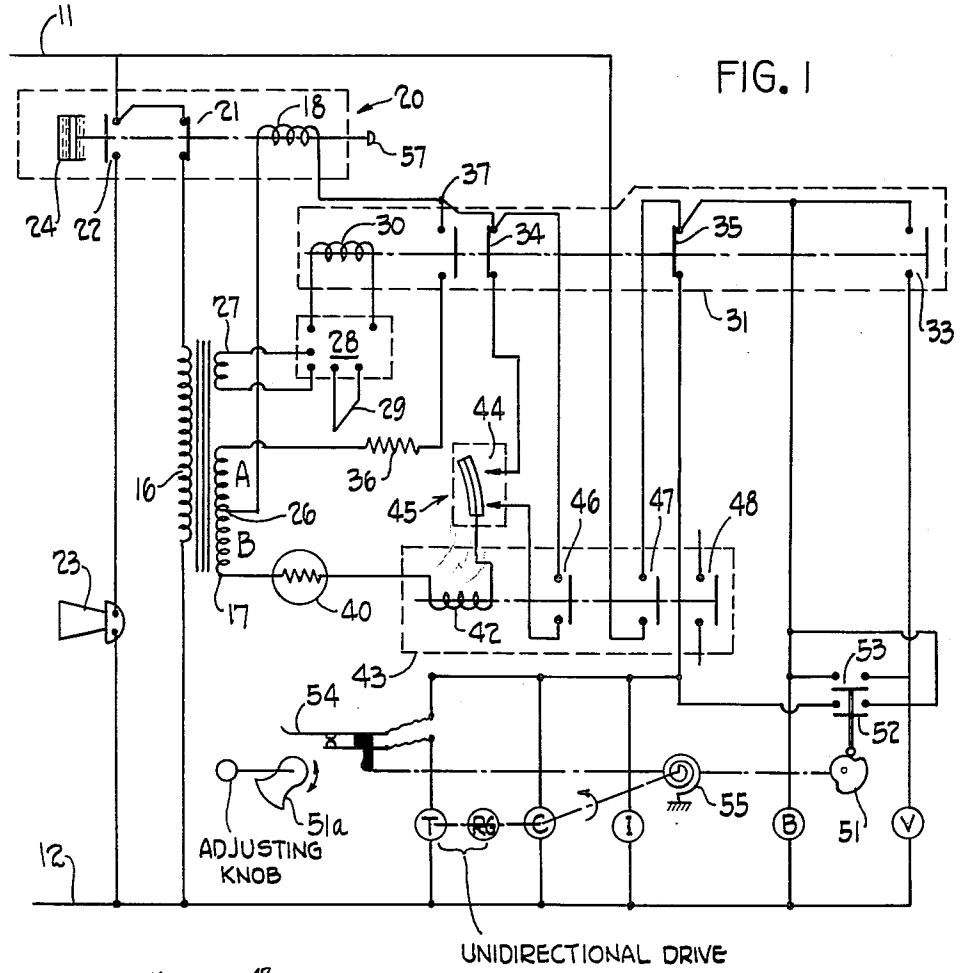
Aug. 14, 1962 P. N. BREDESEN ETAL 3,049,169

SAFETY COMBUSTION CONTROL SYSTEM

Filed June 9, 1958 2 Sheets-Sheet 1

FIG. 1



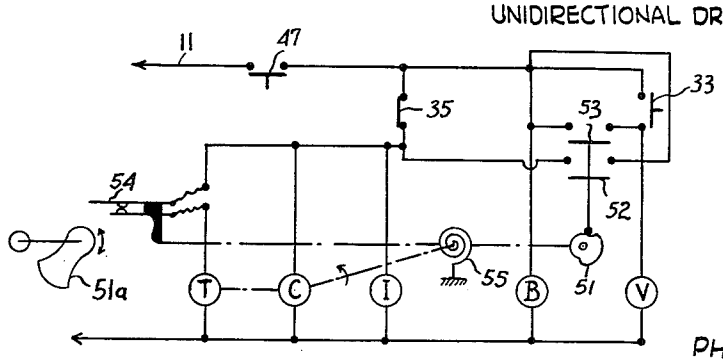


FIG. 2

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SAFETY COMBUSTION CONTROL SYSTEM

