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INDICATOR TUBE

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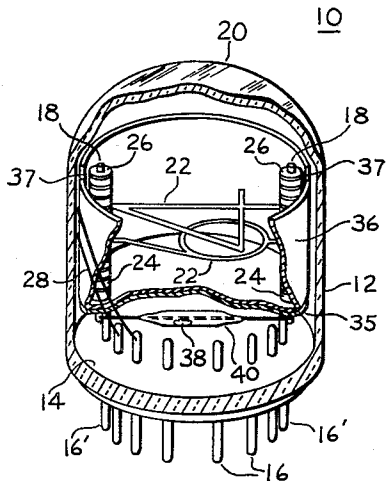


Fig. 1

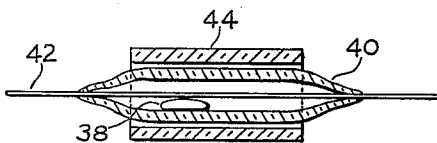


Fig. 2

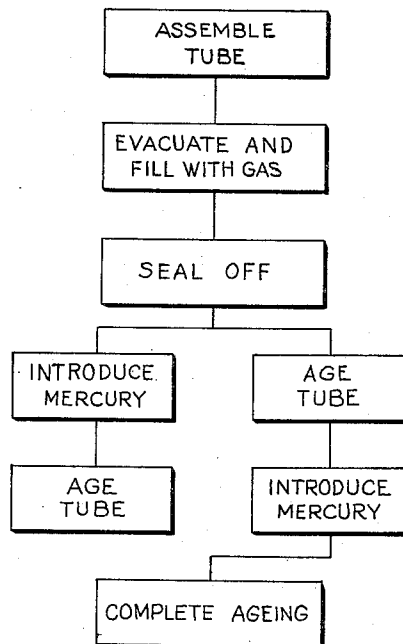


Fig. 3

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This invention relates to gaseous cold cathode glow tubes and to a method of preparing such tubes.

Cold cathode glow tubes of the type to which the present invention relates generally comprise a transparent envelope which contains an anode electrode, one or more cathode glow electrodes, and a gas suitable for supporting cathode glow. When a suitable electrical potential is applied between the anode and a selected cathode electrode, the cathode electrode glows and current flows through the gas from the cathode to the anode. Generally, during this operation, the cathode is bombarded by positive ions which may cause erosion of the material of the cathode surface. This is known as cathode sputtering. The sputtered metal may be deposited on the dormant cathode electrodes in the tube and on the tube envelope. Ultimately, the cathode electrodes from which metal particles are sputtered may be completely eroded, or the electrodes on which the sputtered metal is deposited may be contaminated and rendered inoperative. In addition, the tube envelope may become heavily coated with the sputtered metal and thus rendered opaque so that the glowing cathode electrodes cannot be viewed.

The problem of cathode sputtering is present in all types of gaseous cathode glow tubes, and it is particularly critical in indicator glow tubes which includes a plurality of cathode electrodes in the shape of indicator characters arranged parallel to each other in a stack, the cathode electrodes having a comparatively small unit surface area. In tubes of this type, in the past, the adverse effects of sputtering have been comparatively rapid, and, as a result, the tubes have had undesirably short life. At the present time, in cathode indicator tubes and in other types of gaseous cathode glow tubes, various precautions have been taken to minimize the adverse effects of sputtering. These expedients include the provision of auxiliary shield electrodes within the tube to trap sputtered metal, and in addition, protective coatings have been applied to surfaces which may be adversely affected by sputtering. However, these preventive measures have not been entirely satisfactory in extending tube life, and, in addition, they represent an undesirable portion of the cost of such tubes and they may introduce technical problems in tube construction and operation.

Accordingly, the principles and objects of the invention are directed toward the provision of an improved gaseous, cold cathode glow tube.

The objects of the invention are also concerned with the provision of an improved gaseous, cold cathode indicator glow tube and method for preparing the same.

Briefly, a gaseous, cold cathode indicator glow tube, to which the principles of the invention are particularly applicable, includes an envelope in which is mounted a stack of cold cathode indicator glow electrodes in the form of numerals, letters, or other characters. Each cathode indicator electrode is adapted to glow when a voltage is applied between it and an anode electrode. The envelope is filled with an ionizable, cathode glow-supporting gas and, in order to minimize cathode sputtering, a quantity of sputter-inhibiting agent such as mercury is provided in the envelope.

