United States Patent

Nakada et al.

[15] **3,679,933**

[45] **July 25, 1972**

[54] DISPLAY SYSTEM

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

[22] Filed: **Dec. 22, 1969**

[21] Appl. No.: **886,812**

[30] **Foreign Application Priority Data**

Dec. 23, 1968 Japan.....43/94737

[52] **U.S. Cl.**.....**315/169 TV,** 313/109.5, 315/169 R, 340/336

[51] **Int. Cl.**.....**H05b 37/00**

[58] **Field of Search**.....313/109.5; 315/169, 169 TV; 340/336

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Assistant Examiner—Lawrence J. Dahl

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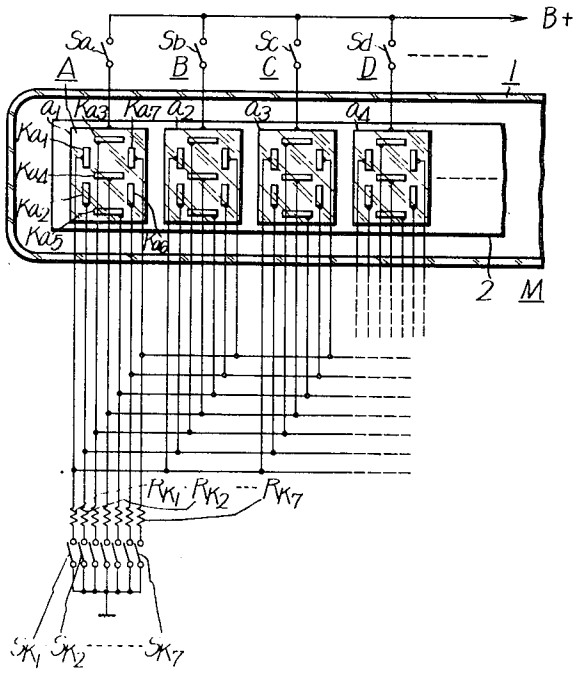
[57] **ABSTRACT**

A display system using a gaseous glow indicator tube having a plurality of indicator electrode units such as seven, for instance, each unit including a plurality of cathodes and having anodes disposed opposite the indicator electrodes. The indicator electrode units and the anodes are contained in an envelope and a driving circuit is provided for selectively feeding current to the indicator electrode units in such a manner that adjacent ones are not caused to glow successively.

