United States Patent

[11] 3,622,996

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[21] Appl. No. **864,076**
[22] Filed **Oct. 6, 1969**
[45] Patented **Nov. 23, 1971**
[73] Assignee **The United States of America as represented by the Secretary of the Navy**

[54] **ELECTROLUMINESCENT DISPLAY**
1 Claim, 4 Drawing Figs.

[52] **U.S. Cl.** **340/166,** 340/336
[51] **Int. Cl.** **G08b 5/36**
[50] **Field of Search** ..... 340/166, 336; 313/308 B; 315/169

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ABSTRACT: An electroluminescent display panel controlled by AC flooding and exciting voltages of different frequencies for obtaining rapid response times.

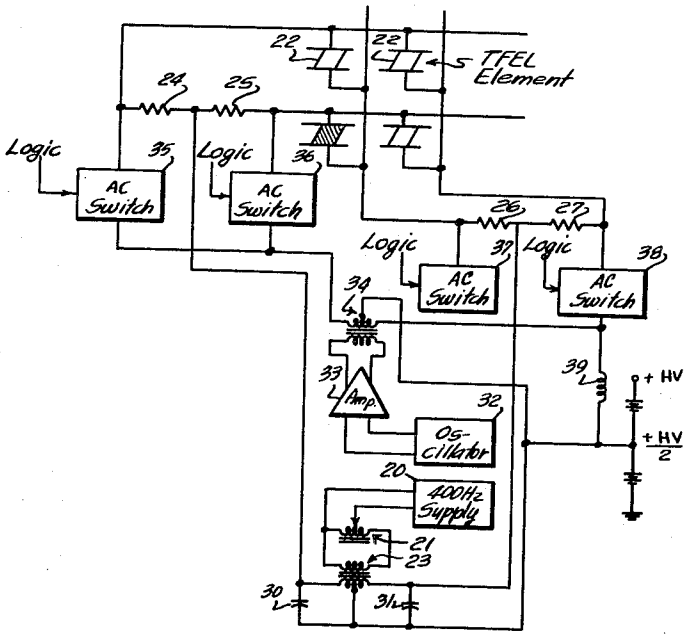


FIG. 1

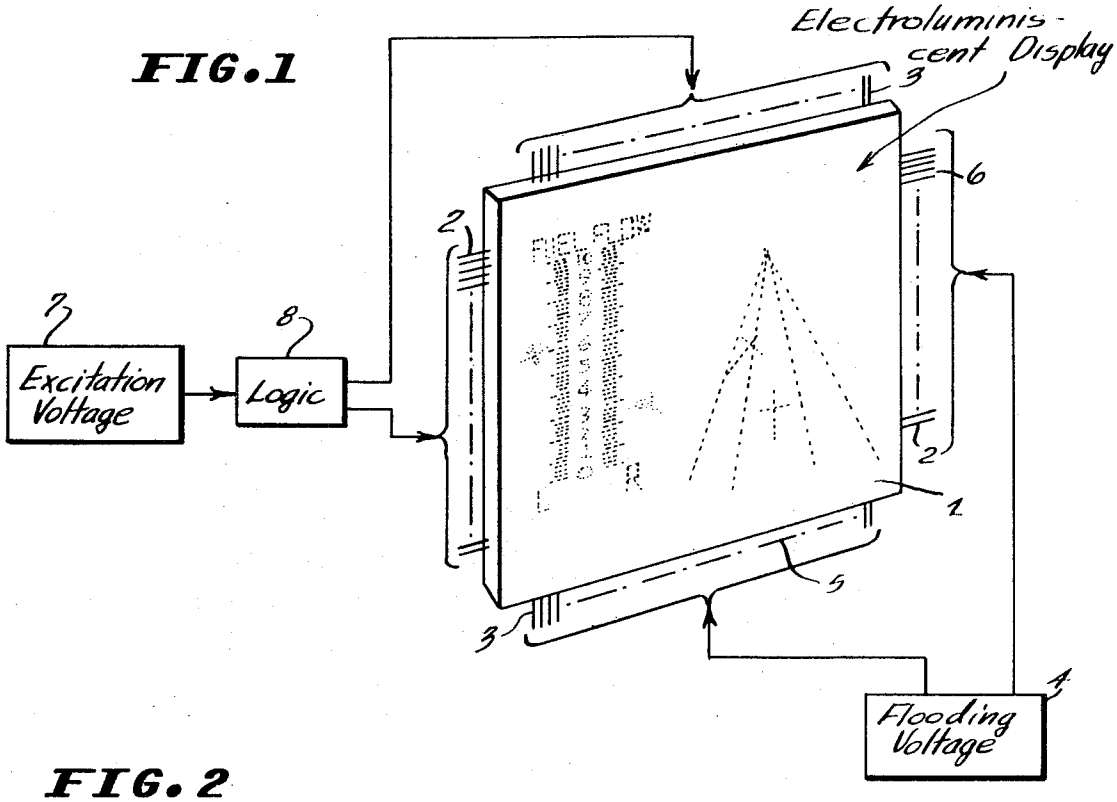
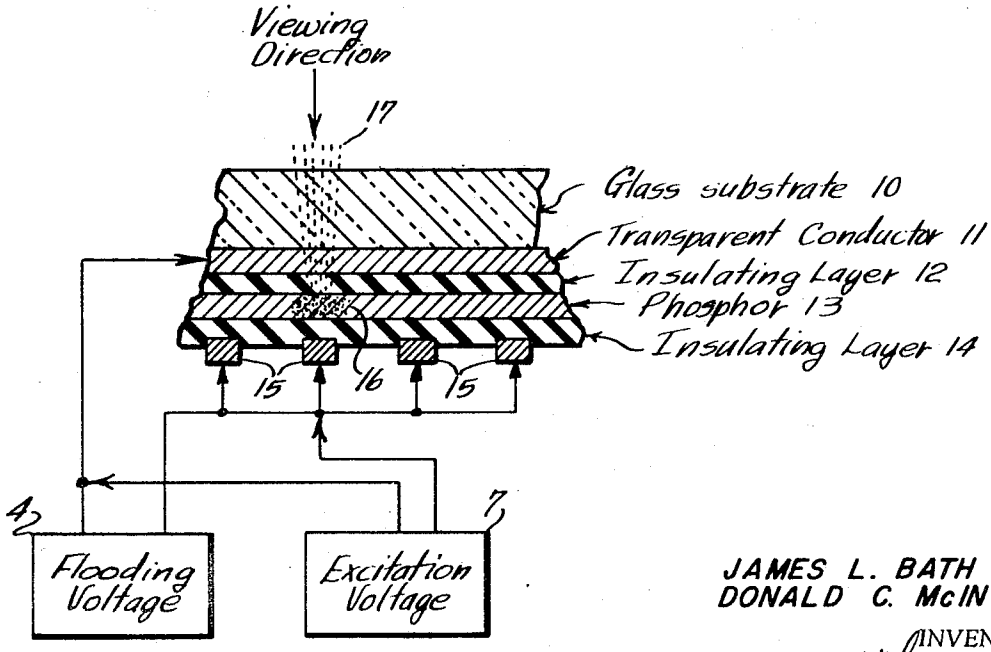


