

[54] **ELECTROLUMINESCENT DISPLAY SYSTEM AND METHOD OF DRIVING THE SAME**

[75] Inventor: **Robert D. Webb**, Hacienda Heights, Calif.

[73] Assignee: **Sigmatron, Inc.**, Santa Barbara, Calif.

[22] Filed: **Nov. 8, 1971**

[21] Appl. No.: **196,434**

[52] U.S. Cl. **315/167, 315/169 TV, 340/336**

[51] Int. Cl. **H05b 37/00**

[58] Field of Search **315/167, 169 R, 169 TV; 340/336**

[56] **References Cited**

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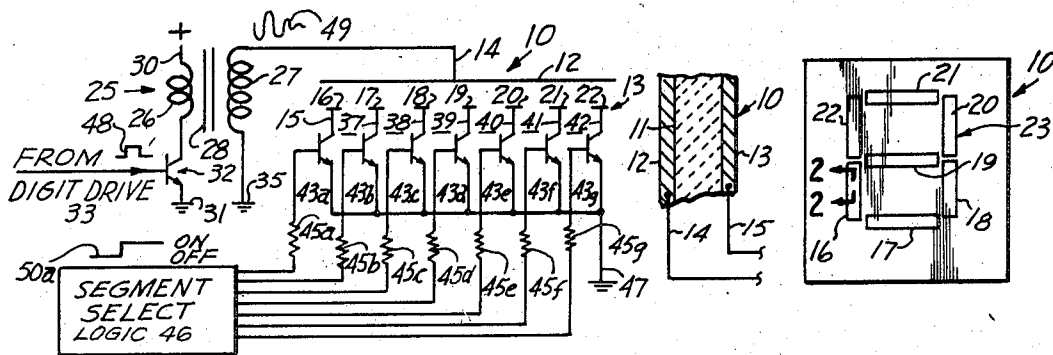
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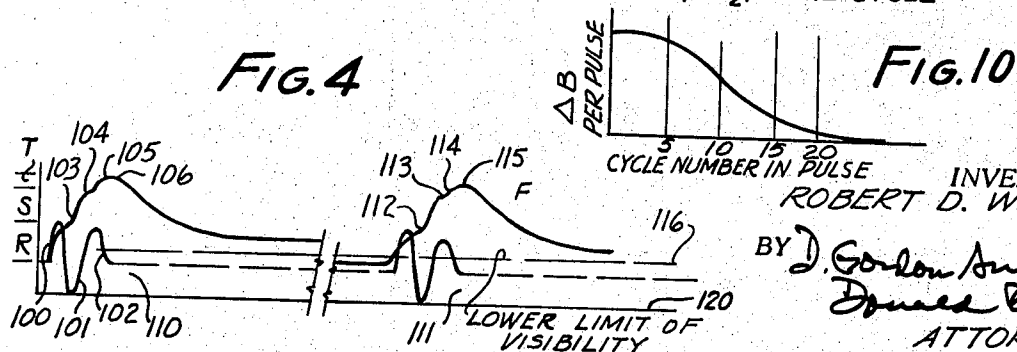
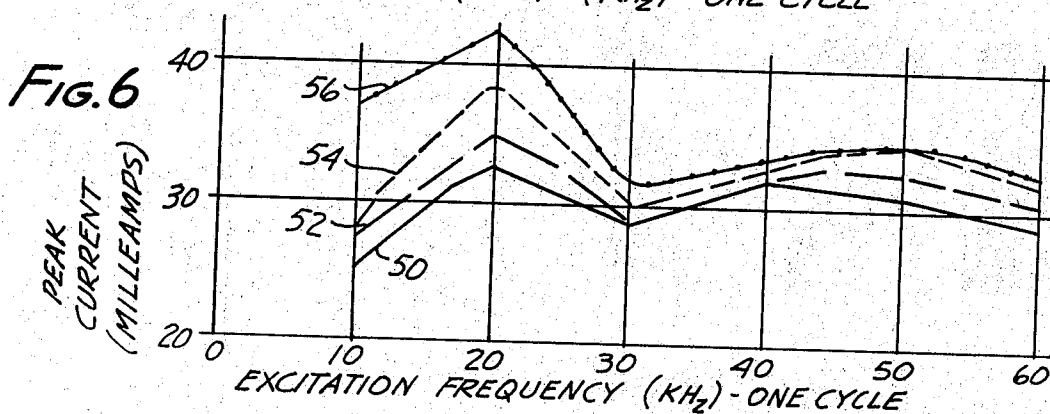
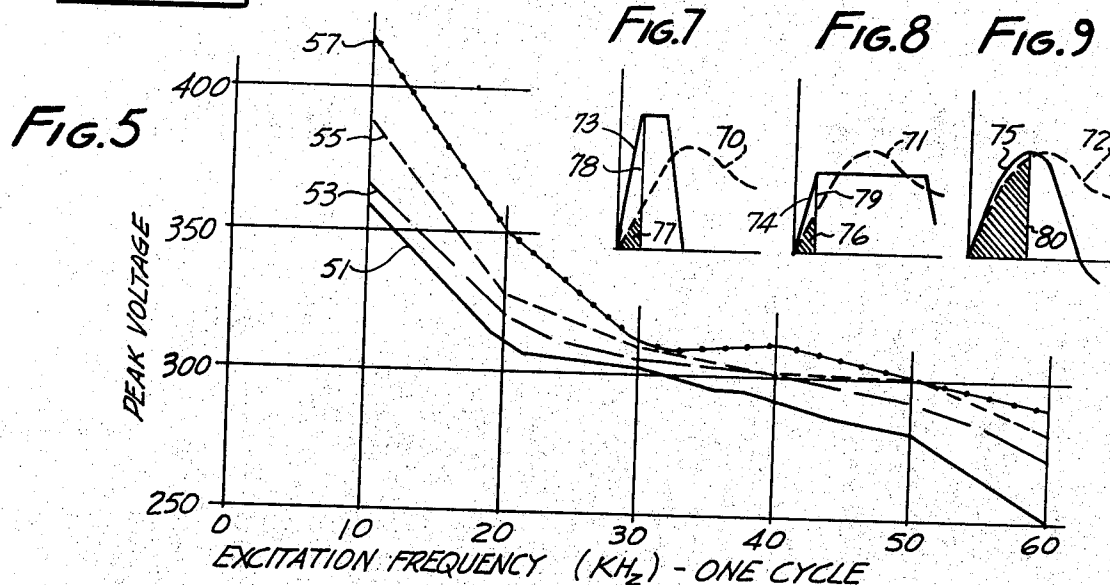
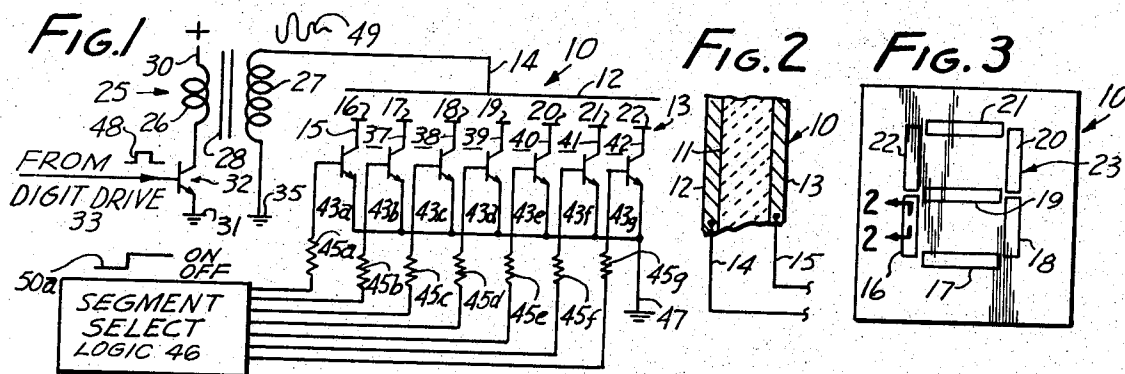
Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Lawrence J. Dahl
Attorney, Agent, or Firm—Pastoriza & Kelly

