United States Patent [19]

Ogle

[11] **3,811,071**

[45] **May 14, 1974**

[54] **DRIVE REGULATION AND DELAY CONTROL IN DISPLAY SYSTEMS**

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[22] Filed: **July 13, 1972**

[21] Appl. No.: **271,576**

[52] **U.S. Cl.** ..... **315/169 TV,** 315/169 R
[51] **Int. Cl.** **H05b 37/00**
[58] **Field of Search** ..... 315/169 R, 169 TV

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[57] **ABSTRACT**

Apparatus addressing multi-position display devices directly from semiconductor integrated circuits and driving the display electrodes without exceeding the limitation on voltage excursions for the outputs of such circuits. The apparatus develops and applies to threshold-responsive display devices, including gas discharge display tubes or display panels, only the amount of voltage that is needed to operate them. Potential for operating the device is accumulated in steps until the device fires, it being applied to the display electrodes of the device in response to open-circuit input signals. The potential is regulated to maintain ionization delay in the device as a certain fraction of the display period and the required selection voltages for the electrodes of the device are minimized.

The potential for driving the cathodes is developed across a capacitance common to all of them, and a regulator circuit coupled to it and to the cathode drivers automatically increases the bias until the device fires. The potential that proves to be necessary to operate a device is stored for continued operation of it. The driver for a cathode element that is frequently operated alone is coupled to the regulator circuit by a high impedance connection for increasing the energizing potential sufficiently to ensure ionization. The anodes are driven from semiconductor logic circuit often without intermediate circuit elements.