According to the method of the invention, the mercury is introduced into the envelope after the tube has been completely assembled and at a selected time in the tube aging process. The mercury may be provided as a drop-

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let in a capsule which is mounted inside the tube envelope. At a selected time during the processing of the tube, the capsule is opened and the mercury escapes therefrom and enters the envelope. The mercury may also be introduced in any other suitable fashion.

It is well known that mercury is employed in "neon" or fluorescent tubes which are used for lighting purposes. However, in these tubes, the mercury serves to increase the brightness of the light emitted from the gas and from a phosphor coating. Apparently, if there is any effect on electrode sputtering, it is either not recognized or not utilized or it is of no significance in a tube in which light output is the primary function and not the viewing of indicator glow cathodes within the tube.

Neon tubes differ markedly in other ways from glow cathode tubes embodying the invention. For example, neon tubes include an inner coating of phosphor material, and light output is obtained from substantially the entire volume of gas which glows and from the phosphor coating. Generally, a neon tube is considered defective if an electrode glows. In indicator cathode glow tubes, a cathode electrode glows and the gas does not glow except for a narrow sheath surrounding the cathode. This difference in the region of glow in the gas is due primarily to differences in gas pressure, for neon tubes contain a very low pressure of gas, for example of the order of 10 mm. of Hg, while cathode glow tubes of the type under consideration operate under gas pressures five to ten times higher than this amount. Neon tubes generally operate with alternating voltage of thousands of volts in magnitude. Cathode glow tubes operate with unidirectional voltages of preferably less than 200 volts.

The invention is described in greater detail with reference to the drawing wherein:

FIG. 1 is a perspective view of a cold cathode gaseous glow tube embodying the invention;

FIG. 2 is a sectional elevational view of apparatus used in practicing the invention; and

FIG. 3 is a flow chart of the steps of the method of the invention.

Referring to the drawings, a typical gaseous indicator glow tube 10 prepared according to the invention includes an envelope 12 which has been evacuated of air and filled with a gas suitable for supporting cold cathode glow. Such a gas may be argon, neon, or the like at a suitable pressure which may be in the range of about 50 to about 100 mm. of Hg. The envelope includes a base portion, or stem 14, through which metal base pins 16 extend and by means of which electrical connection is made to suitable external electrical circuit elements. Two diametrically opposed pins 16' are provided with extension posts 18 within the envelope and are thus adapted to receive and support the various electrode elements of the tube. The posts 18 are coated with a suitable insulating material (not shown) such as glass or the like. The envelope 12 also includes a transparent viewing window 20 through which glowing indicator cathode electrodes 22 are viewed. A sealed-off exhaust tubulation (not shown) is provided in the stem 14.

The cathode glow indicator electrodes 22 of the tube 10 may take substantially any desired shape; for example, they may be numbers, letters, or the like, and they may be as few in number as desired, or as many as is practical for the size of the tube. In one form of the tube 10 wherein the glow cathode indicator elements are numbers, ten of such elements are provided, including the numbers "0" to "9." Fewer than ten glow cathodes are shown in FIG. 1 for purposes of simplification of the drawing. The cathode indicator elements 22 are made of any suitable metal, for example, stainless steel, aluminum, Nichrome, molybdenum, or the like, and they may be made in any suitable fashion, for example, by etching, stamping, or the like.

The cathode elements are provided with diametrically opposed apertured end tabs (not shown) by means of which they are mounted and supported on the extension posts 18 of the pins 16'. The cathode elements 22 are stacked on the posts 18 one above the other with their surfaces oriented parallel to each other and transverse to the vertical axis of the tube and facing the viewing window 20 of the envelope 12. The cathode elements 22 are mounted with suitable insulating spacers 24 between them, the spacers having sufficient surface area to cover and insulate the cathode tabs to prevent them from glowing during operation of the tube. The stack of electrodes is locked on posts 18 by mica rings 26.

Each cathode indicator element is provided with a fine wire connecting lead 28 which is welded or otherwise secured at its free end to one of the pins 16 within the envelope 12. The leads 28 may be of the same material as the numbers, or they may be of any other suitable material.

The tube 10 includes an anode which is in the form of a cup 36 having a pair of diametrically opposed longitudinal slots 37 aligned with the support posts 18 and through which the cathode lead wires 28 extend to the pins 16. The stack of cathode electrodes is, in effect, contained within the cup and, thus, the cup also operates as a shield between the cathodes themselves and the cathode lead wires and pins which are outside of the cup. The leads and pins are thus substantially prevented from glowing when the cathodes glow. The cup rests on, but is insulated from, the pins 16 by an insulating disk 35 of mica or the like. The anode cup is also electrically connected to one of the pins 16 by a suitable lead (not shown).

