

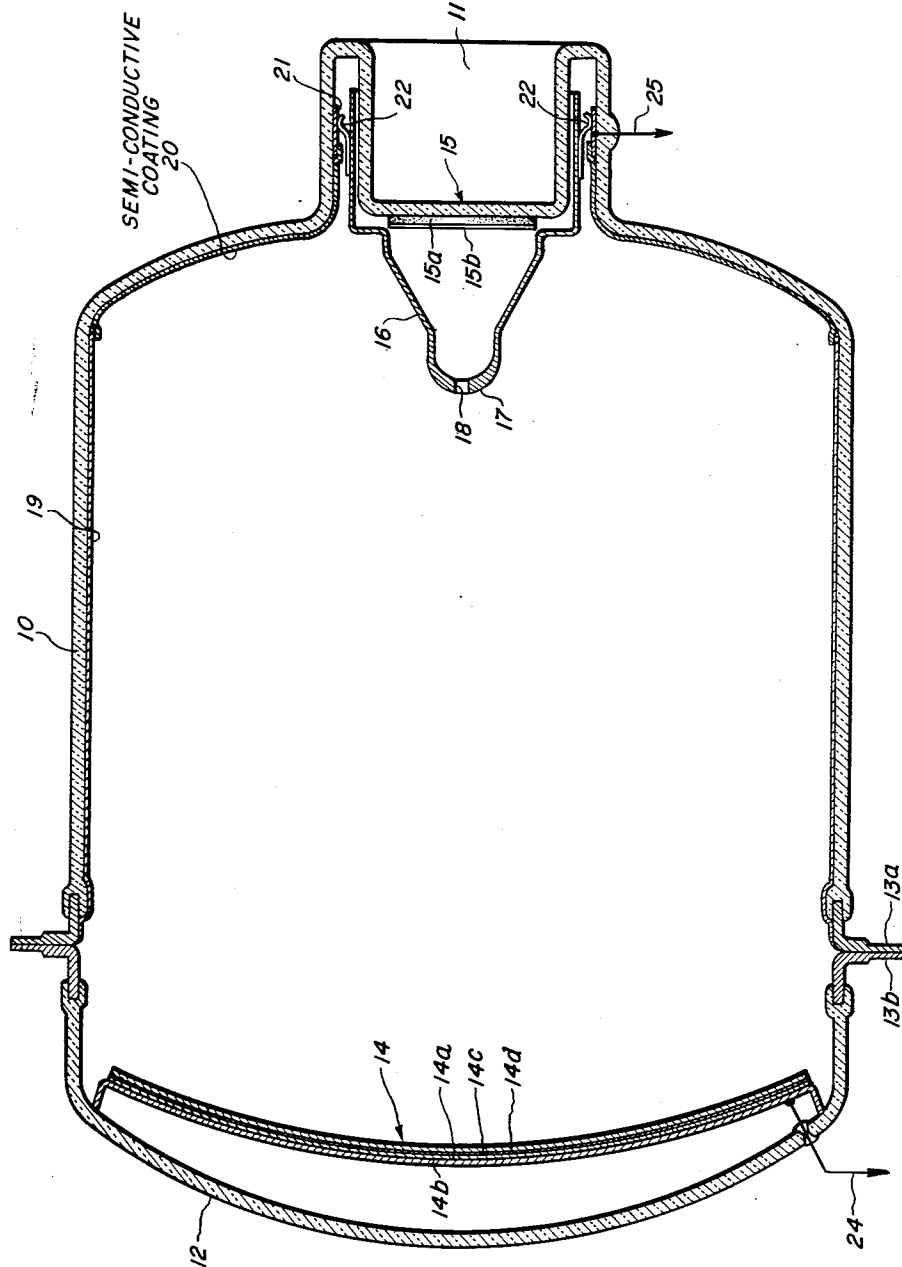
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W. F. NIKLAS

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ELECTRON DISCHARGE DEVICE

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INVENTOR
Wilfrid H. Niklas
BY *Francis W. Crotty*
ATTORNEY

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ELECTRON DISCHARGE DEVICE

Wilfrid F. Niklas, Chicago, Ill., assignor to The Rauland Corporation, a corporation of Illinois
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This invention relates to electron-discharge devices and, more particularly, to electron optical image converters. The application is a continuation-in-part of a now abandoned co-pending application of Wilfrid F. Niklas, Serial No. 715,376, filed February 14, 1958, and assigned to the same assignee as the present application.