[57] **ABSTRACT**

An electroluminescent display utilizing a capacitive display device. The display has an inherent minimum useful illumination term, during which it must be actuated in order to be seen by an observer. The display is driven (actuated), so as to be illuminated, by pulses of actuating alternating current, and there will be more than one of these pulses during each said minimum useful illumination term. The pulse term, or duration, of the individual pulses is shorter than the interval between pulses. The pulses may be shaped so as most efficiently to transfer energy to the display. The driving system improves the efficiency and lengthens the life of single displays, and permits higher-intensity operation of multiple displays. A useful driving system includes a pulse transformer which produces the desired actuating current when it is itself pulsed.

18 Claims, 10 Drawing Figures





N. PULSE INVENTOR.
ROBERT D. WEBB

BY *J. Gordon Smyth &
Donald E. Mon*
ATTORNEYS

ELECTROLUMINESCENT DISPLAY SYSTEM AND METHOD OF DRIVING THE SAME

This invention relates to electroluminescent display systems, and to a method for driving the same.

Electroluminescent display panels of the capacitive type depend for their excitation and resulting luminosity upon the application of an alternating current across two electrodes between which there is disposed a layer of electroluminescent material. Examples of this class of panel are those in which the layer is a compressed powder, a vacuum deposited layer, or a ceramic layer commonly made from a baked compressed layer of electroluminescent material and glass frits. An example of a suitable electroluminescent panel will be found in U.S. Pat. No. 3,560,784, issued to Gordon N. Steele and Edwin J. Soxman on Feb. 2, 1971, entitled "Dark Field, High Contrast Light Emitting Display."

It is presently common practice to illuminate electroluminescent displays by continuously applying an alternating current across the said two electrodes for the full useful illumination term, i.e., the total length of time in which the display is to be illuminated. There have been other practices wherein an alternating current is applied in periodic bursts, but these bursts have been of substantial duration. Such practices have heretofore been believed to be necessary to drive electroluminescent displays, and they have therefore been widely used. However, they do have unfortunate side effects. Among these side effects are excessive heating of the panel which leads to its earlier breakdown, a necessary reduction of voltage in operation in order to minimize this consequence, and a consequent reduction in peak output luminosity. Electroluminescent displays produce light most efficiently at relatively high frequencies and voltages (amplitudes) of actuating current, but these are the same parameters which lead to breakdown of the display when prior art driving practices are used. Accordingly, it has not heretofore been possible to operate an electroluminescent panel of the capacitive type to best advantage utilizing commonly known driving techniques and circuitry.

Furthermore, when multiplex systems are used, i.e., when a plurality of displays are simultaneously driven by a common drive, the division of current from the single source has resulted in a less illumination level. Attempts to correct this situation by raising the voltage and applying the current according to the prior art practices lead to early failure of the displays.

It is an object of this invention to provide an electroluminescent display system and a method for driving the same wherein relatively higher voltages and frequencies may be utilized to drive a given display so as to maximize the luminous output in multiplexed installations, and to lengthen the life and increase the efficiency in both single and multiplex installations. Average current consumption is decreased, and the system can operate with simpler and smaller power supplies.

The system and method according to this invention include an electroluminescent display of the capacitive type connected to a source of alternating current. The display has an inherent minimum useful illumination term, i.e., a minimum period of time it must be illuminated at or above some luminous level in order to be perceived by the eye of an observer as a luminous surface. The display is driven (actuated), so as to be illuminated, by pulses of actuating alternating current. The

pulse interval between the start of adjacent pulses is shorter than the said minimum useful illumination term. The pulse term, or period of duration of the individual pulses, is shorter than the interval between pulses so there will be more than one of said pulses per minimum useful illumination term.

According to a preferred but optional feature of the invention, the pulses are shaped so as more efficiently to transfer energy to the display, because their energy output is closely conformed to the energy acceptance characteristics of the display.

According to still another preferred but optional feature of this invention, the number of cycles per pulse having an amplitude sufficient to contribute significantly to increased luminosity is restricted to that in which a substantial incremental increase in brightness results from each cycle, and preferably there will be about five or less of these contributing cycles per pulse, because within this lesser number of cycles, each cycle provides a differential increment of brightness which is appreciably larger than that provided by later cycles.

The invention will be fully understood from the following detailed description and the accompanying drawings in which:

FIG. 1 is a circuit diagram showing the presently preferred embodiment of the invention;

FIG. 2 is a fragmentary cross-section partly in schematic notation, taken at line 2—2 in FIG. 3;

FIG. 3 is a plan view of an illustrative example of a suitable display panel for use with the invention;

FIG. 4 is a diagram showing the preferred pulse train and wave form for use in the practice of this invention together with a diagram of the resulting luminosity of the driven display;

FIGS. 5 and 6 are graphs showing peak voltage and peak current versus excitation frequencies to produce a given luminosity, utilizing the wave form of FIG. 4 and;

FIGS. 7, 8, 9 and 10 are schematic graphs showing certain design considerations for the system.

