July 4, 1967 R. H. FOOTE 3,329,856

IMAGE DISSECTOR TUBE FIELD MESH

Filed Sept. 24, 1964

FIG. 1

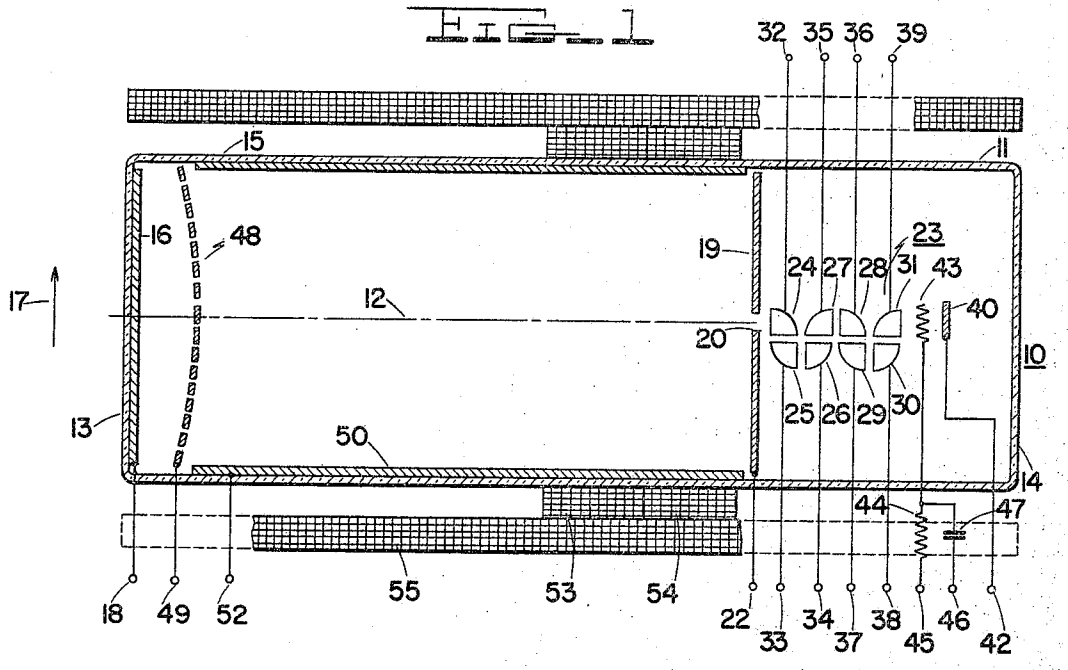
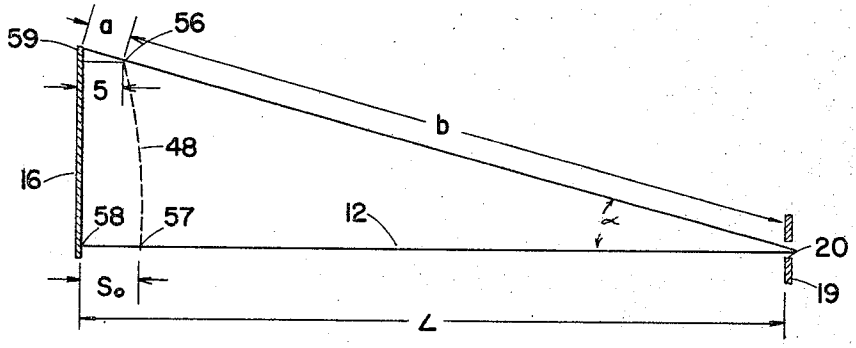


FIG. 2



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IMAGE DISSECTOR TUBE FIELD MESH

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ABSTRACT OF THE DISCLOSURE

A curved field mesh accelerator in an image dissector tube provides focusing for electrons from all areas of a planar photocathode directed toward a scanning aperture.

This invention relates generally to image dissector tubes, and more particularly to an image dissector tube in which the need for dynamic focusing is eliminated.

A common type of image dissector tube comprises an extended area, planar photocathode which provides a low velocity flood beam of electrons modulated in accordance with excitation of the photocathode by an optical image. The modulated flood beam is scanned over a small defining aperture so that the electrons which pass through the aperture at any instant emanate from only a single incremental area of the photocathode. The electrons which pass through the aperture are conventionally multiplied by a secondary electron multiplier to provide a time-based video output signal corresponding to the electron image which has been scanned over the aperture.

