

- [54] **DEVICE FOR VARYING OUTPUT VOLTAGE WITHIN A LIMITED RANGE**
- [75] Inventors: **Shunji Minami, Moriguichi; Shunzo Oka; Takehide Takemura**, both of Hirakata, all of Japan

3,373,295	3/1968	Lambert	307/304 X
3,463,993	8/1969	Beck et al.	307/304 X
3,647,940	3/1972	Harwood	307/304 X
3,728,556	4/1973	Arnell	307/304 X
3,826,970	7/1974	Oka et al.	323/19

- [73] Assignee: **Matsushita Electric Industrial Co., Ltd.**, Osaka, Japan

- [22] Filed: **Dec. 18, 1974**

- [21] Appl. No.: **533,827**

Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 424,717, Dec. 14, 1973, abandoned.

- [30] **Foreign Application Priority Data**

Dec. 20, 1972 Japan..... 47-147211[U]

- [52] U.S. Cl. **323/22 SC; 307/252 T; 307/304; 323/8; 323/24**

- [51] Int. Cl.² **G05F 1/60**

- [58] Field of Search..... 307/139, 141, 251, 252 T, 307/279, 296, 297, 304; 323/8, 16, 19, 22 R, 22 SC, 24; 328/125; 320/1

- [16] **References Cited**

UNITED STATES PATENTS

3,277,362 10/1966 Elliott, Jr. 323/24

Primary Examiner—Gerald Goldberg

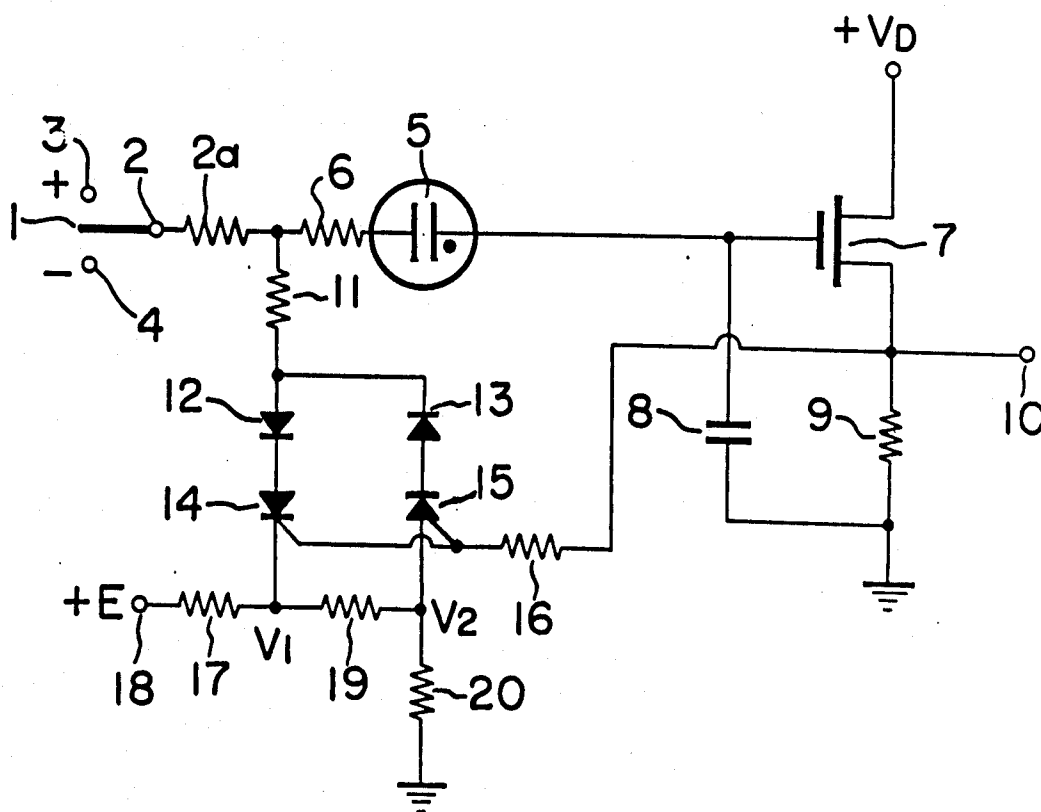
Attorney, Agent, or Firm—Burgess Ryan and Wayne

