

- [54] **DEVICE FOR GENERATING VARIABLE OUTPUT VOLTAGE**
- [75] Inventors: **Shunji Minami; Shunzo Oka; Takehide Takemura**, all of Osaka, Japan
- [73] Assignee: **Matsushita Electric Industrial Co., Ltd.**, Japan
- [22] Filed: **Dec. 14, 1973**
- [21] Appl. No.: **424,647**
- [30] **Foreign Application Priority Data**
- | | | |
|---------------|-------|-----------|
| Dec. 20, 1972 | Japan | 47-128492 |
| Dec. 20, 1972 | Japan | 47-147212 |
| Dec. 20, 1972 | Japan | 47-147213 |
- [52] **U.S. Cl.** **307/227; 307/273; 307/304; 307/246**
- [51] **Int. Cl.** **H03k 4/02**
- [58] **Field of Search** **307/233, 273, 227, 225, 307/304, 246; 328/186, 151**

References Cited			
UNITED STATES PATENTS			
2,999,208	9/1961	Ruehle	328/186 X
3,105,158	9/1963	Nichols	307/227
3,333,111	7/1967	Houle	307/273
3,571,620	3/1971	Hansen	307/233

Primary Examiner—Stanley D. Miller, Jr.
Attorney, Agent, or Firm—Burgess, Ryan and Wayne

[57] **ABSTRACT**

A monostable multivibrator is connected to the input of a device for generating a variable output voltage, in which the output voltage derived from the source of a MOS field-effect transistor is varied in response to the variation of a voltage across a capacitor connected to the gate of the field-effect transistor. The output voltage may be increased and decreased stepwise.

