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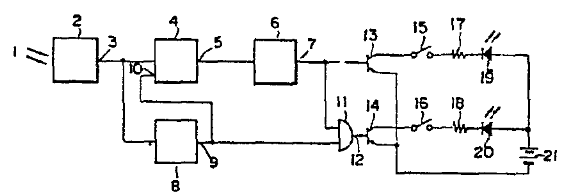
(54) ## DATA DISPLAY APPARATUS.

(57) A data display apparatus using a plurality of light-emitting diodes (19), (20) as display elements to display characters or figures in the form of a chain of dots. The light-emitting diodes (19), (20) are controlled by a photoelectric converter circuit (2) and by pulse oscillation circuits (4), (6) that are connected to the photoelectric converter circuit (2) and that produce pulse signals by changing the ratio of pulse output time in response to output signals of the circuit (2) so that brightness of the diodes is tuned to the ambient brightness (1). A level detector circuit (8) is also provided to change the kinds and numbers of light-emitting diodes that are to be driven.

FIG. 1



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DESCRIPTION

A DATA DISPLAY APPARATUS

FIELD OF THE INVENTION

This invention relates to a data display apparatus which uses several light-emitting diodes (LEDs) as display elements. Specifically it changes number, kinds, radiation (colors), and brightness of the LEDs so as to increase display visibility.

BACKGROUND OF THE INVENTION

A conventional data display apparatus that displays characters, figures, patterns, etc., using several LEDs arrayed in a dot matrix, is liable to fluctuations in display accuracy, such as data content visibility, caused by the brightness level of the LEDs used.

During the day, when the ambient brightness is high, the brightness of the LEDs must also be high to maintain the appropriate level of visibility. However, at night, when ambient brightness is low, the brightness of these LEDs must be lowered to avoid poor visibility due to the halation of displayed characters, figures, patterns, etc.

Moreover, the radiation color of an LED influences its visibility; for example at night, a red color has low visibility, while green or yellow has a higher visibility. During the day, red has high visibility when compared with green or yellow. Therefore, a data display apparatus that uses LEDs, must have its LED brightness adjusted according to the ambient brightness in order to maintain a satisfactory level of visibility.

Consequently, a method has been proposed of changing the brightness of the LEDs by adjusting the electric current flowing through them. This method uilizes the fact that the brightness of LEDs is proportional to the current flowing through them. The potential drop (Vf) across an LED, is also influenced by the materials that make up the LED.

Further, a data display apparatus that mixes the radiation colors of several LEDs and that fluctuates the electric currents flowing them will exhibit large differences in the brightness of those LEDs.

Another method has been proposed of automatically changing the voltage applied to each LED according to the ambient brightness. However, this method, requires a data display apparatus with a large number of LEDs, to have a large electric-current capacity. This in turn will lead to an increase in apparatus size and cost as well as complicated construction, which may deteriorate its reliability.

Our goal, therefore, is to provide a data display apparatus that maintains a high level of visibility by automatically changing the brightness of each LED in accordance with the ambient brightness, without changing the voltage applied to the LEDs.

Another goal is to provide a data display apparatus with high display visibility by changing the number and the kinds (radiation colors) of LEDs in accordance with the ambient brightness.

DISCLOSURE OF THE INVENTION

A data display apparatus in accordance with the present invention having a photo-electric converter circuit to convert the ambient brightness into an electric signal is connected to one or more of the next-stage pulse oscillation circuits. These oscillation circuits produce pulse signals in response to the output signal of the photoelectirc converter circuit by controlling the pulse output time ratio (hereinafter called duty cycle) allowing the LEDs to function optimally. This allows the brightness of each LED to automatically be adjusted to the ambient brightness.