Since the transit time of electrons from the axial center of the photocathode to the defining aperture is normally less than the transit time of electrons emanating from the outer edge of the photocathode, conventional image dissector tubes have employed various dynamic focusing systems in an effort to achieve optimum focusing of electrons emanating from the entire area of the photocathode and thus to provide optimum resolution. Such dynamic focusing systems, however, require external circuitry for generating and applying the dynamic focusing waveforms thus increasing the complexity and in turn, the cost of the system in which the tube is employed.

It is accordingly an object of the invention to provide an image dissector tube in which optimum focusing of the electron beam is provided without the use of a dynamic focusing system.

The invention in its broader aspects provides an image dissector tube having a source of an extended area electron beam with first electrode means spaced axially from the beam source and having a defining aperture therein and with secondary electron multiplier means being provided for receiving and multiplying the electrons of the beam which pass through the aperture. A screen electrode is provided disposed between the beam source and the first electrode and means are provided acting upon the beam between the screen electrode and the first electrode for scanning the beam over the aperture. The beam is focused by means of an axial magnetic field extending through the tube and a suitable potential is applied to the screen electrode so that essentially all of the acceleration of the beam electrons occurs between the beam source and the electrode. In order to insure that the transit times of the electrons of the beam from all points on the beam source to the aperture are substantially equal to the times required for the electron to make an integral number of complete revolutions in the magnetic field, the screen electrode is curved toward the first electrode.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic cross-sectional view showing the improved image dissector tube of the invention; and

FIG. 2 is a diagram useful in explaining the invention.

Referring now to FIG. 1, the improved image dissector tube of the invention, generally indicated at **10**, comprises a conventional elongated evacuated envelope **11** having a longitudinal axis **12**, opposite ends **13**, **14** and a side wall **15**. A conventional photocathode **16** is deposited or otherwise positioned on the inner surface of the end wall **13** which is transparent to the wave length of the optical image **17**. The optical image **17** is thus impressed upon the photocathode **16** which thus emits a low velocity flood beam of electrons area-modulated in accordance with the optical image **17**; photocathode **16** thus emits an electron image corresponding to the optical image **17**. Photocathode **16** is coupled to terminal **18** adapted to be connected to a suitable source of potential.

Electrode **19** is axially spaced from the photocathode **16** and has a defining aperture **20** formed therein concentric with the axis **12**. Electrode **19** is connected to terminal **22** adapted to be connected to a suitable source of potential. A conventional secondary electron multiplier assembly **23** is disposed between electrode **19** and end wall **14** of the envelope **11** for receiving and multiplying the electrons of the beam which pass through the defining aperture **20**. Electron multiplier **23** comprises a plurality of dynode stages **24–31** respectively connected to terminals **32–39** adapted to be connected to sources of progressively higher potentials. A final target electrode **40** is provided connected to terminals **42** which is adapted to be connected to a suitable source of potential and an output electrode **43** is positioned between target electrode **40** and the final dynode stage **31**. Target electrode **43** is coupled by load resistor **44** to terminal **45** adapted to be connected to a suitable source of potential and is also connected to output terminal **46** by coupling capacitor **47**.

In order to provide for initial acceleration of the beam electrons and also to provide an essentially field-free space within the envelope for deflection of the electron beam, a field screen electrode or mesh **48** is provided extending across envelope **11** between photocathode **16** and electrode **19** and closely spaced from the photocathode **16**, as shown. Field mesh **48** is connected to terminal **49** adapted to be connected to a suitable source of accelerating potential. A tubular electrode **50** is provided extending axially substantially the entire distance between the field mesh electrode **48** and electrode **19**. Electrode **50** may be formed as a conventional conductive coating on the interior surface of side wall **15** of the envelope **11** and may be connected to the field mesh electrode **48** and the electrode **19**, or may be electrically isolated therefrom, as shown. Tubular electrode **50** is formed of nonmagnetic material in order to permit magnetic deflection of the electron beam. Tubular electrode **50** is connected to terminal **52** adapted to be connected to a suitable source of potential. Terminals **49**, **52** and **22** may be connected to the same potential, or terminals **52** and **22** may be connected to a source of potential a few volts higher than that connected to terminal **49**, either connection establishing an essentially field-free space within envelope **11** between the screen electrode **48** and the electrode **19** to permit magnetic deflection of the electron beam.

Conventional vertical and horizontal magnetic deflection yokes **53**, **54** are provided on the exterior of the side wall **15** of envelope **11** and thus act upon the electron beam within the tubular electrode **50** to scan the same over the defining aperture **20** in the electrode **19**.

