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ELECTRONIC TIMER

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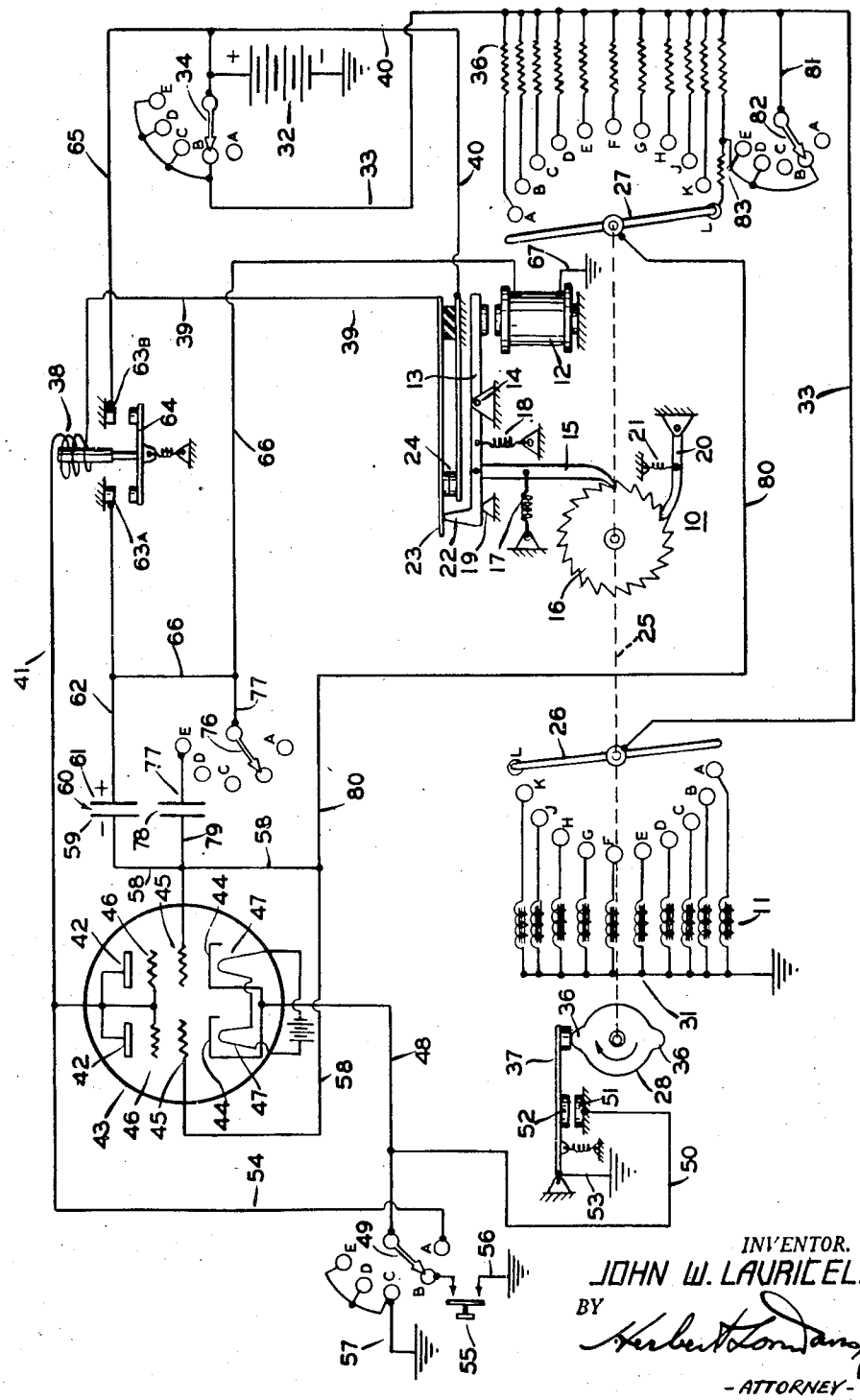

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ELECTRONIC TIMER

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7 Claims. (Cl. 171—97)

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The invention relates to improvements in electrical timing apparatus of the type disclosed in the copending application Serial No. 607,736, filed July 30, 1945 by Dwight Wilson Bloser and more particularly to that type of timing apparatus wherein a series of load devices are sequentially operated for a predetermined time and there is automatically provided a predetermined interval of time between cycles of operation.

