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G. G. OUTTERSON

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ELECTRICAL CONTROL FOR COMBUSTION SYSTEMS

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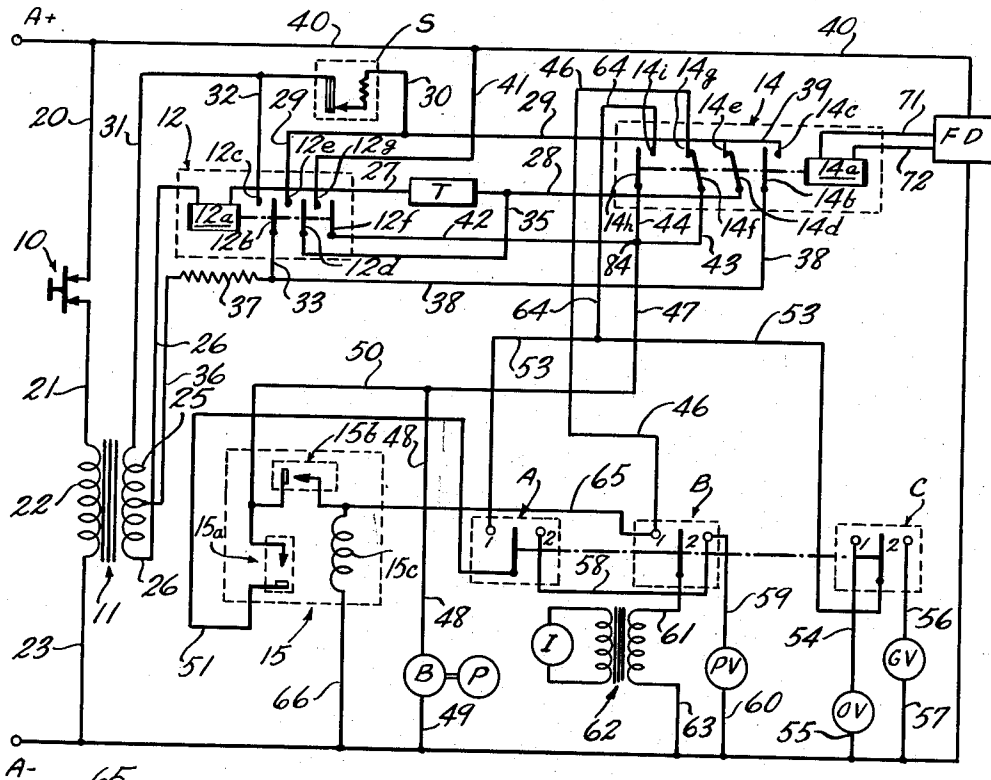


Fig. 1.

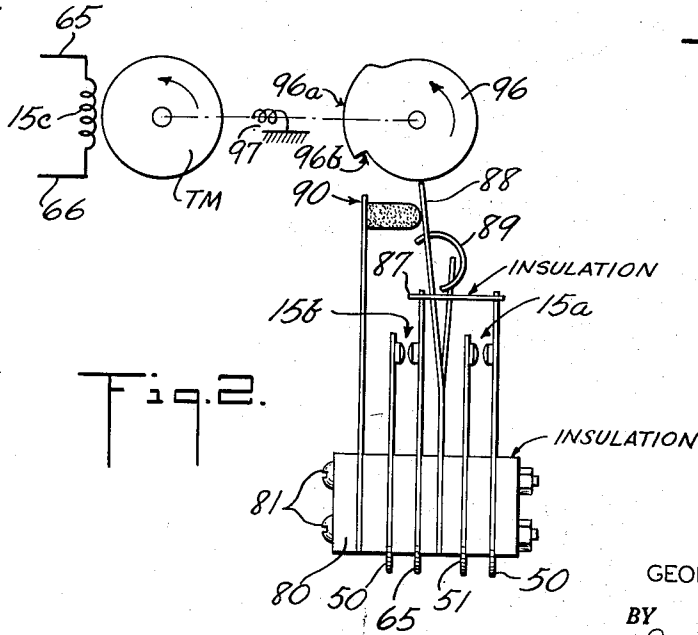


Fig. 2.

