Dec. 6, 1966 E. A. SACK 3,290,554

ELECTROLUMINESCENT DISPLAY SCREEN AND CIRCUIT THEREFOR

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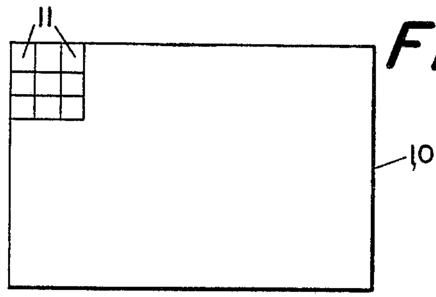

Fig. 1

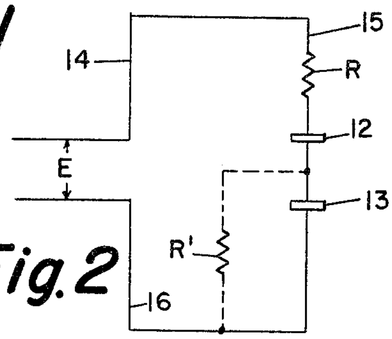

Fig. 2

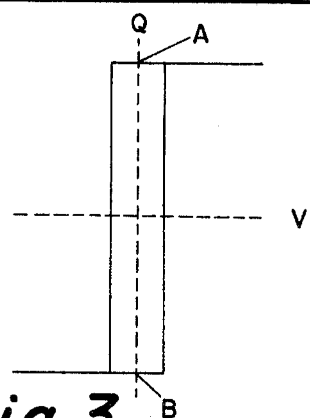

Fig. 3

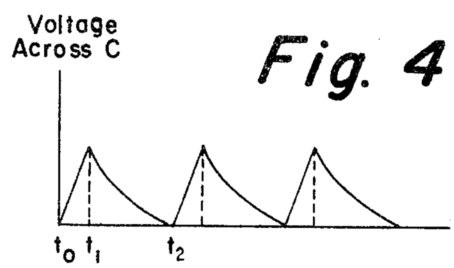

Fig. 4

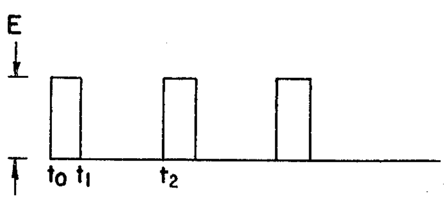

Fig. 5

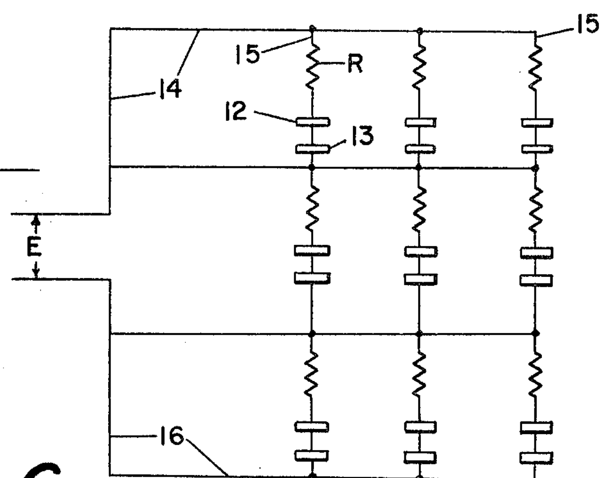

Fig. 6

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ELECTROLUMINESCENT DISPLAY SCREEN AND CIRCUIT THEREFOR

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1 Claim. (Cl. 315—169)

This invention relates to display devices and, more particularly, to solid state display screens formed of an array of electroluminescent ferroelectric elements.

In the operation of such display screens, a contro charge or signal is applied to each element, which functions as a non-linear capacitor, and the charge is later removed by another signal or charge. The elements are provided with an electroluminescent material and the period during which the element is charged by the control signal sets the brightness of the element.

Ferroelectric capacitor elements have been used as the storage means for controlling the light from the electroluminescent material since a screen formed of these elements provides a display having high brightness and a minimum of flicker. The electroluminescent material or element may be applied to or formed on the ferroelectric element in various ways and emits light in accordance with an alternating or time varying potential appearing across it, while the ferroelectric capacitor causes this potential to be altered in accordance with the applied video control potential.

This invention concerns an electroluminescent ferroelectric display screen formed of barium titanate crystals or square loop barium titanate ceramic elements in which the control charge is supplied to the elements in a manner to provide the elements with inherent controlled persistence characteristics in order that the electroluminescent material or element may be operated to "on" condition by a control signal and remain on for a pre-selected period and return to the off state without the necessity of using an "off" signal.

One object of the invention resides in the provision of a display screen formed of electroluminescent ferroelectric elements having circuitry for controlling the supply of control charge to the elements to provide excitation of the electroluminescent material for a selected time period.

Another object of the invention resides in the provision of a display screen formed of electroluminescent ferroelectric elements having circuitry for controlling the supply of the control charge to the elements and also for excitation of the electroluminescent material for predetermined time periods.

