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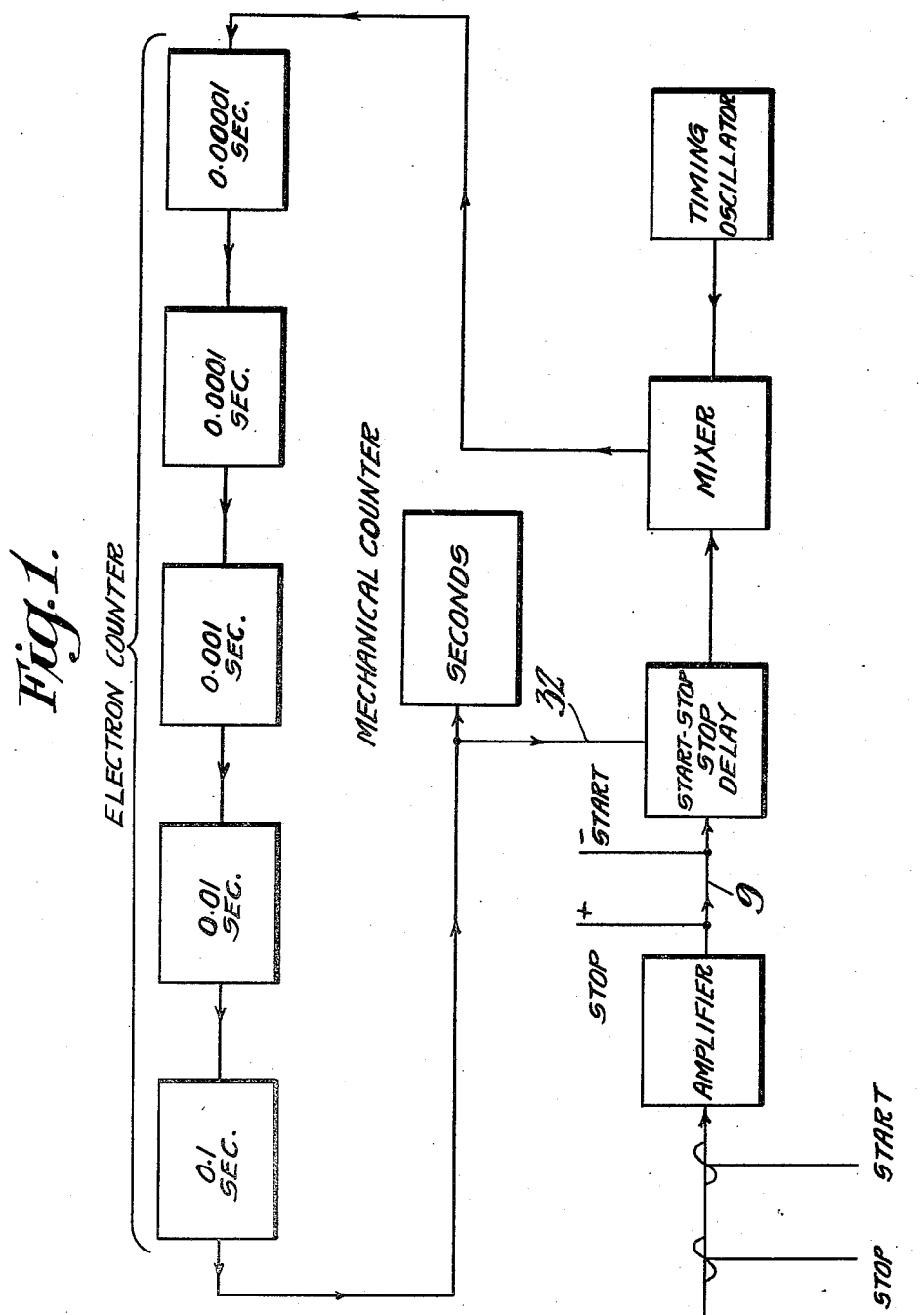
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ELECTRONIC SWITCHING CIRCUITS