6 Claims, 5 Drawing Figures

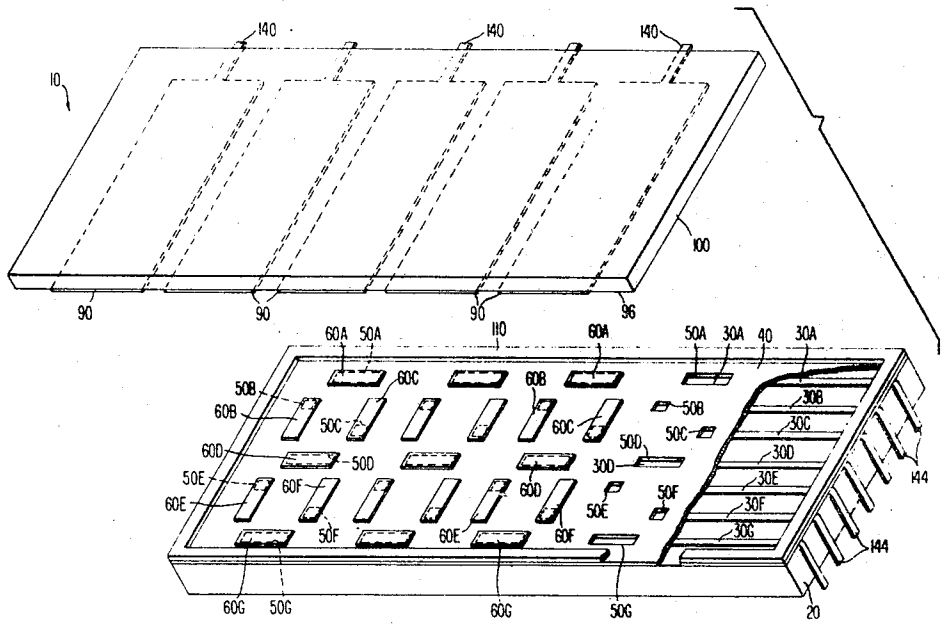


Fig. 1

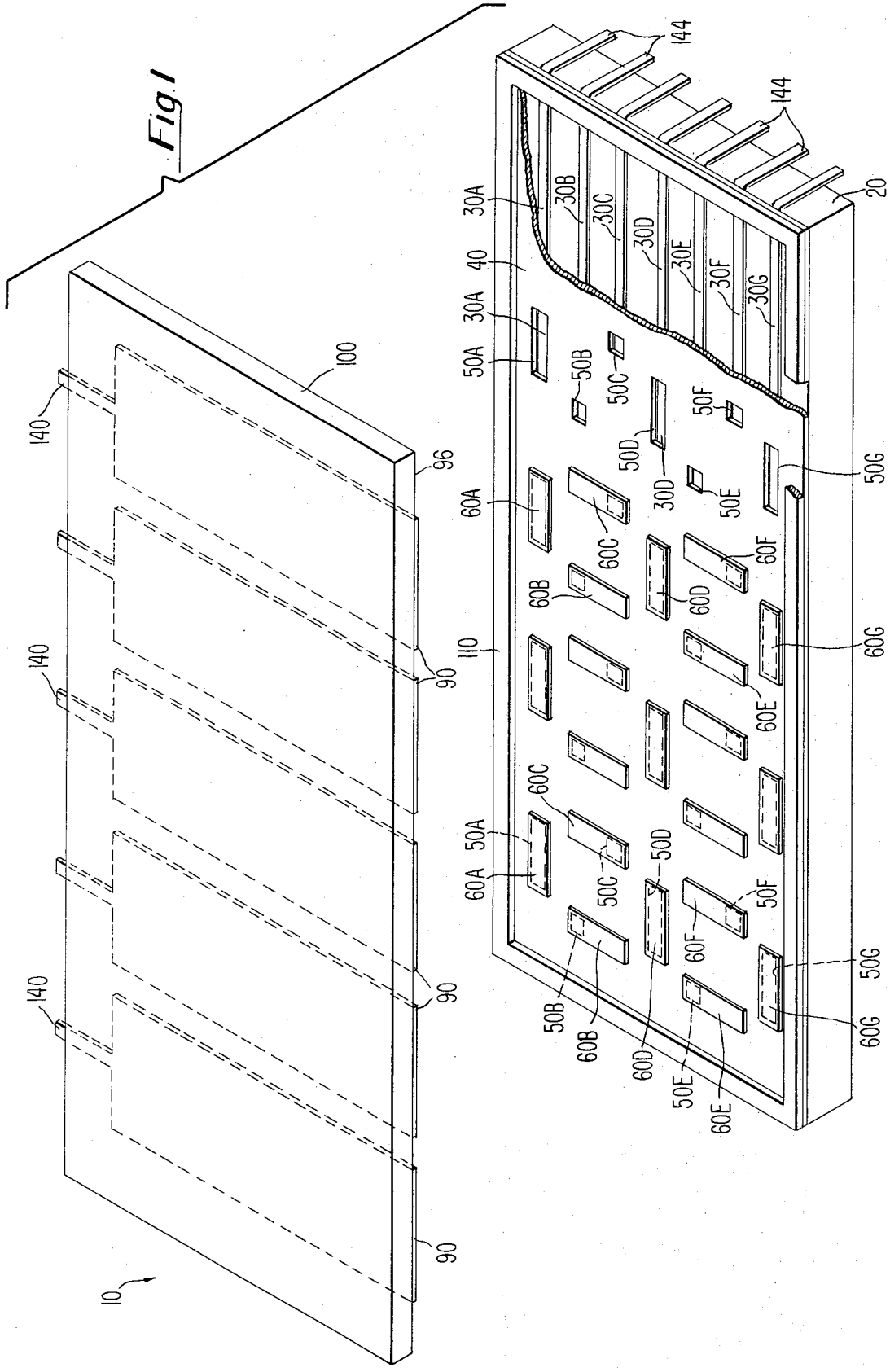
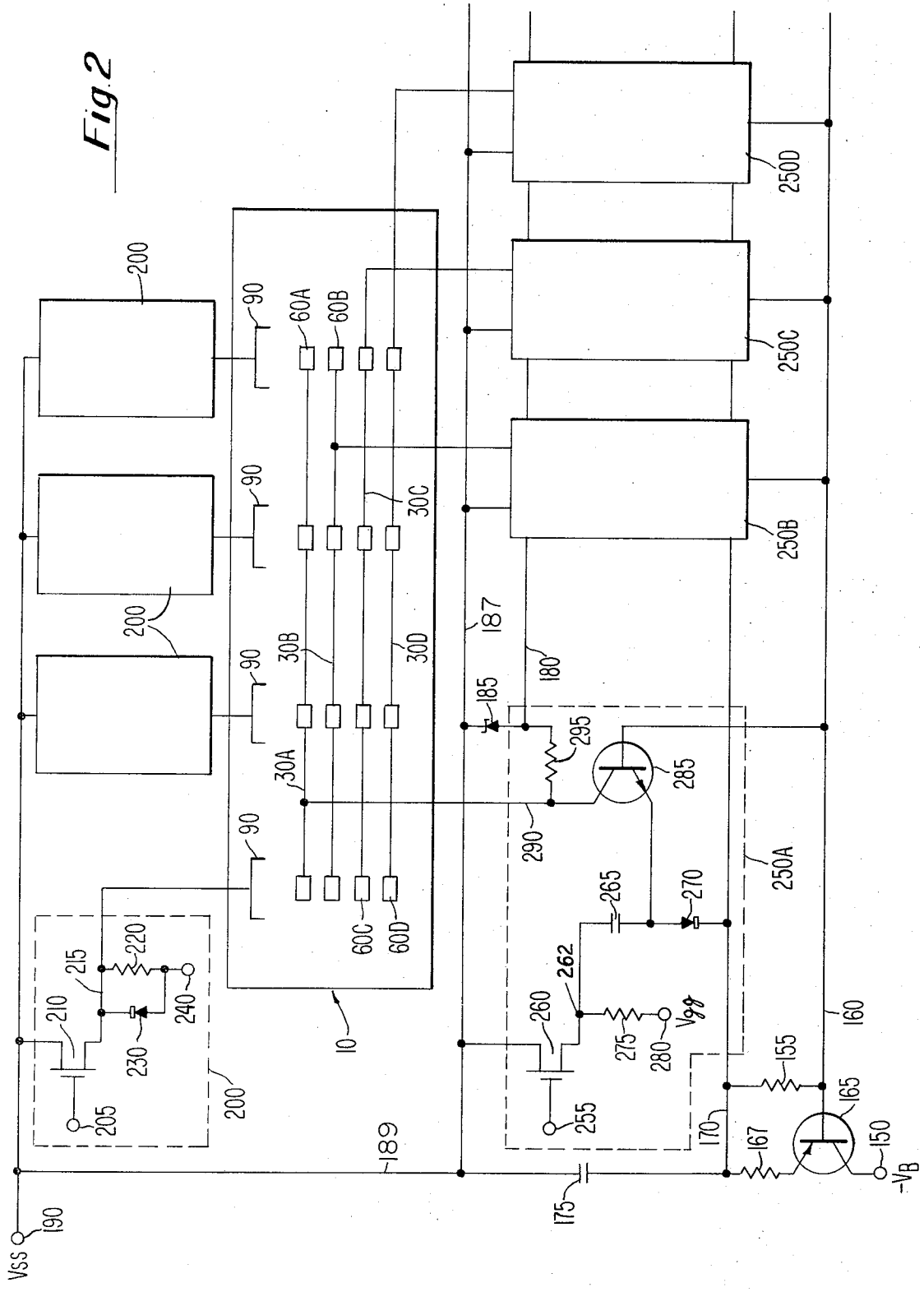

