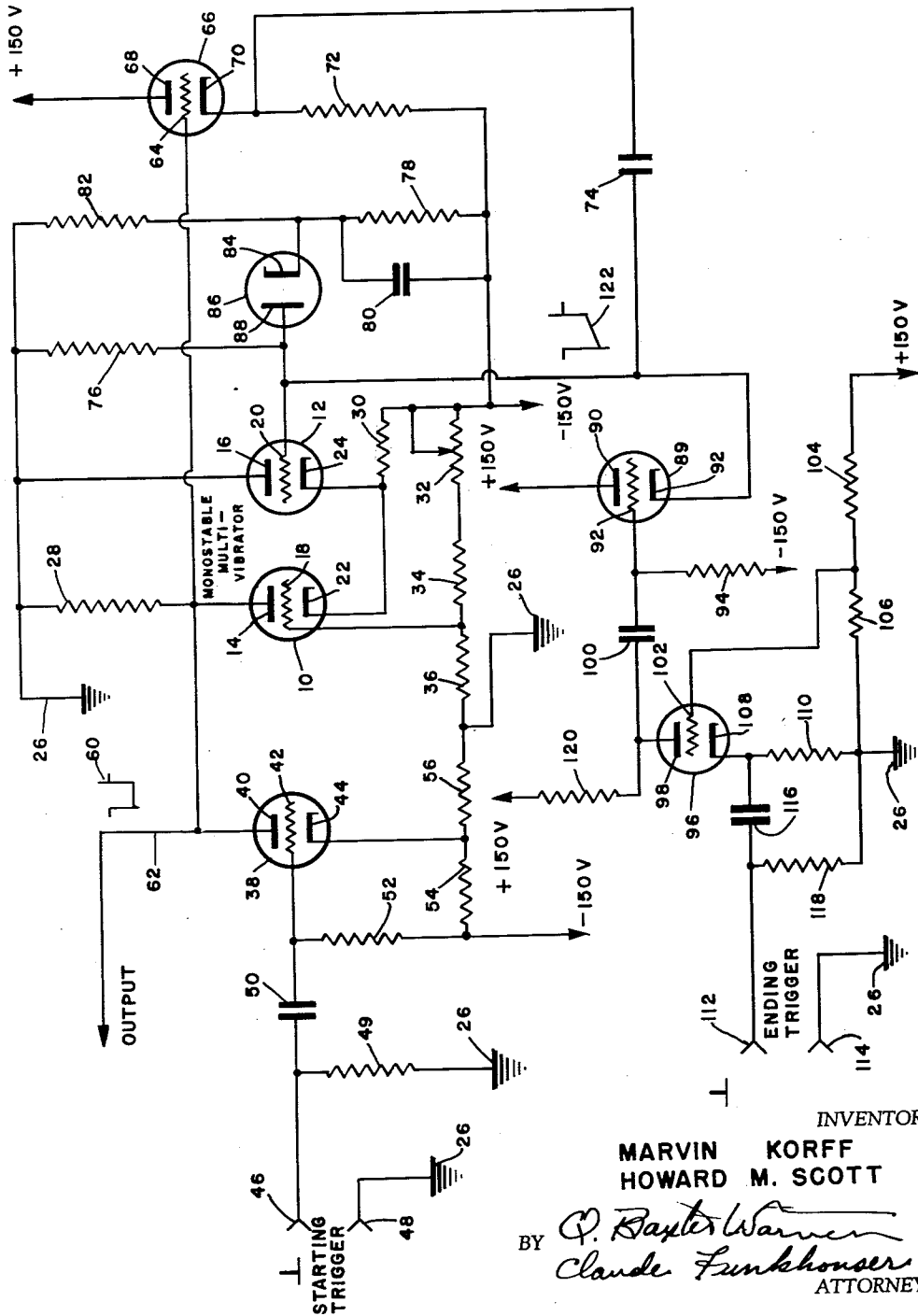


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TIMING MULTIVIBRATOR

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This invention relates to a timing multivibrator and more particularly to circuitry for terminating the output of a monostable multivibrator at a precise instant.

A multivibrator is a circuit generally consisting of a pair of electron tubes cross coupled in such a manner that one of the tubes conducts at a given instant while the other is in a nonconducting condition. Multivibrators may be astable, monostable, or bistable. In the astable circuit the electron tubes of the multivibrator alternate in their conducting and nonconducting states, each producing a free running square wave oscillation. In the bistable circuit, an outside input is required to switch the circuit from one stable conducting state to the other.

