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G. SMILEY

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ELECTRONIC TIMING CIRCUIT

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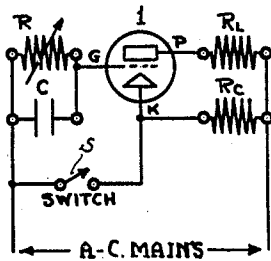


FIGURE 1.

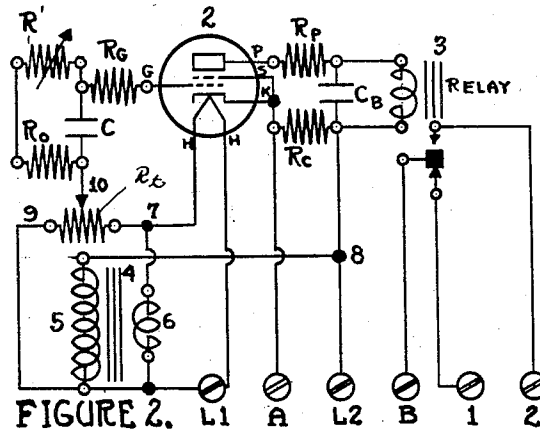


FIGURE 2.

FIGURE 3A.

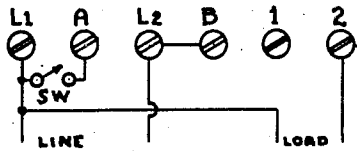


FIGURE 3B.

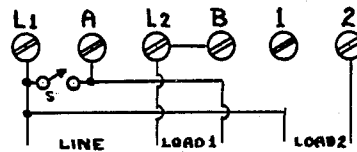


FIGURE 3C.

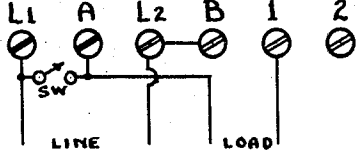


FIGURE 3D.

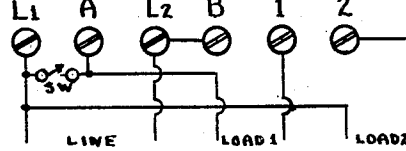


FIGURE 3E.

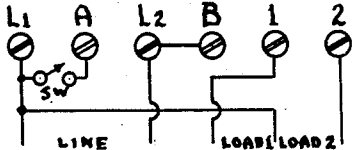


FIGURE 3F.

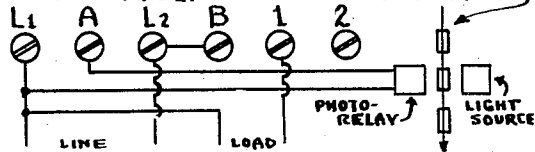


FIGURE 3G.

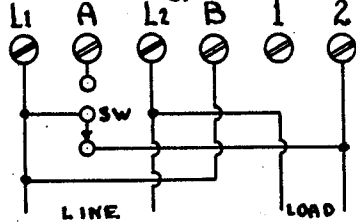
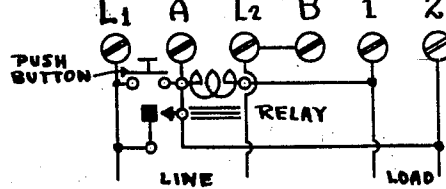


FIGURE 3H.



BY

GILBERT SMILEY
Gilbert Smiley
 ATTORNEY.

UNITED STATES PATENT OFFICE

2,296,580

ELECTRONIC TIMING CIRCUIT

Gilbert Smiley, Hingham, Mass., assignor to General Control Company, Cambridge, Mass., a corporation of Massachusetts

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4 Claims. (Cl. 250—27)

The present invention relates to an electronic timing circuit capable of adjustment for operating electrical devices a definite selected time after the closing of a circuit.

The circuits of the present invention may be developed with the use of either a gas tube having a hot cathode, or with other types of electronic tubes, either high vacuum tubes or gaseous tubes having argon or other similar gases and also with mercury vapor tubes.

In the present invention the timing range may without change of any of the elements in the circuit be controlled from intervals as short as fractions of one hundredth of a second, to a number of seconds. The broad range of timing control is obtained in the present invention by the use of a condenser discharge circuit incorporated in the timing circuit in such a way that even for very long time intervals, the same condenser may be used as for short intervals.

Other advantages and features of the present invention will be more fully understood from the drawing, in which:

Figure 1 shows a simplified form of the circuit employed.

Figure 2 shows a modification of the circuit of Figure 1, adapted for more general use, and,

Figures 3A, 3B, 3C, 3D, 3E, 3F, 3G and 3H, show different methods in which the circuit of Figure 2 may be used.