144
144
20
30A
30B
30C
30D
30E
30F
30G
40
30A
50A
50B
50C
50D
50F
50G
30D
50E
60A
60C
60B
60D
60F
60G
110
60E
60C
50A
60A
50C
50D
50F
60F
50G
60G
50B
60B
60D
50E
60E
140
140
140
100
96
90
90
90
10

Fig.2


200
90
60A
60B
30C
30B
30D
30A
60C
60D
10
187
180
185
295
285
290
250A
250B
250C
250D
265
270
262
260
275
280
V_{SS}
255
155
160
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200
210
215
220
240
230
205

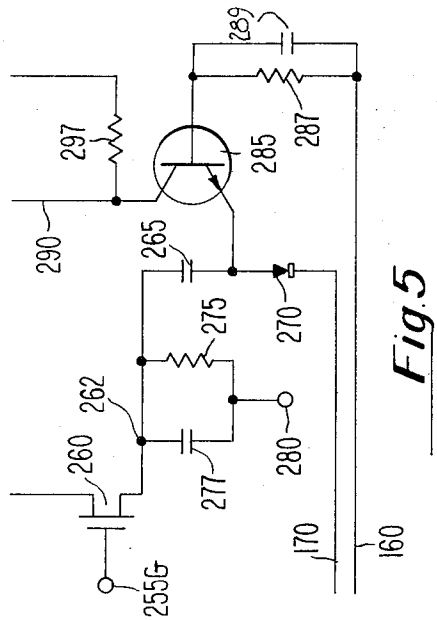


Fig. 5

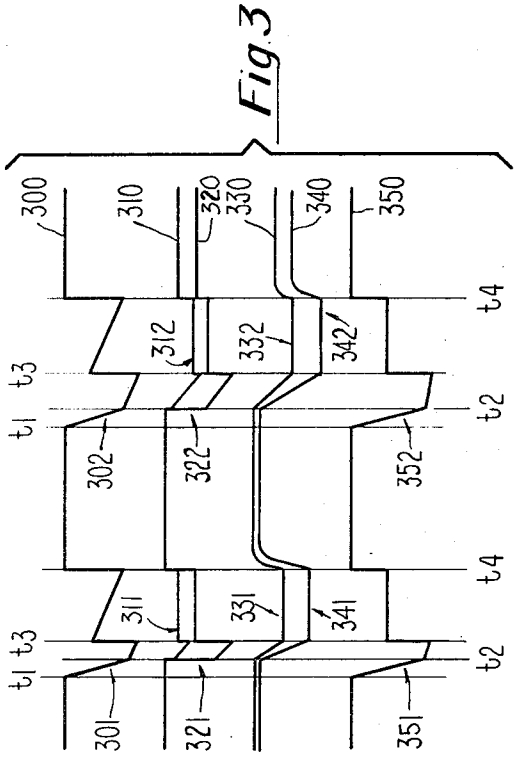


Fig. 3

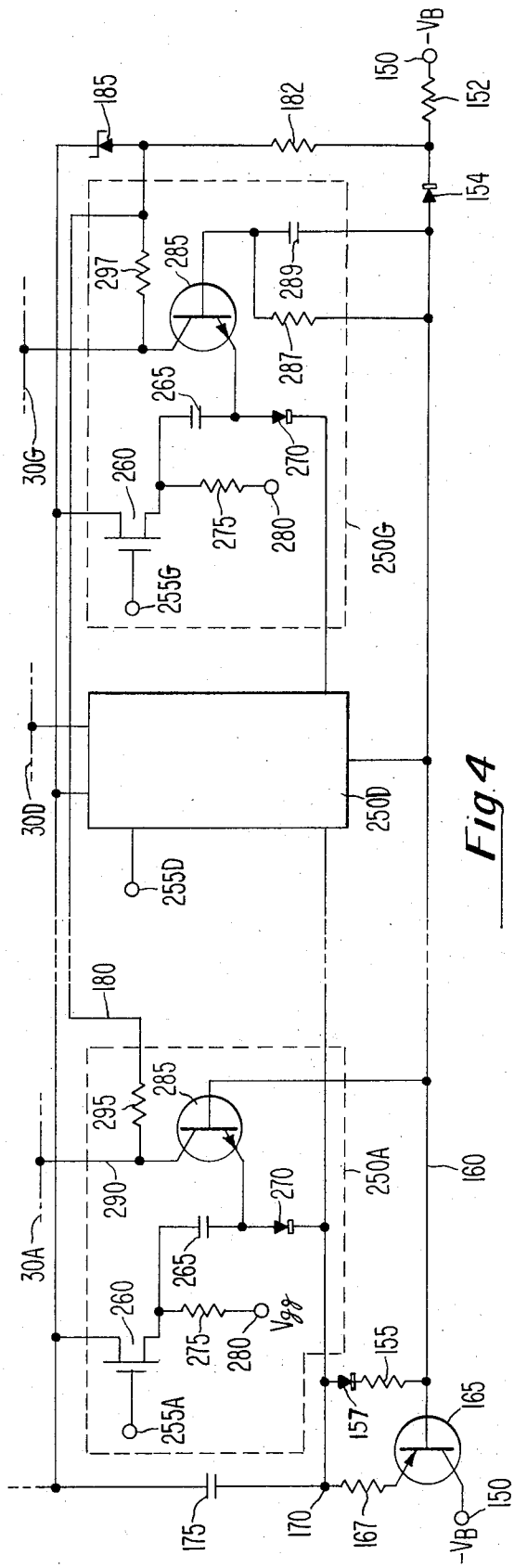


Fig. 4

DRIVE REGULATION AND DELAY CONTROL IN DISPLAY SYSTEMS

BACKGROUND OF THE INVENTION

This invention relates to apparatus for operating segmented-electrode display devices which are threshold-responsive to selection signals applied to them, including gas discharge display tubes and display panels. More particularly, the invention relates to apparatus for addressing multiple-position gas discharge devices directly from semiconductor integrated circuits and the like and to driving display elements thereof without exceeding the voltage limitations on the circuits employed.

