United States Patent [19]

Yanagisawa et al.

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[45] **Nov. 4, 1975**

[54] **MULTI-POSITION INDICATOR DISPLAY TUBE**

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[73] Assignee: **Sony Corporation,** Tokyo, Japan

[22] Filed: **July 23, 1973**

[21] Appl. No.: **381,796**

Related U.S. Application Data

[60] Division of Ser. No. 365,334, June 4, 1973, abandoned, which is a continuation of Ser. No. 177,990, Sept. 7, 1971, abandoned.

[30] **Foreign Application Priority Data**

Sept. 11, 1970 Japan 45-80378

[52] **U.S. Cl.** **313/519;** 313/190; 313/217; 313/218

[51] **Int. Cl.²** **H01J 61/067;** H01J 61/66

[58] **Field of Search** ..... 313/517, 519, 190, 218, 313/217; 315/169 R, 169 TV

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Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

An indicator display tube in which indicator electrode units, each consisting of anode and cathode segments, lie in the same plane and in which all of the cathode segments are simultaneously energized and the anode segments are energized on a time sequential basis in such a manner that only the indicator electrode unit having its anode segments energized will glow at a particular time. The cathode segments of each indicator unit are connected in parallel. The indicator display tube has barrier segments for preventing accidental discharge of adjacent indicator electrode units which would produce erroneous message displays. At least the cathode but preferably all of the segments are formed of a silver paste coated with nickel. The base material on which the silver paste is coated is glass. This arrangement prevents sputtering.