A data display apparatus in accordance with the present invention is also provided with a level detector circuit that produces an active-level output signal whenever it detects that the output signal of the photoelectric converter circuit is beyond a specified cutoff point. This detector circuit enables changing the number and kinds (radiation collors) of LEDs used.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 shows a preferred drawing of the data display apparatus. In FIGURE 1, number 1 represents the light radiated from the data display apparatus onto the surroundings of the LEDs. Number 2 represents the photoelectric converter circuit comprised of cadmium sulfide and electrical circuits. Using phototransistors, the converter circuit places its output signal at output terminal 3 after either raising or lowering the output according to the amount of light the phototransistors received. To this photoelectric converter circuit 2, both a voltage control oscillator 4 and a level detector circuit 8 are connected so that the output signal of circuit 2 placed at output terminal 3 can enter oscillator 4 and circuit 8 simultaneously.

Level detector circuit 8, comprised of zener diodes, places its high-level output at output terminal 9 whenever it detects that input voltage sent from circuit 2 is in excess of a specified cutoff point. Output terminal 9 of detector circuit 8 is connected to both input terminal 10 of voltage control oscillator 4 and one input terminal of AND gate 11 so that the output signal at terminal 9 can enter oscillator 4 and the AND gate simultaneously.

Concerning the other input terminal of AND gate 11, monostable multivibator 6 is connected so that its output signal at output terminal 7 can enter this input terminal. Monostable multivibrator 6 is also connected to voltage control oscillator 4 so that its own output pulse signal, having duty time lapse (t), can be placed at output terminal 7 at the leading edge of the output signal placed at terminal 5 of oscillator 4. That is, voltage fluctuations which appear at terminal 3 of converter circuit 2 change the oscillation frequency sent from oscillator 4 at terminal 5. This changed oscillation frequency changes the duty time lapse (t) of the output pulse of monostable multivibrator 6 placed at output terminal 7. This process configures a pulse generator circuit that changes the duty cycle according to the input voltage. To this pulse oscillation circuit, an LED driver circuit is connected.

In the example shown in FIGURE 1, two transistors 13 and 14 are used to drive the LEDs. Transistor 13 is directly connected to monostable multivibrator 6 at output terminal 7 and transistor 14 is indirectly connected to multivibrator 6 at terminal 7 via AND gate 11. Therefore, when the output pulse signal sent from multivibrator 6 is being placed at the base of transistors 13 and 14, these transistors are conductive from the collector to the emitter. To transistor 13, more than one yellow-color radiating LEDs 19 are connected through switch 15 and resistor 17, and to transistor 14, more than one red-color radiating LEDs 20 are connected through switch 16 and resistor 18. Both transistors 19 and 20 are powered by a single DC power supply 21.

In this type of circuit, when switch 15 is turned on, an electric current sent from DC power supply 21, flows through LED 19 from the anode to cathode, then resistor 17, and switch 15, and finaly transistor 13 from its collector to emitter. After this the current goes back to DC power supply 21 at its minus side, thus driving LEDs 19 by the pulse signal that enters transister 13 at it base to emit the yellow light.

When level detector circuit 8 sends out its active-level signal at output terminal 9 and, simultaneously, monostable multivibrator 6 sends out its output pulse signal at terminal 7, AND gate 11 places the pulse signal at terminal 12. Then this signal enters transistor 14 at its base, causing it to be conductive from the collector to emitter during the period when the pulse signal at the base of transistor 14 is at the active level. If switch 16 is on, an electric power current sent from DC power supply 21 at its plus side flows through LEDs 20 from the anode to cathode, then to resistor 18, switch 16, and finally transistor 14 from its collector to emitter. Then this current goes back to the DC power supply at its minus side, thus driving LEDs 20 by the pulse signal that enters transistor 14 at its base to emit the red light.

As can be seen from the above description, transistors 13 and 14 are combined to separately drive LEDs 19 and 20 which have different radiation colors.

FIGURE 2 is a timing chart for the above example. The following paragraphs explain, based on this timing chart, the output potential and waveform of the component circuits for each of the following cases: (a) where the amount of surrounding light is small, (b) where it is relatively large, (c) where it is large, and (d) where it is very large.