Filed Dec. 7, 1943

2 Sheets-Sheet 1



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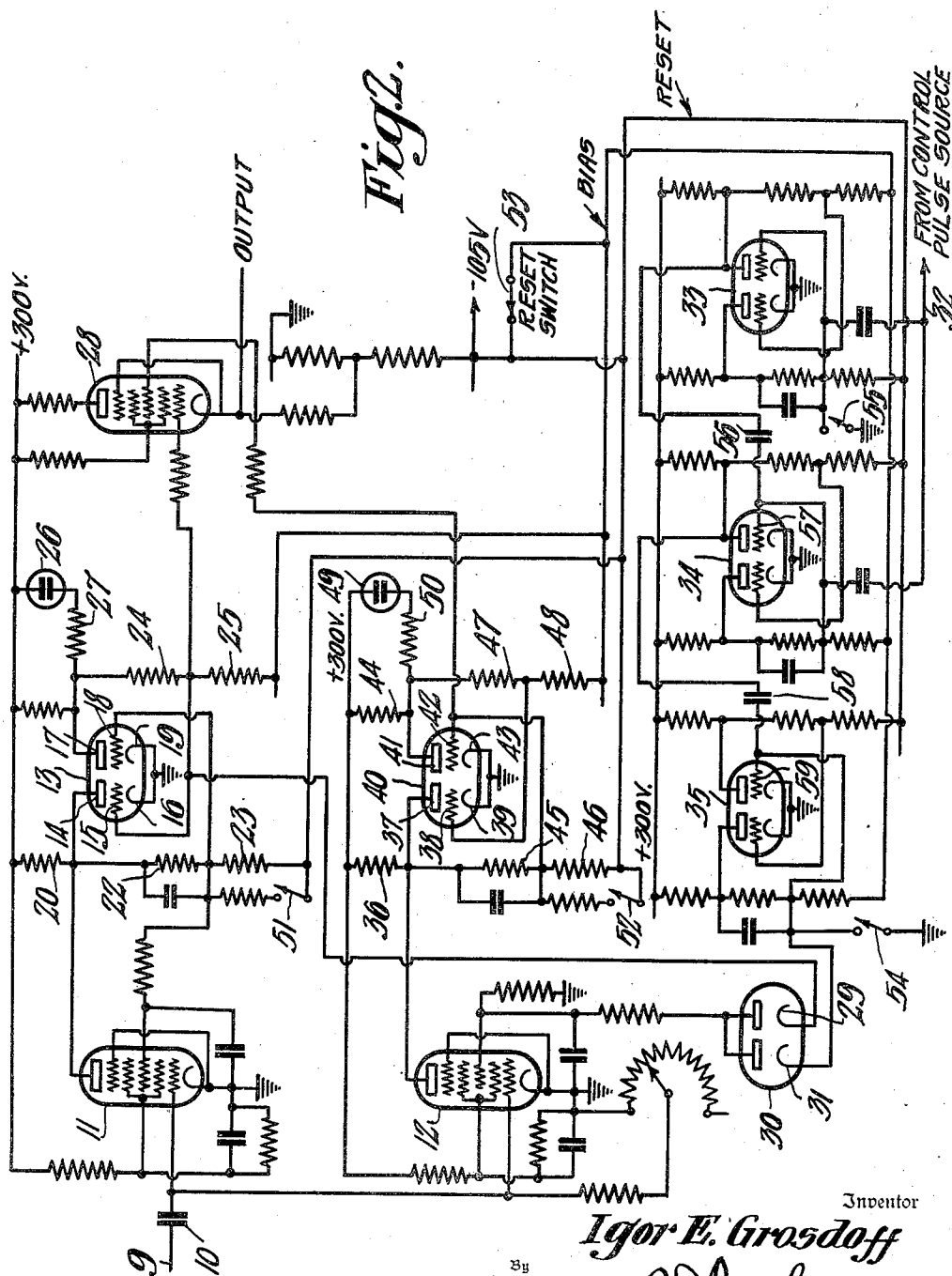
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ELECTRONIC SWITCHING CIRCUITS

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6 Claims. (Cl. 250—27)

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This invention relates to switching circuits such as are suitable for controlling the operation of time measuring apparatus and the like, and has for its principal object the provision of an improved switching circuit and method of operation whereby the controlled apparatus is put into and out of operation in response to signals spaced from one another. A further object is the provision of means for precluding termination of the operation indefinitely or for a predetermined period following its initiation.