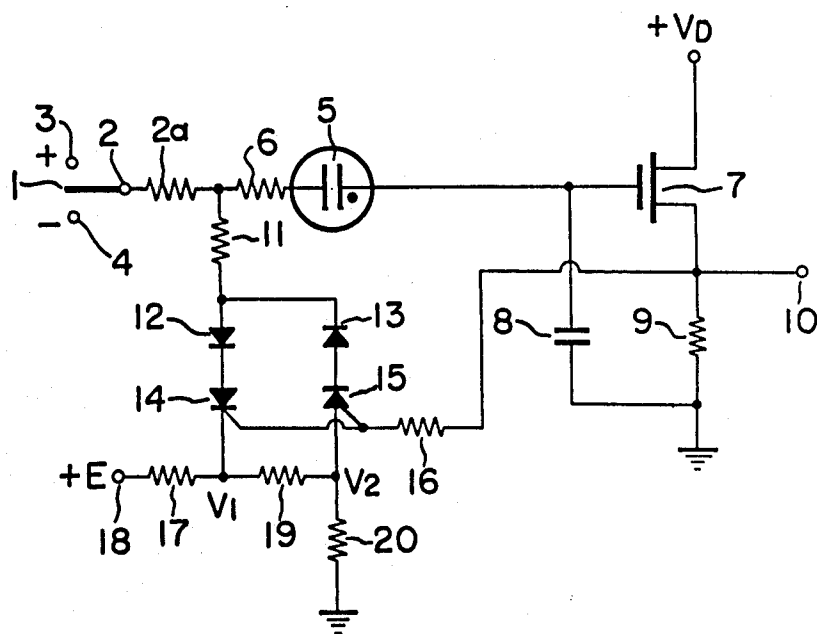
[57]

ABSTRACT

A device is disclosed which may vary an output voltage within a limited range. The device is an improvement of a device of the type in which the voltage across a capacitor connected to the gate of a MOS field-effect transistor is controlled through a neon bulb, which in turn is so controlled by a single-pole, double-throw, center-off switch or relay that selectively applies a positive, negative or zero voltage to the neon bulb and in which the output voltage is varied in response to the voltage across the capacitor. The improvement comprises a limiting circuit adapted to determine a range through which the output voltage may be arbitrarily varied.

6 Claims, 1 Drawing Figure





DEVICE FOR VARYING OUTPUT VOLTAGE WITHIN A LIMITED RANGE

This application is a continuation-in-part of U.S. Ser. No. 424,717, filed Dec. 14, 1973 and now abandoned.

The present invention relates to a device for varying the output voltage within a predetermined range, said device comprising a device of the type providing a continuously variable output voltage controlled by a switch adapted to selectively apply a positive, negative or zero voltage to said device, and a limiting circuit adapted to determine a range through which the output voltage may be varied.

In general, variable resistors are widely used in order to vary voltage, but since the armatures of the variable resistors slide over resistor elements, noise is produced. Furthermore, the characteristics of the resistor elements tend to be easily changed in response to fluctuations in ambient temperature.

One of the objects of the present invention is therefore to produce a device for providing a variable output voltage which may eliminate the sliding contact between the armature and the resistance element of a conventional variable resistor, but may exactly accomplish the function of a variable resistor in a more satisfactory and advantageous manner.

Another object of the present invention is to provide a device of the type described above further incorporating a voltage limiting circuit, so that the output voltage may be varied arbitrarily and continuously within a predetermined voltage range.

A further object of the present invention is to provide a device of the type described above which is capable of varying the output voltage within a predetermined voltage range using a switch to selectively connect the device to a positive, negative or zero voltage source.

Briefly stated, in accordance with the present invention, a non-polarized capacitor is inserted between the gate of a MOS field-effect transistor and the ground, and the gate is connected to one terminal of a neon bulb whose other terminal is connected through resistance means to the armature of a single-pole, double-throw, center-off switch. A voltage limiting circuit is connected to the switch and to the source of the MOS field-effect transistor through a control resistor. When the armature of the switch is connected to a positive fixed terminal connected to a positive source, the voltage across the capacitor is increased so that the output voltage derived from the MOS field-effect transistor is increased. On the other hand, when the armature is connected to a fixed terminal connected to a negative voltage source, the voltage across the capacitor is reduced so that the output voltage is decreased. When the armature is placed in the center off position, the voltage across the capacitor is maintained at a constant level, so that the output voltage remains constant. Thus, the output voltage may be arbitrarily and continuously varied within a pre-determined voltage range which is set by control voltages applied to the voltage limiting circuit.