INVENTOR.
GEORGE G. OUTTERSON

BY
Campbell, Owen & Jones
his ATTORNEYS

UNITED STATES PATENT OFFICE

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ELECTRICAL CONTROL FOR COMBUSTION SYSTEMS

George G. Outterson, Mexico, N. Y.

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The present invention relates to a control for a combustion system in which the air-supplying means, the fuel-supplying means and the ignition are sequentially controlled. It relates more particularly to control systems for producing a predetermined cycle of operations for setting into operation and controlling the operation of fuel burners and for safety control mechanisms for assuring proper and safe operation of such fuel burners.

A fuel burner of the type generally referred to above, such as an oil burner, includes a device such as a pump or gravity feed system for supplying the fuel oil to a combustion zone; a blower for supplying air for combustion of the fuel; and a device for igniting the fuel. The usual control systems for such oil burners include a thermostat or a pressure limit switch or other pressure or temperature responsive device which is used to start or otherwise regulate the fuel burner.

In addition, such systems include a flame detector for detecting whether the burner is operating properly. Many of these prior devices, however, are not entirely dependable, and it often happens that when the device is actuated and the flame is not detected, or when an unstable flame is detected, the fuel and air-supplying means may continue to operate for a period of time before their operation is discontinued, thereby discharging an explosive fuel-air mixture into the combustion chamber.

When heat is called for in a combustion system of the prior type, by the closing of the thermostat, aquastat, or similar means, the air blower, fuel pump and ignition are all turned on simultaneously. If a flame is detected, usually by a stack switch, the system continues to operate. While this is satisfactory for a domestic combustion system, it is not suitable for larger commercial installations because in the latter case it is necessary that the blower be started first in order to clear out the combustion chamber or the stack of any accumulated gases before the ignition and fuel supply are turned on.

In order to accomplish this, it is necessary to introduce a time delay control which will operate the fuel valve and ignition after the blower has been set in operation in predetermined time relationship.

By virtue of the applicant's novel combustion system, a time delay means is provided which will operate for a given timing period only, assuring, thereby, a safe programming sequence. Such an arrangement avoids the use of a time delay control such as a thermal warp switch, which has a period of operation dependent upon ambient conditions and which, as a result, creates difficulty in resetting in operation the combustion system.

The present invention has, therefore, as a

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principal object, the provision of a control system whereby danger of explosion of an air and fuel mixture is overcome.

Another object of the invention is to provide a control system for fuel burners whereby positive control of the sequence of operations of the blower, fuel-supplying means and igniting devices is obtained and wherein a combustible mixture of air and fuel is purged from the combustion chamber before the igniting device is set into operation.

A further object of the invention is to provide a control system for fuel burners utilizing a time delay means for controlling the initiation of the igniting means and the fuel-supplying means in a definite predetermined time relationship and for permitting overlapping operation of the igniting and fuel-supplying means upon ignition of the fuel.

A further and more general object of the invention is to provide a control system which is rendered safe when any of its component parts or the device controlled thereby fail to function properly.

The invention may be best understood from the following detailed description, taken in conjunction with the accompanying drawings, in which:

Figure 1 is a schematic diagram of a typical control system for oil-fired or gas-fired fuel burners embodying the present invention; and

Figure 2 is a plan view of a time delay relay utilized in accordance with the invention.

Referring now to Figure 1, a circuit for an oil-fired or gas-fired fuel system is shown which may include a double contact manually operated switch 10, a step-down transformer 11, a control switch member T, which, for example, may be a pressure controlled switch, aquastat or thermostat; a relay 12 having a relay coil 12a and normally open contacts 12b—12c, 12d—12e and 12f—12g; and a flame detector mechanism FD which in a typical embodiment may include a metal helix actuated by heat, a photoelectric cell or electric probe, or any device which can perform a switch operation at the presence of flame in the burner. The flame detector FD controls a relay 14 including a relay coil 14a having associated therewith normally closed contacts 14d—14e and 14f—14g and normally open contacts 14b—14c and 14h—14i. The system also includes a time delay relay 15 (Fig. 1), further shown in Figure 2, which comprises a laminated base 80 which may be made, for example, of a plastic of the phenol formaldehyde type secured together by screw means 81 and which supports contacts 15a and 15b. The movable parts of contacts 15a and 15b are ganged together by means of a suitable insulating member 87 so that upon movement of a flexible feeler arm 88 extending

