

SPECIFICATION

Activating electroluminescent panels

- 5 This invention relates to an electroluminescent device or lamp suitable as a light source for passive electrooptic displays. More particularly, this invention relates to electroluminescent devices and lamps having reduced power consumption.

Typically, electroluminescent (EL) devices comprise a pair of spaced electrodes with one or more layers of field-responsive phosphor material sandwiched between the two electrodes. When an alternating potential is applied between the two electrodes, the resulting electric field excites the phosphor to luminesce.

- However, the main drawback to the commercial use of known EL devices as a light source, particularly for use as a backlight in small battery operated devices such as electrooptic display type wristwatches, is their relatively poor efficiency in converting electrical energy to light.

Accordingly, it is an object of this invention to reduce the power consumption and improve the efficiency of an electrically energized electroluminescent device.

- A further object of this invention is to provide an improved arrangement for driving an EL cell.

- A further object of this invention is to provide an improved electroluminescent panel or lamp having improved efficiency to enable its use as an illumination source for battery powered electrooptic displays.

- In accordance with the invention, there is provided a lamp device comprising an electroluminescent panel having a pair of electrodes with electroluminescent material interposed therebetween, at least one of said electrodes being light transparent; an inductance connected in parallel circuit relationship across the electroluminescent panel to form a parallel resonant tank circuit therewith; pulse generator means for generating repetitive current impulses; and connection means for supplying said current impulses to the tank circuit for exciting the tank circuit into bursts of oscillation substantially at the natural resonant frequency thereof, wherein the capacitive reactance of the electroluminescent panel and the inductive reactance of the inductance are such that the tank circuit has a resonant frequency substantially higher than the repetition rate of the current impulses and is operable to provide resonant oscillations between each of said current impulses; and wherein the pulse generator means is such that the repetition rate of the current impulses is high enough to ensure an effectively continuous perceivable non-flickering light output from the electroluminescent panel.

- Preferably the tank circuit has a resonant

frequency equal to or greater than one kilohertz and the repetition rate of the current pulses is equal to or greater than thirty-two current pulses per second for continuous perceivable non-flickering light output from the electroluminescent panel. Preferably also, the battery power source has a voltage between one and five volts; and the alternating electric field potential produced by the tank circuit has a voltage between twenty and one hundred volts and a frequency between five hundred hertz and twenty kilohertz.

Preferably the tank circuit oscillation has a duty cycle of less than twenty-five percent.

- The invention will now be further described with reference to the accompanying drawings, in which:—

Figure 1 is a cross-sectional side view of an electroluminescent panel;

- Figures 2a and 2b are a schematic view of an explanatory circuit and resulting impulsing wave forms, respectively, for use in explaining the operation of the invention;

- Figure 3 is a block diagram of an embodiment of the invention;

Figure 4 is a sketch of electrical potential which result as the EL panel illustrated in Fig. 3 is periodically coupled to a power source; and

- Figure 5 is a plan view of a multiplexed EL panel impulse energised in accordance with the present invention.

- Referring now to Fig. 1 of the drawings, the EL cell 1 illustrated comprises a transparent outer protective foundation or plastics layer 2 having coated thereon a light-transmitting first electrode 3. Over the first electrode 3 is coated a layer 4 of electroluminescent phosphor material. Over the phosphor layer 4 is a second electrode 5, and over the second electrode 5 is a second protective layer 6. An epoxy seal 7 is used to bind the EL cell together. Electrical lead conductors 8, 9 are electrically connected to the electrodes 3 and 5, respectively, and are adapted to be connected across a source of AC electrical potential (not shown).

- In the explanatory circuit shown in Fig. 2a electrode 9 is connected to ground. Electrode 8 is connected to an AC source 10 via a series switch 11 which may be mechanical or electronic.