8 Claims, 14 Drawing Figures



PATENTED JUL 25 1972

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SHEET 1 OF 6

Fig. 1

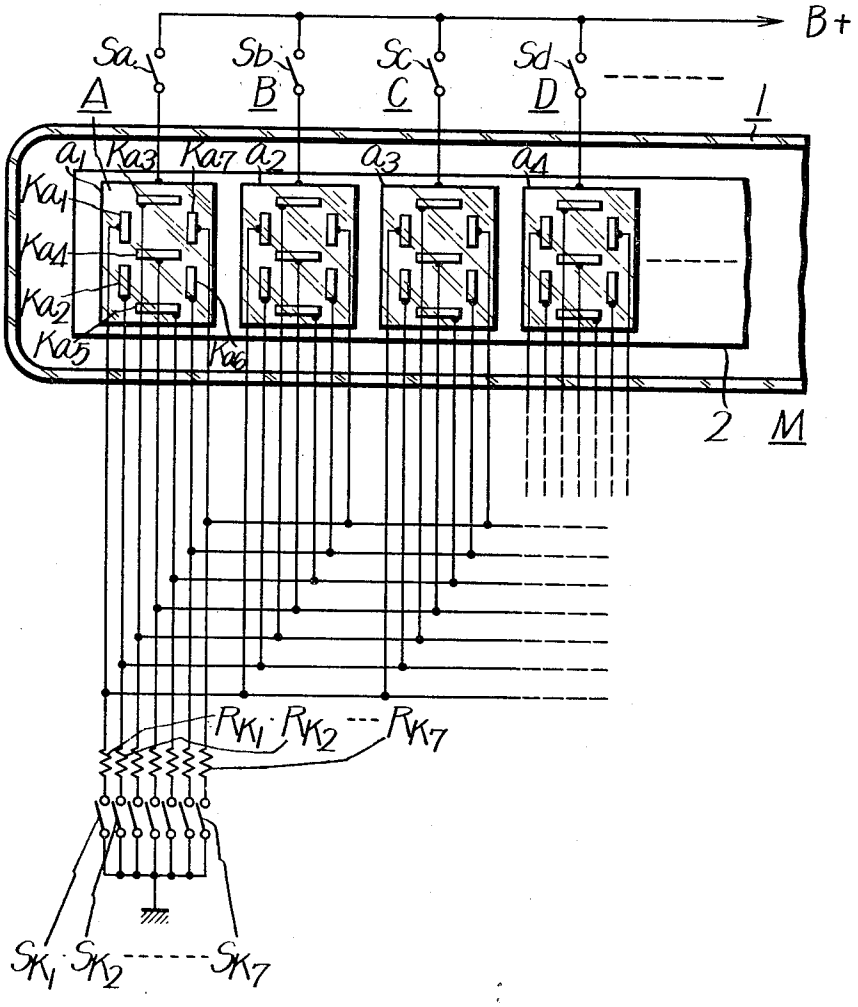

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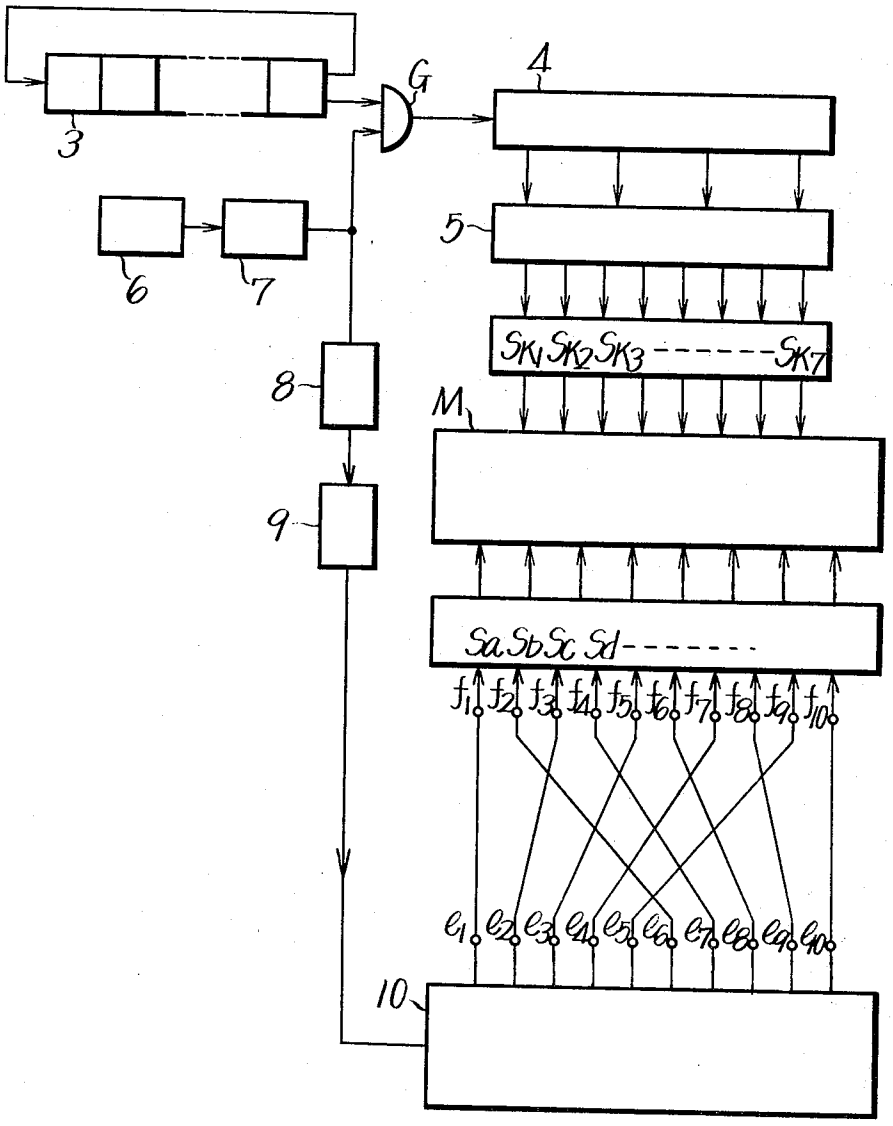
Fig. 2



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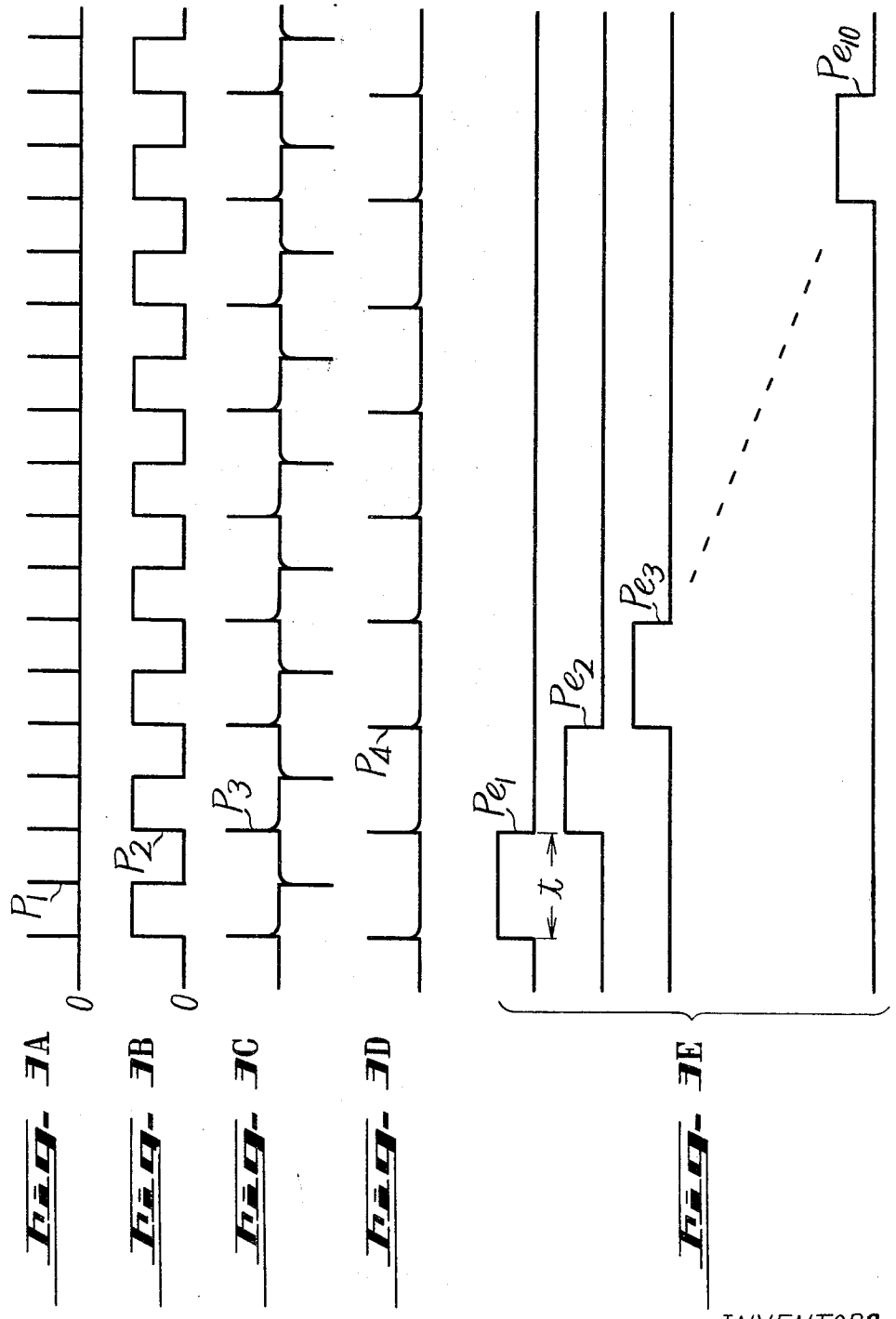