therethrough, the contacts move from an initial open position to a closed position in performing the switching operation. The movement of the feeler arm 88 is controlled by a cam 96 which, in operation, moves in the direction of the arrow, as shown in Figure 2, and which is suitably energized by a spring reset shift motor TM. This is a commercially available motor which turns in a given direction when energized and which returns by spring propulsion to its initial position when deenergized. The word "cam" is used in its generic sense to include any eccentrically arranged means for operating contacts 15a and 15b in the desired time sequence, to be explained. A rolling spring assembly 89 secured to insulating member 87 and feeler arm 88 provides snap action for the switching mechanism. In a preferred form, a shock absorber assembly 90 is used in conjunction with the switching mechanism. The time delay snap switch is momentary in that the contacts 15a and 15b will remain closed only so long as they are held closed by the cam 96. To effect the desired action the cam 96 is formed with an extension portion 96a having a radial leading surface 96b. As the radial surface 96b, moving counterclockwise, engages the follower or feeler arm 88, the contacts 15a and 15b will be snapped closed due to the action of the rolling spring 89 and the contacts will remain closed so long as the cam projection 96a engages the follower. When the cam projection 96a releases the follower, after a preestablished time interval determined by the circumferential length of the cam extension 96a and the rate of cam rotation, the contacts will be snapped open by the rolling spring. It will be understood that in returning to its initial position due to resetting action of the timer motor, the cam extension may engage the follower moving clockwise and force its way over it without causing the contacts 15a and 15b, which will then be open, to close. The resiliently supported shock absorber 90 serves to facilitate this action.

The system also includes a safety device S (Fig. 1) which may consist of a bi-metallic warp switch of conventional construction.

Fuel under pressure may be supplied by gravity, line pressure or by a pump P (Fig. 1) by a suitable motor. Solenoid valves OV and GV are operated electrically to control the flow of fuel, oil and gas, respectively, to the burner. A blower B for the fuel burner may be driven by the same motor that drives the fuel pump P. The ignition of the combustible mixture is initiated by an igniting device I. A solenoid valve PV is provided for opening a gas pilot in gas operation. Selector switches A, B and C, preferably single-pole double-throw switches ganged together to operate simultaneously, are provided to set the system either for oil or gas operation.

The system is connected to the power lines A+ and A- which supply suitable operating voltage. The power line A+, as illustrated, is connected to one contact of switch 10 by conductor 20, and then by means of conductor 21 to the primary winding 22 of transformer 11, the latter being connected by conductor 23 to power line A-. The low voltage or initiating circuit through the secondary winding 25 of transformer 11 is completed by means of conductor 26 to relay coil 12a of relay 12, conductor 27, control switch T, conductor 28, normally closed contacts 14d-14e of relay 14, conductor 29, conductor 30, safety switch S and conductor 31. The conductor 29 is connected to contact 12e of relay 12, the cooperating contact 12d thereof connecting to con-

ductor 28 by means of conductor 35. The secondary winding 25 of transformer 11 is center-tapped by conductor 36 which connects to a resistor 37, a conductor 38 and to contact 14b of relay 14, the cooperating contact 14c thereof being connected by means of conductor 39 to conductor 29. Contacts 12c-12b of relay 12 are respectively connected to conductors 31 and 38 by means of conductors 32 and 33.

The power line A+ is also connected by means of conductor 40 to the flame detector FD, the other side of which connects to power line A-. A circuit is completed from the desired detecting mechanism in flame detector FD to relay coil 14a of relay 14 through conductors 71 and 72. A conductor 41 connects conductor 40 to normally open contacts 12g-12f of relay 12, conductor 42, junction 84, conductor 43, normally closed contacts 14f-14g of relay 14, conductor 45 and contact 1 of switch B. Conductor 44 completes the circuit from normally open contact 14h of relay 14 and junction 84, conductor 47, conductor 48 to the pump P and blower B, the other side of the latter connecting to power line A- by means of conductor 49. Conductor 47 also connects to conductor 50 and to contacts 15a and 15b of time delay relay 15, the former of which connects to the switch arm of switch A through conductor 51. Contact 15b connects to motor coil 15c and then to power line A- through conductor 66, and also through conductor 65 to contact 1 of switch B.

