

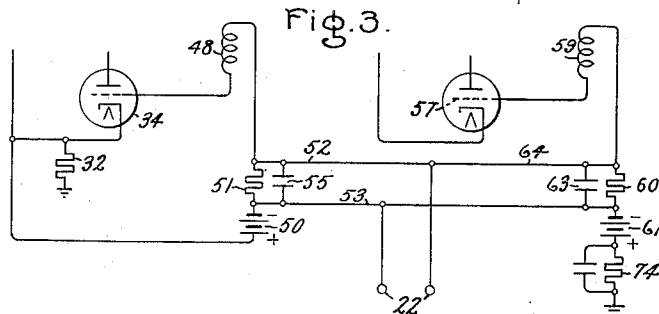
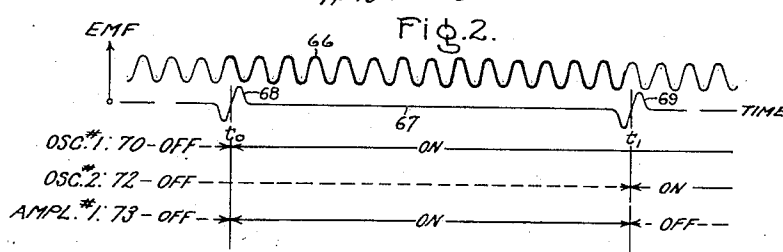
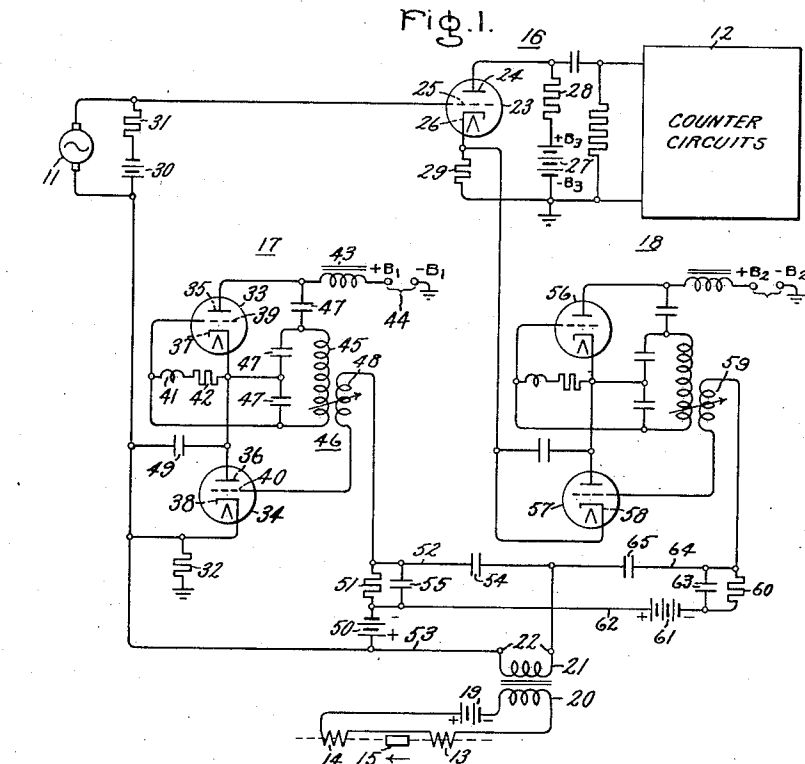
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2,332,300

INTERVAL TIMER

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2,332,300

INTERVAL TIMER

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2 Claims. (Cl. 161—15)

My invention relates to timing arrangements and concerns particularly electronic control circuits.

It is an object of my invention to provide an accurate, fast-acting, reliable circuit for connecting or disconnecting a source of electrical energy in response to an electrical impulse.

It is a more specific object of my invention to provide such a control arrangement for an alternating current wave or pulsating current, especially one of high frequency of oscillation.

Another object of my invention is to provide arrangements for turning on and off a timing wave applied to a counter circuit utilized for measuring a time interval by counting the number of impulses from a constant frequency source which occur during the time interval.

Other and further objects will become apparent as the description proceeds.