Fig. 3A Fig. 3B Fig. 3C Fig. 3D Fig. 3E

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PATENTED JUL 25 1972

3,679,933

Fig. 4

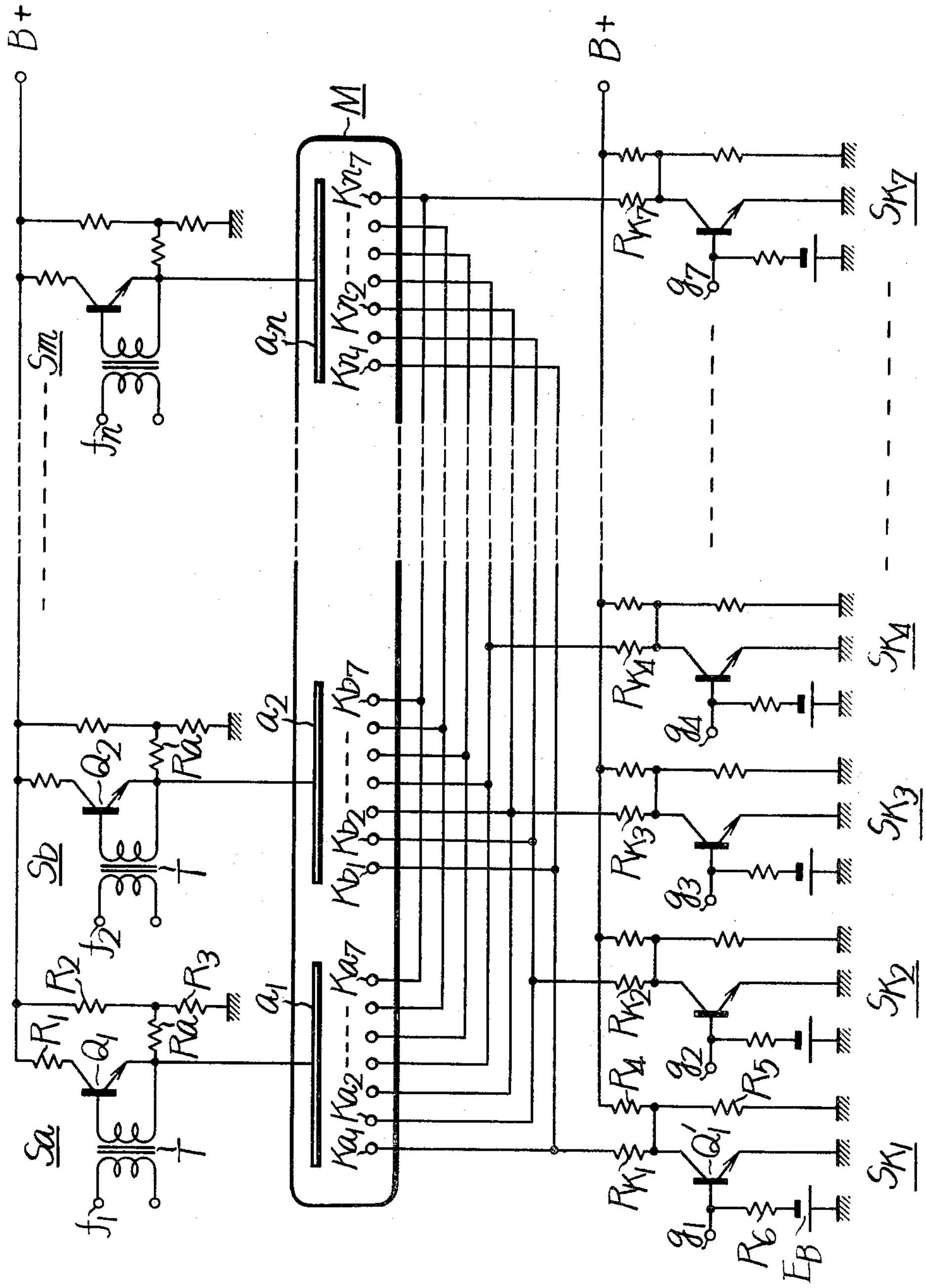

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Fig. 5A

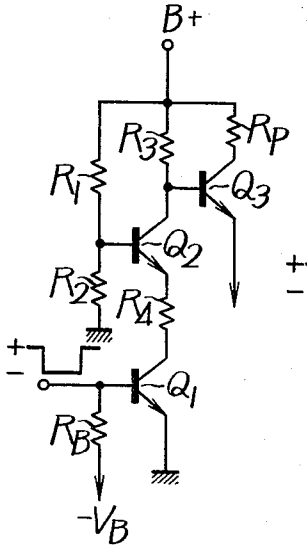

Fig. 5B

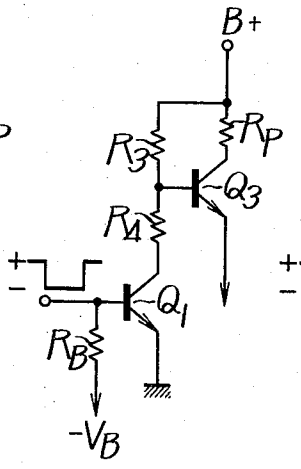

Fig. 5C

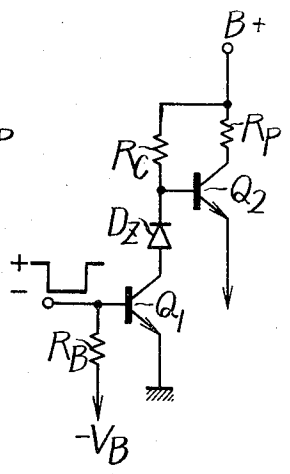

Fig. 6

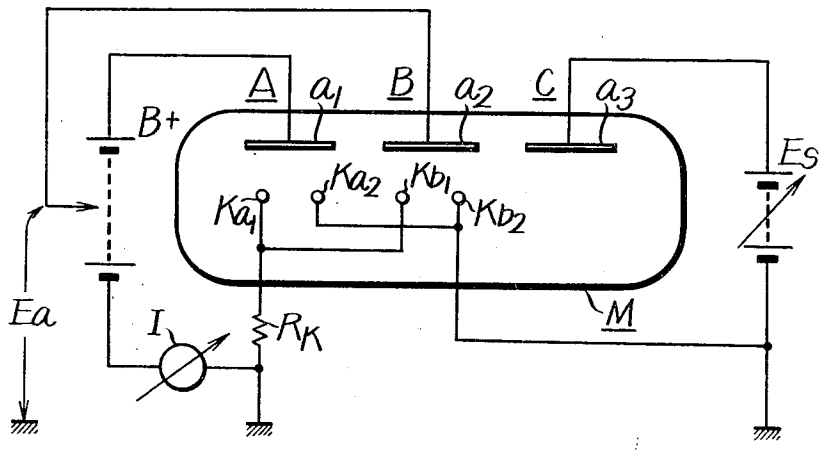

