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IMAGE TUBE

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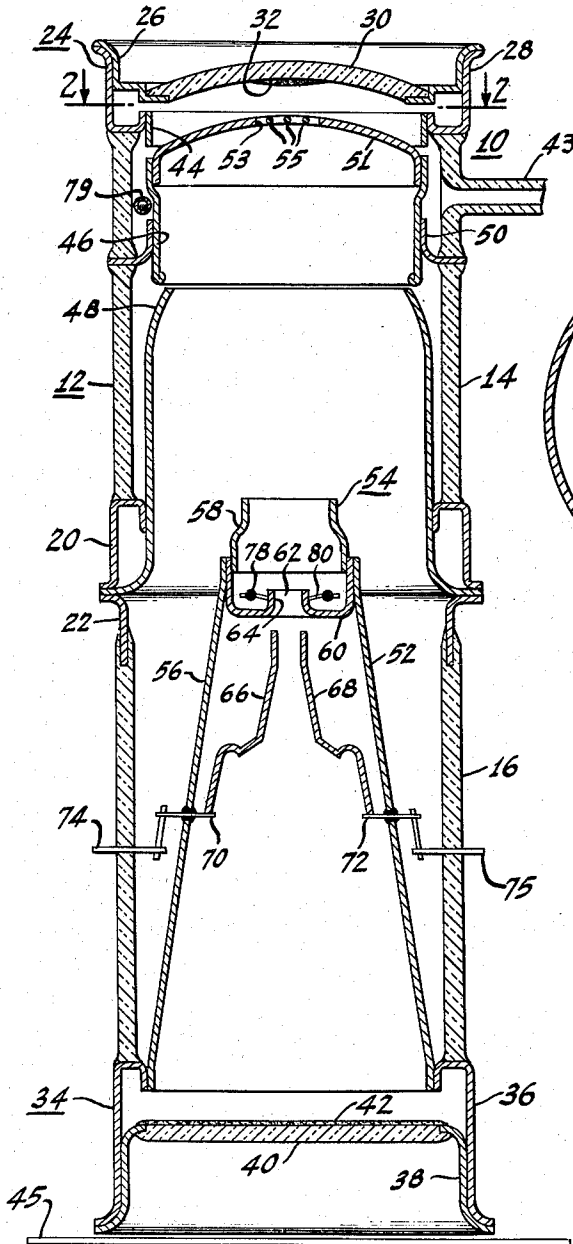


Fig. 1.

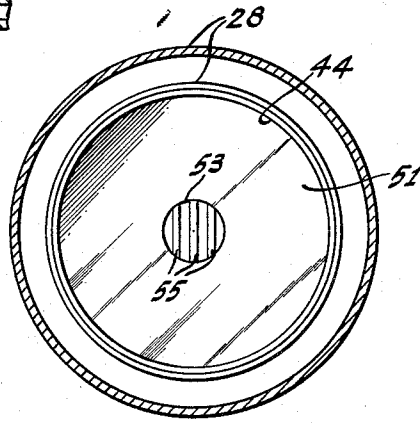


Fig. 2.

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IMAGE TUBE

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This invention relates to image tubes, particularly to improvements in so-called "light-shutter" tubes for use in high speed photography and has for its principal object to provide an improved gating and focusing electrode system for such tubes.

The foregoing and related objects are achieved, in accordance with the invention, by the provision of a 2-electrode gating and focusing system wherein the gating electrode (for passing or blocking the electron-image) is of a special construction (later described) and is mounted close to the image cathode. The other or "focusing" electrode operates in conjunction with the gating electrode to focus the gated (i.e. "passed") electron-image on a phosphor viewing screen. Deflection plates are also provided for directing the focused electron-image to any of different locations on the phosphor screen.

The invention is described in greater detail by reference to the single sheet of drawings wherein:

Fig. 1 is a sectional, elevational view of an image tube embodying the invention; and,

Fig. 2 is a sectional view along the line 2—2 of Fig. 1 showing the gating electrode of the tube.

In the drawings, an image tube 10 includes an envelope 12 which consists of two hollow cylindrical glass portions 14 and 16 of substantially equal length and diameter. The glass portions 14 and 16 are axially aligned and joined together by cylindrical metal rings 20 and 22 sealed to adjacent ends thereof. At the other end of the cylindrical glass portion 14 remote from the ring 20 is provided a cathode support assembly 24. The cathode support assembly comprises an outer metal ring 26 sealed to an inner metal ring 28 which comprises the cathode cylinder. A glass face plate 30, preferably spherical in form, is sealed across the open portion of the outer ring 26 transverse to tube axis and a suitable electron emissive photocathode 32 is provided on the inner concave surface of the face plate. The photocathode occupies a limited area at the center of the face plate 30. This area may conveniently have a diameter of about one inch.

At the end of the glass cylinder 16 remote from the rings 20 and 22 is provided a phosphor screen assembly 34 which includes an inner ring 36 sealed to an outer ring 38 and a generally flat glass plate 40 sealed across the open portion of the outer ring. The glass plate 40 is transverse to the tube axis and has a diameter substantially equal to that of the face plate 30. A suitable phosphor screen 42 is formed on the inner surface of the flat glass plate 40. An exhaust tubulation 43 is provided in the envelope 12 closely adjacent to the photocathode 32. Photographic film 45 or the like may be provided outside of the tube 10 in operative relation with the phosphor screen 42 to record light images produced by the phosphor screen.