According to the invention, sputtering of the metal of the cathodes 22 during operation of the tube is substantially eliminated by the inclusion of a sputter-inhibiting agent within the envelope. The preferred inhibiting agent is mercury. In one method of manufacture of a tube containing mercury, the mercury is held immobilized within the tube envelope while the tube is assembled. After the tube is assembled, it is aged, and at a selected time either before or during the aging process, the mercury is freed and admitted to the envelope. In one arrangement for carrying out this process, referring to FIG. 2, a small ball of mercury 38 is placed in an evacuated frangible capsule 40, of glass or the like, through which a heating wire 42 extends. The capsule is sealed in the tube envelope, and at the desired time in the manufacturing process, heating current is passed through the wire, and the mercury is heated and caused to vaporize and crack the glass capsule. When the capsule cracks, the mercury escapes and condenses on the tube envelope. Under some circumstances, it may be desirable to position the capsule 40 in a tubular thermal shield 44 of metal or glass. The shield 44 serves to maintain the temperature of the capsule at a suitable low level during processing of the tube to prevent premature breaking of the capsule.

Of course, other procedures and apparatus may be used for introducing the mercury into the tube envelope, if desired. For example, metal capsules may be used or side tubulations may be attached to the tube envelope and may be used to introduce the mercury into the tube envelope from a source external to the envelope.

According to the method of the invention and referring to the flow chart of FIG. 3, in preparing the tube 10, the stem 14 of the envelope carrying the pins 16 is first prepared and the mercury-containing capsule 40 is secured thereto by having the free ends of the wire 42 soldered or welded to two of the contact pins 16 (FIG. 1). The two selected pins are pins which are not connected to active tube electrodes in the completed tube. Next, the various electrodes are mounted on the support posts 18, and the envelope 12 is secured to the stem 14. The envelope is then evacuated and baked-out at about 400° C., and filled with neon, argon, or some other suit-

able glow-supporting gas to a suitable pressure of about 70 millimeters of mercury. Next, the tube is subjected to an aging process and the mercury is introduced into the envelope. The mercury may be introduced into the envelope at different times in the following process. The mercury is effective as a sputter-inhibiting agent, regardless of when it is introduced.

According to one procedure in the method of the invention, immediately after the tube has been processed as described above, it is allowed to cool and the mercury is introduced into the envelope. The quantity of mercury employed is not particularly critical, and only a small amount is required. In a tube having a height and diameter of about one inch, a gas pressure of about 70 mm. of Hg, and stainless steel cathodes having a width of about .015 inch, and a length of about 0.75 inch, a ball of mercury having a diameter of about one millimeter is used. The operation of releasing the mercury from the capsule 40 comprises passing an electrical current through the capsule heater wire 42 and thus heating the mercury until it vaporizes and cracks the glass wall of the capsule. When the capsule wall is cracked, the mercury vapor escapes into the tube envelope and condenses on the wall of the envelope and on various ones of the electrode elements within the tube.

Next, the tube is aged. The aging of gas tubes is well known in the art and the process, essentially, comprises operating the tube electrodes under rather drastic electrical conditions for a comparatively short time. The specific conditions employed in the aging process depend on several factors including tube size, gas pressure, and electrode sizes and materials. The efficacy of the sputter-inhibiting agent, according to the present invention, does not depend on a single critical set of conditions used in the aging process. The following aging process is one which was employed with a tube having a height and diameter of about one inch, a gas pressure of about 70 mm. of Hg and stainless steel cathode electrodes of about .015 inch in width and about 0.75 inch in length. In the aging process, first, all of the cathodes are allowed to glow at greater than normal brightness for about one hour. This is achieved by passing a current of about 30 milliamperes at about 300 volts between each of the cathode electrodes and the anode electrode.

In the next step of the aging process, the cathodes are allowed to glow for about six hours at a current of about 6 milliamperes and about 300 volts. Finally, the cathodes are allowed to glow for about 24 hours at a current of about 4 milliamperes and about 300 volts.

The foregoing aging process parameters may be varied as is well known in the art, and other processing steps may be included as desired.

In an alternate process, the tube is assembled and evacuated and filled with gas as described above. Then, the aging process is begun. First, all of the cathodes are allowed to glow at greater than normal brightness for about one hour with a cathode-to-anode current of about 30 milliamperes and with about 300 volts between each of the cathode electrodes and the anode electrode.

Next, the tube is allowed to cool and the mercury is introduced into the envelope in the manner described above. The aging process is then continued and the cathodes are allowed to glow for about six hours at a current of about 6 milliamperes and about 300 volts. Finally, the cathodes are allowed to glow for about 24 hours at a current of about 4 milliamperes and about 300 volts. Here, too, the aging process parameters may be varied as is well known in the art, and other processing steps may be included as desired.