When the amount of light 1 is small, photoelectirc converter circuit 2 places a low output potential at output termianl 3. This causes voltage control oscillator 4 to send a correspondingly low output frequency to output terminal 5. At the same time, level detector circuit 8 does not place its active-level output signal at output terminal 9 in case (a). Hence, monostable multivibrator 6 sends out a pulse signal having a correspondingly low duty cycle at output terminal 7. When this pulse signal enters transistor 13 at its base, only LEDs 19 are driven. LEDs 19 in this case, give off a low brightness, corresponding to the low ambient brightness, because of the low duty cycle during which they are lit.

Next, where light 1 is relatively large, photoelectric converter circuit 2 places a relatively high output voltage at output terminal 3, which in turn causes voltage control oscillator 4 to send out a correspondingly high output frequency at output terminal 5. At this time, however, level detector circuit 8 is not operative, so no active-level output is sent from it. Monostable multivibrator 6, therefore, sends out a pulse signal having a correspondingly high duty cycle at output terminal 7. When this pulse signal enters transistor 13 at its base, LEDs 19 are driven. LEDs 19, in this case, give off a high brightness corresponding to the relatively high ambient brightness because of the large duty cycle during which they are lit. Where the light 1 is large in amount, photoelectric converter circuit 2 places a high output voltage at output terminal 3, which causes voltage control oscillator 4 to send a correspondingly high output frequency to output terminal 5. This is because level detector circuit 8 is operative and sends its active-level signal to oscillator 4 at terminal 10. Both monostable multivibrator 6 and AND gate 11, therefore, send pulse signals having low duty cycles to output terminals 7 and 12 respectively. When these two types of pulse signals subsequently enter transistors 13 and 14 at their base, both LEDs 19 and 20 are driven. LEDs 19 and 20, despite the low duty cycle, give off a high brightness. This is due to a mixture of yellow and red color emitted from LEDs 20.

Where the light 1 is very large, photoelectric converter circuit 2 places a very high output voltage at output terminal 3, which in turn causes voltage control oscillator 4 to send out a correspondingly high output frequency at output terminal 5. This is because level detector circuit 8 is operative and sends its active level signal to oscillator 4 at terminal 10. Both monostable multivibrator 6 and AND gate 11 send pulse signals having high duty cycles at output terminals 7 and 12 respectively. When these two types of pulse signals subsequently enter transistors 13 and 14 at therir base, both LEDs 19 and 20 are driven. LEDs 19 and 20, in this case, have high duty cycles and, therefore, give off a very high brightness.

The above description is based on the assumption that the frequency sent out of voltage control oscillator 4 at output terminal 5 is set at a level high enough so that an operator will not be able to catch the alternating turn-on and -off of both LEDs 19 and 20.

FIGURE 3 shows a layout drawing of LEDs used in a data display apparatus. In FIGURE 3, numners 22 and 30 represent yellow-collor radiating LEDs connected to transistor 13 at the collector, through resistor 17 and switch 15. Numbers 31 and 39 represent red-color radiating LEDs connected to transistor 14 at the collector, through resistor 18 and switch 16, as shown in FIGURE 1. Therefore, appropriately connecting and breaking switches 16 and 17, connected to LEDs 19 and 20, enable the turning on of the desired LEDs to display characters, figures, patterns, etc. Moreover, it also enables changing both the kinds (radiation colors) and number of LEDs in accordance with the ambient brightness to automatically increase or decrease their brightness for increased display visibility.

In contrast to this example, where voltage control oscillator 4 and monostable multivibrator 6 are integrated into one conponent as shown in FIGURE 1, another example is possible that provides an integrated component for each kind (radiation color) of LED and that changes the mixed color by changing the duty cycle of each kind (radiation color) of LED. Another possible example is the use of transistors, SCRs (sillicon-controlled rectifiers), or other semiconductor elements instead of switches 15 and 16 and to employ various LED radiation colors other than yellow and red and simultaneous selection of one or more radiation colors.

The present invention provides a simple configuration that easily changes both the kinds (radiation colors) and number of LEDs according to the ambient brightness without changing the voltage applied to them. Moreover, this invention also controls the duty cycle of the pulses which drive the LEDs so that their radiation brightness can be automatically tuned to the ambient brightness.

