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BISTABLE CIRCUITS

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Fig. 1

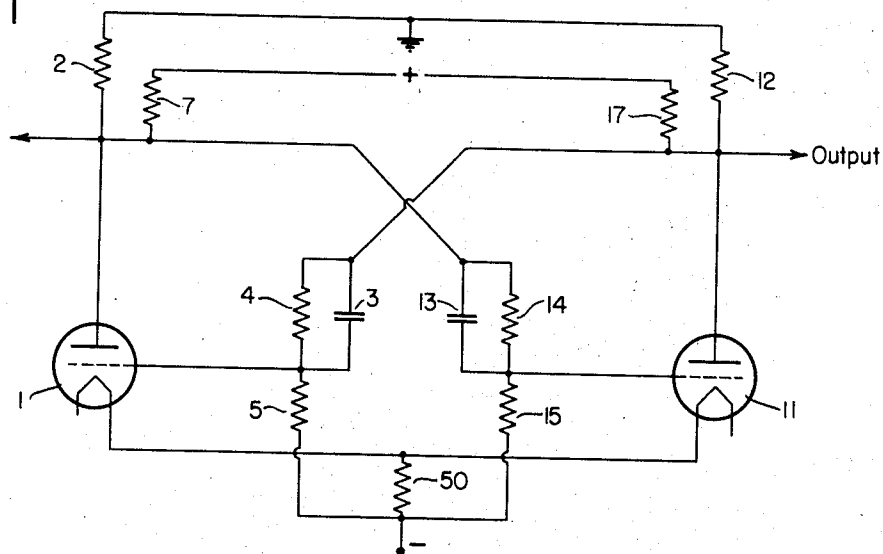
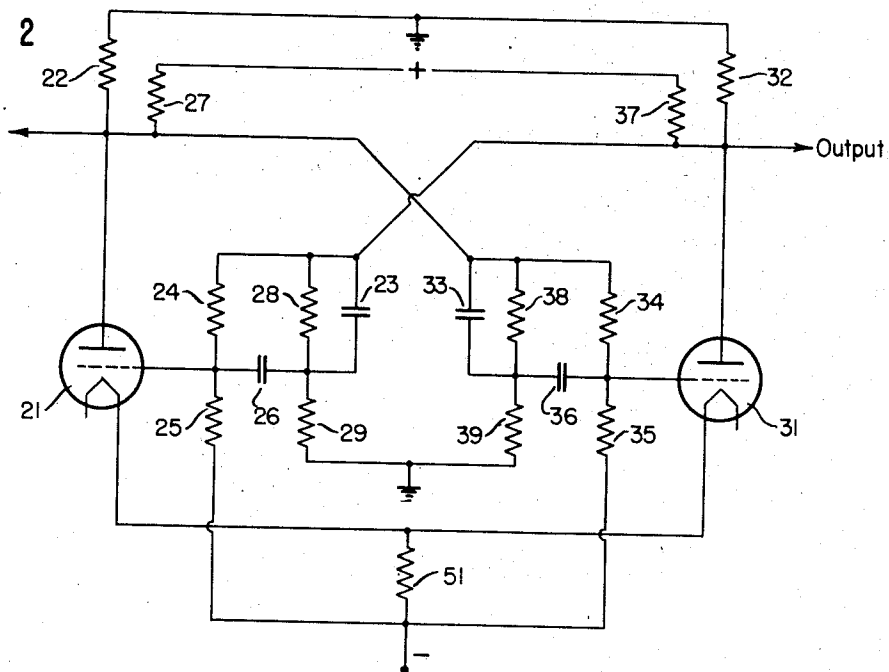


Fig. 2



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BISTABLE CIRCUITS

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3 Claims. (Cl. 250—27)

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This invention concerns an improved bi-stable circuit for use as a multivibrator, trigger, or the like, and in particular a bi-stable circuit which combines a short resolution time with a high degree of output stability and accuracy.

The development of bi-stable circuits has gone through a cycle starting with the simplest well-known designs and progressing first toward designs of increased complexity in order to achieve specific results and then back in more recent years to simplified designs which allowed easier maintenance and longer life. These circuits have become an integral part of many modern pieces of electronic equipment and in particular of computing machines. In many cases these circuits are used to control gate tubes and for this use a number of characteristics are desired. For computer use particularly the resolution time which governs the speed at which the circuit can be operated should be as short as possible. Also it is desirable that the output of the circuit be either at ground or slightly positive during that period when the gate tube is conducting. This is desirable in order that the cathode of the gate tube can be tied to ground.