In carrying out my invention in its preferred form I utilize a constant frequency generator of suitable type and a high speed impulse counter circuit, and I interpose an amplifier between the high frequency generator and the counter, the amplifier being so arranged that its degree of amplification may be varied in response to initiating and terminating impulses in order to control the application of impulses from the generator to the counter circuit. For this purpose I provide auxiliary electronic control circuits which are respectively responsive to an initiating impulse and a terminating impulse for supplying to the amplifier a dynamic bias which is sufficient to produce the amplifying condition when the initiating impulse is received and supplying a second dynamic bias which is sufficient to restore the amplifier to a non-amplifying condition when the terminating impulse is received.

A better understanding of my invention will be afforded by the following detailed description considered in connection with the accompanying drawing, and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended hereto.

In the drawing Fig. 1 is a circuit diagram of one embodiment of my invention; Fig. 2 is a graph illustrating the principle of operation, and Fig. 3 is a fragmentary circuit diagram of a modification of the arrangement of Fig. 1. Like reference characters are utilized to designate like parts throughout the drawing.

The arrangement illustrated is designed for controlling the application of timed impulses from a suitable generator 11 to a suitable impulse counter circuit 12 represented merely by a rec-

tangle since the counter circuit per se is not claimed in the present application.

The present invention is not limited to the use of particular counter circuits, although, for high frequency, electronic counter circuits are considered desirable. A suitable form of counter circuit is described in my copending application, Serial No. 421,129, filed December 1, 1941, and assigned to the same assignee as the present application. The arrangement described in the present application is such as to respond to two successive impulses produced by another source, the first of which is referred to as the initiating impulse and the second as the terminating impulse. Such an arrangement is useful in connection with the measurement of the speed of moving objects by measuring the time required to traverse the distance between two points. For example, the crossing of the first point produces a first or initiating impulse, and the crossing of the second point a fixed distance away produces a second or terminating impulse. To this end a pair of current-conducting coils 13 and 14 may be mounted at a known distance apart along the path of a moving object 15, so that an initiating impulse is produced when the object 15 enters into inductive relation with the coil 13 and a terminating impulse when the object enters into inductive relation with the coil 14. An amplifier or controlled current-producing device 16 is interposed between the generator 11 and the counter 12. An electronic control circuit 17, responsive to the initiating impulse, is provided for causing the amplifier 16 to acquire a high degree of amplification and a second electronic control circuit 18, responsive to the terminating impulse, is provided for restoring the amplifier 16 to the non-amplifying condition.

Any desired arrangement may be provided for producing the initiating and terminating impulses. For example, the coils 13 and 14 may be connected in series with a current source 19 in the primary winding 20 of a transformer having a secondary winding 21 to which a pair of terminals 22 are connected, which may be referred to as the control impulse terminals.

Ordinarily the generator 11 produces successive voltage cycles identical in wave shape and time duration so that their frequency remains constant. Such constancy of frequency is necessary when the apparatus is to be used for timing by counting cycles. However, my invention in general is not limited to use of a generator producing regularly recurring impulses with the

control devices or connecting and disconnecting arrangements.

The amplifier 16 may take the form of an electronic discharge device 23, preferably of the vacuum tube type, having an anode 24, a control electrode or grid 25, and a cathode 26. For energizing the anode-cathode circuit a current source 27 is provided having a positive terminal marked $+B_3$ and grounded negative terminal $-B_3$. An anode resistor 28 is provided in the anode lead and a cathode resistor 29 is provided in the cathode lead. For normally maintaining the tube 23 in the non-amplifying condition a fixed bias 30 is provided which may consist of a battery of cells. The battery 30 is connected to the control electrode circuit of the tube 23 with a resistor 31 in series. The impulse generator 11 is connected across the fixed bias 30 and the series resistor 31 for impressing voltage impulses on the control electrode 25. A second resistor 32 is interposed between the positive side of the bias voltage source 30 and ground for the purpose of providing a dynamic initiating bias in the control electrode circuit in a manner which will be described hereinafter, the resistor 32 forming a cathode resistor of the electronic control circuit 17.