3 Claims, 10 Drawing Figures

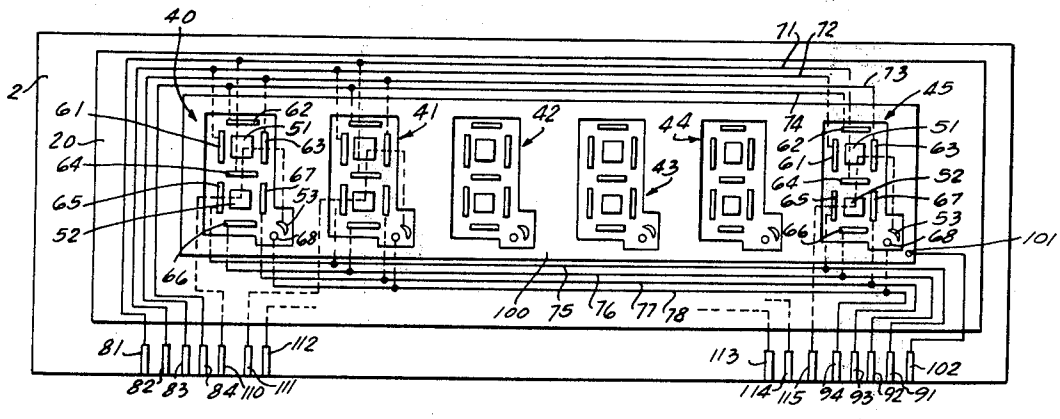


Fig. 1

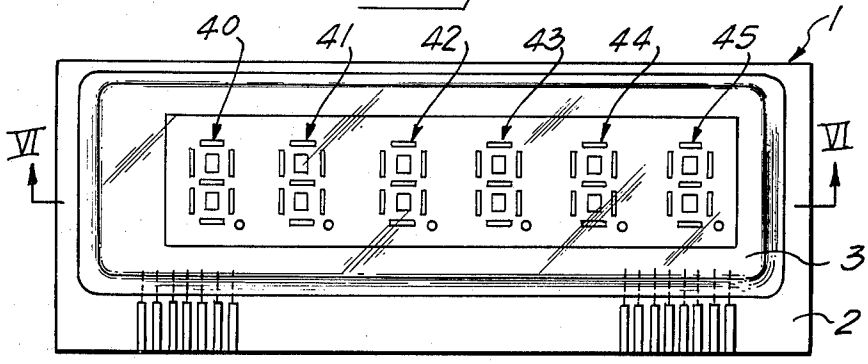


Fig. 2

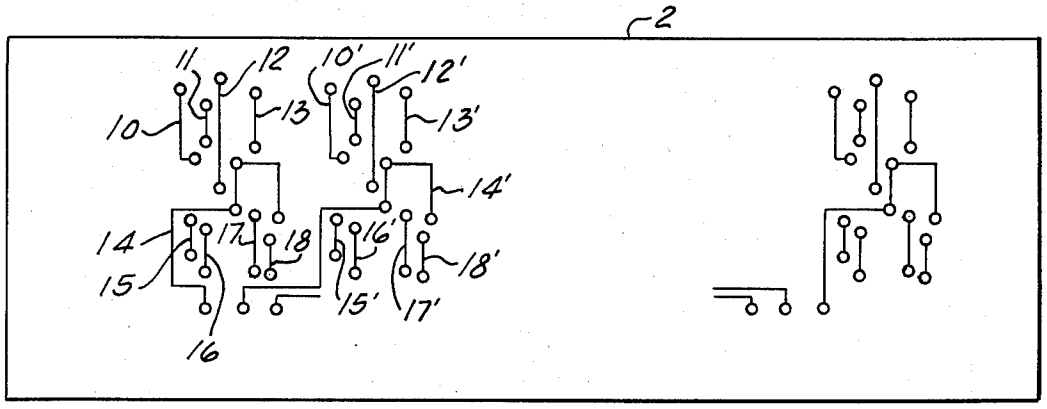
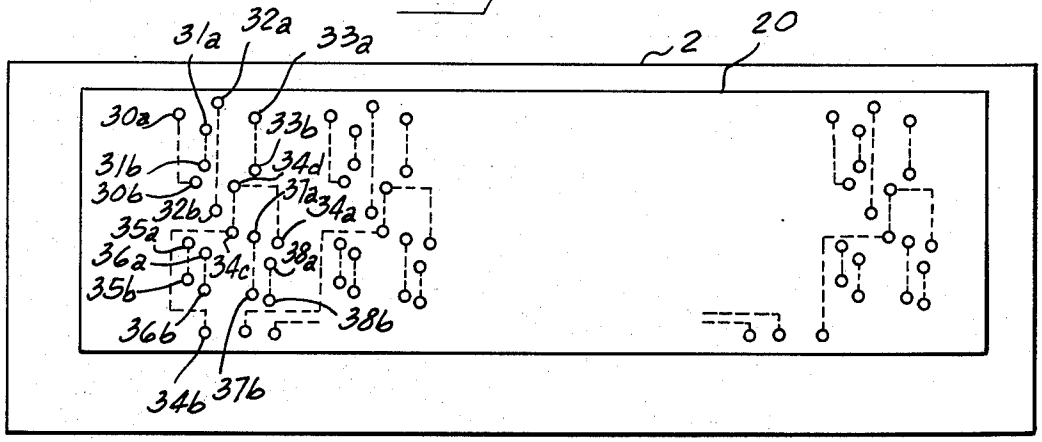