A circuit is completed from contact 1 of switch A by means of conductor 53 to the switch arm of switch C. Contact 1 of switch C is connected by means of conductor 54 to the oil solenoid valve OV and conductor 55 to power line A-. Conductor 53 connects to contact 14i of relay 14 by means of conductor 64. Contact 2 of switch C connects to the gas solenoid valve GV by means of conductor 56 and then to power line A- by means of conductor 57. Contact 2 of switch A and contact 2 of switch B are made common by conductor 58. The switch arm of switch B connects by means of conductor 61 to the igniting means I which may be energized through a transformer 62, conductor 63 connecting the transformer and power line A-. Pilot solenoid valve PV connects contact 2 of switch B by means of conductor 59, and power line A- by means of conductor 60.

Assume now that switch 10 is closed so that the above described system is in an operative condition and a circuit is completed through conductor 20, conductor 21, the primary winding 22 of transformer 11, and the conductor 23 to the power line A-. Also assume that the burner is not in operation and when the boiler pressure, water and room temperature reaches the desired low value, the control member T calls for heat. Further assume that the switches A, B, and C are all in the left-hand position, that is engaging contact 1, so that the system is set for operation on oil.

Thus, a circuit is completed through conductor 28, normally closed contacts 14d-14e of relay 14, conductor 29, conductor 30, safety switch S, conductor 31, the secondary winding 25 of transformer 11, conductor 26, relay coil 12a of relay 12 and conductor 27. Energization of relay coil 12a closes contacts 12b-12c, 12d-12e and 12f-12g thereof. Current can flow from control member T through conductor 28 and contacts 14d-14e of relay 14, as described above, or can flow through a parallel path created by conductor

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35. contacts 12d—12e of relay 12, conductor 29 and conductor 30 to the safety switch S. Another parallel circuit is completed from the safety switch S through conductor 32, contacts 12c—12b of relay 12, conductor 33, resistor 37, conductor 36 to the center tap on secondary winding 25 of transformer 11.

When the relay 12 is set in operation by the control member T, the contacts 12f—12g of relay 12 close, and a circuit is established from power line A+ through conductor 40, conductor 41, conductor 42, junction 84, conductor 47, conductor 48, pump P and blower B motor and conductor 49 to power line A—. Since the contacts 14f—14g of relay 14 are normally closed, a circuit is also completed from these contacts through conductor 46, contact 1 of switch B and conductor 61 to operate the ignition I. At the same time, a circuit is completed through motor coil 15c by means of conductor 65 and conductor 66, and the timing motor TM is set into operation.

After a period of about 10 seconds, or any other desired interval, and when feeler arm 88 is engaged by the extended portion 96a on cam 96, switches 15b and 15a are closed, creating a circuit from junction 84 through conductor 47, conductor 50, conductor 51, contact 1 of switch A, conductor 53, contact 1 of switch C, conductor 54, the fuel oil solenoid valve OV and conductor 55 to power line A—. Thus, the main oil solenoid valve OV is in operation, and since ignition I has already been turned on, the oil will be ignited in the normal operation.

As soon as a flame is detected, relay coil 14a of relay 14 is energized through conductors 71 and 72, from the detecting mechanism in the flame detector FD.

When relay coil 14a is energized, cooperating contacts 14b—14c close and cooperating contacts 14d—14e open, and relay 12 is maintained closed through contacts 12d—12e of relay 12 and contacts 14b—14c of relay 14 and contacts 12b—12c of relay 12, thereby short-circuiting the safety switch S. At the same time contacts 14f—14g thereof open, disconnecting the circuit from power line A+, conductor 41, contacts 12g—12f of relay 12, conductor 42, junction 84, conductor 43, conductor 46, contact 1 of switch B, conductor 61, conductor 63 to power line A—. The motor coil 15c of timing motor TM, however, continues to draw current through contact 15b from conductor 50, conductor 47, junction 84, conductor 42, contacts 12f—12g of relay 12, conductor 41, conductor 40 and from power source A+, as does the ignition I from contact 15b through conductor 65, contact 1 of switch B and conductor 61.

