

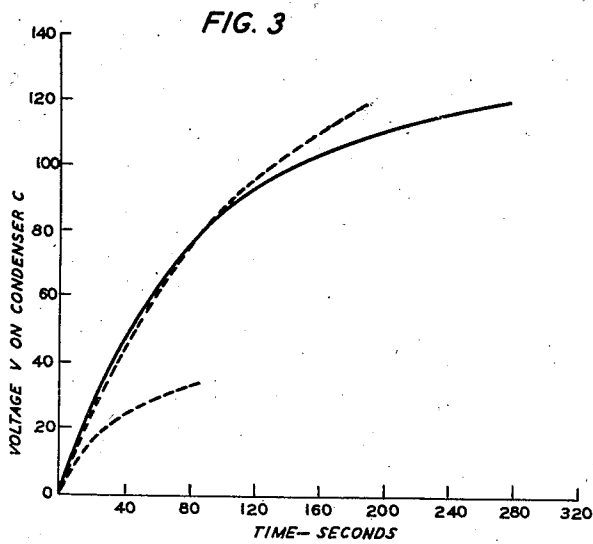
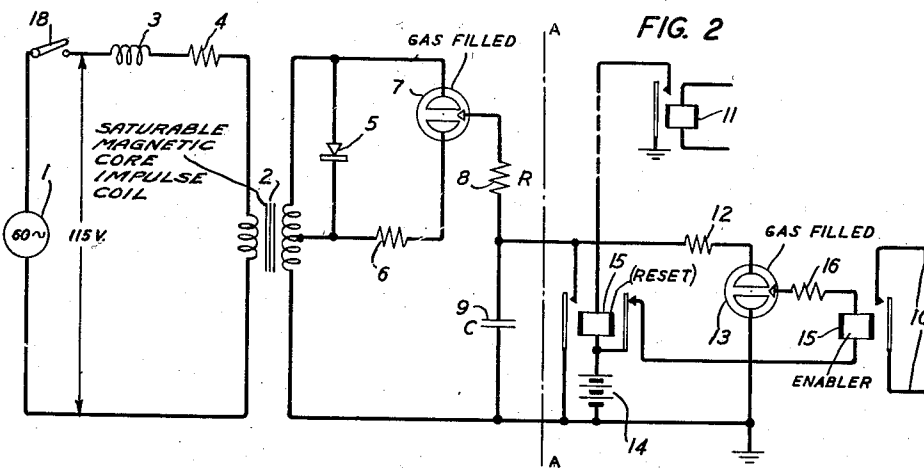
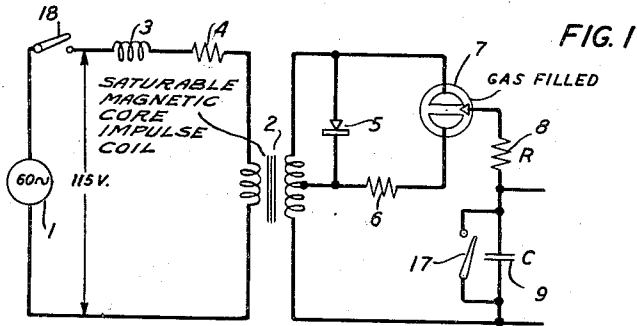
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SLOW-OPERATE ELECTRICAL CIRCUIT

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SLOW-OPERATE ELECTRICAL CIRCUIT

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The invention relates to electrical circuits, and particularly to slow-operate electrical control circuits.

An object of the invention is to obtain slow-operate times for an electrical control circuit, of easily controllable lengths which are in the order of several minutes, and thus not readily obtainable with the usual resistance-condenser networks charged from a direct current source.

This object is attained in accordance with the invention by a circuit including an impulse coil and a cold-cathode gas-filled discharge tube, for charging a capacitor from an alternating current source.

The various objects and features of the invention will be clear from the following detailed description when read in conjunction with the accompanying drawing in which:

Fig. 1 shows schematically a circuit embodying the invention;

Fig. 2 shows the application of the circuit to a particular type of alarm or testing circuit; and

Fig. 3 shows curves illustrating the performance of an experimental circuit in accordance with Fig. 1, as noted by tests.

In the circuit of Fig. 1, a 60-cycle, 115-volt alternating current source 1 is connected by the closing of manual switch 18 across the primary winding of an impulse coil 2 having a saturable magnetic core, through the series inductance element 3 and resistance element 4 having values, in this case 1.3 henrys and 300 ohms, respectively, such as to increase the alternating current impedance of the coil to higher frequencies. Half of the secondary winding of coil 2 is connected across the copper oxide rectifier 5, which in turn is connected through the proper series limiting resistance (0.25 megohm) 6 across the control discharge gap of a cold-cathode, gas-filled discharge tube 7, which may be a Western Electric Company 196 GY tube. The main discharge gap of the tube 7 is connected in series with the resistance 8 and condenser 9 across the whole secondary winding of the impulse coil 2. A manually operated switch 17 is provided for short-circuiting the condenser 9 to discharge it, in order to condition the slow-operate circuit for operation.

