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[54] **AN ELECTROSTATIC FOCUSED ELECTRON IMAGE DEVICE**

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[51] **Int. Cl.** **H01j 31/50**

[58] **Field of Search**.......250/213 VT, 227; 313/65 R, 313/65 A, 65 B

[56] **References Cited**

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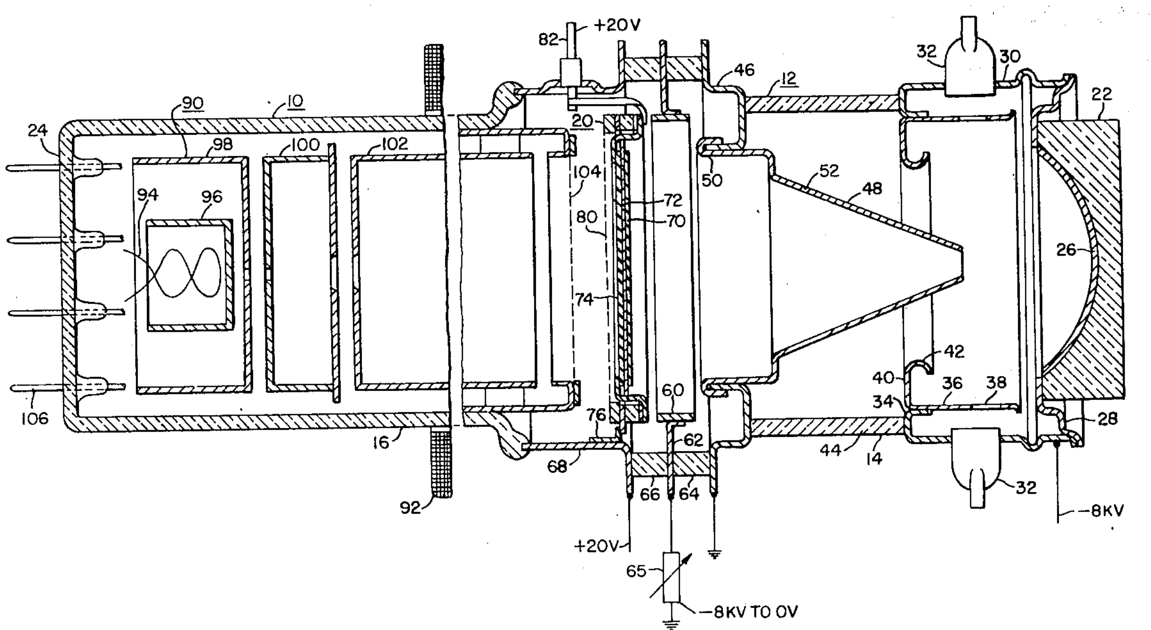
[57] **ABSTRACT**

An electron image device having an electron optical system including a photocathode element capable of converting a radiation image into an electron image. The electron image generated by said photocathode is focused by a cylindrical focusing system onto a substantially flat target surface. The cylindrical focusing system includes an anode electrode positioned intermediate said photocathode and said target and is the primary electrode for a main lens for focusing the electron image onto the target. A distortion correction electrode is positioned intermediate the anode and the target for correcting distortion within the image. The distortion correction electrode is electrically isolated from both the anode and the target and is provided with an adjustable voltage source for correcting the distortion within an image under different operating conditions.