FIG. 2



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FIG. 3

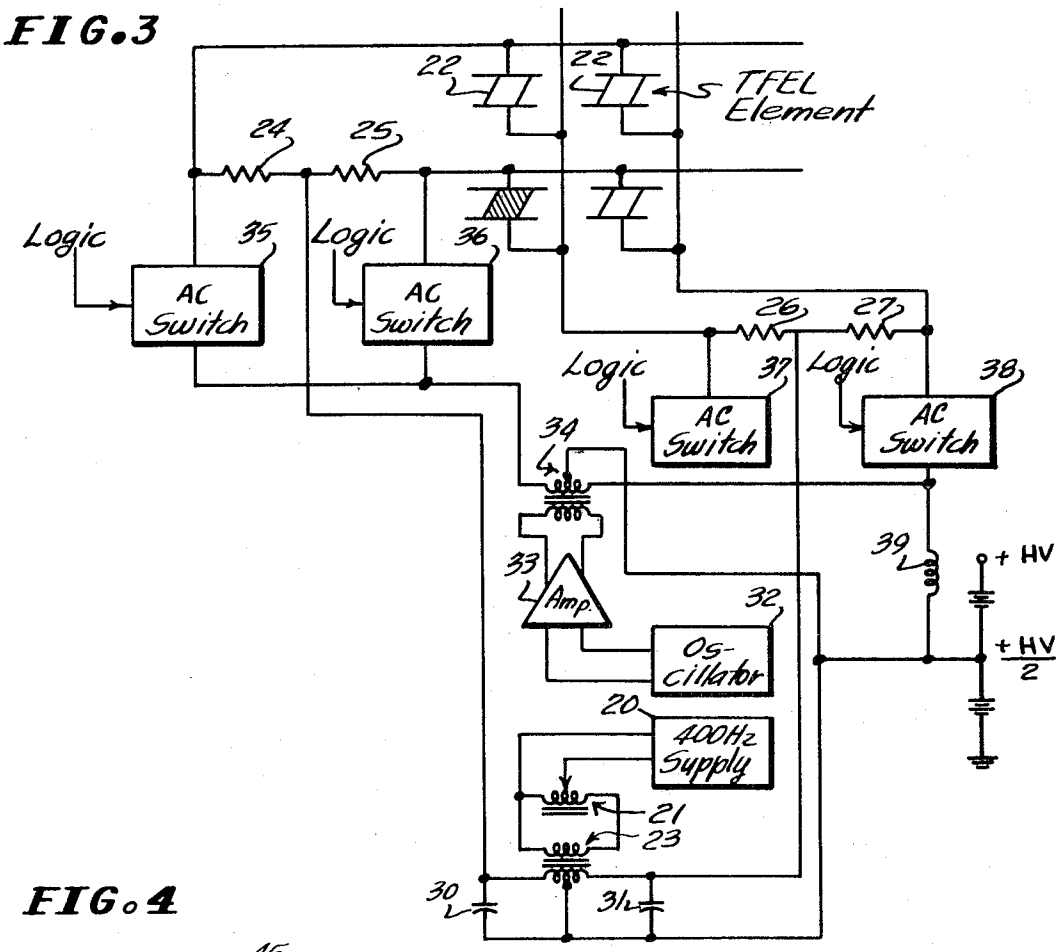
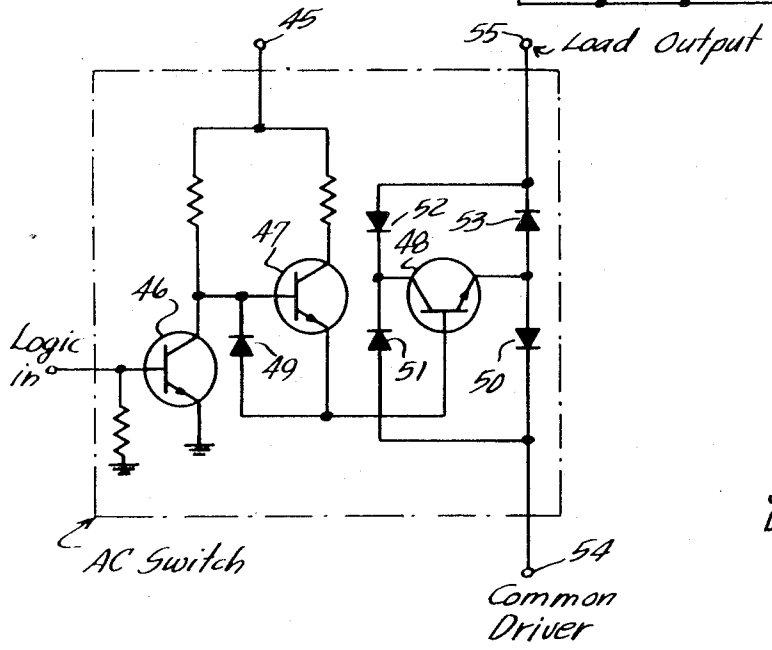


FIG. 4



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ELECTROLUMINESCENT DISPLAY

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to electroluminescent display devices and, more particularly, to a method for obtaining rapid response times from the individual elements in a multielement, thin-film, electroluminescent display panel.

One of the main problems with a digitally addressed, thin-film, electroluminescent-matrixed display is the relatively long turn-on time of the phosphor elements. This turn-on time has precluded the use of these thin-film panels for animated displays or for the display of fast-changing parameters. The concept which, when employed, permits rapid response times for the elements is called "flooding." Flooding is the process by which each of the elements are continuously excited to a point immediately below illumination level. When an individual element is to be activated, a small additional voltage is applied across this element. The resultant turn-on time is reduced to the order of a few hundred microseconds. Except for some design advantages, a DC, DC; a DC, AC; or an AC, AC excitation-flooding voltage may be used to decrease the turn-on times of the thin-film elements. In order to minimize element deterioration and flooding power requirements, AC excitation and flooding voltages having different frequencies are used in the preferred embodiment.

It is therefore an object of this invention to provide a method and apparatus for increasing the response times of electroluminescent devices by providing them with a flooding voltage at a point just below their excitation levels.