Fig. 3



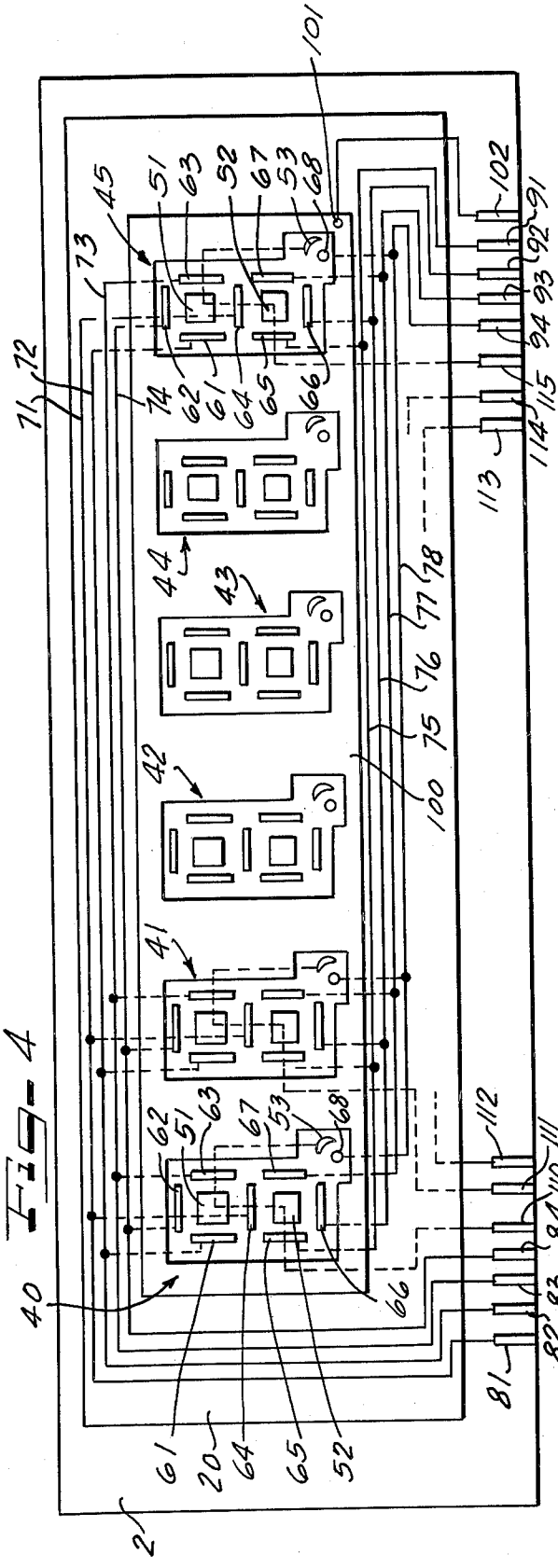


Fig. 4

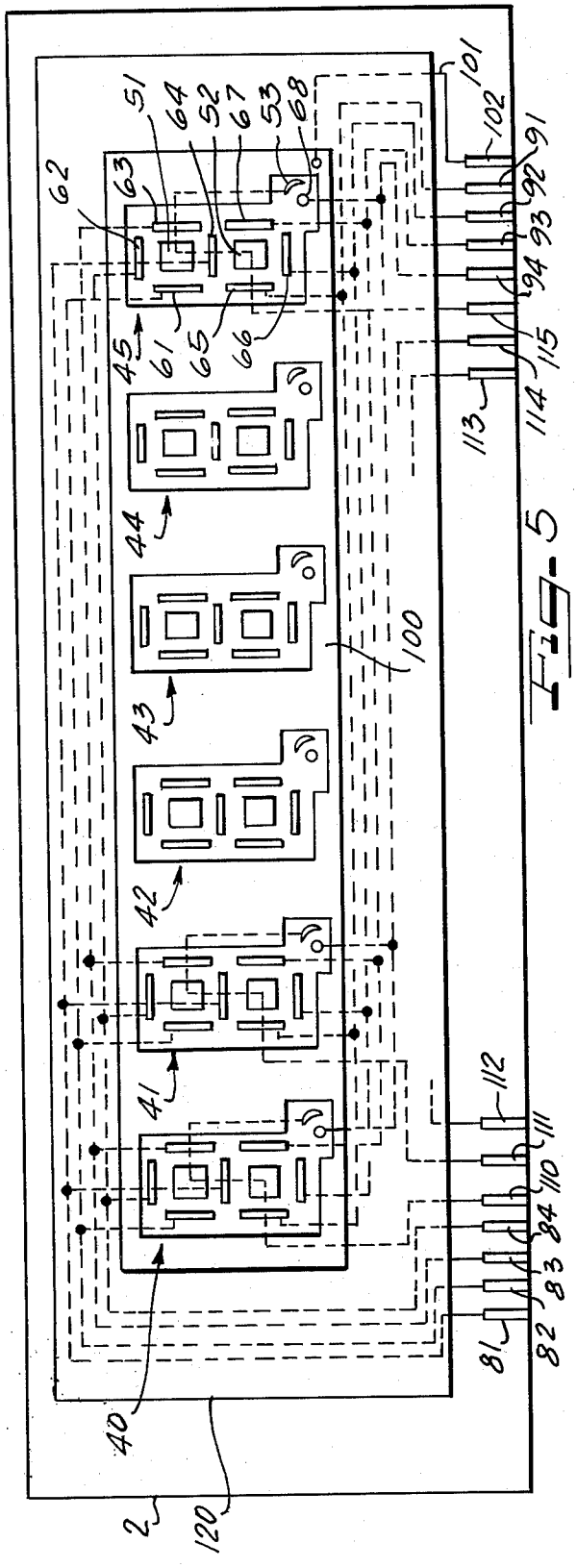


Fig. 5

Fig. 6

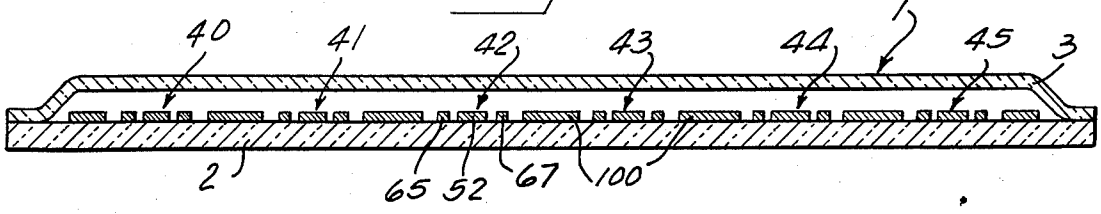


Fig. 7

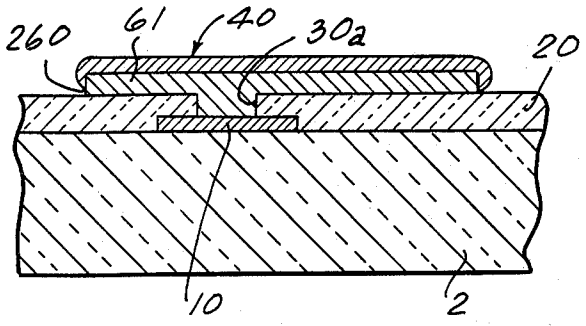


Fig. 8

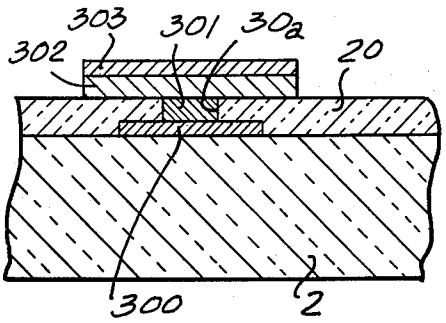


Fig. 9

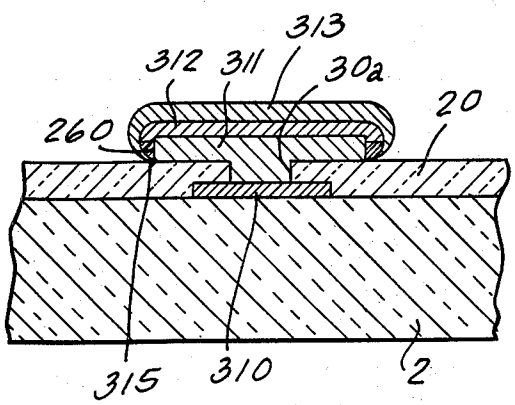
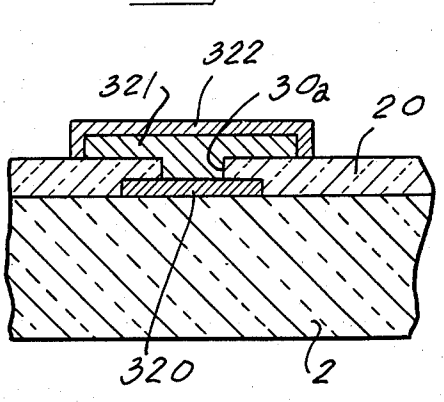


Fig. 10



MULTI-POSITION INDICATOR DISPLAY TUBE

This application is a division of our copending application, U.S. Pat. Ser. No. **365,334,** filed June **4, 1973,** and which in turn was a continuation of our application U.S. Pat. Ser. No. **177,990,** filed Sept. **7, 1971,** now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to an indicator display tube and, in particular, to a novel indicator display tube and to a method for making it.

2. Description of the Prior Art

Generally, indicator display tubes, which are of the type including a plurality of indicator units mounted inside a transparent envelope for displaying numerals, symbols, letters or the like, have been used with electronic counters and other various indicating devices.

U.S. Pat. Ser. No. **3,588,571** discloses an indicator display tube of the type having a plurality of indicator units, each consisting of an anode and a plurality of cathode segments, formed on an insulating plate with the cathode segments in each unit connected in common to those in the other units and connected to common energizing leads but in which the anodes are connected to separate energizing leads which are led out of the envelope. This indicator display tube has advantages in that the number of the leads required is smaller than that of the earlier prior art tubes.

SUMMARY OF THE INVENTION

The present invention relates to a particular structure for the cathode, anode, and barrier segments of an indicator display tube, which indicator display tube is of the type having a number of indicator units whose anode and cathode segments are formed in a common plane, and which additionally includes barrier segments to prevent accidental discharges. The structure of the cathode, anode and barrier segments is in the form of a silver paste formed on a glass base, and which silver paste is coated with nickel to prevent sputtering. It is preferable that at least the cathode segments of the unit be formed in this manner.