In FIGS. 2 and 3 there is shown a capacitive electroluminescent display 10 of a type useful with this invention, in the form of a panel FIG. 2 shows it as comprising a layer 11 of electroluminescent material disposed between a pair of electrodes 12, 13, one of which will preferably be transparent. This will usually be the "common" electrode, and is connected to lead 14. There may be, and usually there will be, additional layers and components. For one such example, reference may be had to the aforesaid U.S. Pat. No. 3,560,784.

It is customary for numerical displays to be disposed in segments such as segments 16, 17, 18, 19, 20, 21 and 22 (See FIG. 3). By means of selecting various segments to be illuminated, any desired numeral from zero through nine can be displayed in accordance with known techniques. Segment 16 is shown connected to lead 15. Similar leads are connected to each individual one of the segments, and the segments are isolated from one another so they can be illuminated individually. Ordinarily, there will be more than one of these panels 10 to build up a larger display. If so, each will be provided with its own driving circuitry.

The driving circuitry includes a transformer 25 having a primary winding 26, a secondary winding 27, and a core 28. The transformer is sometimes called a "source of alternating current." Its primary winding

has fewer windings than its secondary winding. Its output will ordinarily be about 200 volts rms, and a convenient winding ratio is 10 : 1. Very inexpensive audio transformers may be used for this purpose. The core will be selected such that a single pulse applied to the primary winding will produce an output alternating current pulse of the desired characteristics.

A transformer has the characteristic of "ringing," meaning that a single pulse applied to its primary winding will create a train of sine waves of diminishing amplitude. The core is selected so as to limit the number of cycles having an amplitude above the minimum actuating voltage needed for excitation of the display to cause visible illumination (there is such a minimum, and voltages below this level are not considered part of a "pulse"). These cycles will be few in number, for each pulse, and will definitely be less than would occupy the full interval between the start of two successive pulses. With many practical transformers, at the most three full cycles, and preferably only one or one and one-half, cycles will have a voltage sufficient to cause luminosity. A minimum of one cycle (two half-cycles) is needed for illumination. The selection of the number of cycles per pulse will be discussed in greater detail below. The term "cycles" as used herein also includes fractions of cycles.

A source of voltage 30, such as a battery or a buss bar, is connected to one lead of the primary winding. The other lead of the primary winding is connected to ground 31 through transistor 32. The transistor may be an RCA 40327, the base of which is connected to a pulse source 33 which is a digit drive device to illuminate segments of a given digit (or panel). Pulses are periodically supplied to transistor 32. The selection of which if any segments light up is otherwise made. The collector is connected to the primary winding, and the emitter is connected to ground 31.

One lead of the secondary winding is connected to ground 35, and its other lead 14 is connected to electrode 12. This electrode is common and relates to all of the segments. The electrodes comprising the segments on the opposite face are connected to individual leads 15, 37, 38, 39, 40, 41 and 42, each of which is connected to a respective switch means 43a-43g. The switch means comprises transistors whose bases are connected through respective resistors 45a-45g to segment select logic 46, which will provide a pulse to turn on to flow selected ones of the seven switch means, and cause the respective selected segment or segments to light up when a pulse is generated in the secondary winding. The switch means are all identical. Conveniently, they may comprise a transistor with its base connected as aforesaid, its collector connected to the electrode of the respective one of the segments, and its emitter to ground 47.

Transistor 32, and the circuitry and circuit components connected to the display, except for transformer 25, are sometimes collectively referred to as "means for periodically and intermittently applying alternating current to the electrodes."

In operation, a wave pulse, such as shown at 48, is applied across the primary winding. This will generate a sinusoidal wave, such as shown at 49 in FIG. 1. It is a "ringing" wave of decreasing amplitude, only the first few cycles, and preferably only the first one or one and one half, having sufficient amplitude to actuate the display. Because this wave goes to a common electrode,

potentially all of the segments could light up. However, only those whose switch means will permit current flow will in fact light up. Accordingly, during the time a respective segment is to light up, a signal will be applied to its respective switch means from the segment select logic to permit current flow therethrough. Then these selected segments will light when actuation voltages are applied across their respective electrodes.

All previous displays of this type, utilizing frequencies in excess of a few hundred hertz, have recommended the usage of continuous sine or square wave excitation continuously for the full duration of the illumination term. Occasionally actuation has been suggested using intermittent bursts of pulses of substantial duration. In these prior art arrangements, the actuation voltage was applied for a substantial number of cycles, and then, especially in multiplexed applications, was repeated after a pause. As a consequence of the continuous drive during the period of actuation of each burst the voltage and illumination had to be minimized to prevent destruction of the panel. The upper frequency and voltage limits under continuous actuation are determined by rates of power dissipation, as well as by the breakdown voltage limitation, which may vary as functions of display surface area. These previous arrangements still will function, but it has now been found that short pulse, low percentage of illumination term actuation as described herein is more useful, especially for large area multiplex display applications.