It is a further object of this invention to provide thin-film electroluminescent devices with an AC source of excitation voltage and an AC source of flooding voltage.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

FIG. 1 is a representation of the electroluminescent display panel showing the application of flooding and excitation voltages thereto;

FIG. 2 is a drawing indicating the construction of a typical thin-film electroluminescent display panel;

FIG. 3 is a schematic diagram of one system for applying flooding and excitation voltages to the individual elements in a thin-film electroluminescent display panel; and

FIG. 4 is a circuit diagram of the AC switch shown in FIG. 3.

Referring to FIG. 1, a typical electroluminescent display panel 1 with a symbolic digital display is shown. At the edges of this display are shown row conductors 2 and column conductors 3. These conductors pass through the panel from one side to the other so that connections to the conductor may be made at either end. The aforementioned flooding voltage, shown diagrammatically at 4, is applied at 5 and 6 to all of the column conductors and all of the row conductors, respectively, by the system shown in FIG. 3. This effectively applies the flooding voltage across each individual electroluminescent element by creating a potential across the points that each of the row conductors overlies each of the column conductors. In the panel and as will be described subsequently, the row conductors are separated from the column conductors by two insulating layers and a layer of electroluminescent material sandwiched therebetween. When the flooding voltage is applied in the manner described, a potential is created across the electroluminescent material in much the same way as a potential is developed across the plates of a conventional capacitor. The flooding voltage is set such that the potential thus created is only slightly less than that necessary to cause the electroluminescent material to fluoresce. The excitation voltage, shown at 7, is applied across those row and column conductors selected by logic 8 to activate the electroluminescent material sandwiched between the points of intersection of the selected row and column conductors. The potential at these points of intersection or overlapping is thus raised above that necessary to cause fluorescence. The materials sandwiched between overlapping conductors along with the overlapping portions of the conductors are referred to hereinafter as thin-film electroluminescent (TFEL) elements. A typical TFEL display panel is fabricated as shown in FIG. 2.

Vacuum-deposited, electroluminescent thin-films have been employed to provide a uniform brightness over large area display surfaces used for visual readout. One such display panel currently available is provided with the above crossed electrode or conductor configuration. This is a 258×258 array of 66,564 individual elements in a 7-inch square active area to provide a linear resolution of 36 elements per inch. Its active element is a phosphor film which, because of its lack of granularity, provides high resolution. The intersection area of a pair of crossed electrodes or conductors accurately defines and locates the area of a specific light-emitting element. There can be no displacement or positional flicker of this solid-state element since the position of the intersection does not change. The topmost electrode or conductor is transparent to enable the luminescence to be visible. Wide angle viewing is inherent in this type of display since all elements are in one plane near the top or front surface of the panel.

FIG. 2 shows the laminar construction of the panel in cross section. The panel is constructed on a glass substrate 10 which forms the front surface of the display. On top of the substrate are deposited a series of transparent conductors in parallel rows. One such conductor is shown in cross section at 11. In one embodiment, these conductors were tin oxide layers etched into the substrate. A layer of dielectric or insulating material 12 is then deposited over the transparent conductors and onto the substrate. This dielectric film is also transparent to allow the luminescence to be seen. Over the dielectric film is deposited a film of electroluminescent material 13 which in one embodiment is a phosphor. Another insulating layer or dielectric film 14 is then deposited over the phosphor. This film has an index of refraction equal to that of the electroluminescent film and is nearly opaque to absorb any ambient light which may enter through the substrate. If all of this light is absorbed, the contrast between the light from the display and the background will be at a maximum.

On top of this last insulating layer are deposited a series of metal electrodes 15 which are layed out so that they are in parallel rows perpendicular to the parallel rows of transparent conductors. When excitation voltage 7 is applied across the phosphor, it luminesces or fluoresces as shown at 16, emitting light 17 through the substrate towards the viewer.

It will be appreciated that with the appropriate insulating materials and phosphors crosstalk between the elements can be reduced. Crosstalk occurs when more than one element fluoresces when only one element is activated. A portion of the circuitry shown in FIG. 3 not only allows for rapid turn-on of each element but also further reduces crosstalk.

While the flooding and excitation voltages may both be DC, AC driving and flooding voltages have the advantage of slower element deterioration and less power drain over DC—DC or DC—AC combinations. In the above-mentioned panel, AC voltages of 740 volts peak to peak have been used to drive the display depending on the frequencies of the voltages employed.