In order to focus the electrons of the beam onto the plane of the defining aperture **20**, a solenoid coil **55** is provided coaxial with axis **12** and surrounding side wall **15** of the envelope **11** and the deflection coils **53**, **54**. Solenoid coil **55**, when suitably energized provides a solenoidal magnetic field extending axially through the envelope **11** parallel with the axis **12**.

Proper focusing of the electron beam onto the plane of the aperture **20** is obtained when the photocathode **16** is spaced from the plane of the aperture **20** by an integral number of full loops of focus, i.e., when the transit time of the electrons from the photocathode **16** to the plane of the aperture **20** is equal to the time required for an electron to make an integral number of complete revolutions in the magnetic field provided by the solenoid focusing coil **55**.

Referring now additionally to FIG. 2, L is the distance between the photocathode **16** and the plane of the aperture **20**, S_0 is the distance along the axis **12** between photocathode **16** and screen electrode **48**, **56** is a point on the screen electrode **48** radially spaced from axis **12**, *b* is the distance between point **56** and aperture **20**, i.e., the line of travel of a beam electron from point **56** to aperture **20**, *a* is the distance from the point **56** on screen electrode **48** to the photocathode **16** formed as an extension of the line of travel of the electron, and S is the distance from photocathode **16** to point **56** on screen electrode **48** parallel with the axis **12**. Proper focus is obtained when the transit time *t* of an electron from the photocathode **16** to the aperture **20** is equal to the time required for the electron to make an integral number of complete revolutions in the magnetic field provided by the solenoid coil **55**. Thus:

$$t=\frac{2\pi}{\omega} \tag{1}$$

In the case of an electron emanating from point **58** on the photocathode **16** and thus traveling along axis **12**:

$$t_1=\frac{2\pi}{\omega}=\frac{S_0}{V/2}+\frac{L-S_0}{V}=\frac{L+S_0}{V} \tag{2}$$

It will be seen, however, that electrons emanating from point **59** on photocathode **16** or from any other point thereon radially spaced from axis **12**, when deflected to the aperture **20** by the scanning field provided by deflection coils **53**, **54** move with a higher angular velocity. Thus:

$$\omega_1=\frac{\omega}{\cos\alpha} \tag{3}$$

Therefore, in order to provide the proper transit time for all electrons deflected to the aperture **20** without regard to their point of origin on the photocathode **16**, the transit time of the off-axis electrons must be decreased so that:

$$t_2=t_1\cos\alpha \tag{4}$$

From (2) and (4)

$$t_2=\frac{(L+S_0)\cos\alpha}{V} \tag{5}$$

Also

$$t_2=\frac{a}{V/2}+\frac{b}{V}=\frac{2a+b}{V} \tag{6}$$

Then

$$2a+b=(L+S_0)\cos\alpha \tag{7}$$

From the geometry shown in FIG. 2, it will be seen that:

$$a+b=\frac{L}{\cos\alpha} \tag{8}$$

Solving (7) and (8) for *a*,

$$a=(L+S_0)\cos\alpha-\frac{L}{\cos\alpha}$$

$$=\frac{(L+S_0)\cos^2\alpha-L}{\cos\alpha} \tag{9}$$

Thus, it is seen that the separation S between the photocathode **16** and the field screen electrode **48** at any point radially spaced from the axis **12** is:

$$S=(L+S_0)\ \mathrm{Cos}^2\ \alpha-L \tag{10}$$

In a specific example of a tube incorporating the invention in which the distance L is 6.25 inches and the distance S_0 is 0.25 inch, the following values for S defining the curvature of the screen electrode **48** toward the aperture **20** are calculated in accordance with the Equation 10 above:

α	S
1°	0.2474
2°	0.2422
3°	0.2318
4°	0.2188
5°	0.2006

The foregoing specific example in which a focusing field of 40 gauss is provided, the following potentials may be applied:

	Volts
18	−2390
22	−1890
32	−1640
33	−1460
34	−1280
35	−1100
36	−920
37	−740
38	−560
39	−380
42	−200
45	0
49	−1890
52	−1890

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention.

What is claimed is:

1. An image dissector tube comprising: a source of an extended area electron beam; first electrode means spaced axially from said beam source and having a defining aperture therein; secondary electron multiplier means for receiving and multiplying the electrons of said beam which pass through said aperture; a screen electrode between said beam source and first electrode; means acting upon said beam between said screen electrode and first electrode for scanning said beam over said aperture; and means for providing a magnetic field extending axially through said tube for focusing said beam onto the plane of said aperture; said screen electrode being curved toward said first electrode so that the transit times of the electrons of said beam from all points on said beam source to said aperture are substantially equal to the times required for said electrons to make an integral number of complete revolutions in said magnetic field.

