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IMAGE TUBE WITH TRUNCATED CONICAL ANODE AND A PLURALITY OF COAXIAL SHIELD ELECTRODES

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Fig. 1.

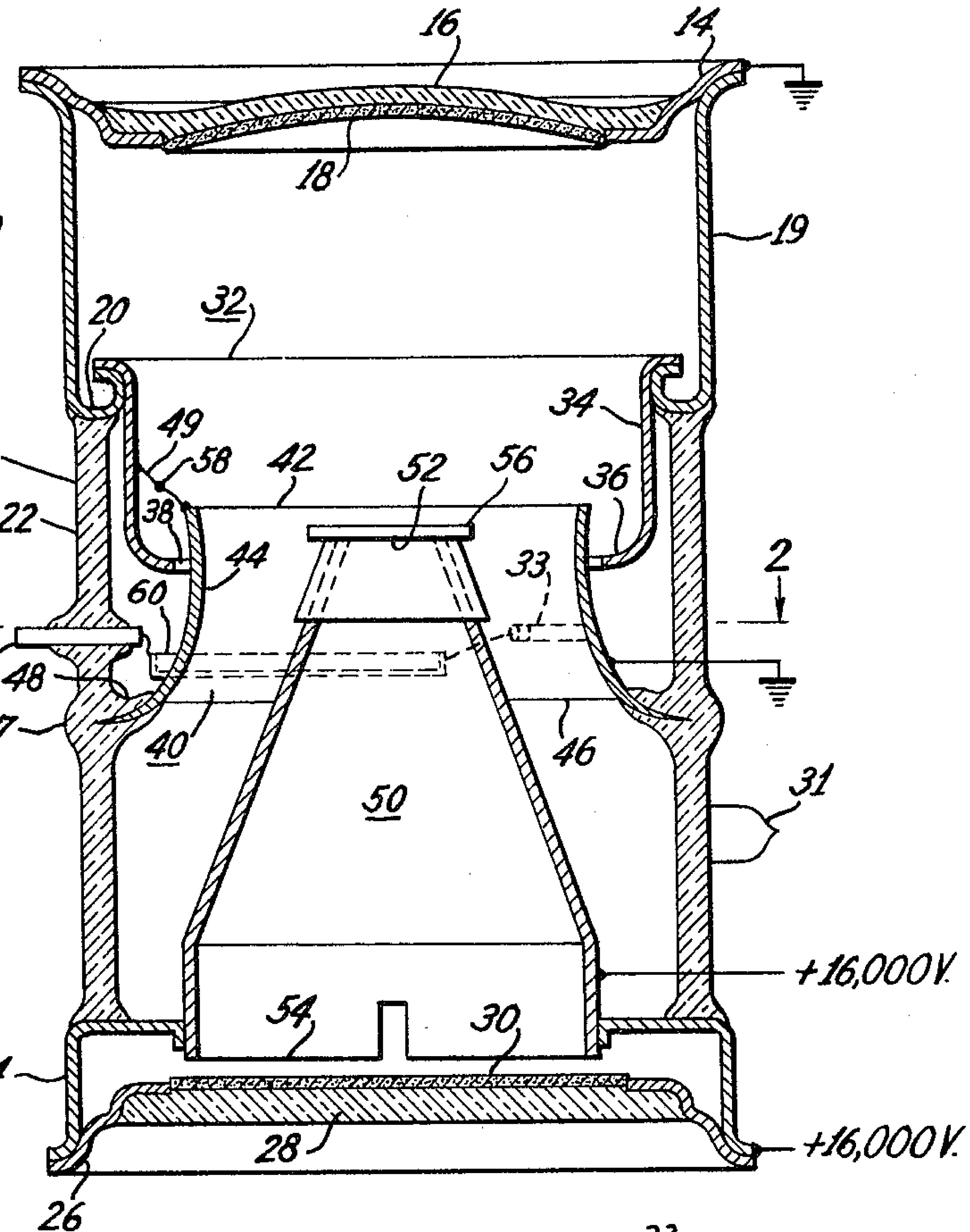
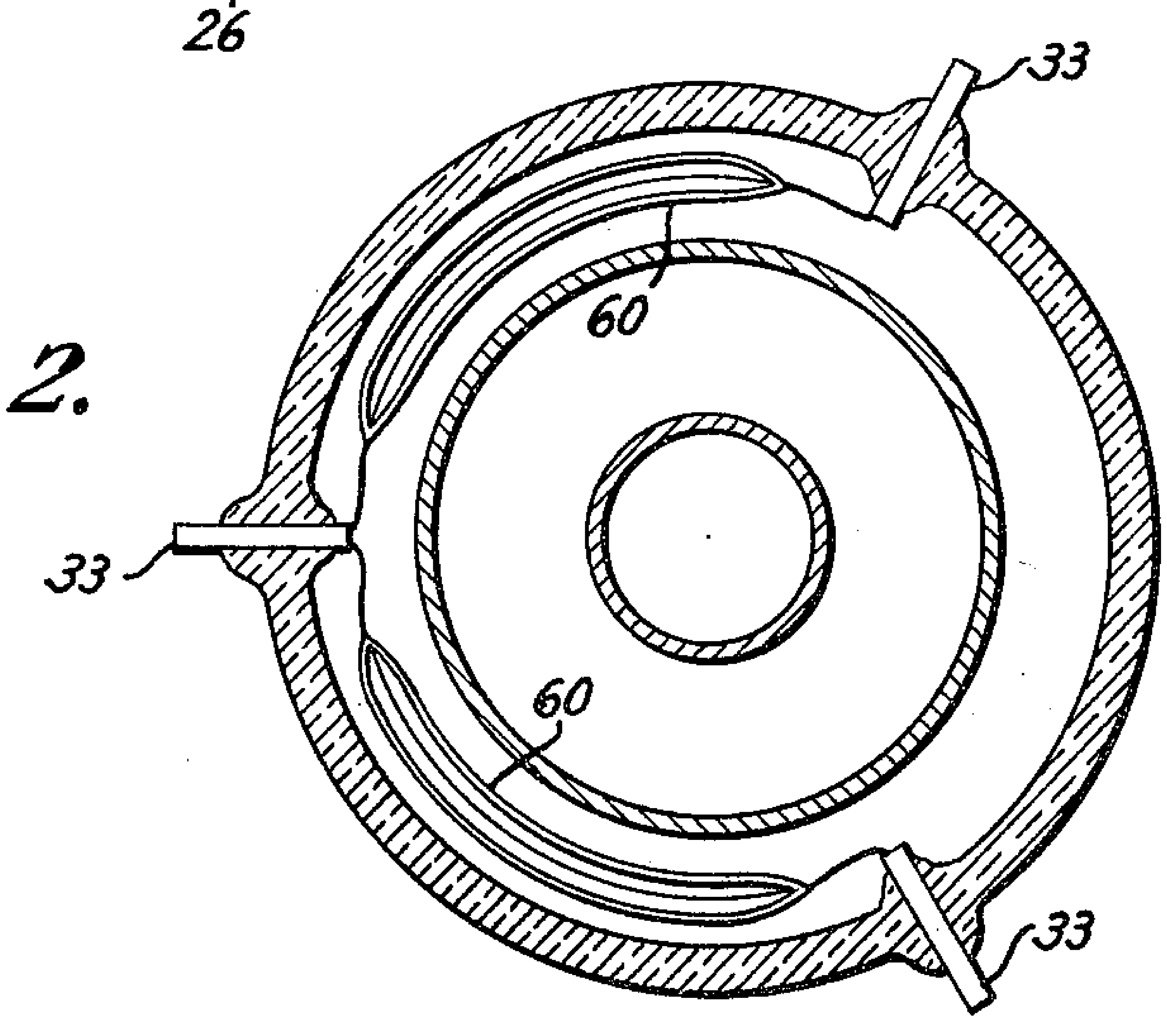