Contacts 14h—14i of relay 14 also close when relay 14a is energized, and a circuit is completed from the power line A+ through conductor 40, conductor 41, contacts 12g—12f of relay 12, conductor 42, conductor 44, conductor 64, conductor 53, contact 1 of switch C, conductor 54, the main oil solenoid valve OV and conductor 55 to power line A—. It is seen that contacts 15a and 15b of the time delay relay 15 remain closed in overlapping predetermined time relationship with respect to contacts 14h—14i of relay 14, to provide for the so-called post-ignition period. Thus, a safety feature is assured during the interval in which flame may not be sufficiently stable to maintain itself. When contacts 15a and 15b of time delay relay 15 open during a normal programming cycle, motor coil 15c is de-energized

and the timer motor TM returns to its initial position by suitable spring driven mechanism 97, for example. The ignition I also turns off when contacts 15a and 15b open.

When the heating demands are satisfied, control member T disconnects the initiating circuit and relay coil 12a of relay 12 is de-energized. Thus, contacts 12f—12g, as well as contacts 12d—12e, 12b—12c of relay 12, return to their original open position. When this occurs, the main oil solenoid valve OV is shut off due to the opening of contacts 12f—12g of relay 12 and as flame is no longer detected, relay coil 14a of relay 14 is de-energized. Contacts 14b—14c and contacts 14h—14i open and contacts 14d—14e and 14f—14g close.

In the case of an oil system, therefore, the sequence is as follows:

(1) Turn on ignition I, blower B and pump P, and energize the motor coil 15c of the timer motor TM;

(2) Turn on main fuel solenoid valve OV by time delay relay 15; and

(3) If flame is detected, safety switch S is short-circuited, the ignition I is disconnected and the time delay relay 15 is de-energized, the latter occurring only after maintaining the oil solenoid valve OV in operation in overlapping relationship with respect to the ignition I.

An advantage of this system is that the current for the main oil solenoid valve OV is obtained from two sources for an overlapping period, as described above, namely through the time delay relay 15 and the contacts 14h—14i of relay 14. Thus, there is a smooth change-over during the starting period when the operation is more apt to be erratic.

(4) If flame is not detected within a short period of time, the so-called ignition failure, the relay coil 14a of relay 14 is not energized and contacts 14b—14c thereof do not close and contacts 14f—14g thereof do not open. Timer motor TM continues to operate and after contacts 15a and 15b of the time delay relay 15 open, the circuit is broken through the main fuel solenoid valve OV and the fuel supply and the igniting means I are shut off. Safety switch S opens due to the heating of the bi-metallic element by the continued flow of current therethrough, de-energizing relay 12 and opening contacts 12f—12g thereof. Thus, the circuit through the normally closed contacts 14f—14g of relay 14 to the motor coil 15c is disconnected, as well as the circuit through the contacts 12f—12g of relay 12, and the timer motor TM can return to start position. The time required for safety switch S to open is preferably shorter than the time for the motor to complete one revolution. To re-start operation, the safety switch S must be manually reset after the reason for the failure of the flame is determined.

(5) In the case of flame failure during operation of the burner, the relay 14 is de-energized and the contacts 14h—14i thereof open, cutting out the supply of fuel to the main solenoid fuel valve OV. Simultaneously, the contacts 14f—14g close, completing the circuit through the motor coil 15c and the timer motor TM starts and the programming cycle is restarted, as initially. Thus, as explained, if flame is again not detected, the safety switch S will heat, breaking the initiating circuit.

If safety switch S fails to open, relay 12 remains in, permitting contacts 12f—12g thereof to remain closed, operating the blower B and

ignition I. The timer motor TM, however, will run past the point when contacts 15a and 15b of the relay 15 open and will stall by a stop means (not shown), and cannot be returned to its initial position until the safety switch S opens or switch 10 is opened or thermostat T operates to open the circuit.

When this system is used for gas, the switches A, B and C are in the right-hand position, that is, engaging contact 2. The operation of the initiating circuit is generally similar to that described above in connection with the oil-fired system. Thus, when contacts 12f—12g of relay 12 are closed, a circuit is completed from the power line A+, conductor 40, conductor 41, conductor 42, junction 84, conductor 43, normally closed contacts 14f—14g of relay 14, conductor 46, and conductor 65 to the coil 15c of timer motor TM, the latter being connected by means of conductor 66 to power line A—. At the same time, the blower B is set into operation, as explained, to purge the system of any gases that may have remained therein from the preceding operation.

