March 25, 1952 W. H. T. HOLDEN 2,590,248

VOLTAGE SENSITIVE CIRCUIT

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FIG. 1

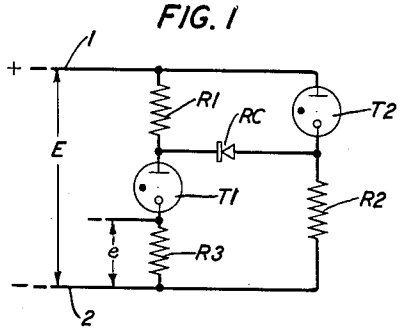
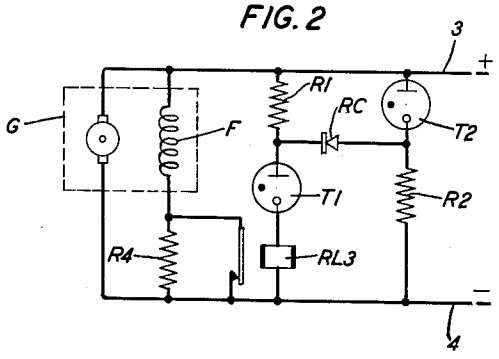


FIG. 2



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VOLTAGE SENSITIVE CIRCUIT

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2 Claims. (Cl. 323—23)

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This invention relates to voltage-sensitive circuits.

Gas-discharge diode tubes lend themselves to use as voltage standards in voltage regulators and similar devices because of their well-known characteristic of constant sustaining voltage across their terminals when conducting. Such tubes are, therefore, manufactured for this purpose in a limited number of types, each type designed to have a definite sustaining voltage, there being only a small variation in this respect among tubes of the same type. In the usual voltage regulator, one tube is employed as a voltage standard and where the value at which the voltage is to be regulated differs materially from the sustaining voltage of any available tube, arrangements which complicate the circuits must be made to compensate for this difference.

The present invention discloses a novel and convenient voltage-sensitive circuit having a superior characteristics useful in voltage regulators and similar devices.

A feature of the invention is that the value of the voltage at which the regulating characteristic of the circuit is effective is the sum of the sustaining voltages of two tubes. Because of this feature the circuit is adapted for a wide range of regulated voltage values merely by the selection of suitable combinations of tubes from a stock of tubes having only a limited number of different sustaining voltages.

Another feature of the invention is that the effective controlling voltage is directly equal to the excess of the applied voltage over the regulated value, making the circuit very sensitive to variations in the applied voltage.

Still another feature of the invention is the few and simple elements employed, namely, two tubes, three resistors, and a rectifier.

These and other features of the invention, its construction and its operation will be more apparent from the accompanying description, the appended claims, and the drawing, in which:

Fig. 1 shows my voltage-sensitive circuit; and

Fig. 2 shows this circuit applied to the regulation of the output voltage of a generator, illustrating one of the many uses of my voltage-sensitive circuit.

In the drawing, T1 and T2 are gas-filled diode tubes, preferably of the cold-cathode type. These two tubes may have the same or different electrical characteristics. RC is a rectifier or device having a high resistance to the passage of current of one polarity and a low resistance to the passage of current of the opposite polarity, poled as shown, and may be of any suitable type of such

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device. R1, R2, and R3 are simple resistors. The resistance value of resistor R1 should be high compared to the value of resistor R3. For example, the value of resistor R3 may be in the order of 500 ohms and the value of resistor R1 in the order of 100,000 ohms. Resistor R2 need not have any particular value but it is advisable that it have a high resistance to save power loss.

Referring to Fig. 1, if a voltage E sufficient to cause breakdown of both of tubes T1 and T2 is applied across the input conductors 1 and 2, and said tubes are thereby caused to conduct, the voltage drop in each of said tubes is equal to their respective sustaining voltages. The voltage drop in resistors R1 and R3 is equal to the difference between the voltage E and the sustaining voltage of tube T1. Since, however, the resistance value of resistor R1 is high compared with that of resistor R3, the voltage drop *e* across resistor R3 is negligible. The anode of tube T1 is, therefore, practically at the sustaining voltage of tube T1. The voltage drop in resistor R2 is equal to the difference between the voltage E and the sustaining voltage of tube T2 and, therefore, is of the same order as the voltage drop in resistor R1. The anode of tube T1 is, therefore, at a higher potential than that of the cathode of tube T2 but practically no current flows through rectifier RC owing to the high resistance of said rectifier to the passage of current from the anode of tube T1 to the cathode of tube T2.

