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SAW-TOOTH MULTIVIBRATOR CIRCUIT

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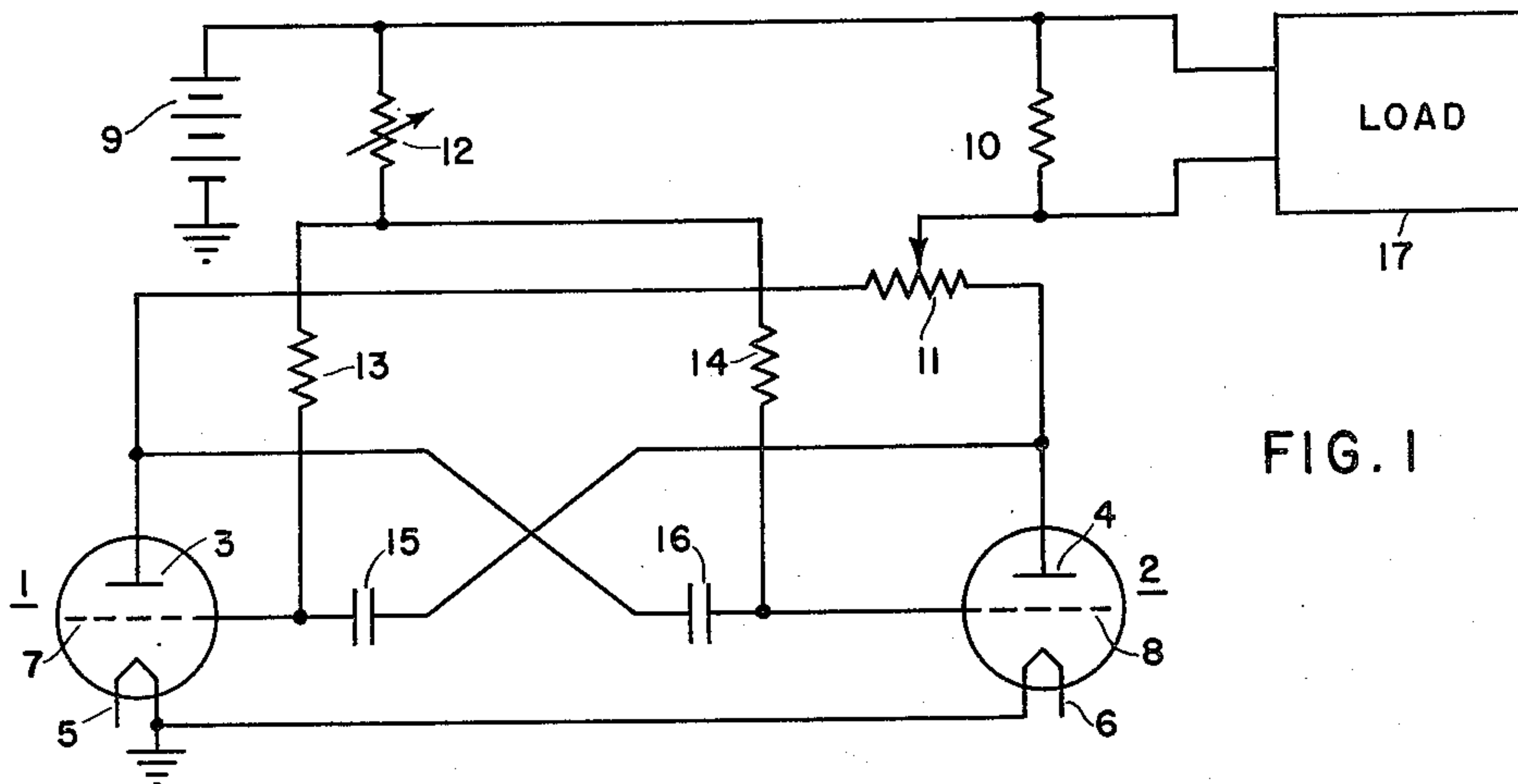


