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Doane et al.

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[54] **APPARATUS FOR OPERATING MULTIPLE POSITION DISPLAY TUBES**

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[51] **Int. Cl.**..... **H05b 41/00**, H01j 17/48

[58] **Field of Search**..... 315/167, 168, 169, 169 TV, 315/334, 336; 313/109.5; 340/334, 336

[56] **References Cited**

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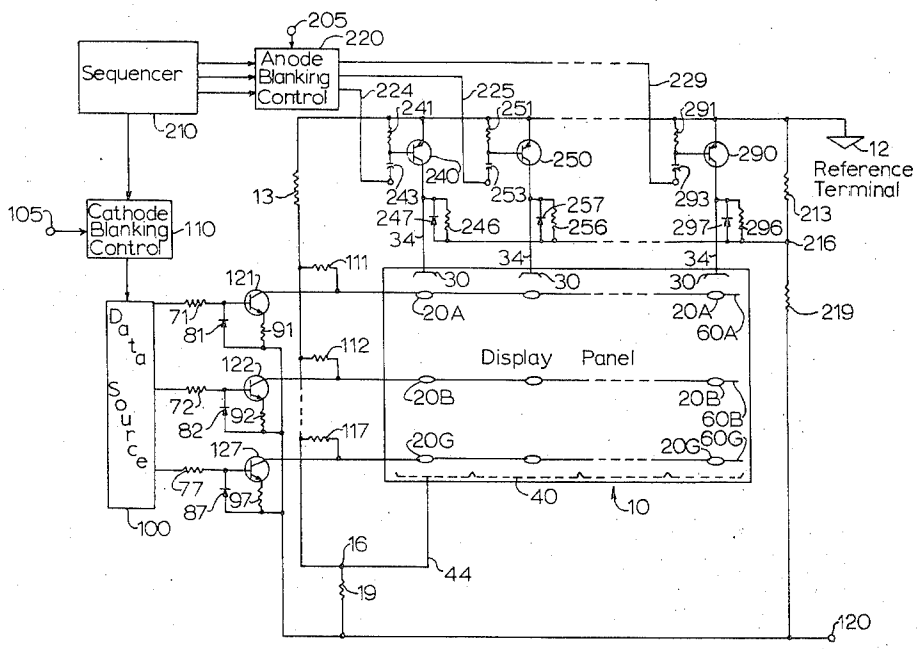
[57] **ABSTRACT**

The apparatus of the invention is adapted for operating multiple position display devices having a plurality of groups of display cathode segments or elements, with corresponding elements electrically interconnected, an anode electrode associated with each group of display segments, and an auxiliary electrode common to all of the groups of electrodes for preventing spurious glow between them. The simplified circuit biases the OFF cathodes from a voltage divider common to them and the auxiliary electrode, thus eliminating separate biasing for the OFF cathodes. The signals applied to the display tube or panel are also blanked during an interval in advance of signal transitions in the device, for inhibiting spurious glow under varying conditions of operation. Voltage divider apparatus also is provided for biasing the OFF anodes in a nonconductive state at a potential proportional to the tube bias potentials.

19 Claims, 4 Drawing Figures



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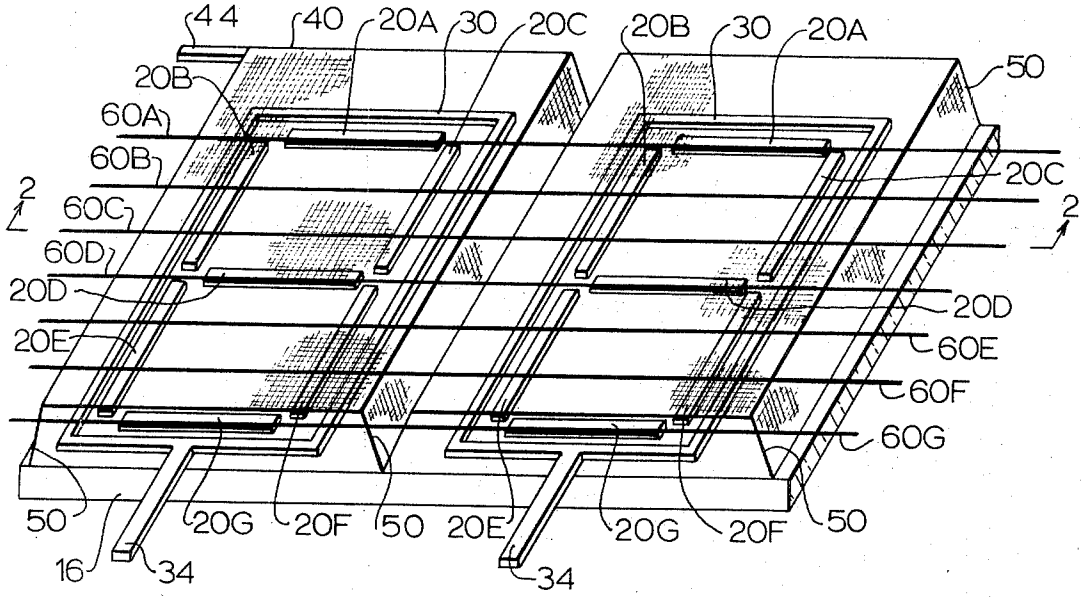
SHEET 1 OF 3

