Sept. 25, 1945. J. EATON 2,385,616

SEQUENCE CONTROL SYSTEM

Filed July 1, 1943

Fig. 1.

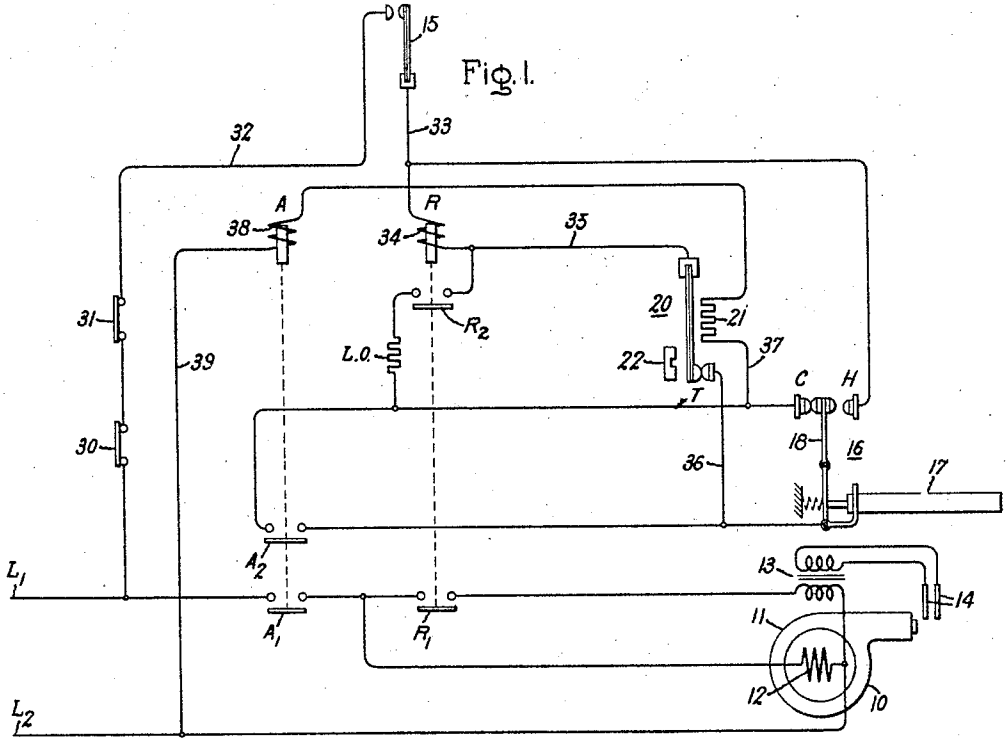


Fig. 2.

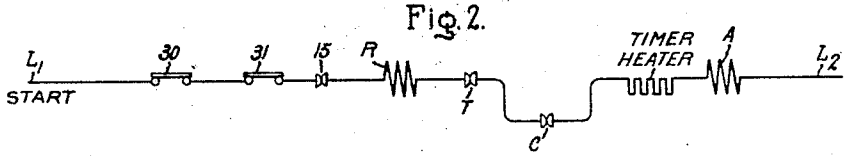


Fig. 3.

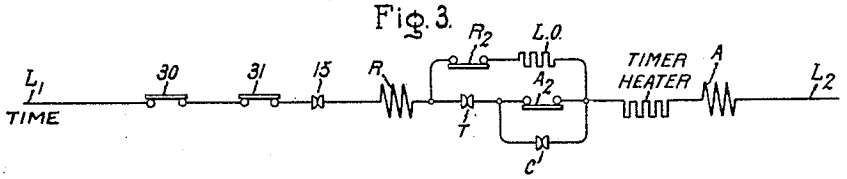


Fig. 4.