Various segmented-electrode display devices have been developed in recent years for use as readout indicators for electronic calculators and the like. One such device is the PANAPLEX™ panel display which is a multiple-position gas discharge device having a plurality of segmented display cathodes and a plurality of associated anode electrodes. Such display panels usually include several groups of cathode segments, with like segments of the different groups being interconnected, and an anode electrode associated with each group of cathodes.

In a recently developed version of the PANAPLEX panel display, the cathode elements are deposited or formed along the front surface of an insulating base plate and planar anode electrodes are spaced closely above the cathodes. A relatively large difference in potential between an anode and one or more cathodes is required initially to ionize a display position, while a lower potential across them will sustain the discharge. It has been discovered, however, that either the anodes or the cathodes thereof, if both are suitably biased, can be operated by signals which do not exceed the maximum voltage excursions that are allowed on the outputs of some metal-oxide semiconductor (MOS) integrated circuits.

Such MOS integrated circuits are available in the form of calculator circuits, decoder circuits, counters, registers, and the like. Substantial economies would be obtained if the display positions of such devices could be either addressed or selected directly from MOS circuits with a minimum amount of intermediate amplifying or coupling circuitry being required.

A condition precedent to the use of such low voltage signals is that the electrodes of the device be biased toward discharge as much as possible without causing spurious discharges. Higher voltages also have to be made available on one set of the electrodes for initial ionization and re-ionization without violating the allowable voltage ratings on the MOS or other low voltage signal source.

The total potential required for initially ionizing and for re-ionizing the display positions in gas discharge display panels, however, varies with the gas pressure and with operating temperature. It also can vary significantly from tube to tube. A set of bias voltages provided to allow the electrodes of one lot of such devices to be addressed or driven with minimum possible signal voltages may not be sufficient or may exceed the potential required to operate another lot of tubes of the same general type.

SUMMARY OF THE INVENTION

Accordingly, an object of the invention is to simplify and reduce the cost of addressing and driving multiple-position display devices or panels.

Another object is to address the display positions of gas discharge devices from semiconductor integrated circuits or the like without exceeding voltage limitations on the circuits.

A further object of the invention is to regulate the drive voltage applied to multiple-position display devices and to control the delay in activating the display positions in them.

The invention provides apparatus for driving the display electrodes of multiple-position display devices and for addressing them directly from low voltage signal sources without exceeding the voltage limitations on the signal source. The potential for driving the cathodes is developed across a capacitance common to all of them and a regulator circuit coupled to the cathode drivers controls the voltage so that the device will fire at the predetermined ionization delay.

A major portion of the voltage applied to the display cathodes in this system is stored between display periods for application to the selected cathodes in succeeding periods. This stored reference potential, and consequently the operating voltage, are adjusted automatically to compensate for differences in the potential thresholds for different units and for threshold changes caused by changes in temperature or mode of operation.

DESCRIPTION OF THE DRAWINGS

Other advantages and features of the invention are made clear in the following description, relating to the attached drawings, wherein:

FIG. **1** is an enlarged, exploded view of a segmented-electrode display panel shown in perspective;

FIG. **2** is an electrical schematic diagram of an operating system for such a display panel;

FIG. **3** is a diagram of electrical waveforms reflecting the operation of the system; and

FIGS. **4** and **5** are electrical schematic diagrams of the other embodiments of display electrode drivers for a panel.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The display panels described herein are thin, flat, sheet-like members which may have substantially any desired shape and size, and may include substantially any number of character display positions. The panels may include any suitable ionizable gas such as neon, argon, xenon, etc., singly or in combination, with a vapor of a metal such as mercury usually included in the gas to minimize cathode sputtering. A wide range of gas pressures may be used, for example, from about 20 to about 250 Torr at ambient temperature with about 70 to 120 Torr being a commonly used pressure range.

Referring to FIGS. **1–3**, a display device **10** embodying the invention includes an insulating base plate **20** of glass, ceramic, or the like, with an inexpensive glass being suitable and preferred. A plurality of conductive connectors or runs **30A** to **30G** are formed on the top surface of the insulating plate **20**. The runs **30** are parallel to each other and are aligned with the horizontal axis of the base plate. Seven such runs **30A** to **30G** are

shown; however, more or fewer may be provided, the number being determined by the total number and type of characters to be displayed. The runs **30** may be formed by an evaporation process, a silk-screen process, an electroless plating process or the like, or they may be discrete strips of metal, heat-sealed, and plasma-sprayed, or otherwise secured to the insulating plate **20.** A silk-screen printing process is particularly suitable because it is fast, efficient, and reproducible.

A second thin layer **40** of insulating material such as glass or ceramic is formed on the conductive runs **30,** preferably by a silk-screen process, and the second layer **40** includes a plurality of groups of vias or apertures **50A** to **50G,** each aperture exposing one of the runs **30A** to **30G.** Thus, each group of apertures includes aperture **50A** which exposes run **30A,** aperture **50B** which exposes run **30B,** aperture **50C** which exposes run **30C,** etc. Four such groups of apertures are illustrated.