A suitable transformer for this system will convert a dc power source voltage to about 600 volts peak-to-peak amplitude at its terminals. Each segment of the display is individually selected by grounding it through the transistor of its respective switch means. These transistors 45 should have a breakdown voltage equal to the actuation voltage. However, reduced ratings merely cause incomplete turn-off of the segments. It has been found that reduction of actuation voltage by as little as 25 percent reduces light emitted as a consequence of its actuation to a level below that which is visible under normal ambient conditions. In selecting the parameters of the transformer, it is only necessary that the cycles after the number desired for actuation have an amplitude insufficient to actuate the display to a visible level. Of course, means can be provided to chop off all cycles other than the exact number desired.

The results of exerting excitation for less than the full illumination term (i.e., for less than the total term the display is to be luminous), and in the manner described hereinafter, are shown in FIGS. 5 and 6 wherein graphs 50 and 51 in solid line represent actuation at 12.5 percent of the illumination term, the long dashed lines 52 and 53 represent actuation at 6.25 percent of the illumination term, short dashed lines 54 and 55 represent actuation at 3.125 percent of the illumination term, and the dotted lines 56 and 57 represent actuation at 1.56 percent of the illumination term. These graphs illustrate the current and voltage relationships to frequency for providing 15 foot-Lambert, time averaged brightness which is produced by pulses of one and one-half full sine waves applied periodically to occupy the respective percentage of the full illumination term. In fact, the curves represent utilization of the wave train shown in FIG. 4, in which only the first three half cycles as illustrated are of sufficient amplitude as to actuate the display, that is, which have amplitudes sufficient to

contribute a significant increment of increased luminosity. Such cycles (or half-cycles) are sometimes called "contributing cycles" in the sense that they contribute significantly to the actuation of the display to visible luminescence. The term "actuation" is used to denote excitation of the panel to levels of perceptible, useful luminescence. It will be seen in FIG. 5, that for the same luminosity, the peak voltage may be increased as the percentage of illumination term occupied by pulses of actuating level decreases. Accordingly, the device can be driven at higher frequencies, where the efficiency in illuminating the display is greatest, and still produce relatively less heat, thereby extending the life of the display.

Similarly, the current is plotted in the same manner in FIG. 6 as voltage was in FIG. 5, and it will be noted that, as the percentage of the illumination term occupied by contributing cycles decreases, the same luminosity may be obtained with increased current flow but for materially lesser periods of time, thereby again decreasing the breakdown rate of the panel. It is the rms value which determines the heating effect, and this situation is improved with a frequency increase, while still enabling a higher current level to be used.

As a practical means of operation, this invention could utilize continuously-running sources of single or multiple pulses of suitable amplitude to illuminate a segment, passing some pulses and blocking others, such as in the case of 12.5 percent of the illumination term, passing every eighth pulse and blocking the first seven.

The criteria for driving single and multiplex displays will now be described in greater detail. In the case of single displays, such as shown in FIG. 1, the techniques will be used without reference to other displays. In the case of multiplexed displays, there will be a plurality of panels 10, and each will be actuated to illuminate the respective digit, but the actuation occurs serially and not simultaneously. Thus, each additional panel will be actuated by the same class of alternating current wave form in the same manner, during the interval between starts of successive pulses. It follows that the pulse term times the number of panels (displays) will not exceed the time duration of the minimum useful illumination term, and should be less in order that there will be more than one pulse per minimum useful illumination term per display. FIG. 1 therefore illustrates the actuation of a single display, or the actuation of each of a plurality of displays, in sequential operation.

FIGS. 4, 7, 8 and 9 illustrate certain characteristics of an electroluminescent panel relative to currents which actuate them to luminescence, and also present facts to be considered in selecting the frequency, voltage and wave form of the driving current.

The display, a capacitor, will accept energy input during a finite period, which period is determined by the specific physical and electrical characteristics of the specific device. In particular the period during which it will accept energy is related to its time constant, which in turn is primarily a function of its internal series resistance and of its capacitance. The device will, of course, accept energy only during the time in which current flows.

If maximum efficiency of energy transfer is to be attained, then it is necessary to match the energy-accepting characteristics of the device to the output characteristics of the energy source. The quantity of

light emitted by the device is directly determined by the energy accepted by the device from the power source.