It is well understood in the art of image converters and intensifiers that an electron image may be projected from a photoemissive cathode in response to the excitation of an incident radiation, whether visible or invisible, representing a source or object image. The photoemissive cathode, responding to the incident radiation, generates an electron image which may be directed by the use of a suitable electric field to a fluorescent viewing screen where the electron image is converted to a visible reproduction constituting a replica of the original image projected on the photoemissive cathode.

Most modern image converters employ an electron optical system intermediate the photoemissive cathode and the fluorescent viewing screen for the purpose of focusing and accelerating the electrons to the screen while minimizing distortion of the reproduced image. A typical electron optical system comprises an anode containing an aperture through which electrons emitted by the photocathode may be directed to impinge upon the fluorescent screen. An accelerating voltage is imposed upon the anode to establish the necessary electric field and a suitably shaped focus electrode is interposed between the anode and photocathode to accomplish, in conjunction with the anode, the necessary focusing effect. Usually, in order to achieve substantial intensification of the visible image, the photoemissive cathode surface is large compared to that of the viewing screen, and the focusing effect is, of course, necessary to direct the electron image in proper optical aspect to the viewing screen. The focus electrode may be a conductive coating of copper deposited on the inner wall of the tube envelope and it is normally maintained at a potential intermediate that of the cathode and anode, although quite low with respect to anode potential.

Anode voltages of the magnitude required to accomplish sharp focusing and to achieve a high degree of brightness on the viewing screen tend to produce stray electron emission which may result in non-uniform charge patterns on the internal surface of the enclosing envelope. These charge patterns may approach the anode voltage in magnitude and cause distortion, background illumination of the viewing screen and other undesirable effects. Moreover, where the photoemissive cathode comprises an active conductive element, such as cesium as is typical of cesiated cathode structures, there is a possibility of imperfections resulting from the presence of free cesium. In particular, migratory cesium in the form of vapors may condense and deposit on the inside surface of the envelope resulting in elemental areas of the envelope which exhibit very low surface resistivity. Where this is experienced, the reduced resistivity of the envelope, particularly if the area of reduced resistivity is intermediate the focus and anode electrodes, may occasion voltage breakdown. This is obviously highly undesirable.

It has been proposed that the edge of the focus electrode closest the anode be overlapped by a band of semi-conductive material. The presence of such a band improves the properties of the converter with respect to

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breakdown by reducing local high potential gradients in this region. However, the composition and quantity of the binder used to apply this semi-conductive material are of importance. Improper chemical composition or quantity of the binder may defeat the purpose of the semi-conductive material completely and, in addition, may contribute other problems, such as the development of unwanted gas within the tube.

In prior image converter structures, the contrast of the visible image has been diluted by internal reflections of light originating at the phosphor or fluorescent layer usually included in the multi-layer structure serving as the pick-up screen. Previous efforts to minimize such reflections feature the use of a copper coating on the tube envelope as a focus electrode, taking advantage of the fact that copper is not particularly reflective at frequencies corresponding to that of the light emitted by the pick-up screen. Extreme care, however, must be employed in the application of copper. The most common method of laying down the copper coating is by evaporation, but successful evaporation of copper is difficult to achieve. Moreover, the evaporated copper coating is subject to oxidation and copper oxide may sublime during the later processing stages of the photoemissive cathode, causing reduced sensitivity of the photoemissive cathode.

The image plane of the electron optical system of the usual image converter is not flat; rather it is curved, generally being concave in the direction of electron propagation, yet in normal use the image converter is employed in conjunction with an external light optical system for projecting the visible image produced upon the fluorescent screen. Conventional light optical systems are optimally useful in conjunction with a flat or single plane source. Their use with the curved image which is characteristic of the electrostatic optical system of image converters introduces loss of definition and pincushion effect. This type of distortion is sometimes known as field curvature distortion and imposes a severe limitation on the maximum useful size of the output image.

It is a principal object of the invention, therefore, to provide a new and improved image converter in which one or more of the aforementioned difficulties encountered with prior devices of this type are greatly alleviated or substantially eliminated.

Another object of the invention is to provide an image converter having a marked improvement in contrast in the visible image.

