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CONDUCTIVE COATING ON GLASS

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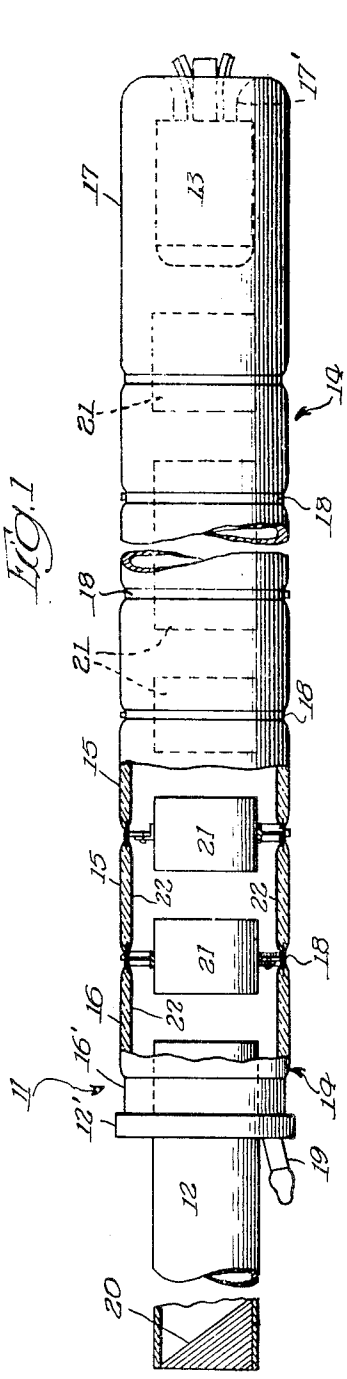