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Fig. 7

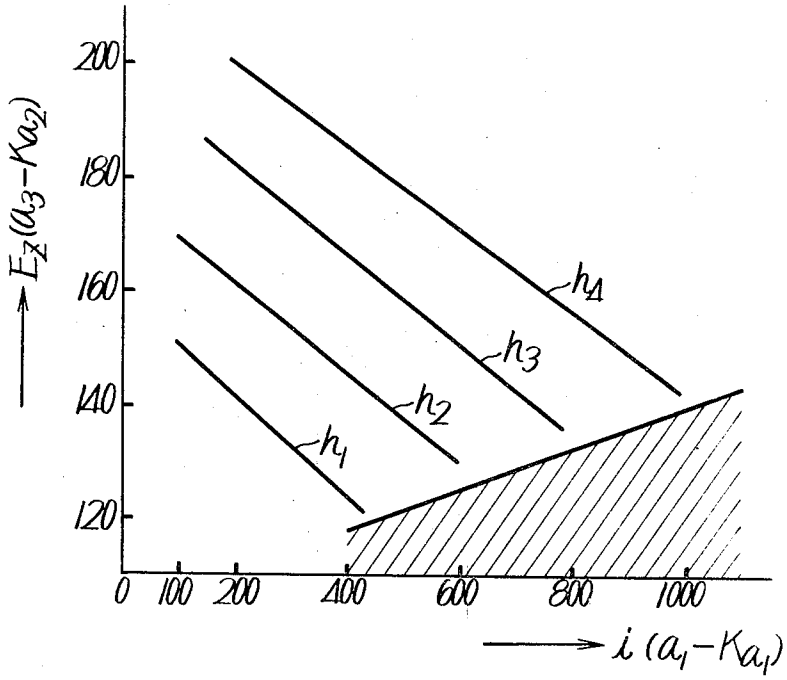
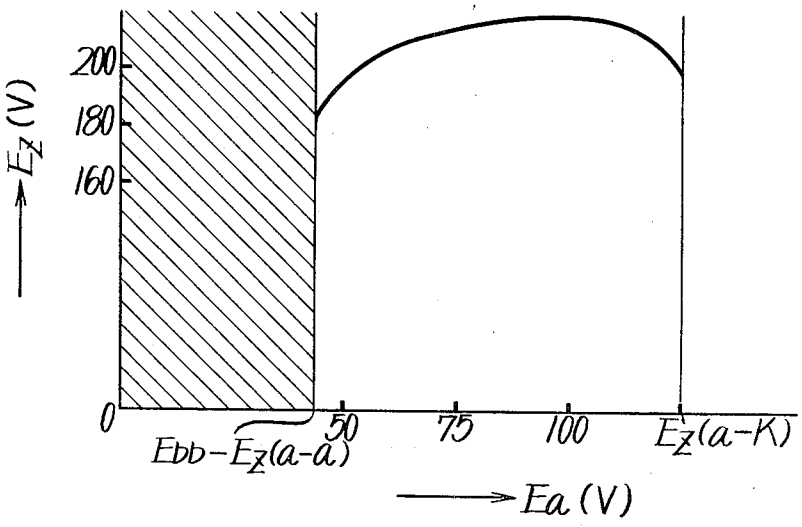


Fig. 8



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DISPLAY SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a display system for driving a gaseous glow indicator tube having a plurality of indicator electrode units mounted in the same envelope.