4 Claims, 8 Drawing Figures

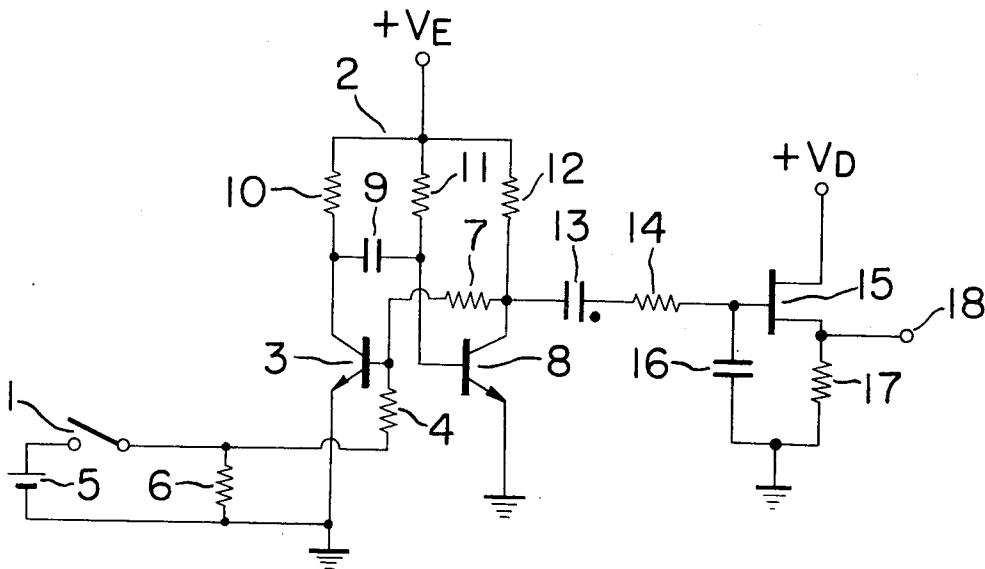


FIG. 1

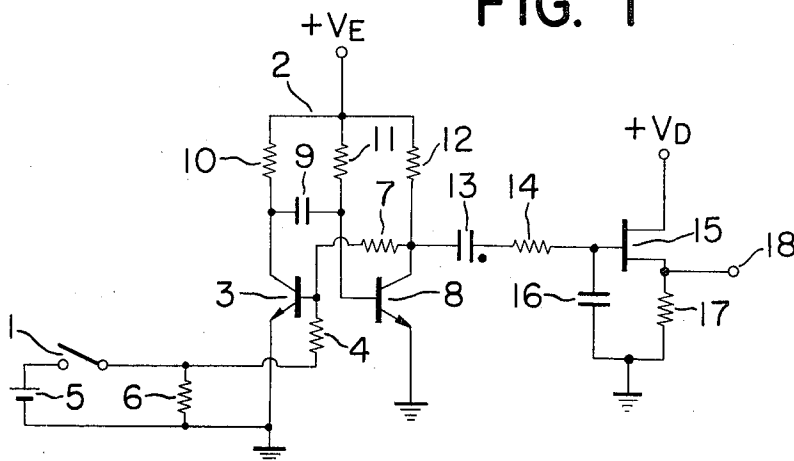


FIG. 2

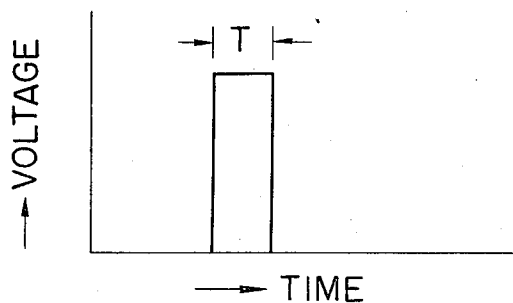


FIG. 3

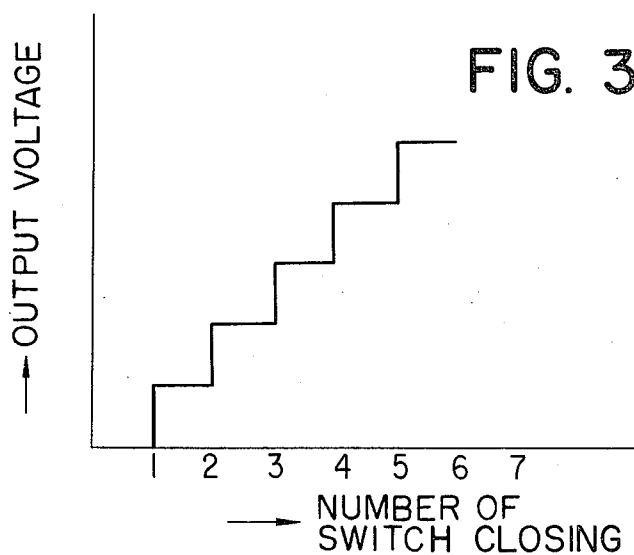


FIG. 4

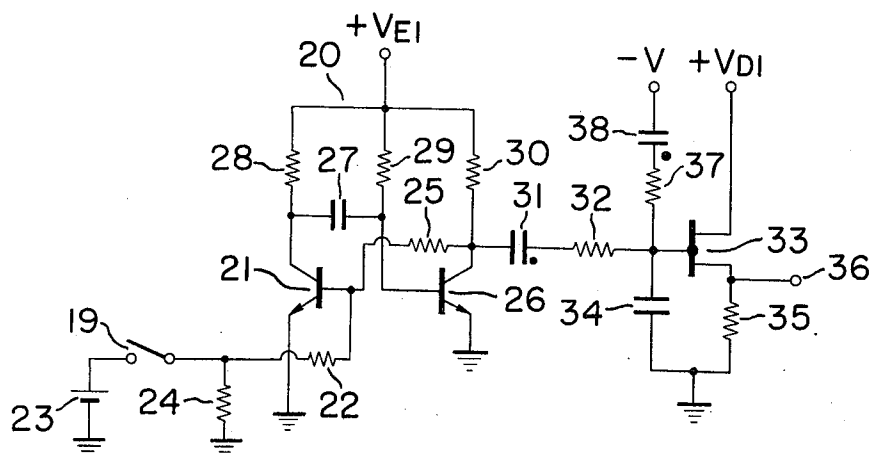


FIG. 6

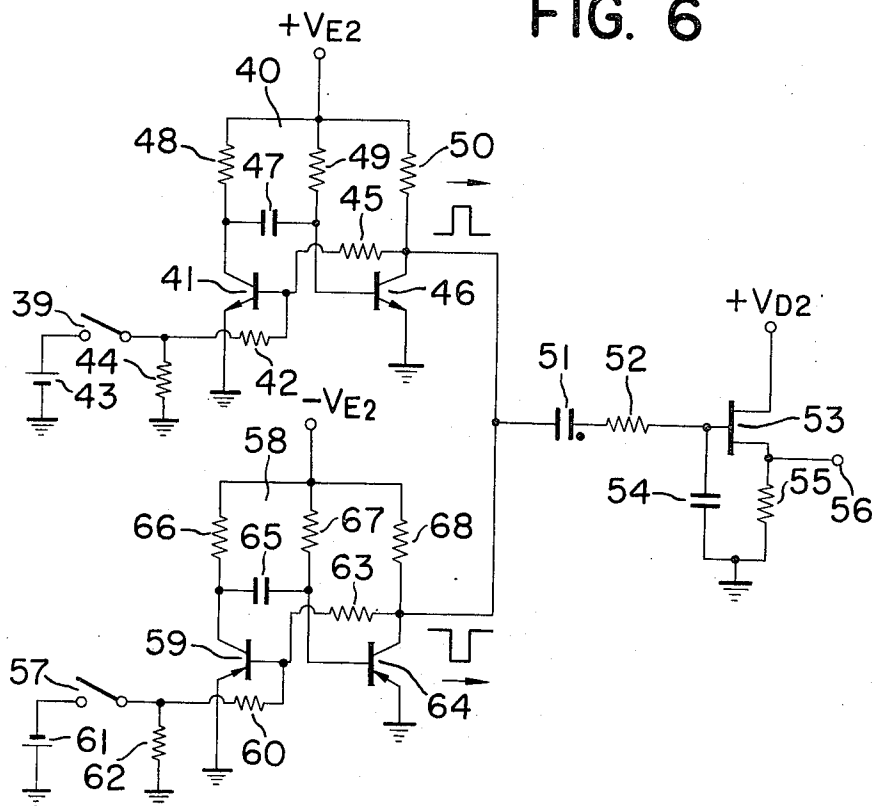


FIG. 5

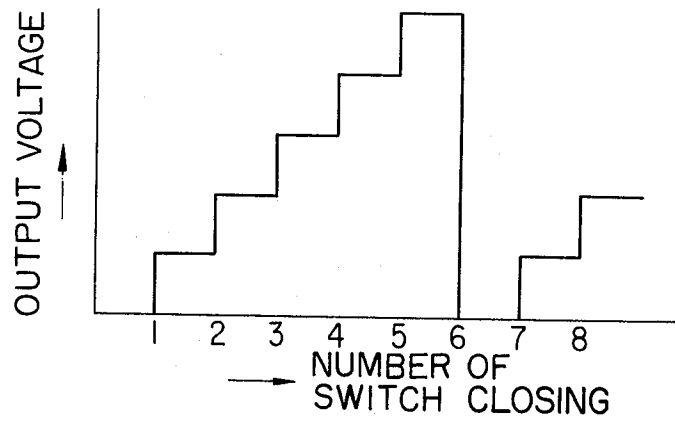


FIG. 7

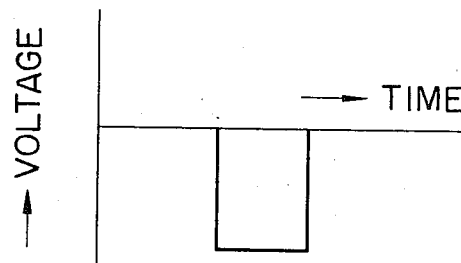
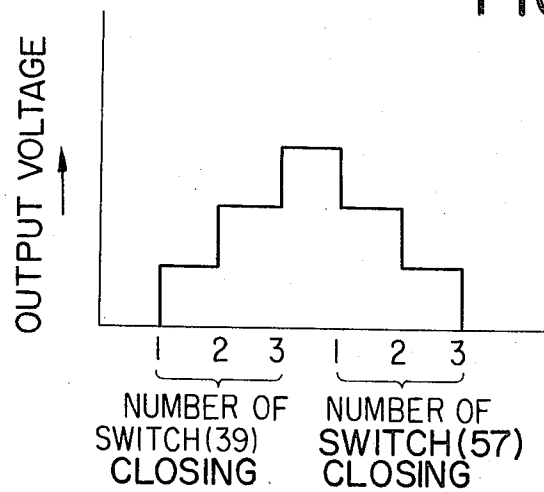


FIG. 8



DEVICE FOR GENERATING VARIABLE OUTPUT VOLTAGE

BACKGROUND OF THE INVENTION

The present invention relates to a device for generating a variable output voltage of the type in which a voltage across a capacitor connected to the gate of a MOS field-effect transistor is controlled in response to a pulsatory voltage generated by a monostable multivibrator so that the output voltage derived from the source of the MOS field-effect transistor may be varied stepwise.