It has been found that the former process substantially eliminates all cathode sputtering in the tube. In the latter process, there is only a trace of cathode sputtering which apparently occurs during the first step of the aging process before the mercury is introduced into the envelope. However, this trace of sputtering does not adversely affect

tube operation. In any case, after the mercury is introduced into the tube, substantially no sputtering occurs in the tube operation.

A cold cathode indicator glow tube containing mercury as described above has the primary advantage that cathode sputtering is, for all practical purposes, completely eliminated. Thus, even under the least favorable operating conditions wherein only one cathode of a multi-cathode tube is operated and the others remain dormant for a considerable length of time, for example, over one thousand hours, neither the envelope nor the other electrodes show any evidence of cathode sputtering. It has also been found that, even if there is some sublimation of metal onto the other dormant cathodes, these cathodes can operate in normal fashion. In similar tubes which do not contain mercury, where one cathode has been allowed to glow steadily, the effects of cathode sputtering have been quite noticeable after a comparatively short time. Since sputtering is effectively eliminated, the tubes of the invention have considerably longer life, and, if desired, less expensive materials which heretofore have not been used due to their susceptibility to excessive sputtering, may now be used. In addition, auxiliary shields or screens for trapping sputtered metal may now be omitted so that a saving in cost is effected and a simplification in the mechanical and electrical features is achieved.

What is claimed is:

1. A gaseous cold cathode glow tube including an envelope having a viewing window, a plurality of cathode glow electrodes in the shape of indicator characters arranged in close proximity to one another in a stack and an anode electrode within said envelope, said cathode electrodes facing said viewing window and being adapted to glow when a voltage is applied between any one of them and said anode, and a filling of an ionizable gas in said envelope at a pressure capable of sustaining a negative glow discharge along the surface of said cathode electrodes, said filling including mercury vapor for inhibiting sputtering from said cathode electrodes.

2. A gaseous cold cathode glow tube including an envelope having a viewing window, a plurality of cathode electrodes and an anode electrode spaced apart within said envelope, each said cathode electrode being adapted to glow when a voltage is applied between it and said anode, and a filling in said envelope of an ionizable gas selected from the group consisting of argon and neon, said filling being at a pressure capable of sustaining a negative glow discharge along the surface of said cathode electrodes, and including mercury vapor for inhibiting sputtering from said cathode electrodes.

3. A gaseous cold cathode glow tube for the selective display of a variety of indicator characters in a substantially common field including an envelope having a viewing window, an anode electrode within said envelope, a plurality of closely spaced substantially planar cathode electrodes each having a metallic filament portion in the form of one of the indicator characters, said cathode electrodes being arranged in said envelope in closely spaced electrical insulatively stacked relationship, the space between the filament portions of successive ones thereof being free of intervening insulation material or light obstructing or reflecting material, each cathode electrode being adapted to glow when a voltage is applied between it and said anode, and each such electrode having at least one thin metallic mounting tab integral with its character portion and extending laterally in a direction away from the area generally defined thereby, mounting means in fixed relationship in said envelope but located outside of the area defined by the character portions of the cathode electrodes, said mounting means engaging the tabs of successive cathode electrodes in substantial alignment and serving to mount said cathode electrodes in said stacked relationship in the envelope, and a filling in said envelope of a gas including neon and mercury in an amount sufficient to inhibit sputtering from said cathode electrodes,

said filling being at a pressure capable of sustaining a negative glow discharge along the surface of said cathode electrodes.

4. A cold cathode gaseous indicator tube for selective display of a variety of luminous indicator characters in a substantially common field including an envelope, an anode electrode within said envelope, a plurality of cathode indicator electrodes each having a metallic filament portion in the form of one of the indicator characters, said cathode electrodes being spaced apart within said envelope in closely spaced electrical insulatively stacked relationship, the space between the filament portions of successive ones of said cathode electrodes being free of intervening insulation material or light obstructing or reflecting material, each cathode electrode being adapted to glow when a voltage is applied between it and said anode, and each such electrode having at least one thin metallic mounting tab integral with its character portion and extending laterally in a direction away from the area generally defined thereby, mounting means in fixed relationship in said envelope but located outside of the area defined by the character portions of the cathode electrodes, said mounting means engaging the tabs of successive cathode electrodes in substantial alignment and serving to mount said cathode electrodes in said stacked relationship in the envelope, and a filling in said envelope of argon and an amount of mercury vapor sufficient for inhibiting sputtering from said cathode electrodes, said filling being at a pressure capable of sustaining a negative glow along the surface of said cathode electrodes.