Fig. 1



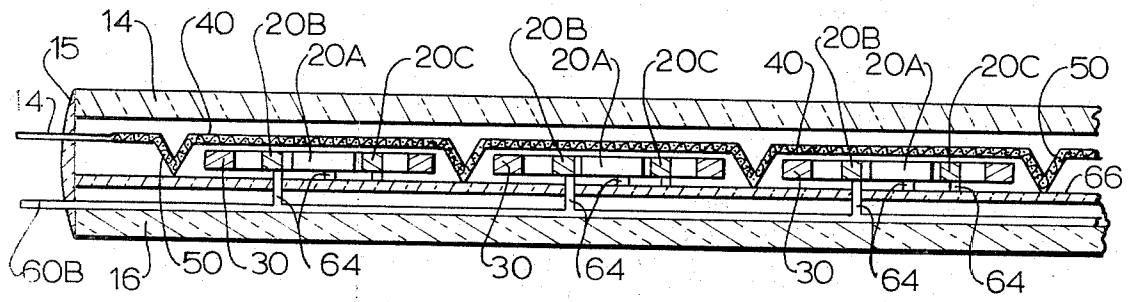


Fig. 2

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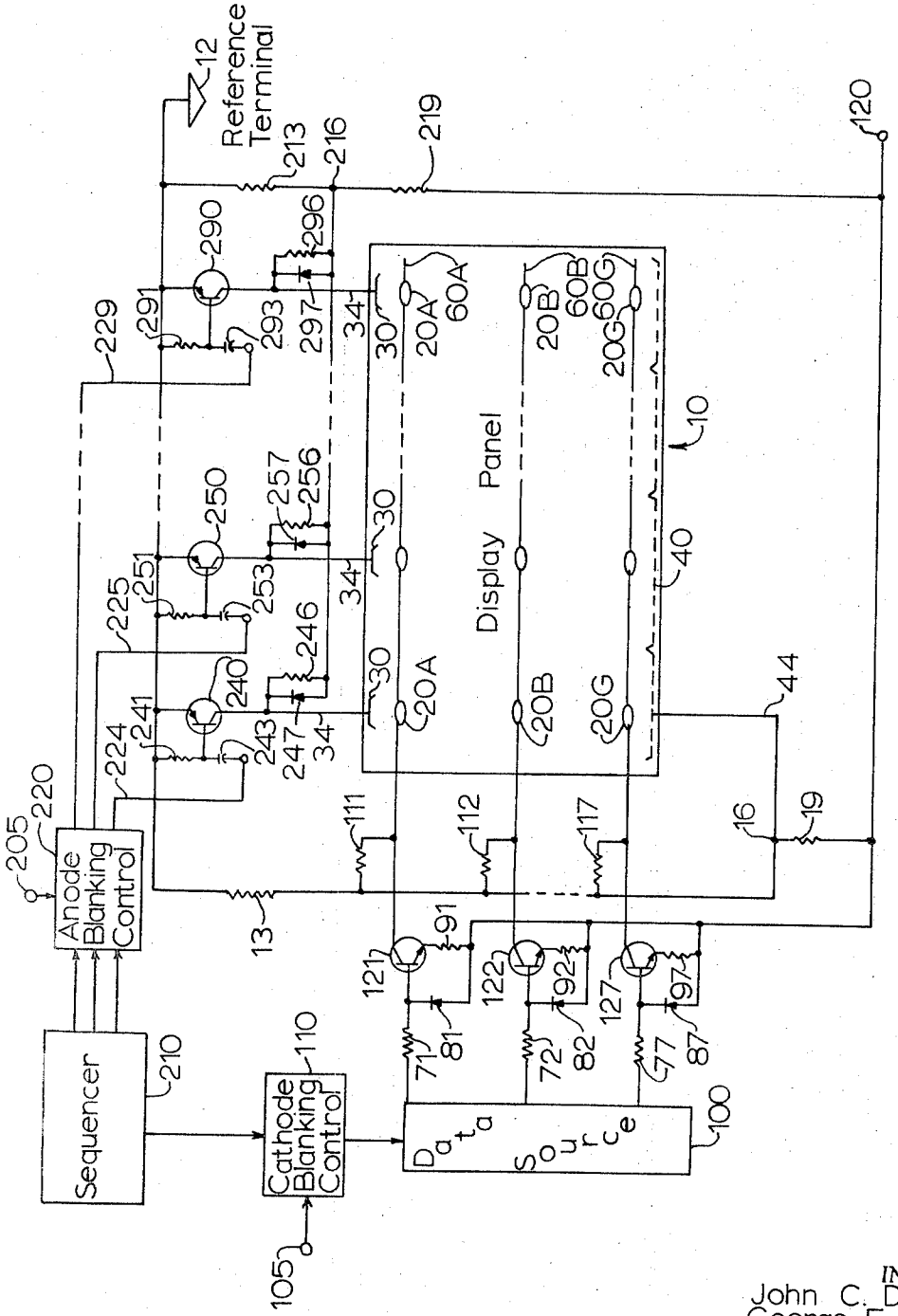