4 Claims, 2 Drawing Figures



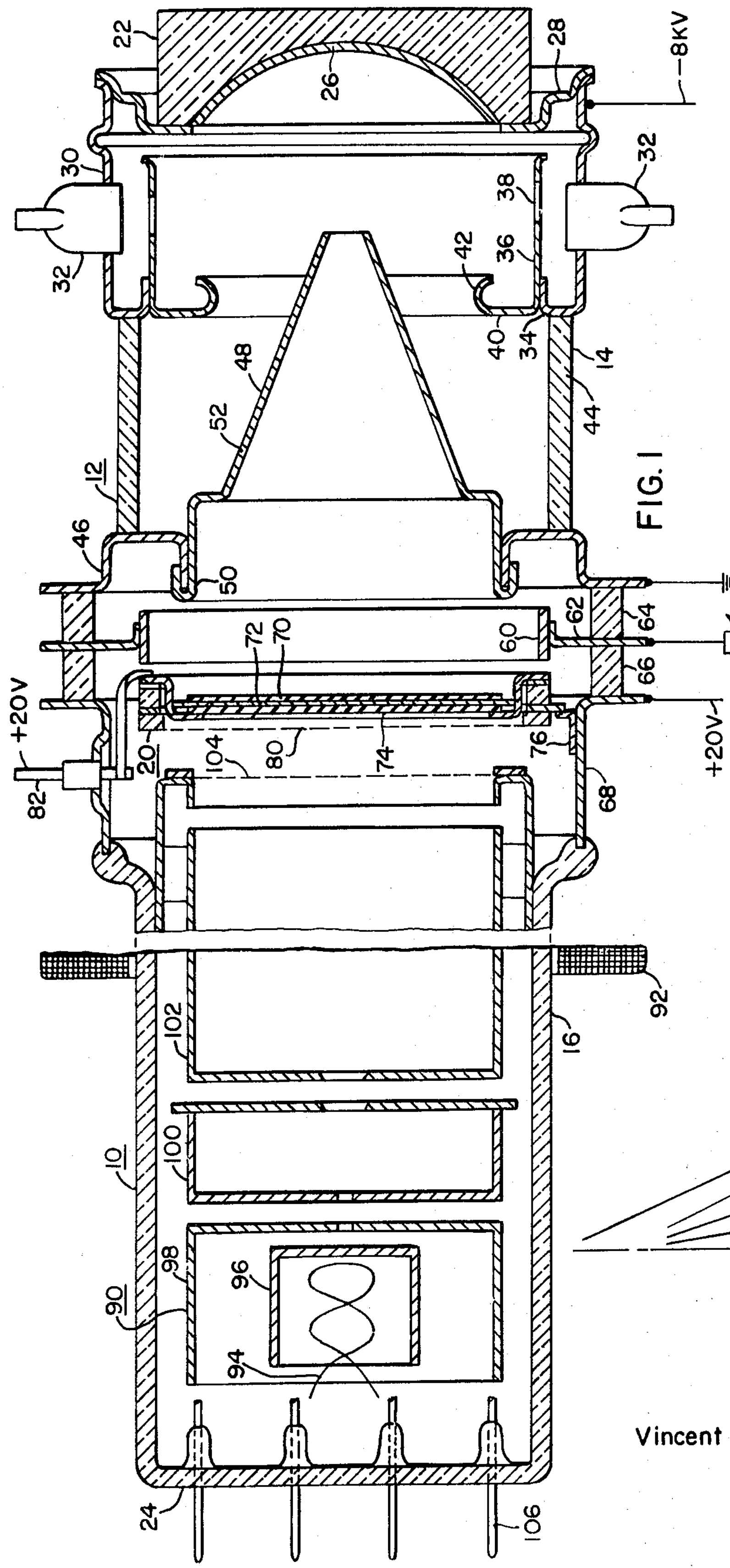


FIG. 1

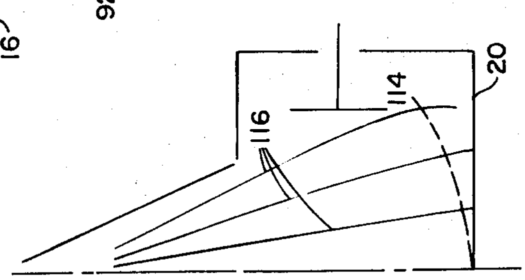


FIG. 2

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AN ELECTROSTATIC FOCUSED ELECTRON IMAGE DEVICE

The invention herein described was made in course of or under a contract or subcontract thereunder with the Department of the Army.