It is a particular object of the invention to provide an image converter in which unwanted internal light reflections are reduced and suppressed.

Another specific object of the invention is to achieve substantial correction of field curvature distortion in an image converter.

Still another specific object of the invention is to provide an image converter structure having a cesiated cathode and in which objectionable effects of migratory traces of cesium are minimized or eliminated.

Yet another important object of the invention is to provide an image converter having such electrical properties that pick-up screen structures of substantially increased physical size may be employed to permit materially larger image areas to be viewed and projected without suffering a deterioration in resolution.

An image converter in accordance with the invention comprises an evacuated envelope including a substantially cylindrical center portion, a transparent closure portion at one end of the cylindrical portion and an inwardly extending shoulder portion of insulating material at the other end of the cylindrical portion. An electron source including a photoemissive cathode is located within the envelope at the transparent end for exposure to radiation.

A fluorescent screen is positioned within the envelope at the other end of the cylindrical portion, being encompassed by the shoulder portion and having transverse dimensions small with respect to those of the cathode. There is a focusing and accelerating electrode system intermediate the cathode and the screen. This system comprises a focus electrode spanning substantially the entire length of the cylindrical portion and an anode, likewise having transverse dimensions small with respect to those of the cathode. The anode encompasses the screen and has an access opening between the cathode and screen. A coating of a non-reflective semi-conductive material is provided on the shoulder portion of the envelope between the focus electrode and the anode.

The advantages of the invention are especially apparent when embodied in X-ray image converters in which the size of the source image, for which a useful output image can be obtained, is larger than 5 inches in diameter. X-ray image converters featuring the present invention accommodate much larger source images, providing a useful output representing a source image of 10 inches in diameter. Devices accommodating source images of that size have been constructed and successfully operated, permitting an X-ray of the entire chest cavity of an average individual to be intensified electronically without excessive distortion. Accordingly, the invention will be described as embodied in an X-ray image intensifier, although it will be understood that the inventive teaching may also be applied with great advantage to image converters of other types.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the annexed drawing in which the single figure is a cross-sectional view of an X-ray image intensifier embodying the invention.

The image converter shown in the drawing comprises an evacuated envelope having a cylindrically shaped central section, a shoulder portion at one end of the cylindrical portion extending radially inwardly toward the axis thereof and closure portions at the opposite ends of the composite section constituted by the first mentioned portions. More specifically, there is an envelope section 10 which, for most of its length, is substantially a cylinder and this section of the envelope is closed by a re-entrant press 11. The aforementioned shoulder portion of the envelope is that which interconnects the cylindrical section with the re-entrant press. The remainder of the glass envelope comprises a substantially spherical glass section 12 having a diameter approximately equal to that of the cylindrical portion of envelope section 10. The sections 10 and 12 are pre-sealed around their perimeters to respective metal flanges 13a and 13b which, in turn, are sealed together by heliarc welding or the like after the two envelope sections 10 and 12 have been separately processed. In this manner the necessity of complex constructions required to avoid antimony deterioration during the process of joining the two envelope sections is obviated.

Suitably mounted within envelope section 12 is an electron source in the form of a large diameter multi-layer pick-up screen 14 which approximates a sector of a sphere oriented so that its concave surface faces toward the re-entrant end of envelope section 10. The pick-up screen, for the specific embodiment under consideration, is sensitive to impinging X-rays and to that end includes an X-ray sensitive phosphor layer such as silver activated zinc sulfide or the like, embedded in a suitable silicone resin 14a and applied to a spherically shaped aluminum support member 14b. Superimposed on the phosphor layer is the usual barrier layer 14c which may be of aluminum oxide or the like and on the surface of

which is applied a photoemissive cathode layer 14d. Photoemissive cathode 14d may be of conventional antimony-cesium composition.

A small diameter fluorescent screen is positioned within the envelope within the area encompassed by the shoulder portion thereof and facing the pick-up screen. More specifically, re-entrant section 11 is closed by a flat glass plate 15 having transverse dimensions small with respect to those of the cathode and bearing on its inner face a suitable fluorescent coating to constitute a viewing screen 15a. Silver activated zinc-cadmium sulfide or the like is the fluorescent material generally employed and the screen is preferably aluminized or otherwise provided with a metallic backing layer 15b.