FIG. 1

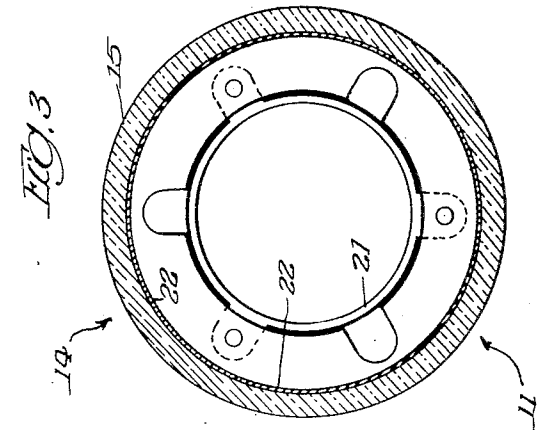

FIG. 3

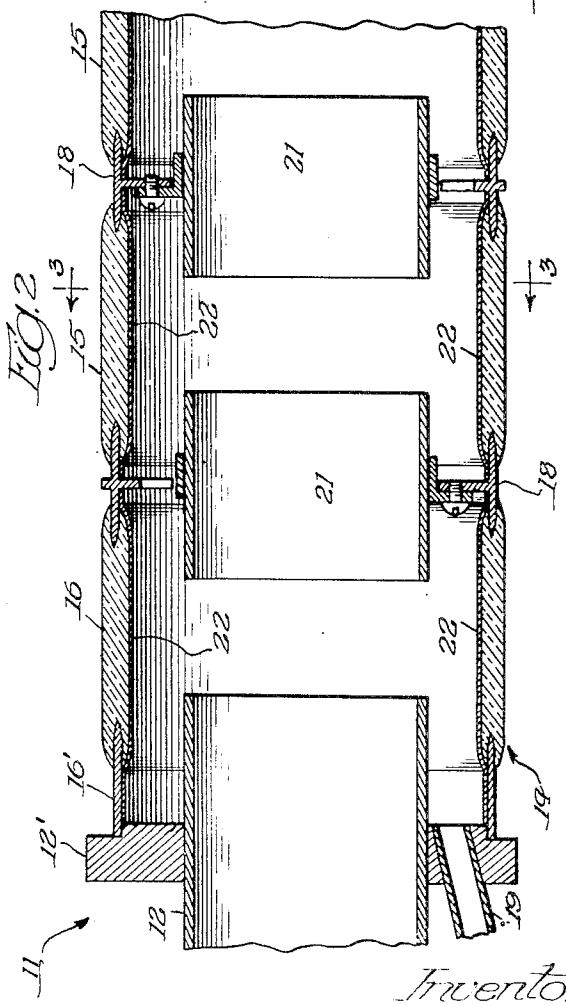

FIG. 2

Inventor:
Michael J. Zunick
By: Spencer, Margall, Johnston & Cook
Attys

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CONDUCTIVE COATING ON GLASS

Michael J. Zunick, Chicago, Ill., assignor to General Electric X-Ray Corporation, Chicago, Ill., a corporation of New York

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6 Claims. (Cl. 250—146)

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The present invention relates in general to electron flow devices and has more particular reference to flow devices including X-ray generators, especially those adapted for high voltage operation.

Electron flow devices of the character mentioned may comprise an electron emitting cathode and a cooperating anode affording an electron target adapted to receive impingement of electrons emitted by the cathode, the anode and cathode being enclosed in a sealed envelope, usually comprising glass. In the operation of electron flow devices, electrical potential is applied between the anode and the cathode for the purpose of driving electrons emitted by the cathode and causing them to impinge upon the anode target. Some of these electrons may deviate from the desired path, between the anode and cathode, and impinge upon the envelope walls. The glass portions of the envelope may thus be subjected to electrostatic charges which may build up upon the envelope sufficiently to rupture the same and thus end the useful life of the device.

An important object of the present invention is to provide means for protecting the glass envelopes of electron flow devices against the deleterious effects of electrical stresses to which the same are or may be exposed during the operation of the devices of which they are a part.

Another important object resides in providing the interior surfaces of electron flow device envelopes with coatings of desired conductivity to allow the draining off of electrical charges applied thereto as a result of the operation of the flow device; a further object being to utilize conductive coatings adapted to resist electron bombardment and also the high temperature to which the same are exposed in the flow device during its operation.

Another important object is to provide the conductive coating at and adjacent the inner wall surfaces of the envelope which are exposed to maximum electrical stress during the operation of the flow device, the coating having limited conductivity whereby to drain off the accumulated charges at a rate sufficient to prevent the development of destructive potentials on the envelope; a further object being to apply the protective coating on the wall surfaces of the flow device at and adjacent the anode.

Another important object is to provide a conductive, transparent, adherent and non-soluble coating which is stable in vacuum and at high temperatures of the order of 450° C.; a further object being to provide the coating by spraying

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the surface to be treated with a solution comprising substantially equal portions by weight of indium chloride and a suitable solvent such as commercial alcohol.

Another important object is to accomplish desired conductivity of the coating by varying the composition of the spray and the temperature at which it is applied, the sprayed on coating being applied to the glass at a temperature of the order of 500° C.

Another important object is to provide an X-ray generator having a glass envelope the inner walls of which are coated with a layer comprising a derivative of an indium salt such as indium chloride forming a conductive coating for draining off electrical potentials occurring as a result of the operation of the X-ray tube of which the envelope is a part.

Another important object is to provide for the successful operation of high tension electron flow devices, in which, necessarily, the distance between the anode and cathode of the device is substantial and in which there is appreciable tendency for wall charges to accumulate upon the envelope walls as a result of electron deviation in traveling the extended path between anode and cathode.

Another important object is to provide an electron flow device having an elongated sectional envelope of the sort employed in high voltage X-ray generators including a coating of desired limited conductivity, particularly on the inner walls of the envelope sections at and adjacent the anode end of the device, whereby to protect such sections against destructive voltage stresses accumulating thereon through impingement of stray electrons.

The foregoing and numerous other important objects, advantages, and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

Referring to the drawing:

Fig. 1 is a view taken longitudinally of a high voltage X-ray generator embodying the present invention;

Fig. 2 is an enlarged view of a portion of the device shown in Fig. 1; and

Fig. 3 is a sectional view taken substantially along the line 3—3 in Fig. 2.

