

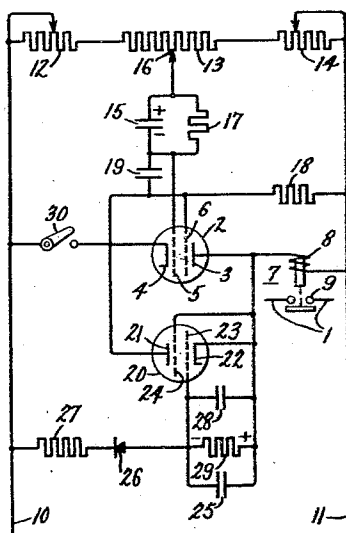
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ELECTRIC TIME DELAY RELAY

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## UNITED STATES PATENT OFFICE

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## ELECTRIC TIME DELAY RELAY

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My invention relates to electric circuits and more particularly to electric circuits for obtaining a time delay operation of electric apparatus.

Electric valve apparatus or electric discharge devices have found relatively wide application in those systems where it is desired to produce a time delay operation, such as the closure or opening of an electric circuit, a predetermined interval of time after the initiation of a circuit controlling operation such as the closure of a switch or equivalent apparatus. In accordance with the teachings of my invention described hereinafter, I provide a new and improved control system wherein greater precision and accuracy of operation are obtained than that afforded by the prior art arrangements, and which affords greater flexibility in the establishment of the timing interval.

It is an object of my invention to provide a new and improved electric control circuit.

It is another object of my invention to provide a new and improved electric valve control circuit.

It is a further object of my invention to provide a new and improved electric valve time delay circuit whereby alternating current is transmitted to the energizing means of circuit controlling apparatus a predetermined interval of time after operation of a circuit controlling means.

Briefly stated, in the illustrated embodiment of my invention I provide a new and improved electric valve time delay relay whereby alternating current is transmitted to an actuating coil of a contactor or relay a predetermined interval of time after the initiation of a circuit controlling operation, such as the closure of a switch. A pair of reversely connected electric discharge devices are connected to the actuating coil of the relay. One of the discharge devices is normally maintained non-conducting by virtue of a control circuit connected to the grid of the discharge device and which is charged through the grid-cathode circuit thereof through a circuit comprising a capacitance and a voltage divider which are energized from an alternating current supply circuit. The other discharge device is normally maintained non-conducting and is controlled to conduct current only during those half cycles immediately succeeding half cycles of conduction by the first electric discharge device. The second electric discharge device is maintained non-conducting by impressing on its grid a negative or hold-off voltage produced by a polarity responsive circuit which comprises a

capacitance and a properly poled unidirectional conducting device.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims. The single figure of the accompanying drawing diagrammatically illustrates an embodiment of my invention as applied to a time delay system for effecting energization of the actuating core of a relay.

Referring now to the single figure of the drawing, I have there illustrated my invention as applied to a system for controlling the energization of an electric circuit 1 by means of apparatus including an electric discharge device 2. The electric discharge device 2 is preferably of the type employing an ionizable medium, such as a gas or a vapor, and comprises an anode 3, a cathode 4 and a control means such as a control grid 5. If desired, the discharge device 2 may have an additional control means such as a shield grid 6 which is connected to the cathode 4.

If desired, the electric discharge device 2 may control the energization of the electric circuit 1 through a contactor means or a relay 7 having an actuating coil 8 and contacts 9. The electric circuit 1 is closed or energized when the contacts 9 are closed, and this operation is effected when the electric discharge device 2 conducts current.

In order to control the conductivity of the electric discharge device 2 by controlling the potential of grid 5, I provide means energized from an alternating current circuit comprising conductors 10 and 11. This means may include a voltage divider comprising serially connected resistances 12, 13 and 14 which may be adjustable. I provide time delay means, such as a capacitance 15, for controlling potential of grid 5 to render the electric device 2 conducting a predetermined interval of time after the initiation of a circuit controlling operation. The capacitance 15 is connected between grid 5 and an adjustable contact 16 of resistance 13. I provide a discharge path including a resistance 17 connected across capacitance 15. Shield grid 6 and cathode 4 may be connected to conductor 11 through a resistance 18 and a filtering capacitance 19 may be connected between the cathode 4 and grid 6.