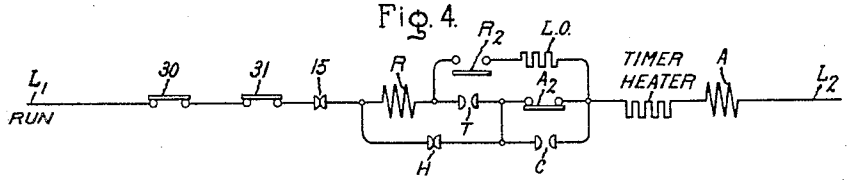
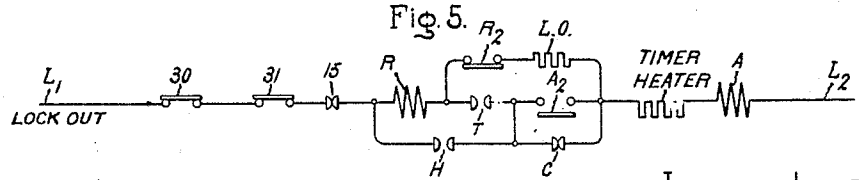


Fig. 5.



Inventor:
John Eaton,
by Harry E. Dunham
His Attorney.

Patented Sept. 25, 1945 2,385,616

UNITED STATES PATENT OFFICE

2,385,616

SEQUENCE CONTROL SYSTEM

John Eaton, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application July 1, 1943, Serial No. 493,066

11 Claims. (Cl. 175—320)

The invention relates to sequence control systems, particularly automatic combined timing and condition responsive sequence control systems, suitable for controlling oil burners or other devices which require an automatic safety lockout in case a prerequisite condition is not established within a predetermined time interval after starting operation of the device to control another condition.

My prior Patents 2,085,577 and 2,278,252, and also my application Serial No. 493,008, filed concurrently herewith, disclose and claim certain improvements in sequence control systems of the above type.

One of the objects of the present invention is to further improve sequence control systems of the above type by providing an improved form of electrical safety lockout.

A more specific object is to provide an improved form of control system employing an electrically heated thermal timer and a pair of electrically differentiated relays selectively energized for providing a combined time and condition responsive sequence control and a safety lockout.

A further object is to provide an improved series and multiplex shunt circuit combination for enabling the thermal timer and the pair of electrically differentiated relays to provide not only automatic safety lockout but also undervoltage protection, and insure that the control will start the burner or other device controlled thereby only when all of the control elements have returned to their initial starting position.

Other objects and advantages of the invention will appear in the following description of the accompanying drawing in which Fig. 1 is a schematic circuit diagram of an oil burner control system embodying the improvements of the present invention; and Figs. 2, 3, 4, and 5 are simplified line diagrams of the control circuits of Fig. 1 showing more clearly the series and multiplex shunt control connections established during start time, run and lockout phases of operation of the burner control system shown in Fig. 1.

In Fig. 1 the oil burner 10 is shown as of the usual type having a driving motor 11 provided with an operating winding 12. The combustible mixture of oil and air provided by burner 10 upon energization of the operating winding 12 is ignited by means of the ignition transformer 13 and the ignition arc electrodes 14.

The burner 10 is operated automatically under the control of the master switch 15 which may be a room thermostat, an aquastat, or a pressurestat, or responsive to any other condition that is to be regulated by operation of the burner 10.

The automatic operation of burner 10 also is under the control of a safety condition responsive switch 16 which, in the form shown, is responsive to the absence and presence of combustion and has the expansible tube 17 located to be heated when combustion is established for operating the slip clutch contact arm 18 from the cold position C in which it is shown to the hot position H.

A thermal timer 20 having an electric heater 21 is arranged to open the timed switch T at the end of a predetermined heating interval, a snap action opening and closing of switch T being provided by the permanent magnet 22.

A pair of electrically differentiated relays A and R are interconnected in series circuit with the master condition responsive switch 15, the prerequisite condition responsive switch 16, and the thermal timer 20 so as to be initially controlled by the master switch 15 and then selectively controlled by the prerequisite condition responsive switch 17 and the thermal timer 20. The main relay A is provided with a main contact A_1 for controlling the energization of the burner motor operating winding 12. Relay A also is provided with an auxiliary contact A_2 for controlling the opening and closing of one of the shunt circuits involved in the improved control system of the present invention.

The auxiliary relay R is provided with a main contact R_1 for closing and opening the energizing circuit of the primary winding of the ignition transformer 13, which, it will be observed, is energized in parallel with the motor operating winding 12 when both the relay switches A_1 and R_1 are closed. The auxiliary switch R_2 controls the opening and closing of another shunt circuit involved in the improved sequence control system of the present invention. This shunt circuit includes the lockout resistor L0.