Panel **10** includes a group of cathode electrodes **60** (A to G) for each group of apertures **50.** The cathodes are generally elongated bars or segments, and they are usually arrayed in a figure "8" pattern, as is well known in the art. The cathodes **60** may be formed on insulating layer **40** by means of a silk-screen process using a conductive paste such as palladium-gold, platinum-gold, palladium-silver, or the like. Each cathode element is in contact with one of the runs **30** exposed by one of the apertures or vias **50,** and it substantially fills the aperture **50** and covers a portion of layer **40** to achieve the desired shape and size.

The cathodes **60A, 60B,** etc. may also be formed of discrete strips of metal, preferably brazed to a conductive run **30** by means of a mass of brazing material deposited in each of the apertures **50** in the insulating layer **40.** The brazing material itself may be deposited by a silk-screen process. One suitable brazing material is a gold-germanium substance known as FORMON and sold by E. I. DuPont de Nemours & Co. The cathodes may also be formed in any other suitable manner such as by the electrolytic or electroless plating of nickel or the like or by arc plasma spraying through a suitable mask.

Thus, cathodes **60** are preferably thin, flat members which do not project to any significant extent above the top surface of insulating layer **40.**

Panel **10** includes anode electrodes **90** for the groups of cathode electrodes **60.** The anode electrodes comprise thin, transparent conductive films of gold, NESA, or the like formed on the lower surface **95** of the panel face plate or viewing plate **100** which is made of glass. The anode films are of the order of a few Angstroms thick and, in effect, are coplanar with the bottom surface **95** of the face plate. Thus, the anodes, for all practical purposes, do not project into the gas discharge space in the panel. The anode films are generally rectangular in shape, or are otherwise shaped, depending on the orientation of the cathodes. Anodes **90** are dimensioned and positioned so that they overlay the total area defined by the associated group of cathode electrodes. If desired, each anode **90** may be somewhat narrower and shorter than the area defined by its cathodes as shown, but in any case, the anode must overlay and be in operative relation with a sufficient portion of each of its cathodes. Other suitable anode shapes may be employed, depending upon the character and symbol configuration of the cathodes to be operated.

Preferably, the spacing between each anode **90** and its group of cathodes **60** should be of the order of 20 to 25 mils, and the spacing between each anode and the adjacent group of cathodes should be of the order of 30 to 40 mils. With this relationship at the usual pressure range, each anode is in a favorable operating position with respect to its own cathodes, but is sufficiently remote from adjacent groups of cathodes so that the panel may be operated over a suitably wide range of potentials without developing cross-talk between adjacent groups of electrodes. Another factor tending to prevent cross-talk is the location of the anodes in substantially coplanar relation with the surface of the glass cover plate and not projecting into the gas space in which cathode glow takes place.

Another advantage of the close spacing of each anode to its group of cathodes, thus providing a thin volume of gas, is that metastable-state atoms produced in the gas during discharge diffuse to, and are readily neutralized at, these closely spaced surfaces. In addition, excited or charged particles are readily swept out through the anode-cathode circuit path. The tendency for cross-talk to develop is minimized by these two factors.

The top glass cover plate **100** is of substantially the same length as the insulating layer **40** and the bottom plate **20,** and it is spaced from the base plate **20** by a rectangular glass frame **110** which is disposed between the top glass plate **100** and the insulating layer **40.** Frame **110** may be an integral part of the top and/or bottom plates. The rectangular frame serves thus to provide the desired spacing between each anode and its associated group of cathode electrodes. The top glass plate **100** is also preferably slightly wider than the insulating layer **40** and base plate **20** so that one edge, say the upper edge, extends beyond the remainder of the panel and is accessible to permit the connection of leads **140** to each of the anode films **90.** The three glass members **20, 100,** and **110** are sealed together in any suitable manner, for example, by means of a seal **120** formed of a glass frit or the like.

Connection to the runs **30** may be made, as an example, by means of L-shaped pins or contacts **144** which are embedded in the seal **120** at one or both ends of the panel.

The panel **10** can be filled with the desired gas atmosphere through a tubulation **150** secured to the base plate **20** and communicating with the interior of the panel through a hole **154** in plate **20** and layer **40,** and, generally, mercury is introduced from a glass capsule (not shown) held in the tubulation and suitably processed at the desired stage in the assembly process.

The invention relates to panel-type segment display devices which include a plurality of groups of cathode electrodes which comprise elongated bars or segments arrayed in a pattern so that the cathodes of each group can be selectively energized to display a character. For reasons of economy, corresponding electrodes in each group, usually cathodes, have a common conductor. The anodes are separately energizable and the panel is operated in a multiplex mode of operation. In this mode of operation, operating potential is applied to selected cathode conductors at time t_a and thus to selected cathode segments, and the first anode is energized and a first character is displayed by the energized

cathode segments in the first group. At time t_b, operating potential is applied to the same or other cathode conductors and to the second anode and a second character is displayed by the second group of cathodes. This same operation is carried out for each character position, and it is repeated continually along the entire display panel at a suitable frequency so that stationary but changeable characters can be displayed.