As a means for energizing the actuating coil 8 of relay 7 so that alternating current is transmitted to this coil from the alternating current circuit, I provide an electric discharge device

20, also preferably of the type employing an ionizable medium such as a gas or a vapor, and comprising an anode 21, a cathode 22, a control grid 23, and may include a shield grid 24 which is connected to the cathode 22. The electric discharge device 20 is poled in opposition to the electric discharge device 2 so that these devices conduct current during half cycles of voltage of opposite polarity.

I provide means in the time delay system for maintaining the electric discharge device 20 non-conducting except during those intervals or half cycles immediately following half cycles of conduction by electric discharge device 2. This means comprises means responsive to the conductivity of the electric discharge device 2, or means responsive to the voltage appearing across the anode and cathode of electric discharge device 2. For example, I provide a polarity and voltage responsive circuit comprising a capacitance 25, which is charged through a circuit including a unidirectional conducting device 26, and which normally impresses a negative or hold-off voltage on grid 23. If desired, this circuit may be connected to the alternating current circuit including conductors 10 and 11 through a current limiting resistance 27 and actuating coil 8 of relay means 7. The time constant of the discharge circuit for capacitance 25 including the resistance 29 determines the rate of change of the bias voltage for discharge device 20. A suitable filtering means, such as a capacitance 28, may be connected between the control grid and cathode of electric discharge device 20.

I provide circuit controlling means, such as a switch 30, which may be connected in the anode-cathode circuits of electric discharge devices 2 and 20 and which, when in the open circuit position, permits charging of capacitance 15 to impress a negative hold-off timing voltage on grid 5 of electric discharge device 2 and, when in the closed circuit position, permits discharging of the capacitance 15, thereby decreasing the magnitude of the biasing potential and rendering electric discharge device 2 conducting a predetermined interval of time after closure.

The operation of the time delay relay shown in the single figure of the drawing will now be explained. So long as the switch 30 is maintained in the open circuit position, the actuating coil 8 of relay 7 is not energized. Of course, under these conditions neither electric discharge device 2 nor electric discharge device 20 conducts current through its anode-cathode circuit. By virtue of the grid rectification characteristic of the electric discharge device 2, the lower plate of capacitance 15 is charged negatively thereby producing initially the desired negative timing voltage. The circuit through which the capacitance 15 is charged to the polarity indicated during those half cycles when the conductor 10 is positive in potential relative to conductor 11, is resistance 12, the left-hand portion of resistance 13, capacitance 15, control grid 5, cathode 4 and resistance 18.

Upon closure of switch 30, voltage is applied to the anode-cathode circuits of the electric discharge devices 2 and 20. The voltage applied to grid 5 of electric discharge device 2 then consists of two components; one of these components is the alternating voltage derived from the voltage divider, particularly contact 16 of resistance 13 and the conductor 10; the second component is a unidirectional voltage appear-

ing across capacitance 15. The alternating component of voltage tends to render the potential of control grid 5 positive when the anode is positive but is rendered ineffective for a predetermined interval of time dependent upon the time constant of the discharge circuit for capacitance 15. Initially, the magnitude of this biasing potential is maximum and substantially full line voltage appears between the conductor 10 and the anode of discharge device 2. Under these conditions, a unidirectional voltage is produced across discharge resistance 29 in such a direction and having a polarity, due to the unidirectional conducting device 20, to maintain the grid 23 of discharge device 20 negative. Capacitance 25 is fully recharged during each positive half cycle of applied anode-cathode voltage that the electric discharge device 2 does not conduct current. In this manner, the electric discharge device 20 is also maintained in a non-conducting state.