Figure 1 illustrates a simplified form of a circuit which is here principally used to explain the operation of the circuit. The tube 1 may be a simple triode or as illustrated in Figure 2, may be a gas tetrode, preferably of the type 2050 or 2051 which has been somewhat recently developed.

In Figure 1 the triode tube 1 with cathode K, anode P, and control grid G has in its normal inoperative state, the A. C. potential applied between the grid on the one side through the parallelly connected resistance R and condenser C, and on the other side to the cathode K and anode P, respectively, through the resistances R_c and R_L respectively. The values of the condenser C and the resistance R determine the rate of discharge of the condenser C, while in addition the magnitude of the other elements including the resistance R_c , the applied potentials and the kind of tube that is used, determines the rate and amount of charge accumulated by the condenser C. Initially when the switch S is opened, the condenser C is being charged through the grid cathode circuit of the tube 1 acting as a rectifier, the A. C. potential being applied across

the series circuit made up of the condenser C, in parallel with resistor R the grid cathode circuit of the tube 1 and the resistance R_c . The condenser C is charged during the alternate half cycles that current flows through the tube and is discharged through the resistance R across the condenser. The charging rate must therefore be of such a value that the condenser approximately reaches its normal steady state charge at the time of the closing of the switch, so that the condenser will begin its timing discharge from a substantially given value. The system can of course also be used with the condenser only partially charged where the switch is closed a known time after it is opened. In that case the condenser charge assumes a definite known value dependent upon the time interval between the opening and the closing of the switch.

The charge built up on the condenser C is always such as to put the negative charge on the condenser electrode next to the grid so that the grid is negatively biased with respect to the cathode at the instant that the switch is closed. When the switch S is closed, the A. C. potential is thrown across the cathode anode circuit of the tube between the cathode K and the anode P in series with the impedance or resistance R_L . The grid circuit is, under these conditions, returned to the cathode but through the negatively biasing condenser C which is now losing its charge by leakage across the resistance R, so that the grid is gradually becoming less negative with respect to the cathode, thus releasing its control when the negative potential of the grid drops below the critical value for ionizing the gas tube. When this occurs the tube will ionize or "fire" on the first succeeding cycle that makes the anode positive with respect to the cathode. In the present system the resistance R is adjustable from a given low value to any desired high value. The lowest allowable value of R is determined by the other conditions in the circuit. If R were practically zero no charge could accumulate on the condenser C because it would immediately leak off. R must be large enough therefore to give C a chance to charge to the desired value between the opening of the switch S and the following closing. This may or may not be the full charge which the condenser could receive under the given rectifier A. C. voltage. If the condenser C becomes fully charged however, then the grid C will always be biased the same amount under the same A. C. applied voltage and the starting point for the operation of the timing circuit will always be substantially the

same. Where the condenser is not fully charged, a constant number of conducting half cycles between the opening of the switch S and its following closing will allow constant charge to accumulate on the condenser which will take a constant time to leak off to the point where the tube will fire. Thus if the switch S is controlled by some constant synchronous timing interval as a tuning fork or the like, the operation of the tube may therefore be similarly controlled even if the condenser does not become fully charged.

While the discharge of the condenser C is controlled entirely by the value of the resistance R, the charge of the condenser C is controlled mainly by the value of R_c which limits the value of rectifier current when the tube 1 acts as a rectifier with the grid G serving as the anode. In general usage the value of R may run up to the order of ten megohms or more, while the value of R_c is comparatively low. When the switch S is closed, then the A. C. potential of the mains is thrown across the cathode plate circuit and as soon as the grid G loses control, the current will flow through the impedance or resistance R_L which of course might be the relay or external circuit control device, an indicator, a lamp, or almost any desired element.

In the system described in Figure 1 as well as in that of the other figures, it will be noted that the timing control is obtained by the application of a constant voltage with a variable or selective control of the magnitude of resistances or impedances in the circuit. The advantage of this method of control will be more readily appreciated by consideration of the circuit of Figure 2 which embodies the usual elements used in the present timing control circuit. The resistance R of Figure 1 in the arrangement in Figure 2 is made up of a constant fixed resistance R_0 and a variable resistance R' so that even when the resistance R' is reduced to zero, the condenser C will still have connected across it the fixed resistance R_0 which will prevent complete and instantaneous discharge of the condenser. The tube indicated in Figure 2 may be the newly developed gas tetrode tube 2050 or 2051. This tube in common with all gaseous, hot cathode, grid controlled rectifiers, has the advantage of passing practically no space current prior to the point where arc formation becomes possible, at which point the rectifier output suddenly assumes a high and definitely greater value unlike the high vacuum tube which under similar operating conditions will slowly increase its output making the exact point of relay operation somewhat indefinite in the face of relay armature vibrations.