The display system of FIG. 2 incorporates improved operating apparatus for a multiple-position display device **10** having several groups of cathode segments or elements **60** (A–D) interconnected by cathode conductors **30** (A–D) and a plurality of associated anode electrodes **90.** A digit selecting or addressing switch **200** is connected between a voltage supply terminal **190** labeled V_{ss} and each of the anode electrodes **90.** The anode switches are all identical and only one of them is illustrated in detail. The cathode circuit includes current drivers **250** (A–D) connected to the corresponding cathode electrodes **60** (A–D) by leads **290** and to capacitor **175** of a biasing circuit by bus **170.** Capacitor **175** is connected at its other end to voltage supply terminal **190** and is in electrical series with emitter resistor **167** of transistor **165,** the collector of which is connected to a negative voltage supply terminal **150** labeled $-V_B$. Transistor **165** serves as the pass element of a bias regulator circuit including feedback bus **160** and is coupled to capacitor **175** which maintains bias potential on bus **170** for the cathode drivers.

The voltage switches **200** for addressing anodes **90** and thereby selecting a digit or display position in panel **10** are each controlled by a metal-oxide semiconductor (MOS) transistor **210** having a gate terminal **205.** These MOS transistors **210** may all be formed on the same MOS integrated circuit chip, and may be part of a complex multiple-function integrated circuit. Similarly, anode switch transistors **210** may be field-effect transistor (FET) units or other suitable low voltage units. The source electrodes of transistors **210** are connected to V_{ss} terminal **190.** The drain electrodes **215** are connected directly to the anode electrodes. A biasing resistor **220,** which holds the anode below operating potential normally, and a reverse-biased clamping diode are connected between it and a bias terminal **240.** The anodes can thus receive the full voltage swing from V_{ss} to the most negative voltage that can be applied to terminal **240** without violating the rated voltage limitations on the MOS or FET transistors **210.**

The cathode circuit consists of segment current drivers **250** (A–D) and a bias voltage regulator including transistor **165** connected in series with capacitor **175,** which stores the bias voltage for the drivers. Cathode drivers **250** and transistor **165** operate together as a feedback loop to develop bias voltage across capacitor **175** by conducting current out of it through the collector-emitter circuit of transistor **165** until the associated display device becomes activated.

The current drivers **250** for the cathodes are controlled by MOS transistors **260** or the like, which also may form part of a complex integrated circuit such as a calculator chip or the like. Furthermore, cathode input transistors **260** may be formed on the same integrated circuit chip as anode switch transistors **210** even though the anodes and cathodes, themselves, are operated at different voltage levels that exceed the rated voltage limitations of customary integrated circuits. Capacitors **265** couple the cathode input switches **260** to cathode current drivers **285,** while isolating both the anode switches **210** and the cathode input switches **260** from the voltage levels on the cathode drivers. The anode switches **210** and the cathode input switches **260** are thus operated from the same bias point (anode voltage level V_{ss}) and may be formed on the same integrated circuit chip.

The source electrodes of input transistors **260** for the cathode drivers are connected to V_{ss} terminal **190.** Their drain electrodes are coupled at junction **262** to the emitter electrodes of cathode driver transistors **285** by capacitors **265** and are coupled to a negative voltage terminal **280** labeled V_{gg} by resistors **275.** The emitter electrodes of driver transistors **285** are also connected to voltage bus **170** by diodes **270.** The collector electrodes are connected by leads **290** to connectors **30** (A–D) of cathode electrodes **60** (A–D) of the display device and to pull-up bias resistors **295,** which hold the cathodes above their operating potential normally. The other ends of cathode bias resistors **295** are connected to a bus **180** which is coupled to V_{ss} terminal **190** by a reverse-biased Zener diode **185** through leads **187** and **189.** The base electrodes of cathode driver transistors **285** are connected to bus **160** which connects to the base electrode of transistor **165** of the bias voltage regulator.

This system allows direct addressing or selection of the anodes of a display device from transistors **210** of an MOS circuit chip or the like, and keeps the voltage swing on the digit output terminals **215** of the integrated circuit chip strictly within customarily specified voltage limits for them. Frequently specified voltage limitations on such circuits range from a conservative 20 or 25 volts to approximately 30 volts or more. The system also is operated by open circuit (negative going) selection signals for the cathode segments, which in the case of MOS data sources are open drain inputs.

Cathode drivers **250** (A–D) are selectively enabled when the normally-conducting transistors **260** of the MOS data source are opened (turned off). This unclamps the input side of coupling capacitor **265** which is pulled negative by resistor **275** as shown in waveform **300** of FIG. **3,** it having been held normally at V_{ss} by that transistor. This signal current into resistor **275** appears as emitter current in driver transistor **285** via coupling capacitor **265** and is considerably larger than the collector pull-up current through cathode bias resistors **295.** The collectors, therefore, go increasingly negative during ionization delay until transistors **285** become saturated, as indicated by waveform **350** of FIG. **3.** Most of the emitter current of transistors **285** is then drawn from their base electrodes and through bus **160** and the regulator **165.** The sum of the base currents of all the selected cathode segment drivers **250** (A–D) is conducted by resistor **155** and the base of transistor **165** which causes a proportionately larger current in emitter resistor **167** and charges capacitor **175** more negative.

The ratio between emitter resistor **167** and feedback resistor **155** of regulator transistor **165** determines the approximate proportion between the re-ionization delay and the digit display period at which the system will stabilize. Under typical display conditions with a 200 microsecond digit display period, a segment re-ionization delay of about 20 to 40 microseconds, for example, is usually suitable. After the device fires, transistor **285** comes out of saturation and the major part

of its emitter current is then drawn from the associated cathode via conductor **30** (A–D) and the collector of the transistor to coupling capacitor **265.** Resistors **275** will limit the current thus conducted from the display and capacitors **265** are discharged thereby. The voltage on bias storage capacitor **175** will change little once breakdown occurs in the device since the feedback current to regulator **165** from the base electrodes of drivers **285** will drop gently when they come out of saturation.