Fig. 2.



INVENTORS
RICHARD G. STOUDENHEIMER &
JOSEPH C. MOOR

BY William A. Zalesak
ATTORNEY

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IMAGE TUBE WITH TRUNCATED CONICAL ANODE AND A PLURALITY OF COAXIAL SHIELD ELECTRODES

Richard G. Stoudenheimer, Lancaster, and Joseph C. Moor, Manheim, Pa., assignors to Radio Corporation of America

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This invention relates to tubes of the type which produce a visible image in response to radiant energy, such as ultra-violet light, visible light, infrared rays or X-rays. In particular, this invention relates to tubes of this type, which are normally referred to as image tubes, or to image sections of more complex tubes or of multiple section tubes in which it is desirable to produce a bright, clear image in response to a relatively weak input signal image.

An image tube, or an image section of a more complex device, is an image device in which there is at least one difference of potential between two electrodes. One of these electrodes is a negative electrode including an electron-emissive photocathode and the other is a positive electrode including an anode and a phosphor screen. Image devices are known in the prior art but these devices are so constructed that they cannot be operated at desirably high electrical potentials. Also, these tubes tend to produce inferior, distorted images on the phosphor screen. In addition, these devices are constructed so that they frequently suffer from field emission if they are operated at relatively high electrical potentials. Field emission is the emission of electrons from one surface that has a high electric field applied between that surface and another surface. Any field emission which bombards the phosphor screen in devices of this type results in a background image, or noise, which tends to obscure faint signal images.

The objects of the invention are to provide an improved image device, or image section, that is capable of operating at a comparatively high difference of potential between its two electrodes and one that is capable of producing high quality visible images without suffering from field emission or image distortion.

An image device according to this invention includes a spherically curved photocathode adapted to produce an electron image corresponding to a light, or other radiant energy, image and a truncated conical anode electrode which is arranged substantially coaxial with the photocathode. Such an arrangement tends to provide spherical, equipotential surfaces between these electrodes which promote optimum focusing of an electron image onto a phosphor screen positioned substantially at the base or larger diameter of the truncated conical anode. An electrical shielding means, in the form of generally tubular electrodes, is electrically connected to the photocathode and surrounds the space between the photocathode and the truncated conical anode. The smaller diameter end of the truncated conical anode is provided with a planar cap, the diameter of which controls the convergence of the electrical fields near the anode and thereby controls the focusing action of the tube. The end of the shield that is remote from the photocathode is embedded in a glass wall portion of the envelope, and the portion of the shield that is closely adjacent to the glass wall is coated with a thin film of glass or feathered edge. This thin glass coating over metal allows electrical charges on the glass to gradually leak through the thin glass to the metal whence they are dissipated. Thus, any build-up of charge on the glass, and resultant field emission, is prevented. The various electrodes of the tube are shaped to promote the production of a distortion-free image and an optimum mounting of the materials which are used in preparing the photocathode and in gettering the tube.

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 in FIG. 1.

An image tube **10**, according to this invention, includes an envelope **12** which is generally tubular in form and has, at one end, a metal ring **14** which has a spherical glass face plate **16** sealed across the open portion of the ring **14** and transverse to the longitudinal axis of the envelope **12**. A photocathode **18** is formed on the inner spherical surface of the face plate **16**. The radius of curvature of the photocathode **18** should be such that the center of the radius of curvature is approximately between the object distance and twice the object distance, for minimum image distortion, so that the electron image will travel most of its path in the direction of a radial field toward the anode. The photocathode **18** may be of any suitable type, for example, antimony cesium, silver-bismuth or the like. The photocathode **18** may be made responsive to any desired wave length, such as visible, infrared, X-rays etc., by the selection of known materials that are sensitive to the desired wave lengths. The ring **14** carrying the face plate **16** is sealed to one end of a hollow metal cylinder **19**, which forms a portion of the envelope and which forms a portion of the cathode assembly. The other end of the metal cylinder **19** is turned inwardly into a smoothly formed U-shaped annular portion **20** to avoid any sharp corners which might hinder the electrical operation of the tube by field emission.

The envelope **12** further comprises an open-ended hollow glass cylinder **22** which is sealed at one end to the U-shaped portion **20** of the metal cylinder **19** with which it is axially aligned. The other end of the glass cylinder **22** is provided with first and second concentric metal rings **24** and **26**, respectively. The metal rings **24** and **26** are sealed together at their peripheries. The second ring **26** has a flat glass plate **28** sealed across it and transverse to the axis of the envelope **12**. The inner surface of the glass plate **28** is provided with a suitable phosphor screen **30** which acts as an electron collector. The phosphor screen **30** is aluminized and the materials therefor may be selected from any of the known electron sensitive phosphors, one example of which is zinc-cadmium-sulphide activated with silver. An exhaust tubulation **31** is provided in the wall of the glass cylinder **22**. Three metal pins **33** are sealed through the glass portion of the envelope **12** and are spaced apart approximately 120°.