Fig. 3

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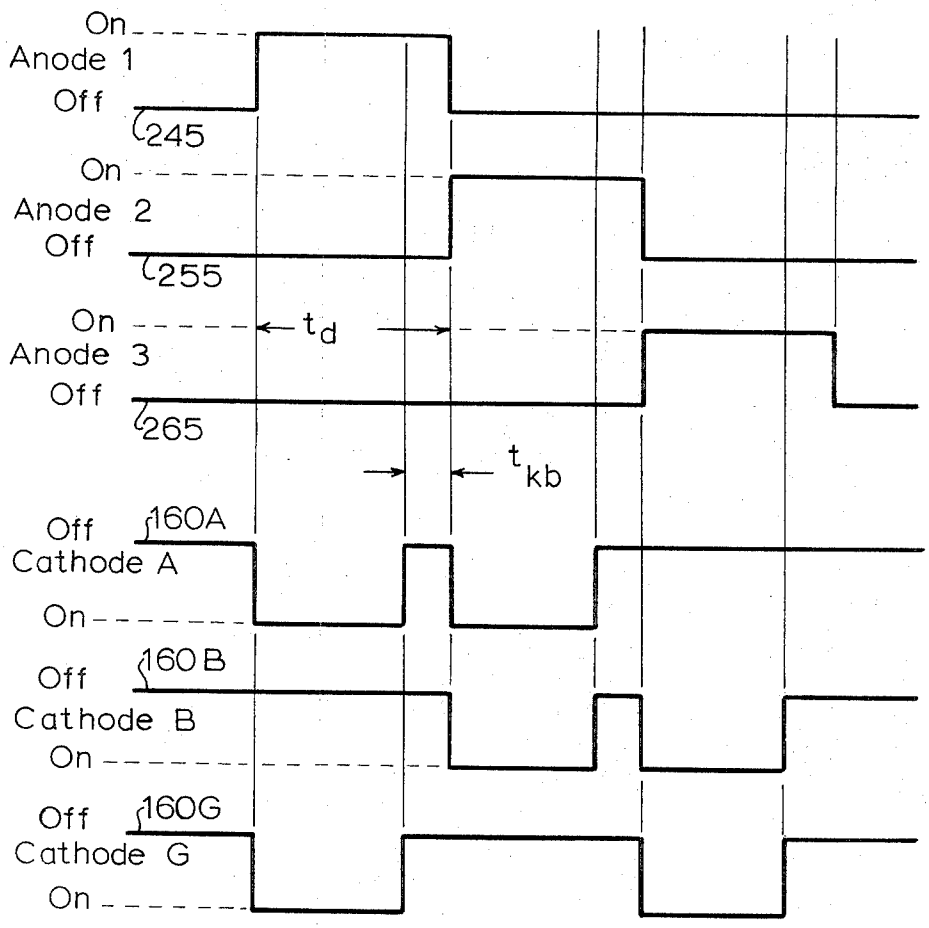
Fig. 4



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APPARATUS FOR OPERATING MULTIPLE POSITION DISPLAY TUBES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of application Ser. No. 126,826, filed Mar. 22, 1971, and now abandoned.