It is an object of the present invention to provide a novel indicator display tube having long life, and in which any sputtering from the surface of the electrodes is substantially reduced.

Other objects, features and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view schematically illustrating an indicator display tube having novel electrode structure of the present invention;

FIG. **2** is a plan view of the backing plate with a plurality of interconnecting leads formed thereon;

FIG. **3** is a plan view of the backing plate of FIG. **2** with an insulating layer formed over the interconnecting leads;

FIG. **4** is a plan view of the backing plate of FIG. **3** with a plurality of indicating units and selecting leads formed over the insulating layer;

FIG. **5** is a plan view of the backing plate of FIG. **4** with an insulating layer formed thereon;

FIG. **6** is a sectional view taken on line VI—VI of FIG. **1**;

FIG. **7** is an enlarged fragmentary sectional view of the backing plate of FIG. **5**; and

FIGS. **8, 9** and **10** are sectional views, similar to FIG. **7**, showing other modified forms of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1** there is illustrated generally one example of a gaseous glow type indicator display tube **1** produced according to this invention. The indicator display tube **1** is made up of a base plate **2** of an insulating material as, for example, glass. A plurality of indicator units **40,** 41, 42, 43, 44, and **45,** of the same pattern are formed by printing techniques on the base plate **2** in alignment with one another and a transparent cover plate **3,** as of glass, is attached at its periphery in an air-tight manner to a glass base plate **2** and its center is spaced a predetermined distance from the indicator units.

One form of structure in which the present invention may be embodied is disclosed in FIGS. **2** to **6.** Here there is shown an enlarged plan view of the base plate **2** and illustrates a plurality of interconnecting leads **10** to **18** which are formed on the insulating base plate **2** by suitable thin film techniques such as, for example, by printing. It is to be particularly noted that the interconnecting leads **10** to **18** are grouped so that they will align with indicator units to be formed above a particular group. Thus, the interconnecting leads for the first indicator unit are designated by numerals **10** to **18** and the interconnected leads for the second unit are designated by numerals **10′** to **18′**. The interconnecting leads are formed of silver paste which adheres well to the glass base plate **2.**

After the interconnecting leads are formed by printed circuit techniques on the base plate **2,** the plate and leads are baked to provide suitable bonding.

It is to be realized that the lengths of the interconnecting leads **10** to **18** are such that they will be capable of interconnecting the cathode and anode elements of the indicator units to suitable selecting leads as will become more apparent in the description.

FIG. **3** is a plan view of the base plate **2** in which a glass insulating layer **20** has been deposited on the base plate **2** so as to cover a substantial portion of the interconnecting leads **10** to **18.** The insulating layer **20** may be formed by a glass coating method by applying glass coating by spraying two or three times and then by drying it to provide it with a suitable insulating coating **20** over the interconnecting leads.

Windows are formed in the insulating layer **20** at opposite ends at each of the interconnecting leads **10** to **18** so as to allow electrical conducting paths to be formed through the insulating layer **20** to the interconnecting leads **10** to **18.** For example, windows **30*a*** and **30*b*** are formed through the insulating layer **20** at opposite ends of the interconnecting lead **10.** Windows **31*a*** and **31*b*** are formed at opposite ends of the interconnecting lead **11** and additional windows **32*a*** and **32*b*** through **38*a*** and **38*b*** are respectively formed at opposite ends of leads **12** to **18.** Additional windows intermediate the ends of lead **14** are formed and are designated **34*c*** and **34*d***.

It is to be realized, of course, that the windows formed through the layer **20** are formed for each of the

indicator units although they are only particularly numbered in FIG. 3 for the first indicator unit.

FIG. 4 illustrates the next step of the method of making the indicator unit and illustrates a plurality of indicating units 40 to 45 which are formed on the top of the insulating layer 20.

In the next step, the plurality of indicator units 40 to 45 (the number depending upon the desired number) are formed on the insulating layer 20 and aligned with the windows through the layer 20 so that electrical contact will be made with the interconnecting leads. Each of the indicator units comprises electrically conducting anode segments 51, 52 and 53, as well as an associated plurality of cathode elements 61 to 68. At the same time, a plurality of selecting leads 71 to 78 are formed on the insulating layer 20 with the leads 71 to 74 extending along the top of the indicator units 40 to 45 as shown in FIG. 4 and the selecting leads 75 to 78 extending along the bottom of the indicator units 40 to 45 as shown in FIG. 4. The anode and cathode segments and selecting leads are formed by suitable thin film techniques and are formed so as to align with the windows 30*a* to 38*a* and 30*b* to 30*b* so that electrical connections will be made between the selecting leads 71 to 78 and the anode and cathode segments. The composition of the anode and cathode segments will hereinafter be described in connection with Figures.

