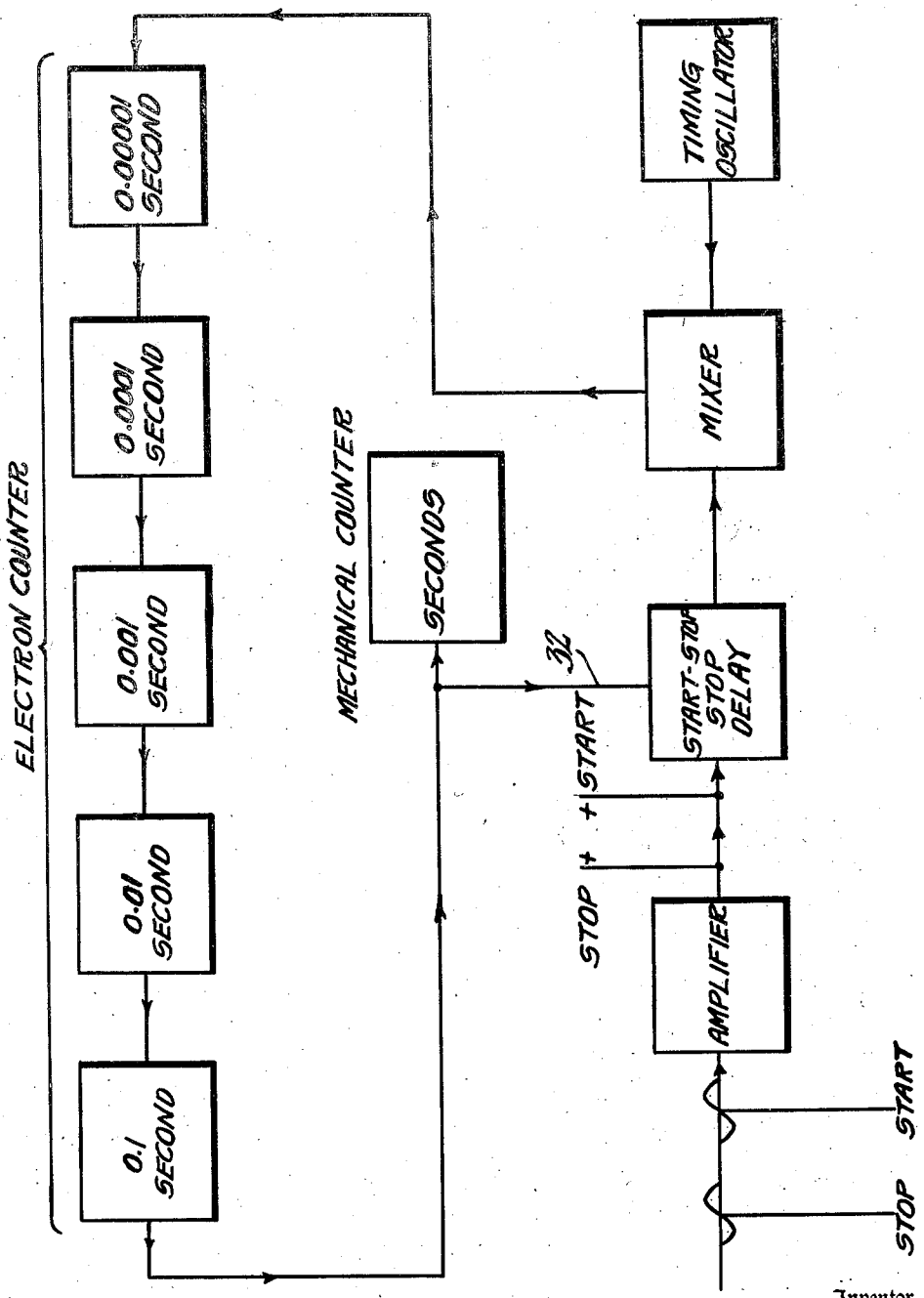
July 16, 1946. I. E. GROSDOFF 2,403,918

METHOD OF OPERATING THE ELECTRONIC CHRONOGRAPHS

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Fig. 1.