To illustrate the invention the drawing shows an X-ray generator 11 comprising an anode 12 and a cathode 13 in opposed relation enclosed

within an envelope 14 of generally tubular configuration, the cathode being mounted at one end and the anode at the other end of the envelope.

The generator is adapted for operation at relatively high voltage values applied between the anode and cathode which, it will be noted, are relatively widely spaced apart at the opposite ends of the elongated envelope structure. The necessary length of the envelope makes difficult the provision of an all glass structure, and consequently the envelope preferably comprises a series of sleeve-like intermediate glass sections 15 and glass end sections 16 and 17 arranged in end to end alignment, the abutting ends of the adjacent sections being interconnected by preferably metallic connector sleeves 18, said connector sleeves having opposite ends forming glass-to-metal seals with the facing ends of the glass envelope sections 15, 16 and 17. At the cathode end of the tube, the end section 17 may be formed with a re-entrant portion 17' making a glass-to-metal seal as with a skirt portion of the cathode 13. At the anode end of the envelope, the end section 16 may form a glass-to-metal seal with an annular ring 16' which, in turn, may be sealed to a collar 12' sealed on and forming a portion of the anode element 12. The anode 12, as shown, comprises a tube having a closed end forming a target and an open end exposed within the envelope and facing toward the cathode 13. The collar 12' also may carry an exhaust fitting 19 adapted for connection as with a vacuum pump for the evacuation of the interior of the envelope, the exhaust fitting being adapted to be sealed off and disconnected from the exhaust pump after the generator has been sufficiently evacuated during the making of the same.

It should be understood, of course, that X-ray generators function to develop X-rays at the anode by impingement thereon of electrons emitted at the cathode, such emitted electrons traveling from the cathods in an electron stream directed toward and impinging upon a target 20, forming a portion of the anode.

The emitted electrons may be generated and liberated at the cathode as by electrically heating an electron emitting filament, comprising a part of the cathode structure, the electron stream being impelled toward the anode under the driving influence of electrical potential applied, from a suitable power source, between the anode and cathode.

In passing from the cathode toward the anode, electrons may deviate from the desired path and may impinge upon the inner walls of the envelope 14, such impingement of deviating electrons tending to be a maximum at and adjacent the anode end of the envelope. Such electronic impingement upon the envelope walls results in the building up of electrical charges upon the inner surface of the envelope, which, should they become sufficiently large, may puncture the envelope, particularly in the envelope portions adjacent the anode. Electrical charges thus built up on the envelope may also result in the etching of the inner surfaces of the envelope, with consequent weakening thereof. Such charges also, if allowed to remain upon the envelope, may exert an electrostatic effect upon and disturb the flow of the electron stream to the anode, and such disturbance, in turn, may result in causing further unwanted deviation of electrons and the impingement thereof on the envelope walls.

Electron deviation may be minimized, to some extent, by the provision of a series of electronic

lenses or screens comprising metallic tubes or sleeve members 21 arranged in spaced relationship within the envelope, between the anode and cathode, and in axial alignment therewith. These lenses are preferably disposed each opposite an envelope sealing ring 18, and supported thereon in any suitable or preferred fashion. The lenses, accordingly, are electrically connected with the connector sleeves 18, and if desired may be electrically biased with respect to the anode or cathode in order to aid in controlling and maintaining electrons in the desired path between cathode and anode.

In spite of the provision of electron lens elements 21, many electrons may escape from the desired electron flow path and may impinge upon the inner wall surface of the envelope sections 15, 16 and 17, particularly the envelope sections toward the anode end of the envelope, with the undesirable results heretofore mentioned. Where lens elements are omitted the aforesaid undesirable results are, of course, present in full force.

