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COMBUSTION APPARATUS PROGRAM CONTROL

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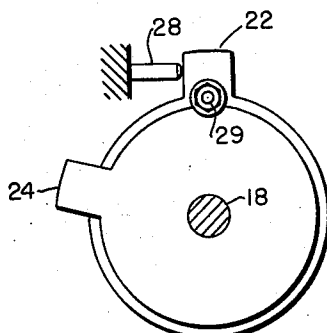
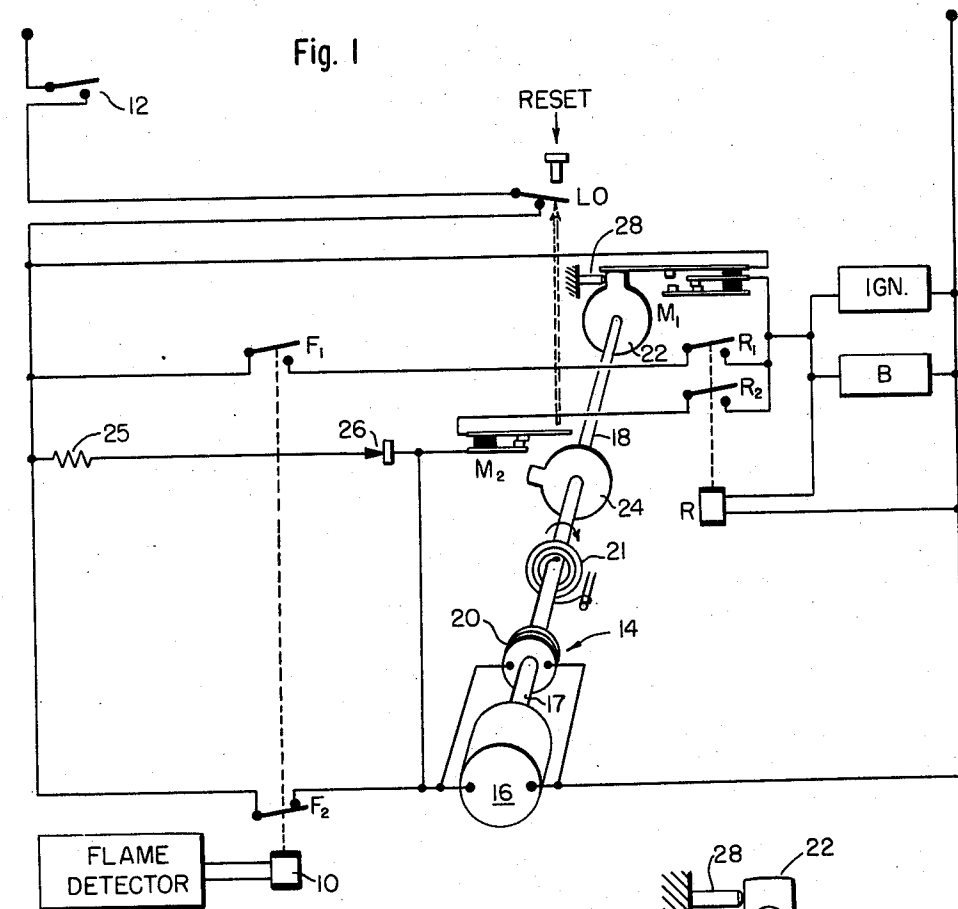
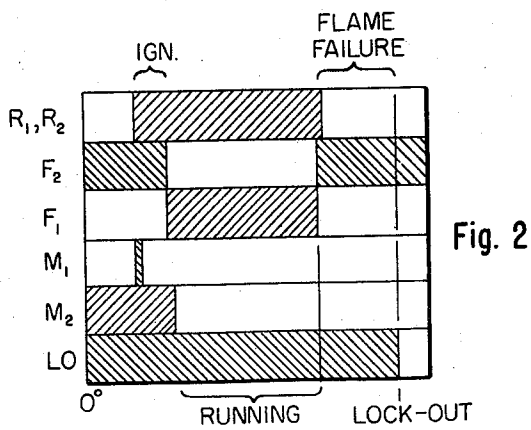


Fig. 3



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COMBUSTION APPARATUS PROGRAM CONTROL

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6 Claims. (Cl. 158—28)

This invention relates to control systems for combustion apparatus and comprises a novel program control system which operates in response to a flame detector to control electrically operated combustion apparatus.

