing system which differs from that shown in Fig. 1 by the fact that a first condensing cylinder 6 is directly attached to the suctional anode 5, whilst a second condensing cylinder 7' is directly attached to the perforated diaphragm 7. The two cylinders 6 and 7' are of very different length, the latter being approximately three times the length of the former. The order of magnitude is approximately 3 mm. inner diameter and 3 and 8 mm. length respectively, with a spacing of 1 mm. The applicant has found that an unsymmetrical cylinder arrangement of this kind offers the advantage that the same represents a combined lens system, which acts first, viz., at the edge of the cylinder 6, as a collecting lens, and thereafter in the interior of the cylinder 7' as a dispersing lens (shown in broken lines). The dispersing effect is the greater the longer the cylinder 7' is made in relation to 6' and the narrower it is. It has already been shown in the patent applications Ser. No. 730,111, filed June 11, 1934, and Ser. No. 756,126, filed Dec. 5, 1934, that a dispersal of the ray of this kind shortly in front of the diaphragm aperture 7 offers the great advantage of directing the rays entering the long tubular member 8 more parallel than would be possible with the collecting systems of short focus usually employed. In this way losses by stopping in the rear part of the tube are avoided. The two constructions of collecting systems described above comprise comparatively small cylindrical structures with regard to which con-

siderable accuracy is required in respect of their mechanical construction and assembly. This requirement is rendered particularly difficult by the fact that the electrodes of the electron-optical collecting systems are situated comparatively close to the hot cathode and accordingly also become very hot. If it is considered that the intermediate image which is produced on the surface of the diaphragm is merely ½ mm. in diameter, and that the diaphragm aperture is of the same size, it will be recognized that losses of current of up to 75% must necessarily occur with displacements amounting to even as little as one-half the size of the aperture. In view of the comparatively large free length of ray in the condensing system, displacements of this kind are only to be avoided by special constructions according to the invention, which are illustrated in Figs. 3 and 4.

In a collecting system according to Fig. 3 the positioning is ensured in a very simple way by slipping over the two cylinder electrodes an insulating guide tube 10, which exactly fits about them. The tube 10 must be made of porcelain or glass and other materials which are properly heat-resisting and adapted for use in a high vacuum.

According to the invention, the entire collecting system may also be made of a single glass tube 10, which is silvered on the inside, the silver coating being removed from a small ring shaped zone. By taking the silver coating about the edge of the tube, a reliable connection with the inner silver coating may be established with the aid of an outer flange 11. In place of silver it is naturally also possible to employ graphite, because the requirements as regards the conductivity of the coatings are very small owing to the absence of any current in these coatings.

A similar idea of using insulating tubes coated with metal or graphite may be utilized in the production of a condensing system according to Fig. 1.

Fig. 4 shows the intermediate diaphragm 5. In front of this intermediate diaphragm there is situated the insulating tube 10, which is furnished with an inner and outer graphite coating of the desired length, these inner and outer coatings forming one combined coating. A flange 11 exactly fitting over the coated tube is extended to form a supporting collar 12, which with the aid of borings is centered in relation to the anode 5 in the above explained manner usual in the applicant's tubes. The diaphragm 7 is supplemented by a thicker plate 13 applied to the same, the aperture of which provides a cavity into which the glass tube 10 exactly fits. Centering may already be tested when welding the plate 13 on to the diaphragm 7. The whole is then attached to common glass rods 14 by welding. In place of the flange 12 it is also possible to employ with advantage a special insulating member 15, which is applied to the anode 5 and contains recesses into which the tube 10 exactly fits. The flange 11 then merely plays the part of a contact-making device. By means of an insulating tube construction of this kind guided in flange at both ends there is ensured not only the correct position of the axis in relation to the center of the ray, but also the direction of this axis, and it is in this way always accomplished that the ray passes entirely through the diaphragm aperture 7.

The stated, more particularly geometrical data are naturally merely to be regarded as examples. It may be important, however, to adhere in certain cases to the ratios in the dimensioning of the different electrodes resulting from the considerations set forth.

I claim:

1. The method of adjusting the preliminary concentration of an accelerated bundle of cathode rays to be afterwards focussed to produce an electron image in a receiving plane, more particularly in a television tube, by adjusting, independently from the subsequent focussing, the speed to which the electrons forming the bundle are first accelerated.

2. In combination a cathode ray tube comprising means for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising electrodes to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane, at least one of said electrodes being electrically independent from said focussing means; means for supplying said electrodes with different potentials and means for adjusting one of the potentials applied to said electrodes, one applied to an electrode which is electrically independent from said focussing means so that the degree of preliminary concentration is regulated.

3. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, said suctional anode being electrically independent from said focussing means, a preliminary concentrating system comprising electrodes including said suctional anode and to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said electrodes with different potentials and means for adjusting the potential applied to said suctional anode, so that the degree of preliminary concentration is regulated.

4. In combination a cathode ray tube comprising means including a cathode and a plate-shaped suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, said suctional anode being electrically independent from said focussing means, a preliminary concentrating system comprising electrodes including said suctional anode and to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said electrodes with different potentials and means for adjusting the potential applied to said suctional anode, so that the degree of preliminary concentration is regulated.

5. In combination a cathode ray tube comprising means for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising electrodes to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane, at least one of said electrodes being electrically independent from said focussing means, means for deflecting said bundle to cause said image to sweep over said receiving plane; means for supplying said electrodes with different potentials and means for adjusting the

potentials applied to said electrodes, one applied to an electrode which is electrically independent from said focussing means so that the degree of preliminary concentration is regulated.

6. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising said suctional anode and a concentrating cylinder mounted near said suctional anode in the space more remote from said cathode than said suctional anode and axially alined with said cathode and said suctional anode, said suctional anode and said concentrating cylinder being adapted to be supplied with different potentials decreasing in the direction away from the cathode for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said suctional anode and said concentrating cylinder with different potentials and means for adjusting the potential applied to said suctional anode so that the degree of preliminary concentration is regulated.

7. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising said suctional anode and a concentrating cylinder mounted near said suctional anode in the space more remote from said cathode than said suctional anode and axially aligned with said cathode and said suctional anode, said suctional anode and said concentrating cylinder being adapted to be supplied with different potentials decreasing in the direction away from the cathode for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for applying a fixed potential to said concentrating cylinder, means for applying to said suctional anode a potential higher than said fixed potential, and means for adjusting the potentials applied to said suctional anode so that the degree of preliminary concentration is regulated.

8. In combination a cathode ray tube comprising electrodes at least partly belonging to the means hereinafter recited which are incorporated in said cathode ray tube; said cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising said suctional anode and a concentrating cylinder mounted near said suctional anode in the space more remote from said cathode than said suctional anode and axially aligned with said cathode and said suctional anode, said suctional anode and said concentrating cylinder being adapted to be supplied with different potentials decreasing in the direction away from the cathode for preliminarily concentrating said bundle before it is focussed on the receiving plane; means for supplying said electrodes with their operating potentials, said last mentioned means comprising a direct conductive connection disposed inside said cathode ray tube from said concentrating cylinder to another one of said electrodes which is not said suctional anode and is supplied with a fixed potential, said last mentioned means further comprising means for applying to said suctional anode a potential different from that applied to said concentrating cylinder, and means for adjusting the potential applied to said suctional anode so that the degree of preliminary concentration is regulated.

9. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising said suctional anode and a concentrating cylinder mounted near said suctional anode in the space more remote from said cathode than said suctional anode and axially aligned with said cathode and said suctional anode, said suctional anode and said concentrating cylinder being adapted to be supplied with different potentials decreasing in the direction away from the cathode for preliminarily concentrating said bundle before it is focussed on the receiving plane, a direct conductive connection disposed inside said cathode ray tube from said concentrating cylinder to said cathode; means for supplying said suctional anode with a positive potential relatively to said cathode, and means for adjusting the potential applied to said suctional anode so that the degree of preliminary concentration is regulated.

10. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising said suctional anode, a plate shaped electrode mounted between said cathode and said suctional anode, and a concentrating cylinder mounted near said suctional anode in the space more remote from said cathode than said suctional anode and axially aligned with said cathode and said suctional anode, said suctional anode, said plate-shaped electrode and said concentrating cylinder being adapted to be supplied with different potentials whereof that applied to said suctional anode is the highest, said suctional anode and said concentrating cylinder being adapted to be supplied with different potentials decreasing in the direction away from the cathode for preliminarily concentrating said bundle before it is focussed on the receiving plane; means for supplying said plate-shaped electrode, said suctional anode and said concentrating cylinder with different potentials, whereof that applied to said suctional anode is the highest, and means for adjusting the potential applied to said suctional anode so that the degree of preliminary concentration is regulated.