- It has been determined that power consumption is reduced and efficiency improved by impulsing the EL cell with a high frequency-low duty cycle alternating AC voltage potential. A minimum power requirement is obtained when the cell or panel or segment of the panel is excited by a spurt of one cycle of a high frequency alternating potential, for example, between 1KHZ and 10KHZ, at a repetition or refresh rate of slightly greater than the flicker rate of 32 HZ. This yields a duty cycle of 0.3 to 3 percent.

- It has been experimentally determined that

a spurt of at least one cycle 17 of a high frequency AC voltage potential periodically applied at a repetition rate above the flicker rate is adequate for activation of the phosphors in an EL cell to produce a glow that equals that of a continuous wave activated EL cell. Power requirements of approximately 3 percent of the continuous wave power requirements have been achieved.

10 The waveform illustrated in Fig. 2b can be applied across the EL cell 1 by periodically closing the series switch 11. Of course, it is assumed that the peak-to-peak voltage 12 is sufficient, for example, 60 to 80 volts, for exciting the phosphor layer 4. The AC wave pulse(s) repetition rate can be calculated or empirically determined such that the EL cell or lamp would not be perceived as flickering due to retinal retention.

20 Referring to Figs. 3 and 4, a preferred embodiment of the present invention is illustrated which has particular application as a display illumination source in low voltage/power battery operated devices such as watches, calculators, meters and the like.

25 One electrode lead 8 of the EL panel 1 is coupled to a positive terminal of a first battery 13 of a split battery power source 13, 14. The other terminal of battery 13 (not shown) is connected to ground. Electrode lead 9 is coupled via a switching transistor or circuit 15 to a negative terminal of a second battery 14 of the split battery power source. The other (positive) terminal of battery 14 (not shown) is connected to ground. An inductance 16 is coupled across the EL panel 1 to form an LC tank or ringing circuit comprising inductance 16 and the capacitance of the EL cell 1. The LC tank circuit is periodically impulsed, by closing the circuit between the split battery power source 13, 14 with switching transistor 15, to induce at least one oscillatory signal 17 across the EL (capacitive) panel 1. The switching transistor 15 is responsive to a control signal/pulse 18, applied to its control gate (not shown), to close the normally non-conducting, i.e. open, switching transistor 15, which thereby permits a voltage-current pulse 21 to flow through switching transistor 15 to supply generative or regenerative energy to the LC tank circuit. At resonance the power dissipated is resistive with the LC tank reactive components nulled out. A pulse shaper circuit 19 provides the control signal/pulses 18.

30 is connected to ground. Electrode lead 9 is coupled via a switching transistor or circuit 15 to a negative terminal of a second battery 14 of the split battery power source. The other (positive) terminal of battery 14 (not shown) is connected to ground. An inductance 16 is coupled across the EL panel 1 to form an LC tank or ringing circuit comprising inductance 16 and the capacitance of the EL cell 1. The LC tank circuit is periodically impulsed, by closing the circuit between the split battery power source 13, 14 with switching transistor 15, to induce at least one oscillatory signal 17 across the EL (capacitive) panel 1. The switching transistor 15 is responsive to a control signal/pulse 18, applied to its control gate (not shown), to close the normally non-conducting, i.e. open, switching transistor 15, which thereby permits a voltage-current pulse 21 to flow through switching transistor 15 to supply generative or regenerative energy to the LC tank circuit. At resonance the power dissipated is resistive with the LC tank reactive components nulled out. A pulse shaper circuit 19 provides the control signal/pulses 18.

55 As a result of tuning out the capacitive shunt component of the panel by the addition of the inductance 16, a resonant circuit is obtained which now can be used to generate the high voltage pulse 17 required to activate the phosphors in the EL panel 1 from the low voltage split battery power source 13, 14. This also reduces the power expended on creating the high voltage pulse by other circuitry. Therefore, this embodiment provides a means for impulsing an EL panel 1 with a

high voltage and high frequency AC signal obtained from a lower voltage single or split (dual) battery power source such as used in watches and the like.

