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SEQUENTIAL LOAD SWITCHING UTILIZING DISCHARGE TIMING MEANS

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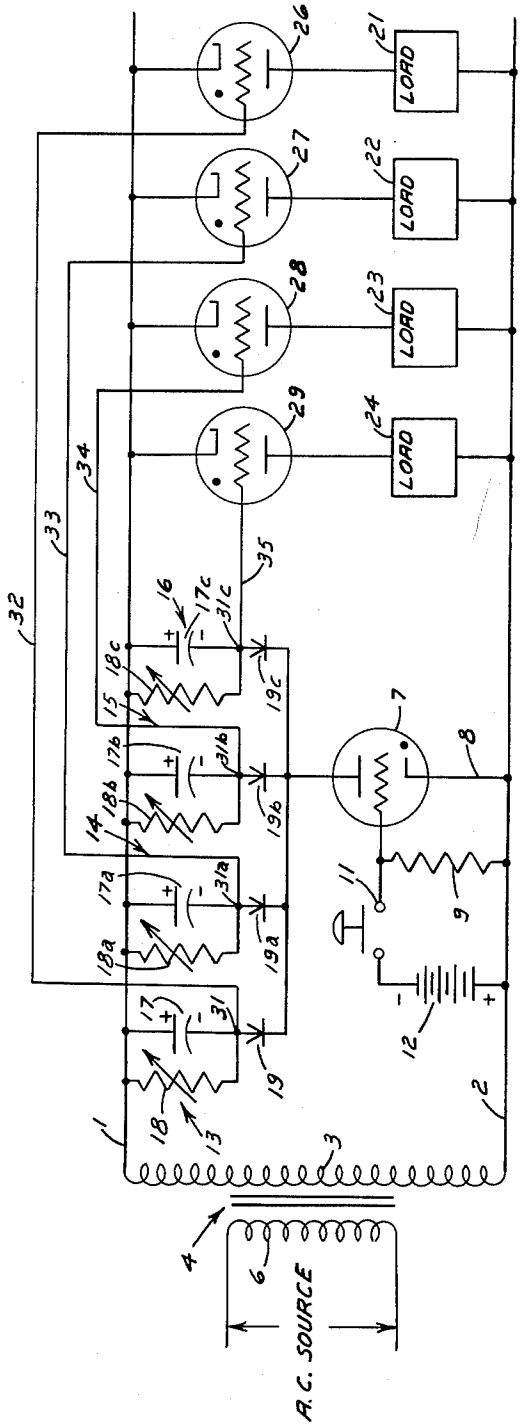

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SEQUENTIAL LOAD SWITCHING UTILIZING DISCHARGE TIMING MEANS

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This invention relates to electrical timing equipment and it relates particularly to circuitry for simultaneously starting a plurality of independently operable timers, each thereof being connected to an independently operable load actuating device.

There are numerous instances in the designing of various types of electrical equipment where it is desirable to utilize a plurality of independently operable timers which are each connected to a valve and load circuit and which are connected with respect to each other in such a manner that the timers will operate in a definite relationship to each other. One way in which an accurately controllable relationship may be established between said timers is to effect a simultaneous starting of the timing function of each thereof. Prior attempts to provide circuitry of this nature, insofar as I am aware, have resulted in undesirably complicated circuits or circuits whose functioning was not entirely accurate.

Accordingly, the objects of the invention include the following:

(1) To provide a circuit for simultaneously starting a plurality of independently operable timers, each of said timers being respectively connected to an independent valve and load circuit.

(2) To provide a circuit, as aforesaid, of relatively simple construction having both low initial construction cost and low maintenance cost.

(3) To provide a circuit, as aforesaid, whose operation is initiated by the actuation of only a single control element and wherein each timer is free from interference by any of the other associated timers.

(4) To provide a circuit, as aforesaid, which can be readily adapted for handling differing numbers of timing circuits and their respectively associated valve and load circuits.

(5) To provide a circuit, as aforesaid, which will be capable of operating with a high degree of accuracy.

(6) To provide a circuit, as aforesaid, which will initiate a plurality of timing functions upon a change in the conductive condition of a single electric discharge device.

Other objects and purposes of the invention will become apparent to persons acquainted with apparatus of this general type upon reading the following disclosure and inspection of the accompanying drawing which is a schematic diagram of a circuit embodying the invention.