In the monostable multivibrator, the circuit is arranged to prefer the conduction of one of its tubes over the other, and if left undisturbed for its period of operation, will always revert to a condition wherein a first tube is conducting and a second tube is nonconducting. Monostable multivibrator circuits are employed to generate a pulse or a gate of a particular length starting with an input pulse which changes the operation of the circuit from its preferred state of operation to its nonpreferred state. Thus, if an output connection is taken from the tube which is normally nonconducting and this tube is made to conduct by application of an input signal or a spike to some electrode thereof, a negative going square wave will appear at its plate, this output always being equal in length to the time it takes for the multivibrator to reassume its preferred state of operation.

In a particular monostable multivibrator the plate of the normally nonconducting tube is coupled by means of an R-C time constant circuit to the grid of the normally conducting tube, while the cathode of the two tubes share a common cathode resistor. If the normally nonconducting tube is forced into operation, a negative surge is coupled through the capacitor of the R-C circuit to the grid of the second tube causing it to be cut off. The second tube will remain cut off only so long as it takes for this capacitor to discharge to the tube's cutoff voltage. When the cutoff voltage is reached, the tube will again return to its normally conducting condition drawing current through the common cathode resistor. The voltage drop through the common cathode resistor will then elevate the cathode of the first tube above its cutoff potential, thereby returning the first tube to its normally nonconducting condition. The length of this cycle and therefore the circuit's output is more or less constant providing component values and operating voltages are held reasonably constant. It is often desired, however, to terminate the cycle of operation in accordance with a second input signal at a precise instant prior to the normal cycle duration and thus regulate or select the length of the output pulse or gate derived from the monostable circuit. Yet, it is very difficult to well define the exact moment at which the output from the monostable multivibrator will be terminated, even

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though the time of the terminating signal is known and this terminating signal ultimately brings about the transition of the multivibrator from its quasi-stable to its normal state. The exact time of transition depends upon such factors as the amplitude and duration of the terminating pulse and may in fact vary so much as to render the circuit useless for an exacting application. For many purposes, however, the output signal from a monostable multivibrator must be accurately and immediately terminated. Such applications are in precision counters used in digital computers and in range gating circuits used in radar PPI displays. Furthermore, the monostable multivibrator circuit has to be made available for immediate recycling, that is for generating a second and additional accurately timed output pulses or gates.

It is accordingly an object of this invention to provide an improved timing circuit producing an output pulse or gate which may be exactly terminated at a selected time.

It is another object of this invention to provide an improved timing circuit employing a monostable multivibrator and apparatus for accurately terminating the quasi-stable state of the multivibrator.

It is another object of this invention to provide an improved timing circuit providing an output pulse of a predetermined length in accurate response to input trigger signals, and which will be available for immediately producing a second output pulse after termination of the first.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein:

FIG. 1 is a schematic diagram of one embodiment of the invention.

In accordance with the invention, a monostable multivibrator circuit is provided with means for triggering its state from a normal quiescent condition to a quasi-stable condition. The multivibrator circuit has a low impedance recovery path for the multivibrator's interstage timing capacitor, said capacitor determining the normal operating period of the multivibrator. The multivibrator circuit is also provided with a cathode follower type device which is normally in a nonconducting or cutoff condition and has its cathode or low impedance terminal connected to the current flow control element or grid of the multivibrator stage which is normally conducting. This cathode follower device is pulsed into conduction by an amplified trigger employed for ending the quasi-stable condition in the multivibrator. The anode element of the cathode follower is returned to a comparatively high voltage so that when the cathode follower conducts, a low impedance path from such high voltage point is established to the afore-mentioned grid or control element in the multivibrator. This conduction path immediately terminates the quasi-stable state of the multivibrator by causing its normally conducting stage to immediately resume conduction, and therefore terminates the circuit's output pulse substantially instantaneously.

According to another feature of the invention a grounded grid amplifier receives the positive pulse-ending trigger. The anode of the grounded-grid stage is coupled by means of a capacitor to a grid of the cathode follower device,

this grid being returned to a source of relatively large negative voltage through an appropriate input resistor.