In general, variable resistors have been widely used in order to vary a voltage, but they have the objectionable feature in that noise is produced because the armature slides over the resistor element. Furthermore, the variable voltage obtained by the variable resistor is not stable because the characteristics of the resistor element tend to be greatly affected by the environmental temperature.

SUMMARY OF THE INVENTION

One of the objects of the present invention is therefore to provide a device for generating a variable output voltage which eliminates the use of a variable resistor, but may accomplish precisely the function of the variable resistor.

Another object of the present invention is to provide a device capable of increasing stepwise a DC output voltage.

A further object of the present invention is to provide a device capable of increasing stepwise an output voltage and of dropping the output voltage to zero when it reaches a predetermined level.

A still further object of the present invention is to provide a device which may increase stepwise an output voltage when one switch is closed and may decrease stepwise the output voltage when the other switch is closed.

Briefly stated, according to the present invention, a non-polarized capacitor is inserted between ground and the gate of a MOS field-effect transistor, and the gate is connected through an input resistor and a neon bulb to a monostable multivibrator whose operation is controlled by a switch. Whenever the switch is closed, the output voltage is increased step by step. Furthermore, the output voltage may be returned to zero after it has reached a predetermined level. Moreover, the output voltage may be increased stepwise when a switch of a first monostable multivibrator is closed, and may be reduced also stepwise when a switch in a second monostable multivibrator is closed. Therefore, the devices of the present invention are very advantageous when used with a circuit adapted to control the intensity of a lamp.

The devices of the present invention may eliminate the use of an armature or brush and a resistor element of a conventional variable resistor, and may exactly accomplish the function of a variable resistor. Therefore, the noise problem may be overcome, and the aging problem caused by the sliding contact of the armature with the resistor element may be eliminated.

The above and other objects, features and advantages of the present invention will become more apparent from the following description of some preferred embodiments thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a circuit diagram of a first embodiment of the present invention;

FIGS. 2 and 3 are graphs used for the explanation thereof;

FIG. 4 is a circuit diagram of a second embodiment of the present invention;

FIG. 5 is a graph used for the explanation thereof;

FIG. 6 is a circuit diagram of a third embodiment of the present invention; and

FIGS. 7 and 8 are graphs used for the explanation thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

First Embodiment, FIGS. 1, 2, and 3

The base of a transistor 3 of a monostable multivibrator generally indicated by 2 is connected through a resistor 4 and a switch 1 to a power source 5. A resistor 6 connects the junction between the switch 1 and the resistor 4 to ground. The base of the transistor 3 is also connected through a resistor 7 to the collector of the other transistor 8 of the multivibrator 2, and the collector of the transistor 3 is connected through a capacitor 9 to the base of the transistor 8. The emitters of both transistors 3 and 8 are grounded, and their collectors are connected through resistors 10 and 12, respectively, to a positive DC power source $+V_E$. The base of transistor 8 is also connected through a resistor 11 to the source $+V_E$. The collector of the transistor 8 is also connected through a neon bulb 13 and an input resistor 14 to the gate of a MOS field-effect transistor 15. A non-polarized capacitor 16 connects the gate of the field-effect transistor 15 to ground, while the source of the field-effect transistor is grounded through an output resistor 17 and is connected to an output terminal 18. The drain of the field-effect transistor 15 is connected to a DC source $+V_D$.