Combustion apparatus is commonly operated automatically in response to a sensing device, such as a thermostat, by which the demand for heat is determined. Since safe operation requires that the apparatus be shut down in the event of a flame failure, a system for detecting the presence of a flame and for shutting down the apparatus when a flame is not detected is commonly employed. The present invention provides a programming system which operates in conjunction with both the demand sensing device and the flame detector to control the starting up of the apparatus and then to provide for its continued operation after ignition under the control of the flame detector.

In its operation the system first functions during a brief initial test period to prevent a startup if a flame is initially detected. Such would indicate an abnormal condition either because a flame is present or because the flame detector is not functioning properly. This initial test period is then followed by a startup period during which a first (startup) power circuit to the apparatus is provided to permit ignition of the burners. Following this, a running circuit is provided which permits continued operation of the apparatus so long as it functions normally. The running circuit is, however, under the control of the flame detector and will open if a flame failure occurs, and a lockout switch through which power to the entire circuit is drawn will then deenergize the system.

A feature of this invention accordingly is a pair of power circuits to the combustion apparatus, each of which is initially open so that startup will not occur until after the initial flame test period.

The invention further features timer operated means closing the startup power circuit for a predetermined time interval, then opening that circuit to place continued operation under a running circuit responsive to the flame detector.

The preferred control mechanism operating the circuits according to sequence utilizes switch actuating cams on a spring biased timer shaft which is driven through a magnetic clutch by an induction motor, the rotor of which will be held steady when energized with direct current. The motor is driven by alternating current through switches providing power when no flame is sensed and, also during the startup period, and the magnetic clutch is energized in parallel with the motor. A parallel rectifier circuit also energizes the motor and clutch, but in a manner holding the rotor, and through it the timer shaft, stationary during normal running conditions. Upon flame failure, however, an A. C. energizing circuit is again established and the motor is driven to a lockout condition shutting down the entire circuit.

The combustion apparatus itself, while forming no part of the invention, should be electrically operated such that startup and continued operation occur when power is

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supplied. In general, such apparatus will ordinarily take the form of a burner system requiring electrical power to place it in operating condition, and an electrically operated ignitor. The burner may accordingly be an oil burner to which fuel is supplied by means of a fuel pump powered by an electric motor, or a gas burner supplied with gas through an electro-magnetically operated solenoid valve. The ignitor may be a spark gap device of ordinary design.

In systems of this invention, the flame detector monitors the operation of the burner and provides a control means to which the system is responsive. Flame sensing devices are well-known in the art, and any of numerous types may be used if it is capable of providing for the switching operations controlled by it. Almost any flame sensing device may be adapted to provide electrical energization of a circuit, and may accordingly be easily adapted to this invention by the use of electro-magnetically operated switches or relays energized by the detector. A particularly suitable type of detector is described in detail in the copending application of Glenn E. Andrews and Fred B. Aubert, Serial No. 412,161, filed February 24, 1954, and in applicant's copending application Serial No. 575,141 filed concurrently herewith.

A preferred embodiment of this invention is described in detail below with reference to the accompanying drawings in which:

Fig. 1 is a schematic circuit diagram;

Fig. 2 is a chart showing the actuation sequence of the switches, and

Fig. 3 is a front elevation showing the switch actuating cams and means for varying the time between their functioning.

In the embodiment illustrated the combustion apparatus is shown diagrammatically as an ignitor and a burner, of conventional construction, each being electrically operated under the surveillance of a flame detector which also may be of conventional design. The flame detector functions to operate a relay coil 10 which actuates a normally open running switch F1 and a normally closed startup switch F2 when a flame is sensed, the order of actuation being to make before break.

The operating circuit is through a demand switch 12, operating to close when normal operations are to be begun, and a manually reset lockout switch LO by which the entire circuit may be opened.

The ignitor and burner may be powered by either of two parallel circuits. The first is a startup circuit through the normally closed flame detector operated startup switch F2 and a normally closed timer operated master switch M2. The other is a running circuit through the normally open flame detector operated running switch F1. Both of these circuits are initially open at relay switches R1 and R2, each being operated simultaneously by a relay coil R having an energizing circuit through a normally open timer operated relay energizing switch M1.

The timer 14 may be electrically powered through the normally closed startup switch F2 and through a parallel circuit through the normally open running switch F1, the relay switches R1 and R2 and the normally closed timer operated master switch M2. Its sequence of operation is first to make momentary contact at the relay energizing switch M1, to energize relay R and close switches R1 and R2 which then connect the relay coil across the line and provide a holding circuit.

A definite time interval thereafter the master switch M2 is opened to place the ignitor and burner under the control of the running circuit through the normally open flame detector operated running switch F1, which in normal operation will at this time be actuated through energization of the relay 10 by the flame detector.