When condenser 9 is discharged, the circuit as described above operates to provide a slow charging of the condenser by the application thereto of separated, short unidirectional voltage impulses, instead of by the application of a steady direct current potential as in the usual slow-operate circuit.

When a steady alternating current flows in its primary winding, the secondary voltage of an impulse coil on open circuit consists of a series of narrow, peaked impulses. The rate of build-up of these voltage impulses is much lower than the rate of decay. Each voltage impulse is of saw-tooth-like shape, neglecting the high peak. The impulses are alternating, the positive and negative halves being symmetrical.

Such narrow peak voltage impulses are produced in the secondary winding of coil 2 by the application of the 60-cycle, 115-volt voltage from source 1 to the primary winding of the coil. The voltage drop in the upper half of the secondary winding of coil 2 is applied across the copper oxide rectifier 5 to the control discharge gap of tube 7 which is connected to act as a rectifier. The applied voltage has to build up to the striking potential of the control gap of tube 7 before the main gap thereof is made conductive to allow the condenser 9 to start to charge through the main discharge gap of tube 2 and series resistance 8.

The impedance of the 196 GY tube 7 while non-conducting is very high. Without the copper oxide rectifier 5, the maximum voltage on condenser 9 is limited to a comparatively low value (about 38 volts, as shown by the lower dotted curve of Fig. 3) by the inverse current produced by the combination of the condenser voltage and the negative part (with respect to the anode of tube 7) of the voltage impulse produced by coil 2. The copper oxide rectifier 5 by its shunting effect reduces the negative half of each impulse below the striking potential of the control gap of tube 7, so that only the alternate positive unidirectional portions of the voltage wave are effective to charge condenser 9. The use of this rectifier effectively increases the voltage range over which the gas tube rectifier 7 will operate, and thereby increases the slow-operate time range of the circuit.

The performance of the circuit of Fig. 1 is illustrated by the solid curve of Fig. 3 showing the voltage V on condenser 9 plotted against the time in seconds required for it to reach that voltage, for the case where the capacity C of condenser 9 is 1 microfarad, the value R of the series resistance element 8 is 0.5 megohm with $RC=0.5$. It will be seen from this curve that it takes about $4\frac{1}{2}$ minutes to build up the charge on condenser 9 to 120 volts. As a comparison the upper dotted curve of Fig. 3 shows the performance of a circuit in which approximately the same rate of charge is attained by the application of a steady direct

current voltage to the condenser 9 in the circuit shown in Fig. 1. The necessary value of RC in this case is 116. Thus, the ratio of RC between the steady direct current and the unidirectional pulses is 232, and this ratio could probably be increased by proper selection of circuit elements.

The advantage of using the cold-cathode gas triode is: (1) it limits the duration of the impulse; (2) it provides high impedance while non-conducting; (3) it does not require heater current; and (4) it has an indefinitely long life, since the conduction current is very small. The 196 GY tube was used on account of its high main discharge gap-breakdown voltage.

In a practical application of the circuit of Fig. 1, action would be initiated when the voltage across condenser 9 exceeds the given value. For instance, the circuit could be readily arranged so that when the condenser voltage reaches the desired value an alarm circuit would be set off, or another circuit put in action.

The circuit arrangement of Fig. 2 illustrates the latter application. It is desired to condition the circuit 10, which may be an alarm circuit or a testing circuit, for action whenever the relay 11 has not operated within a definite time interval of appreciable duration, say 1 to 3 minutes.

In the circuit arrangement of Fig. 2, the portion to the left of the dot-dash line A—A is identical with the circuit of Fig. 1, as indicated by the use of corresponding identification characters. The condenser 9 of this portion of the circuit is connected across the control discharge gap of a second cold-cathode, gas-filled discharge tube 13 through the series limiting resistance 12. Connected in series with the main discharge gap of the tube 13 is a battery 14, the operating winding of the "enabler" relay 15 and the resistance 16, the battery 14 normally positively biasing the anode of the tube 13. Another relay 17 which may be called the "reset" relay, is adapted to be operated by current from battery 14 to open its right-hand contacts to open the anode circuit of tube 13 and simultaneously to close its right-hand contacts to short-circuit the condenser 9, whenever the relay 11 operates to close its contacts.