FIG. 1

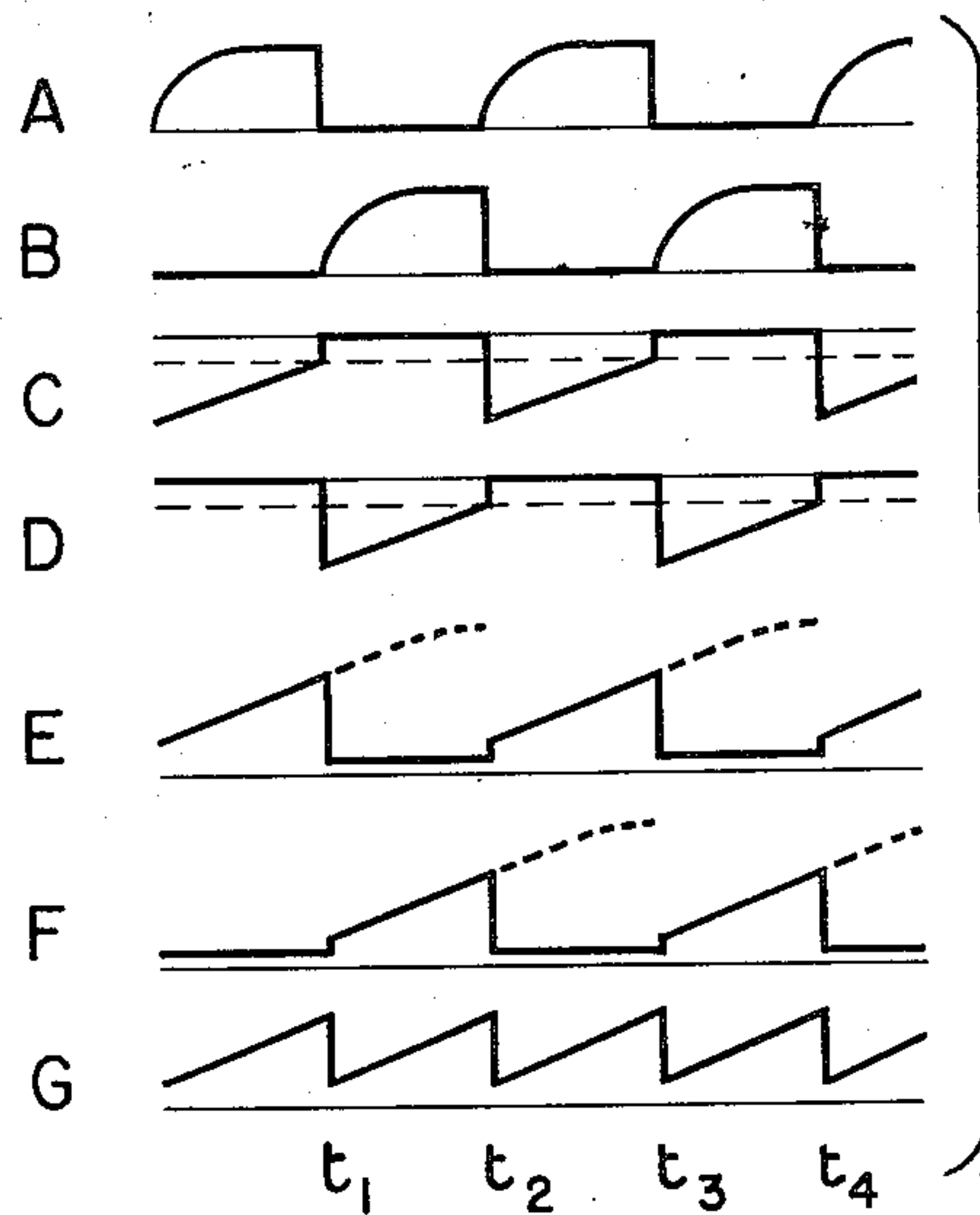


FIG. 2

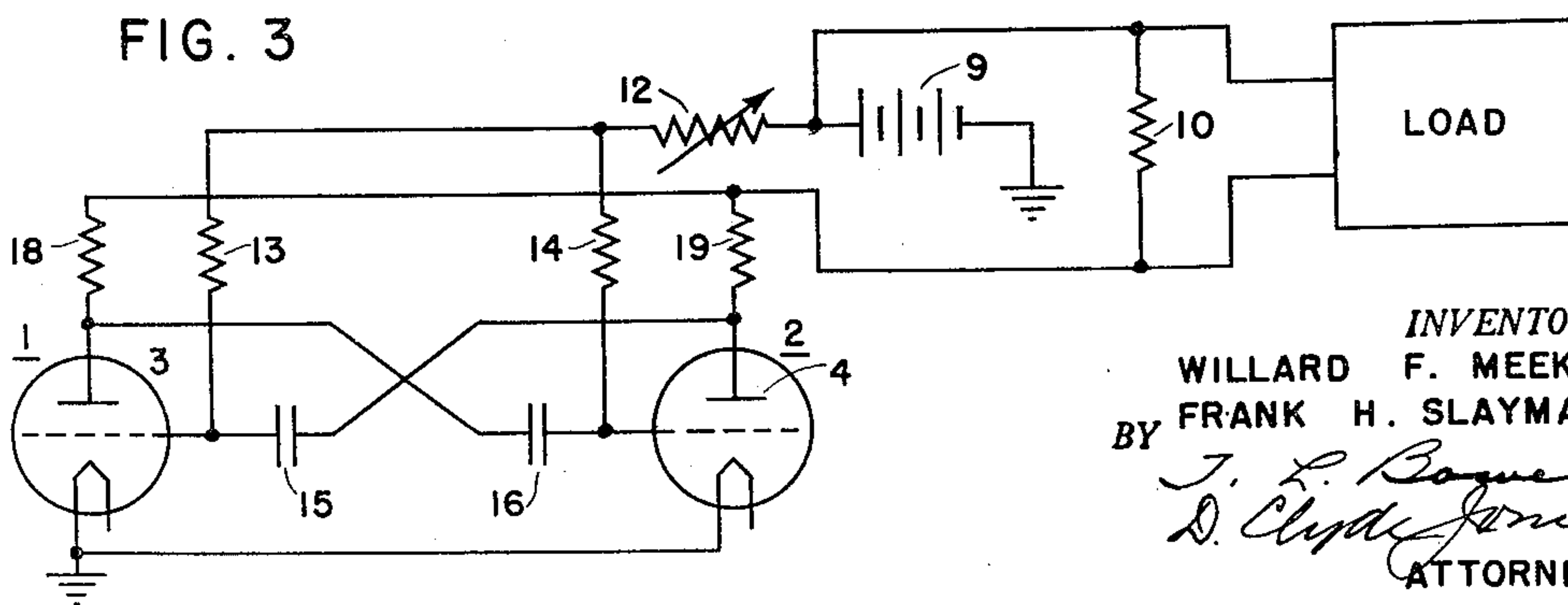


FIG. 3

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## SAW-TOOTH MULTIVIBRATOR CIRCUIT

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5 Claims. (Cl. 250—36)

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This invention relates to wave generators and more particularly to means for generating saw-tooth waves.

Circuits have heretofore been devised for producing or generating waves having a saw-tooth configuration. For example, blocking oscillators have been used frequently for this purpose but relatively high voltage plate or anode supplies are required.

It is an object of this invention to provide a new and improved means for producing a saw-tooth wave using a minimum number of parts, having a low cost, which is light in weight and which enables use of electron discharge devices utilizing low current filaments and relatively low anode voltages.

It is another object of this invention to employ a multivibrator circuit to produce saw-tooth waves. This object is achieved by making the values of resistance and capacitance associated with the anodes of the multivibrator tubes of such values that the time constant thereof is relatively long.