Internally between the photocathode 32 and the phosphor screen 42, the tube 10 includes an electrode system for providing a convergent field to focus an electron image on the phosphor screen. This electrode system includes

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a plurality of hollow cylindrical electrodes, for example, three coaxial electrodes 44, 46, 48 of the same diameter and increasing length as they progress longitudinally from the photocathode. These electrodes are coaxial with the tube envelope 12. The first cylindrical electrode 44 is positioned close to the photocathode and is connected to the cathode cylinder 28. The second electrode 46 is positioned close to the first electrode 44 so that little or no space is provided between them so that the glass envelope is shielded. Second electrode 46 is electrically connected to a metal ring 50 sealed in the wall of the envelope 12.

A metal plate 51, oriented parallel to the photocathode and preferably also spherical in form and having substantially the same radius of curvature as the face plate 30 is secured to the end of the second cylindrical electrode 46 which is adjacent to the tube face plate and is thus positioned close to the face plate and photocathode. The curved plate 51 (Fig. 2) has a central aperture 53 having a diameter of the order of the diameter of the photocathode. The aperture 53 is crossed by a plurality of equally-spaced fine metal wires 55.

The third cylindrical electrode 48 is positioned with one end close to the second electrode 46 and with its other end connected to the ring 20. The end of the electrode 48 which is adjacent to the second electrode 46 is curved inwardly to shield the glass envelope 12 from materials evaporated during formation of the photocathode 32. The electrodes 46 and 48 comprise the aforementioned 2-electrode gating and focusing electrode system of the tube 10.

Between the third electrode 48 and the viewing screen 42 is provided an anode 52 which is preferably, but not necessarily, conical in form and includes an apex 54 positioned just inside the adjacent end of the third electrode 48 at approximately the center of curvature of the photocathode. The anode 52 also includes a base 56 positioned closely adjacent to the phosphor screen 42 and having a diameter substantially equal to that of the phosphor screen support plate 40. The apex 54 of the anode includes a short hollow cylinder 58 having a diameter which is small compared to the diameter of the tube 10. The diameter of this short cylinder 58 may be of the order of one-quarter of the diameter of the tube 10. Positioned directly behind the short cylinder 58 of the apex 54 is a metal plate 60 having a small central aperture 62 centered on the axis of the tube 10 and defined by a longitudinally curved rim portion 64. The diameter of the aperture 62 is considerably smaller than that of the end of the short cylinder 58 which faces the photocathode. The base of the anode is welded or otherwise secured to the inner ring 36 of the phosphor screen assembly 34 of the envelope.

A pair of electrostatic deflection plates 66 and 68 are mounted in the field-free space within the anode and suitable leads 70 and 72 extend from the deflection plates and pass through and are insulated from the wall of the anode and are connected to pins 74 and 75 in the wall of the envelope 12. The crossover point for electrons coming from the photocathode is between the deflection plates near the apex 54 of the anode 52. This allows the deflection plates to be closely spaced and provides maximum deflection sensitivity. In addition, since the deflection plates 66 and 68 are positioned behind the metal plate 60 which has the small aperture 62, the deflection plates cannot adversely affect the electrical focusing field between the apex of the anode and the photocathode.

Metals to be evaporated for the formation of the photocathode 32, for example antimony, silver, or the like, may be mounted in the form of pellets 78 on electric heater wire 80 suitably connected to leads (not shown) whereby heating current may be passed there-

through. Alternatively, these materials may be introduced by way of the exhaust tabulation 43.

If cesium is used as a component of the photocathode, it is provided in a suitable container 79 mounted between the outer surface of the cylinder 46 and the inner surface of the envelope 12. This arrangement restricts the deposition of cesium vapor to the region of the photocathode. Cesium in the other parts of the tube is to be avoided since other electrodes should not be photosensitive. If other electrodes were photosensitive, spurious photoemission would result which could not be gated off by the electrode 46 which is the gating electrode of the tube 10. In addition, cesium on other electrodes and on the glass envelope near electrodes operating at a high potential causes field emission which would hamper the operation of the tube.

Typical approximate dimensions for the tube 10 are as follows:

	Inches
Overall length	10
Diameter	4
Length of electrode 44	1/4
Length of electrode 46	1.5
Length of electrode 48	2.5
Length of anode 52	5
Diameter of apex of anode	0.8
Radius of curvature of face plate	4
Photocathode-to-gating electrode spacing	0.3

Typical operating voltages for the tube are as follows:

	Volts
Anode supply voltage	15,000
Electrode 48	3,000
Electrode 46 operating voltage	190 to 210
Electrode 46 cut-off voltage	-50 to -16

In operation of the tube, in order to gate the photocathode off, the gating electrode 46 is biased at or beyond the cut-off voltage. The electrode 48 is, so to speak, the operating partner of the gating electrode 46. It serves, in conjunction with the gating electrode, to focus the electron image on the phosphor screen 42. To transmit an electron image from the photocathode to the phosphor screen, the proper voltages are applied to the other electrodes, the gating electrode 46 is pulsed to its positive operating voltage which gates the photocathode on. The electron image is thus allowed to pass along the tube toward the phosphor screen and the deflection plates 66 and 68 are employed to position the electron image at different locations on the phosphor screen. As the electron image is focused at each position on the phosphor screen, the visible image produced is recorded on photographic film. Thus, a series of related pictures or frames may be produced. It can now be seen that the area of the photocathode depends on the desired number of frames to be formed on any single piece of photographic film with the selected size of phosphor screen.