POSSIBLE INDUSTRIAL APPLICATIONS

A data display apparatus of this type qualifies itself for use in traffic signal equipment, which requires high visibility, and in connection with display equipment that must attract the attention of operators by controlling the display brightness or changing the radiation colors according to the ambient brightness at an installation site.

WHAT IS CLAIMED IS:

1. A data display apparatus which comprises a photoelectric converter circuit which converts the received light into electric signals and pulse oscillation circuits which receive the output signal of the photoelectric converter circuit to change the duty cycle of the output pulses according to the output signal in order to decrease the duty cycle of the output pulses when the ambient brightness is low and to increase them when the ambient brightness is high so that LED radiation brightness can be automatically tuned to the ambient brightness.

2. A data display apparatus in accordance with claim 1, in which a level detector circuit is also provided to produce an active-level output signal when the output signal level of said photoelectric converter circuit exceeds a specified cutoff point so that both the kinds (radiation colors) and number of LEDs used can be changed.

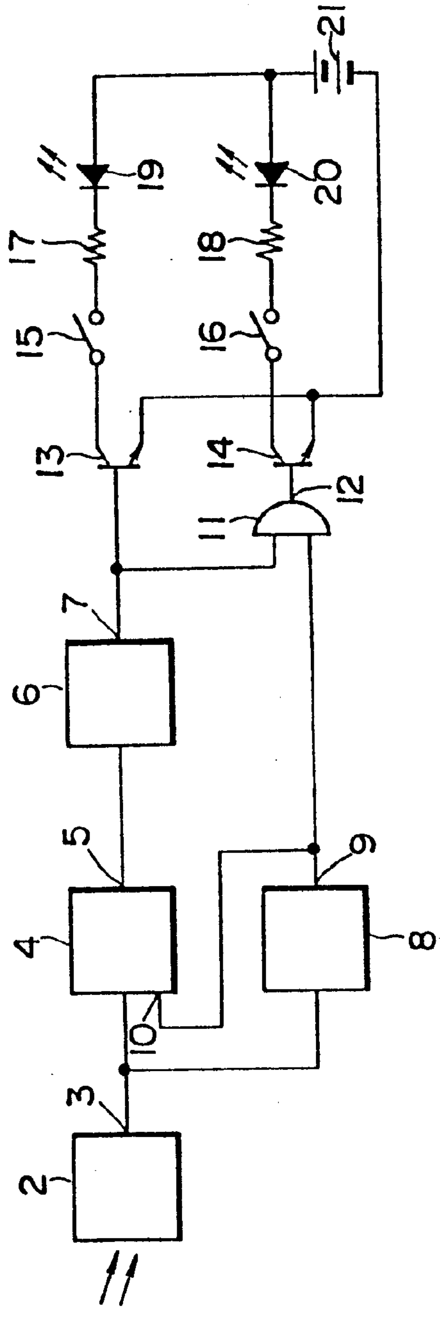
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FIG.1