Other objects and advantages of this invention will become apparent as the following description proceeds when read with reference to the accompanying drawing in which Fig. 1 is a circuit diagram illustrating an embodiment of the invention, Fig. 2 comprises a series of diagrams useful to a complete understanding of the operation of the circuit of Fig. 1, and Fig. 3 is a modification of the circuit shown in Fig. 1.

Referring to Fig. 1, there is shown a multivibrator comprising a pair of electron discharge devices 1 and 2 including anodes 3 and 4, respectively, filaments 5 and 6 respectively, and control electrodes 7 and 8 respectively. The operating current supply includes a suitable source of potential 9 whose negative terminal is grounded and whose positive terminal is connected to anodes 3 and 4 through suitable resistances 10 and 11 as shown. The filaments 5 and 6 are grounded in this embodiment of our invention. The control electrodes 7 and 8 are positively biased by means of a connection to the source of potential 9 through resistors 12, 13 and 14 as shown, the resistor 12 being common to both biasing circuits and preferably being variable to enable easy adjustment of the bias and hence of the frequency of oscillation. In order to cause the discharge devices to operate in multivibrator fashion, a condenser 15 is connected between control electrode 7 and anode 4 and a condenser 16 is connected between control electrode 8 and anode 3.

As is well understood, in customary multivibrator circuits, there are periodically produced at

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the anodes substantially square pulses. This condition is illustrated in Fig. 2 wherein at A is depicted the potentials appearing at one of the anodes (let us assume anode 3) and at B is illustrated the potentials existing at the other anode (anode 4) at the same instants of time.

In accordance with our invention the capacitance of capacitors 15 and 16, and the resistance of resistor 11 are so chosen that the anode and control-electrode potentials change so slowly that the control electrode increases in the positive sense to cut-off while the anode potential is still increasing linearly. In Fig. 2, at C and D are represented possible potentials at control-electrodes 7 and 8 respectively varying with time. Cut-off is represented by the dashed line. At E and F of Fig. 2, possible potentials of anodes 3 and 4 are shown. The dotted lines represent the potential relationship if the multivibrator period is long enough to permit the potential to reach its maximum. In accordance with the conditions set forth above, however, at time  $t_1$  for example, the control electrode of discharge device 1 reaches cut-off and device 1 conducts. During the rise of potential at control-electrode 7 (Fig. 2C), the anode potential is increasing as shown at Fig. 2E. The potential at control-electrode 8 now begins to rise toward cut-off (Fig. 2D) and at time  $t_2$  the multivibrator again switches. Figs. 2E and 2F therefore show that saw-tooth pulses of voltage appear alternately at the anodes. In other words, the R-C, or time constants, of the anode circuits are so chosen that the anode potential rises linearly throughout the non-conducting or "off" period of each discharge device. The anodes may be connected through suitable resistance means which may be a single tapped resistor, a potentiometer, or two separate resistors, one end of each being connected to an anode and the other ends connected to load resistor 10. In Fig. 1 there is illustrated a potentiometer 11. Fig. 3 shows the use of two resistances 18 and 19. A load 17 connected across resistor 10 will have supplied to it a saw-tooth wave of form illustrated by Fig. 2G.

Resistance 11 is preferably a potentiometer in which the ends of the resistance portion are respectively connected to the anodes 3 and 4 and the movable arm member is connected to one end of resistor 10 and the load 17. Use of a potentiometer facilitates balancing of the circuit to insure likeness of successive saw-teeth.

In Fig. 3 there is shown a modification eliminating the potentiometer 11. In this arrangement anodes 3 and 4 are connected to the ends of resistors 18 and 19 respectively, and the common



connection between the resistors is connected to the positive terminal of source 9 through resistor 10.

To illustrate suitable parameters for the practice of our invention, referring to Fig. 3, satisfactory results have been obtained using type CK509AX discharge devices, resistances 13 and 14 of one megohm each, resistances 18 and 19 of 0.47 megohm each, resistance 10 of 0.1 megohm and capacitors 15 and 16 of 0.3 microfarad each.