Next the mode of operation will be described hereinafter. When the switch 1 is turned off, the transistor 8 is conducting so that its collector voltage becomes substantially zero. Therefore, the neon bulb 13 is not conducted. When the switch 1 is closed, the current flows into the base of the transistor 3 through the resistor 4 so that the transistor 3 conducts. The collector potential of transistor 3 at this time is substantially zero so that the base potential of the transistor 8 is also substantially zero. As a result, the transistor 8 is turned off so that its collector voltage rises to a level almost equal to the voltage $+V_E$, thereby exceeding the firing potential of the neon bulb 13 and causing it to conduct. The base potential of the transistor 8 gradually rises with a time constant which is dependent upon the values of the capacitor 9 and the resistor 11, and finally the transistor 8 is turned on. Then, the collector potential drops substantially zero so that the neon bulb 13 is turned off, and the transistor 3 is turned off because its base is grounded. The transistors 3 and 8 and the neon bulb 13 remain in the above state even when the switch 1 is kept closed.

Therefore, whenever the switch 1 is closed, one rectangular waveform voltage as shown in FIG. 2 is generated, and the neon bulb 13 conducts during the pulse duration T of this pulse voltage, so that the capacitor 16 is charged through the input resistor 14. In this case,

the gate voltage V_G of the field-effect transistor 15 is given by

$$V_G = E_0 \left(1 - e^{-\frac{T}{RC}} \right)$$

where E_0 = voltage after the neon bulb 13 conducts;

R = resistance of the input resistor 14; and

C = capacitance of the capacitor 16.

Since the pulse duration T is dependent upon the time constant which is dependent upon the values of the resistor 11 and the capacitor 9, the rise of the gate voltage V_G is dependent upon the time constant, which in turn is dependent upon the values of the input resistor 14 and the capacitor 16. The drain current of the MOS field-effect transistor 15 is in proportion to the gate voltage V_G until the field-effect transistor 15 is saturated, so that the output voltage which is the product of the drain current and the value of the output resistor 17 is also in proportion to gate voltage V_G . Therefore, the output voltage derived from the output terminal 18 is increased stepwise whenever the switch 1 is closed as shown in FIG. 3.

FIG. 3 shows the number of switch closings, spaced along the horizontal axis of the graph by a fixed, arbitrary distance that does not take into account the time between switch closings.

To return the output voltage to zero, the gate voltage V_G is decreased to zero.

Second Embodiments, FIGS. 4 and 5

Next referring to FIG. 4 illustrating a circuit diagram of the second embodiment of the present invention, the base of a transistor 21 of a monostable multivibrator generally indicated by 20 is connected through a resistor 22 and a switch 19 to the positive terminal of a power source 23, and a resistor 24 connects the junction between the resistor 22 and the switch 19 to ground. The base of the transistor 21 is also connected through a resistor 25 to the collector of the other transistor 26. The collectors of the transistor 21 and 26 are connected through resistors 28 and 30, respectively, to a positive DC power source $+V_{E1}$ and their emitters are grounded. The base of the transistor 26 is connected through a resistor 29 to the DC source $+V_{E1}$. The collector of the transistor 21 is connected through a capacitor 27 to the base of the transistor 26, and the collector of the transistor 26 is connected through a neon bulb 31 and an input resistor 32 to the gate of a MOS field-effect transistor 33. The gate of the field-effect transistor 23 is connected through a control resistor 37 and a neon bulb 38 to a negative power source $-V$, and is grounded through a non-polarized capacitor 34. The drain of the transistor 33 is connected to a DC power source $+V_{D1}$ and the source is grounded through an output resistor 35, and is connected to an output terminal 36.

Next, the mode of operation will be described. When the switch 19 is opened, the transistor 26 is turned on so that its collector potential is substantially equal to zero. Therefore, the neon bulb 31 does not conduct. When the switch 19 is closed, the current flows into the base of the transistor 21 through the resistor 22 so that the transistor 21 is turned on. The collector potential drops to zero so that the base potential of the transistor

26 also drops to zero. As a result, the transistor 26 is turned off so that its collector potential rises to a level substantially equal to $+V_{E1}$, thereby raising the neon bulb 31 to its firing potential and causing it to conduct.