Referring to the drawing, a monostable multivibrator is composed of electron tubes 10 and 12, each having an anode, a grid and a cathode denoted at 14 and 16, 18 and 20, and at 22 and 24, respectively. Anode 16 is returned to a point of common reference potential or ground 26, while anode 14 is returned to the same point through load resistor 28. Cathodes 22 and 24 share a common feedback circuit consisting of resistor 30 connected to a source of negative operating voltage. In the present circuit tubes 10 and 12 are halves of a type 5670 tube and the source of negative operating voltage used is a minus 150 volts. The operating voltage employed would vary with the electron tube devices selected. A voltage divider comprising variable resistor 32, resistor 34, and resistor 36 are serially connected between the minus 150 volt point and the point of common reference potential 26. The grid 18 of electron tube 10 is returned to the juncture between resistors 36 and 34 of the voltage divider. Variable resistor 32 then functions as a width control to help adjust the normal length of time the multivibrator remains in a quasi-stable state providing no outside ending trigger concludes the quasi-stable operation of the multivibrator.

A trigger amplifier 38 having an anode 40, a grid 42, and a cathode 44 is employed to amplify starting positive trigger pulses applied to terminal 46 with respect to terminal 48. Terminal 48 is returned to ground 26. Terminal 46, shunted to ground by impedance matching resistor 49, is coupled through input capacitor 50 to the grid 42 of amplifier 38. Grid 42 is returned to a source of negative 150 volts or other appropriate negative operating voltage through grid resistor 52. A voltage divider including resistors 54 and 56, in series between the minus 150 volt point and ground, has its mid-point connected to cathode 44 of amplifier tube 38 to provide the proper operating potential thereto. Anode 40 of amplifier 38 is coupled to anode 14 of multivibrator tube 10 for applying the resulting negative going output signal from the anode of amplifier 38 to the multivibrator. The desired accurately timed pulse or gate output 60 is also taken at this point through output lead 62.

Anode 14 of multivibrator tube 10 is coupled to the grid 64 of a coupling cathode follower tube 66 and its anode 68 is returned to a source of positive operating voltage, here a plus 150 volts. The cathode 70 of tube 66 is serially connected to the minus 150 volt point through cathode output resistor 72. Timing capacitor 74, which determines the normal operating period of the multivibrator, is inserted between the cathode 70, and grid 20 of multivibrator tube 12. Grid 20 is also returned to the point of common reference potential 26 through grid resistor 76. A voltage divider composed of the parallel combination of resistor 78 and capacitor 80 in series with resistor 82 is connected between the minus 150 volt point and ground. The mid-point of this voltage divider is selected to provide the proper operating potential for a cathode 84 of diode 86 whose anode 88 is connected to grid 20 of multivibrator tube 12. The voltage divider is adjusted to set cathode 84 at a higher potential than anode 88 during the time that tube 12 is nonconducting; hence, the diode 86 will not conduct during this time. The voltage applied to the cathode 84 is arranged to be low enough to act as a "grid catcher" and provide a conducting path in parallel with the grid cathode circuit of tube 12 when grid 20 is raised to a point above cutoff voltage. Capacitor 80 across resistor 78 is employed as a filtering capacitor to help stabilize the voltage at the mid-point of the voltage divider.

A cathode follower tube 89 has its anode 90 returned to a positive 150 volts, or some other source of relatively high positive voltage, and has its cathode 92 connected to grid 20 of multivibrator tube 12. Grid 92 of the cathode follower tube 89 is returned to a source of relatively high negative voltage designed to insure a cut-off condi-

tion for the cathode follower tube 89 through grid resistor 94. A trigger amplifier tube 96, having a plate 98 coupled by means of capacitor 100 to a grid 92 of cathode follower 89, is employed to amplify positive pulses called ending trigger pulses applied at the exact time it is desired to conclude the output pulse from the monostable multivibrator. The amplifier 96 is connected in a grounded grid fashion to cause positive output pulses to appear at the plate 98. Grid 102 of amplifier 96 is returned to the mid-point of a voltage divider consisting of resistors 104 and 106 in series between the positive 150 volt point and the point of common reference potential. Cathode 108 of amplifier 96 is also returned to ground through cathode resistor 110. The ending trigger is applied to terminal 112 with respect to terminal 114, the latter being returned to ground and the former connected to cathode 108 through coupling capacitor 116. Impedance matching resistor 118 is shunted between terminal 112 and ground. Plate 98 of amplifier 96 is supplied positive operating voltage from a source of a positive 150 volts or any convenient source through plate load resistor 120.