An object of the invention is to provide improved electrical timing apparatus controlled by the charged condition of a capacitor or condenser.

Another object of the invention is to provide an electronic timer of the type described in which a charging circuit for the capacitor is completed through the grid and cathode of an electronic control valve.

Another object of the invention is to provide a novel relay switch having the double function of closing the charging circuit of the capacitor and the energizing circuit of a stepper relay.

Another object of the invention is to arrange the latter relay switch so as to effect a discharging circuit for the capacitor upon opening and the shifting of the stepper switch.

Another object of the invention is to provide an electronic timer having a stepper relay and a novel operator-controlled switch effective for shunting the electronic valve so that during operation of said timer, the stepper switch may at will be returned to a predetermined home position.

Another object of the invention is to provide improved timing apparatus for controlling the periods of inflation of a series of solenoid controlled inflatable elements or boots for preventing the accumulation of ice on or the removal of ice from aerofoil surfaces of an aircraft. The latter system of inflatable elements may be of the type described and claimed in the copending applications Serial No. 498,248 of Donald M. Lawrence, David Gregg and Myron L. Taylor, filed August 11, 1943, and application Serial No. 498,250 of Myron L. Taylor, William B. Pond and Herbert A. Eayrs, filed August 11, 1943.

These and other objects and features of the invention are pointed out in the following description in terms of the embodiment thereof which is shown in the accompanying drawings. It is to be understood, however, that the drawings are for the purpose of illustration only, and are not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

The drawing is a diagrammatic view illustrating an electrical timing circuit embodying the invention.

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Referring now to the drawing, there is shown a system for timing the operation of a stepper relay 10 which controls the energization of a series of loads 11, indicated as a plurality of electromagnets. The electronic timer is particularly adapted for use in conjunction with the manifold type of inflatable ice eliminating systems described in the aforenoted copending application. The electromagnets 11 may serve upon energization to open the boot-inflating valves automatically in the proper sequence and for proper time intervals.

The stepper relay 10 may be of a conventional type comprising an electromagnetic winding 12 which controls the movement of an armature 13 pivotally supported at 14. A ratchet arm 15 is pivotally mounted on the armature 13 and is biased into engaging relation with a ratchet wheel 16 by a spring 17. A second spring 18 biases the armature 13 in a counterclockwise direction into contacting relation with a stop 19. A pawl 20 is biased into engaging relation with the teeth of the ratchet wheel 16 by a spring 21 so as to prevent rotation of the ratchet wheel 16 in a counter-clockwise direction.

It will be readily seen from the foregoing that upon energization of the electromagnet 12 the armature 13 will be pivoted in a clockwise direction in opposition to the force of the spring 18 causing the ratchet arm 15 to engage the next succeeding tooth of the ratchet wheel 16. At the extreme limit of movement of the armature 13 an actuating member 22 carried thereby engages the free end of a leaf spring 23 so as to open the contacts of a switch 24.

The opening of the switch 24 breaks the circuit of the electromagnet 12, as will be explained hereinafter, causing de-energization of the electromagnet 12, whereupon the spring 18 actuates the armature 13 in a counterclockwise direction causing the pawl 15 to impart an increment of movement to the ratchet wheel 16 in a clockwise direction.

The ratchet wheel 16 is connected through a suitable shaft 25 indicated herein by dotted lines to switch arms 26 and 27, and a cam 28.

The switch arms 26 and 27 are each arranged to contact in succession a series of contacts 26A—L and 27A—L. The switch arms 26 and 27 move from one contact to the next succeeding contact for each increment of movement imparted to the ratchet wheel 16 by the stepper relay 10 and upon one end of the switch arm

moving out of contacting relation with the contact L the opposite end closes the contact A.

The switch contacts 26A—K are connected respectively through suitable electrical conductors to one terminal of corresponding load devices or electromagnets 11. The opposite terminal of the electromagnets 11 are connected by an electrical conductor 31 to the negative terminal of a source of electrical energy 32 through a grounded connection.

The switch arm 26 is connected by a conductor 33 through a control switch 34 to the positive terminal of the source of electrical energy 32. The switch 34 controls contacts 34A—E. Contact 34A is open, while contacts 34B to E are connected to conductor 33.

The contact 26L is an open contact so that upon the switch arm 26 contacting the same, the circuit to all of the load devices 11 are open for a purpose which will appear hereinafter.