5 The base potential of the transistor 21 gradually rises with a time constant which is dependent upon the values of the resistor 29 and the capacitor 27, and the transistor 26 is turned on. Then, its collector potential drops to about zero so that the neon bulb 31 is turned off, and the transistor 21 is turned off, since the base of the transistor 21 is almost grounded. The transistors 21 and 26 and the neon bulb 31 remain in the above states even when the switch 19 is kept closed. That is, whenever the switch 19 is closed, one rectangular waveform voltage as shown in FIG. 2 is generated, and the neon bulb 31 conducts during the pulse duration T , so that the capacitor 34 is charged through the input resistor 32. The gate voltage V_{G1} is given by

$$V_{G1} = E_{01} \left(1 - e^{-\frac{T}{RC}} \right)$$

where

E_{01} = voltage after the neon bulb 31 conducts;

R = resistance of the resistor 32; and

C = capacitance of the capacitor 34.

10 The pulse duration T is dependent upon the values of the resistor 29 and the capacitor 27, so that the rise of the gate voltage V_{G1} is dependent upon a time constant which is determined by the values of the resistor 32 and the capacitor 34. The drain current of the MOS field-effect transistor 33 is in proportion to the gate voltage V_{G1} so that the output voltage which is the product of the drain current and the value of the output resistance 35 is also in proportion to the gate voltage V_{G1} . Thus, the output voltage derived from the output terminal 36 is increased stepwise whenever the switch 19 is closed as shown in FIG. 5.

Since the neon bulb 38 is connected to the negative voltage source, it conducts when the voltage across the capacitor 34 and hence the gate voltage V_{G1} rises in excess of a predetermined level, so that the capacitor 34 is discharged through the resistor 37 and the neon bulb 38. Therefore, the voltage across the capacitor 34 drops. When the voltage across the capacitor 34 drops to a predetermined level which is lower than the firing voltage of the neon bulb 38, the discharge of the capacitor 34 is stopped, and the voltage across the capacitor 34 is such that the pinch-off of the field-effect transistor 33 takes place. The above steps are cycled whenever the switch 19 is closed as shown in FIG. 5.

Third Embodiment, FIGS. 6, 7 and 8

In the third embodiment shown in FIG. 6, one terminal of a neon bulb 51 is connected to two monostable vibrators generally indicated by 40 and 58, respectively, and substantially similar in construction, except that the monostable multivibrator 40 uses NPN transistors 41 and 46, while the monostable multivibrator 58 uses PNP transistors 59 and 64. Therefore, it will suffice to describe only the arrangement of the monostable vibrator 40, which is also substantially similar in construction to the monostable multivibrator 20 shown in FIG. 1.

The base of the NPN transistor 41 is connected through a resistor 42 and a switch 39 to the positive terminal of a power source 43, and a resistor 44 connects ground to the junction between the resistor 42 and the switch 39. The base of the transistor 41 is also connected through a resistor 45 to the collector of the NPN transistor 46, and the base of the transistor 46 is connected through a capacitor 47 to the collector of the transistor 41. The transistors 41 and 46 have their collectors connected through resistors 48 and 50, respectively, to a positive DC voltage source V_{E2} and their emitters grounded. The bases of the transistor 46 is connected through a resistor 49 to the source V_{E2} . The collector of the transistor 46 is connected to one terminal of the neon bulb 51 whose the other terminal is connected through an input resistor 52 to the gate of a MOS field-effect transistor 53. A non-polarized capacitor 54 connects ground to the gate of the MOS field-effect transistor 53. The drain of the field-effect transistor 53 is connected to a positive DC voltage source V_{D2} , while the source is connected to an output terminal 56, and is grounded through an output resistor 55.

In the monostable multivibrator 58, the base of the PNP transistor 59 is connected through a resistor 60 and a switch 57 to the negative terminal of a power source 61, and the collectors of the transistors 59 and 64 are connected through resistors 66 and 68, respectively, to a negative DC voltage source $-V_{E2}$, and their emitters are grounded. The base of the transistor 64 is connected through a resistor 67 to the source $-V_{E2}$.