The charge on capacitance 15 is dissipated through resistance 17, thereby causing the voltage applied to grid 5 to rise exponentially, that is, the negative bias voltage decreases at a rate determined by the time constant of that circuit. After a predetermined interval of time dependent upon the values of capacitance 15 and resistance 17 and the setting of contact 16, the grid voltage of electric discharge device 2 will become substantially zero and the electric discharge device 2 will become conductive during positive half cycles of applied anode-cathode voltage, thereby energizing actuating coil 8 of relay 7. As soon as electric discharge device 2 conducts current, the voltage appearing across the anode and cathode thereof, and hence the voltage applied to the charging circuit for capacitance 25, decreases to a small value. Consequently, capacitance 25 is not recharged and because of the low time constant of the discharge circuit for capacitance 25, the grid voltage of discharge device 20 decreases to a value sufficiently small to permit this valve to conduct current during each half cycle immediately following the half cycles of conduction by electric discharge device 2. Therefore, since discharge devices 2 and 20 conduct alternately, alternating current is supplied to the actuating coil 8 of relay 7. The system may be reset in its operation by opening switch 30, which circuit controlling operation reestablishes the bias on the grids of discharge devices 2 and 20.

An important advantage of my invention is the incident increased accuracy of the timing operation. This is due in a large measure to the use of two electric discharge devices which insure that an even number of half cycles of current will be supplied to the relay coil. This improved accuracy is particularly apparent where the time delay relay is employed to provide short timing intervals. For example, the advantage of this timing means is particularly apparent in those applications, such as welding controls, where accurate timing of welding operations is desired.

Another advantage of my electric time delay relay is that a standard type alternating current relay may be used in a normal manner in the system without requiring the use of additional current limiting means to prevent overload or overheating of the actuating coil of the relay. Furthermore, when two electric discharge devices are employed, the current in each discharge device is less than in a single valve system. Con-

sequently, larger ratings can be obtained without exceeding the ratings of the electric discharge devices.

While I have shown and described my invention as applied to a particular system of connections and as embodying various devices diagrammatically shown, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. A time delay relay comprising a source of alternating voltage, an electric discharge device having an anode, a cathode and a grid and connected to be energized from said source, means comprising a capacitance energized from said source for impressing on said grid a hold-off potential, a load circuit, a contactor mechanism having contacts connected in series relation with said load circuit and having an actuating coil which is energized in series relation with the anode-cathode circuit of said discharge device, a second electric discharge device connected across the anode and cathode of the first-mentioned discharge device and being poled in opposition thereto, means responsive to the conductivity of the first-mentioned discharge device for controlling the conductivity of said second discharge device, and a switch connected in series relation with said actuating coil across said source for controlling the charge of said capacitance.

2. In combination, an alternating current circuit, an electric circuit, means for controlling the energization of said electric circuit comprising an electric discharge device having an anode, a cathode and a grid, means comprising a capacitance connected to said alternating current circuit for impressing a bias voltage on said grid tending to maintain said discharge device non-conducting, a relay having a contact in said electric circuit and an operating coil connected in the anode-cathode circuit of said electric discharge device, a second electric discharge device having a grid and being connected across the anode and cathode of the first-mentioned discharge device and poled in opposition thereto, means for impressing on the grid of the second discharge device a voltage for controlling the conductivity thereof in response to the conductivity of the first-mentioned discharge device, and circuit controlling means for controlling said capacitance and for rendering the first-mentioned discharge device conducting a predetermined interval of time after operation thereof to operate the contact in said electric circuit with a time delay.

3. A time delay relay comprising a source of alternating voltage, an electric discharge device having an anode, a cathode and a grid, means energized from said source and comprising a capacitance for impressing on said grid a negative biasing potential tending to maintain said discharge device non-conducting, a load circuit, a contactor mechanism having contacts connected in series relation with said load circuit and having an actuating coil connected in series relation with the anode-cathode circuit of said discharge device, a second electric discharge device connected across the first-mentioned discharge device and being poled in op-

position thereto and having a grid, means energized from said source for impressing a hold-off voltage on the grid of said second discharge device and responsive to the conductivity of the first-mentioned discharge device, and a switch connected in series relation with said actuating coil across said source and being arranged to effect charge of said capacitance through the grid-cathode circuit when in the open circuit position and to effect discharge of said capacitance when in the closed circuit position to render said electric discharge devices conducting a predetermined interval of time after the closure thereof.