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METHOD OF OPERATING THE ELECTRONIC CHRONOGRAPHS

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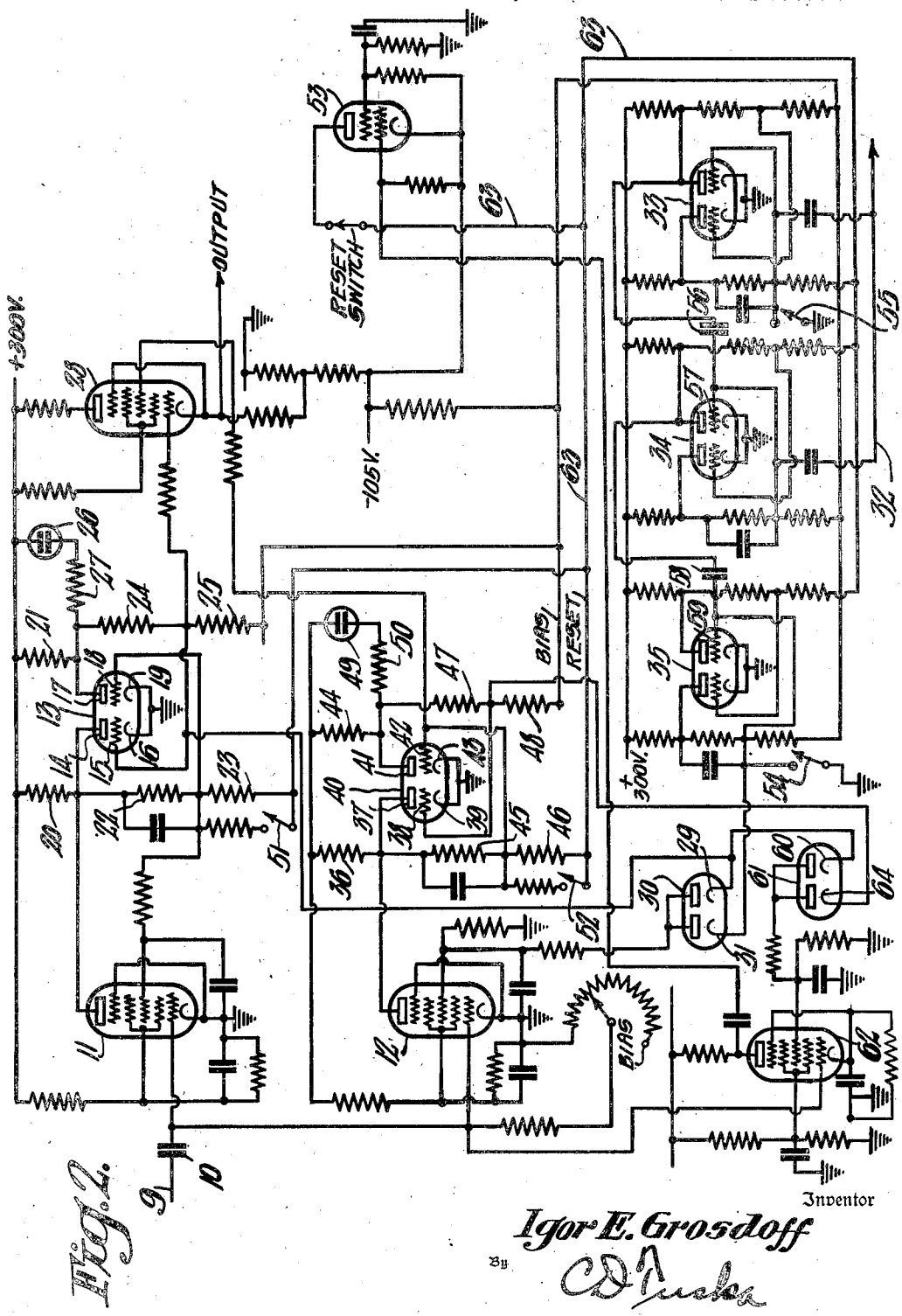


Fig. 2.