When, after a desired predetermined period the contacts 15a—15b of the time delay relay 15 close, a circuit is completed from contact 15a to the pilot solenoid valve PV by means of conductor 51, contact 2 of switch A, conductor 58, contact 2 of switch B and conductor 59. Simultaneously, a circuit is completed from contact 2 of switch B to the igniting means I and the ignition is turned on.

When the flame detector FD detects the flame from the gas pilot, relay coil 14a of relay 14 is energized, as explained above, and contacts 14b—14c and 14h—14i close and contacts 14d—14e and 14f—14g open. Thus, when contacts 14h—14i close, a circuit is completed from the power line A+ through these contacts and conductor 53, contact 2 of switch C and conductor 56 to the main gas solenoid valve GV which stays on through contacts 14h—14i when and as long as flame is detected. When the pilot flame is detected and contacts 14f—14g of relay 14 open, the timer motor TM as well as the ignition I and the pilot solenoid valve PV remains energized through contacts 15b and 15a, respectively, of time delay relay 15. After the contacts 15a and 15b of time delay relay 15 open in normal operation, the motor coil 15c is deenergized and the timer motor TM resets, and the circuit through the ignition I and the pilot solenoid valve PV is disconnected.

When the heating demand is satisfied, the system returns to its initial position as explained above in connection with the oil-fired circuit.

Thus, in the case of gas system, the sequence of operation is as follows:

(1) Turn on the blower B and the time delay relay 15;

(2) Gas pilot PV and the ignition I are turned on through the closing of contacts 15a and 15b of time delay relay 15;

(3) When pilot flame is detected, the main gas valve GV is turned on; and

(4) The ignition I and the gas pilot PV is turned off when the contacts 15a and 15b of time delay relay 15 open, this occurring only after being maintained open in predetermined time relationship with respect to the main fuel valve GV. In the case of a gas system, therefore, there is a smooth transition of sequence because the gas pilot PV and the ignition I remain on through contact 15a after the main gas valve GV is opened through contact 14h—14i of relay 14. Thus, the

pilot is maintained on for a short period after the main valve is opened at a time when the flame is more apt to be erratic.

(5) If the pilot flame is not detected, the relay coil 14a of relay 14 is not energized and contacts 14f—14g thereof do not open. Thus, the main solenoid fuel valve GV does not open and the fuel supply remains off. Timer motor TM continues to operate and after contacts 15a and 15b of the time delay relay 15 open, the circuit is broken through the gas pilot PV and the ignition I. Safety switch S then operates to disconnect the initiating circuit, as described in connection with the oil-fired system. As before, the safety switch S must be manually reset after the reason for the failure of the flame is determined.

(6) In case of flame failure during operation of the burner, a similar series of events takes place as with the oil-fired system. It should be noted that in the gas burner, as with the oil burner, the blower B operates to clear the system of a combustible mixture before the ignition sequence is begun, thus providing an additional safety feature.

In order to have an unsafe system, the flame as well as both safety switch S and the time delay relay 15 must fail, a condition which is extremely unlikely to occur.

From the preceding description of typical forms of fuel burner control systems embodying the invention, it will be clear that a system is provided wherein a positive sequence of operations, assuring safe functioning of the fuel burner, is assured under all normal conditions of operation. The system is susceptible of considerable change in the type of heating device controlled thereby, the type of flame detector used therein and the time delay relay used for controlling the sequence of operations. The delay may be any electrically responsive device which is unaffected by ambient conditions, and which provides a limited predetermined timing period. Thus, the above description should be considered as illustrative of the invention and not as limiting the scope of the following claims.

I claim:

1. In a combustion system, having electrically controlled air supplying means and fuel supplying means adapted for cooperative action to effect combustion, a control system for timing the initiation and controlling the operation of said components, and a source of electrical energy, said control system comprising electrical connections therethrough to said air supplying means and fuel supplying means from said source and including first switch means for energizing and deenergizing both of said components, a safety switch including actuating means energized during closure of the first switch to open the safety switch after the time period normally sufficient to establish combustion, means responsive to actuation of said safety switch for actuating said first switch means to render the air supplying means and fuel supplying means inoperative, a motor-driven timer including second switch means connected in series with said first switch means and connected in the electrical connection to said fuel supplying means, circuit means for energizing said motor-driven timer upon closure of said first switch means, and means whereby said timer is adapted to actuate said second switch means after a given time interval to render said fuel supplying means inoperative through the circuit including the second switch means.

