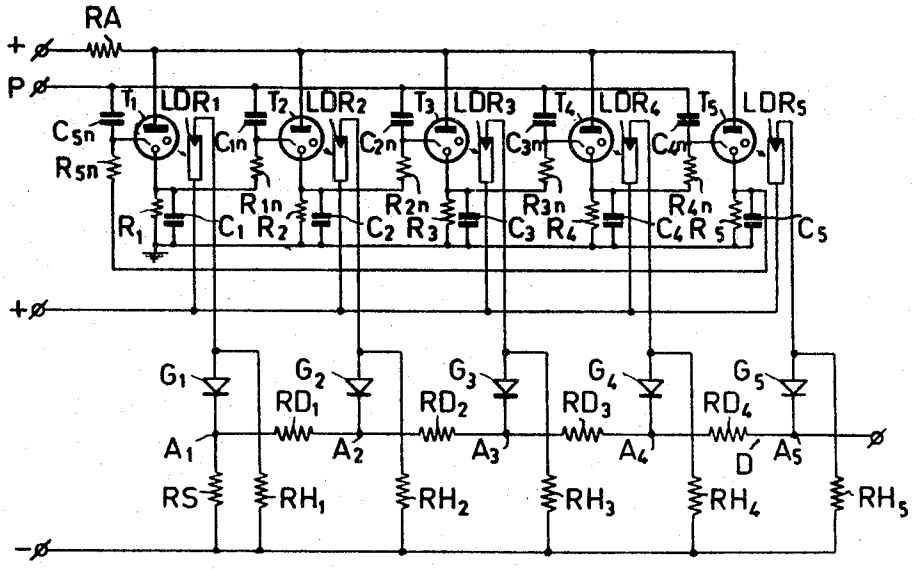
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DEVICE FOR CONVERTING A LIGHT SIGNAL CORRESPONDING TO A DIGIT PLACE INTO A VOLTAGE VALUE CORRESPONDING TO THE DIGIT VALUE

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INVENTOR.
DANIËL J.G. JANSSEN

BY

Frank R. Trifari

AGENT

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# DEVICE FOR CONVERTING A LIGHT SIGNAL CORRESPONDING TO A DIGIT PLACE INTO A VOLTAGE VALUE CORRESPONDING TO THE DIGIT VALUE

Daniël Johannes Gerardus Janssen, Emmasingel, Eindhoven, Netherlands, assignor to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

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The invention relates to a device for converting a light signal corresponding to a digit place into a voltage value corresponding to the digit value.

In the field of application of these devices, for example in digital voltmeters, the problem presents itself of converting the setting of a counting circuit into a voltage value corresponding to the setting of the counter, which value serves as a comparison value for an unknown voltage.

In order to read the setting of counting circuits which are equipped with gas-filled tubes or with electroluminescent cells, it has been proposed to use light-sensitive resistors which are optically coupled to the tubes or cells. The light-sensitive resistors serve as switching contacts for switching on a cathode of a digit indicator tube formed in accordance with the digit to be reproduced.

An object of the invention is to provide a simple and cheap device of the type mentioned above which uses light-sensitive resistors as switching contacts and is highly independent of the properties of the light-sensitive resistors used, for example CdS-cells. The device according to the inveniton is characterized in that for each digit place the device comprises the series arrangement of a light-sensitive resistor and a undirectionally conducting element. These series arrangements are connected so that the free end of the unidirectionally conducting elements are connected to tappings of a potentiometer and the free ends of the light-sensitive resistor are connected to a terminal of a voltage source. The other terminal of the voltage source is connected through a series resistor to the potentiometer and also is connected through resistors individually associated with the series arrangements to the junction of the light-sensitive resistor and the unidirectionally conducting element of each series arrangement.

In order that the invention may readily be carried into effect, an example thereof will now be described more fully, by way of example, with reference to the accompanying drawing.

The device shown in the drawing for converting a light signal corresponding to a digit place into a voltage value corresponding to the digit value is controlled by a ring counter of a commonly used type. This ring counter comprises five identical stages which may arbitrarily be numbered from 1 to 5 and of which the same elements are indicated by the same reference and by the number of the stage. The same holds for the elements between the stages. Each stage comprises a gas-filled tube T, the cathode of which is connected to ground through a resistor R shunted by a capacitor C and the anode of which is connected through an anode resistor RA, which is common for all the stages, to the positive terminal of a voltage source, not shown, the negative terminal of which is connected to ground. The cathode of a gas-filled tube T is connected through a resistor R*n* to the ignition electrode of the gas-filled tube T of the following stage. The ignition electrodes of the tubes are connected to a pulse line P through separate capacitors C*n*. The



ring counter is proportioned so that at any instant of time only one gas-filled tube can be ignited. The ignited tube supplies a bias voltage, through the resistor R*n*, to the ignition electrode of the gas-filled tube of the following stage. As a result, this tube ignites upon receipt of the next positive ignition pulse from the pulse line P, and the preceding tube extinguishes. The ignition pulses consequently move the discharge from a gas-filled tube through the ring counter, the tube which is each time conductive irradiating light on a light-sensitive resistor LDR coupled optically to the tube. This optical coupling is effected by providing the light-sensitive resistor, for example a CdS-cell, against the glass envelope of the tube and is indicated in the drawing by an arrow.