Filed June 9, 1958 2 Sheets-Sheet 2

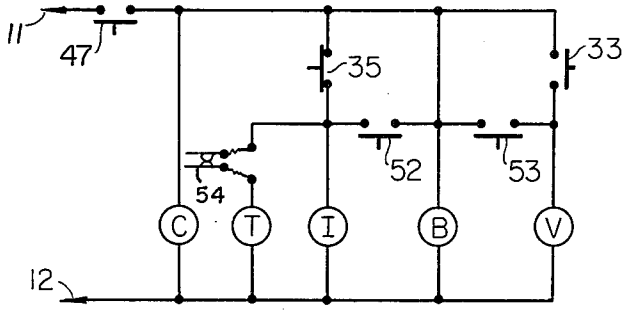


FIG. 3

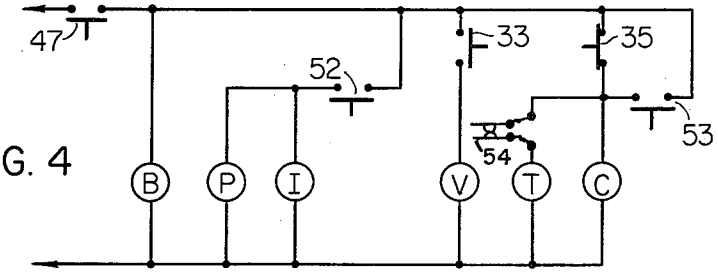


FIG. 4

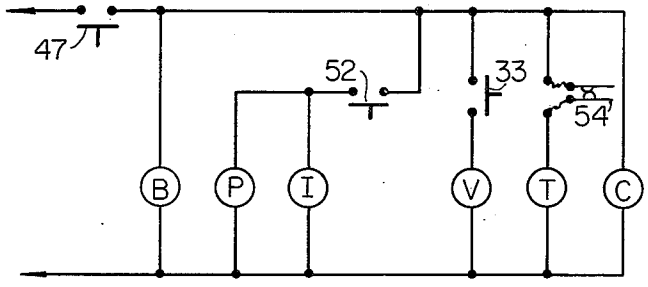


FIG. 5

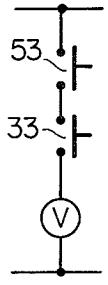


FIG. 6

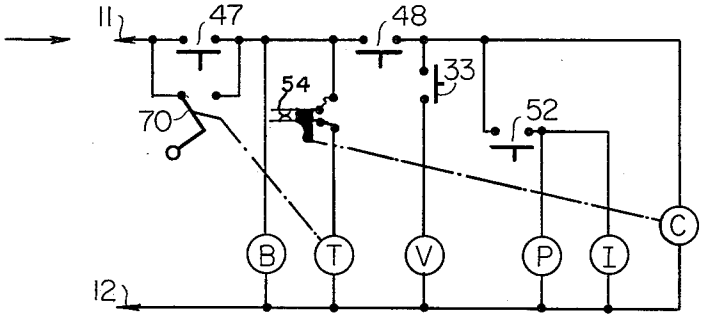


FIG. 7

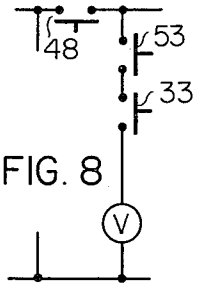


FIG. 8

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United States Patent Office 3,049,169 Patented Aug. 14, 1962

3,049,169

SAFETY COMBUSTION CONTROL SYSTEM

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Filed June 9, 1958, Ser. No. 740,887
10 Claims. (Cl. 158—28)

The present invention relates to control for a combustion system, for example of the oil or gas-fired type and in which various devices such as ignition and fuel supplying means are sequentially controlled. More particularly the invention relates to control systems for producing a predetermined cycle for setting into operation and controlling the operation of fuel supply and safety control mechanisms, and pilots, blowers, alarms, and the like, for assuring proper and safe operation.

Heretofore there has been a difficulty in such equipment in that it has lacked versatility, not being capable, without great modification, of meeting varied job requirements.

It is an object of the present invention to provide simple and inexpensive means for overcoming the above mentioned difficulty.

The invention is defined in the appended claims when read in the light of the following description of preferred embodiments, all of which employ separate circuits to energize a timer motor and an electric clutch to operate cam switches and provide advantages of greater versatility as will hereafter become evident.

Other objects and advantages will become apparent and the invention will be better understood from consideration of the following description taken in connection with the accompanying drawing, in which:

FIG. 1 is a schematic diagram of a typical control system for an oil or gas-fired furnace embodying the present invention;

FIG. 2 is a simplified diagram of a portion of the circut shown in FIG. 1, and

FIGS. 3 through 8 illustrate modifications.

Referring first to FIG. 1, there is shown a preferred embodiment of the invention adapted to operate furnace equipment when a source of control power is connected to lines 11 and 12 and other events occur as explained below.

Connected across lines 11 and 12 is a step-down transformer primary winding 16. The transformer secondary 17 provides low voltage for a circuit including the operating winding 18 of a safety switch 20 having a normally closed contact 21 in the circuit of the transformer primary 16 and a normally open contact 22 in the circuit of an alarm device 23 connected in series with the contact 22 across the lines 11—12. Switch 20 may be a time delay relay, e.g., having a dashpot 24, and this has been found to provide improved performance over a bimetal thermostat switch operated by a heater coil as disclosed and claimed in U.S. Patent 2,673,603 issued March 30, 1954 to George G. Outterson. Switch winding 18 may be hooked into a portion of a balance bridge involving a center tap 26 on the secondary 17 with the secondary winding portions A and B thus formed connected back through other equipment somewhat as described and claimed in said patent or as described hereinafter.