In accordance with the invention, start and stop signals are applied in common to the input circuits of start and stop channels, each of which includes an input tube and a multivibrator connected to the output terminals of the input tube. These multivibrators are both so connected to a control tube that this tube functions to initiate the supply of the quantity to be measured in response to the start signal and functions to terminate this supply in response to the stop signal which is spaced from the start signal.

The start and stop channels are so interlocked that the stop channel (1) is blocked until the start signal is transmitted to the control tube and (2) is unblocked by such transmission of the start signal. The channel interlocking means utilized is a duodiode having its anodes connected to a control element of the blocked circuit and one of its cathodes connected to the multivibrator of the start or unblocked channel. The other diode is connected to a delay network which is provided for precluding operation of the stop channel indefinitely or for a predetermined period following the application of the start signal. Suitable means are provided for excluding the effect of this delay network so that the supply of the measured quantity may be terminated immediately in response to the application of a stop signal.

The invention will be better understood from the following description considered in connection with the accompanying drawings, and its scope is indicated by the appended claims.

Referring to the drawings:

Figure 1 is a block diagram illustrating the application of the "start-stop-stop-delay" circuit to a device for measuring small intervals of time in terms of the cycles of a 100-kilocycle source, and

Figure 2 is a wiring diagram of the control circuit of the present invention.

While the present invention concerns only the switching circuit of the time measuring device of Figure 1, it is helpful to have a general understanding of this device as a whole. It is essen-

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tially an electronic stop watch of high precision and is capable of measuring time intervals to one hundred thousandth of a second. Its essential parts and sequence of operation are indicated by the legends and arrow heads of Figure 1. A continuously operating 100-kilocycle quartz crystal serves as the timing element. The oscillations are passed to a mixer from which they are released by the action of the control circuit of the present invention.

A block of these oscillations representing the time interval measured is passed to the five stages of electronic counters. Here the oscillations are registered and the number is indicated by means of neon lamps.

Each stage of the counters represents one fractional decimal place of a second. Hence the capacity of the electron part is 0.99999 of a second in 0.00001 second steps. The whole seconds are counted and indicated on a mechanical counter with four indicating wheels. The total capacity of the counter is 9999.99999 seconds.

In Figure 1, the circuit of Figure 2 is indicated by a box bearing the legend "Start-stop-stop-delay."

This circuit includes a terminal 9 and a capacitor 10 through which start and stop signals are applied to the control grids of a pair of input tubes 11 and 12. The tube 11 constitutes the input of the start channel and the tube 12 the input of the stop channel.

The output circuit of the tube 11 is connected to the left hand side of a multivibrator 13. This multivibrator includes two electron discharge elements 14—15—16 and 17—18—19, anode resistors 20 and 21, and grid resistors 22—23 and 24—25. A neon tube 26 and a resistor 27 are connected in shunt to the resistor 21 for indicating when the multivibrator is in a condition to apply a positive potential to the lower control grid of a control tube 28 which is unblocked by this positive control potential to start the supply of oscillations to the controlled device (in the case of Figure 1, the time measuring device).

At the same time a positive potential is applied to the multivibrator grid 15 and to the cathode 29 of a duodiode 30 through which a grid bias of the stop channel input tube 12 is controlled. The potential of the other cathode 31 is derived either directly or from the controlled device through a lead 32 and a delay circuit constituted of multivibrators 33, 34 and 35 which are connected in cascade to produce a desired delay, for example a two second delay. Unless both cathodes 29 and 31 are at a positive potential, the in-

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put tube 12 is biased off and a stop signal applied to its lower grid is ineffective to terminate the supply of oscillations to the controlled device.