The switch arm 27 is arranged to sequentially close contacts 27A—L connected to suitable resistor elements 36 which are in turn connected at the opposite end to conductor 33 for a purpose which will be explained hereinafter.

The shaft 25 also drives a cam 28 having portions 36 arranged to actuate an off normal switch 37 to an open position upon the switch arms 26 and 27 being positioned so as to close the respective contacts 26L and 27L. Upon the switch arms 26 and 27 being adjusted into contacting relation with one of the other contacts, the cam 28 permits the switch 37 to close for purposes which will be explained.

A relay winding 38 has one terminal connected by an electrical conductor 39 through the normally closed switch 24 and a conductor 40 to the positive terminal of the source of electrical energy 32. The opposite terminal of the winding 38 is connected by an electrical conductor 41 to an anode or plate 42 of an electronic valve 43.

The electronic valve 43 has cathodes 44, control grids 45, shield grids 46, heater or filaments 47 and the plates 42.

The cathodes 44 are connected by a conductor 48 to a manually operable selector switch 49 and through a conductor 50 to one contact 51 of the off normal switch 37. The opposite contact 52 is connected through the switch arm 37 and a grounded conductor 53 to the negative terminal of the source of electrical energy 32.

The switch 49 cooperates with switch contacts 49A—E. A conductor 54 leads from the contact 49A to the conductor 41 so that upon switch arm 49 closing contact 49A the electronic valve 43 may be effectively shunted.

Contact 49B may be connected through a push button switch 55 to the negative terminal of the source of electrical energy 32 through a grounded conductor 56. Thus upon switch 49 closing contact 49B, the cathodes 44 of the electronic valve 43 may be directly connected to the negative terminal of the source of electrical energy 32 by closing the push button 55.

The remaining switch contacts 49C, 49D and 49E are connected to the negative terminal of the source of electrical energy 32 through a grounded conductor 57. Thus the cathodes 44 may be connected to the negative terminal of the source of electrical energy 32 by adjustment of switch 49 so as to close contacts 49C, 49D or 49E.

The electron flow from the cathodes 44 to the plates 42 is controlled by grids 45 connected by a conductor 58 to a plate 59 of a condenser 60. The opposite plate 61 of the condenser 60 is

connected by a conductor 62 to a contact 63A of a normally open switch 64 controlled by the electromagnetic relay winding 38. An opposite contact 63B is connected by a conductor 65 to the conductor 40 and thereby to the positive terminal of the source of electrical energy 32.

A conductor 66 leads from the conductor 62 to the relay winding 12 which is connected at its opposite terminal through a grounded conductor 67 to the negative terminal of the source of electrical energy 32.

Thus energization of relay winding 38 causes in turn relay 12 to be energized, whereupon switch 24 is actuated to an open position, thereby effecting de-energization of winding 38, opening of switch 64 and de-energization of the stepper relay winding 12.

A switch arm 76 is connected by a conductor 77 to the conductor 66. The switch arm 76 cooperates with switch contacts 76A—E. The contacts 76A, 76B, 76C and 76D are open contacts, while the contact 76E is connected by a conductor 77 to a second capacitor or condenser 78 connected by conductor 79 to the conductor 58 and across the capacitor 60 upon the closing of the switch contact 76E so as to increase the capacity of the timing condenser.

A conductor 80 leads from the conductor 58 to the stepper relay switch arm 27. Thus the plate 59 of the capacitor 60 is connected by the conductors 58 and 80 to the switch arm 27 which, as previously described, is arranged to close sequentially the contacts 27A through L.

Leading from the contacts 27A through L, respectively, are the resistors 36A—L each of a value sufficient to effect a predetermined discharge period for capacitor 60 or time interval for energizing the load device 11 corresponding thereto. The resistors 36A—L may be of different value so as to effect different time intervals of operation for each load device.

Leading from the opposite terminals of the resistors 36A—L is the conductor 33. Connected to the conductor 33 by a conductor 81 is a switch arm 82 for cooperating with contacts 82A—E. The conductor 81 connects the switch arm 82 to the positive terminal of the source of electrical energy 32.

The switch arm 82 is arranged to selectively contact one of the five contacts including two open contacts 82A and 82C and three contacts 82B, 82D and 82E connected by an electrical conductor 83 to the resistor 36L at a point intermediate the opposite ends of the latter resistor.