In accordance with the present invention, the two relays A and R are provided with separate operating electromagnets electrically differentiated so as to have different minimum energization response, that is, relay A will drop out at a higher energization value than the value required to drop out relay R, both of the relays being biased to their drop-out positions in which they are shown.

Operation

When the master condition responsive control switch 15 closes its contacts, the main series energizing circuit is established from supply line L1 through the safety limit switches 30, 31, con-

ductor 32, master switch 15, conductor 33, the operating winding 34 of relay R, conductor 35, the normally closed time switch T, conductor 36, the prerequisite condition responsive switch arm 18 in its initial position C in which it is shown, conductor 37, the heater 21, the operating winding 38 of relay A, and conductor 39, to the other supply line L2. If low voltage energization of the control circuits is desired, the circuit as just described may be energized from the secondary of a voltage reducing transformer having its primary permanently connected across the supply lines L1, L2.

Upon closure of the main series control circuit, which is separately shown in Fig. 2, by the master switch 15, the operating windings of both relays A and R, together with the thermal timer heater 21, are simultaneously energized. Both relays A and R pick up and close their respective main and auxiliary contacts. As a result of closure of the main contacts A_1 and R_1, the operating winding 12 of the oil burner motor is energized to start operation thereof to project a combustible mixture of oil and air from the burner nozzle. At the same time the ignition transformer 13 is energized in parallel with the motor operating winding 12 to establish an ignition arc at the electrodes 14 to initiate the establishment of combustion. Also at the same time, the heater 21 is energized to start heating of the thermal timer 20 so as to effect opening of the timer switch T at the end of a predetermined heating interval. However, the closure of auxiliary contact R_2 completes the lockout shunt circuit including the lockout resistor L0 for shunting the timer contact T. This shunt circuit shunts both the timer contact T and the cold flame detector contact C, as indicated in Fig. 3. Furthermore, the closure of auxiliary switch A_2 separately shunts the flame detector cold contact C.

The improved control system continues in operation with the two shunt connections made, as shown in Fig. 3, during the predetermined heating time of the thermal timer 20. Thus the opportunity is afforded for the oil burner to successfully establish combustion during this interval.

In case combustion is successfully established, then the combustion responsive switch 16 will respond to move its contact arm 18 from the cold contact C to the hot contact H. The opening of the cold contact C, however, leaves the lockout resistor L0 still in shunt with the thermal timer contact T and the auxiliary contact A_2, as shown in Fig. 4. The closure of the flame detector hot contact H establishes a third shunt circuit extending around the operating winding of relay R and the timer contact T. Thus, as soon as the closure of the hot contact H occurs, relay R is in effect short-circuited and thereby deenergized. As a result, relay R opens its main contact R_1 to deenergize the ignition transformer 13. At the same time, relay R opens its auxiliary contact R_2 to open the lockout shunt circuit including the lockout resistor L0. This leaves the operating winding of the main control relay A energized in series with the timer heater 21 with the burner running control circuit extending in series through the auxiliary contact A_2, the hot contact H of the flame detector and the master switch 15. Thus in case of voltage failure, relay A will become deenergized to stop operation of the burner 10 and also open the auxiliary contact A_2 to insure that all the control elements return to their initial positions before the burner 10 can be restarted. Also if for some reason the burner combustion should fail so that the flame detector hot contact H opens, then relay A also becomes deenergized to stop the burner and opens its auxiliary contact A_2 to insure the same result. Likewise, whenever the master switch responds to open its contacts, relay A is deenergized to stop operation of the burner and insure return of all the parts to their initial positions.