Should the power source supply power in a form not acceptable by the device, either the device will not be optimally illuminated, or excess power will be dumped into the system which will heat up the system and shorten its life. Thus, reaching a peak voltage or current limit for the system prior to the time the device can accept an optimum amount of energy results in a less-than-optimum amount of energy being used for actuation. Should the voltage be increased to make the device light up to its optimum intensity under these conditions, the excess energy will tend to destroy the device.

In FIGS. 7, 8 and 9, dashed lines 70, 71, 72 schematically illustrate the energy acceptance characteristic (ordinate) versus time (abscissa) of the electroluminescent capacitor. Solid lines 73, 74, 75 show three types of applied current wave forms with voltage as the ordinate and time as the abscissa.

Line 73 is a very steep, flat sided nearly square wave, with a large amplitude and short duration. Line 74 is a flat-topped square wave which, however, has sloping sides which more nearly match segment 76 or line 74, and has a lesser amplitude and longer duration. Line 75 is a sine wave and rather closely matches the increasing value portion of line 72.

Attention is now called to the common area below both of lines 70, 71 and 72, and the rising portions of respective lines 73, 74 and 75. These areas are shaded for illustration. It is this area which is proportional to the energy actually transferred to the device, and which causes illumination. The areas under the lines showing applied voltage (lines 73, 74 and 75) not also under lines 70, 71 and 72 involves problems for the system.

Area 77 (FIG. 7) is quite small relative to area 78, and this class of wave form is very disadvantageous, because it is quite small compared to the unshaded area 78 above it that represents energy which must be dissipated. With its high voltage peak it can cause destructive current peaks during the time the device is accepting energy. Area 79 in FIG. 8 shows the advantage of more closely "tailoring" the shapes of the curves to correspond to one another, because the energy it represents is smaller than area 78, while area 76 is about the same as area 77. This also illustrates why a longer pulse term is useless, because the device will not accept further energy.

In FIG. 9 area 80 occupies nearly the same area as that under either of the curves. Optimum illumination will be caused, and the actuating current promptly drops off, while the illumination only gradually diminishes. FIG. 9 shows, therefore, that only a short burst of energy, if properly tailored relative to the energy acceptance characteristics, will cause optimum illumination with minimum energy to be dissipated, and minimum risk to system components. Thus, the wave form of the actuating current should be such as to supply energy to the display at substantially the same rate it will be accepted by the display.

Bearing the foregoing in mind, reference should now be made to FIG. 4. In order to fit this figure to any practical drawing scale, it has been necessary greatly to foreshorten the abscissa. In point of fact, the period of time an electroluminescent device need be actuated by

applied alternating current, in order to produce an optimum level of illumination is only a small part of the illumination term, because the relaxation period during which the phosphor continues visibly to glow is much longer than the rise time, and its rate of change is much shallower. For example, in many electroluminescent devices, the rise period will be approximately equal to the pulse term, which can be quite short and can be varied and the relaxation period will be of the order of one millisecond regardless of the pulse term. It follows that energy can be injected into an electroluminescent display much faster than it can be radiated as light.

Further, there are certain other considerations to be born in mind in considering FIG. 4 and the parameters of this system. The first is that for any display there is a maximum resulting light intensity, whatever the details of excitation. In present systems, the applied voltage to reach this intensity is limited by the mode of operation and the heat which it generates. Another consideration is that the rate of increase in intensity of light output during the rise period is much greater than the rate of decrease in intensity during the relaxation period. For example, it will frequently be found that a 50 percent decrease in luminosity may take on the order of ten times the period of time it took to rise to maximum intensity.

With the above in mind, it will be seen that successive charge and discharge cycles in a successive pulse will produce a smaller incremental increase in intensity than the respective cycles in the earlier pulse, if the later pulse is applied before luminescence ceases. If the cycles in the second and successive pulses produce less of an increase in intensity than the first, it is apparent that efficiency will decrease. For example, in FIG. 4, there is shown a pulse consisting of three half-cycles 100, 101 and 102. These result in increases in luminosity denoted by segments of the luminosity curve by segments 103, 104, 105 which terminate at a point 106 which represents the maximum light intensity which will be derived from the applied cycles of that pulse. If subsequent pulses are begun when the illumination level is above zero (right-hand portion of FIG. 4), then the maximum light intensity may become somewhat higher, subject, of course, to the inherent limit of the display itself.