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METHOD OF OPERATING THE ELECTRONIC CHRONOGRAPHS

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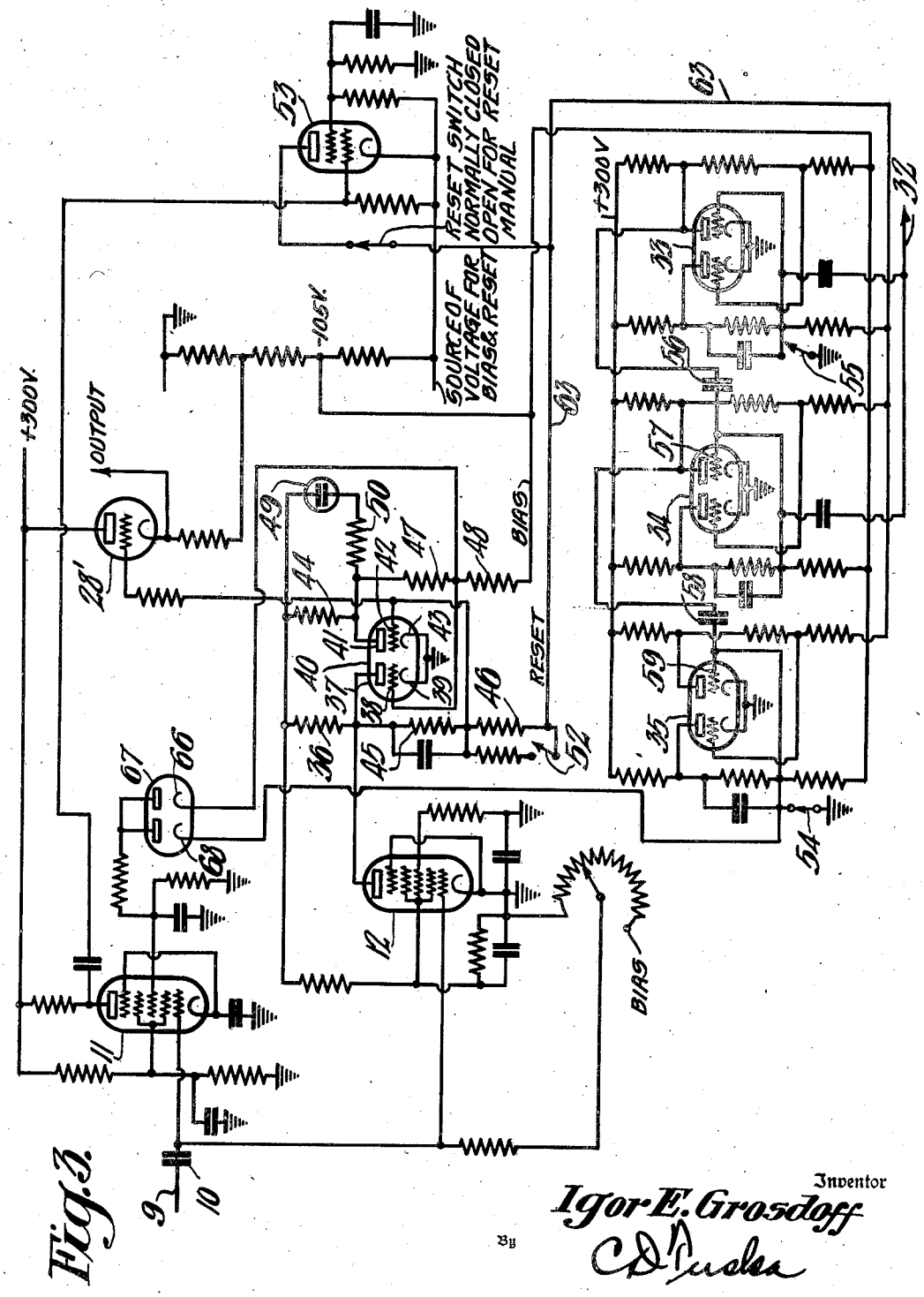


Fig. 3.

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METHOD OF OPERATING THE ELECTRONIC CHRONOGRAPHS

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Application December 29, 1943, Serial No. 516,086

5 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 automatically resetting the apparatus between both of its operations in response to the spaced signals.

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. A reset channel is connected to the same input terminal as the start and stop channels or the start signal itself may be utilized to reset the apparatus.

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 duo-diode 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 reset channel, in one modification of the invention, is so interlocked with the start and stop channels that it becomes effective only after the apparatus has been started and stopped. In another modification, the apparatus is reset and immediately started by the applied signal.

The present invention is an improvement on that disclosed by a copending application Serial Number 513,317, filed December 7, 1943.

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.

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Referring to the drawings:

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

Figure 2 is a wiring diagram of the control circuit of one modification of the present invention, and

Figure 3 is a similar diagram of a second modification of the 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 essentially 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 Fig.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 and 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 indi-

cating 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 Fig. 1, the time measuring device).