A focusing and accelerating electron system is interposed intermediate the photoemissive cathode and viewing screen and it comprises a focus electrode 19 adjacent the inner surface of the envelope and an anode 16 encompassing viewing screen 15a. The focus electrode spans substantially the entire cylindrical portion of the envelope and may conveniently take the form of a conductive wall coating having one end terminated at and electrically connected to metal flanges 13a and 13b. If desired, the focus electrode may be a wall coating of copper as in prior art devices although, as pointed out more particularly hereinafter, the present invention deviates in that respect and employs an improved focus structure. The anode 16 is a metallic electrode structure which is partially cylindrical and partially conical in shape terminated at its large end with a skirt portion which may be accommodated by mounting over the re-entrant or returned portion of envelope section 11. The opposite end of the anode terminates in a substantially spherical shaped cap 17 having an axial and circular aperture 18 which provides access for electrons originating at the photoemissive cathode, admitting such electrons for impingement against viewing screen 15. Like screen 15, the anode also has small transverse dimensions relative to those of the cathode. This, it will be recognized, is usual practice, employing a circular viewing screen having a much smaller diameter than the photocathode in order to obtain a marked intensification of the visible image. The convex face of anode cap 17 faces the concave surface of pick-up screen 14. The anode encloses viewing screen 15 and is electrically connected thereto so that the screen is maintained at the same electrical potential as the anode. The structural details of the image converter as thus far described may be entirely conventional and will be familiar to those skilled in the art.

Focus electrode 19 in conjunction with anode 16 constitutes an immersion lens for the purpose of focusing electrons originating at the pick-up screen through the anode aperture on to the fluorescent viewing screen. In achieving the lens structure, it is desirable to have the end of electrode 19, which is closest to the anode, overlap the anode cap although it is appreciated that the focus electrode may terminate in line with or even short of the anode cap but these other structures require modification of the focusing potentials in a manner well understood in the art.

The improvements contributed by the present invention center particularly about a preferred form of focus electrode 19 and other matters which overcome many deficiencies of the prior structures and impart to the device under consideration very desirable properties. In accordance with the invention, a layer or coating 20 is deposited on the shoulder or closure portion of the tube envelope adjacent the anode and screen structure 15, 16. The coating is semi-conductive and non-reflecting and is applied by way of a binder which contributes desired gettering properties. The coating may include such semi-conductive material as chromium sesquioxide or iron oxide (hematite). Preferably, it spans the entire shoulder portion of the envelope extending from one end of

focus electrode 19 into re-entrant section 11 and is connected at its opposite ends to the focus electrode and to the anode. It overlaps the terminal edge of the focus electrode and thereby effects electrical connections therewith and is brought into contact with an electrically conductive coating 21 of colloidal graphite or the like which coats a section of re-entrant press 11. Anode 16 is electrically connected to coating 20 through the graphite by means of a plurality of metallic contact springs 22 extending from the supporting skirt of the anode structure.

It has been found that focus electrode 19 particularly in the presence of the non-reflective semi-conductive coating 20 may consist of a coating of aluminum whereas heretofore it had been expected that aluminum would not be suitable for use as this electrode structure.

In the operation of the described structure, the pick-up screen is operated at or near ground potential through a lead extending through envelope section 12 as indicated at 24. The anode structure connects through a lead 25 to a high voltage power supply (not shown) which establishes an anode potential of between 25 and 35 kilovolts. Focusing potential is applied to electrode 19 by connections through the flanges 13a, 13b and the focus potential is usually in the order of several hundred volts. Having established the operating potentials, an X-ray image may be admitted through end section 12 of the envelope to impinge upon pick-up screen 14 and excite phosphor layer 14a. The excitation of the latter produces a visible image of the impinging X-radiation and the light image traverses transparent barrier layer 14c to excite photoemissive layer 14d. As a consequence, the photoemissive layer emits an electron image having a charge distribution corresponding to the incident light and, therefore, to the original X-ray image. The focusing and accelerating electron system causes the electron image to be accelerated, reduced in size and focused on viewing screen 15a through anode aperture 18. Focusing of the electron image on the viewing screen results in a visible image and is highly intensified compared with the original X-ray image. Moreover, an unexpected improvement in contrast was obtained with tubes using evaporated aluminum as focus electrode 19 in conjunction with semi-conductive coating 20.