The operation of the circuit arrangement of Fig. 2 is as follows: Assume that the reset relay 17 has just released in response to the release of relay 11, and, therefore, the charge C on condenser 9 is zero. The voltage on condenser 9 will then start to build up in response to the applied unidirectional voltage impulses produced by the application of the 60-cycle voltage from the source 1 to the circuit including impulse coil 2, copper oxide rectifier 5 and the cold-cathode, gas-filled tube 7, in the manner previously described in connection with Fig. 1. If the reset relay 17 does not operate in response to operation of relay 11 within a given time interval T, the voltage on the condenser 9 will reach the striking potential of the control gap of tube 13 causing conduction in the main gap of that tube and energization of the enabler relay 15 by current from the battery 14. The consequent operation of the enabler relay 15 to close its front contacts will condition the circuit 10 for operation. The circuit 10 will be maintained so conditioned until the reset relay 17 again operates in response to operation of the relay 11 to break the anode circuit for tube 13 and to short-circuit condenser 9, discharging it. When the relay 11 releases, the reset relay 17 will again be operated to start the series of operations above

described. If the relay 11 operates to cause operation of the reset relay 17 once within any given time interval T, the enabler relay 15 will not be operated. By proper selection of the constants of the circuit which has been described, any desired slow-operate time may be obtained.

Some of the advantages of the slow-operate circuits of the invention over other types of slow-operate circuits are: (1) a longer slow-operate time; (2) no mechanical timing mechanism is required; (3) utilization of a small amount of power; (4) easily controllable duration of slow-operate time; and (5) long life.

Various modifications of the circuits which have been illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. A slow-operate circuit comprising a source of alternating current, means responsive to the application of alternating current thereto from said source to produce during each half-cycle of said current a narrow peaked impulse, a gas discharge tube having striking electrodes and main electrodes, means responsive to each of certain of the produced impulses to apply a voltage to said striking electrodes to cause a discharge between said main electrodes of said tube, a capacitor connected in circuit with said main electrodes and said means for producing impulses, of such characteristics that it will be charged to a given value by the discharge through said tube only after the application of a number of the half-cycle impulses, and marginal means responsive to a voltage produced across said condenser when it is charged to a given value.

2. A slow-operate circuit comprising means responsive to the application thereto of alternating current to produce during each half-cycle thereof an impulse building up slowly and decaying rapidly, a cold-cathode gas discharge tube having a control discharge gap and a main discharge gap, means responsive only during alternate half-cycles of said alternating current to apply a voltage across said control gap to start a discharge in said main gap, a capacitor connected in circuit with said main gap and the source of impulses, so as to be charged up gradually by the application of the short unidirectional voltage impulses thus periodically transmitted through said tube, and marginal operating means responsive to the voltage across said capacitor.

3. The circuit of claim 1 in which said means for producing narrow peaked impulses is an impulse coil having a saturable magnetic core, a primary winding connected across said source of alternating current, and a secondary winding having a portion thereof connected across said striking electrodes of said tube and a greater portion thereof connected in circuit with said capacitor and the main discharge gap of said tube.

4. The circuit of claim 2, in which said impulse producing means comprises an impulse coil having a saturable magnetic core, a primary winding connected across the source of alternating current and a secondary winding having one portion thereof connected across the control discharge gap of said tube so as to apply the voltage induced in said one portion of said secondary winding by the alternating current applied to said primary winding, across said control gap to start a discharge in said tube, and a relatively larger portion connected in circuit with said capacitor

and said main gap of said tube, and said means responsive only during alternate half-cycles of said alternating current comprises a unilaterally current-conducting device connected across said one portion of said secondary winding.

5. A slow-operate electrical circuit comprising a source of alternating current, an impulse coil having a saturable magnetic core, a primary winding connected across said source, and a secondary winding, a cold-cathode gas-filled tube having a control discharge gap connected across a portion of said secondary winding through a limiting resistance, and a main discharge gap, a capacitor and a second resistance connected in series with said main gap of said tube across said secondary winding, a copper oxide rectifier shunting said portion of said secondary winding and marginal means responsive to the voltage produced across said capacitor.

6. In combination, a source of alternating current, an impulse coil having a saturable magnetic core, a primary winding connected across said source and a secondary winding, said impulse coil producing in its secondary winding a

5 narrow peaked voltage impulse for each half-cycle of applied alternating current, a cold-cathode gas-filled electron discharge tube having a control discharge gap and a main discharge gap, said control gap being connected across a portion of said secondary winding and being responsive to the voltage produced therein to make said main gap conductive, a capacitor connected in series with said main discharge gap across a relatively greater portion of said secondary winding, so as to be charged up gradually by the application of short unidirectional voltage impulses thus periodically transmitted through said tube, marginal operating means responsive to the given voltage across said capacitor, and means to effectively increase the voltage range over which said gas-filled tube will be rendered conductive.

10 7. The combination of claim 6, in which the last-mentioned means comprises a copper oxide rectifier shunting said control gap and thereby preventing said tube from being made conductive during alternate half-cycles of the applied voltage wave.

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