2. In a combustion system as set forth in claim

1, including an ignition means and electrical connections therefrom through said control system to said source, and third switch means controlled by said timer and interposed in said electrical connections for rendering said ignition means inoperative through said third switch means.

3. In a combustion system as set forth in claim 1, including a flame detector, electrical connections for energizing said fuel supplying means shunted across the second switch means, fourth switch means in said shunt connections, and means responsive to said flame detector for actuating said fourth switch means to energize said fuel supplying means through said shunt circuit.

4. In a combustion system, electrically controlled air supplying means and fuel supplying means adapted for cooperative action to effect combustion, a control system for timing the initiation of said air and fuel supplying means, and a source of electrical energy, said control system comprising separate electrical connections to said air and fuel supplying means from said source and including a first switch common to both of said electrical connections for rendering said air and fuel supplying means operative and inoperative, a safety switch including actuating means energized during closure of the first switch to open the safety switch after the time period normally sufficient to establish combustion, means responsive to actuation of said safety switch for actuating said first switch to render said air and fuel supplying means inoperative, and a motor driven timer, means for energizing said motor driven timer upon closure of said first switch, said motor driven timer operating in a time period less than the time period for said safety switch and controlling a second switch interposed in the connections to said fuel supplying means and connected in series with said first switch, said timer being adapted to actuate said second switch to render said fuel supplying means inoperative independently of said air supplying means.

5. In a combustion system as set forth in claim 4 including ignition means having electrical connections thereto from said source in series with said first switch, a third switch under the control of said timer, means whereby said third switch is adapted to control said ignition means independently of said air supplying means, a flame detector and switch means controlled thereby including a fourth switch closed in the absence of flame and through which the ignition means and motor driven timer are energized, and a fifth switch closed in the presence of flame and through which the fuel supplying means is energized.

6. In a combustion system, combustion controlling components including electrically controlled air-supplying means, fuel-supplying means, and ignition means adapted for mutually cooperative action to establish combustion, a source of electrical energy, and a control system for operating said combustion controlling components in timed relationship comprising first switch means through which each of said combustion controlling components may be connected to said source of electrical energy, said first switch means being adapted to be closed to initiate operation of the system and to be opened to shut down the system, safety switch means including actuating means energized during closure of the first switch means to open the safety switch after a time period normally sufficient to establish combustion, timer motor and

second switch means including two sets of normally open contacts adapted to be operated thereby, means whereby said second switch means is controlled by said timer motor, a flame detector and third switch means adapted to be operated thereby, said third switch means including contacts which close in the absence of combustion and contacts which open in the absence of combustion, means forming a series electrical circuit between the first switch means and the timer motor including contacts of said third switch which close in the absence of combustion, means forming a series circuit between the timer motor and the first switch means including a first set of contacts of said second switch means, means forming a continuously closed circuit between the first switch means and the air-supplying means, means connecting the contacts of the third switch means which open in the absence of combustion in common with one contact of each set of contacts of the second switch means, means connecting a contact, other than the common contact, of the second set of contacts of the second switch means to the fuel-supplying means, means forming a series electrical circuit between the fuel-supplying means and said first switch means through the contacts of said third switch means which open in the absence of combustion and means connecting said ignition means in parallel with said timer motor.

7. A combustion system as set forth in claim 6, said timer motor including a cam for actuating the second switch means, said cam being adapted to close the second switch means for a preestablished interval during actuation of the timer motor in one direction, said second switch means including a cam follower yieldable to permit the passage of the cam in the reverse direction without closing the contacts, and spring means for reversing said timer motor to set the cam at its initial position in the absence of electrical power.

8. Combustion control apparatus as set forth in claim 6, said fuel-supplying means comprising an oil valve and a gas valve and a selector switch for connecting one or the other valves in the control circuit, said ignition means comprising an electrical oil-burner ignition and a valve controlled gas pilot and selector switch means for connecting the oil ignition in parallel with the timer motor or the oil ignition in parallel with the gas pilot, and a third selector switch for selectively connecting one contact of one set of contacts of the second switch means of the timer motor to said third switch means open in the absence of combustion or to the said gas pilot.

GEORGE G. OUTTERSON.

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