Since no variable resistor is used, no noise is produced, and the problem of aging of the armature and resistor element of a variable resistor may be completely eliminated.

The above and other objects, features and advantages of the present invention will become more apparent from the following description of one preferred em-

bodiment thereof taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single figure is a circuit diagram of a preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referring to the single figure, a single-pole, double-throw, center-off switch 1 has its contacts 3 and 4 connected to positive and negative power sources, respectively, and has an armature 2 connected to one terminal of a neon bulb 5 through resistors 2a and 6. The other terminal of the neon bulb is connected to the gate of a MOS field-effect transistor 7. A non-polarized capacitor 8 is inserted between the gate of the field-effect transistor 7 and the ground. The drain of the field-effect transistor 7 is connected to a DC source V_D , while the source is grounded through an output resistor 9 and connected to an output terminal 10.

A resistor 11 is connected between the two resistors 2a and 6. The armature 2 of the switch 1 is also connected through the resistors 2a and 11 to the anode of a diode 12 and to the cathode of a diode 13. The cathode of the diode 12 is connected to the anode of a p-gate type, silicon-controlled rectifier 14, while the anode of the diode 13 is connected to the cathode of an n-gate type silicon-controlled rectifier 15. The gates of the silicon-controlled rectifiers 14 and 15 are connected through a resistor 16 to the source of the field-effect transistor 7. The cathode of the silicon-controlled rectifier 14 is connected through a resistor 7 to a DC power source +E, and the anode of the silicon-controlled rectifier 15 is connected through a resistor 19 and the resistor 17 to the DC power source +E, and is also grounded through a resistor 20.

Next the mode of operation will be described hereinafter. If the armature 2 is connected to the positive fixed terminal 3 when the silicon-controlled rectifiers 14 and 15 are turned off, the neon bulb 5 conducts after its breakdown potential is exceeded, so that the capacitor 8 is charged. In response to the increase in voltage across the capacitor 8, the drain current of the field-effect transistor 7 is increased, so that the voltage across the output resistor 9 is increased. Thus, the output voltage derived from the output terminal 10 is increased. On the other hand, when the armature 2 is connected to the negative fixed terminal 4, the output voltage is decreased in a similar manner. When the armature 2 is in the center "off" position, a constant output voltage in proportion to a voltage across the capacitor 8 may be obtained.

When the DC voltage E is applied to the terminal 18, the voltage given by

$$V_1 = \frac{R_{19} + R_{20}}{R_{17} + R_{18} + R_{20}} \times E$$

is applied to the cathode of the silicon-controlled diode 14, while the voltage given by

$$V_2 = \frac{R_{20}}{R_{17} + R_{18} + R_{20}} \times E$$

is applied to the anode of the silicon-controlled rectifier 15.

3

Therefore, if the armature 2 is connected to the positive fixed terminal 3 when the voltage E is applied to the terminal 18, the silicon-controlled rectifier 14 is turned on when the output voltage exceeds the voltage V_1 , because the source of the MOS field-effect transistor 7 is connected through the resistor 16 to the gates of the silicon-controlled rectifiers 14 and 15.

Assuming the voltage level at the connecting point between resistors 2a and 6 to be V_{in} , the value for V_{in} is determined as follows. When SCR 14 conducts, one end of the resistor 11 is then grounded. In this situation;

$$V_{in} = \frac{R_6}{R_{12} + R_6} \times V \text{ where } R_{2a} > R_6.$$

V_{in} in this case is less than the firing voltage of neon bulb 5, which then stops firing. The same considerations govern when SCR 15 becomes conductive, i.e., V_{in} drops to a level below the firing voltage of the neon bulb 5 to prevent firing of the said bulb.

However, when SCR's 14 and 15 are both in a non-conductive state, which can occur where $R_{2a} \ll R_{11}$, V then becomes equal to V_{in} and the neon bulb works unaffected by the SCR's. When SCR 14 conducts, the input voltage to the neon bulb 5 drops below the firing voltage, so that even when the positive voltage is applied to the armature 2, the output voltage will not be in excess of the voltage V_1 .

When the armature 2 is connected to the negative fixed terminal 4 so that the output voltage decreases to less than V_2 , the silicon-controlled rectifier 15 is turned on, so that the neon bulb 5 is grounded. Therefore, the discharge of the capacitor 8 is stopped so that the output voltage will not drop to less than V_2 .