In case combustion is not successfully established before the end of the predetermined heating period of the thermal timer 20, then the flame detector cold contact C will remain closed and the hot contact H will remain open. As a result, when the thermal timer switch T is opened, as shown in Fig. 5, the lockout shunt circuit closed by auxiliary contact R_2 and including the lockout resistor L0 becomes effective to maintain the series energizing current of relay R through the heater 21 and the operating winding of relay A at a value which is below the minimum energization response value of relay A but above the minimum energization response value of relay R. Consequently, relay A will drop out and thus return its contacts to the circuit opening position in which they are shown in Fig. 1. The opening of contact A_1 will stop the burner 10 while the opening of contact A_2 will remove the separate shunt circuit from the flame detector cold contact C. However, the timer heater 21 will remain effectively energized along with relay R so as to maintain the timed switch T open until the relay R is deenergized by opening of the circuit controlled by the master switch 15. This may be accomplished by opening the main switch controlling the power supply lines L1, L2. When relay R is thus deenergized, then its auxiliary contact R_2 opens the shunt circuit through the lockout resistor L0 and restores all of the parts to their initial positions.

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

1. In a control system, a pair of control devices having separate electrically differentiated electroresponsive operating means and an electric heater connected to be energized therewith in a series circuit having normally closed thermally actuated switching means therein opened by the heating action of said heater at the end of a limited heating period, and a current limiting shunt interconnected by one of said devices upon energization of said operating means thereof with said switching means for preventing both deenergization of said heater and said operating means of said one device and effective energization of said operating means of the other control device upon said opening of said switching means.

2. In a control system, a pair of control devices having separate electrically differentiated electroresponsive operating means, an electric heater connected to be energized in a series energizing circuit having said operating means therein and normally closed thermally actuated switching means therein opened by the heating action of said heater at the end of a limited heating period, a current limiting shunt interconnected by one of said devices upon energization of said operating means thereof with said switching means for preventing both deenergization of said heater and said operating means of said one device and effective energization of said operating means of the other control device upon said opening of said switching means, and means for shunting said shunt and said operating means of said one

device to maintain both said heater and said operating means of said other control device effectively energized upon said opening of said switching means.

3. In a sequence control system, a pair of control devices having separate electrically differentiated electroresponsive operating means energized in a series circuit having an electric heater therein and electro-thermal time switching means heated thereby for opening said circuit at the end of a heating period, a current limiting shunt interconnected by one of said devices upon energization of said operating means thereof with said time switching means for preventing both deenergization of said heater and effective energization of said operating means of the other of said devices after said period, and condition responsive switching means for shunting said operating means of said one device and said time switching means during said period to maintain said operating means of said other device and said heater effectively energized thereafter.

4. In a sequence control system, a pair of control devices having separate electrically differentiated electroresponsive operating means and a heater connected to be energized in a series energizing circuit having condition responsive switching means for closing said circuit and normally closed thermo-electric time switching means actuated by said heater for opening said circuit at the end of a heating period, a current limiting shunt interconnected by one of said devices upon energization of said operating means thereof with said time switching means for preventing both deenergization of said heater and effective energization of said operating means of the other of said devices after said period, and switching means responsive to a predetermined condition for shunting said operating means of said one device and said time switching means during said period to maintain said operating means of said other device and said heater effectively energized thereafter under the control of both said condition responsive switching means.

5. In a sequence control system, a pair of devices having separate electrically differentiated electroresponsive operating means and a heater connected to be energized in a series circuit having a pair of separate condition responsive switching means for closing said circuit and normally closed thermo-electric time switching means thereby energized for opening said circuit at the end of a heating period, a current limiting shunt interconnected by one of said devices upon energization of said operating means thereof with said time switching means for preventing both deenergization of said heater and effective energization of said operating means of the other of said devices after said period, a switch actuated by said other device upon energization of said operating means thereof for shunting one of said condition responsive switching means, and separate connections controlled by said one condition responsive switching means for shunting said operating means of said one device and said time switching means during said period to maintain said operating means of said other device and said time switching means effectively energized thereafter under the control of both said condition responsive switching means.

6. In a sequence control system, a pair of control devices having separate electrically differentiated electroresponsive operating means having a series energizing circuit provided with a pair of separate condition responsive switching means for closing said circuit and normally closed thermo-electric time switching means thereby energized for opening said circuit at the end of a heating period, a current limiting shunt interconnected by one of said devices upon energization of said operating means thereof in shunt with said time switching means for preventing both deenergization of said time switching means and effective energization of said operating means of the other of said devices after said period, a switch actuated by said other device upon energization of said operating means thereof for shunting said circuit around one of said condition responsive switching means, and separate connections controlled by said one condition responsive switching means for shunting said operating means of said one device and said time switching means during said period to maintain said operating means of said other device and said time switching means effectively energized thereafter under the control of both said condition responsive switching means.