The timer conveniently consists of an induction drive

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motor 16 having an output shaft 17 which connects with the timer shaft 18 through a magnetic clutch 20. The timer shaft 18 is biased at the startup position by a spring 21 which serves to return the shaft to its initial position when the clutch 20 is deenergized. Cams 22 and 24 carried by the timer shaft 18 serve to actuate in order switches M1, M2 and the lockout switch LO, when the motor 16 and clutch 20 are energized through the parallel circuits to them.

The running condition in which operation is entirely under the control of the actuated normally open flame detector operated running switch F1, depends on cam 24 holding the master switch M2 open. At this state the clutch 20 is energized and the motor shaft 17 is held stationary by direct current energization supplied by a rectifier circuit through a resistor 25 and rectifier 26 in parallel with the now open flame detector operated startup switch F2. With the master switch M2 open at this time, the rectifier circuit supplies the only current to the motor 16 which, being an induction motor, is held against rotation by the constant polarity supplied by this current. The clutch 20 is energized in this condition and the timer shaft 18 is accordingly held against rotation.

Timer units comprising an induction drive motor coupled magnetically to a spring biased timer shaft are well known in the art, and are available commercially. Such accordingly form no part of this invention and a more detailed description of their construction is not necessary to its understanding. Apparatus embodying a suitable unit of this type is described in U. S. Patent No. 2,548,604 to which reference may be had for further details.

The operation of the program control system involves operations which are shown schematically in the shaded operation sequence chart of Fig. 2, in which the shaded areas represent times when the respective switches are closed.

When the demand switch 12 closes upon signal, for instance from a thermostat, for heat, an open circuit to the combustion apparatus (the ignitor and burner) is presented since relay switches R1 and R2 are open. Under normal conditions, the circuit to the timer 14 is closed through the flame detector switch F2 and the timer starts its operation.

If, however, an abnormal condition has resulted in a false flame sensing such that relay coil 10 is energized, the circuit to the timer will be open at F2 and startup will not occur.

After a brief interval from the demand point, operation of the timer 14 closes momentarily a circuit at the relay energizing switch M1, through first closing of the open contact points followed by opening of the closed contact points, supplying an energizing current to relay coil R, whereupon relay switches R1 and R2 are closed, and through each of them a holding circuit for relay R is provided. At this point a startup circuit through the normally closed flame detector operated startup switch F2, the closed cam operated master switch M2 and the relay switch R2, permits operation of the ignitor and burner; combustion commences.

When under normal conditions the burner has ignited, the energization of the relay coil 10 by the flame detector causes the normally closed startup switch F2 to open immediately following the closing of the normally open running switch F1. A running circuit to the ignitor and burner is thereby provided through relay switch R1, and a parallel circuit to the timer 14 is provided through relay switch R2 and master switch M2. The timer 14 thus continues to function until the master switch M2 is opened by the cam 24. At this point only D. C. energization of the timer through the rectifier 26 is present and the timer and the switches M1 and M2 operated by it are held in their then condition, and running conditions are established through the running circuit through the now closed running switch F1.

If, however, during the normal ignition period the

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burner fails to ignite, an A. C. circuit to the timer 14 through the normally closed startup switch F2 is provided notwithstanding the opening of the master switch M2, and the timer is driven to open the lockout switch LO, which is shown as being actuated by continued rotation of cam 24 beyond the position at which the master switch M2 opens. When this occurs the entire circuit is rendered inoperative until the lockout switch is manually reset to closed position.

If, after normal burner operation has been established, a flame failure should occur, the running circuit through the running switch F1 will be immediately opened, and a circuit to the timer 16 through the standby flame switch F2 is closed. The A. C. energization then provided, drives the timer to the lockout position, as described above, by which the entire circuit is opened.

When deenergization of the timer 16 occurs, through opening of either the lockout switch LO or the demand switch 12, generally the latter, the clutch 20 is deenergized and permits the timer shaft 18 to return to its initial reset position, which is located by a stop member 28 to which the cam 22 returns.

Since the nature of the particular combustion apparatus with which the system of this invention may be used, and the proper duration of the ignition period will accordingly vary, an adjustment is preferably provided for the relationship between the cam 22, which causes the beginning of the ignition period through operation of the relay energizing switch M1, and the cam 24, which causes termination of the ignition period through opening of the master switch M2. As shown in Fig. 3, the cam 24 is mounted for rotation on the shaft 18 and is held in any desired relationship with the cam 22 by a bolt 29 which engages the edge of the cam 24 and permits it to be tightened against the face of the cam 22. This adjustment permits variation of the duration of the ignition period.