Electrodes mounted inside the envelope **12** include a cup-shaped hollow cylindrical electrode **32** which is secured at one end to the U-shaped portion **20** of the metal cylinder **19**. The upper end of the cylindrical electrode **32** gradually curves over the end of the U-shaped portion

20 so that no sharp corners are present, again to prevent field emission. The electrode 32 has a straight side wall 34 which terminates in an inwardly turned end plate 36 having a large area aperture 38 therein. The side wall 34 is substantially parallel to but spaced from the glass cylinder 22. The cup-shaped electrode 32 forms an electrical extension of the metal cylinder 19 and shields the signal electrons from any charges which may accumulate on the glass portion of the envelope 10. Also, the cup-shaped electrode 32 shields the glass cylinder 22 from the evaporated materials which are used to form the photocathode 18.

A hollow, substantially cylindrical, anode shield 40 is provided within the tube 10. The anode shield 40 has a first small open end 42 from which its side wall 44 flares outwardly to a second larger open end 46. The minimum diameter of the shield 40 is within the approximate range of 0.5 to 0.75 the maximum inside diameter of the envelope 12 near the photocathode 18 in order to produce the proper electrical fields. The first open end of the anode shield extends through the aperture 38 and is positioned within the cup-shaped electrode 32. Thus, the high electric field that is in the region around the anode does not reach the sharp edges of the aperture 38. In accordance with a feature of this invention, the large open end 46 of the anode shield 40 is embedded in the glass cylinder 22 with the rim of the end 46 covered with a thickness of glass 47 which insulates this end of the shield from the outside of the envelope. It has been found that, if the end of the anode shield 40 were extended through the glass tube 22 to the outside of the envelope 12, an electrical leakage path would be provided between this exposed end and the anode ring 24. If this leakage path, along with corona discharges, were present, the maximum voltage at which the tube might otherwise be operated would be substantially reduced.

A thin film, or feathered edge, 48 of glass is also provided on the inner and outer walls of the cylindrical shield 40 within the envelope and adjacent to the end 46. The film 48 of glass may be of the order of 5 to 15 mils thick and may be formed by applying a glass frit prior to making the seal between the electrode 40 and the envelope wall. This film of glass prevents field emission from the shield 40 since it has sufficient electrical conductivity so that an electrical charge built up on the glass wall will leak off through the electrode, which is grounded during operation of the tube. The anode shield 40 is electrically connected to the cup-shaped electrode 32 by means of a wire 49. Thus far, the cathode or negative electrode assembly has been described. It can be seen that the cathode assembly comprises a stepped cathode cylinder made up of axially aligned cylinders 19, 32 and 40 which become progressively smaller in diameter the more remote they are from the photocathode 18.

The positive electrode portion of the tube includes a truncated conical anode 50 that is axially aligned with the cathode cylinders, and has a smaller diameter 52 and a larger diameter, or base, 54. The smaller diameter of truncated conical anode is disposed substantially at the cross over point for the electrons emitted by the photocathode. Thus, during operation of the device 10 the object distance is the axial spacing between the photocathode 18 and the smaller diameter of the truncated conical anode while the image distance is the axial distance between the smaller diameter of the anode and the phosphor screen. Depending upon the type of operation desired, the image distance is selected to be within the approximate range of equal to the object distance to five times the object distance. Furthermore, the small diameter 52 is within the shield 40 adjacent to the first small open end 42 thereof. The base 54 of the anode 50 is secured to the first ring 24 and is disposed adjacent to the phosphor screen 30 that is on the glass