A plurality of external leads 81 to 84 are formed on the insulating plate 2 adjacent the lower edge relative to FIG. 4, and are respectively connected to the selecting leads 71 to 74. A plurality of external leads 91 to 94 are respectively connected to the selecting leads 75 to 78 and are formed on the insulating plate 2 along the bottom edge as shown in FIG. 4.

It is to be realized that the indicator units 40 to 45, the selecting leads 71 to 78 and the external leads 81 to 84 and 91 to 94 are formed at the same time by a silk screen process and when the indicator units 40 to 45 and selecting leads 71 to 78 are printed on the insulating layer 20, each of the elements 61 to 68 and 51 to 53 are respectively connected to the associated selecting leads through the windows 30*a* to 38*d* formed in the insulating layer 20. For example, the cathode element 62 is formed so that it aligns with window 21*b* which connects it to one end of the interconnecting lead 11 and the selecting lead 74 is formed over the window 31*a* so that the selecting lead 74 is connected to the cathode segment 62 through the interconnecting lead 11. Simultaneously, all of the corresponding cathode segments 62 of all of the indicator units 40 to 45 are connected to lead 74 through associated windows and thus all of the segments 62 of all of the indicator units are electrically connected together and to the external lead 84. Similarly, all of the cathode segments 61 are connected by interconnecting lead 10 to selecting lead 72 and to external lead 82. All of the cathode segments 63 are connected by interconnecting leads 13 to selecting lead 73 which is connected to external lead 83. Each of the cathode segments 64 is connected by interconnecting lead 12 to selecting lead 71 which is connected to external lead 81. Each of the cathode segments 65 is connected by interconnecting lead 15 to selecting lead 75 and to external lead 91. Each of the cathode segments 66 is connected by interconnecting lead 16 to selecting lead 76 which is connected to external lead 92. Each of the cathode segments 67 is connected by interconnecting lead 17 to selecting lead 77 which is connected to external lead 93. Each of the cathode segments 68 is connected by interconnecting lead 18 to selecting lead 78 which is connected to the external lead 94.

Thus, in the structure defined thus far, the associated cathode segments of all of the indicator units 40 to 45 are electrically connected together and thus can be electrically energized by the eight cathode selecting leads 81 to 84 and 91 to 94. The three anode segments 51, 52 and 53 of each of the indicator units 40 to 45 are interconnected together by the interconnecting lead 14 and a separate external lead is formed along the lower edge of the insulating plate 2 so that the anode segments of each of the indicator units can be individually energized. For example, an external lead 110 is connected to interconnecting lead 14 of the indicator unit 40 which is connected to the anode segments 51, 52 and 53 of the indicator unit 40 and the indicator unit 40 will be energized when the external lead 110 is energized with a selective pattern of the cathode segments.

Likewise, the anode segments of the indicator unit 41 are connected through an interconnecting lead to the external anode lead 111 for the indicator unit 41. An external lead 112 is connected to the associated anode segments of the indicator unit 42 in a similar manner. An external lead 113 is connected to the anode segments of the indicator unit 43 and an external lead 114 is connected to the anode segments of the indicator unit 44. An external lead 115 is connected to the anode segments of the indicator unit 45.

The indicator display tube is adapted to prevent an incorrect message display which is caused by accidental discharge of the indicator units. For this purpose in the illustrated example an auxiliary electrode or barrier segment designated at 100 is utilized. The barrier electrode 100 may be formed around the indicator units 40 to 45 on the insulating layer 20 at the same time as the indicator units and leads and has suitable windows for the indicator units as shown. A lead 101 is also formed on the insulating layer 20 and extends from the barrier electrode 100 to an external lead 102 so that a suitable voltage may be applied. The leads 101 and 102 are formed at the same time that the barrier electrode 100 is formed. The leads, cathode and anode segments and barrier segments are all formed of silver paste coated with nickel which adheres well to the glass insulating layer 20.

As shown in FIG. 5, a second insulating layer 120 of glass is deposited over the selecting leads 71 to 78 and 101 but the indicator units are left uncovered by this second insulating layer 120. In other words, the cathode segments 61 to 68 and the anode segments 51 to 53 of each of the indicator units are left uncovered by the second insulating layer 120. The external leads are also left uncovered by the second insulating layer 120.