When the cathodes 29 and 31 are both positive, however, a stop signal applied to the lower grid of the tube 12 operates through this tube and the anode resistor 36 to apply a negative pulse to the grid of the right hand electron discharge element 41—42—43 of a multivibrator 40. The multivibrator 40 includes a second electron discharge element 37—38—39 and is provided with a second anode resistor 44, with grid resistors 45—46 and 47—48 and with a neon tube 49 and a resistor 50 connected in shunt to the resistor 44 for indicating when the multivibrator is in a condition to permit the supply of oscillations to the controlled device. It will be noted that the multivibrator control grid 42 and the upper control grid of the control tube 28 have their potential determined by the drop of the resistor 36 so that when the multivibrator element 37—38—39 is conducting, a more negative potential is applied to these grids.

The start and stop channels are provided with test switches 51 and 52.

A reset switch 53 is open and closed for applying a positive potential to the right hand grids 18 and 42 of the multivibrator units 13, 40 and 33 and to the left hand grids of the multivibrator units 34 and 35 preparatory to operation of the circuit. In their reset condition, the right hand sides of the multivibrators 13, 40 and 33 and the left hand sides of the multivibrators 34 and 35 are conducting as indicated by arrows so that a negative potential is applied (1) to the first or lower control grid of the control tube 28, (2) to the cathode 29 of the diode 39, and (3) to the cathode 31 of the diode 39 unless a switch 54 be closed for excluding the effect of the delay network and raising the potential of the cathode 31.

The switch 54 is closed when immediate cessation of the supply of the measured quantity in response to the first stop signal is desired. Switches 54 and 55 are open when it is desired that the measured quantity be supplied for at least two seconds before it can be interrupted by a stop signal. Switch 55 is closed when the measured quantity is to be supplied for an indefinite time.

With the switch 54 closed and the various multivibrators in their reset condition, the application of a start signal to the terminal 9 unblocks the tube 11 which draws current through the resistor 20 thereby applying a more negative potential to the grid 18 and transferring current from the right to the left side of the multivibrator 13. This transfer of current results in a more positive potential at the lower grid of the control tube 28, this tube passes current, its cathode becomes more positive and the supply of oscillations to the controlled device is started.

At the same time the cathode 29 of the duodiode 30 is made more positive, so that, with the switch 54 closed, the input tube 12 is unblocked and responsive to the application of a stop signal.

The application of a stop signal to the tube 12 causes this tube to draw current through the resistor 36 thereby transferring current from the right to the left side of the multivibrator 40 and applying a more negative potential to the grid 42 of this multivibrator and to the upper control grid of the control tube 28 which terminates the supply of oscillations to the controlled device.

With switches 54 and 55 open, a negative pulse derived from the control pulse source by way of

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lead 32 functions to transfer current from the right to the left side of the multivibrator 33 thereby producing a positive pulse which is applied through a capacitor 56 to the grid 57 of the multivibrator 34. As a result, current is transferred to the right side of this multivibrator 34. Hence grid 57 becomes positive and receptive to next negative signal from lead 32. In a similar manner the multivibrator 35 is operated by a positive pulse from the multivibrator 34, and current is transferred to the right side of the multivibrator 35 and the cathode 31 is made more positive. When this occurs, the multivibrator functions, as previously explained, to bias off the control tube 28 and interrupt the supply of oscillations to the controlled device.

It should be understood that the lead 32 may be connected to any source of pulses to obtain the desired delay. For example, while three multivibrators 33, 34, 35 are used in the circuit of Figure 2, any other number of multivibrators may be included to increase the delay, or the pulse source may be chosen to affect less delay.

While the control circuit has been described as applied to a time measuring device, it is apparent that it is applicable to various types of devices having a mode of operation based on the supply of an accurate block of oscillations or the like cut from the output of a continuously operating source.

I claim as my invention:

1. The combination of a pair of input tubes each having input and output terminals, a control tube having two control grids, a first multivibrator having a first electron discharge element connected to one of said output terminals and a second electron discharge element connected to one of said control grids, a second multivibrator having a first electron discharge element connected to the other of said output terminals and a second electron discharge element connected to the other of said control grids, means for applying spaced signals to both of said input terminals, and means including a first diode responsive to the current of the second electron discharge element of said first multivibrator for applying a control potential whereby the first of said signals is blocked from the second of said multivibrators and the second of said signals is passed to said second multivibrator, and means including a second diode connected in parallel with said first diode for delaying the unblocking of said second multivibrator for a predetermined time after current is taken by the second electron discharge element of said first multivibrator.