4. In combination, an alternating current circuit, a load circuit, and time delay means for controlling the energization of said load circuit comprising an electric discharge device having an anode, a cathode and a control grid, means for controlling the potential of said control grid including a voltage divider connected across said alternating current circuit and a capacitance connected between a point of said voltage divider and said grid, a second electric discharge device connected across the anode and cathode of the first-mentioned discharge device and being poled in opposition thereto, means for controlling the potential of the grid of said second discharge device in response to the magnitude of the voltage appearing across the anode and cathode of said first-mentioned discharge device during half cycles of voltage of predetermined polarity comprising a capacitance and a unidirectional conducting device so that said second discharge device conducts current during only those positive half cycles of applied voltage immediately succeeding half cycles of conduction of the first-mentioned discharge device, a relay having a contact controlling the energization of said load circuit and an operating coil connected in circuit with the anode-cathode circuits of said electric discharge devices, and circuit controlling means connected to the first-mentioned discharge device for controlling the charging and discharging operations of the first-mentioned capacitance to control the energization of the operating coil of said relay.

5. In combination, an alternating current circuit, a load circuit, means for controlling the energization of said load circuit comprising an electric discharge device having an anode, a cathode and a control grid, means energized from said alternating current circuit for controlling the potential of said grid and comprising a voltage divider and a capacitance connected to said grid, a second electric discharge device connected in opposition across the anode and cathode of the first-mentioned discharge device and including a grid, a second capacitance connected to the grid of said second discharge device, polarity responsive means for charging said second capacitance in response to the voltage appearing across said first-mentioned discharge device, and switching means connected in circuit with the anode-cathode circuit of said first-mentioned discharge device for controlling the charging and discharging operations of the first-mentioned capacitance.

6. In combination, an alternating current circuit, an electric circuit, means for controlling the energization of said electric circuit and comprising an electric discharge device having an anode, a cathode and a grid, means for controlling the potential of said grid comprising a voltage divider connected across said alternating current circuit

and a capacitance connected between a point of said voltage divider and said grid, a second electric discharge device connected across the anode and cathode of the first mentioned discharge device and poled in opposition thereto, said second discharge device having a grid, means for impressing on the grid of said second discharge device a voltage tending to maintain said second discharge device normally non-conducting and to increase the potential of the grid in a positive direction in response to conduction by the first-mentioned discharge device, a relay having a contact connected to control said electric circuit and an operating coil connected in circuit with the anode-cathode circuits of said electric discharge devices, and a switch connected to the first-mentioned discharge device to effect charge of said capacitance when in the open circuit position to maintain said discharge device non-conducting and to initiate discharge of said capacitance when in the closed circuit position thereby rendering the first-mentioned discharge device conducting a predetermined interval of time after the closure thereof to effect energization of the operating coil of said relay with a time delay.

7. In combination, an alternating current circuit, a relay mechanism comprising an actuating coil and contacts, an electric circuit connected

to said contacts, and means for transmitting alternating current to said actuating coil a predetermined interval of time after a predetermined circuit controlling operation and comprising an electric discharge device having an anode, a cathode and a control grid, means for controlling the potential of said grid comprising a voltage divider connected across said alternating current circuit and a capacitance connected between a point of said voltage divider and said control grid, a second electric discharge device connected across the anode and cathode of the first-mentioned discharge device and being poled in opposition thereto, means for controlling the potential of the grid of said second discharge device comprising a circuit responsive to the voltage appearing between said anode and said cathode and including a second capacitance and a unidirectional conducting device for charging said second capacitance during the positive half cycles of voltage applied to said anode and said cathode, and circuit controlling means comprising a switch connected to the first-mentioned discharge device for controlling the charging and discharging operations of the first-mentioned capacitance and for controlling the potential of the first-mentioned grid.

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