A more complete understanding of the contribution of coating 20 may be obtained from a consideration of conditions encountered within the tube structure. Theoretically, there is a uniform potential gradient along the inner surface of the shoulder section of the envelope extending between graphite coating 21 and the adjacent edge of focus electrode 19. However, this is only a theoretical matter and is realized only in the presence of a tube structure that is chemically clean. It is indeed extremely difficult to attain chemically clean surfaces, especially in view of the processing of the cathode and the like which is necessary in constructing the tube. Hence, as a practical matter the shoulder surface of the envelope is not chemically clean, but instead has areas that may be greasy or may be covered with impurities. The presence of such impurities causes the potential distribution along the shoulder section of the envelope to be non-uniform and to exhibit a potential distribution pattern with discrete jumps or step-ups intervening portions that may be essentially flat. The consequence of this type potential distribution is an unacceptable tendency to voltage breakdown which, of course, would destroy the operation of the tube. The application of semi-conductive coating 20 to this area of the tube greatly avoids such discontinuities of the potential gradient. The semi-conductive coating is, in effect, a resistive path in parallel to that represented by the shoulder section of the envelope and, as is well understood, the two paths in parallel present a net resistance which is less than that which would be exhibited by the envelope alone, assuming it to be chemically clean. The coating 20, while having less than the theoretical high resistance of chemically

pure glass, does nevertheless represent a high resistance in excess of 500 megohms in illustrative embodiments of the structure. It imparts to the structure the desired characteristic of uniform potential gradient between electrode 19 and anode 16 and has permitted successful operation of this type converter with an operating anode voltage in excess of 45 kilovolts without adverse effects.

It is convenient to apply coating 20 in a manner analogous to that employed in depositing graphite in the neck section of cathode ray tubes, but the composition and the amount of the binder used in the coating are important. One coating mixture that has been used very successfully comprises 15 cubic centimeters of 0.5 percent by volume of tetra-butyl-titanate (TBT) assaying 0.32 gram of titanium dioxide per cubic centimeter of tetra-butyl-titanate and 99.5 percent by volume of n-heptane, in combination with 8.5 grams of chromium sesquioxide.

Mention has been made thus far of the contribution of coating 20 in realizing a substantially uniform potential gradient along the shoulder portion of the tube envelope which is most desirable in that it permits operation with the magnitude of anode potential required effectively to translate electron images from very large diameter cathodes. It contributes additional desirable properties to the tube. For example, the excitation of screen pack 14 entails energization of the phosphor layer 14a and that layer, when excited, issues visible radiations. These radiations, of course, are necessary to produce the desired electron image from the photoemissive cathode and yet they may contribute to a dilution in the contrast of the visible image produced on screen 15. Such dilution may result from multiple internal reflections of this light within the tube envelope. The described coating 20, however, is non-reflective to those radiations and in effect absorbs them which materially enhances the contrast characteristic of the converter.

Additionally, the photocathode of the converter is of the cesiated type and, as is common experience in the art, such cathode structures generally are attended by some amount of free cesium. As a consequence, there can be a migration of cesium from the photocathode. Often times undesirable cesium vapors may migrate through the tube structure and condense, in the absence of coating 20, on the shoulder portion of the envelope. Where this is encountered, the cesium deposits representative elemental areas of the envelope section of unusually low resistance. This, if permitted, is an aggravation of the aforementioned discontinuities in potential gradient established on the shoulder section of the envelope and leads inevitably to breakdown. Coating 20 obviates this undesired result by reason of the fact that the binder through which the coating is applied serves as a getter for the cesium. Specifically, the titanium dioxide of the binder contributes this function. The gettering property of the binder is certainly desirable as explained but it also makes clear the need for controlling the quantity of binder employed in applying coating 20.

Since the gettering action effectively introduces into coating 20 a conductive component represented by the cesium, it tends to reduce the resistivity of the coating below that which it would be were it not for the gettering effect. Consequently, even though an increase in the amount of binder increases the adhesive properties of the coating, an excess of binder results in gettering excessive amounts of cesium vapors during the subsequent processing of the photocathode and may result in excessive electrical leakage. It has been found that a blow-off test may be conveniently adopted in determining the maximum permissible limits of the amount of binder. It has been learned that an adhesion which is sufficient to withstand a maximum of 15 pounds per square inch of air pressures directed perpendicularly to coating 20 through an aperture of approximately 0.1 inch held approximately 0.25 inch away from the coating is accep-

table. Obviously, the minimum adhesion is that required to cause the coating to adhere to the envelope.