The monostable multivibrator portion of the circuit diagram is conventional and its operation will be set out only in brief. The resistor values in the cathode and anode circuits of multivibrator tubes 10 and 12 are chosen to secure normal conduction of tube 12 and normal non-conduction of tube 10. It is desired to alter or reverse the positions of the two tubes such that tube 10 will conduct for a brief period with tube 12 cut off. The duration of this quasi-stable condition is equal to the duration of the negative-going output pulse 60 secured from anode 14 of tube 10. With a positive starting trigger applied to terminals 46 and 48 (and no ending pulse applied to the circuit), the anode 14 of tube 10 receives a negative going pulse from anode 40 of amplifier tube 38 due to phase inversion in that stage. This negative going pulse is coupled to the input grid 64 of coupling cathode follower tube 66, and hence appears across output resistor 72 of that stage. The negative going pulse is coupled to the grid 20 of tube 12 through timing capacitor 74, whose initial discharge current through resistor 76 produces sufficient drop across the resistor to bring grid 20 below the cutoff point of tube 12, and hence temporarily concludes conduction in tube 12.

Since tubes 12 and 10 share a common cathode resistor, the elimination of current therethrough, caused by tube 12's nonconduction, drops cathode 22 to a low enough value to initiate conduction in tube 10. Conduction in tube 10 reinforces the negative voltage originally applied to the plate 14 thereof and an exchange in conductive states between tubes 10 and 12 takes place in a regenerative manner well known in the art. The undisturbed or normal period of time that the circuit will maintain itself in this quasi-stable state, with tube 10 conducting and tube 12 cut off, is determined by how long grid 20 is maintained below cutoff voltage. Since it was originally driven beyond cutoff voltage by the discharge current through capacitor 74, tube 12 will remain in a cutoff condition only so long as the charge current through capacitor 74 causes a sufficient voltage drop across resistor 76 to maintain grid 20 below cutoff. As the capacitor 74 continues to discharge, its current decreases until grid 20 rises to cutoff voltage. At this point tube 12 resumes conduction. A voltage drop through cathode resistor 30 occurs on account of tube 12's plate current which in turn raises cathode 22 of tube 10 above its cutoff voltage with reference to grid 18. The negative going output pulse derived at anode 14 of tube 10 is thus necessarily concluded as tube 10 ceases conduction. The longest output pulse has been generated which the circuit is ordinarily capable of generating.

Before a second output pulse can now be generated by a trigger at terminal 46, the circuit must recover its original quiescent condition. Capacitor 74 must return to its original charged voltage, which is essentially equal

to the voltage difference between anode 14 of tube 10 and grid 20 of tube 12. Cathode follower 66 is employed as a low impedance source of current for coupling capacitor 74 so that capacitor 74 will not have to charge through resistor 28, as would be the case in a normal multivibrator circuit without a cathode follower coupler, and delay its charge time. Practically all the current flowing through the cathode follower from the positive 150 volt point on plate 68 to the common ground point 26 is available for recharging the capacitor 74. Furthermore, the diode 86 is conducting at this time due to the choice of cathode voltage previously made, and therefore the capacitor 74 will quickly recharge through this anode cathode circuit of tube 86 and resistor 82 rather than slowly through the high resistor 76. Diode 86 also maintains the quiescent level of grid 20 to help in maintaining the normal timing of the multivibrator. The addition of cathode follower 66 and diode 86 to the multivibrator allows the circuit to rapidly recover its quiescent voltage levels and the circuit is therefore ready for relatively immediate application of a second starting trigger thereto.

An ending trigger for bringing the output signal on lead 62 to an accurate end prior to the grid reaching cutoff voltage, is applied between terminals 112 and 114 and is amplified in grounded-grid stage 96. This ending trigger is positive and since the grounded grid configuration is used, a positive signal will appear at anode 98 for coupling through capacitor 100 to grid 92 of tube 89. Tube 89 has its cathode 92 directly connected to the grid 20 of multivibrator tube 12, but is normally maintained in a cutoff condition by a relatively high negative source applied to grid 92 through grid resistor 94. The ending trigger, received at grid 92, is sufficient to drive grid 92 above cutoff since the trigger is amplified by tube 96. When tube 89 is driven above cutoff, positive voltage is applied to grid 20 forcing tube 12 into immediate conduction, thereby accurately terminating the output pulse of the multivibrator.

