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ELECTRON-OPTICAL DEVICE

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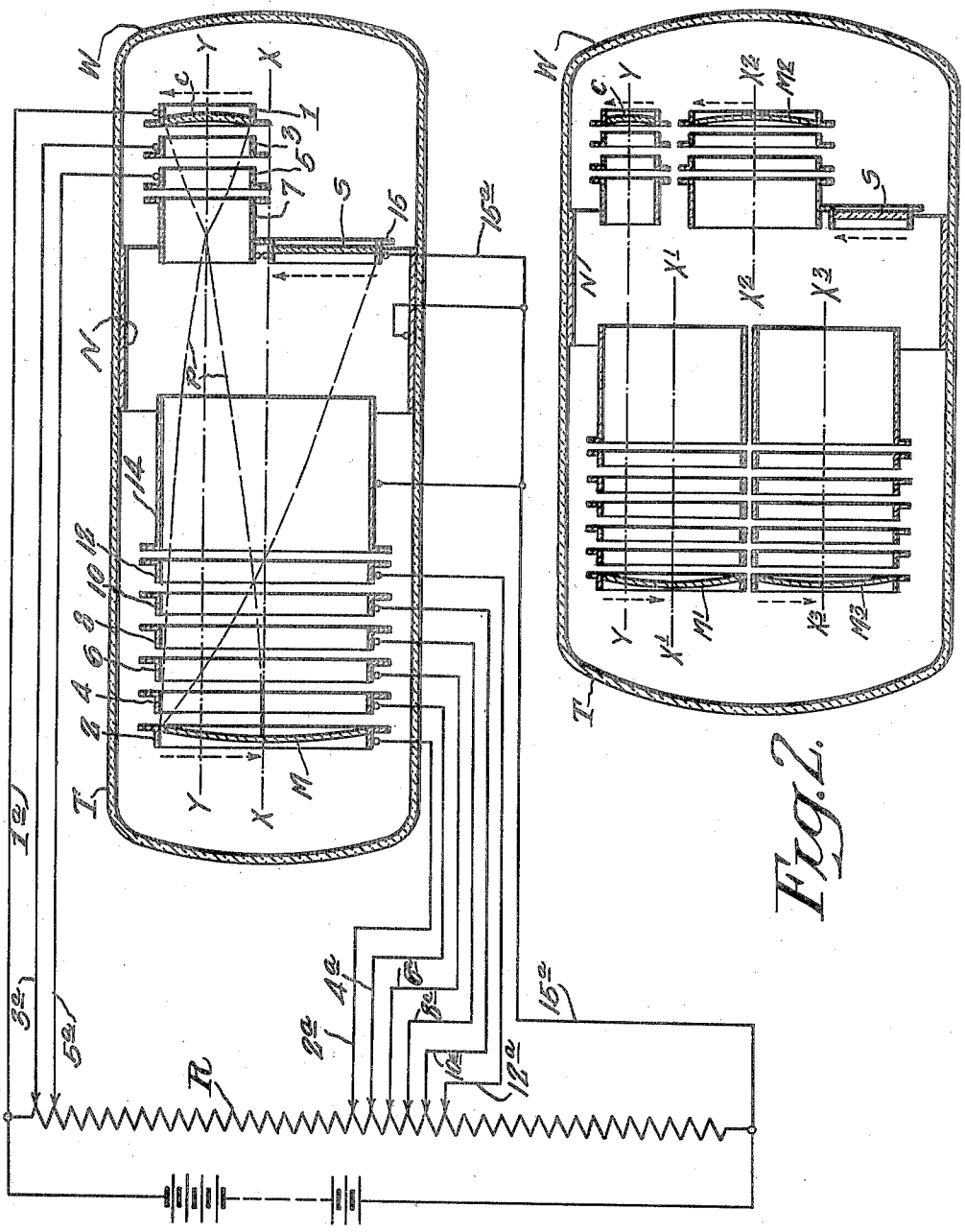


Fig. 2.

Fig. 1.

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ELECTRON-OPTICAL DEVICE

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8 Claims. (Cl. 250—150)

This invention relates to electron-optical devices and particularly to means for intensifying an optical-image as by converting the same into a primary-electron image, and successively, into one or more secondary-electron images, and then back to an optical-image of the desired intensity or brilliance.

Image devices of the general type to which the present invention is applicable are now commonly referred to as "image-multipliers." Such devices find useful application, by way of example, as electron-telescopes, in which case they may be employed to inspect images constituted of infra-red or other rays of a wave length beyond the range of the human eye.

An "image-multiplier" is comprised, essentially, of (1) a photosensitive cathode adapted to release a primary-electron image in response to the impress thereon of a light-image, (2) an electrode adapted (as by an application of caesium or equivalent substance) to release a secondary-electron image in response to the impress thereon of the primary-electron image, and (3) a target electrode adapted to respond to the impress of the secondary-electron image. The target electrode is generally in the form of a fluorescent screen, but may comprise a mosaic electrode in cases where the intensified image is to be televised.