The unwanted results of ambient electron impingement upon the inner walls of the envelope are prevented, in accordance with the teachings of the present invention, by applying to the inner surface of the glass portions of the envelope a transparent, conductive, adherent, non-soluble coating 22. While the coating 22 may be applied to the inner surfaces of all of the glass envelope portions, adequate protection against the destructive effects of ambient electron impingement on the envelope walls will usually be afforded if the coating is applied only in the sections at and adjacent the anode end of the device. The coating 22 may be applied to the envelope surfaces requiring treatment by spraying the same with a solution comprising an indium salt such as indium chloride and a suitable solvent such as commercial alcohol. The solution may comprise equal parts by weight of the indium chloride constituent and the solvent carrier, and is preferably applied to the glass surfaces requiring treatment while maintaining the glass at a temperature of the order of 500° C. By varying the composition of the spray and the temperature of the glass during the spraying operation, variations in the conductivity of the resultant coating may be obtained, accurate control of the resulting coating, in this manner, being obtainable through a relatively wide resistance range of the order of from 25 to 500 ohms per square.

The exact composition of the resulting coating is not known. It is an end product resulting from the application of the coating solution applied to glass in the manner described. It is surmised that the indium compound decomposes at the temperature of application, and the indium constituent is probably integrally bonded with the glass possibly as an oxide or other compound thereof; and it is thought that the indium decomposition product is integrated with the glass probably by being at least partially dissolved therein at the coated surfaces thereof.

The so applied conductive coating, of course, will be in electrical communication with the metallic connector sleeves 18 and also with the metal sealing ring 16', whence accumulated charges may be drained off from the interior of the envelope walls substantially as quickly as they accumulate. As a consequence, the deleterious results of accumulated envelope wall charges are eliminated.

Coatings of the character herein described do

not affect the appearance of the device, since the same are transparent. The coatings are substantially inert to heat at the normal operating temperature of the generator, are strongly adherent, are non-soluble, and are substantially unaffected by electron bombardment; and the coatings are stable under vacuum conditions.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. An X-ray generator for operation at high voltage comprising an envelope, an anode and cathode mounted in spaced apart relationship on and within the envelope, said envelope comprising glass, and a conductive coating comprising indium adhered upon the inner surface of said envelope to drain off electrostatic charges that may accumulate on the envelope during and as a result of the operation of said generator, said coating being transparent, substantially inert to temperatures of the order of 500° C., and having resistivity of the order of from 25 to 500 ohms per square.

2. An X-ray generator for operation at high voltage comprising a plurality of glass envelope sections and metallic connector rings sealed together in end-to-end relation to form an elongated tubular envelope, an anode and a cathode mounted in spaced apart relationship in and at the opposite ends of said envelope, and a conductive coating comprising indium adhered to the inner surface of said sections at and adjacent the anode end of the envelope.

3. An X-ray generator for operation at high voltage comprising a plurality of sleeve sections of glass and metal sealed together in end-to-end relation to form an elongated envelope, an anode and a cathode mounted in spaced apart relation on and within the envelope, and a conductive coating comprising indium adhered upon the inner surface of the envelope and extending in contact with at least a glass and an adjacent metal sleeve section to drain off electrostatic charges that may accumulate on said envelope during operation of said generator.

4. An electron flow device having an envelope comprising glass, an anode and a cathode enclosed within and mounted on said envelope, and a conductive layer comprising indium coated on the inner surfaces of said envelope to depth such that said layer has resistivity of the order of from 25 to 500 ohms per square, whereby to drain off, at a desired rate determined by the resistivity of said layer, electrostatic charges that may accumulate on said envelope during the operation of the device.

5. A device of the character described having an envelope comprising glass, an anode and a cathode mounted in spaced apart relationship within the envelope, and a transparent conductive coating comprising indium sprayed upon and adhering to the inner surfaces of said envelope.

6. An electron flow device having a glass envelope, an anode and a cathode mounted in spaced apart relationship within the envelope, and a conductive coating comprising indium adhered upon the inner surface of said envelope for draining electrical charges from the interior surfaces of said envelope.

MICHAEL J. ZUNICK.

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