The ring counter thus supplies a light signal which, under the control of the ignition pulses, is moved through the five digit places of the ring counter, a following light-sensitive resistor LDR being illuminated each time. These light-sensitive resistors form part of a converting device which converts the light signal corresponding to a digit place into a voltage value corresponding to the digit value. This converting device also comprises five stages which may be numbered from 1 to 5 and of which the same elements are indicated by the same reference and by the number of the stage. Each stage comprises the series arrangement of a light-sensitive resistor LDR and a rectifier diode G of which the free end of the rectifier diode is connected to a tapping A1–A5 of a potentiometer D and of which the free end of the light-sensitive resistor LDR is connected to the positive terminal of a voltage source not shown. The negative terminal of this voltage source is connected through a series resistor RS to the potentiometer D and is also connected through the resistors RH, associated individually with the series arrangements, to the junction point between the light-sensitive resistor LDR and the rectifier diode G of each series arrangement. The output voltage between the tappings A1–A5 of the potentiometer D increases gradually if the light-sensitive resistors LDR1–LDR5 are illuminated successively. The resistors RD1–RD4 of the potentiometer D between the tappings A1–A5 may be adjusted so that after each ignition pulse the output voltage increases by the same amount, for example, by steps of 1 volt. In a decimal system the ring counter, as also the converting device, comprises 10 stages, as a result of which all the whole voltage values between 0 and 9 volts can be adjusted at the output of the converting device.

The operation of the converting device is as follows, it being assumed that at a given instant a discharge takes place in the gas-filled tube T1. This tube illuminates the light-sensitive resistor LDR1 and decreases the resistance thereof from the very high dark value of 0.5 to a few megohms to an illuminated value of approximately 1000 ohms. The CdS-cells used have a switching-on time delay in the order of magnitude of 100 msec and have a switching-off time delay in the order of magnitude of 100 msec. In a practical embodiment of the converting device, the supply voltage is 150 volts and the resistors RS and RH have values of $RS=100k\Omega$ and $RH=220k\Omega$, while the resistors RD1–RD4 are adjustable resistors of $1000\Omega$. The resistors RD1–RD4 may also be fixed precision resistors which are once adjusted at the desired value. The illuminated light-sensitive resistor LDR1 has a low resistance value, as a result of which a current flows from the positive terminal of the voltage source, through the light-sensitive resistor LDR1, the rectifier diode G1 and the series resistor RS, to the negative terminal of the voltage source. The resistors RS and RH1 are each much larger than the sum of the pass resistance of the rectifier diode G1 and the resistance of the illuminated light-sensitive resistor

LDR1, as a result of which the voltage across the resistor RS substantially equals the supply voltage of 150 volts. No current flows through the resistors RD1–RD4 of the potentiometer D, so that the voltage of the tappings A2–A5 also is 150 volts. The non-illuminated light sensitive resistors LDR2 and LDR5, together with the resistors RH, form potentiometers between the terminals of the voltage source, as a result of which the voltage between the junction points of the light-sensitive resistors LDR and the resistors RH and the negative terminal of the voltage source is much smaller than 150 volts, even if the light-sensitive resistors have not yet reached the dark value entirely. The voltage on the cathode side of the rectifier diodes G2–G5 thus is substantially 150 volts, while the voltage at the anode side is much smaller than 150 volts, so that these rectifier diodes are cut off.

As the result of the supply of an ignition pulse to the pulse line P, the discharge of the gas-filled tube T1 moves to the tube T2 in the following stage. This tube illuminates the light-sensitive resistor LDR2, the resistance value of which rapidly decreases in the short switching-on time, while the value of the light-sensitive resistor LDR1 comparatively slowly increases to the dark value. The voltage of the junction point of the light-sensitive resistor LDR1 and the rectifier diode G1 decreases with respect to the negative terminal of the voltage source, while the voltage of the tapping point A2 and of the tapping A1 increases. At a given instant, decreasing and increasing voltages pass one another and the diode G1 is cut off. A simple calculation proves that at the given resistance values, the rectifier diode G1 is cut off as soon as the value of the light-sensitive resistor LDR1 has increased to approximately three times the value of the light-sensitive resistor LDR2. This means that after a time interval of the same order of magnitude as the switching-on time of the light sensitive resistor LDR2, the rectifier diode G1 is cut off. The cut off rectifier diode G1 renders the light-sensitive resistor LDR1 inoperative, so that the operation of the converting device is independent, to a high degree, of the long switching-off time of the light-sensitive resistors.

A current flows from the positive terminal of the voltage source through the illuminated light-sensitive resistor LDR2, the rectifier diode G2, the resistor RD1 and the series resistor RS to the negative terminal. This current causes a voltage drop across the resistor RD1 which can be adjusted, for example, to 1 volt by means of the resistor RD1, so that the output voltage between the tappings A1 and A5 of 0 volt has increased to 1 volt in one step.