The prior art discloses two general arrangements of the electrodes; in one case the multiplying electrode, i. e., the secondary-electron emitter, is of grid-like construction and presents one surface to the image cathode and the other to the target or screen electrode; in the other case, the secondary-electron emitter is in the form of a plate and is so mounted with respect to the cathode and screen that its emissive surface is presented at an angle to both electrodes.

One very real objection to the first mentioned arrangement is that a lattice-like shadow of the multiplying electrode appears on the screen, marring the image. (If the mesh of the multiplying electrode is too fine to produce noticeable image defects, then but little electron multiplication is achieved owing to the difficulties incident to drawing the secondary electrons through the minute grid apertures.)

In the case of an electrode arrangement wherein the secondary-electron emissive electrode is at an angle or is askew with respect to the image cathode and image-target, axial symmetry is wanting and, as a consequence, it is impossible to achieve an electron image entirely free from aberrations.

Accordingly, a principal object of the present invention is to provide an electron-optical system capable of producing an extended or "entire" electron image which is substantially free from shadows, aberrations, and other image defects peculiar to the prior art.

The above and other objects are achieved in accordance with the present invention by the provision of a lens system for the primary electrons and another lens system for the secondary electrons, the lens elements being so designed, positioned and arranged that the central axes of said systems are adjacent and parallel one with the other. More specifically, the present invention contemplates and its construction provides an electron-optical system which includes a lens system for the primary electrons and a lens system for the secondary electrons, the second mentioned lens system having an axis of symmetry which is subsantially normal to the plane of the cathode, multiplying and screen electrodes, and which is preferably offset by approximately one-half the radius of the multiplying electrode from the axis of symmetry of the first mentioned system. As will hereinafter more fully appear, this relative arrangement of the primary and secondary-electron lens systems is made possible by the use of oversize focusing and terminal electrodes in the secondary-electron lens system.

Certain details of construction, together with other objects and advantages, will be apparent and the invention itself, both as to its principle and method of operation, will be best understood by reference to the following specification and to the accompanying drawing, wherein

Figure 1 is a partly diagrammatic longitudinal sectional view of an electron image device constructed and operated in accordance with the principle of the invention, and

Figure 2 is a longitudinal sectional view of a multi-stage "image intensifier" embodying the invention.

In Fig. 1 is shown a highly evacuated cylindrical envelope T, the central longitudinal axis of which is marked by the broken line x—x. The envelope or tube T is preferably constituted in whole or in part of glass and, in any event, has a transparent window W adjacent which a photosensitive transparent image-cathode C is mounted. A suitable optical-lens system, not shown, may be provided for focusing an infra-red or other "light" image upon the cathode.

The cathode C is preferably curved in a known manner to correct for curvature of the image field and for so-called "pin-cushion" distortion. A series of spaced rings 1, 3 and 5, in the first of which the cathode C is seated, and a short cylinder 7, constitute a primary electron lens system which, when supplied with suitable potentials from a source exemplified in the drawing by a voltage divider R, serves to focus the photo or primary electrons from the cathode upon a portion of the surface of an electrode M adjacent the opposite end of the envelope T. The primary electron lens system comprising elements 1, 3, 5 and 7 has an axis of symmetry y—y which is parallel to the axis x—x and which may be said to be normal to the plane of both the cathode C and electrode M. The dotted lines p indicate the focusing action of the primary electron lens system upon the electrons constituting the primary electron image. As indicated by the arrows, the image is inverted in transmission.

It will be observed that the surface area of the electrode M upon which the primary electron image impinges is of considerably greater extent than is necessary to accommodate the said image. In this embodiment of the invention, electrode M has substantially four times the surface area of the photosensitive cathode C, the exact area depending to some extent upon the degree of magnification required in the intensified image.

Electrode M, or at least that part of it upon which the primary electrons impinge, is treated with caesium or like substance to enhance its ability to release secondary electrons upon impact of the primary electrons thereon. Like the cathode C, electrode M is curved to correct for certain image defects.

The rings 2, 4, 6, 8, 10 and 12, and the focusing cylinder 14, constitute elements of a secondary-electron lens system which, when energized in the manner later described, serves to focus the secondary or impact electrons from electrode M upon a target which may comprise a screen S of willemite supported as in a metal annulus 15. The focusing electrodes are preferably of the same "oversize" diameter as the secondary electron emitter M. A shield N contiguous the inner wall of the tube intermediate the primary and secondary-electron lens systems forms no part of either lens system but serves merely to prevent the accumulation of spray electrons on the glass.

It will be observed that the axis x—x marks the axis of symmetry of the electrodes constituting the secondary electron lens system, and this axis (x—x) is parallel to the axis (y—y) of the primary electron lens system but is offset therefrom a distance corresponding substantially to one-half the diameter of the area available for the primary electron image upon the secondary electron emitter M.