It will be seen then that when the switch arm 82 closes one of the contacts 82B, 82D and 82E, a portion of the resistor 36 leading from the contact 27L will be shunted out of the circuit leading from the positive terminal of the source of electrical energy 32 and the plate 59 of the condenser 60. However, upon the switch arm 82 contacting one of the open contacts 82A and 82C, the full resistance of the resistor 36 leading from the contact 27L will be inserted in the latter circuit.

The control switches 34, 49, 76 and 82 may be arranged for operation in unison from a single control or may be manually adjusted separately as desired.

Operation

The foregoing electronic timer is particularly designed for use in conjunction with the manifold type of ice eliminating system for airfoil surfaces of aircraft and is arranged to open the boot in-

flating valves automatically in the proper sequence for the proper time intervals. Since ice does not form at the same rate or to the same degree on all occasions, a certain flexibility of control has been incorporated to permit the operator to vary certain components of the system to suit the prevailing conditions.

Referring to the drawing, and with the control switches in the position shown, operation is initiated by closing the push button 55.

The cathodes 47 are then connected through the push button 55 to the negative terminal of the source of electrical energy 32. The bias applied at the grids 45 is positive at the time the push button 55 is closed since the grids 45 are connected through the switch arm 27 and contact 27L to the positive terminal of the source 32. Thus a large plate current flows effecting energization of the relay winding 38 causing switch 64 to close contacts 63A and 63B. The closing of the switch 24 then effects a charging circuit for the capacitor 60 in which the electronic flow from the cathodes 44 to the grids 45 and through the conductors 58 applies a negative charge to the plate 59 of the capacitor 60, while a positive charge is applied to the plate 61 through conductor 62, switch 64, conductor 65 and conductor 40 to the positive terminal of the source of electrical energy 32.

The closed relay switch 64 thus causes the condenser 60 to become quickly charged and in turn the relay winding 12 to become energized so as to open the switch 24 in the plate circuit.

The opening of the interrupter switch 24 then cuts off the plate current, which de-energizes the relay winding 38 which opens switch 64 and the energizing circuit for the stepper relay winding 12. The spring 18 then draws the armature 13 downward in a counterclockwise direction and effects movement of the ratchet gear 16 together with the stepper switches 26 and 27 to a position closing contacts 26A and 27A respectively and energizing circuit 11A.

Upon the opening of switch 64, the direction of electron flow relative to the condenser 60 reverses and the condenser 60 discharges. Thus, upon the opening of switch 64, there is an electron flow to the positively charged plate 61 of the condenser 60 through grounded conductor 67, stepper relay winding 12, conductor 66, and conductor 62. The negatively charged plate 59 of the condenser 60 discharges through the conductor 58, conductor 80, stepper relay switch 27, contact 27A, resistance 36A, conductor 33 and through switch 34 to the positive terminal of the source 32.

The negative charge on the plate 59 of the condenser 60 applies a negative bias to the grids 45 through conductor 58 which is sufficient to keep the grid biased beyond cut off for a predetermined period dependent upon the value of the resistance 36 connected in the discharging circuit through operation of the stepper relay switch 27.

The charge on the condenser 60 is thus gradually neutralized through the resistance 36 until the bias on the grids 45 becomes sufficiently positive to allow enough plate current to flow to again effect energization of relay winding 38 so as to close switch 64. The time required is dependent upon the time constant of the resistor 36 and capacitor 60.

When the relay winding 38 is energized closing switch 64, the condenser 60 is again recharged. The normally open switch 64 remains closed until the interrupter contacts 24 are opened momentarily by energization of the stepper relay 12 opening the circuit for the relay winding 38 and deenergizing the stepper relay 12 so as to cause the stepper switches 26 and 27 to advance to position 26B and 27B respectively. A new timing interval then begins during which circuit 11B is energized.

Similarly the load circuits 11C—11K are energized for time intervals depending upon the value of the then connected resistor 36 and condenser 60. However, upon the stepper switch 27 moving to a position closing contact 27L, the cam 28 is adjusted so as to position the portion 36, as shown in the drawing, so as to open the off normal switch 37, whereupon no power is then supplied to the cathodes 44. In order to initiate operation with the control switch 49 in the position shown, the push button 55 must be pressed so as to complete the cathode circuit through the grounded connection 56 to the negative terminal of the source 32. As soon as the stepper switches 26 and 27 have moved to position A as described, the cam 28 is also adjusted so as to permit switch 37 to close contacts 51 and 52 and thereby connect the cathodes 44 through grounded conductor 53 to the negative terminal of the source 32. At the end of the cycle, cam 36 is adjusted through shaft 25 so as to once again actuate switch 37 so as to open the contacts 51 and 52.