In general, the invention provides a plurality of parallel connected, independent, time-constant circuits connected in the anode circuit of a suitable electric discharge device, such as a thyratron. A rectifier is connected between each time constant circuit and the anode of said electric discharge device. The negative side of the capacitor in each time-constant circuit is connected for controlling the conductivity of a suitable potential responsive electric valve, such as by being connected to the grid of a thyratron, for controlling actuation of the respective loads.

Turning now to a more detailed consideration of the circuit illustrating and embodying the invention, there is shown a pair of bus conductors 1 and 2 which are connected to any suitable source of alternating potential, said source in this case being the secondary winding 3 of a transformer 4 whose primary winding 6 is energized by a suitable A.C. source.

A suitable electric valve 7 is connected between the bus conductors 1 and 2. The valve 7 is here shown as being a single thyratron tube, but it could also be an entire electronic circuit or any other suitable form of electric valving apparatus. The cathode of the valve 7 is connected by a conductor 8 to the bus conductor 2. The grid of the valve 7 is connected through a resistance 9 to said bus conductor 2 and is also connected through a switch 11 and a battery 12 to the bus conductor 2, the negative side of said battery being connected to said grid. It will be recognized that the switch 11 may also be either a single instrumentality, such as the manually operable switch shown in the drawing, or it may be an entire switching circuit.

The anode of the valve 7 is connected to one side of a plurality of parallel connected, time constant circuits 13, 14, 15 and 16 and the other sides of said circuits are connected to the bus conductor 1. All of the time-constant circuits are substantially the same and hence a detailed description of only circuit 13 will be given, the description applying equally to the other circuits. The corresponding parts of the other circuits 14, 15 and 16 are indicated by the same numerals as utilized for circuit 13 with the suffixes *a*, *b*, and *c*, respectively, added thereto.

The circuit 13 comprises a conventional time-constant circuit consisting of a capacitor 17 connected in parallel with a resistor 18, one of said elements, here the resistor 18, being variable for time adjustment purposes. The parallel connected capacitor 17 and resistor 18 are connected to a junction point 31 and thence serially connected through a rectifier 19 to the anode of the valve 7. The rectifier 19 is sensed to permit current flow from bus conductor 1 to bus conductor 2 so that the side of the capacitor 17 adjacent thereto is negative.

A plurality of loads 21, 22, 23 and 24 are respectively connected in series to suitable valves 26, 27, 28 and 29. Each load and its valve, sometimes herein referred to as a "load-and-valve" circuit, are connected to any suitable source of power, which sources may be the same or different from each other provided only that the cathodes of each of the valves 26, 27, 28 and 29 are connected to the positive sides of the respectively related capacitors, said last-named source being here shown as the bus conductors 1 and 2. The junction point 31 located between the negative side of capacitor 17 and the rectifier 19 is connected by the conductor 32 to the grid of the valve 26. Corresponding junction points 31*a*, 31*b*, and 31*c* are similarly connected by conductors 33, 34 and 35 to the grids of the valves 27, 28 and 29, respectively.

Suitable filament connections for the valves are made in a conventional manner but are not shown herein for the sake of simplifying the illustration.

Operation

The operation of this apparatus will be readily understood but will be briefly summarized for purposes of completeness.

With the tube 7 normally conductive, potential will be conducted through the rectifiers 19, 19*a*, 19*b*, and 19*c* in one direction to charge the capacitors 17, 17*a*, 17*b* and 17*c*. Thus, a negative potential is normally applied to each of the valves 26, 27, 28 and 29, respectively, to hold said valves blocked. The several variable resistors 18, 18*a*, 18*b*, and 18*c* may be set in a conventional manner to obtain the desired rate of discharge of the charge on the capacitor connected thereto.

Upon closure of the switch 11, the negative bias from the battery 12 is applied to the control electrode of the

tube 7 thereby blocking said tube and terminating the charging of the several capacitors. This initiates simultaneous commencement of discharge of the capacitors through their respectively connected variable resistances at rates determined by the setting of the variable resistances. When the capacitors have discharged to a point such that the potential appearing at the points 31, 31*a*, 31*b*, and 31*c*, respectively, reach certain predetermined levels, corresponding potentials appearing on the control electrodes of the several valves 26, 27, 28 and 29, respectively, will thereby permit said valves to conduct, which conduction occurs at preselected periods of time following the closure of the switch 11 and which periods of time are determined by the settings of the variable resistors. The rectifiers 19, 19*a*, 19*b* and 19*c* prevent the charge on any given capacitor from affecting the potential at any of said points 31, 31*a*, 31*b* and 31*c* other than the point directly connected to said given capacitor.