After the indicator units are formed on the base plate 2, the cover plate 3 is attached to the base plate 2 as shown in FIG. 6 by suitable cement or other means so as to form a sealed chamber between the base plate 2 and cover plate 3 which encloses the indicator units. The external leads have portions which extend beyond the cover plate 3 on the base plate 2 so that electrical connection can be made.

The anode and cathode segments of the indicator display tube of this invention are formed by plating nickel on silver paste coated on the glass base plate because silver paste has a low firing temperature and adheres

well to the glass base plate. In general, however, silver sputters easily in an atmosphere of a neon, argon or like gas within a discharge tube and for this reason, nickel which does not sputter easily is plated on the silver paste to prevent sputtering.

FIG. 7 is an enlarged fragmentary cross-sectional view of the indicator unit shown in FIG. 5. It can be noted in this figure that nickel has not been deposited in sufficient thickness on the edges 260 of the silver paste layer 61 and there is the possibility that the silver will sputter and cause an incorrect message display or shorten the service life of the indicator display tube.

FIG. 8 schematically illustrates in section one portion of an improved indicator unit which avoids the defect caused by the edges of the silver paste not being covered. In the illustrated example an interconnecting lead 300 connected to a selecting lead is formed of silver paste on the glass base plate 2 and an insulating glass layer 20 of a low melting point is formed on the base plate 2 over the interconnecting lead 300. A window 30*a* is formed in the glass layer 20 at a location corresponding to one portion of the interconnecting lead 300.

Then, nickel is electro-plated in the window 30*a* of the glass layer 20 to form a nickel plated layer 301 therein.

Then a nickel layer 302 about one micron thick is formed by non-electrolytic plating over the entire area of the insulating glass layer 20 including the nickel plated layer 301 and then a nickel layer 303 about 5 to 10 microns in thickness is formed by electroplating over the nickel layer 302.

Then an etching mask layer (not shown) of the same pattern as that of the electrodes to be ultimately formed is deposited on the uppermost nickel layer 303 and the nickel layers 302 and 303 are selectively etched away through the etching mask layer. Thereafter, the etching mask layer is removed. In this manner, electrode segments of a desired pattern are formed on nickel on the glass layer 20 to provide a desired indicator unit.

Thus, the cathode and anode segments are all formed of nickel, and hence will resist sputtering and will withstand long usage. Also, the lead 300 connected to the electrode segment is formed of silver paste which adheres well to the glass base plate 2 and the mechanical bonding of the electrodes is excellent.

FIG. 9 illustrates another modification of this invention in which an interconnecting lead 310 is formed of silver paste on the glass base plate 2 and an insulating glass layer 20 is formed on the interconnecting lead 310 with one portion of the latter left uncovered to form a window 30*a*. Then, silver paste of the same pattern as an electrode to be ultimately formed is printed by printing techniques on the glass layer 20 including the window 30*a* and is baked to form a sub-structure layer 311 constituting one portion of the electrode segment. The layer 311 and the interconnecting lead 310 are both formed of the same silver paste and they will be firmly joined together mechanically through the window 30*a* in the glass layer 20.

Thereafter, the layer 311 is plated with a copper layer 312, which is then plated with a nickel layer 313. The entire structure is heated to a range of about 350° to 430°C. in an oxidizing atmosphere to oxidize the edge portion 260 of the copper layer 312 to which the nickel plated layer 313 has difficulty in adhering and a copper oxide layer 315 such as Cu_2O, CuO will be formed to form the desired electrode.

With such an arrangement, the upper surfaces of the silver paste layer constituting the cathode or anode segment are covered by the nickel layer 313 over the copper layer 312 and the peripheral edge portion 260 is covered by the copper oxide layer 315, so that sputtering of the silver paste will be completely prevented.

FIG. 10 shows a further modification of the invention in which an interconnecting lead 320 is formed of silver paste on the glass base plate 2 and an insulating glass layer 20 is formed over the base 2 and has a window 30*a* to expose one portion of the interconnecting lead 320. Then, a platinum paste layer 321 of a predetermined pattern is printed by printing techniques on the insulating glass layer 20 and over the window 30*a* and the entire structure is baked. A nickel layer 322 is then plated onto the platinum paste layer 321 to provide desired cathode and anode segments.

The platinum paste has a baking temperature of about 560°C. and adheres well to glass.