In order to obtain such an output combined with high speed of operation it has heretofore been common to use additional tubes or crystal diodes, both of which had inherent disadvantages, primarily inaccuracy and relatively short life. In addition they result in the circuit complexities which it is desirable to keep at a minimum. It is also possible to use A. C. coupling but in such a case the operation being performed by the circuit must be halted periodically in order to recharge the coupling capacitor.

It has also been proposed to directly compensate the output through the use of a positive voltage supply, but this method requires a critically adjusted supply voltage of high stability if the circuit is to have a short resolution time.

It is the object of this invention to provide a bi-stable circuit which will allow the use of a relatively uncritically adjusted supply voltage in order to provide direct compensation of the output while at the same time permitting the short resolution time which is desirable in many applications.

It is a further object to provide a simpler means for obtaining short resolution time and accurate control of the circuit output.

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It is a further object to provide a circuit which will have a relatively long life combined with small current consumption.

In the drawings Fig. 1 illustrates one of the simpler basic forms of a bi-stable circuit; Fig. 2 is a diagram of a circuit embodying the present invention.

The traditional circuit (Fig. 1) consists of two triodes 1 and 11, the grid of each triode being coupled to the plate of the other by like networks consisting of equal capacitors 3 and 13 in parallel with equal resistors 4 and 14, respectively. The tube cathodes are coupled to a negative supply through a resistor 50 and the plates are coupled to ground through two equal resistors 2 and 12. The grid voltage of each tube is controlled by a voltage dividing network which for tube 1 consists of two resistors, one being the resistor 4 and the other a resistor 5 leading from the grid to the negative supply. A duplicate voltage divider for the other tube is provided by the resistors 14 and 15.

The fundamental requirement basic to all bi-stable circuits is that when one of the two tubes is conducting, the other be cut off and that when a trigger pulse is fed to each tube, the circuit reverses and the tube which was conducting cuts off. The output can be taken from a number of points on the circuit, but in this instance it will be assumed that the output is taken from the plate of each tube. Frequently, this output will be used to operate a gate tube. A positive voltage supply to directly compensate or control the output is shown connecting through resistors 7 and 17 with the plates of the tubes, as will be described later.

Since the plate of each triode is coupled to the grid of the other, if tube 1 starts to conduct, there will be an increase of plate current in that tube, causing a greater potential drop across the plate load 2 and this will lower the grid potential on tube 11. This in turn decreases the plate current of tube 11 and lowers the potential drop across the associated plate load 12 causing an increase in the grid potential of tube 1 and therefore further increasing the current through that tube. This change continues until tube 1 is conducting fully, tube 11 being cut off and the circuit stable. The plate current of the conducting tube produces a voltage drop across its plate load and across resistor 50 the common cathode re-

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sistor, the values of these resistors being selected so that the cathode potential of both tubes is above the grid potential of the cut-off tube when the conducting tube is fully on.

It is the function of this type of bi-stable circuit to reverse its state whenever the circuit receives an input pulse. The circuit may be designed for either positive or negative pulses; in either case both tubes are cut off and the previously non-conducting tube then commences conducting. Since the use of a negative pulse in the grids of both tubes would require minor additions in circuitry it will be assumed for purposes of illustration that the circuit is triggered by a pulse raising the voltage of both cathodes. If we assume that tube 11 is conducting it will immediately be cut off and its plate voltage will begin to rise. Since this plate is coupled to the grid of tube 1 this rise will be coupled over and the grid of tube 1 will rise until conduction begins. The plate of tube 1 and the associated grid of tube 11 will have remained relatively unchanged until conduction begins; however, once conduction begins the plate of tube 1 will drop suddenly and will carry the grid of tube 11 along with it, thus effectively insuring that tube 11 will stay off after the pulse passes. It should be noted, however, that while the plate of tube 1 swings only slightly below its conducting equilibrium voltage, it drags the grid of tube 11 well below its equilibrium voltage. This potential must regain its stable non-conducting voltage before the circuit can be triggered again, and the time required is governed by the resolution (discharge) time of condenser 13. This, in turn, depends on the size of the components in the voltage dividing network, and in particular in the size of resistor 14. The larger these resistors in relation to the condenser, the longer the time before the circuit can be triggered again.

The basic limitation on the speed of the circuit comes from the following facts:

The size of the condensers 3 and 13 must be several times the tube input capacitance in order that most of the transient voltage be coupled to the grid. The reason for this requirement may be easily seen if it is remembered that in changing from one steady state to the other both tubes are cut off and it is necessary to over-compensate the circuit in order that the tube which had formerly been conducting will remain off until the other tube starts to conduct. In order to obtain a relatively short resolution time the discharge time for condensers 3 and 13 should be as short as possible. This in turn is governed by the size of the voltage dividing networks 4 and 5 and 14 and 15, the resistances of which should be kept as small as possible in order to obtain fast operation.

However, this will result in a large current consumption for the circuit and will result in an unstable positive output voltage. It is desirable that the output voltage be stable, easily controlled, and either be absolutely ground, or perhaps slightly positive during any period when its output is allowing transmission through a gate tube.

If positive compensation is applied through resistors 7 and 17 in the circuit in Fig. 1, where 4, 5 and 14, 15 represent low impedance dividers, such a voltage must be critically adjusted and very stable. If this problem is met by greatly increasing the values of the resistors of the voltage dividing networks, a very long resolution time for the circuit will result.

The present invention, as shown schematically in Fig. 2, allows both a short resolution time and precise voltage correction. To accomplish this result this invention contemplates the use of double voltage dividing networks. Many of the components are in general similar to those of Fig. 1 and are similarly numbered as to the last digit. The left-hand network comprises the resistors 24 and 25, which constitute a high impedance divider, the midpoint of which leads to the grid of the tube 21, together with a low impedance divider comprising resistors 28 and 29. Resistor 28 is connected with resistor 24 to the plate of tube 31 and resistor 29 leads to ground. The mid-points of the dividers are connected by a large condenser 26 one hundred times the size of capacitor 23. The condenser 23 which corresponds in function and size to the condenser 3 in Fig. 1 is connected in parallel with resistor 28. The right-hand coupling and dividing network is identical and consists of elements 31 through 39. Like elements carry the same last digit.

Operation of the left hand half of the circuit consisting of elements 21 through 29 may be described as follows. During the transient period capacitor 26 acts as a short circuit and effectively couples together the midpoints of the two voltage dividers. In this way the time constant (i. e. recovery time) of 23 is dominated by the low impedance divider 28 and 29 and is thus relatively short. As has been pointed out, however, the high impedance divider makes it much easier to compensate the output. This becomes apparent if it is noted that the compensation is needed only when the output is approximately at ground. Since the resistances of resistors 24 and 25 may be large, the current through them will be small and the resistors 27 and 37 may be of high resistance. The possibility of using high resistances for 27 and 37 in turn means that the voltage correction may be proportionately less critically adjusted. In addition the whole circuit combines high speed operation with low current consumption. The corresponding elements in the other half of the circuit perform in the same manner as described above.

While it is not essential to this invention, it has been found that optimum performance is obtained when the components 24, 25, 28 and 29 (and their counterparts 34, 35, 38, 39) have resistances in the proportion

$$\frac{R_{24}}{R_{25}} = \frac{R_{28}}{R_{29}}$$

This results from the fact that each divider controls the grid voltage for certain periods, and the above proportionality tends to minimize different transient effects at different duty cycles.

The above description of the operation of this circuit is, of course, somewhat simplified. For example, the time constants for condensers 23 and 33 are dependent on the discharge time for those condensers which depend not only on the value of resistors 28 and 38, respectively, but also on the other circuit elements.

Having thus described my invention, I claim:

1. A bi-stable circuit comprising two tubes each having a grid and a plate, a network connecting the plate of each tube with the grid of the other, each network including a high-impedance element effective under stable conditions and a low-impedance element to provide a short resolution time, and high-capacitance coupling means between said elements

2. A bi-stable circuit comprising two tubes each having a grid and a plate, a network con-

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necting the plate of each tube with the grid of the other, each network comprising a capacitor, a high-impedance voltage divider and a low-impedance voltage divider, whereby the low-impedance divider provides a discharge circuit of short resolution time for the capacitor, and a high-capacitance coupling for the junctions of the dividers.

3. A bi-stable circuit comprising two tubes each having a grid and a plate, a network connecting the plate of each tube with the grid of the other,

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each network comprising a capacitor, a high-impedance voltage divider and a low-impedance voltage divider, whereby the low-impedance divider provides a discharge circuit of short resolution time for the capacitor, the dividers having impedances in substantially equal ratios, and a high-capacitance coupling for the junctions of the dividers.

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No references cited.