BACKGROUND OF THE INVENTION

There are several image devices known in the art in which an electrostatic focusing system is utilized for transforming an optical image into an electrical signal, or an amplified or converted optical output image. In these devices, an electrostatic image section is provided wherein the input optical image is focused onto an input faceplate. This faceplate may be of glass or fiber optics. A photocathode capable of emission of photoelectrons in response to the input radiations is provided on the inner surface of this input faceplate. The photoelectrons emitted from the photocathode are electrostatically focused onto a target. The target may take the form of a fluorescent output screen or may be of some type of storage material capable of storing the electron image from the photocathode and converting this into an electrical signal by suitable means. An electrostatic imaging system is described in a copending application Ser. No. 560,385,filed June 23, 1966 entitled "Electron Image Device" by James Vine. It is found that the system described therein does provide high resolution but does suffer image distortion. It is found that the surface of unity magnification is a concave surface toward the photocathode. In most applications, the target is in the form of a flat surface and the resulting image suffers from distortion in that there is a non-uniformity of magnification radially out from the center of the image. It is found that the magnification difference from the center to the edge may be as great as 20 percent. The magnification increases from the center to the edge and therefore the result is a pin cushion type of distortion.

It is accordingly a general object of this invention to provide a distortion correction electrode within the electrostatic focusing system to remove the distortion and provide linear magnification over the output target surface. It is also a general object to provide correction in a small tube volume.

SUMMARY OF THE INVENTION

This invention is directed to the removal of distortion for an electrostatic imaging device. This is accomplished by providing a distortion correction electrode within the region of the electrostatic lens system between the anode and the target surface. By providing an electrode which is electrically isolated from the anode and the target electrode, a control voltage may be applied to the distortion correction electrode so as to provide a substantially distortion-free image.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a sectional view of a radiation sensitive pickup tube embodying the present invention; and

FIG. 2 is a schematic representation illustrating the electron paths within the imaging section of the device illustrated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a pickup tube **10** is illustrated. The tube **10** comprises an evacuated envelope **12** having an image section **14** and a readout section **16**. A target structure **20** separates the image section **14** and the readout section **16**. The end of the image section **14** remote from the target **22** is closed off by an input window **22**. The end of the readout section **16** remote from the target **22** is closed off by a base portion **24**.

The image section **14** consists of the input window **22** which may be of a suitable material transmissive to the input radiations. In the specific embodiment shown, the window **22** is of a fiber optic glass structure in which the light pipes are perpendicular to the exterior plane of the input window **22**. A photoemissive coating **26** is provided on the inner curved surface of the input window **22**. A suitable material for the photoemissive coating **26** is a cesium antimony. A flange member **28** is secured to the input window **22** and is also utilized as an electrical conductor for applying a voltage to the photoemissive coating **26**. The flange member **28** is in turn secured to a tubular metallic portion **30** forming a part of the envelope **12**. A plurality of tubulations **32** are disposed in the tubular member **30** for evacuating the envelope **12** and evaporating the photoemissive coating **26**. The tubular member **30** is provided with an inturned flange **34** to which a cathode shield or focusing electrode **36** is secured. The cathode shield **36** is of a smaller diameter than the tubular member **30** and is electrically connected to the photocathode **26** by means of the tubular member **30** and the flange **28**. The cathode shield electrode **36** consists of a cylindrical portion **38**, an inturned flange portion **40** is provided on the cathode shield electrode **36** on the remote side of the cylindrical portion **38** with respect to the photocathode **26**. The flange portion **40** is provided with a lip portion **42**.

A tubular insulating member **44** is secured to the flange portion **34** of the tubular member **30** with the other end of the member **44** secured to an anode flange member **46**. The anode flange member **46** is of electrically conductive material and provides means of applying potential from the exterior of the envelope to an anode electrode **48** positioned within the envelope **12**. The anode flange member **46** also supports the anode electrode **48**. The anode **48** consists of cylindrical portion **50** with a conical portion **52** provided thereon with the smaller portion of the conical portion **52** facing the photocathode **26**. The anode **48** is coaxial with the cathode shield electrode **36** and in the specific embodiment shown the conical portion **48** projects into the region defined by the focusing electrode **36**. The photocathode **26**, cathode shield electrode **36** and the anode **48** form the main focusing lens.