In constructing the tube 10, it is desirable that all corners inside the envelope be smoothly rounded to avoid field emission. In addition, the area of the photocathode may be varied depending on the desired size of the image on the phosphor screen.

The grid wires 55 should be as few as possible and as fine as possible. Three wires of the order of 1/2 mil in diameter have been found to be satisfactory in the tube described.

For all practical purposes, the speed of operation of the tube 10 is limited by the pulsing circuit which is used to provide gating pulses to the gating electrode 46. The tube 10 has been used to take pictures in a time as short as 10⁻⁸ second. In addition, with respect to picture resolution, the tube 10 has resolution of about 22 to 30 lines per mm. With the dimensions given, the tube 10 may be used to provide four pictures on the phosphor screen.

In the present invention, the provision of the combi-

nation of gating electrode and focusing electrode allows the voltages applied to these electrodes to be balanced to provide optimum focus of a high quality electron image on the phosphor screen.

What is claimed is:

1. An image device comprising an electron-emissive photocathode adapted to release an electron image in response to the impression of a light image thereon, a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon in its movement along a path between said photocathode and said phosphor screen, grid means surrounding said path and including an apertured portion having a plurality of apertures, for gating said electron image, said path extending through said apertures, and means for focusing said electron image, on said phosphor screen.

2. An image device comprising an electron-emissive photocathode adapted to release an electron image in response to the impression of a light image thereon, a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon, said phosphor screen and said photocathode forming a path for said electron image, a 2-electrode system surrounding said path for gating and focusing said electron image on said phosphor screen, and said gating system including an apertured grid supported adjacent to said photocathode and substantially parallel to said photocathode.

3. An image tube comprising an electron-emissive photocathode adapted to release an electron image in response to the impression of a light image thereon, a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon in its movement along a path between said photocathode and said viewing screen, a 2-electrode system surrounding said path for gating and focusing said electron image on said phosphor screen, said system including a first hollow cylindrical electrode having a grid positioned adjacent to and substantially parallel with said photocathode and a second hollow cylindrical electrode adjacent to said first electrode.

4. An image tube comprising an electron-emissive photocathode adapted to release an electron image in response to the impression of a light image thereon, a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon, said phosphor screen and said photocathode forming a path for said electron image, a 2-electrode system surrounding said path for gating and focusing said electron image on said phosphor screen, said system including a first hollow cylindrical electrode having a closed-end including apertures positioned adjacent to said photocathode and a second hollow cylindrical electrode adjacent to said first electrode, the apertured area of said closed-end having substantially the same area as said photocathode.

5. An image tube comprising an electron-emissive photocathode adapted to release an electron image in response to the impression of a light image thereon, a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon in its transit along a path from said photocathode to said viewing screen, a 2-electrode system adjacent to said path for gating and focusing said electron image on said phosphor screen, said system including a first hollow cylindrical electrode having an apertured closed-end positioned adjacent to said photocathode and adapted to gate the photocathode on and off, and a second hollow cylindrical electrode adjacent to said first electrode, the aperture in said closed-end being spanned by a plurality of spaced wires and being aligned with said photocathode and having substantially the same area as said photocathode.

6. An image tube comprising an electron-emissive photocathode adapted to release an electron image in

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response to the impression of a light image thereon; a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon; an anode electrode in front of said phosphor screen; said photocathode and said phosphor screen providing the ends of a path for said electron image through said tube, a 2-electrode system adjacent to a portion of said path for gating and focusing said electron image on said phosphor screen, said system including a first hollow cylindrical electrode having an apertured closed-end positioned adjacent to said photocathode and a second hollow cylindrical electrode adjacent to said first electrode; and a pair of deflection plates disposed within said anode, the crossover point for electrons from said photocathode being between said deflection plates.

7. An image tube comprising an electron-emissive photocathode adapted to release an electron image in response to the impression of a light image thereon; a phosphor screen adapted to emit a light image in response to the impression of said electron image thereon; said photocathode and said phosphor screen forming a path for said electron image through said tube, a 2-electrode system positioned around a portion of said path

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for gating and focusing said electron image on said phosphor screen, said system including a first hollow cylindrical electrode having an apertured closed-end positioned adjacent to said photocathode and a second hollow cylindrical electrode adjacent to said first electrode; a generally conical anode electrode having an apex disposed within said second hollow electrode and a base positioned adjacent to said viewing screen; and a pair of deflection plates mounted within said anode near the apex thereof and at the crossover point for electrons from said photocathode.

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