The electronic control circuit 17 comprises a pair of electronic discharge devices 33 and 34 such as vacuum tubes, for example, having anode-cathode circuits connected in series comprising the anodes 35 and 36, and the cathodes 37 and 38, with control electrodes 39 and 40 respectively. The tube 33 is arranged as an oscillator, having a reactance 41 and a resistor 42 in the control electrode-cathode circuit, having a choke coil 43 connected in the anode lead between the $+B_1$ terminal of an anode voltage source 44 and the anode 35, and having a conventional tank circuit consisting of one coil 45 of a variable mutual inductor 46 and suitable condensers 47, providing a tuned oscillatory circuit with the anode and control electrode circuits coupled for the purpose of producing oscillations. The electronic discharge tube 34 is provided for controlling the oscillations of the oscillator tube 33 by controlling the anode current. The second coil 48 of the mutual inductor 46 is connected in circuit between the control electrode 40 and the cathode 38 of the control tube 34; and a condenser 49 is connected between the anode and cathode of the tube 34 to carry the discharge current of the oscillator 33 during the non-conducting half cycles of the control tube 34.

For normally maintaining the control tube 34 non-conducting and the oscillator 33 non-oscillating, a fixed bias 50 is provided in the control electrode circuit of the tube 34, and for overcoming the bias in response to an initiating impulse a resistor 51 is also included in series in the control electrode circuit. For passing current through the resistor 51 to overcome the bias 50 in response to an initiating impulse, a pair of conductors 52 and 53 are provided which are connected to the control impulse terminals 22 directly or through the interposition of a D. C. blocking condenser 54. A by-pass condenser 55 is provided across the resistor 51. The upper end of the resistor 32 is connected to the cathode 38, and the lower end is grounded so that the resistor 32 serves as a cathode resistor for the tubes 33 and 34. As already explained, the cathode resistor 32 is included also in the control electrode-cathode circuit of the amplifier tube 23, so that the initiation of discharge cur-

rent in the tubes 33 and 34 serves to introduce a dynamic bias in the control electrode circuit of the amplifier 23 for rendering it amplifying.

The constants of the circuit of the oscillator tube 33 are so chosen that its frequency of oscillation is high with respect to the frequency of the source 11, so that the initiation of oscillation in the tube 33 causes prompt application of the next timing impulse from the source 11 to the counter circuit 12. The constants of the circuit of the control tube 34 and the inductive coupling with the tube 33 are so chosen that a feeble oscillation initiated by the passage of an initiating impulse current through the resistor 51 to overcome the bias rapidly builds up in the tank circuit of the tube 33 to produce strong oscillations and continued discharge current through the tubes 33 and 34. The electronic control circuit consisting of the tubes 33 and 34 for passing current through the resistor 32 in response to an impulse at the control impulse terminals 22 is not a part of my present invention but is described more in detail in my Patents Nos. 1,876,449 and 2,015,591.

For producing passage of current through the cathode resistor 29 of the amplifier 16 of sufficient magnitude to overcome the dynamic bias provided by the resistor 32 and to restore the amplifier 16 to the non-amplifying condition, the second electronic control circuit 18 is provided. The circuit 18 resembles the circuit 17 having also an oscillator tube 56 and a control tube 57 with corresponding electrodes and circuit elements. The cathode 58 of the control tube 57, however, is connected to the positive end of the resistor 29 which serves as the cathode resistor of the amplifier tube 23, in order that initiation of discharge in the tubes 56 and 57 will produce current in the resistor 29 of the intensity required for raising the cathode potential of the tube 23 to the point at which it becomes non-amplifying. The control electrode circuit of the control tube 57 includes the coil 59 corresponding to the coil 48 of the control circuit 17, a resistor 60, an additional fixed bias 61 in the form of a battery of cells, the fixed bias 50, which is a part of the control circuit of the electrode tube 34, and the resistors 32 and 29. The resistor 60 is also provided with a by-pass condenser 63. For impressing a terminating impulse from the control impulse terminals 22 in the control electrode circuit of the control tube 57, by passing an impulse current through the resistor 60, the conductors 64 and 53 may be provided, with a D. C. blocking condenser 65 interposed in conductor 64 if desired. The additional fixed bias 61 is of such magnitude that the control tube 57 and therefore the oscillator 56 are held non-conducting so long as no current is passing through the resistor 32 but small enough so that the passage of current through the resistor 32 will overcome the bias 61 to an extent which will permit the terminating impulse to raise the control electrode potential of the tube 57 sufficiently to initiate discharge current and oscillation in the electronic control circuit 18.