At the same time a positive potential is applied to the multivibrator grid 15, to the cathode 29 of a duo-diode 30 through which a grid bias of the stop channel input tube 12 is controlled and to the cathode 60 of a reset channel diode 61. The potential of the other cathode 31 of the diode 30 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 of the diode 30 are at a positive potential, the input 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 tube 53 and a reset switch are provided for removing the negative potential from a lead 63 to establish a standby or reset condition 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 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 30, (3) to the cathodes 60 and 64 of the reset channel diode 61 and (4) to the cathode 31 of the diode 30 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.

The reset tube 53 is controlled from the input terminal 9 through the input tube 62 by a reset pulse which follows the stop puise or precedes the next start pulse so that the cycle of operation is readily repeated without manual adjustment of the apparatus. The circuit of Fig. 2 differs from

that of the aforesaid copending application in that it is a three pulse system instead of a two pulse system.

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 duo-diode 30 and the cathode 60 of the duo-diode 61 are 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, applying a more positive potential to the cathode 64 of 61 and applying a more negative potential to the grid 42 of the multivibrator 40 and to the upper control grid of the control tube 28 which terminates the supply of oscillations to the controlled device. The apparatus is now in condition to be reset by a reset pulse applied through the terminal 9 to the input tube 62.

With switches 54 and 55 open, a negative pulse derived from the control pulse source by way of lead 32 functions to transfer current from the left to the right 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 Fig. 2, any other number of multivibrators may be included to increase the delay, or the pulse source may be chosen to effect less delay.

The circuit of Fig. 3 is a two pulse system, the starting pulse being utilized to reset and immediately start the system. The system is similar in many respects to the three pulse system of Fig. 2 but differs therefrom in that it requires the use of less tubes. Thus the input tube 11 is utilized, together with the reset tube 53, to reset the multivibrator 40 so that current is transferred to its right side. When this occurs, the output tube 28' takes current, its cathode becomes more positive and the supply of oscillation to the controlled device is started. At the same time, the cathode 66 of a duo-diode 67 is made more negative by the potential drop of the resistor 44 so that the input tube 11 is biased off. If the switch 54 is open, the tube 11 is biased off by the cathode 68 for a predetermined interval after the start signal as previously explained.

A closing pulse applied to the terminal 9 causes the tube 12 to draw current through the resistor 36. Current is thereupon transferred to the left side of the multivibrator unit 40, the cathode 66 is made more positive, the grid of the output 28' is made more positive and the supply of oscillations to the controlled device is terminated.

While the control circuit has been described as applied to a time measuring device, it should be understood that it is applicable to various types of devices having a mode of operation based on the supply of an accurately measured 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 plurality of input tubes each having input and output terminals, a control tube having a control grid, a multivibrator having a first electron discharge element connected to one of said output terminals and to said control grid and a second electron discharge element, reset means connected to the other of said output terminals and to said second electron discharge element for transferring current from one to the other of said elements, means for applying spaced signals to said input terminals, and means for blocking the second of said signals from said reset means.

2. The combination of a plurality 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 the first 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 second of said output terminals and a second electron discharge element connected to the other of said control grids, reset means connected to the third of said output terminals, means for applying spaced signals to all of said input terminals, means for blocking the first of said signals from said second multivibrator and said reset means during its transmission through the first of said multivibrators, means responsive to said transmission for unblocking said second multivibrator to the second of said signals.

3. The combination of a plurality 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 the first 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 second of said output terminals and a second electron discharge element connected to the other of said control grids, reset means connected to the third of said output terminals, means for applying spaced signals to all of said input terminals, means for blocking the first of said signals from said second multivibrator and said reset means during its transmission through the first of said multivibrators, means responsive to said transmission for unblocking said second multivibrator to the second of said signals and means responsive to the second of said signals for unblocking said reset means to the third of said signals.

4. The combination of a pair of input tubes each having input and output terminals, a control tube having a control grid, a multivibrator having a pair of electron discharge elements one of which is connected to one of said output terminals and to said control grid, means including a reset element connected to said electron discharge element, means for applying spaced signals to both of said input terminals and means including a diode responsive to the current of the other of said electron discharge elements for applying a control potential whereby the first of said signals is made ineffective to operate said multivibrator and the second of said signals is made effective to operate said multivibrator.

5. 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 multivibrator by the second of said signals for applying a negative potential to the other of said control grids, and means responsive to the third of said signals for resetting said multivibrators.

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