The present invention is applicable whenever a gate pulse must be terminated at a critical time, and the circuit made available for immediate recycling. The point of reset can be determined with considerable accuracy as the circuit will operate on ending trigger pulses of less than half a microsecond in width. Should no ending trigger occur, the circuit will operate as a normal monostable multivibrator generating a gate determined by the R-C time constant in the grid circuit of tube 12.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A timing circuit comprising: a mono-stable multivibrator type device including first and second translating means each with a current flow path and a current flow regulating element, and a time constant circuit coupled from the current flow path of the first translating means to the current regulating element of the second translating device, a point of reference potential, impedance means returning the current regulating element of said second translating device to said point of common reference potential; a cathode follower type translating device having as its load the current regulating element circuit of said second translating device, said cathode follower translating device being normally in a cutoff condition; and means for causing said cathode follower device to conduct thereby to cause conduction of said second translating device substantially instantaneously therewith.

2. A timing circuit comprising a mono-stable multivibrator having, a first electron tube having an anode, a cathode and a grid, a second electron tube having an anode, a cathode and a grid, a point of common reference potential, a resistor between said point of common ref-

erence potential and the anode of said first tube, a first cathode follower tube having its grid driven by the plate of said first tube, a source of voltage negative with respect to said point of common reference potential, a cathode follower load resistor between the cathode of said first cathode follower tube and said source of negative voltage, a timing capacitor between the cathode of said first cathode follower and the grid of said second tube, a resistor returning the grid of said second tube to said point of common reference potential, a voltage divider between said point of common reference potential and said source of negative voltage, a positively poled diode between the grid of said second tube and a point on said voltage divider, a source of positive voltage, a second cathode follower tube having as its load the grid circuit of said second tube and having its anode connected to a source of positive voltage, means for biasing said second cathode follower tube to cut off, and means for supplying an input to said second cathode follower to cause it to conduct.

3. The apparatus as recited in claim 2, wherein said means for causing said second cathode follower tube to conduct includes a grounded-grid amplifier having a cathode, an anode and a grid, a point of positive voltage, a point of common reference potential, a point of negative voltage, a load resistor connected between said point of positive voltage and the anode of said grounded-grid amplifier, a capacitor connected to the cathode of said grounded-grid amplifier for supplying a positive trigger thereto, a cathode resistor between the cathode of said grounded-grid amplifier and the point of common reference potential, a voltage divider means between said point of positive voltage and said point of common reference potential for supplying voltage to the grid of said grounded-grid amplifier, and including a coupling capacitor between the anode of said grounded-grid amplifier and the grid of said second cathode follower tube, and wherein said means for normally biasing said second cathode follower to cut off comprises a grid resistor connected between the grid of said second cathode follower and the point of negative voltage.

4. A timing circuit comprising, a mono-stable multivibrator including a first and second electron tube, a point of predetermined potential, a source of voltage positive with respect to said point of predetermined potential, a trigger amplifier having its output coupled to said multivibrator for initiating conduction in said first electron tube and discontinuing conduction in said second electron tube, a timing circuit between the plate of said first electron tube and the grid of said second electron tube including at least a capacitor coupled from the plate of said first electron tube to the grid of said second electron tube and a resistor between said grid and the point of predetermined potential, a cathode follower tube having its plate connected to said source of voltage and having as its load the grid circuit of said second tube, biasing means for maintaining said cathode follower tube in a normal nonconducting condition, and means coupled to the grid of said cathode follower tube for causing it to conduct.

5. In combination with a mono-stable multivibrator circuit comprising a first electron tube having an anode, a cathode and a grid, a second electron tube having an anode, cathode and a grid, common coupling between said cathodes, a source of reference potential, and a time constant circuit between the anode of said first electron tube and the grid of said second electron tube, said time constant circuit including at least a capacitor and a resistance returned to the source of reference potential: a cathode follower electron tube having as its load the grid circuit of said second tube, said cathode follower electron tube normally being maintained in a cut off condition; and means for securing conduction in said cathode follower tube including a grounded-grid amplifier, means for application of positive trigger pulses to the

cathode of said grounded-grid amplifier, the plate of said grounded-grid amplifier being coupled for alternating current to the grid of said cathode follower tube, a terminal for connection to a voltage sufficient to cut off said cathode follower tube, and a grid resistor for said cathode follower tube returned to said terminal.

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