After the following ignition pulse on the pulse line P, the light-sensitive resistor LDR3 is illuminated and a current flows through the resistors RD1 and RD2 in series. The resistor RD2 may be adjusted so that the voltage drop across these resistors is 2 volts. In this manner the output voltage between the tappings A1 and A5 increases by 1 volt after each ignition pulse so that with the converting device indicated each whole voltage value between 0 and 4 volts is adjustable. In a decimal system each whole voltage value is adjustable between 0 and 9 volts. After each ignition pulse the rectifier diode G in the preceding series arrangement is very rapidly cut off, as a result of which the pulse recurrence frequency of the ignition pulses can be increased to 100 c./s. while using the converting device with the CdS-cells used therein.

What is claimed is:

1. Apparatus for converting a source of light signals representing numerical values into electric signals corresponding to the digit values comprising, a source of voltage having a pair of output terminals, voltage attenuating means having a plurality of distributed taps, a plurality of photosensitive elements, one for each digit value, optically coupled to said light signal source, a plurality of unidirectional conducting elements, means connecting each photosensitive element in series circuit with



a corresponding unidirectional conducting element between one terminal of said voltage source and a corresponding tap on said voltage attenuating means, each of said series circuits having a junction point common to said photosensitive element and to said unidirectional conducting element, a first resistor, means connecting said first resistor in series with the other terminal of said voltage source and a tap on said voltage attenuating means, a plurality of second resistors, and means connecting each of said second resistors to said other terminal of the voltage source and to corresponding ones of said junction points.

2. Apparatus as described in claim 1, further comprising output means coupled across a pair of taps of said voltage attenuating means for deriving a voltage value representative of the digit value of said light source.

3. Apparatus as described in claim 1, wherein said light source comprises a plurality of discrete light radiating elements arranged to emit light in mutually exclusive time intervals in accordance with the digit value to be represented, each of said discrete light radiating elements being optically coupled to a corresponding one of said photosensitive elements.

4. Apparatus as described in claim 2, wherein said light source comprises a ring counter in which each of said discrete light radiating elements comprises a gas discharge tube.

5. Apparatus for converting light signals representing numerical values into electric manifestations thereof corresponding to the digit values, comprising a light source arranged to emit a plurality of discrete light signals, means for selectively energizing said light source to emit a single discrete light signal in accordance with a numerical value to be electrically represented, first and second terminals connected to a source of direct voltage, voltage attenuating means having a plurality of equally distributed taps, a plurality of photosensitive elements optically coupled to individual ones of said discrete light signals, a plurality of diodes, means connecting each of said photosensitive elements in series circuit with a corresponding one of said diodes to form a plurality of element-pairs having a common junction point therebetween, means connecting the free end of each of said photosensitive elements to said first terminal and the free end of each of said diodes to corresponding taps of said voltage attenuating means, a first resistor connected between said second terminal and one end tap of said voltage attenuating means, a plurality of second resistors, means connecting one end of each of said second resistors to said second terminal, and means connecting the other end of said second resistors to different individual ones of said junction points.

6. Apparatus as described in claim 5, further comprising output means connected to the end taps of said voltage attenuating means for deriving a voltage representative of the digit value of said light source.

7. Apparatus as described in claim 6, wherein said voltage attenuating means comprises a resistance voltage divider subdivided into substantially equal resistance values between each pair of its tap points.

8. Apparatus as described in claim 6, wherein said photosensitive elements comprise photoconductive cells of the type having a fast response time going from the dark to the light condition and a substantially slower response time going from the light to the dark condition.

9. Apparatus for converting light signals representing numerical values into electric signals corresponding to the digit values comprising, a light source arranged to selectively emit a plurality of discrete light signals in accordance with a numerical value to be represented, first and second terminals connected to a source of voltage, voltage attenuating means having a plurality of taps distributed thereon, a plurality of photosensitive elements optically coupled to individual ones of said discrete light signals so as to be individually illuminated thereby, a plurality of unidirectional conducting elements,

means connecting each of said photosensitive elements in series circuit with a corresponding one of said unidirectional conducting elements between said first terminal and a corresponding tap of said voltage attenuating means, a resistor connected in series with said second terminal and a given one of said taps of said voltage attenuating means, and means for applying biasing voltages to said unidirectional conducting elements, the illuminated one of said photosensitive elements producing a voltage at its corresponding tap of said voltage attenuating means which coacts with said voltage biasing means so that at a given instant of time all of said unidirectional conducting elements but one are rendered nonconductive, said one being that one of said unidirectional conducting elements which is serially connected to the photosensitive element which is then illuminated.

**10.** Apparatus as described in claim **9** wherein each



of said series circuits has a junction point common to said photosensitive element and to said unidirectional conducting element, and wherein said means for applying biasing voltages comprises a plurality of other resistors and means connecting each of said other resistors in series with said second terminal and corresponding ones of said junction points.

**11.** Apparatus as described in claim **9** wherein said light source is arranged to emit said discrete light signals in mutually exclusive time intervals.

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