With the above arrangement, the sub-structures of the cathode and anode segments are formed of platinum which does not sputter and the electrode segments will have long life.

Furthermore, in order to prevent oxidation of the surface of anode segments, a precious metal, for example, platinum or gold, may be used for anode segments. For this purpose, the cathode segments may be formed by plating nickel on silver paste as described above.

It will be apparent that many modifications and variations may be effected without departing from the spirit and scope of the novel concepts of this invention.

We claim:

1. An indicator display tube comprising:
a plate of an insulating material;
a plurality of interconnecting leads formed on said plate;
a first insulating layer formed on said plate over said plurality of interconnecting leads with windows aligned with said interconnecting leads;
a plurality of indicator units formed on said first insulating layer and each consisting of a number of strip conductive elements and a plurality of selecting leads on said first insulating layer with said indicator units and said selecting leads connected to corresponding ones of said interconnecting leads through said windows respectively; certain of said strip conductive elements comprising cathode gaseous discharge sustaining display electrodes and others of said strip conductive elements comprising anode gaseous discharge sustaining and counter electrodes;
barrier means of electrically conductive material formed on said first insulating layer and formed with openings in which said associated strip conductive elements of said indicator units are mounted;
a second insulating layer formed on said selecting leads;
a transparent cover attached to said plate and forming an envelope for enclosing said indicator units and barrier means;
an ionizable gas sealed in said envelope, said first insulating layer being formed of glass and said strip conductive elements and said selecting leads being formed of silver;

said first insulating layer of glass formed partially over the edges of said strip conductive elements to leave a portion thereof uncovered, a first layer of nickel deposited over said uncovered portions of said conductive elements, and a second layer of nickel formed over said first layer of nickel and extending partially over said first insulating layer of glass.

2. An indicator display tube comprising:

a plate of an insulating material;

a plurality of interconnecting leads formed on said plate;

a first insulating layer formed on said plate over said plurality of interconnecting leads with windows aligned with said interconnecting leads;

a plurality of indicator units formed on said first insulating layer and each consisting of a number of strip conductive elements and a plurality of selecting leads on said first insulating layer with said indicator units and said selecting leads connected to corresponding ones of said interconnecting leads through said windows respectively; certain of said strip conductive elements comprising cathode gaseous discharge sustaining and display electrodes and others of said strip conductive elements comprising anode gaseous discharge sustaining and counter electrodes,

barrier means of electrically conductive material formed on said first insulating layer and formed with openings in which said associated strip conductive elements of said indicator units are mounted;

a second insulating layer formed on said selecting leads;

a transparent cover attached to said plate and forming an envelope for enclosing said indicator units and barrier means;

an ionizable gas sealed in said envelope, said first insulating layer being formed of glass and said strip conductive elements and said selecting leads being formed of silver;

said first insulating layer of glass formed partially over the edges of said strip conductive elements to leave a portion thereof uncovered;

a second layer of silver deposited over said uncovered portions of said strip conductive elements and partially overlying said first insulating layer;

a layer of copper overlying said second layer of silver, and a layer of nickel overlying said second layer of silver and extending to said second insulating layer.

3. An indicator display tube comprising:

a plate of an insulating material;

a plurality of interconnecting leads formed on said plate;

a first insulating layer formed on said plate over said plurality of interconnecting leads with windows aligned with said interconnecting leads;

a plurality of indicator units formed on said first insulating layer and each consisting of a number of strip conductive elements and a plurality of selecting leads on said first insulating layer with said indicator units and said selecting leads connected to corresponding ones of said interconnecting leads through said windows respectively; certain of said strip conductive elements comprising cathode gaseous discharge sustaining and display electrodes and others of said strip conductive elements comprising anode gaseous discharge sustaining and counter electrodes;

barrier means of electrically conductive material formed on said first insulating layer and formed with openings in which said associated strip conductive elements of said indicator units are mounted;

a second insulating layer formed on said selecting leads;

a transparent cover attached to said plate and forming an envelope for enclosing said indicator units and barrier means;

an ionizable gas sealed in said envelope, said first insulating layer being formed of glass and said strip conductive elements and said selecting leads being formed of silver;

said first insulating layer of glass formed partially over the edges of said strip conductive elements to leave a portion thereof uncovered, a layer of platinum overlying said uncovered portions of said conductive elements and extending partially over said first insulating layer of glass, and a coating of nickel overlying said layer of platinum and extending downwardly to said first insulating layer of glass.

* * * * *