11. In combination a cathode ray tube comprising means for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising two cylindrical electrodes adapted to be supplied with different potentials and mounted in axial consecution to be axially traversed by said bundle, the second one of said cylindrical electrodes taken in the direction away from the cathode being several times longer than the first one of said cylindrical electrodes and adapted to be supplied with a higher potential than said first one of said cylindrical electrodes so that said bundle is subjected to a concentration and subsequent dispersion in the space included by said two cylindrical electrodes and before it is focussed onto the receiving plane; means for supplying said two cylindrical electrodes with different potentials increasing in the direction away from said cathode and means for

adjusting the potential applied to that one of said cylindrical electrodes disposed nearer the cathode.

12. In combination a cathode ray tube comprising means for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising a supporting cylinder of an insulating material engaging in corresponding guiding structures and furnished with conductive coatings separated from each other by at least one separating zone and thus being adapted to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said electrodes with different potentials and means for adjusting one of the potentials applied to said electrodes so that the degree of preliminary concentration is regulated.

13. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising electrodes including said suctional anode and to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said electrodes with different potentials, means for adjusting the potential applied to said suctional anode so that the degree of preliminary concentration is regulated and means for applying to said suctional anode potential impulses for controlling, more particularly blocking, said bundle.

14. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, said suctional anode being electrically independent from said focussing means, a preliminary concentrating system comprising electrodes including said suctional anode and to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said electrodes with different potentials, means for adjusting the potential applied to said suctional anode so that the degree of preliminary concentration is regulated and means for applying to said suctional anode potential impulses for controlling, more particularly, blocking, said bundle.

15. In combination a cathode ray tube comprising means for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising two cylindrical electrodes adapted to be supplied with different potentials and mounted in axial consecution to be axially traversed by said bundle, each of said cylindrical electrodes being completely open at its side facing the other one, the second one of said cylindrical electrodes taken in the direction away from the cathode being several times longer than the first one of said cylindrical electrodes and adapted to be supplied with a higher potential than said first one of said cylindrical electrodes so that said bundle is subjected to a concentration and subsequent dispersion in the space included by said two cylindrical electrodes and before it is focussed onto the receiving plane; means for supplying said two cylindrical electrodes with different potentials increasing in the direction away from said cathode and means for adjusting the potential applied to one of said cylindrical electrodes.

16. In combination a cathode ray tube comprising means for producing a bundle of cathode rays, means for focussing said bundle to produce an electron image in a receiving plane, a preliminary concentrating system comprising two cylindrical electrodes adapted to be supplied with different potentials and mounted in axial consecution to be axially traversed by said bundle, the second one of said cylindrical electrodes taken in the direction away from the cathode being several times longer than the first one of said cylindrical electrodes and adapted to be supplied with a higher potential than said first one of said cylindrical electrodes so that said bundle is subjected to a concentration and subsequent dispersion in the space included by said two cylindrical electrodes and before it is focussed onto the receiving plane, an insulating tube having an outside diameter considerably larger than that of said cylindrical electrodes and being tightly fitted about said two cylindrical electrodes for centering them in relation to each other; means for supplying said two cylindrical electrodes with different potentials increasing in the direction away from said cathode and means for adjusting the potential applied to one of said cylindrical electrodes.

17. In and for a cathode ray tube a preliminary concentrating system structure comprising a tube of insulating material, two cylindrical electrodes tightly fitting within said insulating tube, plate-shaped members provided with guiding holes and having said tube of insulating material secured thereto with its axis disposed at right angles relatively to the planes of said plate-shaped members, rod-shaped members mounted in the cathode ray tube parallel to the axis thereof and having said plate-shaped members slipped thereover by their guiding holes to support said electrodes.

18. In and for a cathode ray tube a preliminary concentrating system structure comprising a tube of insulating material, two electrodes formed by coatings to said tube, plate-shaped members provided with guiding holes and having said tube of insulating material secured thereto with its axis disposed at right angles relatively to the planes of said plate-shaped members, rod-shaped members mounted in the cathode ray tube parallel to the axis thereof and having said plate-shaped members slipped thereover by their guiding holes to support said electrodes.

19. In combination a cathode ray tube comprising means including a cathode and a suctional anode for producing a bundle of cathode rays, said suctional anode consisting of an apertured plate and a short tubular abutment mounted on said plate at its side facing away from said cathode, means for focussing said bundle to produce an electron image in a receiving plane, said suctional anode being electrically independent from said focussing means, a preliminary concentrating system comprising electrodes including said suctional anode and to be supplied with different potentials for preliminarily concentrating said bundle before it is focussed onto the receiving plane; means for supplying said electrodes with different potentials and means for adjusting the potential applied to said suctional anode, so that the degree of preliminary concentration is regulated.

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