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(54) IMPROVED LEVEL INDICATING CIRCUIT ARRANGEMENT

(71) We, SANYEI ELECTRONICS CORPORATION, a Japanese company of 4-41 Minamikamei-cho, Yao-shi, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an improved indicating device which is especially useful to visually indicate signal level, source voltage and the like.

Although analog indicators and meters have been generally used for this purpose, they have had disadvantages such that they often go out of order and are unreliable since they include mechanically moving parts, and that they are inconvenient in use since they require illuminating means for reading in the dark.

Accordingly, an object of this invention is to provide an improved level indicating device which has high reliability and long life and, furthermore, can be read in the dark without external illumination.

According to the present invention there is provided a level indicating circuit arrangement comprising first and second terminals for receiving a voltage of which the level is to be indicated, a first series combination of a plurality of similarly poled diodes having junctions therebetween, a second series combination of a plurality of resistors of the same number as said diodes having junctions therebetween, a plurality of light emissive diodes connected respectively between the corresponding ones of said junctions and between the respective ends of said first and second series combinations, so as to bridge the two series combinations to form a ladder-like configuration, and a first end of said first series combination and the opposite end of said second series combination being connected respectively to said first and second terminals.

Preferred features of this invention will be described in detail hereinafter with

reference to the accompanying drawings, in which:

Figure 1 is a diagram representing the basic circuit configuration of a level indicating device according to this invention; and

Figures 2, 3, 4 and 5 are circuit diagrams representing four examples of level indicating device, in which the circuit of Figure 1 is embodied.

Throughout the drawings, the same reference numerals and symbols are applied to corresponding components.

Referring to Figure 1, the circuit includes a pair of terminals 10 and 20 which are connected to a variable voltage source 11 of which the voltage level is to be indicated. A series combination of similarly poled diodes $D_1, D_2, D_3, \dots, D_n$ having junctions 1, 2, ..., (n-1) is provided and the free terminal (anode) of the first diode D_1 is connected to the terminal 10. A series combination of resistors $R_1, R_2, R_3, \dots, R_n$ having junctions 1', 2', ..., (n-1)' is also provided and the free terminal 12 of the last resistor R_n is connected through a protection resistor 13 to the other terminal 20. A light emissive diode L_0 is connected between the anode of the first diode D_1 and the free end of the first resistor R_1 . Similar light emissive diodes $L_1, L_2, \dots, L_{n-1}$ are connected respectively between the junctions 1 and 1', 2 and 2', ..., (n-1) and (n-1)' and a further similar light emissive diode L_n is connected between the free end (cathode) of the last diode D_n and the junction 12 of the resistors R_n and 13. All the light emissive diodes $L_0, L_1, L_2, \dots, L_n$ are similarly poled as shown. The diodes $D_1, D_2, D_3, \dots, D_n$ may be silicon diodes having the same characteristics. These diodes serve a function of producing an abrupt step in the forward voltage-to-current characteristics of the light emitting diodes $L_0, L_1, L_2, \dots, L_n$, whereby clarifying distinction of actuation and deactuation of the respective light emitting diodes.

In the above-described level indicating

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device, none of the light emitting diodes L_0 does not exceed its threshold voltage. However, when the source voltage rises and the voltage across the light emissive diode L_0 reaches its threshold voltage, it is actuated to emit light. When the source voltage rises further and the voltage drop across the series connection of the light-emissive diode L_0 and the resistor R_1 increases until the voltage across the diode D_1 exceeds its turn-on voltage, the light emissive diode L_1 is also actuated in addition to the first light emissive diode L_0 . In this fashion, the light emissive diodes $L_2, L_3, \dots, L_n$ are actuated sequentially with increase of the source voltage and, therefore, the source voltage can be known from the number of the actuated light emissive diodes.

The relation between the source voltage and the number of actuated light emissive diodes can be determined not only in linear fashion but also in logarithmic, inverse logarithmic or any other fashion, by selecting as the diodes $D_1, D_2, D_3, \dots, D_n$ diodes having appropriate turn-on voltages respectively, instead of diodes having the same characteristics.

In operation, the current of the light emissive diode L_0 flows through the resistor R_1 , the currents of the light emissive diodes L_0 and L_1 flow through the resistor R_2 and the currents of the all light emissive diodes flow through the resistor 13. Accordingly, if the resistor 13 is selected sufficiently large, the major part of the voltage applied between the terminals 10 and 20 is shared between the series resistors following the actuated light emissive diodes and no significant change occurs in the voltages across the light emissive diodes or in the currents therethrough, regardless of the number of actuated light emissive diodes, that is, the level of the source voltage. It is a matter of course that the current of the each light emitting diode can be individually confined to any value, if necessary, by selecting the values of the resistors $R_1, R_2, \dots, R_n$ appropriately. The protection resistor 13 may be omitted as occasion demands.