Next, the mode of operation will be described hereinafter. When the switch 39 of the monostable multivibrator 40 is opened, the transistor 46 conducts so that its collector voltage is almost equal to zero. Therefore, the neon bulb 51 is not conducting. When the switch 39 is closed, the current flows into the base of the transistor 41 through the resistor 42 so that the latter is turned on. The collector voltage drops to almost zero so that the base potential of the transistor 46 also drops to almost zero and the transistor 46 is turned off. Therefore, the collector potential of the transistor 46 approaches $+V_{E2}$ so that the neon bulb 51 conducts. The base potential of the transistor 46 gradually increases with a time constant which is dependent upon the values of the resistor 49 and the capacitor 47, and the transistor 46 is turned on. Then, the collector potential of the transistor 46 drops to almost zero so that the neon bulb 51 is turned off. The transistor 41 is turned off because its base is almost grounded. The transistors 41 and 46 and the neon bulb 51 remain in the above states even when the switch 43 is kept closed. That is, when the switch 39 is closed, the rectangular waveform collector voltage as shown in FIG. 2 is generated. The neon bulb 51 conducts during the pulse duration T so that the capacitor 54 is charged through the input resistor 52. The gate voltage V_{G2} of the MOS field-effect transistor 53 is given by

$$V_{G2} = E_{02} \left(1 - e^{-\frac{T}{R_2 C_2}} \right)$$

where

E_{02} = voltage after the neon bulb 51 conducts;
 R_2 = resistance of the resistor 52; and
 C_2 = capacitance of the capacitor 54.

The pulse duration T is dependent upon a time constant which is determined by the values of the capacitor 47 and the resistor 49 so that the rise of the gate voltage V_{G2} is dependent upon the time constant which is dependent upon the values of the resistor 52 and the capacitor 54. Since the drain current of the MOS field-effect transistor 53 is in proportion to the gate voltage, the output voltage which is the product of the drain current and the resistance of the output resistor 55 is also in proportion to the gate voltage. Therefore, the output voltage derived from the output terminal 56 is increased stepwise whenever the switch 39 is closed.

When the switch 57 is closed, the transistor 64 is turned off so that its collector potential drops to almost $-V_{E2}$. Therefore, the rectangular waveform negative voltage as shown in FIG. 7 is generated at the collector of the transistor 64. As a result, the capacitor 54 is discharged so that the gate voltage of the MOS field-effect transistor 53 drops by a predetermined level. Therefore, the output voltage also drops stepwise.

As described hereinbefore, the output voltage increases stepwise whenever the switch 39 is closed while whenever the switch 57 is closed, the output voltage drops stepwise. FIG. 8 shows the output voltage which is increased stepwise by three steps and then decreased stepwise by three steps, but it is understood that the output voltage may be increased and decreased in any step.

What is claimed is:

1. A device for generating variable output voltage comprising
 - a. a MOS field-effect transistor,
 - b. a non-polarized capacitor connecting the gate of said MOS field-effect transistor to ground,
 - c. a neon bulb,
 - d. an input resistor connected in series with the neon bulb,
 - e. a monostable multivibrator means connected to the gate of said MOS field-effect transistor through said input resistor and said neon bulb for providing a single square wave output pulse in response to an input signal, said square wave output pulse having a predetermined electrical potential and a duration sufficient only to charge said non-polarized capacitor through said input resistor and said neon bulb to a potential that is less than one-half the predetermined electrical potential.
 - f. a switch connected to said monostable multivibrator means for providing said input signal, and
 - g. an output resistor connecting the source of said MOS field-effect transistor to ground, whereby when said switch is repeatedly closed, the output voltage derived from the source of said MOS field-effect transistor increases stepwise.
2. A device for generating variable output voltage as defined in claim 1 wherein said monostable multivibrator comprises a pair of PNP transistors.
3. A device for generating variable output voltage as defined in claim 1 wherein the gate of said MOS field-effect transistor is connected through a control resistor to a second neon bulb, whereby an output voltage which increases stepwise to a predetermined level by a predetermined number of steps and then falls to zero may be repeatedly generated.

4. A device for generating variable output voltage as defined in claim 1 further comprising
a second monostable multivibrator means comprising
a pair of transistors of one conductivity type
wherein the first monostable multivibrator means
comprises a pair of transistors of the opposite conductivity type, a switch connected to the base of
one of said pairs of transistors of said second monostable multivibrator means, and the collector of the
other transistor of said second monostable multivibrator means being connected to said one terminal

of said neon bulb, and a second switch for providing an input signal to said second monostable multivibrator means,
whereby when the switch of one of said first and second monostable multivibrator means is closed, the output voltage may be increased stepwise while when the switch of the other monostable multivibrator means is closed, the output voltage may be decreased stepwise.

* * * * *

15

20

25

30

35

40

45

50

55

60

65