70 While a wide variety of types of EL panels, inductors, transistors, frequencies, voltage-batteries and associated elements may be employed, the circuit and EL (lamp) panel illustrated in Fig. 3 was constructed and successfully operated using the following components:

Voltage source 13	2 OV
Voltage source 14	2 OV
80 EL panel capacitance	.02 nf
Inductor 16	68 nh
LC tank circuit f_{LC}	342 KHZ
LC pulse voltage Peak-to-Peak	9 OV
Pulse 17 duty cycle	0.2%

85 Referring now to Fig. 5, a subdivided EL panel 2 is shown. Based on investigations of EL panels, it was determined that a direct relationship exists between the surface area of a parallel plate configured EL panel and the resultant current drain through the device. A basic watch display EL panel, for example, requires in the range of 42 microamperes of current at 60 HZ to produce sufficient illumination to read a liquid crystal display in low or adverse light conditions. Using the theory of multiplexing the backlight panel, the total current requirement would be the sum of all the discrete segments of the panel divided by the number of discrete segments. If the number of multiplexed segments is chosen as six (3A-3F) then the current being drawn is reduced, for example, to seven microamperes. Also the peak or surge current is reduced which improves the life of the EL panel 20.

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105 In the embodiment illustrated in Fig. 5, each segment 3A-3F is sequentially energized to luminesce by a low duty cycle high frequency pulse as described above. In this manner, the inherent cross talk which EL panels tend to exhibit is beneficially utilized to obtain an illumination (lamp) panel having substantially uniform and continuous light output, when actuated, with improved efficiency.

115 CLAIMS

1. A lamp device comprising an electroluminescent panel having a pair of electrodes with electroluminescent material interposed therebetween, at least one of said electrodes being light transparent; an inductance connected in parallel circuit relationship across the electroluminescent panel to form a parallel resonant tank circuit therewith; pulse generator means for generating repetitive current impulses; and connection means for supplying said current impulses to the tank circuit for exciting the tank circuit into bursts of oscillation substantially at the natural resonant frequency thereof, wherein the capacitive reac-



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tance of the electroluminescent panel and the inductive reactance of the inductance are such that the tank circuit has a resonant frequency substantially higher than the repetition rate of the current impulses and is operable to provide resonant oscillations between each of said current impulses, and wherein the pulse generator means is such that the repetition rate of the current impulses is high enough to ensure an effectively continuous perceivable non-flickering light output from the electroluminescent panel.

2. A lamp device as claimed in claim 1, wherein the repetitive current pulses have a predetermined repetition rate that is greater than the decay rate of the electroluminescent material.

3. A lamp device as claimed in either of claims 1 or 2, wherein the tank circuit has a resonant frequency equal to or greater than one kilohertz, and the repetition rate of the current pulses is equal to or greater than thirty-two current pulses per second for continuous perceivable non-flickering light output from the electroluminescent panel.

4. A lamp device as claimed in any one of the preceding claims, wherein the repetitive current pulses are provided from a battery power source via a repetitively operated switching device forming part of said pulse generator means; and each burst of oscillation comprises at least one cycle of high voltage alternating electric field potential having a voltage greater than said battery power source for application across the electrodes of the electroluminescent panel.

5. A lamp device as claimed in claim 4, wherein the battery power source has a voltage between one and five volts; and the alternating electric potential produced by the tank circuit has a voltage between twenty and one hundred volts and a frequency between five hundred hertz and twenty kilohertz.

6. A lamp device according to either one of claims 4 or 5 wherein the pulse generator means further comprises a control circuit for repetitively closing said switching device to thereby intermittently couple said battery power source to said tank circuit.

7. A lamp device as claimed in any one of the preceding claims, wherein the tank circuit oscillation has a duty cycle of less than twenty-five percent.

8. A lamp device substantially as hereinbefore described with reference to the accompanying drawings.