Figure 2 shows a tuning indicator circuit arrangement in which the level indicating device 40 of this invention is embodied. In this embodiment, five light emitting diodes L_0, L_1, L_2, L_3 and L_4 are included in the device 40. The terminal 20 is connected through the collector-to-emitter path of a transistor 14 to a terminal 22. To the base electrode of the transistor 14, is connected a voltage doubler circuit 24 including diodes 30 and 31 and a capacitor 32. The signal to be indicated is supplied from an intermediate frequency amplifier 16

through a capacitor 18 to the voltage doubler circuit 24.

When a predetermined fixed voltage is applied between the terminals 10 and 22, the light emissive diodes are actuated in accordance with the degree of conduction of the transistor 14, accordingly, upon the state of tuning, and the latter can be known therefore from the number of actuated, light-emitting diodes. Due to the characteristic of the transistor 14, in this circuit, the relation between the output voltage of the intermediate frequency amplifier 16 and the number of actuated, light-emitting diodes becomes inversely logarithmic.

In Figure 3 there is shown a circuit arrangement in which the level indicating device 40 of this invention (shown only in part), is used for indicating the output level of an amplifier. Although the circuit of this embodiment is essentially the same as that of Figure 2, the signal to be indicated is applied to the capacitor 18 through a resistor 35 from the secondary winding of an output transformer 34, instead of from the intermediate frequency amplifier 16, as in Figure 2. If the condition is adjusted previously such that a suitable number of light emissive diodes are actuated by a required output level by selecting the value of the resistor 35, the degree of conformity of the output level to the required value can be distinctly distinguished. This circuit can be utilized for indicating the recording and reproducing levels of a tape recorder.

Figure 4 shows an embodiment in which the level indicating device 40 of the invention (shown only in part) is used for indicating a source voltage. In this circuit, instead of the voltage doubler circuit 24 of Figure 2, a voltage divider circuit consisting of series-connected resistors 46 and 48 has its tapping connected to the base electrode of the transistor 14, and the source voltage to be indicated is applied between the free end 42 of the resistor 46 and the terminal 22. In this embodiment, the relation between the source voltage and the number of actuated light emitting diodes depends upon the base-emitter voltage to collector current characteristic of the transistor 14. In this circuit, the light emitting diodes can be sequentially actuated over a wide range of variation of the source voltage such as 5 volts to 10 volts.

Figure 5 shows a modification of the circuit arrangement of Figure 4. In this embodiment, a Zener diode 50 is inserted between the resistor 46 and the terminal 42 of Figure 4. When the source voltage is applied between the terminals 42 and 22 of Figure 5, the Zener voltage of the Zener diode 50 is subtracted from the source voltage and the residue is applied through

the voltage dividing circuit to the base electrode of the transistor 14. Accordingly, in this circuit, the number of actuated light emitting diodes can be changed by a slight change of the source voltage, and, for example, a change of the source voltage in a range from 9 volts to 10 volts can be informed.

As described above, the level indicating device of this invention has high reliability and long life due to the absence of moving parts and, moreover, can give bright indication even in the dark.

It should be noted that the above embodiments are presented only for explanation purpose and various modifications and changes can be made without departing from the scope of this invention as defined in the appended claims.

WHAT WE CLAIM IS:—

1. A level indicating circuit arrangement comprising first and second terminals for receiving a voltage of which the level is to be indicated, a first series combination of a plurality of similarly poled diodes having junctions therebetween, a second series combination of a plurality of resistors of the same number as said diodes having junctions therebetween, a plurality of light emissive diodes connected respectively between the corresponding ones of said

junctions and between the respective ends of said first and second series combinations, so as to bridge the two series combinations to form a ladder-like configuration, and a first end of said first series combination and the opposite end of said second series combination being connected respectively to said first and second terminals.

2. A circuit arrangement in accordance with claim 1, wherein a resistor is inserted between one end of said second series combination and the respective said terminal.

3. A circuit arrangement in accordance with claim 1 or claim 2, and further comprising a transistor having its collector-to-emitter path connected to said second terminal, the signal to be indicated being applied to the base electrode of said transistor.

4. A circuit arrangement in accordance with claim 3, wherein the signal to be indicated is applied to the base electrode of said transistor by way of a Zener diode.

5. A level indicating circuit arrangement substantially as herein described with reference to Figure 1, 2, 3, 4 or 5 of the accompanying drawing.

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