In Fig. 2 the wave form produced by the generator 11 is represented by the wave 66 and the voltage appearing at the control impulse terminals 22 is represented by the curve 67. In the graphs formed by curves 66 and 67 voltage is plotted in the vertical direction and time in the horizontal direction. The instants of passage of the moving object 15 through the coils 13 and

14 and the occurrences of the impulses 68 and 69 in the curves 67 are at times t_0 and t_1 , respectively. Line diagrams 70, 72, and 73 represent the conditions of the electronic control circuit 17, electronic control circuit 18, and the amplifier circuit 16, respectively. Before the time t_0 all three of these circuits are off. However, after the time t_0 , the electronic control circuit 17 and the amplifier 16 are on; the electronic control circuit 18 remaining off. At the time t_1 the electronic control circuit 17 remains on the terminating impulse turns on the electronic control circuit 18 and thus causes the amplifier 16 to be turned off. This action is produced by the bias effects in the tube circuits. The discharge current of the electronic control circuit 17 introduces a dynamic positive bias through the resistor 32 in the circuit of the amplifier 16 at the time t_0 , which predisposes the control circuit 18 to be ready to act on receiving the terminating signal. Upon receiving the terminating signal the electronic control circuit 18 produces passage of additional current through the cathode resistor 29 of the amplifier 16 at the time t_1 for increasing the effective negative bias on the control member 25 to the extent that flow of plate current in tube 23 is completely prevented. It will be understood that the electronic control circuits 17 and 18 are set to the "off" condition before another time interval is measured in any suitable manner as by momentarily opening the cathode circuits. In Fig. 2, the curve 66 is shown in heavy lines during the period of time that the impulses are transmitted through the amplifier 16 to the counter 12.

If desired the connection between the control impulse terminals 22 and the resistors 51 and 60 in the control electrode circuits of the control tubes 34 and 57 respectively may be made direct as shown in the fragmentary diagram in Fig. 3 and with the condensers 54 and 65 omitted. In this case, however, it is desirable to connect the positive side of the fixed bias 61 to ground through a separate resistor 74 instead of to the negative side of the fixed bias 50.

I have herein shown and partially described certain embodiments of my invention and certain methods of operation embraced therein for the purpose of explaining its practice and showing its application, but it will be obvious to those skilled in the art that many modifications and variations are possible, and I aim therefore to cover all such modifications and variations as

fall within the scope of my invention which are defined in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. Apparatus for measuring time intervals comprising the combination of a generator of constant frequency impulses, a circuit for counting such impulses, an amplifier interposed between said generator and the counter with means for normally maintaining the amplifier in a non-amplifying condition, means for putting it in an amplifying condition in response to an initiating impulse at the beginning of a time interval, means for restoring the amplifier to a non-amplifying condition in response to a terminating impulse at the end of the time interval, such amplifier being of the electric discharge type having a control circuit including a fixed bias serving as a means for normally maintaining the amplifier in a non-amplifying condition, a pair of resistors, one serving as a dynamic bias for putting the amplifier in amplifying condition for overcoming the fixed bias, and the second serving as a dynamic bias for overcoming the first dynamic bias, the first-mentioned dynamic resistor having associated therewith a circuit for passing current therethrough in response to an initiating impulse and the second dynamic bias resistor having associated therewith a circuit for passing current therethrough in response to a terminating impulse.

2. In combination with a source of alternating current, apparatus for transmitting cyclic impulses from said source during a time interval fixed by initiating and terminating impulses other than the cyclic impulses from said source, said apparatus comprising an amplifier having input and output connections the input connections being connected to said alternating current source so as to be responsive thereto, a control circuit for the amplifier including said input connections having two different conditions one for maintaining the amplifier in a nonamplifying condition and one for rendering it amplifying and including impulse responsive elements for rendering the amplifier amplifying in response to an initiating impulse and for rendering it nonamplifying in response to a terminating impulse, and a cycle counter connected to the output connections of said amplifier for counting the number of cyclic impulses of said source transmitted by said amplifier between the initiating and terminating impulses.

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