

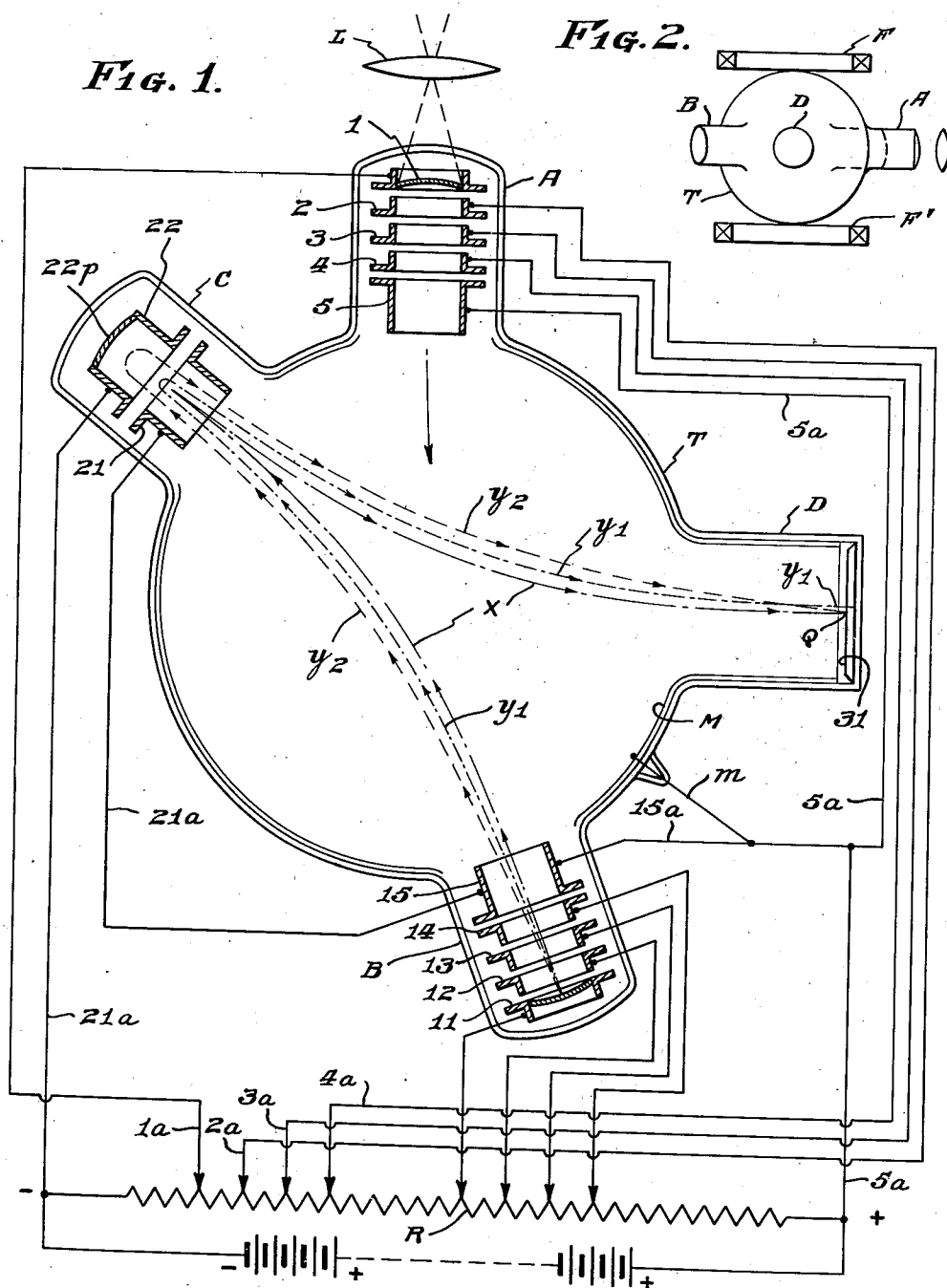
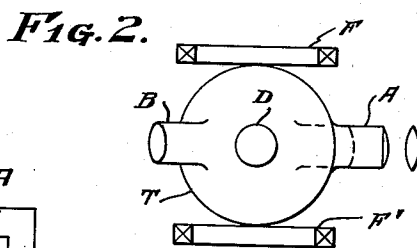
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ELECTRON-IMAGE DEVICE

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ELECTRON-IMAGE DEVICE

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Our invention relates to electron-optical systems of the type designed to handle "extended" or "entire" electron-images (as distinguished from images built up or "scanned" by a moving pencil or beam of electrons).

The principal object of our invention is to provide novel methods and apparatus for correcting certain image defects peculiar to the production and transmission of entire electron-images.

The image defects with which our present invention is chiefly concerned are usually manifest in electron-microscopes, electron-telescopes, electron-image intensifiers, and similar electron-image devices, by an apparent lack of focus which persists even when the electrostatic or magnetic focusing elements are adjusted for optimum performance.

Our invention is predicated upon the knowledge that such image defects are due, at least in part, to the fact that the electrons leaving a given object point in the usual electron-image device are subject to various degrees of convergence in passing to the next succeeding electrode, whereby some of the electrons are directed toward and impinge upon points other than the image point upon which it is desired that they should impinge. The lack of uniformity in the convergence of the electrons we attribute to the fact that the electrons as emitted exhibit various velocities and velocity components so that the paths of the individual electrons are not uniformly affected by the electromagnetic and electrostatic focusing and accelerating fields.

By changing the direction of the electrons (in the space between any two electrodes) we effect a change in the direction and relative rate of convergence of electrons having different velocities, and are thus able to direct a substantial majority of the electrons from a given object point to the corresponding image point on the next succeeding target or screen electrode, whereby the above-described image defects are substantially obviated.

We do all this with mirrors, i. e., with "electron-mirrors."

While our invention will be described as applied to an electron-image tube of the type disclosed in our copending application Serial No. 193,134, filed February 28, 1938 (RCV D-5563), it will be apparent that our invention is not limited to such application and that the disclosure in this respect is merely illustrative for purposes of explaining the inventive concept.

Figure 1 is a partly diagrammatic plan view of an electron-image intensifier device in which is

incorporated an electron-mirror designed, positioned and arranged in accordance with the principle of our invention to correct electron-image defects, and

Figure 2 is a side elevational view, on a reduced scale, of the device of Fig. 1, showing the device subjected to a magnetic field, as in normal operation.

In the drawing, T designates generally a highly evacuated envelope which has four "neck" portions or extensions A, B, C and D, respectively. The vacuous space in the main or bulbous body portion of the tube and in the necks A, B, C and D is continuous.

The inner wall of the bulbous part of the tube is provided with a coating M of metal to which a potential may be applied through a lead m. This metal layer M, which constitutes an anode, extends to the mouth of each of the extensions A, B, and C, and into the extension D to the point adjacent the terminal end thereof.

Mounted in the neck portion A of the tube is a photo-sensitive cathode I which is adapted to release an entire primary-electron image in response to the impress thereon of a light image from a source exemplified in the drawing by an optical lens L. The image-cathode I is preferably curved in a known manner to correct for image defects. A series of spaced rings 2, 3 and 4, and a cylinder 5, arranged in the order named, constitute an electron-lens system which, when supplied with suitable potentials from a source exemplified in the drawing by a voltage divider R, will project the electrons constituting the entire primary-electron image into the vacuous interior of the main portion of the tube. Unless some force intervenes, the electrons constituting such image will continue to advance along the axis of the extension A and miss the extension B which, as will more fully hereinafter appear, contains an image-intensifying electrode. For the purpose of directing the primary-electrons into the extension B, a magnetic field is required which is perpendicular to the plane containing the longitudinal axes of the extensions A, B, C and D. Such magnetic field may be produced in the manner indicated in Fig. 2, i. e., by a pair of coils F, F' suitably energized and supported exteriorly of the envelope T.

The primary or photoelectrons leaving the cathode I are subject to the accelerating field produced cooperatively by the voltages applied through adjustable leads 2a, 3a, 4a, etc., to the focusing rings 2, 3 and 4, and to the focusing cylinder 5, and anode M, through leads 5a and

m, respectively, which, as indicated in the drawing, are connected to the most positive point (say, 5,000 volts) on the voltage divider R. Primary-electrons thus approach the open end of the extension B at a relatively high velocity.

Electrode 11, adjacent the closed end of the neck B, is the "intensifying" or electron-multiplying electrode. This electrode may comprise a silver or other metal plate, treated with caesium or equivalent substance in order to enhance its ability to release secondary-electrons by impact excitation. The ring-like electrodes 12, 13 and 14 and the cylinder 15 comprise elements of an electron-lens system which serves to focus the primary-electron image upon the multiplying electrode 11 and likewise serves to accelerate and focus the secondary-electrons from that electrode into the open central portion of the tube, where they are subjected to the influence of the magnetic field and directed into the extension C, which contains the electron-mirror that we employ in curing defects in the electron-image.

Extension D contains an output electrode, here shown in the form of a fluorescent screen 31, upon which the corrected image eventually impinges to form a light-image which is visible through the transparent end of extension D.

Considering the cathode 1 to be maintained at ground potential, the focusing rings 2, 3 and 4, at potentials such as to produce a sharp image on the multiplying electrode 11, e. g., each 50 volts positive with respect to the next preceding electrode, and the focusing cylinder 5, and anode M, to be maintained at, say, 5000 volts positive, with respect to the cathode, it will be apparent (since the magnet in no wise affects the speed of the electrons) that the primary electrons will approach the extension B with a velocity of 5000 volts because the cylinder 15 in that extension is maintained at that potential by lead 15a. The speed of the primary electrons passing through the cylinder 15 and the focusing rings 14, 13 and 12 will be reduced as they approach the multiplying electrode 11 and in striking that electrode their speed will be determined by the voltage applied thereto, in this case 1000 volts. The relative voltage distribution among the focusing rings 12, 13 and 14 and cylinder 15 may be substantially the same as that of the rings 2, 3 and 4 and cylinder 5 in the extension A, that is to say, each ring-like electrode may be maintained at a voltage, e. g., 50 volts, higher than its next preceding electrode while the cylinder 15 is maintained at the anode potential, e. g., 5000 volts.

While the electrons constituting the primary-electron image and those constituting the secondary-electron image both pass through an electrode 15 maintained at a voltage of 5000 volts positive with respect to the cathode, the departing secondary-electrons will actually be traveling much slower (i. e., 1000 volts slower) than the entering primary-electrons, because the potential drop between the electrode 11 and the anode M or the cylinder 15 is less than the drop between that electrode and the cathode 1. Since the magnetic field has a greater effect upon slower moving secondary electrons than upon the faster moving primary electrons, the angle formed by the intersection of the axes of extensions B and C should be smaller than the angle formed by the intersection of the axis of A with the axis of B.

It might be inferred from the foregoing that

all of the electrons released from the secondary-electron emitter 11, which are subject to the accelerating potentials applied to electrodes 12 to 15, and the anode M have the same velocity.

Such is not the case. Indeed, if it were, the application of the invention to tubes of the type described would be without utility. Actually the electrons leaving any given object point on electrode 11 (or cathode 1) will have various velocities, approximately 90% of which will be within, say 3 volts of each other. This difference in velocity may be made up of different components, e. g., a "forward" component and a "lateral" component; both of which cause the electrons to travel in paths which may be described as "out of register" with the path traveled by the electrons (from the same image point) emitted with zero velocity. This is indicated by the curved lines x , y_1 and y_2 of Fig. 1. Line x represents the path of an electron emitted from electrode 11 with zero velocity, line y_1 representing the path of an electron, from the same image point, having a forward velocity component of, say, $\frac{1}{4}$ volt, and a lateral velocity component of, say, $\frac{1}{2}$ volt, and line y_2 represents an electron from the same point having a forward velocity component of 1 volt and a lateral component of, say, two volts.

While in the drawing the relative curvature of the electron paths x , y_1 and y_2 will be understood to be exaggerated, nevertheless, in practice, the paths of the electrons are such that, with the usual electron lens systems, many of the electrons from a given object point will miss the corresponding image point on the target or screen electrode sufficiently to give rise to the previously described visible aberrations or image defects.

By means of an electron mirror, we bring all electrons of any two velocities to a focus at exactly the same point on the screen 31. Electrons having intermediate velocities are focused at slightly different points. However, we achieve an improvement in the image of five or more times, i. e., the circle of diffusion is reduced by a factor of five or more.

While various types of electron mirrors are known, we prefer to use a construction comprising two spaced coaxial cylinders 21 and 22, disposed in the extension C, and between which the electrostatic field which constitutes the mirror is generated. The outer cylinder 22 is preferably closed as by a plate 22p, which, like the cathode 1, may be curved to correct for other image defects. The leading cylinder 21 is preferably maintained by adjustable lead 21a at the same high potential as the anode M, while the second cylinder 22 is connected by lead 22a to a point on the voltage divider R, which may be several hundred volts negative with respect to the image cathode 1.

With the cylinders 21 and 22 thus energized, the electrons entering them and subject to the electrostatic field therebetween have their direction reversed. The departing electrons, under the influence of the magnetic field provided by the coils F, F' are directed toward the extension D and focused upon the target or screen electrode 31 in a manner hereinafter more fully described.

The effect of the mirror (i. e., the electrostatic field between 21 and 22) depends upon the potentials applied to the cylinders 21 and 22. For a given potential distribution, electrons of two

different velocities are made to focus at exactly the same point.

The effect of the electron mirror will perhaps be better understood when it is recalled that fast moving electrons, from an emitting object point which is on the axis of an electron-optical system, will not, in passing through an electron lens, converge upon the axis of the system as rapidly as electrons emitted, from the same point, with low velocities. However, if an electron mirror is used in conjunction with the lens, the rate of convergence of the fast and slow moving electrons may be altered; that is to say, the convergence of the fast moving electrons may be increased by a larger amount than the slow moving electrons. Thus, by a proper selection of potentials applied to the mirror and lens elements, electrons of two different speeds may be made to converge upon a single point on the axis of the system to produce a true image of the object point. (Electrons from object points which are off the axis of the system are similarly focused.)

In the drawing, the path x of those electrons from a central image point on electrode 11 which have substantially zero axial velocity all converge upon point Q on screen 31. The line y_2 represents the trajectories of electrons from the same object point which have an axial velocity of 1 volt. These electrons, by the action of the mirror and the lens system (including the external magnet) are made to converge upon the same point, Q. It should be noted, however, that the path y_1 of electrons having lower initial velocities does not converge exactly upon point Q because the mirror can be made to perfectly correct for only two values of initial velocity.

We are aware that others have previously proposed the use of an electron-mirror or mirrors in a Braun tube to increase the length of the path of the electron beam and to thereby increase the sensitivity of the device. However, such use is not to be confused with our use of electron-mirrors for the purpose of curing image defects which occur in the production of extended or "entire" electron-images.

What is claimed is:

1. An electron-image device comprising a photosensitive image-cathode adapted to release an entire electron-image in response to the impress thereon of a light-image, an image-intensifying electrode, an electron-mirror and an image-target electrode each having a surface area corresponding substantially to the area of said image-cathode, means for directing said electron-image from said cathode to said intensifying electrode, means for directing a secondary electron-image from said intensifying electrode to said electron-mirror, and means for directing said secondary-electron image to said target electrode.

2. An image intensifier device, comprising an image cathode, a secondary-electron emissive image intensifying electrode, an electron mirror and an image target electrode circumferentially arranged about a common center, and magnetic means for directing an electron image from said cathode to said image intensifying electrode, thence to said electron mirror and finally to said image target electrode.

3. An image intensifier, comprising an evacuated envelope having a central globe-like portion and a plurality of radially extending neck portions, a photosensitive image cathode and a plurality of electron lens elements in one of said neck portions, a secondary-electron emissive surface and a plurality of electron lens elements in another of said neck portions, a plurality of electron-mirror elements in a third neck portion and an image-target in a fourth neck portion, and magnetic means exterior of said envelope for directing the photoelectron image formed by said first-mentioned electron-lens elements in a curved path to said secondary-electron emissive surface, and for directing the secondary-electron image formed by said second-mentioned electron-lens elements successively to said electron-mirror and target electrodes..

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