From the foregoing description it will be readily seen that this invention provides a simple, yet dependable and effective, programming system for combustion apparatus which may be used with, or adapted for use with, any of numerous types of equipment. In particular, its use is not limited to any particular type of flame detector of any particular type of burner or ignitor, since it is contemplated that the functions of the flame detector may be had with other types. Other equipment utilizing a pair of power circuits, one for startup and one for running, are similarly well-known in the art and may similarly be used in the program control system of this invention. Thus, although the invention has been described in detail with reference to a preferred embodiment, it is contemplated that obvious modifications will occur to men skilled in the art and that such may be made without departing from the scope of the invention.

Having thus disclosed my invention and described in detail a preferred embodiment thereof, I claim and desire to secure by Letters Patent:

1. In a combustion control circuit for energizing electrically operated combustion apparatus during normal operation in response to a flame detector: a program system comprising a first power circuit to said apparatus including a normally open flame detector responsive switch and a first normally open relay switch; a second power circuit in parallel with said first power circuit including a normally closed flame detector responsive switch, a normally closed timer operated switch and a second normally open relay switch; electromagnetic means for actuating said relay switches and a holding circuit therefore connected through said parallel first and second power circuits; an energizing circuit for said electromagnetic means in parallel with said holding circuit including a normally open timer operated switch; an electrically powered self-restoring timer adapted after an initial time interval to close momentarily said normally open timer operated switch and after a startup inter-

val following said initial time interval to open said normally closed timer operated switch; and a power circuit to said timer for energizing said timer in response to the flame detector when flame is absent and also during said startup interval, whereby said timer operates at first only if flame is absent.

2. The circuit defined by claim 1 wherein the power circuit to said timer has two parallel branches one being through said normally closed flame detector responsive switch and the other being through said normally closed timer operated switch.

3. In a combustion control circuit for energizing electrically operated combustion apparatus during normal operation in response to a flame detector, a program system comprising a first power circuit including a normally open flame responsive switch and a first normally open relay switch; a second power circuit in parallel with said first power circuit including a normally closed flame responsive switch, normally closed timer operated switch and a second normally open relay switch; electromagnetic means for actuating said relay switches and a holding circuit therefore connected through said parallel first and second power circuits; an energizing circuit for said electromagnetic means in parallel with said holding circuit including a normally open timer operated switch; an electrically powered self-restoring timer adapted after a time interval to close momentarily said normally open timer operated switch and after a startup interval to open said normally closed timer operated switch; a power circuit to said timer for energizing said timer in response to the flame detector when flame is absent and also when flame is present during said startup interval; and a lock-out switch connected to said circuit and responsive to energization of said timer beyond said startup interval for deenergizing the system.

4. The circuit defined by claim 2 wherein the power circuit to said timer has two parallel branches one being through said normally closed flame detector responsive switch and the other being through said normally closed timer operated switch.

5. In a combustion control circuit for energizing electrically operated combustion apparatus during normal operation in response to a flame detector, a program system

comprising a power circuit having power switching means therein controlling said circuit, movable means operatively associated with said power switching means, and timer controlled means for operating said power switching means in normal operation, said timer controlled means including an induction motor having a rotor driven by A. C. energization and held by D. C. energization, and electrically operated clutch means adapted to connect said rotor with said movable means, an A. C. circuit to said motor including a normally closed switch responsive to the flame detector and opened thereby during flame detection, a D. C. rectifier circuit in parallel with said A. C. circuit for holding said rotor during normal operation, and a circuit for said clutch means energized by said A. C. circuit and by said D. C. circuit.

6. In a combustion control circuit for energizing electrically operated combustion apparatus during normal operation in response to a flame detector, a program system comprising a power circuit having power switching means therein controlling said circuit, including a normally closed lockout switch, movable means operatively associated with said power switching means adapted to be moved to a position to open said lockout switch, and timer controlled means for operating said power switching means in normal operation, said timer controlled means including an induction motor having a rotor driven by A. C. energization and held by D. C. energization, and electrically operated clutch means adapted to connect said rotor with said movable means, an A. C. circuit to said motor including a normally closed switch responsive to the flame detector and opened thereby during flame detection, a D. C. rectifier circuit in parallel with said A. C. circuit for holding said rotor during normal operation, and a circuit for said clutch means energized by said A. C. circuit and by said D. C. circuit.

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