If control switch 49 is adjusted so as to close contacts C, D or E, the cathodes 44 are connected through grounded conductor 56 to the negative terminal of the source 32 and hence in this position of control switch 49, the operation is continuous between cycles.

If control switch 82 be adjusted so as to close open contact 82C, a high resistance 36L gives a "dwell" of, for example, approximately 60 seconds between cycles, if switch 49 closes contacts 49C, 49D or 49E. If control switch 82 be adjusted to close contacts 82D or 82E, the greater portion of resistor 36L is short circuited making the operation substantially continuous without dwell, provided, of course, switch 49 closes contacts 49C, 49D or 49E. If in addition switch 76 be adjusted so as to close contact 76E, the additional condenser 78 is switched into the timing circuit and coacts with condenser 60 so as to increase all time intervals by a predetermined value of, for example, fifty per cent.

In addition, the circuit has a "homing" characteristic, that is; if the control switch 49 be adjusted so as to close the contact 49A during a timing cycle, the stepper switches 26 and 27 will return without delay to the starting or L position. This is accomplished by the application of power directly through the off normal switch 37 and contact 49A to the relay 38 closing relay switch 64 and causing the stepper relay 12 to continuously operate the stepper switches 26 and 27 until the energizing circuit for the relay winding 38 is opened by the off normal switch 37 at the end of the cycle of operation.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangements of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A time delay circuit controlling apparatus comprising an electronic valve having an anode,

a cathode, and a control grid, a first electromagnetic winding, a first circuit including said anode, cathode, and first winding, a capacitor to supply a bias to said control grid upon discharging, a second electromagnetic winding, a switch element controlled by said first winding for closing a charging circuit for said capacitor and an energizing circuit for said second winding, a second switch element controlled by said second winding for opening the first circuit upon energization of the second winding, and a discharging circuit for said capacitor effective upon the opening of said first circuit.

2. The combination defined by claim 1 in which said charging circuit includes the cathode and grid of said electronic valve.

3. The combination defined by claim 1 in which said discharging circuit includes said second winding and additional means for retarding the discharge of said capacitor, whereby the control bias is applied to said grid for the time of said delay, and means for varying said retarding means, said last mentioned means controlled by said first and second windings.

4. The combination defined by claim 1 in which said charging circuit includes the cathode and grid of said electronic valve, and the discharging circuit includes said second winding and additional means for retarding the discharge of said capacitor, whereby the control bias is applied to said grid for the time of said delay, and means for varying said retarding means, said last mentioned means controlled by said first and second windings.

5. A time delay circuit controlling apparatus comprising an electronic valve having an anode, a cathode, and a control grid, a first electromagnetic winding, a first circuit including said anode, cathode and first winding, a capacitor to supply a bias to said control grid upon discharging, a second electromagnetic winding, a switch element controlled by said first winding for closing

a charging circuit for said capacitor and an energizing circuit for said second winding, a second switch element controlled by said second winding for opening the first circuit upon energization of the second winding, a discharging circuit for said capacitor effective upon the opening of said first circuit, said discharging circuit including said second winding and resistor means for retarding the discharge of said capacitor, whereby the control bias is applied to said grid for the time of said delay, and means varying said resistor means, said last mentioned means operated by said second winding and controlled by said first winding.

6. A time delay circuit controlling apparatus comprising an electronic valve having an anode, a cathode and a control grid, a first electromagnetic winding, a first circuit including said anode, cathode and first winding, a capacitor to supply a bias to said control grid upon discharging, a stepper relay, a switch element controlled by said first winding for closing a charging circuit for said capacitor and an energizing circuit for said stepper relay, a second switch element controlled by said stepper relay for opening the first circuit upon energization of the stepper relay, a discharging circuit for said capacitor effective upon the opening of said first circuit, and a plurality of load devices, said stepper relay sequentially closing energizing circuits for said load devices for time intervals dependent upon the discharge period of said capacitor.

7. The combination defined by claim 6 in which there is included a manually operable switch means for shunting said anode and cathode so as to effect energization of said first winding and undelayed operation of said stepper relay, and means actuated by said stepper relay for opening said shunt circuit upon said stepper relay reaching a home position.

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