BACKGROUND OF THE INVENTION

The subject invention relates to apparatus for operating multiple position display panels having a plurality of groups of cathode electrode elements or segments for displaying characters side-by-side. Each group of segments has its own anode electrode and corresponding cathode segments in the several groups are connected together to a common terminal. More particularly, the invention relates to improved and simplified apparatus for operating gas discharge display devices having a plurality of groups of interconnected cathode electrode segments positioned in a row.

A multiple is oriented display device of the type described above that is available commercially is known as the PANAPLEX numeric panel display. This display panel includes a plurality of groups of cathode elements which are in the form of elongated bars or segments. Each group of cathodes has its own anode electrode and is oriented in a figure 8 pattern or the like. The various cathodes can be selectively energized, together with a selected anode, to display one or more desired characters on the groups of segments by electrical discharges with the energized anode(s). The electrical discharges in the device ionize the gas and result in cathode glow on the selectively energized segments for displaying the characters.

One type of PANAPLEX panel display includes an auxiliary electrode common to all of the electrode groups which is biased at a potential intermediate the cathode and anode potentials for preventing spurious glow in the device as described and claimed in Harvey, et al., Ser. No. 78,045, filed on Oct. 5, 1970. Under some circumstances, however, spurious glow sometimes develops in an adjacent group of electrodes or between adjacent electrode groups when a particular anode is energized.

These problems are solved satisfactorily in G. E. Holz, et al., U.S. Pat. No. 3,694,693, in G. E. Holz, Ser. No. 87,048, filed Nov. 5, 1970, and in E. L. Harvey, Ser. No. 324,023, filed Jan. 16, 1973. However, under some circumstances or in some modes of operation, such spurious glow still occurs. Extraneous discharges sometimes occur between adjacent positions at the time of signal transition, for example, which result in spurious cathode glow and positive column glow in the device.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to improve and simplify spurious glow suppression in multiple position display devices having interconnected cathode elements or segments.

A further object of the invention is to increase the reliability of apparatus for operating such devices by eliminating uncritical and unreliable components therefrom.

In accordance with these objects, apparatus for operating multiple position display devices is provided including a plurality of individual anode drivers, each coupled to a first reference terminal and voltage dividing means coupled between that potential terminal and a second potential terminal and having a junction point to which the auxiliary electrode is coupled for initial biasing. Also included is a plurality of individual cathode element drivers, the outputs of which are coupled both to the cathode electrodes and to the junction point of the voltage dividing means through suitable impedance means. The value of the impedance means is pre-adjusted for initially biasing the OFF cathodes at an appropriate potential as well as for drawing sufficient current, when energized, to adjust the glow suppression potential on the auxiliary electrode responsive to the number of cathode elements being energized.

Also provided is means for blanking the signals applied to the cathode electrodes during an interval in advance of signal transitions on the anode and cathode electrodes in the device. Voltage dividing means coupled between the two reference potential terminals is also provided for biasing the OFF anode at a nonoperative level when not energized.

DESCRIPTION OF THE DRAWINGS

Other advantages and features of the invention will be made clear in the following description wherein:

FIG. 1 is an isometric view of a segmented cathode display tube having individual anodes and an auxiliary electrode adapted to be operated by the present apparatus;

FIG. 2 is an elevational view of a longitudinal section of the display tube or panel of FIG. 1;

FIG. 3 is an electrical schematic diagram of apparatus suitable to implement the present invention; and

FIG. 4 is a timing diagram illustrating the desired timing and blanking intervals in the device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principles of the invention are particularly applicable to operation of the type of display device described and claimed in the above-mentioned Harvey, et al patent application. Reference is made to that application for a detailed description of the device. Only portions of such a device are illustrated in the present drawings. Display device 10 includes a gas-filled envelope having a base plate 16 and a face plate 14 (FIG. 2). The envelope contains a plurality of groups of cathode segments 20 (A,B,C,D,E,F,G) and an anode electrode 30 for each group. In this type of device, the cathodes are segments or bars arrayed in the form of a figure 8, as is well known in the art. Additional segments could also be included, together with decimal points and commas or the like, if desired. Cathode elements shaped in the form of symbols might also be incorporated.