The amount of getter material, titanium dioxide for the case under consideration, included in the binder may be determined, alternatively, on the basis of quantity of getter per square inch of coating. The illustrative coating composition detailed hereinabove has been utilized most effectively with a concentration of titanium dioxide in the amount of 128 micrograms per square inch of chromium sesquioxide coating. The greatest effective concentration of titanium dioxide has been determined to be approximately 600 micrograms per square inch of coating. Thus, it appears that the acceptable amount of getter material is within a range of approximately 100 to 600 micrograms per square inch of coating.

Improved results are attained, in accordance with another aspect of the invention, by having focusing electrode 19 consist of an aluminum coating applied to the inner surface of the cylindrical portion of the tube envelope by evaporation in a conventional manner. It had previously been thought that the use of aluminum as a focus electrode would be unsatisfactory with respect to contrast, but it has been discovered through considerable experimentation that an aluminum focus electrode in conjunction with non-reflective coating 20 in the shoulder region of the tube envelope provides superior contrast to that attained with tubes employing a copper focus electrode. Aluminum as the focus electrode presents advantages. Aluminum is substantially easier and more economical to evaporate on the inner surface of the tube envelope than copper, and aluminum oxide which may be formed on the focus electrode will not sublime during the subsequent processing of the photoemissive cathode with an attendant reduction in cathode sensitivity.

It will be appreciated that the image plane of the electron optical system of the tube approximates a spherical surface open toward the cathode whereas a flat image plane permits most efficient magnification or projection of the visible image through a light optical system. Some correction of the field curvature distortion resulting from the fact that the electron image plane is not flat may be realizable by increasing the thickness of the anode aperture, but necessarily there is a distinct limit to the amount of correction available in this fashion if other undesirable effects are to be avoided. It has been found that semi-conductive layer 20 contributes substantial improvement in respect to curvature distortions, beyond the correction that is possible through increasing the diameter of the anode aperture. The coating establishes a potential distribution which causes the equipotential surfaces in the anode region of the tube to change their shapes from that established in the absence of such a semi-conductive coating with a consequent decrease in field curvature. Field curvature distortions are generally expressed by the width of the widest peripheral ring in the image in which the resolution is substantially inferior to the center resolution. Coating 20 has been found to occasion a decrease in the width of this distortion ring by more than 30 percent.

The gettering action resulting from the titanium dioxide of the binder to which coating 20 is applied to the envelope section has another advantageous effect, namely, it contributes to a reduction in pinhole leaks in metal-to-glass seals of the image converter which have been experienced because of free cesium emitted from the cesiated cathode. This extends the useful life of the device.

By way of summary, the described structure has numerous advantages over previous devices, including: more uniform potential gradient in the envelope section intermediate the focus electrode and anode which reduces the possibility of breakdown in the presence of high anode voltages; ability to employ pick-up screens of larger diameter which extend the utility of the devices; an im-

proved contrast as well as decreased field curvature distortion.

While one embodiment of the present invention has been shown and described, various changes and modifications may be made therein, and it is therefore intended in the appended claims to cover all such changes and modifications as may fall within the true spirit and scope of the invention.

I claim:

1. An image converter comprising: an evacuated envelope including a substantially cylindrical center portion, a transparent closure portion at one end of said cylindrical portion, and an inwardly extending shoulder portion of insulating material at the other end of said cylindrical portion; an electron source including a photoemissive cathode within said envelope at said one end of said cylindrical portion and exposed to radiation through said transparent closure portion; a fluorescent screen within said envelope at said other end of said cylindrical portion and encompassed by said shoulder portion and having transverse dimensions small with respect to those of said cathode; a focusing and accelerating electrode system intermediate said cathode and screen comprising a focus electrode spanning substantially the entire length of said cylindrical portion, and an anode, likewise having transverse dimensions small with respect to those of said cathode, encompassing said screen and having an access opening between said cathode and screen; and a coating of a non-reflective semi-conductive material on said insulating shoulder portion of said envelope between said focus electrode and said anode.