5. A gaseous glow tube comprising an envelope, an inert gas filling in said envelope at a pressure capable of sustaining a cathode glow discharge for establishing a glow indication along the surface of a cathode, a transparent viewing window comprising a portion of said envelope, a plurality of glow electrodes mounted in close proximity to one another in a stack within said envelope for viewing through said window, a plurality of lead-in conductors extending into said envelope and along the side periphery of said cathode stack and respectively connected to said electrodes, and a barrier member mounted within said envelope between said glow electrodes and the associated lead-in conductors to prevent glow of said lead-in conductors, at least a portion of said barrier member being electrically conductive and operable as an anode, and a heavy molecular weight gas provided within said envelope to substantially prevent sputtering of said cathode electrodes.

6. The tube defined in claim 5 wherein said heavy molecular weight gas is mercury.

7. A cold cathode gaseous indicator tube comprising an envelope having a viewing window and containing an inert gas filling therein at a pressure capable of sustaining a cathode glow discharge for establishing a glow indication along the surface of a cathode, a plurality of cathode glow electrodes in the form of characters, each of said electrodes having a pair of oppositely disposed mounting tabs, a plurality of lead wires secured to said tabs, support means engaging said tabs for supporting said electrodes in close proximity to one another in a stack opposite said window, and a conductive shield electrode interposed between said cathode glow electrodes and said lead wires to prevent said lead wires from glowing, said shield electrode also functioning as an anode, and a small quantity of mercury provided within said envelope to prevent sputtering of said cathode electrodes.

8. A cold cathode gaseous indicator tube comprising an envelope having a viewing window therein, a plurality of cathode glow indicator electrodes in the form of characters, support means for supporting said electrodes in close proximity to one another in a stack before said window, a plurality of lead wires respectively connected to said electrodes, and a cup-shaped member enclosing said stack of electrodes, a filling of an ionizable gas in said envelope at a pressure capable of sustaining a cath-

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ode glow discharge for establishing a glow indication along the surface of a cathode, and a quantity of a heavy molecular weight vapor added to said gas filling to substantially prevent sputtering of said cathode glow electrodes.

9. The tube defined in claim 8 wherein said heavy molecular weight vapor is mercury.

10. A cold cathode gaseous indicator tube comprising an envelope having a viewing window therein, a cathode glow indicator electrode in the form of a character, said cathode electrode having a pair of oppositely disposed mounting means, a lead wire secured to said cathode, support means engaging said mounting means for supporting said electrode facing said window, and shield means proximately disposed with respect to said cathode indicator electrode, said shield means having a portion interposed between said indicator electrode and said lead wire, a gas filling in said envelope at a pressure capable of sustaining a cathode glow discharge for establishing a glow indication along the surface of a cathode, and a quantity of mercury added to said gas filling to substantially prevent sputtering of said cathode electrode.

11. The tube defined in claim 10 wherein said shield means includes a conductive portion operable as an anode electrode.

12. A gaseous cold cathode glow tube including an envelope having a viewing window, a plurality of cathode glow electrodes in the shape of indicator characters and an anode electrode arranged in close proximity to one another in a stack within said envelope, said cathode electrodes facing said viewing window and being adapted to glow when a voltage is applied between any one of them and said anode, and a filling of an ionizable gas in said envelope at a pressure capable of sustaining a cathode glow discharge for establishing a glow indication along the surface of a cathode, said filling including a heavy molecular weight gas for preventing sputtering of cathode material onto other tube parts.

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13. The tube defined in claim 12 wherein said heavy molecular weight gas for preventing sputtering is a monatomic gas having a relatively large atomic weight whereby it prevents the ions of said ionizable gas from bombarding said cathodes with such energy that cathode metal is caused to sputter away from the cathodes onto other tube parts.

14. A cold cathode gaseous indicator tube comprising an envelope having a viewing window therein, a cathode glow indicator electrode in the form of a character, said cathode electrode having a pair of oppositely disposed mounting means, a lead wire secured to said cathode, support means engaging said mounting means for supporting said electrode facing said window, and shield means proximately disposed with respect to said cathode indicator electrode, said shield means having a portion interposed between said indicator electrode and said lead wire, a gas filling in said envelope at a pressure capable of sustaining a cathode glow discharge for establishing a glow indication along the surface of a cathode, and a quantity of mercury added to said gas filling to substantially prevent sputtering of said cathode electrode.

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