2. Description of the Prior Art

There has been proposed a gaseous glow indicator tube comprising an envelope containing a plurality of indicator electrode units for providing a display of a number containing a plurality of figures. In the gaseous glow indicator tube, ionized plasma is produced by glow discharge in the envelope, and even after the discharge is stopped, ions are not destroyed and still remain in the vicinity of the discharged indicator electrode units. The presence of the residual ions leads to glow of neighboring electrode units, thus causing a wrong message display. This can be avoided by providing a partition between adjacent indicator electrode units to prevent the influence of the residual ions upon the neighboring electrode units, but this introduces difficulty in the fabrication of indicator tubes.

SUMMARY OF THE INVENTION

Based upon the fact that the residual ions do not move very far before they are destroyed, in the present invention the indicator electrode units are caused to discharge not sequentially but, for example, alternately so as to avoid successive discharge of adjacent electrode units and hence prevent accidental discharge due to the presence of residual ions.

Accordingly, one object of this invention is to provide a display system for gaseous glow indicator tubes which are free from accidental discharge of the indicator electrode units.

Another object of this invention is to provide a display system for gaseous glow indicator tubes of the type having a plurality of indicator electrode units mounted in the same envelope which employs a driving circuit for holding the anode potentials of undischarged ones of the indicator electrode units sufficiently low to prevent accidental discharge.

Still another object of this invention is to provide a display system for gaseous glow indicator tubes of the type having a plurality of indicator electrode units mounted in the same envelope which employs a driving circuit for holding the anode potentials of undischarged ones of the indicator electrode units sufficiently low to prevent accidental discharge and for maintaining the potentials of unused cathodes positive.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic showing one example of an indicator tube to which this invention is applicable;

FIG. 2 is a block diagram illustrating one example of an indicator tube of this invention;

FIGS. 3A–3E are waveform diagrams for explaining the operation of the indicator tube of FIG. 2;

FIG. 4 is a schematic showing one example of the principal part of this invention;

FIGS. 5A, 5B and 5C are schematics illustrating other examples of the principal part of this invention.

FIG. 6 is a schematic showing one example of an experimental device, for explaining the operation of the principal part of this invention; and

FIGS. 7 and 8 are graphs, for explaining the operation of the device depicted in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 there is illustrated one example of a known indicator tube M for displaying a number containing a plurality of figures. Reference numeral 1 indicates a planar glass envelope in which an insulator base plate 2 having mounted thereon a plurality of aligned indicator electrode units A, B, C, D, . . . is

placed and sealed with an ionizable gas suitable for supporting a glow discharge, as for example, argon or neon. The indicator tube M is caused to sequentially display the figures not concurrently but in a time-divisional manner so as to simplify the circuit construction and reduce power consumption of the indicator tube M. In this case the indicator electrode units A, B, C, D, . . . are identical in construction with another.

The indicator electrode unit A, for example, comprises an anode a_1 and a plurality of cathodes Ka_1, Kb_1, Kc_1, . . . Kg_1 arranged in the form of a number "8" on the base plate 2 in a predetermined spaced relation to the anode a_1. The anodes a_1, a_2, a_3, a_4, ... of the indicator electrode units A, B, C, D, . . . are respectively connected to an anode power source B+ through control switches Sa, Sb, Sc, . . . Sn. Further, the cathodes Ka_1 to Kn_1, Ka_2 to Kn_2, Ka_3 to Kn_3 . . . of the indicator electrode units A, B, C, D, . . . are respectively connected together and are grounded through discharge ballast resistors Rk_1 to Rk_7 and selector switches Sk_1 to Sk_7.

When the selector switches, for example, Sk_2, Sk_3, Sk_4, Sk_5 and Sk_7 are closed so as to display the number "2," those cathodes of each indicator electrode unit which correspond to the pattern "2" are grounded, and any of the control switches Sa, Sb, Sc, Sd, . . . is closed to light the indicator electrode unit supplied with the anode voltage through the control switch selectively closed, thus providing a display of the number "2."

Under such conditions, if the control switches Sa, Sb, Sc, Sd, . . . Sn are sequentially actuated, all the indicator electrode units sequentially display the number "2." Further, it is possible to cause the indicator electrode units A, B, C, D, . . . to display a number containing a plurality of different figures in a time-divisional manner by altering the selected condition of the selector switches Sk_1 to Sk_7 in such a manner that the indicator electrode unit, for example, B is caused to display the number "3," while the control switches Sa to Sn are changed over one after another, that is, during the intervals between the closings of the switches Sa and Sb, for example. In the event the indicator electrode unit A displays the number "2" and then the unit B displays the number "3," there occurs the so-called crosstalk phenomenon such that the number "2" displayed by the unit A is lightly superimposed with the number "3" displayed by the unit B.

To avoid this, there has been proposed that partition walls be provided between adjacent indicator electrode units. However, providing partitions introduces difficulty in the placement of the insulator base plate 2 with the cathodes mounted thereon into the envelope 1.

In view of the foregoing, this invention provides a driving circuit for the indicator tube which avoids the crosstalk phenomenon without requiring partition walls.

In accordance with the present invention the indicator electrode units A, B, C, D are caused to glow at least alternately in a time-divisional manner. In order to light every other indicator electrode unit, the display system of the indicator tube may be constructed as shown in FIG. 2, which illustrates one example of this invention as applied to the display device of an electronic computer.