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

FIG. 1 shows diagrammatically an outline of a display screen with a representative group of barium titanate ferroelectric elements incorporated therein and greatly enlarged;

FIG. 2 shows the circuitry for one of the cells of FIG. 1;

FIG. 3 is a graph showing hysteresis loops for the barium titanate elements of FIG. 1;

FIG. 4 shows a wave form when the elements are of the voltage responsive type;

FIG. 5 shows a wave form when the elements are of the current responsive type;

FIG. 6 is a schematic showing the circuitry of FIG. 2 arranged for supplying the charge to the representative group elements of FIG. 1.

Referring to FIG. 1, the display screen **10** shows a small group of elements **11** which are greatly enlarged in the figure but are actually of miniature size and a practical display screen may contain upwardly of 250 elements per square inch. Regardless of the actual number of elements used to form a screen, the functions of the elements **11** are those of emitting light in accordance with the A.-C. potential appearing across an element and of causing this potential to be altered in accordance with the applied video control potential.

In FIG. 2, the circuitry for a single element **11** of the display screen is shown. In this figure, an element **11** is separated into two of its component parts which are indicated at **12** and **13**. The component **12** represents the barium titanate ferroelectric material while the component **13** represents the electroluminescent material. The circuit for the signal charge is from the voltage source E by line **14**, to line **15** having resistor R therein, components **12** and **13** and return line **16** to source E. Resistance R′ is in parallel with the electroluminescent material **13** and represents the inherent screen resistance which determines the leakage of voltage from the element **13**.

Refer to FIG. 3, wherein the vertical axis represents electrical displacement and the horizontal axis represents voltage applied across the ferroelectric component **12**. Assume that the ferroelectric material is barium titanate and point A is the "on" condition and point B is the "off" condition, that is, point A represents the charged condition and point B the discharged condition. By selection of the values of pulse voltage E and resistor R, a desired net charge may be supplied to component **12** during a cycle to set the component to the point A or "on" condition in order to charge this component for exciting the component 13 during a discharge period.

If component **13** is voltage responsive and the charge is a voltage sufficient to excite electroluminescence, the wave form across C will be as shown in FIG. 4. The charge period t_1–t_0 is made a small fraction of the period of electroluminescence t_2–t_1 and the values of E and R will be adjusted so that substantially all of the charge leaks off component **13** by R′ during the period t_2–t_1.

If component **13** is current responsive, the wave form is then as shown in FIG. 5. Assume N pulses of charge to be supplied to set the material **12** to "on" or point A of FIG. 3, then, after the material is filled, the first pulse thereafter finds the component **12** incapable of accepting the charge and component **13** is excited during a frame period of succeeding pulses. The net result of this operation is that with component **12** starting at point A of FIG. 3, **13** will emit N light pulses [over a time N (t_2-t_0)] and then goes "out" and stays out. Only by resetting **12** to point A, or by reversing the polarity of E, will the element again emit light.

In FIG. 6, the circuitry of FIG. 2 is shown applied schematically to the group of elements **11** of the screen **10** and accordingly a circuit is shown for each of the 9 elements of FIG. 1. In FIG. 6, the circuits for each horizontal row are supplied in parallel from voltage source E which, because of the rather large resistances R, will overcome problems in scanning which may be involved if the circuits were connected in series.

The following paragraph is for the purpose of clarifying the operation of the screen **10** or elements **11**.

Assume the capacitance of component **12** to be 10 micromicrofarads and that 100 volts must appear across **13** in order to provide the desired brightness. Then the charge E would be 10^{-11} farads×100 volts resulting in 10^{-9} coulombs or 1 millimicrocoulomb of current. Assume further that a repetition rate of 1000 pulses per second is necessary for adequate light, and if a frame time is 1/30 second, a charge of

$$\frac{1000 \text{ p.p.s.}}{30 \text{ sec.}} \times 1 \text{ millimicrocoulomb}$$

or approximately 33 millimicrocoulombs would be required and consequently the ferroelectric material **12** would have approximately that quantity. If it is desired that $[(t_1-t_0)/(t_2-t_0)]=0.1$, then it would be necessary to pass 10^{-9} coulombs in 10^{-4} seconds. Consequently, i during the period (t_1-t_0) will be 10^{-5} amps. If the value of E is chosen as 1000 volts then R will be equal to or equivalent to

$$\frac{10^3 \text{ volts}}{10^{-5} \text{ amps}}$$

or have a resistance value of 10^8 ohms.

A display screen having the characteristic of controlled inherent persistence would have particular application with conventional television or C.R.T. equipment where the frame time of the screen scanning is of fixed duration and consequently would eliminate the necessity of equipment for turning the elements to "off" condition. Various modes of scanning the above described screen may be used. It may be placed in a C.R.T. envelope and the electron beam, for example, used as the current source or current diode distribution systems of the prior art may be used requiring only one half this number of diodes necessary since only the "write" or "on" signals would need to be distributed.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It it therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

I claim:

In a display screen formed of a plurality of independently controlled display elements, the improvement in which,

(a) said display elements are formed of barium titanate material having a surface of electroluminescent material,

(b) an electrical circuit including a voltage source and a first resistor connected in series with each of said display elements to apply a charge to the barium titanate material,

(c) a second discharging resistor in said circuit and connected in parallel with the electroluminescent material,

(d) said voltage source and first resistor being operative to supply an electrical charge of predetermined value to the barium titanate material and

(e) said discharging resistor bypassing the barium titanate material and having a value selected to control the rate of discharge of the electrical energy from the barium titanate material and provide a predetermined period of excitation of the electroluminescent material.

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