7. A sequence control system having, in combination, a pair of control devices having separate electrically differentiated electroresponsive operating means, one responsive to a lower energization than the other, a thermal timer having electrical heating means connected to be energized in series circuit with said operating means of said devices to operate both said devices for a limited period and having a timed switch for opening said circuit at the end of said period, and a shunt circuit around said switch for maintaining said heating means energized after said period, said shunt circuit including a switch closed by said one device upon energization of said operating means thereof and a current limiting resistor for maintaining the energization of said heating means upon opening of said timed switch below the energization response of said operating means of the other of said devices and above the energization response of said operating means of said one device.

8. A sequence control system having, in combination, a pair of relays, each having a separate operating electromagnet one having a lower drop-out energization than the other, a thermal timer having electrical heating means connected to be energized in a series circuit with said operating electromagnets to pick up both said relays for a limited period and having a timed switch for opening said circuit at the end of said period, and a circuit for shunting said switch to maintain said heating means energized after said period, said shunt circuit including a switch closed by said one relay upon pick-up thereof and a resistor for reducing the energizing current of said heating means upon opening of said timed switch to a value below the dropout energization of said operating electromagnet of the other of said relays and above the drop-out energization of said operating electromagnet of said one relay.

9. A sequence control system having, in combination, a pair of control devices having separate electrically differentiated electroresponsive operating means, one responsive to a lower energization than the other, a thermal timer having electrical heating means connected to be energized in a series circuit with said operating means and having a timed switch for opening said circuit at the end of a predetermined heating period, a condition responsive switch connected in series with said timed switch for opening said circuit under predetermined conditions, and a circuit for shunting both said timed switch

and said condition responsive switch to maintain said heating means energized independently of both said switches after said period, said circuit including a switch closed by one of said devices upon energization of said operating means thereof and a resistor for maintaining the energization of said heating means upon opening of said timed switch below the minimum energization response of said operating means of the other of said devices and above the minimum energization response of said operating means of said one device.

10. A variable sequence control system having, in combination, a pair of control devices, a separate operating electromagnet for each device, said operating elctromagnets being responsive to different minimum energizations, means for variably controlling the energization of said operating electromagnets including a thermal timer having electrical heating means connected to be energized in series circuit with said operating electromagnets to effect joint operation of said devices for a limited period and having a timed switch for opening said circuit at the end of said period, a shunt circuit for shunting said switch to maintain said heating means energized after said period, said shunt circuit including a switch closed by one of said devices upon energization of said operating electromagnet thereof and a resistor for maintaining the energization of said heating means upon opening of said timed switch below the minimum energization response of said operating electromagnet of the other of said devices and above the minimum energization response of said operating electromagnet of said one device and condition responsive switching means for short-circuiting both said timed switch and said one device to effect the opening of said shunt circuit upon the occurrence of a predetermined condition before the end of said period and thereby maintain said operating electromagnet of said other device and said heating means effectively energized in series thereafter.

11. A sequence control system having, in combination, a pair of control devices, a separate operating electromagnet for each device, one responsive to a lower energization than the other, a thermal timer having electrical heating means connected to be energized in a series circuit with said operating electromagnets and having a timed switch for opening said circuit at the end of a predetermined heating period, a condition responsive two-way switch connected in series with said timed switch for closing said series circuit only in response to a predetermined condition, a first shunt circuit for shunting both said timed switch and said condition responsive switch to maintain said heater energized after said period, said first shunt circuit including a switch closed by said one device upon energization thereof and a resistor for maintaining the energization of said heating means upon opening of said timed switch below the minimum energization response of said operating electromagnet of the other of said devices and above the minimum energization response of said operating electromagnet of said one device and a second shunt circuit closed by said two-way switch around said timed switch and said operating electromagnet of said one device in response to the occurrence of a different predetermined condition before the end of said period for effecting the opening of said first shunt circuit and maintaining said operating electromagnet of said other device and said heater energized in series thereafter.

JOHN EATON.