With this tube therefore when current finally passes between the cathode K and the anode P, the operation of the circuit is established and the relay 3 definitely operates without any appreciable time variation. The grid G may be connected to the condenser discharge circuit previously described through a resistance R_g , the function of which is to prevent excessive grid current. Figure 2 also shows the arrangement for heating the cathode through the transformer 4, the primary of which 5, is connected across the line between the terminals L_1 and L_2 and the secondary 6 of which has one of its terminals connected to the point L_1 in such a way that the greatest potential differences occur between the point 7 and the point 8 which is a greater potential difference than between L_1 and L_2 . If the circuit is closed as indicated in some of the other

figures between the points L_1 and A, the cathode of the tube 2 is directly connected to L_1 which is also connected to the point 9 on one side of the slide wire R_t . The transformer is connected in this manner so that the end of the secondary at the point 7 is negative when L_2 or the point 8 is positive with respect to the line L_1 . Thus at any time when L_2 is positive, the slider 10 at R_t is negative to a greater or less extent depending upon its setting. Thus the actual grid bias voltage, when the plate is positive with respect to the cathode is made up of two negative components; one the alternating voltage intercepted by the slider R_t between the points 7 and 10, and the other the decreasing charge in the condenser C. If the negative voltage component supplied from the transformer through RT is almost but not quite equal to the control voltage required to prevent ionization, then the voltage contributed by C to prevent ionization may be extremely small. That is to say, when a part of the bias voltage required, is derived from the slide wire R_t , the time period may be extended considerably as it will require a longer time for the condenser C to discharge to this small value. Consequently R_t provides a means of adjusting the total time period of the device by providing a bias component which may in itself almost furnish the desired value of grid bias necessary to bring the operation of the tube to a critical point. Only a very small condenser charge will then be needed for preventing the operation of the tube so that with comparatively small size condensers adjustment for long time periods may be obtained.

In Figure 2 the relay is shown in place of the elements R_L in Figure 1. If the relay used is a direct current type, it will be necessary to shunt the relay by a condenser C_R to allow passage of alternating current. When using a gas tube as described in the present circuit, in order to limit the peak plate current, the resistor R_p is used, but such resistor and condenser may be avoided by the use of a suitable alternating current relay with proper pole shading.

In the various parts of Figure 3, connections for the circuit of Figure 2 are shown in various modified forms. In Figures 2 and 3 throughout, the same terminal notations apply in corresponding figures. In Figure 3A the timing switch SW is connected between A, the cathode and one side of the line L_1 . The timing starts therefore when the switch SW is closed. At the expiration of the timing period, the relay will operate and connect the load, by its operation, across from the point 2 to the point B thus bringing the load directly across the line.

In Figure 3B two loads are shown, load 1 and load 2. The load 1 is connected immediately to the line when the switch SW is closed, and load 2 is thereafter connected in parallel across the line upon the operation to the relay, which, as seen in Figure 2, connects the point 2 to the point B. Both loads are deenergized simultaneously when the switch SW is opened. This type of circuit is especially applicable to industrial devices such as hot cathode, mercury vapor rectifiers in which the first load might be the filament circuit and the second load the plate circuit; the time delay permitting the filaments to assume full operating temperature and to warm up the rectifier prior to the application of the plate voltage.

In Figure 3C the load is immediately energized when the switch is closed, while at the expiration of the timing period the load is disconnected

and will remain off even when the switch SW is open.

In Fig. 3D the load 1 is immediately energized when the switch is closed. At the expiration of the timing period, the load 1 is disconnected through the disconnection of the circuit between points B and 1 and load 2 is simultaneously connected by completion of the circuit between points B and 2.

In Figure 3E the load 1 is directly connected to the line before the switch is closed. When the switch is closed, the timing period starts and when the relay operates, the load 2 is connected to the line through the completion of the circuit between the points B and 2, while load 1 is disconnected through the breaking of the circuit between the points B and 1. This condition will be maintained until the switch SW is opened which will deenergize the relay 1 again and connect the load to the line and disconnect the load 2.

In Figure 3F the switch SW is shown as closed and in this position the load is connected to the line providing the relay 3 is in the position indicated in Figure 2. However, if the switch SW had been closed long enough to bring about the operation of the relay 3, the load would be disconnected from the line so that if the switch is made to open for a series of short intervals separated by less than the timing period, then the timer will be recycled for each opening of the switch and will not have had time to time out before the switch is again opened.