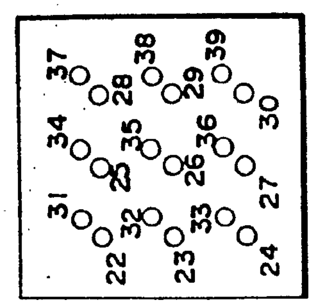
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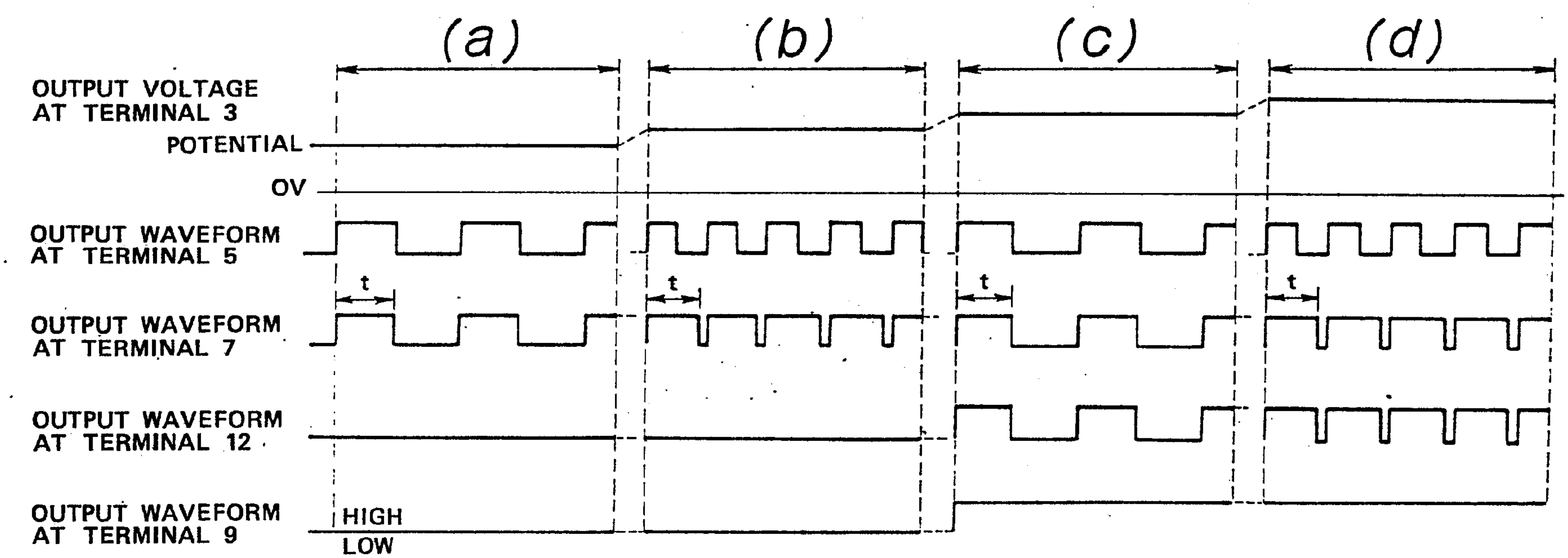
FIG.3

FIG.2


(a)
(b)
(c)
(d)
OUTPUT VOLTAGE AT TERMINAL 3
POTENTIAL
OV
OUTPUT WAVEFORM AT TERMINAL 5
t
OUTPUT WAVEFORM AT TERMINAL 7
OUTPUT WAVEFORM AT TERMINAL 12
OUTPUT WAVEFORM AT TERMINAL 9
HIGH
LOW

INTERNATIONAL SEARCH REPORT

0180642

International Application No. PCT/JP85/00070

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^4 G09G

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC	G09G3/14, 3/32

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

Jitsuyo Shinan Koho	1972 - 1984
Kokai Jitsuyo Shinan Koho	1972 - 1984

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category*	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	JP, U, 55-16593 (Sanyo Electric Co., Ltd.) 1 February 1980 (01. 02. 80) (Family nashi)	1, 2
Y	JP, A, 53-128297 (Toshiba Corp.) 9 November 1978 (09. 11. 78) (Family nashi)	1, 2
Y	JP, U, 57-41669 (Japan Traffic Management Technology Association) 6 March 1982 (06. 03. 82) (Family nashi)	1, 2
Y	JP. A. 52-40995 (Kyodo Microlamp Kabushiki Kaisha) 30 March 1977 (30. 03. 77) (Family nashi)	1, 2
Y	JP, A, 50-62398 (Monsanto Co.) 28 May 1975 (28. 05. 75) & US, A, 3,873,979 & GB, A, 1437098 & DE, A1, 2358814 & BE, A1, 807678 & CA, A1, 1001289	1, 2

* Special categories of cited documents: [15]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
May 20, 1985 (20. 05. 85)	May 27, 1985 (27. 05. 85)
International Searching Authority [1]	**Signature of Authorized Officer** [20]
Japanese Patent Office	