Reference numeral 3 indicates a shift register for memorizing a display output of the computer, the output of the shift resistor 3 being supplied to a buffer 4 through a gate circuit G. The output of the buffer 4 is fed to a decoder 5 for converting a binary digit into a code for display, and the selector switches Sk_1 to Sk_7 connected to the cathodes of the indicator tube M are selectively actuated by the output of the decoder 5 to select those cathodes corresponding to a number defined by the operated output of the shift register 3.

The gate circuit G is supplied with a switching signal to be switchingly controlled, for example, at four-bit time intervals in the shift register 3. To perform this, a timing pulse generator 6 produces a timing pulse P_1 at four-bit time intervals such as shown in FIG. 3A. The output pulse of the timing pulse generator 6 is applied to a flip-flop circuit 7, and its switching output P_2 (such as depicted in FIG. 3B) is, in turn, supplied to the gate circuit G, thereby permitting the application of the

output of the shift register 3 to the buffer 4 at four-bit time intervals.

When a four-bit signal derived from the shift resistor 3 is fed to the buffer 4, the switching output P_2 of the flip-flop circuit 7 is turned off to close the gate circuit G and hence to inhibit the application of the signal to the buffer 4 from the shift register 3 for a subsequent four-bit time period. Meanwhile, the signal of the preceding four-bit time period is stored in the buffer 4, and in the subsequent four-bit time period, the gate circuit G is opened, the output of the shift resistor 3 is then supplied to the buffer 4. That is, an output of a shift pulse train of the shift register 3 is fed to the buffer 4 at four-bit time intervals to select the cathodes of the indicator tube M in accordance with the output of the buffer 4.

One portion of the output of the flip-flop circuit 7 is applied to a differentiation circuit 8 to derive at its output end a differentiated pulse P_3 such as 3C. The resulting differentiated pulse P_3 is fed to a rectifier circuit 9, at the output end of which is obtained pulse P_4 of one polarity derived from the differentiated pulse P_3. The pulse P_4 is supplied to a shift register 10.

In the event that the indicator tube M has indicator electrode units of 10 figures, the shift register 10 is made up of a decimal shift register from output terminals e_1 to e_{10} of which are sequentially derived shift pulses Pe_1 to Pe_{10}, each having a pulse width of eight-bit time t, as shown in FIG. 3E. The shift pulses Pe_1 to Pe_5 derived at the output terminals e_1 to e_5 of the shift register 10 are respectively applied to odd-number driving signal input terminals f_1, f_3, f_5, f_7 and f_9 of 10 control switches Sa to Sj connected to the cathodes of the indicator tube M, while the shift pulses Pe_6 to Pe_{10} derived at the output terminals e_6 to e_{10} are respectively supplied to even-numbered driving signal input terminals f_2, f_4, f_6, f_8 and f_{10} of the control switches Sa to Sj. Thus, the anodes of the indicator electrode units A to J of the indicator tube M are sequentially but alternately supplied with the anode voltage causing the indicator electrode units A to J to glow alternately in a time-divisional manner. Accordingly, the selector switches Sk_1 to Sk_7 are selectively actuated in synchronism with the shift pulses derived from the shift resistor 3, thus providing a display of a predetermined number.

With such a display system, the indicator electrode units having just ceased to glow and those having started to glow are considerably apart from each other. Consequently, it is possible to alleviate the influence of the residual ions of the ionized plasma caused between the cathodes and anode of the indicator electrode unit previously lighted, thus avoiding the crosstalk phenomenon.

However, such a display system may still be defective in that the crosstalk phenomenon can occur when the anode voltage is increased to provide for increased glow intensity. It has been found that this defect can be removed by supplying the anodes of the indicator electrode units with a bias of lower potential than the anode voltage used to cause the units to glow and by applying a predetermined positive bias to those cathodes which are not selected in accordance with the operated output of the shift register 3. This will hereinbelow be described by way of example with reference to FIG. 4.

In the illustrated example control switches Sa to Sm for supplying an anode voltage to the anodes of the indicator tube M in a predetermined interlaced order are made up of transistors Q_1 to Q_m. Since the switching circuits Sa to Sm are all identical in construction, a description will be made in connection with the switching circuit Sa.

Reference character T indicates a transformer, in which input terminals f_i of its primary winding are supplied with, for example, the shift pulse Pe_1 from the aforementioned binary shift register 10, and its secondary winding is connected at one end to the base of the transistor Q_1 and at the other end to the emitter of the transistor. The emitter is connected to the anode a_1 of the indicator tube M. The collector of the transistor Q_1 is connected to an anode power source B+ through a protective resistor R_1 of a relatively small resistance value, and a series voltage dividing circuit consisting of resistors R_2 and R_3 is interposed between the anode power source B+ and ground and is connected from the connection point of the resistors R_2 and R_3 to the emitter of the transistor Q_1, that is, the anode a_1 of the indicator tube M through a resistor Ra of a high resistance value such as about 1 megohm.

With such an arrangement, when the positive shift pulse Pe_1 is applied to the input terminal f_1 from the output terminal e_1 of the shift register 10, the transistor Q_1 becomes conductive to bias the potential of the anode a_1 of the indicator tube M to that of the anode power source B+, causing the indicator electrode unit A to glow. In the event that no shift pulse Pe_1 is applied to the input terminal f_1, the transistor Q_1 remains non-conductive and its emitter, that is, the anode a_1 of the indicator M, is supplied with a divided voltage from the voltage dividing circuit consisting of the resistors R_2 and R_3. When the indicator electrode units A, B, C, . . . are not caused to glow they are all supplied with the predetermined voltage from the voltage dividing circuit incorporated in each of the switching circuits Sa to Sm, that is, a voltage lower than that of the anode power source B+.

The cathodes of the indicator electrode units corresponding in position to one another are respectively interconnected, and the selector switches Sk_1 to Sk_7 are interposed between the groups of the interconnected cathodes and ground. In the present example, the selector switching circuits Sk_1 to Sk_7 are made up of transistors Q_1' to Q_7' in the same manner as the switching circuits Sa to Sm. Since the switching circuits Sk_1 to Sk_7 are identical in construction with one another, a description will be given of the switching circuit Sk_1.

The emitter of the transistor Q_1' is grounded, and its collector is connected through a resistor Rk_1 to the common connection point of the interconnected cathodes Ka_1 to Kn_1 of the indicator electrode units. A series voltage dividing circuit consisting of resistors R_4 and R_5 is interposed between the anode power source B+ and ground, and the voltage dividing point of the circuit is connected to the collector of the transistor Q_1', that is, the common connection point of the cathodes Ka_1 to Kn_1. Further, the base of the transistor Q_1' is connected to a bias power source E_B through a resistor R_6, if necessary.

Thus, when a selector pulse is applied from the decoder 5 to the base input terminal g_1 of the transistor Q_1', the transistor Q_1' is made conductive to bias the cathodes Ka_1 to Kn_1 of the indicator electrode units A to N to ground potential. In the absence of the selector pulse, a positive bias is supplied to the cathodes Ka_1 to Kn_1 from the voltage dividing circuit made up of the resistors R_4 and R_5. Those cathodes of the indicator electrode units which are selected for displaying a desired number are biased to ground potential, while the other remaining cathodes are supplied with the positive bias voltage.

FIGS. 5A, 5B and 5C illustrate modified forms of the switching circuit incorporated in each anode circuit. In FIG. 5A the switching circuit consists of transistors Q_1, Q_2 and Q_3 of a relatively low reverse voltage, in which the input transistors Q_1 and Q_2 are always held in the on state and the transistor Q_3 is held in the off state. The anode of the indicator electrode unit is connected to the emitter of the transistor Q_3 and is normally supplied with a divided voltage based upon the voltage dividing ratio of the resistors R_3 and R_4 through the base of the transistor Q_3. When a negative control pulse is applied to the base of the input transistor Q_1, the transistors Q_1 and Q_2 are rendered non-conductive, so that the base potential of the transistor Q_3 is biased to that of the anode power source B+ thereby biasing the anode to this potential. In the event that the reverse voltage V_{CEO} of the transistor Q_1 is higher than that of the anode power source B+ in the present example, the resistors R_1 and R_2 and the transistor Q_2 can be omitted, thus forming a simple circuit such as depicted in FIG. 5B.

In FIG. 5C the switching circuit consists of an input transistor Q_1, a Zener diode connected in series to the collector of the transistor Q_1 and a transistor Q_2. A voltage corresponding to the Zener voltage of the Zener diode Dz is normally applied through the base and emitter of the transistor Q_2

to the anode of the indicator electrode unit connected thereto so as to stabilize the bias voltage which is normally impressed on the anode. The switching operation of the illustrated circuit is the same as that described in connection with FIG. 5A.

If the divided voltage of low potential supplied to the anodes of the indicator electrode units held inoperative is taken as *Ea*, *Ea* is selected to satisfy the following condition.

$$Ebb - Ez_{(a-a)} < Ea < Ez_{(a-k)} \quad (1)$$

where *Ebb* is the voltage of the anode power source B+, $Ez_{(a-a)}$ is a voltage for initiating a discharge between the anodes of adjacent indicator electrode units and $Ez_{(a-k)}$ is a voltage for initiating a normal discharge between the anode *a* and the cathode *k* of each indicator electrode unit.

FIG. 6 is a circuit diagram showing one example of an experiment for obtaining the above condition. In this example, the indicator tube M is made up of two indicator electrode units A and B including anodes a_1 and a_2 and two pairs of cathodes Ka_1, Ka_2 and Kb_1, Kb_2 disposed opposite the anodes a_1 and a_2 and an anode a_3 of an indicator electrode unit C. The cathodes are interconnected as previously described, and the aforementioned voltage *Ebb* is impressed between the anode a_1 of the indicator electrode unit A and the cathode Ka_1 disposed opposite thereto through a resistor Rk from an anode power source B+ to cause a discharge between the anode a_1 and the cathode Ka_1. Further, a variable voltage is supplied from a variable intermediate output terminal of the anode power source B+ to the anode a_2 of the indicator electrode unit B adjacent the unit A, by which a variable voltage is applied between the anode a_3 of the unit C and the connection point of the interconnected cathodes Ka_2 and Kb_2 from an auxiliary anode power source Es.

The sealed gas, that is, an inert gas such, for example, as argon, neon or the like in the vicinity of the cathode Ka_1 is ionized by the glow discharge between the anode a_1 and the cathode Ka_1 of the indicator electrode unit A to produce the so-called ionized plasma. Consequently, the cathode Ka_2 adjacent to the cathode Ka_1 is excited to be ready for glow discharge by a relatively low electric field and hence is caused to glow by the electric field impressed between the anode a_3 of the indicator electrode unit C and the cathode Ka_2. In practice, when the indicator electrode unit C is caused to glow immediately subsequent to the completion of the glow of the unit A, the cathode Ka_2 which should be held not to glow is caused to glow by the residual ions in the indicator electrode unit A.

With variations in voltage impressed on the anode a_2 of the indicator electrode unit B positioned midway between the indicator electrode units A and C, the discharge initiating voltage *Ez* causing the crosstalk phenomenon changes as indicated by curves h_1, h_2, h_3 and h_4 in FIG. 7, in which the abscissa represents the variations in the discharge current between the anode a_1 and the cathode Ka_1 of the indicator electrode unit A caused by changing the resistance value of the resistor Rk, and the ordinate represents the voltage applied to the anode a_3 of the indicator electrode unit C. The curves h_1, h_2, h_3 and h_4 respectively show the cases where the voltage, *Ea*, impressed on the anode a_2 is 40V, 60V, 80V and 100V, and the oblique lines indicate the range of discharge of the anode a_3. With a gradual increase in the voltage *Ea* impressed on the anode a_2, the crosstalk discharge between the anodes a_2 and a_3 becomes more difficult to occur, so that the discharge initiating voltage *Ez* between the anode a_3 and the cathode Ka_2 can be increased.

However, when the voltage *Ea* increases to some extent, the ionization of the sealed inert gas is initiated between the anode a_2 and the cathodes Kb_1 and Kb_2 disposed opposite thereto and the crosstalk is likely to occur. Consequently, the voltage has an optimum value such that the crosstalk voltage *Ez* is maximum at a certain voltage as depicted in FIG. 8.

In the present example, where the anode power source voltage *Ebb* is 180V, the discharge initiating voltage $Ez_{(a-1)}$ between the anodes is 130V and the normal discharge initiating voltage $Ez_{(a-k)}$ between the anode and the cathode of each indicator electrode unit is 130V, the crosstalk voltage *Ez* is maximum with the voltage *Ea* being approximately 100V. Under these conditions the crosstalk phenomenon can be substantially inhibited.

In the region covered by the oblique lines in FIG. 8 wherein the bias voltage *Ea* impressed on the anodes a_2 is smaller than the difference between the discharge initiating voltage $Ez_{(a-a)}$ between the anodes of adjacent indicator electrode units and the anode power source voltage *Ebb*, the crosstalk generating voltage *Ez* cannot be measured. As has been described above, in the present example the indicator electrode units are alternately caused to glow and, in addition, the anodes of the indicator electrode units which are not caused to glow are supplied with the bias voltage *Ea* of lower potential than the normal discharge voltage of the indicator electrode units, thereby ensuring to avoid the crosstalk phenomenon.

Consequently, this arrangement prevents crosstalk between adjacent indicator electrode units and permits stable time-divisional display without requiring mechanical protective means such as partition walls between adjacent indicator electrode units. Further, this allows ease in the fabrication of the indicator tube.

With an increase in the bias voltage *Ea* supplied to the anodes of the indicator electrode units which are not caused to glow, the crosstalk phenomenon can be prevented with more ease, so that the bias voltage Ea can be increased, by supplying a positive bias voltage to cathodes which are not selected at that time. In other words, the application of a positive bias voltage to those cathodes causes an increase in their mean potential, so that even if the bias voltage *Ea* applied to the anodes opposing those cathodes is increased, it can be held within the range of the discharge initiating voltage $Ez_{(a-a)}$ between the cathodes and the anodes, thereby further avoiding the crosstalk phenomenon.

Although the present invention has been described as being applied to an indicator tube in which a plurality of cathodes are provided in one plane, the invention is applicable to an indicator tube of the type employing a plurality of cathodes arranged one above another as in the Nixie Tube (Trademark of Sylvania).

We claim as our invention:

1. A display system comprising:
- a gaseous glow multi-unit display indicator tube having an envelope;
- a plurality of aligned indicator electrode units disposed within said envelope, each of said indicator electrode units having a plurality of cathodes and an anode respectively disposed generally opposite the cathodes of each unit;
- means associated with each of said indicator electrode units for applying a voltage bias between its anode and selcted ones of its cathodes; and,
- means for selecting and actuating the voltage applying means of different ones of said indicator electrode units successively in a time divisional manner such that two adjacent units are not actuated in adjacent time intervals.

2. A display system in accordance with claim 1 wherein the cathodes of each of the indicator electrode units are arranged in like geometric patterns.

3. A display system as claimed in claim 2 which includes means for interconnecting corresponding cathodes of each of the indicator electrode units.

4. A display system as claimed in claim 2 wherein the cathodes are arranged substantially in a single plane.

5. A display system as claimed in claim 6 wherein a voltage divider is provided at each of said anodes and having means for being coupled to a power supply, said voltage divider normally applying only a portion of said power supply to said anodes, and switching means for causing said voltage divider to apply a larger voltage to said anodes when a signal is received from said drive means.

6. A display system comprising:
- a gaseous glow-unit indicator tube having an envelope;
- a plurality of aligned indicator electrode units disposed within said envelope, each of said indicator electrode

units having a plurality of cathodes and an anode respectively disposed generally opposite the cathodes of each unit;

circuit means for supplying current from said anode to associated ones of said cathodes;

means for switchably coupling selected ones of said cathodes to said circuit means to cause a desired figure display from one of said indicator electrode units; and,

drive means for successively supplying a source of voltage to one of said anodes and to the other anodes on a time sequential basis and such that two adjacent anodes are not actuated in adjacent time intervals through said circuit means.

7. A display system comprising:

a gaseous glow multi-unit indicator tube having an envelope;

a plurality of aligned indicator electrode units disposed within said envelope, each of said indicator electrode units having a plurality of cathodes and an anode respectively disposed generally opposite the cathodes of each unit;

circuit means for supplying current from said anode to associated ones of said cathodes;

means for switchably coupling certain ones of said cathodes to said circuit means to cause a desired figure display from one of said indicator electrode units; and,

drive means for successively supplying a source of energizing voltage to said anode on a time sequential basis and such that adjacent anodes are not energized in adjacent time intervals by said circuit means whereby adjacent indicator electrode units are prevented from developing a display successively.

8. A display system in accordance with claim 6 which includes means for applying a positive bias voltage to certain ones of said cathodes which are associated with anodes which are not biased by said drive means.

* * * * *