2. An image dissector tube comprising: an essentially planar source of an extended area electron beam, said beam source being normal to an axis; first electrode means spaced axially from said beam source and having a defining aperture therein on said axis; secondary electron multiplier means for receiving and multiplying the electrons of said beam which pass through said aperture; an extended area screen electrode extending across said axis between and facing said beam source and first electrode; means acting upon said beam betweeen said screen electrode and said first electrode for scanning said beam over said aperture; and means for providing a magnetic field extending parallel with said axis through said tube for

focusing said beam onto the plane of said aperture; said screen electrode being smoothly curved toward said first electrode with its point on said axis being closer to said first electrode than points radially spaced from said axis so that the transit times of electrons of said beam from all points on said beam sources to said aperture are substantially equal to the times required for said electrons to make an integral number of complete revolutions in said magnetic field.

3. The tube of claim 2 wherein the curvature of said screen electrode responds to the equation:

$$S=(L+S_0)\cos^2\alpha-L$$

where:

L=the distance along said axis between said beam source and said aperture,

S_0=the distance along said axis from said beam source to said screen electrode,

α=the angle defined by said axis with the line of travel of a beam electron between one point on said screen radially spaced from said axis and said aperture,

S=the distance along a line parallel with said axis between said beam source and said one point on said screen electrode.

4. An image dissector tube comprising: an essentially planar source of an extended area electron beam, said source being normal to and concentric with an axis, first electrode means spaced axially from said source and having a defining aperture therein on said axis; secondary electron multiplier means for receiving said muliplying the electrons of said beam which pass through said aperture; an extended area screen electrode extending across and concentric with said axis between and facing said beam source and said first electrode; a tubular electrode concentric with said axis between said screen electrode and said first electrode; means for applying potentials to said screen, tubular and first electrodes thereby to accelerate the electrons of said beam between said beam source and said screen electrode and to provide an essentially field-free space between said screen electrode and said first electrode; magnetic deflection means exterior to said tubular electrode and acting upon said beam therein for scanning said beam over said aperture; and means for providnig a solenoidal magnetic field extending parallel with said axis through said tube for focusing said beam onto the plane of said aperture; said screen electrode being smoothly curved toward said first electrode with its point on said axis being closer to said first electrode than points radially spaced from said axis so that the transit times of electrons of said beam from all points on said beam source to said aperture are substantially equal to the times required for said electrons to make an integral number of complete revolutions in said magnetic field.

5. The tube of claim 4 wherein said beam source is axially spaced from the plane of said aperture by an integral number of full loops of focus of the electrons of said beam.

6. An image dissector tube comprising: an evacuated envelope having a longitudinal axis; an essentially planar source of an extended area electron beam in said envelope, said source being normal to and concentric with said axis; first electrode means in said envelope spaced axially from said source and having a defining aperture therein concentric with said axis; secondary electron multiplier means in said envelope for receiving and multiplying the electrons of said beam which pass through said aperture; an extended area screen electrode in said envelope extending across said axis and concentric therewith, said screen electrode being intermediate said source and said first electrode and closely spaced from said source; a tubular electrode in said envelope concentric with said axis and extending substantially between said screen electrode and said first electrode; means for applying potentials to said screen, tubular and first electrodes thereby to accelerate said beam between said source and said screen electrode and to provide an essentially field-free space between said screen electrode and said first electrode; magnetic deflection means exterior to said envelope and acting upon said beam within said tubular electrode for scanning said beam over said aperture; and a solenoid coil concentric with said axis and surrounding said envelope and said deflection means for providing a solenoidal magnetic field extending axially through said envelope for focusing said beam onto the plane of said aperture; said screen electrode being convexly curved toward said first electrode with its point on said axis being axially closer to said first electrode than points spaced radially from said axis so that the transit times of electrons of said beam from all points on said beam source to said aperture are substantially equal to the times required for said electrons to make an integral number of complete revolutions in said magnetic field; said beam source being axially spaced from the plane of said aperture by an integral number of full loops of focus of the electrons of said beam.

7. The tube of claim 6 wherein the curvature of said screen electrode responds to the equation:

$$S=(L+S_0)\cos^2\alpha-L$$

where:

L=the distance along said axis between said beam source and said aperture,

S_0=the distance along said axis from said beam source to said screen electrode,

α=the angle defined by said axis with the line of travel of a beam electron between one point on said screen radially spaced from said axis and said aperture,

S=the distance along a line parallel with said axis between said beam source and said one point on said screen electrode.

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