The next electrode positioned within the image section is a corrector electrode **60** which is also cylindrical shape and is positioned on the remote side of the anode **48** adjacent to the tubular section **50**. The corrector electrode **60** is of a larger diameter than the cylindrical portion **50** of the anode **48**. An annular flange member **62** extends outwardly from the outer surface of the corrector electrode **60**. An annular insulating member **64** forming a part of the envelope **12** is sealed to the corrector flange **62** and the anode flange **46**. A cylindrical insulating member spacer **66** is secured to the opposite side of the corrector flange **62** and is in turn sealed to metallic flange member **68** which supports the target structure **20**. The flange **62** is of electrically conductive material and provides means of supplying potential to the corrector electrode **60**. A suitable variable potential source **65** is connected to the flange **62**. The target structure **20** is positioned on the opposite side of the corrector electrode **60** with respect to the focusing anode **48**. The target structure **20** may be of any suitable type responsive to electron bombardment and capable of storing a charge image which may then be readout by an electron gun. The target may also be nonstorage phosphor screen. In the specific device shown herein, the target **20** consists of a support layer **70**, an electrical conductive layer **72** and a porous storage layer **74**. A more complete description of this target member **20** may be found in U.S. Pat. No. 3,213,316, entitled "Tube with Highly Porous Target" by G. W. Goetze et al, issued October 1965. The support member **70** may be of any suitable material such as aluminum oxide and the electrical conductive coating **72** may be of a suitable material such as aluminum. The porous layer **74** may be of a suitable material such as potassium chloride in which the density of the deposit is less than 10 percent of the normal bulk density. The layer **74** is extremely porous so that secondary electron conduction within the porous material is within the voids of the layer **74**.

The target **20** may be supported by a flange member **76** secured to the tubular member **68**. This support assembly including the flange **76** and the annular member **68** also provide means of supplying potential to the suppressor grid electrode **80** provided in front of the porous layer **74** and facing the read section **16**. The grid **80** provides means of maintaining a positive potential below the first crossover or breakdown potential of this target so that the exit surface of the layer **74** is limited to prevent destruction of the target. A suitable lead-in member **82** is provided through the envelope **12** and insulated from the annular member **68** to provide means of deriving a signal from the conductive coating **72**. The output signal is derived from the electron tube **10** from the lead **82**.

A suitable electron gun **90** is provided in the read section **16** of the electron tube for generating a small pencil-like electron beam for reading out the charge image on the target **20**. The electron gun **90** may be of any suitable type capable of generating a small electron beam and a deflection means illustrated as at **92** is provided about the envelope for deflecting the read electron beam to scan the raster over the target **20** in a conventional means. In the specific embodiment illustrated, a filament **94** is illustrated for heating a cathode **96**. The cathode **96** is a tubular element with a diaphragm across one end on which an electron emissive coating is provided for generating electrons in a conventional manner. A control grid **98** is provided in front of the cathode **96** and includes a tubular member with a diaphragm having an aperture therein located in front of the cathode **96**. A second grid **100** may be provided in front of the control grid **98** and may include two diaphragms with apertures therein. A final anode **102** comprises a tubular member having a diaphragm adjacent the second grid **100** with an aperture therein. A collector mesh **104** may be provided at the opposite end of the anode **102**. Suitable voltages are applied to the electron gun **90** by means of the lead-in members **106** passing through the tube base **24**.

In the general operation of the tube, a light image is directed onto the photocathode **26** which operates at a potential of about 8,000 volts negative with respect to ground and photoelectrons are generated. These photoelectrons are focused by means of the main lens including the cathode shield electrode **36** which operates at the same potential as the photocathode **26**. The anode electrode **48** operates at a potential of about ground. These photoelectrons are directed onto the target **20** by the main lens. The conductive coating **72** of the target is at a potential of about 20 volts positive with respect to ground. The corrector electrode **60** is operated at a potential of about 4,000 volts negative with respect to ground. The voltage may range from a negative 8,000 to ground. Selection of the proper voltage corrects distortion within the image which will be described in more detail later. The photoelectrons directed onto the target **20** generate a charge image on the surface of the porous layer **74** and this image is read out by means of the electron gun **90** by scanning a suitable raster by means of the deflection coil **92**. A video signal will be obtained from the lead-in **82** representative of the video information within the image directed onto the target **20** and this video signal may be reconstructed in well known manner.