The diodes 12 and 13 are inserted in order to prevent the erratic operations of the silicon-controlled rectifiers 14 and 15 due to the small current induced when the positive or negative voltage is applied to the armature 2. The resistance of the resistor 16 is so selected as to be sufficiently higher than that of the output resistor 9 so that the variation in output voltage may be prevented and the silicon-controlled rectifiers 14 and 15 may be turned on in response to a small current. Since the resistors 17, 19 and 20 are inserted in order to determine the ranges of voltages V_1 and V_2 applied to the silicon-controlled rectifiers 14 and 15, respectively, they may be eliminated provided that control voltages are directly applied to the silicon-controlled rectifiers through any suitable means.

What is claimed is:

1. A device for varying output voltage within a limited range comprising
 - a. a single-pole, double-throw, center-off switch,
 - b. a neon bulb having one terminal in series connection with an armature of said switch,

4

- c. a MOS field-effect transistor the gate of said MOS field-effect transistor being connected to one terminal of said neon bulb,
- d. a non-polarized capacitor connected between the gate of said MOS field-effect transistor and ground,
- e. an output resistor connected between the source of said MOS field-effect transistor and ground,
- f. a first diode and resistance means, the anode of said first diode being connected to said armature of said switch through said resistance means,
- g. a p-gate type silicon-controlled rectifier whose anode is connected to the cathode of said first diode,
- h. a second diode whose cathode is connected to the anode of said first diode,
- i. a n-gate type silicon-controlled rectifier whose cathode is connected to the anode of said second diode, and
- j. a control resistor, the gates of said p-gate type and n-gate type silicon-controlled rectifiers being connected through said control resistor to the source of said MOS field-effect transistor, whereby the output voltage is derived from the source of said MOS field-effect transistor while the control voltage for limiting the output voltage is applied to the cathode of the p-gate type silicon-controlled rectifier or to the anode of the n-gate type silicon-controlled rectifier.

2. A device for varying output voltage within a limited range as defined in claim 1 further comprising an additional resistor, the control voltages being applied through said additional resistor to said p-gate type and n-gate type silicon-controlled rectifiers.

3. A device for varying output voltage within a limited range as defined in claim 1 wherein the cathode of said p-gate type silicon-controlled rectifier and the anode of said n-gate type silicon-controlled rectifier are directly connected to control voltage sources, respectively.

4. A device for varying output voltage within a limited range as defined in claim 1 wherein said control resistor is so selected as to have a resistance value higher than that of said output resistor.

5. A device for varying output voltage within a limited range as defined in claim wherein said resistance means comprises a first resistor, a second resistor and a third resistor, said first resistor being connected to said armature, said third resistor being connected to one terminal of said neon bulb, said first and third resistors being in series connection, said second resistor being connected between said first and third resistors and having one terminal connected to the anode of said first diode.

6. A device for varying output voltage within a limited range as defined in claim 5 wherein the first resistor has greater resistance than the third resistor and is connected to said armature, said second resistor having greater resistance than said first resistor.

* * * * *

60

65

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,925,720 Dated December 9, 1975

Inventor(s) Shunji Minami, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 56: Change "consent" to --constant--.

line 59: Change "pre-determined" to --predetermined--.

Column 2, line 12: Change "repsec" to --respec--.

line 31: Change "filed" to --field--.

Column 3, line 15: Change " $V_{in} = \frac{R_6}{R_{2a} + R_6} \times V$ where $R_{2a} > R_6$ "

to --" $V_{in} = \frac{R_6}{R_{2a} + R_6} \times V$ where $R_{2a} > R_6$ --.

line 43: Change "suffciently" to --sufficiently--.

Signed and Sealed this

twenty-second Day of June 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,925,720 Dated December 9, 1975

Inventor(s) Shunji Minami, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 56: Change "consent" to --constant--.

line 59: Change "pre-determined" to --predetermined--.

Column 2, line 12: Change "repsec" to --respec--.

line 31: Change "filed" to --field--.

Column 3, line 15: Change " $V_{in} = \frac{R_6}{R_{2a} + R_6} \times V$ where $R_{2a} > R_6$ "

to --" $V_{in} = \frac{R_6}{R_{2a} + R_6} \times V$ where $R_{2a} > R_6$ --.

line 43: Change "suffciently" to --sufficiently--.

Signed and Sealed this

twenty-second Day of June 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks