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TRANSFORMER COUPLED FLIP-FLOP

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FIG.1

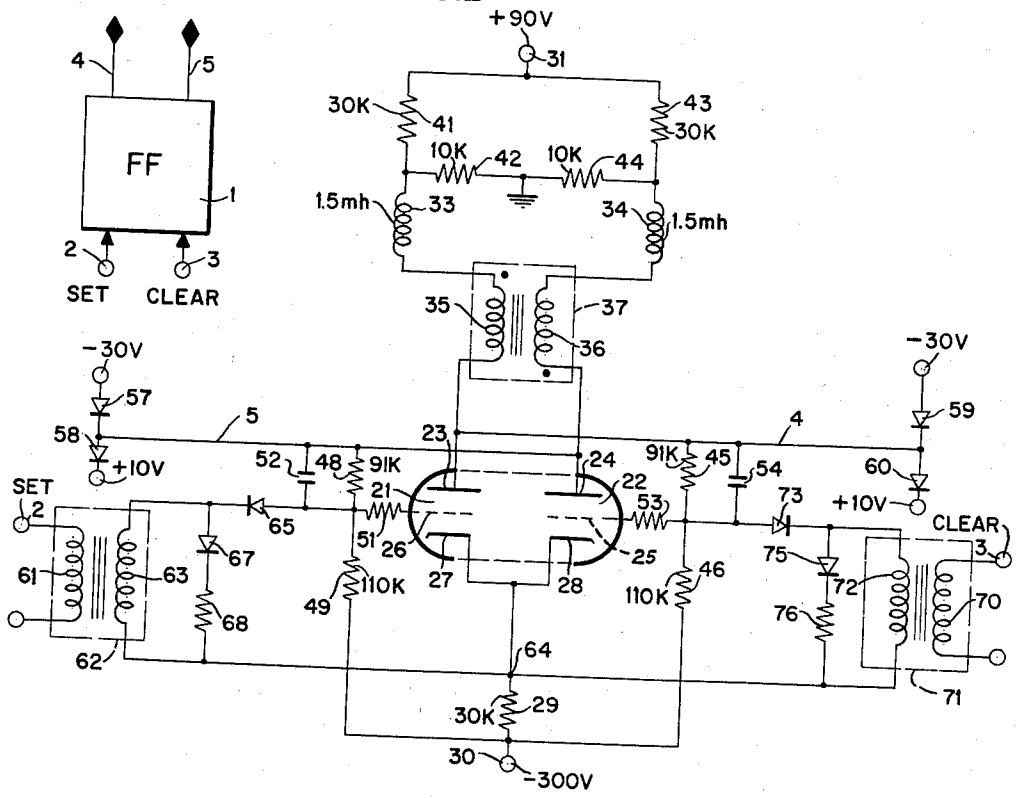
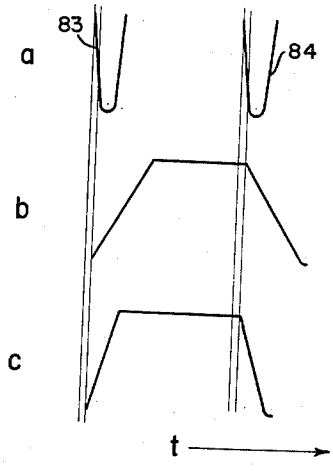


FIG.2



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TRANSFORMER COUPLED FLIP-FLOP

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3 Claims. (Cl. 328—196)

The present invention relates to an electronic circuit and more particularly to an electronic circuit of the flip-flop or trigger type.

An object of the present invention is to provide an improved electronic switching circuit of the dual tube type including transformer coupling between the anodes of the respective tubes.

Another object of the present invention is to provide an improved trigger circuit adapted to decrease the transition time from one stable state to the other and thereby decrease the rise or fall time of the output waveform during each transition.

A further object of the present invention is to provide an improved flip-flop circuit wherein the transformer coupling between the anodes of the trigger tubes aids transition by maintaining the formerly conducting tube in a cutoff condition until completion of transition.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a schematic diagram of a preferred embodiment of the present invention.

Fig. 2 illustrates a family of waveforms identifying the negative signal appearing at the secondary of the input transformer and the waveform of the output signal with and without transformer coupling.

Referring now to the drawings and more particularly to Fig. 1 thereof, there is illustrated in block and schematic form a preferred embodiment of the present invention. As is well known in the art, a flip-flop is a bi-stable switching device which operates so that it is always in one of two stable conditions, the switching from one stable condition to the other being generally accomplished by the application of a short duration pulse applied to the input or inputs of the flip-flop circuit.

As shown in block form in Fig. 1, the subject flip-flop 1 has two inputs and a corresponding number of outputs. A positive pulse applied to the Set input terminal 2 produces a positive D.C. level at the left output labeled conductor 4, and a negative D.C. level at the right output labeled conductor 5; a positive pulse applied to the Clear input terminal 3 produces a negative D.C. level output on conductor 4 and a positive D.C. level on conductor 5. In the ensuing description, the above described former and latter conditions are referred to as the On and Off condition respectively.

Referring now to the schematic diagram of Fig. 1, flip-flop 1 is a symmetrical circuit comprising two substantially indentical circuits, each of these circuits including a trigger tube and associated circuitry. With respect to the ensuing description, it is assumed that the flip-flop circuit is initially in the Off condition, i.e., trigger tubes 21 and 22, which may be the respective halves of a Z-2177 twin triode, for example, are in the conducting and non-conducting states respectively. Anodes 23 and 24 are cross coupled to control grids 25 and 26, while cathodes 27 and 28 are connected through a common resistor 29 to a source of negative potential at terminal 30. Resistor 29 provides cathode degeneration for trigger tubes 21 and 22. Operating D.C. potential is supplied from terminal 31 to anodes 23 and 24 through peaking coils 33 and 34 and transformer windings 35 and 36 respectively. Peaking coils 33 and 34 are tapped from voltage divider networks comprising resistors 41, 42 and 43, 44, each of such networks being serially connected between a source of +90 volts potential and ground.

A further voltage divider network constituting part of the load circuit for anode 23 includes resistors 45 and 46 serially connected between anode 23 and a source of —300 volts potential at terminal 30. An identical network comprising resistors 48, 49, and connected between anode 24 and terminal 30, functions as part of the load circuit for anode 24. Control potential for grid 26 of trigger tube 21 is obtained from the junction of resistors 48 and 49 through parasitic suppressor 51. Capacitor 52, connected across coupling resistor 48, serves as a compensating capacitor and also functions to decrease the transition time required to switch from one conduction state to the other by ensuring that the signal coupled from anode 24 of trigger tube 22 to control grid 26 of trigger tube 21 during a transition of state is applied with sufficient amplitude and proper shape to ensure transition. Since the capacitance of condenser 52 is appreciably higher than the capacitance of trigger tube 21, control grid 26 of trigger tube 21 is forced to respond more rapidly to the change in anode potential of trigger tube 22. Thus any change of potential on anode 24 of trigger tube 22 results in a nearly instantaneous change in potential on control grid 26. Furthermore, with capacitor 52 shunting resistor 48, substantially the full anode swing appears on control grid 26 since resistor 48 is effectively short circuited for these short period changes. Capacitor 52 also functions as a memory capacitor to insure that trigger tube 21 is rendered conductive whenever tubes 21 and 22 are momentarily rendered non-conductive during the transition from the Off to the On state, i.e., vacuum tube 21 is rendered conductive after previously being non-conductive. Similarly, control voltage for grid 25 of trigger tube 22 is obtained from the junction of resistors 45 and 46 through parasitic suppressor 53, while capacitor 54, connected across coupling resistor 45, serves as a compensating and memory capacitor associated with trigger tube 21. Diodes 57, 58 and 59, 60, connected to potential sources of —30 and +10 volts respectively, function to control the lower and upper levels of the output signal, and further define the anode potentials of the conducting and non-conducting trigger tubes respectively.

In order to facilitate an understanding of the present invention, the operation of the subject apparatus will be described in detail with reference to Fig. 1. In the ensuing description, it is again assumed that the flip-flop is initially in the Off condition.

When a positive pulse of 20–40 volts in amplitude is applied to the Set input terminal 2, a negative pulse of 0.1 μsec. is produced in transformer secondary winding 63. When trigger tube 21 is conducting, its grid bias is approximately zero with respect to the cathode, while its cutoff bias is in the order of —8 volts. Since diode 65 is positioned in a loop between grid and cathode, it is similarly biased and therefore is at the threshold of conduction. One end of transformer secondary winding 63 is connected directly to a common terminal 64 of cathodes 27 and 28, while the other end is connected to the cathode of diode 65. The combination of diode 67 and resistor 68 connected across secondary winding 63 is a damping network to prevent transformer 62 from

ringing or oscillating, and further serves to limit positive overshoot voltages which occur on the upper side of secondary winding 63 as a result of the decay of the initiating positive pulse.

The negative pulse produced in the transformer secondary winding 63 causes the cathode of diode 65 to go further negative with respect to its anode, whereupon diode 65 conducts and the negative signal passes through parasitic suppressor 51 to control grid 26 of trigger tube 21. Substantially the full negative pulse is passed by diode 65, provided that the potential on its anode is zero or positive relative to the potential on its cathode. The applied pulse as heretofore described is of sufficient amplitude to cause trigger tube 21 to cut off, which in turn causes trigger tube 22 to conduct in a manner described subsequently, thereby reversing the state of the flip-flop circuit from the Off to the On condition.

During transition, as the potential on control grid 26 drops below a particular level, trigger tube 21 is cut off, anode current decreases and anode potential rises toward a level of +10 volts. This transition of anode potential of trigger tube 21 is coupled to control grid 25 of trigger tube 22 through resistor 45 and capacitor 54, thereby raising the grid bias of trigger tube 22 to the conduction level, whereupon trigger tube 22 conducts and the potential on anode 24 drops toward a level of −30 volts. The change in anode current through winding 35 of transformer 37, arising from the positive variation in potential on anode 23, results in a negative potential being coupled to winding 36 of transformer 37. This negative potential is applied directly to anode 24 of trigger tube 22, thereby enabling the anode to reach a stable level of −30 volts more rapidly. The negative potential is also applied through resistor 48 and capacitor 52 to control grid 26 to assist in maintaining trigger tube 21 in the cutoff state during transition. As will be shown and described in greater detail hereinafter, the results arising from the transformer coupling are reflected in the waveform of the output signal on conductor 4 as a substantial decrease in rise time from the −30 to the +10 volt level. When the anode potential on trigger tube 21 reaches the +10 volt level, it is clipped thereat by diode 69. Accordingly, the output signal on conductor 4 is at a level of +10 volts. The anode potential of trigger tube 22 and the corresponding output level on conductor 5 is maintained at a level of −30 volts by clipping diode 57 during the On condition of the flip-flop.

During the On condition of the flip-flop, trigger tube 21 is non-conducting and its grid potential is considerably below cutoff. Control grid 26 is biased at approximately −22 volts with respect to the cathode, and a negative pulse, whether passed by diode 65 or not, does not affect the non-conducting state of this vacuum tube. Thus positive pulses applied to Set input terminal 2 during the On condition of the flip-flop have no effect.

The above described operation illustrates the transition of flip-flop 1 from the Off to the On condition. The transition from the On to the Off condition is accomplished in like manner.

A positive pulse applied to the Clear input terminal 3 results in a negative pulse being induced in secondary winding 72. The pulse passes through diode 73 and parasitic suppressor 53 to control grid 25 of trigger tube 22. As trigger tube 22 is cut off, the corresponding anode current decreases as the potential on anode 24 rises. This change of current is coupled through transformer winding 36 and appears on winding 35 as a negative potential. This negative potential when applied through resistor 45 and capacitor 54 to control grid 25 assists in maintaining trigger tube cut off during transition. The negative potential is also applied directly to anode 23 of trigger tube 21, enabling it to fall to a stable level of −30 volts more rapidly. This operation is reflected in output conductor 4 as a drop in fall time from the +10 to −30 volt level. It is noted that rise and fall times on output conductor 4 correspond to fall and rise times respectively on output conductor 5. Diode 75 and resistor 76 across transformer winding 72 serve to limit positive overshoot voltages which occur on the upper side of secondary winding 72 of transformer 71 as the result of the decay of the positive pulse applied through Clear input terminal 3 to transformer primary winding 70. Upon completion of the transition from the On to the Off condition, output conductors 4 and 5 have potentials of −30 and +10 volts thereupon respectively.

From the above description it is apparent that two pulses are required to cause the circuit to complete its cycle, i.e., for each tube to pass from the non-conducting to the conducting state and vice versa. With each pulse applied to the circuit to reverse its conduction state, two D.C. level signals are generated, the D.C. level of the tube being triggered being +10 volts and the D.C. level of the opposite tube being −30 volts.

Summarizing the operation of the subject apparatus, to reverse the state of the flip-flop, a positive trigger pulse produces a negative 0.1 μsec. pulse in the transformer secondary winding and this negative pulse causes cutoff of the conducting tube. This produces a sudden decrease in the anode current and a corresponding rise in the anode potential of the associated trigger tube. The rise of anode potential is applied through a coupling network to reverse the conduction state of the formerly non-conducting tube to conduction. The variation in anode current flow through a first winding of a 1:1 transformer produces a negative potential in the second winding of the transformer. This negative potential is applied directly to the anode of the formerly non-conducting tube to assist the anode in reaching its negative stable level more rapidly, and is applied through a coupling network to the control grid of the cutoff tube to maintain cutoff during transition. Clipping circuits ensure uniformity of the D.C. levels of the output signal.

Referring now to Fig. 2, curve "*a*" illustrates the negative pulses which initiate transition by terminating conduction of the normally conducting tube, while curves "*b*" and "*c*" thereof illustrate the waveform of the output signal of the preferred embodiment with and without transformer coupling. It is to be understood that the waveforms of Figures 2*a* through 2*c* do not represent actual quantitative values but represent in a general way the qualitative variations of the voltages with time. While it is recognized that some distortion is present in the illustrated waveforms, such distortion is not important to an understanding of the present invention and accordingly has been omitted from the idealized waveforms of Fig. 2.

Curve "*b*" illustrates the general waveform of the output signal of the circuit of Fig. 1 without transformer coupling at the anodes. As heretofore described, the output signal has fixed lower and upper levels provided by clipping circuits of −30 and +10 volts respectively. The output signal begins to rise from the −30 volts signal level shortly after the time when the negative pulse 83 begins to drop in the negative direction. The duration of the output signal is determined by the time between trigger pulses. The waveform begins to fall shortly after pulse 84 begins to fall. It should be noted that the slope of pulses 83 and 84 is such that the pulses have a steep leading edge and are 0.1 μsec. in duration. The rise time of the waveform illustrated by curve "*b*" is the time required for the anode of the cutoff trigger tube to travel from its original level of −30 volts to a +10 volt level, while the fall time is the time required for the same anode to revert from the +10 volt level to its original level of −30 volts.

Curve "*c*" of Fig. 2 illustrates the waveform of the output signal of the preferred embodiment under the identical conditions described with reference to curve "*b*" except that transformer coupling is provided between the anodes of the trigger tubes. Curves "*b*" and "*c*" are

plotted on the same time base in order to illustrate the substantial reduction in rise and fall time accomplished by the preferred embodiment.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A trigger circuit including first and second electron tubes having at least an anode, cathode and control grid, said tubes being adapted to be alternately rendered conductive to represent one or the other of two stable conditions means coupling the anode of said first tube to the control grid of the second and the anode of said second tube to the control grid of the first to permit transition from one to the other stable condition, a transformer interconnected between each of said control grids and an input circuit for reversing the polarity of each input signal applied thereto, a further transformer having a primary and secondary winding connected respectively to the anodes of said first and second tubes, said further transformer functioning to deliver the voltage change resulting from termination of conduction in the conductive one of said tubes to the anode of the non-conductive tube and thereby enable the anode of the non-conductive tube to more rapidly attain the potential level compatible with the other of said stable conditions, and output means connected to each of said anodes.

2. An electronic switching circuit comprising in combination first and second trigger tubes having opposite conduction states representing two stable conditions, means cross-coupling the anode of each trigger tube to the control grid of the other whereby one of said trigger tubes is conducting and the other of said trigger tubes is non-conducting, said anodes being further connected

to clipping means for providing stable potential levels determined by the conduction state of the associated trigger tube, an input circuit associated with each of said trigger tubes and adapted to reverse the potential of a signal applied thereto, a transformer having a primary winding connected to the anode of said first tube and a secondary winding connected to the anode of said second tube and means for applying a signal to the input circuit associated with said conducting tube to terminate conduction thereof, said transformer responding to the resulting decrease in current flow in said conducting trigger tube to cause a negative potential to be established on the anode of said non-conducting trigger tube more rapidly whereby the transition speed of said electronic switching circuit is substantially increased.

3. A bistable multivibrator circuit for generating output signals having a frequency corresponding to the repetition rate of pulse signals applied thereto comprising in combination first and second vacuum tubes having at least an anode, a cathode and a control grid respectively, means cross coupling the anode of each vacuum tube to the control grid of the other, input means connected to each of said control grids for applying said pulse signals thereto to initiate transition of said multivibrator circuit and a transformer having a primary and secondary winding connected to the anodes of said first and second vacuum tubes, said transformer being polarized to increase the transition speed of said multivibrator circuit from one bistable state to the other upon application of a pulse signal to the appropriate control grid.

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