When cathode input transistor **260** is again closed (turned on) it conducts current from V_{ss} terminal **190** to recharge coupling capacitor **265** through diode **270,** which also discharges bias capacitor **175** toward its initial voltage. If, however, the bias on capacitor **175** had been too small to fire the display then regulator transistor **165** will continue to add charge to it during the entire display period. The recharging current in coupling capacitor **265** will be less and capacitor **175** thus will not be discharged as much as it was charged, but will instead accumulate negative biasing charge until the device fires.

This feedback-controlled voltage is stable once display device **10** becomes activated, since the charging of capacitor **175** is governed primarily by the reionization delay, which decreases as the voltage goes more negative and will increase should it be too positive. The proportion between feedback resistor **155** and emitter resistor **167** of regulator transistor **165** determines this operating point and establishes the bias voltage that is stored across capacitor **175.** The operating bias is thus regulated to maintain the ionization delay as a predetermined fraction of the digit period. This allows operation with smaller signals than would be required for faster ionization, yet ensures that ionization will occur at all selected cathodes.

The apparatus responds effectively to the operation of the device because capacitor **175** is charged to increase the driving potential for the selected cathodes until the device fires and is discharged between display periods by an amount proportional only to the number of segments that were selected.

The potential across capacitor **175** is applied to cathode drivers **250** by bus **170** as bias potential. This is the potential to which coupling capacitors **265** of the cathode drivers are recharged between display periods and, hence, the initial bias potential for the drivers during each display period. This potential is changed by regulator transistor **165,** as the threshold potential of the device also changes. This compensates for the threshold potential of different devices being different or changing with temperature or mode of operation.

The drawing of FIG. **3** reflects the operation of the display system of FIG. **2.** Waveform **300** represents the voltage excursions at input junction **262** of a cathode driver **250.** Two cycles **301** and **302** are illustrated, both of which begin at V_{ss} and are pulled rapidly negative by resistor **175** until transistor **285** conducts, charges distributed capacitances in the circuit, and then becomes saturated at time t**2.** Input waveforms **301** and **302** are pulled farther negative at a slower rate as current in the base-emitter circuit of transistor **285** begins to discharge coupling capacitor **265** during the remaining ionization delay until the device fires.

Waveform **301** represents operation at equilibrium, in which the ionization delay equals the predetermined portion of the display period. Waveform **302** represents operation of the device in which the ionization delay exceeds the predetermined fraction of the display period. At time t**3** breakdown occurs at the selected display position, at which point cathode driver **285** comes out of saturation and the base currents of the selected drivers which are summed in feedback resistor **155** decrease greatly. This causes a corresponding voltage shift in the emitter circuits of the drivers and at input junction **262** of the drivers. The input waveforms then continue to decrease as coupling capacitors **265** are discharged until the end of the display period at time t_4. The input waveforms then return to V_{ss}.

Voltage waveforms **310** and **320** appear on feedback bus **160** connected to the base electrodes of cathode driver transistors **285** and to the base electrode of regulator transistor **165.** They reflect the feedback current in the base of pass element **165** and in base resistor **155** during ionization delay between times t**2** and t**3** and during operation of the device until t**4.** The amplitude of the feedback current during cycle **311** or cycle **312** will depend on how many different cathode segments are being driven by cathode drivers **250** (A–D) during the particular cycle. Waveform **310** represents operation of a few cathodes and waveform **320** represents operation of most of the cathodes. Bias capacitor **175** will be charged more negatively by higher feedback currents, but will be discharged proportionately at the end of the cycle when the corresponding number of coupling capacitors **265** are recharged into it.

Waveforms **330** and **340** represent the voltage excursions on bias voltage bus **170** connected to capacitor **175** and to the coupling capacitors **265** by diodes **270.** Wavefrom **330** represents the excursion if only one or two different cathodes are being driven. Waveform **340** represents the larger voltage excursion when several or all of the different cathode segments or elements are being driven.

Voltage waveform **350** represents the voltage pattern that are applied to the cathode electrodes on leads **290.** When driver **285** begins to conduct its collector and the associated cathodes go negative. At time t**2** driver **285** saturates and its collector therefore follows the voltage on its base until the driver fires at time t**3.** The cathode voltage between times t**3** and t**4** is relatively constant as the voltage drop across a fired display position until the end of the display period. These output waveforms **351** and **352** that are applied to cathode leads **290** beginaand end at a voltage determined by pull-up resistors **295** and zener diode **185** connected between them and V_{ss} terminal **190.**

Since the ionization delay in segmented gas discharge devices depends in part on how many cathode segments are energized, a specialized cathode driver for single segment displays may be desirable. The middle bar or segment in a figure eight pattern is often operated alone as a minus sign, for example. In the cathode circuit of FIG. **4** cathode drivers **250A** through **250D,** etc., are the same as those of the system of FIG. **2,** but cathode driver **250G** is connected differently to the regulator circuit and may have a higher value cathode pull-up resistor **297** for easier driving, if desired.

In the cathode driver **250G** of FIG. **4** for cathodes **60G,** a resistor **287** and a capacitor **289** are coupled in parallel between the base of its driver transistor **285** and feedback bus **160** of the regulator. When its driver transistors **285** saturates during ionization delay the base current in resistor **287** allows the base, and conse-

quently the collector and the associated cathode, to go more negative than feedback bus **160.** This promotes faster ionization and discharge in the display device. Capacitor **289** initially couples the same amount of feedback from cathode driver **250D** as the other drivers provide to avoid the unbalancing the regulator when ionization occurs readily, as when a cathode segment **60G** is energized with several others in a multiple-segment character or symbol. This ensures that the charging and discharging of bias storage capacitor **175** remains approximately equal at the designed ionization delay interval even though a special driver **250G** is being operated with the others. Otherwise, capacitor **175** would be inadequately charged.