2. An image converter comprising: an evacuated envelope including a substantially cylindrical center portion, a transparent closure portion at one end of said cylindrical portion, and an inwardly extending shoulder portion of insulating material at the other end of said cylindrical portion; an electron source including a cesiated photoemissive cathode within said envelope at said one end of said cylindrical portion and exposed to radiation through said transparent closure portion; a fluorescent screen within said envelope at said other end of said cylindrical portion and encompassed by said shoulder portion and having transverse dimensions small with respect to those of said cathode; a focusing and accelerating electrode system intermediate said cathode and screen comprising a focus electrode spanning substantially the entire length of said cylindrical portion, and an anode, likewise having transverse dimensions small with respect to those of said cathode, encompassing said screen and having an access opening between said cathode and screen; and a coating of non-reflective material applied on said insulating shoulder portion of said envelope between said focus electrode and said anode by means of a binder serving also as a getter for cesium.

3. An image converter comprising: an evacuated envelope including a substantially cylindrical center portion, a transparent closure portion at one end of said cylindrical portion, and an inwardly extending shoulder portion of insulating material at the other end of said cylindrical portion; an electron source including a cesiated photoemissive cathode within said envelope at said one end of said cylindrical portion and exposed to radiation through said transparent closure portion; a fluorescent screen within said envelope at said other end of said cylindrical portion and encompassed by said shoulder portion and having transverse dimensions small with respect to those of said cathode; a focusing and accelerating electrode system intermediate said cathode and screen comprising a focus electrode spanning substantially the entire length of said cylindrical portion, and an anode, likewise having transverse dimensions small with respect to those of said cathode, encompassing said screen and having an access opening between said cathode and screen; and a coating of non-reflective material applied on said

insulating shoulder portion of said envelope between said focus electrode and said anode by means of a binder including titanium dioxide as a getter for cesium.

4. An image converter comprising: an evacuated envelope including a substantially cylindrical center portion, a transparent closure portion at one end of said cylindrical portion, and an inwardly extending shoulder portion of insulating material at the other end of said cylindrical portion; an electron source including a photoemissive cathode within said envelope at said one end of said cylindrical portion and exposed to radiation through said transparent closure portion; a fluorescent screen within said envelope at said other end of said cylindrical portion and encompassed by said shoulder portion and having transverse dimensions small with respect to those of said cathode; a focusing and accelerating electrode system intermediate said cathode and screen comprising a focus electrode spanning substantially the entire length of said cylindrical portion and an anode, likewise having transverse dimensions small with respect to those of said cathode, encompassing said screen and having an access opening between said cathode and screen; and a semi-conductive coating on said entire insulating shoulder portion of said envelope between said focus electrode and said anode and electrically connected at its opposed ends to said focus electrode and said anode.

5. An image converter comprising: an evacuated envelope having a cylindrically shaped central section of predetermined cross-sectional dimensions, an end section of reduced cross-sectional dimensions and a shoulder portion of insulating material inter-connecting these sections; a photoemissive cathode within said envelope; a fluorescent screen disposed in said reduced end section; a focusing and accelerating electrode system intermediate said photoemissive cathode and said fluorescent screen comprising a focus electrode consisting of an internal conductive coating on said central section of said envelope and an anode encompassing said fluorescent screen; and

a non-reflective semi-conductive coating on said shoulder portion inter-connecting said focus electrode and said anode.

6. An image converter comprising: an evacuated envelope including a substantially cylindrical center portion, a transparent closure portion at one end of said cylindrical portion, and an inwardly extending shoulder portion of insulating material at the other end of said cylindrical portion; an electron source including a cesiated photoemissive cathode within said envelope at said one end of said cylindrical portion and exposed to radiation through said transparent closure portion; a fluorescent screen within said envelope at said other end of said cylindrical portion and encompassed by said shoulder portion and having transverse dimensions small with respect to those of said cathode; a focusing and accelerating electrode system intermediate said cathode and screen comprising a focus electrode spanning substantially the entire length of said cylindrical portion, and an anode, likewise having transverse dimensions small with respect to those of said cathode, encompassing said screen and having an access opening between said cathode and screen; and a coating of non-reflective material applied on said insulating shoulder portion of said envelope between said focus electrode and said anode by means of a binder including a component serving as a getter for cesium and in a concentration within a range from approximately 100 to 600 micrograms per square inch of coating.

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