A study of the luminosity created by the equal actuating cycles within a given pulse will show that increments R and S (left-hand portion of FIG. 4) are substantially equal, and that linear increases in luminosity are attained, while increment T is less than either of increments R and S. Accordingly, greater efficiency results if actuation is caused by a limited number of cycles per pulse. Fairly linear results are then attained. FIGS. 7, 8 and 9 each illustrate a "half cycle."

There is a very important consequence of the foregoing, namely that in allowing substantial relaxation of the phosphor after each period of excitation there would be expected to result a reduction of average intensity. However, it has been found that by frequent excitation of pulses of lesser term, less thermal dissipation need occur, and a higher amplitude of exciting current can be used. There results substantially the same average luminosity, and a higher operating efficiency with lower operating temperatures and an extended operating life.

Accordingly, as can be seen in FIG. 4, two sets of identical actuating pulses 110 (including contributing

half-cycles 100, 101 and 102) and 111 are illustrated. After pulse 110 is applied, the phosphor is permitted to return to an illumination level near or below that which cannot be observed by the eye as being illuminated before another pulse is applied (even though it may be excited, and have luminous intensity B at a level above extinction) before the next pulse 111 is applied. In any event, it will be permitted to return to such a level that the contributing half-cycles of pulse 111 will contribute significantly to illumination, and such that at least some of them do so linearly. The three half-cycles of cycle 111 will cause illumination increases denoted by segments 112, 113, 114 until again a maximum level 115 is reached. Although it is not shown as such in schematic FIG. 4, level 115 will be somewhat higher than point 105, because the actuation started while luminosity was not at zero, but instead at some higher value, still being less than the lower limit of visibility. Should further actuation occur after the first few cycles in a given pulse, more of its energy will simply have to be dissipated as heat. In FIG. 4, the exciting voltage has been shown directly aligned with luminosity for convenience in disclosure of the effect of each cycle. However, in actual result, there is a time lag between actuation and luminosity. This is easily observed by the use of conventional instrumentation techniques.

Line 116 shows the lower level of luminosity below which an observer will not be able to tell that the display is actuated - in other words, even if it is excited, the glow is too dim. The term "actuation" is used to denote the application of current to cause luminosity above this value. In the operation of this invention, it is possible to permit the luminosity to decay to zero (line 120) before again pulsing the display, and if the luminosity produced by successive pulses is sufficient, the eye will perceive an illuminated image. Depending on all the circumstances, this technique may be used. However, it may also be preferable not to permit the luminosity to decay all the way to zero, in which case for best efficiency it will be permitted to decay at least to the lower limit of visibility as exemplified by line 116. There is little point in re-actuating the display while it is still slowing brightly enough to be perceived.

The phrase "minimum useful illumination term" has been used herein. A single pulse as defined herein will not produce sufficient excitation that the display will be perceived by an observer. Persistency and acuity of vision are also involved. Therefore as a matter of definition, the basic "module" for actuation, namely that level of illumination which is required at least to perceive the fact that it has occurred, has been defined. Of course any practical operation will involve durations of illumination longer than this minimum, but the proportions defined with relation to the said minimum useful illumination term also apply to the "illumination term" which is the total period of time the device is to be perceived as illuminated which merely constitutes a sequence of many of such minimum useful illumination terms.

There are certain other considerations involved in the design of the pulse, especially as to the number of actuating cycles per pulse. FIG. 10 shows as its ordinate the increment of luminosity caused per cycle in a pulse starting from zero luminosity. The abscissa represents the cycle number in each pulse.

Examination of FIG. 10 illustrates that for about the first five cycles, the increment of illumination, while decreasing, will remain reasonably constant, after which the value falls off fairly steeply to about twenty cycles, and cycles beyond twenty have little, if any, effect except, of course, to heat up the display.

Therefore in the practice of this invention, one will use a number of cycles per pulse wherein the pulse provides a substantial increment of luminosity, i.e. below about twenty, and preferably in a substantially linear range, i.e., less than about five. FIG. 4 illustrates that, even within this narrow limit, subsequent cycles provide a lesser increment of luminosity.

This invention thereby provides a means for driving an electro-luminescent display with a relatively higher amplitude of actuating current than is tolerable in known operations and operating it at relatively shorter bursts and lesser percentage of the illumination term. Preferably, the pulses are applied so that their contributing cycles comply less than about 25 percent of the minimum useful illumination term and are provided in bursts of not more than three full cycles. The preferred range is between about one percent and about 25 percent of the minimum useful illumination term for the total of the contributing cycles.