2. The combination of first and second input tubes provided with output terminals and with parallel-connected input circuits, means for blocking said second input tube, a control tube having two control grids, a first multivibrator having a first electron discharge element connected to the output terminals of the first of said input tubes and a second electron discharge element, a second multivibrator having a first electron discharge element connected to the output terminals of the second of said input tubes and a second electron discharge element, means for applying spaced signals to said parallel-connected input circuits, means responsive to current produced in the second electron discharge element of said first multivibrator by the first of said signals for applying a positive potential to one of said control grids and to said blocking means, means responsive to current produced in the second electron discharge element of said second

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multivibrator by the second of said signals for applying a negative potential to the other of said control grids, and means for precluding the application of said negative potential for a predetermined period following the application of said positive potential.

3. The combination of a first input tube having input and output terminals, a second input tube having input, output and control terminals, a control tube having first and second control grids, a first multivibrator having a first electron discharge element connected to the output terminal of said first input tube and a second electron discharge element connected to the first grid of said control tube, a second multivibrator having a first electron discharge element connected to the output terminal of said second input tube and a second electron discharge element connected to the second grid of said control tube, means for applying spaced signals to both of said input terminals, a first diode connected between the second electron discharge element of said first multivibrator and the control terminal of said second input tube, a second diode connected in parallel with said first diode, and means including a third multivibrator connected to the cathode of said second diode for delaying operation of said second multivibrator for a predetermined time interval after current is taken by the second electron discharge element of said first multivibrator.

4. The combination of a first input tube having input and output terminals, a second input tube having input, output and control terminals, a control tube having first and second control grids, a first multivibrator having a first electron discharge element connected to the output terminal of said first input tube and a second electron discharge element connected to the first grid of said control tube, a second multivibrator having a first electron discharge element connected to the output terminal of said second input tube and a second electron discharge element connected to the second grid of said control tube, means for applying spaced signals to both of said input terminals, a first diode connected between the second electron discharge element of said first multivibrator and the control terminal of said second input tube, a second diode connected in parallel with said first diode, means including a third multivibrator connected to the cathode of said second diode for delaying operation of said second multivibrator for a predetermined time interval after current is taken by the second electron discharge element of said first multivibrator, and means for selectively changing the length of said time interval.

5. The combination of a first input tube having input and output terminals, a second input tube having input, output and control terminals, a control tube having first and second control grids, a first multivibrator having a first electron discharge element connected to the output terminal of said first input tube and a second electron discharge element connected to the first grid

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of said control tube, a second multivibrator having a first electron discharge element connected to the output terminal of said second input tube and a second electron discharge element connected to the second grid of said control tube, means for applying spaced signals to both of said input terminals, a first diode connected between the second electron discharge element of said first multivibrator and the control terminal of said second input tube, a second diode connected in parallel with said first diode, means for applying a control potential, and means responsive to said control potential for applying to the cathode of said second diode a potential for delaying operation of said second multivibrator for a predetermined time interval after current is taken by the second electron discharge element of said first multivibrator.

6. The combination of a first input tube having input and output terminals, a second input tube having input, output and control terminals, a control tube having first and second control grids, a first multivibrator having a first electron discharge element connected to the output terminal of said first input tube and a second electron discharge element connected to the first grid of said control tube, a second multivibrator having a first electron discharge element connected to the output terminal of said second input tube and a second electron discharge element connected to the second grid of said control tube, means for applying spaced signals to both of said input terminals, a first diode connected between the second electron discharge element of said first multivibrator and the control terminal of said second input tube, a second diode connected in parallel with said first diode, means for applying a control potential, means responsive to said control potential for applying to the cathode of said second diode a potential for delaying operation of said second multivibrator for a predetermined time interval after current is taken by the second electron discharge element of said first multivibrator, and means for changing the extent of said delay.

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