In the special driver for the minus symbol cathode of FIG. **5,** damping is provided in the circuit by capacitor **277** coupled between the drain electrode of input transistor **260** and negative bias terminal **280.** This dampens initial saturation of its driver transistor **285** and if its feedback to the regulator to allow ionization to occur in the display at the lowest possible voltage. It also aids in preventing unbalancing of the bias circuit upon rapid ionization. Coupling capacitor **289** is eliminated, or not, as desired. The special minus symbol cathode driver **250G** of FIG. **5** is otherwise similar to that illustrated in FIG. **4.**

Also, a forward-biased diode **154** may be connected between the base of regulator transistor **165** and a voltage divider formed of resistors **152** and **182** connected between $-V_B$ terminal **150** and zener diode **185,** for example. This causes transistor **165** to follow variations in the $-V_B$ power source and to keep capacitor **175** charged to a minimum level independent of whether the display has been recently operated. This limits transient power demands of regulator transistor **165** when the display is first operated or operated after a long inactivate period.

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.

What I claim is:

1. A system for operating a multiple position flat panel display device which comprises

a base plate and face plate spaced apart and hermetically sealed together along a perimeter to form an envelope which is filled with an ionizable gas, a plurality of conductive runs on said base plate, and a plurality of groups of cathode segments on said base plate but insulated from said conductive runs, with each run being connected to one cathode segment in each group, each said group of cathode segments comprising a character position, and an anode electrode for each of said groups of cathode segments,

said system comprising

a power supply,

a separate anode driver coupled to each of the anode electrodes for applying positive-going signals to the anode electrodes as each character position is energized,

a separate cathode driver having its output coupled to each of said conductive runs for applying negative-going signals to selected ones of the cathode electrodes concurrent with energization of the associated anode electrode to display a character at each character position,

a source of input signals coupled to each cathode driver,

a first bus coupled between said power supply and through separate resistive paths to the output of each said cathode driver,

a second bus connected to the input of each said cathode driver,

a third bus coupled to a portion of each said cathode driver for maintaining bias potential thereon,

an active circuit element coupled between said second and third buses for maintaining bias potential on said third bus,

a capacitor connected between said first and second buses for receiving current from said active circuit element and storing charge, and then applying operating bias potential to each of the cathode drivers, and

impedance means coupled between said capacitor and said active circuit element for charging the capacitor proportionally to the number of cathode segments energized in each said group at each character position to regulate the potential across it so that the firing threshold of the cathodes at the selected position in the device is exceeded and the cathodes exhibit cathode glow.

2. The system defined in claim **1** wherein said active circuit element comprises a first transistor having base, emitter, and collector electrodes with its emitter connected through a first resistive path to said capacitor and to said third bus, and its base electrode connected through a second resistive path to said third bus, and its collector electrode connected to a source of bias potential, and

each said cathode driver comprises a second transistor having base, emitter, and collector electrodes, its base electrode being connected to the base electrode of said first transistor, its emitter electrode being connected both through a capacitor to said source of input signals and through a diode to said third bus, and its collector electrode being connected to one of said conductive runs and through one of said resistive paths to said first bus.

3. A system for operating a multiple position flat panel display device which comprises

a base plate and face plate spaced apart and hermetically sealed together along a perimeter to form an envelope which is filled with an ionizable gas, a plurality of conductive runs on said base plate, and a plurality of groups of cathode segments on said base plate but insulated from said conductive runs, with each run being connected to one cathode segment in each group, each said group of cathode segments comprising a character position, and an anode electrode for each of said groups of cathode segments,

said system comprising

a power supply,

a first bus extending from said power supply,

a second bus, a third bus, and a fourth bus,

a capacitor connected between said second and third buses,

a first transistor connected between said third and fourth buses and having base, emitter, and collector electrodes,

said first transistor and its associated circuitry sensing the number of cathodes energized and to be turned on at any one character position and passing a charging current, proportional to said number of cathodes, to said capacitor, the charge developed therein being applied to said second bus and to said cathode runs and to the associated cathode segments, and

a cathode driver circuit for each of said conductive runs and for each said one cathode segment in each said group of cathode segments,

each said driver circuit including a source of input signals, and a second transistor having base, emitter, and collector electrodes, the emitter electrode being coupled both to said source of input signals and to said third bus, the base electrode being connected to said fourth bus, and the collector electrode being connected both to said second bus and to one of said conductive runs,

whereby when a source of input signals is operated and applies a signal to the second transistor in the associated cathode drive circuit, said second transistor is driven to saturation before the associated cathode turns on and current flows through said first transistor to charge said capacitor proportionally to the number of cathodes to be turned on, said charge being applied as a generally negative potential to said second bus and to the associated cathodes to be turned on.

4. The system defined in claim **3** and including a first resistor coupled between said third bus and the base electrode of said first transistor, and a second resistor coupled between said third bus and one side of said capacitor and the emitter electrode of said first transistor, said first resistor sensing current flow in the cathode segments energized by said signal sources.

5. The system defined in claim **3** wherein, in each cathode driver circuit, the emitter of the second transistor is connected both through a diode to said third bus and through a capacitor to its source of input signals.

6. The system defined in claim **3** wherein, in each cathode driver circuit, the collector of the second transistor is connected through a resistor and diode to said second bus.

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