This circuit may be applied to production machines, in which case the switch may be operated either directly by the product emerging from the machine, or by a photo-electric relay actuated by the product. The timing period is set for a slightly longer interval than the normal period of product emergence. If however the machine fails to deliver a production unit for longer than this normal time interval, the timer will time out or operate the relay thus opening the connection to the line and stopping the machine. This is shown schematically in the figure at the right where the product emerging from the machine periodically interrupts the photo relay at sufficiently short time intervals, so that the relay 3 would not ordinarily operate. If however a product fails to emerge from the machine so that the photo relay operates for a longer period of time, then the timing circuit will have sufficient opportunity to operate the relay 3 and stop the machine if necessary.

Figure 3G is an interesting variation of the circuit. In Figure 3C it was shown how the load was turned on and remained on for the timing period. In Figure 3G the load is normally on and is turned off by the three way switch and remains off for the timing period after which it comes on again.

Figure 3H illustrates the method of applying a momentary contact push button of the normally open type. When the button PB is depressed the relay is energized closing the connection 20 thus shunting the push button connection which may then be released. The normal timing ensues during which time the load is connected to the line. At the expiration of the timing period both the relay coil and the load circuits are opened, thus disconnecting the load from the line, releasing the relay contacts and the timer is recycled to await another impulse. The arrangement of the circuits indicated in Figures 3A to H inclusive shows some of the general arrange-

ments for the completion of the circuit of Figure 2 as far as the operation of the circuit for various purposes.

It will of course be understood that the arrangement of the present invention may be adapted for another variations embracing the features described in the present invention.

Having now described my invention, I claim:

1. An electronic timing delay circuit adapted to be operated by an alternating current power supply, comprising an electronic tube having a cathode, a heating element therefor, an anode and grid elements, a transformer for supplying heating current for said cathode heating element, said transformer having terminal connections for producing a greater potential than that of the alternating current supply for biasing the grid lead to a value more negative than the cathode on the negative alternating current cycle, a discharge circuit having a condenser and a resistance connected across the same, means connecting one terminal of said discharge circuit to the desired potential established by said transformer terminals, and means connecting the other terminal of said discharge circuit to said grid and means operatively connected in the cathode-anode circuit for operating an electric responsive device whereby when said alternating current potential is removed from the cathode-grid circuit to the cathode-plate circuit, said responsive device will respond in definite time relation to said change.

2. An electronic timing delay circuit adapted to be operated by an alternating current power supply, comprising an electronic tube having a cathode, a heating element therefor, an anode and grid elements, a transformer for supplying heating current for said cathode heating element, said transformer having terminal connections for producing a greater potential than that of the alternating current supply for biasing the grid lead to a value more negative than the cathode on the negative alternating current cycle, a discharge circuit having a condenser and a resistance connected across the same, means connecting one terminal of said discharge circuit to the desired potential established by said transformer terminal, and means connecting the other terminal of said discharge circuit to said grid, a cathode-anode circuit having impedance elements and relay means therein, and means connecting said alternating current supply normally between said cathode and grid in series with said discharge circuit, and means adapted to connect said alternating current supply between said cathode and anode electrodes whereby said discharge circuit is permitted to discharge the current produced in the cathode-anode circuit a definite time after said switching means has been operated.

3. An electronic timing delay circuit adapted to be operated by an alternating current power supply, comprising an electronic tube having a cathode, a heating element therefor, an anode and grid elements, a transformer for supplying heating current for said cathode heating element, said transformer having terminal connections for producing a greater potential than that of the alternating current supply for biasing the grid lead to a value more negative than the cathode on the negative alternating current cycle, a discharge circuit having a condenser and a resistance connected across the same, means connecting one terminal of said discharge

circuit to the desired potential established by said transformer terminals and means including a resistance element in series with said discharge circuit for connecting the other terminal of said discharge circuit to said grid, a cathode-anode circuit having impedance elements and relay means therein, and means connecting said alternating current supply normally between said cathode and grid in series with said discharge circuit, and means adapted to connect said alternating current supply between said cathode and anode electrodes whereby said discharge circuit is permitted to discharge the current produced in the cathode-anode circuit a definite time after said switching means has been operated.

4. In combination an electronic timing delay circuit adapted to be operated by an alternating current power supply, comprising an electronic tube having cathode, anode and grid elements, a condenser discharge circuit having one

terminal connected to the grid of said tube and the other terminal connected to a power supply, a cathode-anode circuit having impedance elements connected in series, the other terminal of said alternating current supply being connected at a point between said impedance means, relay means operatively connected in said cathode-anode circuit, switching means connected between said cathode and the terminal of said condenser discharge circuit connected to the power supply whereby said relay will be operative a chosen time interval after the closing of said switching means, said relay having a normally closed contact, a load having its circuit closed by said relay to said power supply and means supplied by said load for normally operating said switching means in time intervals less than the interval necessary for causing the operating of said relay.

GILBERT SMILEY.