If, now, the voltage E is increased until it is greater than the sum of the sustaining voltages of tubes T1 and T2, the voltage drops in said tubes are unchanged but the voltage drop in resistor R1 is greater than that in tube T2. The cathode of said latter tube is, therefore, at a higher potential than the anode of tube T1 and current flows from conductor 1 through the anode-cathode space of tube T2, rectifier RC, the anode-cathode space of tube T1, and resistor R3 to conductor 2, causing an appreciable voltage drop *e* across resistor R3. As the voltage E is further increased, the voltage drop *e* across resistor R3 is increased in like amount.

It is evident, therefore, that if an increasing voltage E is applied to this circuit, tubes T1 and T2 break down and conduct when the voltage E reaches the breakdown voltage of each of said tubes, but there is no appreciable voltage drop *e* across resistor R3 until the voltage E begins to exceed the sum of the sustaining voltages of the tubes T1 and T2. Upon further increase of the voltage E, the voltage drop *e* across resistor R3 is equal to said increase.

This characteristic of the voltage drop across resistor R3 makes the circuit useful for voltage regulators and other applications, an example of which is shown in Fig. 2, the tubes T1 and T2, the resistors R1 and R2, and the rectifier RC in this figure being the same as those shown in Fig. 1. The relay RL3 has a resistance comparable to that of resistor R3 of Fig. 1. G is a generator which normally produces a voltage greater than the sum of the sustaining voltages of tubes T1 and T2 by at least the operating voltage of relay RL3. The resistor R4 is of such a value that, when it is in series with the field coil F of generator G, the voltage output of said generator is less than the sum of the sustaining voltages of tubes T1 and T2 and the holding voltage of relay RL3.

It will be evident, from the description above of the action of the circuit of Fig. 1, that when the output voltage of generator G exceeds the sum of the sustaining voltages of tubes T1 and T2, current flows through the winding of relay RL3. At the normal output of generator G, this current is sufficient to operate said relay, which opens its contacts, removing the short-circuit around resistor R4. With said resistor in series with the field coil F of generator G, the voltage output of said generator falls, releasing relay RL3. Resistor R4 is thereby again short-circuited and the voltage output of generator G again rises so that the action described above is repeated. Relay RL3 need not fully operate but only break its contacts so that its action is rapid. The output voltage of generator G to conductors 3 and 4 is, therefore, regulated at a value practically equal to the sum of the sustaining voltages of tubes T1 and T2.

Whereas in voltage regulators employing a single gas-filled diode tube as a voltage standard complications ensue if the value at which the voltage is to be regulated differs from the sustaining voltage of the tube, it will be observed that in my circuit employing two tubes, available tubes having different sustaining voltages may be chosen so that the sum of their sustaining voltages is equal to the value at which the voltage is to be regulated.

While I have described only one application and one form of my invention, it will be apparent to one skilled in the art that it may equally well be used in other applications and other forms. The terms and expressions which I have used in reference to this invention and its elements are used as terms of description and not of limitation and I have no intention in the use of such terms and expressions of excluding thereby equivalents and modifications thereof but, on the contrary

intend to include therein any and all equivalents and modifications which may be employed without departing from the spirit of the invention.

What is claimed is:

1. A voltage-sensitive circuit comprising in combination a first and a second conductor, means for producing a voltage between said two conductors, a first and a second diode gas-discharge device, a first, a second, and a third resistor, and a rectifier, the anode of said first gas-discharge device being connected to said first conductor and the cathode thereof being connected to said second conductor through said first resistor, the anode of said second gas-discharge device being connected to said first conductor through said second resistor and the cathode thereof being connected to said second conductor through said third resistor, and said rectifier being connected between the cathode of said first gas-discharge device and the anode of said second gas-discharge device, whereby said elements are responsive to said voltage to produce a voltage drop in said third resistor substantially equal to the sum of the sustaining voltages of said gas-discharge devices when said voltage is greater than said sum.

2. A voltage regulator comprising in combination a first and a second conductor, means for producing a voltage between said two conductors, a first and a second diode gas-discharge device, a first and a second resistor, a relay, and a rectifier, the anode of said first gas-discharge device being connected to said first conductor and the cathode thereof being connected to said second conductor through said first resistor, the anode of said second gas-discharge device being connected to said first conductor through said second resistor and the cathode thereof being connected to said second conductor through the winding of said relay, and said rectifier being connected between the cathode of said first gas-discharge device and the anode of said second gas-discharge device, and means responsive to said relay for maintaining said voltage substantially equal to the sum of the sustaining voltages of said gas-discharge devices.

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