For purposes of illustration, the anode electrode 30 for each group of cathodes is shown as a metal ring surrounding each cathode group; but it may take any other desired or useful shape. The anodes have leads 34. In addition, the display device 10 includes an auxiliary electrode 40 in the form of a screen which covers all of the groups of cathodes and anodes and includes walls 50 which extend downwardly between each group of electrodes. The screen 40 has a lead 44.

In actual construction, a common cathode connector **60** (A,B,C,D,E,F,G) is provided for the corresponding cathodes in each group of segments so that connector **60A** is coupled to all cathodes **20A**, connector **60B** is coupled to all cathodes **20B**, etc. The cathodes are secured to their connectors by means of short tabs **64**, and the connectors are suitably supported on base plate **16**. An insulating mica plate **66** or the like (FIG. 2) is positioned between display segments **20** and their connectors **60** both to prevent ionization about the connectors and to shield them from view in case such ionization does occur and cathode glow develops along them.

Briefly, in operation of the tube shown in FIGS. **1** and **2**, drive signals are applied to the cathodes via conductors **60A–60G** in accordance with the input information. Simultaneously, the anodes are energized in turn from left to right, or in any other desired order or sequence via lead **34**, to cause the display segments in the selected groups to exhibit cathode glow. A suitable bias potential intermediate the cathode and anode bias potentials is applied to lead **44** of screen electrode **40** for preventing spurious glow about the cathode segments and between adjacent display positions.

Referring to FIG. **3**, display device **10** and its electrodes are shown schematically in order to simplify the drawing and the description of the apparatus. In addition, only three cathodes **20**(A, B, G) and their corresponding connectors **60**(A, B, G) are shown. The operating circuit includes a separate driver **240, 250, . . . 290** adapted to apply a suitable positive potential to the anodes **30** in turn, responsive to control signals received from a suitable sequencing circuit or device **210** through anode blanking control unit **220** and conductors **224-229**.

The emitters of anode drive transistors **240, 250, . . . 290** are connected to reference terminal **12** and their base-emitter junctions are biased off by resistors **241, 251, . . . 291** connected between the base electrodes and that terminal. The control signals for the anode drivers are coupled through capacitors **243, 253, . . . 293** to their base electrodes. The collectors of the anode drivers are connected directly to the anode leads **34**.

A resistive voltage divider comprising resistors **213** and **219** is connected between reference terminal **12** and cathode bias terminal **120**. The OFF anodes are initially biased in a non-conductive state by the potential on voltage divider junction **216** coupled to the anode leads **34** by resistors **246, 256, . . . 296**. The anodes **30** are clamped in the negative direction by diodes **247, 257, . . . 297** having their cathodes connected to anode leads **34** and their anodes connected to the voltage divider junction. These resistors pull the associated anode down rapidly to is OFF voltage to prevent spurious glow when the cathodes signal change to display the next digit. The diodes clamp the anodes to prevent negative overshoot of their potential when they turn OFF, which can otherwise extinguish residual current to the OFF anode too abruptly and result in positive column discharge to the next energized anode. Alternatively, either diodes **247–297** or resistors **246, 256, . . . 296** connected between the anode leads **34** and voltage divider junction **216** may be eliminated if negative overshoot of the OFF anodes does not result in positive column glow or if rapid pull down of the OFF anodes is not required.

The difference in potential between the OFF anodes and the ON cathodes must be kept below the ionization breakdown potential in the panel. In this invention the potential at voltage divider junction **216**, and hence the OFF anode potential, varies or fluctuates proportional to the tube bias potential between terminals **12** and **120** for preventing spurious discharge with the OFF anodes under varying conditions of operation. Resistor **213** of the voltage divider may be replaced by a Zener diode having its cathode connected to reference terminal **12** and its anode connected to junction **216**, if desired, and still maintain an adequate variation of the bias on the OFF anode electrodes as a direct function of the bias potential between terminals **12** and **120** it has been found.

A separate driver is also provided for each cathode including an NPN transistor **121, 122, . . . 127** having its base or input electrode coupled by resistors **71–77** to a suitable data source **100** of electrical information signals synchronized to the anode control signals by sequencer **210** through cathode blanking control unit **110** having terminal **105** for adjustment of cathode blanking. Such a data source might include a computer and its associated system elements.

The base electrodes of cathode drivers **121–125** are clamped in the negative direction to the cathode bias potential on terminal **120** by diodes **81, 82, . . . 87**. The emitters of the cathode drive transistors are coupled to cathode bias terminal **120** through current-limiting resistors **91, 92, . . . 97** for adjusting the level of the cathode currents in the display panel. The collector of each cathode driver **121–125** is connected to the corresponding segment connector **60**.

A resistive voltage divider comprising resistors **13** and **19** is connected between reference terminal **12** and cathode bias terminal **120**. The lead **44** of auxiliary electrode **40** is connected directly to the junction **16** of voltage divider resistors **13** and **19** and the cathode connectors **60** are each coupled to junction **16** by resistors **111–117**, respectively. The potential on voltage divider junction **16** applies a bias potential to both the auxiliary electrode **40** and the OFF cathodes **20**.

The values of the voltage divider resistors **13** and **19** are preselected to provide a suitable initial biasing potential to the auxiliary electrode **40** between the anode and cathode bias potentials for most effective suppression of spurious glow about the OFF electrodes in the panel.

The values of resistors **111–117** are preselected to satisfy the different requirements of suitably biasing the OFF cathodes and of sufficiently dropping the potential on the auxiliary electrode as more cathodes are energized to maintain effective spurious glow suppression potential on the auxxiliary electrode. The values of resistors **111–117** should be relatively high for biasing the OFF cathodes without excessively shunting cathode driver current of **121–127** away from the display segments **20** when they are activated. The values of resistors **111–117**, conversely, should be relatively lower and closer to the value of voltage divider resistor **19** which they shunt or parallel when cathode drivers **121–127** are operated, for best automatic negative adjustment in the auxiliary electrode potential for most effective spurious glow suppression.

It has been found that the value of the resistors **111–117** can be selected or pre-adjusted to a compromise range between these opposing criteria and still

achieve suitable operation of the device without spurious glow. Enough current can be conducted to the cathode segments **20** and still achieve the desired automatic inverse adjustment of the auxiliary electrode potential as more cathodes are energized.

The tube **10** is operated in the multiplexing mode. In this mode of operation, information signals are applied to each of the cathode input terminals **60** from a suitable data source, and, at the same time, each of the anodes **30** has operating potential applied to it, in turn. As each anode is energized, the appropriate information signals are applied to the cathodes so that, at each position, the proper information is displayed. This mode of operation is well known to those skilled in the art. In the circuit of the invention, as each anode is energized current is conducted by the corresponding cathode driver transistors **121–127** to the cathode connectors **60,** resulting in glow discharge by the cathodes **20.**

In a multiplexed display, it is desirable to use a short blanking interval each time a subsequent digit position is to be energized. This is necessary to prevent the wrong information from being displayed at the next position. The rise and fall times of the cathode and anode waveforms and a possible small skew in the cathode and anode information timing may all be contributing factors to the blanking requirement. This effect can be eliminated by turning off the drivers for a few microseconds during the signal transition period. Besides preventing errors in the information displayed, this blanking interval also increases the effective isolation between adjacent digit positions. This isolation is enhanced by the nature of the gas discharge phenomena itself.

In any gas discharge device the sustaining ionization potential is considerably less than the initial ionization potential. It follows, therefore, that if the anode strobe is immediately transferred from one anode to the next without a blanking interval, the presence of the initial ionization potential at the adjacent anode may tend to sustain the ionization already present in the preceding digit position. Utilization of the blanking interval insures a decay below the sustaining ionization potential at the first digit position before energizing the subsequent digit position.

To achieve this isolation effect the cathode drivers **121–127** are turned OFF prior to anode switching by cathode blanking control unit **110** through data source **100,** subject to a control signal or level applied to terminal **105.** This cathode blanking interval occurs at the beginning of the digit duration. Since drive transistor storage time and stray circuit capacity will delay anode turn off, cathode blanking should be maintained at least for several microseconds after anode switching. This is necessary to prevent extraneous glow on cathode segments, which are energized to form the next digit scanned. Anode blanking control unit **220** having terminal **205** for receiving adjustment control signals is provided if blanking of the anode control signals is desired.

Typical signal waveforms for three representative anodes and for three typical cathodes are illustrated in FIG. **4.** Waveforms **245, 255** and **265** may be applied to leads **34-36** of the first three anodes **30,** for example, and waveforms **160A, 160B,** and **160G** may be applied to cathode connectors **60A, 60B,** and **60C,** respectively. The digit duration or period is designated t_d and the cathode blanking interval is designated t_{kb}.

Although the preferred embodiments of the invention have been described in detail, it should be understood that the present disclosure has been made by way of example only. Many modifications and variations of the invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically disclosed.

We claim:

1. A character display circuit comprising

an envelope containing an ionizable gas,

an anode and a plurality of cathodes within said envelope, each of said cathodes having the shape of a segment of a character to be displayed,

circuit means for establishing a glow potential between said anode and different combinations of said cathodes for causing said different combinations of said cathodes to glow and thereby display different characters,

said circuit means including a plurality of cathode drivers, one connected to each of said cathodes, and means for selectively energizing said cathode drivers to render their connected cathodes glowing,

an auxiliary electrode in contact with the ionizable gas and in operative relation with said anode and cathodes and the circuit means so that the current through said auxiliary electrode is a function of the number of cathodes which are glowing, and bias circuit means for establishing a predetermined voltage on said cathodes when they are not glowing, including a resistance element for each of said cathodes, each being connected from a first terminal to a different one of said cathodes, the first terminals to which each of said resistances are connected all being at substantially the same voltage level,

said auxiliary electrode being electrically connected to said first terminals for biasing said auxiliary electrode to said voltage level,

at least one impedance device electrically connected to said auxiliary electrode,

said cathode drivers being connected electrically across at least a portion of said impedance device by said resistance elements and serving to change the level of the impedance connected to said auxiliary electrode as each cathode driver is energized and its connected cathode rendered glowing.

2. A character display device as in claim **1** wherein the auxiliary electrode is connected electrically in common with at least one of said first terminals.

3. A character display device as in claim **2** wherein all of said first terminals are connected electrically in common.

4. A character display circuit as in claim **1** wherein said current in the auxiliary electrode passes to it from the anode through the ionizable gas, and at least a portion of said current passes through said impedance device and tends to increase the voltage on the auxiliary electrode as the number of glowing cathodes increases, and

wherein the level of the impedance connected to the auxiliary electrode is reduced by the parallel-connected cathode drivers, as each additional cathode driver is energized, to compensate for the tendency of the auxiliary electrode to increase in volt-

age as the number of glowing cathodes increases.

5. A character display circuit as in claim 1 further including

an anode voltage supply terminal and circuit means connecting said terminal to said anode,

a cathode voltage supply terminal, with the cathode drivers being connected between the respective cathodes and said cathode voltage supply terminal, and

wherein said impedance device comprises a voltage divider having a junction connected to said auxiliary electrode, a first predetermined impedance connected from said junction to said anode voltage supply terminal, and a second predetermined impedance connected from said junction to said cathode voltage supply terminal.

6. A circuit to compensate for voltage changes on an auxiliary electrode located in a gaseous atmosphere of a glow discharge indicator tube which has an anode and a plurality of cathodes in operative relative to it in the gaseous atmosphere, each of the cathodes being in the shape of a segment of a character to be displayed and being capable of exhibiting cathode glow when energized, comprising

circuit means for energizing said anode and different combinations of said cathodes to display different characters,

said circuit means including a plurality of cathode drivers, each connected to one of said cathodes and serving to energize the connected cathode to cause it to glow in response to an input signal,

first bias circuit means for establishing a voltage on said auxiliary electrode, said bias circuit means comprising a voltage divider having a junction for connection to the auxiliary electrode, a predetermined impedance connected from said junction to a first reference potential terminal, and a second predetermined impedance connected from said junction to a second reference potential terminal, and

second bias circuit means for establishing a bias voltage on said cathodes when they are not glowing comprising a plurality of impedance elements each connected from a junction of said voltage divider to a different one of said cathodes, each of said impedance elements being bidirectional in its impedance characteristics,

the cathode driver and impedance element connected to each cathode being connected in series with each other across at least a portion of one of said predetermined impedances, to modify the effective impedance that is provided for connection to said auxiliary electrode as each of the cathode drivers responds to an input signal and causes its connected cathode to glow.

7. A voltage compensation circuit as in claim 6 wherein the plurality of impedance elements of the second bias circuit are connected to the junction that is provided for connected to the auxiliary electrode.

8. A voltage compensation circuit as in claim 6 wherein all of said impedance elements are resistors and the cathode drivers are transistors, and the plurality of resistor-transistor series circuits thus formed are connected from a junction of the voltage divider to one of said reference potential terminals.

9. A character display circuit for displaying any one of a plurality of different characters in each of a plurality of side-by-side character positions, comprising

a plurality of anodes, one in each of said character positions,

a plurality of groups of cathodes, each such group being associated with one of said anodes and being located in one of said character positions, each of the cathodes having the shape of a segment of one of the characters to be displayed,

each of said anodes and its associated cathodes being disposed in an ionizable gas atmosphere at a pressure capable of sustaining cathode glow discharge,

a plurality of cathode conductors each electrically connected to one of the cathodes in each character position,

a plurality of cathode drivers, each electrically connected to one of said cathode conductors, for energizing said cathodes selectively in response to a first set of input signals,

circuit means for selectively energizing said anodes, in synchronism with the selective energization of said cathodes, in response to a second set of input signals, for displaying selected characters in each of said character positions,

an auxiliary electrode in the gaseous atmosphere associated with each character position, the current therethrough being a function of the number of cathodes which are glowing,

first bias circuit means for maintaining an electrical potential within a predetermined range on said auxiliary electrode,

said bias circuit means including a terminal at an initial voltage level electrically connected to said auxiliary electrode and at least one impedance device electrically connected to said terminal, and

second bias circuit means for establishing a predetermined bias voltage on said cathodes including a plurality of circuits having bidirectional impedance characteristics, each containing a biasing resistance and being connected from the terminal of the first bias circuit means to a different one of said cathode conductors, and further circuit means connecting each of the cathode drivers and its connected biasing resistance across at least a portion of said impedance device, to reduce the effective impedance connected to said auxiliary electrode as each cathode driver energizes one of said cathodes.

10. A character display circuit as in claim 9 wherein the plurality of anodes and the plurality of groups of cathodes are all located within a common gas-tight envelope,

and wherein the auxiliary electrode is a single electrode associated with all of the character positions and in operative relation to the cathodes and anodes in each such character position.

11. A character display device as in claim 9 wherein the impedance device comprises a voltage divider having a junction connected to the auxiliary electrode, a predetermined impedance connected from said junction to a first reference potential terminal, and a second predetermined impedance connected from said junction to a second reference potential terminal.

12. Apparatus for operating multiple-position display devices having a plurality of electrically interconnected

groups of cathode elements, an anode associated with each of the cathode groups, and an auxiliary electrode that electrically shields the groups from each other in an ionizable medium, comprising

a plurality of cathode drivers having output circuits to be coupled to corresponding ones of the interconnected cathode elements for energizing them selectively in response to a first set of input signals,

voltage dividing means coupled between a pair of different reference potential terminals and having a divider junction to be connected to said auxiliary electrode for biasing it at an initial voltage level,

the output circuits of the cathode drivers including bidirectional impedance means also coupled to the divider junction, both for pre-biasing the cathode elements from it also and for maintaining the bias voltage on the auxiliary electrode despite changes in the number of cathode elements being driven, to prevent spurious glow in the device irrespective of the display pattern, and means coupled to each of the anodes for energizing them select selectively in response to a second set of input signals synchronous with the first set of input signals.

13. The apparatus for operating multiple-position display devices of claim **12** wherein the voltage dividing means comprises series-connected resistances and the cathode driver output circuits include resistance means coupled to the voltage divider junction between the series resistances.

14. The apparatus defined in claim **20** wherein the means for energizing the anodes includes voltage switching means for each of the anodes coupled for shifting the voltage on them responsive to the second set of input signals in synchronism with the first set of input signals applied to the cathode drivers.

15. The apparatus characterized by claim **12** further comprising means for blanking the application of the first set of input signals to the cathode drivers for a predetermined interval in advance of signal transition in the second set of input signals.

16. The apparatus defined in claim **12** further comprising an anode pre-biasing circuit having second voltage dividing means coupled between said pair of reference potential terminals and having a divider junction to which each of the anodes is coupled by impedance means.

17. The apparatus defined in claim **16** wherein the second voltage dividing means comprises a voltage reference device coupled in series with a resistor and the anodes are coupled to the junction thereof by resistance means.

18. The apparatus defined in claim **16** wherein the second voltage dividing means comprises series-connected resistances and the anodes are coupled to the divider junction thereof by resistance means between the series resistances.

19. The apparatus characterized by claim **18** wherein reverse biased unidirectionally conductive means are connected in parallel with the resistance means coupling the anodes to the divider junction of the second voltage dividing means to clamp negative voltage excursions on them.

* * * * *