As to the operation of the system of FIG. 1, the segments to be illuminated are selected by segment select logic 46, which grounds the respective switches 43a-43g. The digit drive is periodically pulsed so as to cause wave form 49 to be produced by the transformer. The wave form 49 will in the preferred method have not more than three half-cycles of amplitude sufficient to cause luminosity above the limit lower of visibility. The ringing cycles beyond those three half-cycles will be of lesser amplitude. The digit drive is pulsed with a frequency that will provide contributing cycles for the selected proportion of the minimum useful illumination term. Accordingly, actuating currents applied in this manner will cause the selected segments to illuminate and remain illuminated so long as the actuating current is applied. The time occupied by three half-cycles is less than the time occupied by the minimum useful illumination term.

This invention is not to be limited by the embodiment shown in the drawings and described in the description, which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

I claim:

1. An electroluminescent display system comprising: a capacitive electroluminescent display having a pair of electrodes and an electroluminescent layer therebetween, the display having an inherent minimum useful illumination term for which term it must be actuated in order to be observed as an illuminated surface, and during which alternating current of voltage at least equal to a minimum actuating voltage necessary to cause visible illumination is applied thereto in order to create a luminous surface; a source of such alternating current having an output frequency such that the period of three of its cycles is less than the said minimum illumination term; and means for periodically and intermittently applying said alternating current to said electrodes in pulses, each pulse containing a number of contributing cycles of such amplitude as to contribute a significant increment of increased luminosity, the pulses being applied with such frequency that said con-

tributing cycles are applied for actuation for a total time of less than about 25 percent of the said minimum useful illumination term, there being more than one of said pulses per minimum useful illumination term.

2. A display system according to claim 1 in which said means applies said current contributing cycles to the electrodes for a total period between about 0.1 and about 25 percent of the said minimum useful illumination term.

3. A display system according to claim 1 in which the number of said contributing cycles in each pulse is less than about twenty.

4. A display system according to claim 1 in which the number of contributing cycles in each pulse is such that each contributing cycle contributes a substantially equal increment of increase in luminosity.

5. A display system according to claim 4 in which the number of said contributing cycles in each pulse is less than about five.

6. A display system according to claim 3 in which said means applies said contributing cycles to the electrodes for a total period between about 0.1 and about 25 percent of the said minimum useful illumination term.

7. A display system according to claim 4 in which said means applies said contributing cycles to the electrodes for a total period between about 0.1 and about 25 percent of the said minimum useful cycles illumination term.

8. A display system according to claim 5 in which said means applies said contributing cycles to the electrodes for a total period between about 0.1 and about 25 percent of the said minimum useful cycles are illumination term.

9. A method of illuminating a capacitive electroluminescent display having a pair of electrodes and an electroluminescent layer therebetween, said display having as an inherent property the actuation to visible luminosity as a consequence of the application across the electrodes of an alternating current having a voltage and frequency sufficient to produce the luminosity, said method comprising applying said alternating current in pulses, said pulses each comprising contributing cycles in number such that each cycle contributes a significant increment of luminosity, the frequency of supplying said pulses being such that the said contributing cycles occupy less than about 25 percent of the inherent minimum useful illumination term for which the display must be actuated in order to be observed as an illuminated surface, there being more than one of said pulses per minimum useful illumination term.

10. A method according to claim 9 in which the said contributing cycles are applied to the electrodes for between about 0.1 and about 25 percent of said minimum useful illumination term.

11. A method according to claim 9 in which the number of said contributing cycles in each pulse is less than about twenty.

12. A method according to claim 9 in which the number of contributing cycles in each contributing cycle is such that each pulse contributes a substantially equal increment of increase in luminosity.

13. A method according to claim 12 in which the number of said contributing cycles in each pulse is less than about five.

14. A method according to claim 11 in which said means applies said contributing cycles to the electrodes

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for a total period between about 0.1 and about 25 per-
cent of the said minimum useful illumination term.

15. A method according to claim 12 in which said
means applies said contributing cycles to the electrodes
for a total period between about 0.1 and about 25 per- 5
cent of the said minimum useful illumination term.

16. A method according to claim 13 in which said
means applies said contributing cycles to the electrodes

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for a total period between about 0.1 and about 25 per-
cent of the said minimum useful illumination term.

17. A display system according to claim 1 in which
the source of alternating current is a pulse transformer.

18. A method according to claim 9 in which each
pulse comprises a train of ringing contributing cycles.

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