plate 28. The smaller diameter of the anode 50 is provided with an apertured flat end plate, or focus disc, 56 having an outer diameter that is smaller than the inner diameter of the first small open end 42 of the shield 40. The longitudinal position of the end plate 56 is approximately the same axial distance from the photocathode 18 as the minimum diameter of the shield 40 in order to minimize image distortion and astigmatism. The inner diameter of the end plate 56 is substantially the same size as the inner diameter of the smaller end of the truncated conical anode 50. The flat plate 56 may be in the form of a separate cap or it may be integral with the smaller end of the andoe 50. The relationship between the outer diameter of the plate 56, at the smaller end of the truncated conical anode, and the inner diameter of the adjacent open end of the shield 40, controls the convergence of the electric fields near the anode and the resultant focus of the electron image, which is an inverted image, at the phosphor screen. Astigmatism will occur in the reproduced image if the focus disc, 56, is out of round or misaligned with respect to the shield 40. The proper selection of diameters depends on the overall length of the tube and the spacing between the photocathode and anode. Thus, for high magnification the outer diameter of plate 56 approaches the inner diameter of the shield 40. For example, for a magnification of approximately 2.5 the outer diameter of plate 56 is approximately 0.8 the size of the inner diameter of shield 40, and for a magnification of 0.5 the outer diameter of plate 56 is approximately 0.3 the inner diameter of the shield 40. It should be noted that the cathode cylinder, made up of electrodes 19, 32 and 40, completely shields the path of the photo electrons between the photocathode and the anode 50.

The substances from which the photocathode is prepared may be included in the tube as follows. One substance, for example silver, may be mounted as a pellet 58 on the wire 49 which is a heater wire and which is connected between the shield 40 and the cup electrode 30. A pair of troughs 60, see FIG. 2, are preferably mounted around the outer wall of the shield 42 and substantially midway between its ends. Electrical contact is made to these troughs by means of pins or rods 33 sealed in the glass tube 22. Cesium and barium emitting mixtures or the like may be placed within the troughs 60. One advantage of this arrangement of parts is that the cesium does not strike the photocathode surface or face plate directly, whereby non-uniformities in the photocathode might result. Another advantage of this structure is that, when using the indirect means for depositing the photocathode 18, the amount of material deposited may be more accurately and easily controlled. The chemicals, as they are evaporated, are shielded by electrode parts and pass gently through the annular space 38. When evaporated in this way, the materials coat the photocathode uniformly.

The image tube 10 described herein is designed so that it operates in focus over a wide range of voltages. In operation, the cathode is operated at ground potential and the anode may be operated at a voltage as high as 20,000 volts. An example of typical operation potentials is shown in FIG. 1. The combination of the stepped cathode cylinder and the truncated conical anode provides favorably spherical equipotential surfaces between the photocathode and the smaller diameter end of the anode. Since field emission is substantially prevented within the tube, and since the electron flow path is completely shielded by electrode structures, a high quality, distortion-free, image having good edge resolution is provided on the phosphor screen of the tube.

In a typical construction, the tube 10 has the following dimensions in inches:

Overall length of tube 10	2.95
Photocathode 18 to screen 28	2.65

Diameter	1.88
Photocathode **18** diameter	1.0
Length of tube **19**	.875
Diameter of tube **19**	1.88
Length of tube **32**	.325
Diameter of tube **32**	1.0
Length of tube **40**	.416
Small diameter of tube **40**	.7
Large diameter of tube **40**	1.1
Photocathode to tube **40**	.964
Photocathode to anode **50**	1.024
Anode cap **56** diameter	.45
Anode smaller diameter	.175
Anode length	1.0
Anode base diameter	.83
Anode smaller end to screen	1.463
Pins to ring	1.5

The tube as described has been directed to a novel image tube. It should be understood that it is within the contemplation of this invention to use a plurality of these structures, each functioning as a different stage, to provide a multiple section or cascaded image tube. When this is done, the light from the phosphor **30** of a first stage strikes the photoemissive member, similar to member **18**, of a second stage. When this is done, the photoemitter for the second stage may be deposited directly onto the exposed surface of the end **28**. Also, when a cascaded multiple section structure is desired the glass plate **28** is made as thin as possible to prevent image distortion between sections, since it need not support a vacuum. The glass plate **28** is curved in a multiple section device to match the curvature of the photocathode glass **16** as shown in FIG. 1.

Furthermore, it is within the contemplation of this invention to use this invention as an image section of other types of tubes such as the image section of an image intensifier image orthicon type pickup tube.