In the specific embodiment described herein, an electron beam is utilized in conjunction with the output target **20** to derive an electrical output. It is of course obvious that any kind of a flat output target could be utilized with the image section **12**. For example, a phosphor screen might be utilized in place of the target **20** to give a visual output. The structure of the image section in the specific device illustrated consists of the following dimensions

Photocathode to target	2.55 inch
Radius of curvature of photocathode	.70 inch
Photocathode to anode (48) tip	.785 inch
Anode aperture	.120 inch
Corrector electrode diameter	1.47 inch
Target diameter	1.00 inch
Length of cathode shield electrode	.75 inch
Length of anode	1.30 inch
Length of corrector electrode	.385 inch
Diameter of cathode shield electrode	1.45 inch

It is found with the above dimensions and voltages and without the corrector electrode that a unity magnification surface illustrated as the dotted line **114** in Fig. **2** is formed. This surface **114** is a concave surface and the output surface of the target **20** is a plane. The result is that a pin cushion type of distortion image is obtained when this focusing structure is utilized with a planar output target. By incorporating the corrector electrode **60** and operating this electrode at a potential of about negative 4,000 volts with respect to ground an electric force is applied in such a way as to bend the photoelectron paths at their end points toward the center of the field of view or the axis of the image section. This is primarily a third-order focusing effect. This is illustrated in Fig. **2** by the electron paths designated as numeral **116**. It is found in this manner by utilizing the corrector electrode **60** that a planar unity magnification surface may be attained upon the surface of the target **20** thus removing the distortion from the image.

The distortion is an image defect which is sometimes referred to as a third order effect based on theory developed by Ludwig von Seidel. This effect deals with the electron rays making angles with the axis that are oblique to distinguish from the substantially paraxial rays. The distortion is one of the image defects which is found in an electrostatic focusing system. Distortion is a non-uniformity in the magnification radially from the axis. This non-uniformity of magnification leads to the well known pin cushion distortion where increased magnification is found with radial image distance. While the converse variation of magnification that is decreasing leads to the barrel distortion the corrector electrode **60** is specifically designed and operated to correct for this third order effect and the first order effect (converging lens effect) is reduced to a low level.

While the preferred embodiment of the invention has been disclosed herein, it is obvious that other modifications are feasible within the spirit and scope of the invention.

We claim as our invention:

1. An electrostatic focused electron optical converter system comprising an envelope, said envelope comprising an input window transmissive to input radiations, a photoemissive cathode positioned on said input window to receive radiations transmitted through said window, a target member positioned within said envelope to receive the photoelectrons from said photocathode, a main electrostatic field shaping electrode system positioned intermediate said photocathode and said target for focusing said electron image produced by said photocathode onto said target, and a corrector electrode having a length less than its diameter positioned between said field shaping electrode system and said target and electrically isolated therefrom to reduce distortion within the electron image directed onto target member.

2. The system set forth in claim **1** in which means is provided for maintaining said corrector electrode at a potential negative with respect to said target and the adjacent electrode of said field shaping electrode system.

3. The system set forth in claim **1** in which said corrector electrode is a tubular member of a diameter such that it does not intercept said electron image and means for applying a potential to said corrector electrode to modify the uniform magnification surface of the electron image from a concave surface facing said cathode to a planar surface on the surface of said target and with minimum converging effect of the said electron image.

4. The system set forth in claim **1** in which said main field shaping electrode system includes a curved photoemissive surface convex with respect to the input window, a cylindrical cathode shield adjacent said photocathode, an anode electrode positioned between said photocathode and said target, said anode comprising a conical portion with the smaller end facing said photocathode, said corrector electrode is a cylindrical member positioned between said anode and said target and means for applying a potential to said correction electrode different from the potential applied to said target and said anode.

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