The frequency of the generated wave is controlled by adjusting the control-electrode potentials by means of resistance 12. The minimum frequency while maintaining linearity is determined by the time during which the anode potential rises linearly.

While we have shown and described a particular embodiment of our invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from our invention in its broader aspects. For example, heater tubes may be substituted for filament devices 1 and 2. We, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim is:

1. A saw-tooth wave generator including a multivibrator comprising a pair of electron discharge devices each having a cathode, an anode and a control electrode, a connection joining said cathodes, continuously conductive means for biasing said control electrodes, cross-couplings between the anode of one of said devices and the control electrode of the other of said devices and between the control electrode of said one device and the anode of said other device, tapped resistance means connected between said anodes, a source of potential and a resistance element connected in series between said connected cathodes and the tap on said resistance means, and a load element connected across a portion of said resistance element, said cross-couplings and resistance means being chosen to provide a time constant sufficiently great to cause the anode potential of each discharge device to rise substantially linearly throughout its own non-conducting periods.

2. A saw-tooth wave generator including a multivibrator comprising a pair of electron discharge devices each having a cathode, an anode and a control electrode, a connection joining said cathodes, continuously conductive means for biasing said control electrodes comprising resistive elements connected to a source of positive potential, the negative terminal of said source being connected to said connected cathodes, cross-couplings between the anode of one of said devices and the control electrode of the other of said devices and between the control electrode of said one device and the anode of said other device, tapped resistance means connected between said anodes, a resistance element connected in series between said source of positive potential and the tap on said resistance means, and a load element connected across a portion of said resistance element, said cross-couplings and resistance means being chosen to provide a time constant sufficiently great to cause the anode potential of each discharge device to rise substantially linearly throughout its own non-conducting periods.

3. A saw-tooth wave generator including a multivibrator comprising a pair of electron discharge devices each having a cathode, an anode and a control electrode, a connection joining said

cathodes, continuously conductive means for biasing said control electrodes, cross-couplings between the anode of one of said devices and the control electrode of the other of said devices and between the control electrode of said one device and the anode of said other device, tapped resistance means connected between said anodes, a source of direct-current potential and a resistance element connected in series between said connected cathodes and the tap on said resistance means, the negative terminal of said source being connected to said connected cathodes, and a load element connected across a portion of said resistance element, said cross-couplings and resistance means being chosen to provide a time constant sufficiently great to cause the anode potential of each discharge device to rise substantially linearly throughout its own non-conducting periods.

4. A saw-tooth wave generator including a multivibrator comprising a pair of electron discharge devices each having a cathode, an anode and a control electrode, a connection joining said cathodes, individual resistive means for biasing each of said control electrodes, cross-couplings between the anode of one of said devices and the control electrode of the other of said devices and between the control electrode of said one device and the anode of said other device, tapped resistance means connected between said anodes, a source of potential and a resistance element connected in series between said connected cathodes and the tap on said resistance means, and a load element connected across a portion of said resistance element, said cross-couplings and resistance means being chosen to provide a time constant sufficiently great to cause the anode potential of each discharge device to rise substantially linearly throughout its own non-conducting periods.

5. A saw-tooth wave generator including a multivibrator comprising a pair of electron discharge devices, each having a cathode, an anode, and a control electrode, a connection joining said cathodes, cross couplings between the anode of one of said devices and the control electrode of the other of said devices and between the control electrode of said one device and the anode of said other device, each of said cross couplings including a capacitor, a source of anode potential, a connection between the positive terminal of said source of potential and each of said anodes including resistance means common to both anode circuits, and an output circuit connected across a portion of said common resistor, the capacitance of each of said capacitors and the resistance of said resistance means being chosen to provide a time constant sufficiently great to cause the anode potential of each discharge device to rise substantially linearly throughout its own non-conducting periods.

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