In operating the device of Fig. 1, the focusing cylinders 7 and 14, the shield N and the supporting ring 15 for the screen S may be maintained, as by lead 15a, at a potential of, say, 5000 volts positive with respect to the cathode C. In this case the focusing ring 5 may be connected through its lead 5a to a point on R which is, say, 175 volts positive with respect to C, and ring 3 may be connected through its lead 3a to a point midway therebetween. The secondary-electron emissive electrode M may be connected through an adjustable tap 2a to a point on R which is, say, 800 volts positive with respect to primary-electron emitting cathode C, in which case the focusing rings 2, 4, 6, 8, 10 and 12 will ordinarily be maintained, respectively, at 825, 850, 875, 900 and 925 volts.

With the device thus energized, it will be apparent that the primary electrons from the cathode C will enter the cylinder 14 of the secondary-electron lens system at a velocity of 5000 volts. At such speed, the primary electrons will be substantially uninfluenced by the focusing rings 2, 4, 6, 8, 10 and 12 and cylinder 14 of the secondary-electron lens system. The secondary electrons released by the impact of the relatively high-speed primary electrons upon the emissive portion of electrode M leave that electrode at very low velocities and are thus susceptible to the focusing action of the electrostatic field between the lens elements 2, 4, 6, 8, 10, 12 and 14.

Since it is the property of the described type of electrostatic lens system to form an inverted electron-image, all of the electrons released from the emissive area on electrode M will be projected to the opposite side of the axis x—x of the secondary-electron lens system and be focused upon the screen S to produce a visible reinverted intensified image corresponding to the light image impressed upon the cathode C.

So far in this description, reference has been made only to image intensifiers employing but a single intensifying or multiplying electrode. Two or more multiplying stages, each with its separate electron-lens system, may be employed if necessary to achieve a desired degree of intensification.

In the embodiment of the invention illustrated in Fig. 2, three multiplying or secondary-electron emissive electrodes M^1, M^2 and M^3 are shown. The other elements, i. e., cathode C, screen S and shield N correspond to the similarly designated parts of Fig. 1. The axis of the primary-electron lens system is designated y—y, as before, while the axes of the secondary-electron lens systems are designated X^1—X^1, X^2—X^2 and X^3—X^3.

Other modifications, such, for example, as the substitution of one or more electromagnetic type electron-lens systems for the described electrostatic type, will be apparent to those skilled in the art. It is to be understood, therefore, that the foregoing is to be interpreted as illustrative and not in a limiting sense except as required by the prior art and the spirit of the appended claims.

What is claimed is:

1. An electron-optical system comprising an image-cathode, an image-intensifying electrode, an image-target, an electron-lens system for focusing primary-electrons from said cathode upon said image-intensifying electrode, a second electron-lens system for focusing secondary-electrons from said image-intensifying electrode upon said image-target and through which both the primary and secondary electrons pass in substantially opposite directions, said electron-lens systems having axes of symmetry which are adjacent and parallel with respect to each other.

2. The invention as set forth in claim 1, wherein the axis of symmetry of the primary-electron lens system is substantially normal to the plane of said image-intensifying electrode.

3. The invention as set forth in claim 1 wherein the axis of symmetry of the secondary-electron lens system is substantially normal to the plane of said image-target.

4. The invention as set forth in claim 1 wherein said target-electrode is mounted on the cathode side of said image-intensifying electrode.

5. An electron-optical system comprising an

image-cathode, an image-intensifying electrode having a diameter substantially no less than twice the diameter of the primary electron image impressed thereon by said cathode, an image-target adapted to respond to the impress thereon of a secondary electron image from said image-intensifying electrode, and an electron-lens system of a diameter substantially no less than the diameter of said image-intensifying electrode and through which said primary and secondary electron images pass.

6. The invention as set forth in claim 5 wherein said cathode and target electrodes are mounted on opposite sides of the axis of symmetry of said electron-lens system, and wherein a primary-electron lens system is provided for confining the path of the primary electrons to the cathode side of said axis of symmetry.

7. An electron optical system comprising an image cathode, a plurality of image intensifying electrodes and an image target mounted in spaced relation in an evacuated envelope, an electron lens system comprising a plurality of apertured elements between each pair of electrodes and through which the electrons travel from their electrode of origin to the next succeeding electrode, the diameter of the apertured lens elements intermediate the image cathode and the image intensifying electrode adjacent thereto in point of electron travel being substantially no greater than one-half the diameter of the apertured lens elements between any two succeeding electrodes.

8. The invention as set forth in claim 7 wherein the axis of symmetry of each of said electron lens systems is adjacent and parallel with respect to the axis of symmetry of the apertured lens elements of the preceding electron lens system.

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