It is a finding of this invention that flooding the panel just described decreases the time necessary to turn on an element to a few milliseconds from turn-on times on the order of seconds. A further finding is that with AC flooding an excitation voltage of substantially different frequencies not only is turn-on time greatly decreased over other flooding excitation arrangements but current drain is diminished and element deterioration is greatly reduced. This result was unexpected because previous tests showed that as flooding voltage was increased, turn-on time also increased. However, as the flooding voltage was increased past a certain point, turn-on time decreased. If the flooding voltage is set so that each element is dimly lit, the turn-on time is faster than the response time of most photomultipliers. Even with the elements dimly lit, con-

trast between the activated and inactivated elements is good. There is, however, a trade-off between fast turn-on time and light output from the panel. As the turn-on time is made to increase, light output decreases. With AC—AC flooding-excitation systems in which two frequencies of AC voltage are used, this trade-off is less critical. In the embodiment shown in FIG. 3, a 400 Hz. flooding voltage was used with an excitation voltage. This excitation voltage has a carrier frequency of 20 kHz. with a pulse repetition rate of 40 Hz. Flooding voltage was 480 volts peak to peak with an excitation voltage of approximately 740 volts peak to peak in the above embodiment.

FIG. 3 shows a portion of the circuit used to drive the TFEL display. In this embodiment, the flooding voltage is generated at supply 20 with a frequency of 400 Hz. The voltage amplitude is regulated by a variac 21 to a point at which the elements shown diagrammatically at 22 are dimly lit. This voltage is coupled across each element through transformer 23 and resistors 24, 25, 26 and 27, which are crosstalk suppression resistors. Capacitors 30 and 31 are provided for additional crosstalk suppression. Without this portion of the circuit, there is no path from suppression resistor to ground for the excitation voltage. This is due to the inductance of transformer 23. To complete a low-impedance path for the excitation voltage, capacitors 30 and 31 are added across each side of the flooding supply transformer to center tap. The value of these capacitors is chosen so that impedance to the 400 Hz. flooding supply is high compared to the impedance to the excitation voltage derived from oscillator 32 which drives power amplifier 33 at 20 kHz. with a pulse repetition rate modulation of 40 Hz. This excitation voltage is coupled across elements 22 through transformer 34 and AC switches 35, 36, 37 and 38. It will be appreciated that switches 36 and 37 must be activated to turn on the shaded element 22. A switch capable of switching the AC excitation voltage to this element is shown in FIG. 4 and discussed hereinafter. It was discovered that the slippage in phase relationship of the 400 Hz. flooding voltage and the 40 Hz. pulse repetition rate resulted in modulation of the light output of the elements. The elements would become bright or dim as the frequency changed phases with respect to each other. A 10 millihenry coil 39 is shown shunted across the column driver load to minimize the amplitude of this modulation. Also, by adjustment of the frequency to obtain a maximum slippage rate of one-half the repetition rate, the flicker of the light modulation can be made unnoticeable.

FIG. 4 is a schematic diagram of an AC switch capable of connecting one side of the excitation voltage to a particular electroluminescent element. It is composed of three transistors 46, 47 and 48 and five diodes 49, 50, 51, 52 and 53. Transistors 46 and 47 are cascaded to form a bias control for transistor 48. Diode 49 is connected in parallel with the base to emitter of transistor 47 so as to ensure that any spurious noise or transient voltages that might tend to reverse bias and destroy the transistor 47 emitter to base junction will be conducted by diode 49 and thereby limit reverse emitter to base voltage to approximately 0.6 volts. When transistor 48 is biased into conduction, the first half cycle of the excitation voltage flows from common driver 54 through diode 51, transistor 48 and diode 53 to load output 55, having been blocked at diodes 52 and 50. The second half cycle flows from load input 55 through diode 52, transistor 48 and diode 50 when transistor 48 is biased into conduction. The second half cycle is likewise blocked at diodes 51 and 53. This diode arrangement serves to shunt the two half cycles of the excitation voltage through transistor 48 and, as such, completes the AC switching circuit.

What is claimed is:

1. A thin film, electroluminescent display apparatus having a fast turn-on time, a relatively low-current drain and a low deterioration of the light emitting material utilized, comprising

a sheet of photoluminescent material;

an electrical insulating layer contacting each side of said sheet;

rows of transparent electrical conductors disposed on one insulating layer and columns of electrical conductors disposed on the other insulating layer to define a rectilinear array of light emitting areas;

means for continuously applying across said rows and columns of electrical conductors a uniform AC flooding voltage of an amplitude just below that necessary to excite said photoluminescent material into fluorescence;

means for applying across preselected conductors of said rows and said columns an AC excitation voltage of a predetermined pulse repetition rate and of a frequency that is different from said AC flooding voltage to produce an optical display; and

means for minimizing the light flicker due to the changing phase relationship between said AC flooding voltage and said AC excitation voltage.

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