What is claimed is:

1. An image tube comprising a photocathode, a plurality of electrically connected hollow cylindrical members decreasing in diameter from a large open end adjacent to said photocathode to a small open end, said photocathode being disposed transverse to the axis of said hollow cylindrical members and substantially at said large open end thereof, the last two of said plurality of hollow cylindrical members from said large open end being nested and having a small annular space between them, a chemical carrier mounted on the outer wall of the last of said cylindrical members and on the side of said annular space remote from said photocathode, a truncated conical anode having a smaller diameter and a base axially aligned with said cylindrical members, said smaller diameter of said anode being disposed within the last of said cylindrical members and substantially at said small open end of said cylindrical members, the crossover point for electrons from said photocathode being within said smaller diameter of said anode, an open-ended hollow glass cylinder coaxially positioned with respect to said cylindrical members and sealed to the first of said cylindrical members and spaced laterally from the remainder of said cylindrical members, said glass cylinder terminating adjacent to the base of said anode and closed by a collector electrode disposed in the electron path defined by said photocathode and anode.

2. An image tube including a hollow cylindrical envelope having a spherical glass member closing one end thereof, a photoemissive layer formed on said glass member, a hollow cylindrical electrode comprising a portion of said envelope in contact with said glass member and extending longitudinally therefrom, a hollow glass cylinder forming the remainder of said envelope and extending from said cylindrical electrode, a hollow truncated conical electrode positioned within said envelope and secured to said glass cylinder, a metallic cylindrical shield extending from said cylindrical electrode and lying between said conical electrode and said glass cylinder and terminating in said glass wall, a portion of said shield closest to said conical electrode being coated with a thin film of glass, and a collector electrode closing the other end of said envelope.

3. An image tube including a hollow cylindrical envelope having a spherical glass member closing one end thereof, a photoemissive layer formed on said glass member, a hollow cylindrical electrode comprising a portion of said envelope in contact with said glass member, a hollow glass cylinder forming the remainder of the envelope and extending from said cylindrical electrode, a hollow truncated conical electrode positioned within said envelope and supported by means including said glass cylinder, a two-part metallic cylindrical shield extending from said cylindrical electrode and lying between said conical electrode and said glass cylinder and terminating in the glass wall, the two parts of said shield having a small annular space between them, the portion of said shield which terminates in said glass wall being coated with a thin film of glass, and a collector electrode closing the other end of said envelope.

4. An image tube including an envelope, said envelope having a first metal wall portion and a second glass wall portion, said portions being coaxial and having adjacent ends and remote ends, the adjacent ends being sealed together, a face pate sealed to a sealing ring, said sealing ring being sealed to said remote end of said metal wall portion and supporting an electron-emissive photocathode, a glass plate-like member sealed across said remote end of said glass wall portion and supporting an aluminized fluorescent screen, a two-part stepped tubular electrode having one end sealed to the adjacent end of said metal wall portion and its other end embedded in said glass wall portion, a generally hollow truncated conical anode having its smaller diameter disposed within said two-part electrode and a base disposed adjacent to said screen, the cross-over point for electrons coming from said photocathode to said electron collector being within said anode and substantially at said smaller diameter.

5. An image device comprising an elongated envelope having two ends, a spherical shaped transparent plate-like member closing one of said ends of said envelope, a photoemissive member on the inner surface of said transparent member, a second transparent plate-like member closing the other of said ends of said envelope, a phosphor screen on said second plate-like member, a hollow truncated conical anode extending from adjacent said second plate-like member toward said spherical plate-like member and terminating in a smaller end in spaced relation from said spherical plate-like member, the center of curvature of said spherical plate-like member being spaced from said spherical plate-like member by a distance within the range of the spacing from said spherical plate-like member to said smaller end and twice the spacing from said spherical plate-like member to said smaller end, a multiple section shield extending from said photocathode toward said anode and terminating around said smaller end, the minimum diameter of said shield being within the range of one half to three fourths the maximum inside diameter of said envelope adjacent to said spherical plate-like member, the spacing between said smaller end and said second plate-like member being within the approximate range of equal to and five times the spacing between said smaller end and said spherical plate-like member.

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RALPH G. NILSON, *Primary Examiner.*

CHESTER L. JUSTUS, FREDERICK M. STRADER, MAYNARD R. WILBUR, *Examiners.*

D. G. BREKKE, M. A. LEAVITT, *Assistant Examiners.*