While a particular preferred embodiment of the invention has been described above, the invention includes such modifications or changes therein as lie within the scope of the appended claims.

What is claimed is:

1. In a circuit for independently affecting the conductivity of a plurality of load-actuating electric valves, each said valve including a potential responsive control means, the combination comprising: a plurality of time-constant circuits, each circuit including a chargeable element and a discharging device; an electric valve having an anode, a cathode and a control electrode; circuitry connecting one end of each of the time-constant circuits to a source of alternating potential; a plurality of one-way conductive means, there being one of each of said one-way conductive means connected in series with each time-constant circuit and circuitry connecting the other end of each of said time-constant circuits, respectively, through one of said one-way conductive means to the anode of said electric valve, said one-way conductive means each being sensed to permit the conduction of potential from one side of said source through its associated chargeable element to said electric valve; means connecting the cathode of said electric valve to the other side of said source; means controlling the conductivity of said valve; a plurality of load-actuating electric valves, each of said last-named valves having a potential-responsive control means and a source of potential connected to each of said last-named valves so that same actuate a load when they are conductive; separate circuits connecting a point located between each of said one-way conductive means and the negative side of the chargeable element associated therewith to said control means for one of said load-actuating electric valves so that said load-actuating electric valves may be rendered conductive in sequence.

2. In a circuit for independently affecting the conductivity of a plurality of electric load-actuating valves, each said valve including a potential responsive control means, the combination comprising: a plurality of time-constant circuits, each circuit including a capacitor and a resistor connected in parallel; an electric control valve having an anode, a cathode and a control electrode; circuitry connecting each of the time-constant circuits at one end thereof to a source of alternating potential; a plurality of continuously one-way conductive rectifiers, one of said rectifiers being connected in series with each time-constant circuit and circuitry connecting the other end of each of said time-constant circuits, respectively, through one of said rectifiers to the anode of said electric control valve, said rectifiers each being sensed to permit the conduction of potential from said one side of said source through said rectifiers to said electric control valve; means connecting the cathode of said electric control valve to the other side of said source; means controlling the conductivity of said control valve; a plurality of load-actuating electric valves each of said last-named valves having a potential-responsive control electrode and a source of potential connected to each of said last-named valve means so that same actuate a load when they are conductive; separate circuits connecting a point located between each rectifier and the negative side of the capacitor associated therewith to said control means for one of said load-actuating electric valves so that said load-actuating electric valves may be rendered conductive in sequence.

3. The apparatus defined in claim 2 wherein the resistances of the time-constant circuits are variable.

4. A circuit for actuating a plurality of loads in timed relation to each other, comprising: a source of alternating potential; a plurality of parallel connected, time-constant circuits comprising an adjustable resistance and a capacitance in parallel, each circuit being connected at one end thereof to one side of said source; a continuously one-way conductive rectifier in series with each of said time-constant circuits and connected to the other end thereof, said rectifiers being sensed to permit current flow from said one end of each of said time-constant circuits to the other end thereof; means connecting said rectifiers to a common point; a normally conductive thyratron having an anode, a cathode and a control electrode; means connecting said anode to said common point and means connecting said cathode to the other side of said source; a source of substantially constant potential; a switch and means connecting the negative terminal of said constant potential source through said switch to said control electrode whereby said thyratron may be rendered non-conductive upon closing of said switch; a plurality of normally non-conductive load thyratrons, each load thyratron having an anode, a cathode and a control electrode; a source of potential connected to said load thyratrons; a load connected to the anode of each load thyratron; means connecting a point between the other end of each time-constant circuit and its associated rectifier to the control electrode of one of said load thyratrons whereby said load thyratrons are, respectively, rendered conductive a predetermined time after closing of said switch.

5. A circuit for actuating a plurality of loads in timed relation to each other; a plurality of loads; a controllably conductive device associated with each load for controlling actuation thereof and means for supplying potential to said device; a plurality of parallel connected timing circuits, each circuit being associated with one of said devices for controlling the conductivity thereof, each circuit including a capacitor; a source of alternating potential and means connecting said source to said timing circuits for charging the capacitors thereof; a plurality of continuously one-way conductive means, each thereof being connected in series with one of said timing circuits for isolating the charge of the capacitor of said timing circuit from the other timing circuits; a single, controllable, normally conductive electric valve in series with all of said timing circuits and connected between the respective sides of said source; a switch; a source of negative potential connected through said switch to said normally conductive electric valve for rendering said valve non-conductive after closing of said switch whereby said loads will be actuated at timed intervals after closing of said switch.

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