As shown in FIG. 1 of the present application, the transformer is provided with a second secondary 27 connected to energize an amplifier 28 for a flame detector 29. Flame detector 29 may take the form of a thermocouple, or thermistor, or metal helix, or electric eye, and it and its amplifier may be conventional items. The output of the flame detector amplifier 28 energizes coil 30 of

a flame relay 31 having normally open contacts 32 and 33 and normally closed contacts 34 and 35.

The far end of the A portion of secondary 17 is connected through a resistor impedance 36 and n.o. contact 32 to a point 37 to form the top leg of the bridge. The safety switch coil 18 is connected across points 26 and 37 to form the middle portion of the bridge, while the far end of the secondary winding portion B is connected through a time delay device 40 which, for simplicity, may be a thermistor, and this circuit (for the bottom leg of the bridge) is completed through a coil 42 of a master relay 43 and the heat demand responsive contact 44 of a thermostat 45 and back through the flame relay n.c. contact 34 and then (when 30 is deenergized) back to the balance bridge common junction 37.

The master relay 43 is provided with an n.o. contact 46 which shorts out the flame relay contact 34, and the main relay is also provided with an n.o. contact 47 contacted in series with line 11 and serving to energize final equipment as hereafter explained. An additional contact 48 may also be included for possible use as later described for FIG. 8.

As suggested in U.S. Patent 2,655,207 issued October 13, 1953 upon an application filed by G. G. Outterson, the equipment is provided with a timer motor T and a timer cam 51 for actuating timer cam switches 52 and 53. In accordance with the present invention the system differs in that there is also provided a limit switch 54 in the circuit of the motor to limit travel of the driven cam without requiring the motor T to stall, and an electrically operated clutch C is energized by a circuit separated from the circuit through the limit switch and thus to the timer motor, and the connections to final equipment are different as may be more apparent from consideration of FIG. 2 which is a simplified diagram of a portion of the circuit of FIG. 1. It will be understood that the motor T is preferably as light, inexpensive, and compact as possible, with the windings of minimum resistance for a maximum electrical efficiency so that it is in danger of overheating and burning out if allowed to stall.

Preferably reduction gearing RG is used and it may conveniently be interposed between T and C to assure that the cam 51 will not drive back through the motor T whenever the clutch is engaged, but the motor de-energized.

With the embodiment shown in FIGS. 1 and 2, when the clutch is energized the cam 51 is driven by T unidirectionally in the direction indicated by the small arrows, but as the clutch C is de-energized the cam is forced to return to the starting (or t_0) position as by the action of a small spring 55 which may be attached either to the shaft driving the same (FIG. 1) or to the cam 51 itself (FIG. 2). In accordance with the present invention the cam is sometimes driven to "limit" at which time the limit switch 54 is provided to de-energize the motor, which prevents it from overheating or burning out or overstressing the mechanical connections in the mechanism. Limit switch 54 may be a simple leaf switch attached to the shaft driving the cam 51 with an associate relatively stationary cam 51*a* made adjustable so that post-purge timing i.e., time required after a normal cycle of attempted furnace firing and for getting rid of raw gases or exhausted products of combustion before starting a new light-up and firing cycle in the event of flame failure during the previous cycle, contact 31 remaining closed, can be varied by adjusting the position of such relatively stationary cam.

As described and illustrated in the above mentioned Patent 2,655,207, cam follower means may be provided to assure that the timer cam switches 52 and 53 will be operated only during motor driven cam advance and will not operate during cam return under the influence of the spring 55.

As described in the above mentioned Patent 2,655,207, and also in U.S. Patent 2,655,208, the control equipment may be used to operate a main fuel valve V, a blower B, and a flame ignition device I as well as the timer T and clutch C. With an arrangement as shown in FIGS. 1 and 2 of the present application, clutch C is energized across the same lines as the ignition I, and interconnections are made from the main relay contact **47** through the flame relay contacts **35** and **33** and through the cam contacts **52** and **53** and through the driven equipment in such manner that as heat demand causes the thermostat contact **44** to close, and as this closes the master relay **43**, a circuit may be traced through line **11**, master relay contact **47**, and (if no fire) through flame relay contact **31** to energize T, C and I. Regardless of position of the flame relay, blower B is also energized and this will purge the system of any exhausted gases in a normal starting sequence.

All of the above may be thought of as occurring at time t_0 (equal to zero seconds), and at a time t_5 (which for FIGS. 1 and 2 might be assumed to be five seconds later) cam switches **52** and **53** close. Cam switch **52** serves to hold the timer T, clutch C and ignition I regardless of operation of flame relay **31** and consequent opening of its normally closed contact **35**. Cam switch **53** serves to energize valve V (unless flame relay operation has already done so). Valve V is assumed to be a solenoid operated valve for the purpose of admitting main fuel to the furnace and it will be seen from FIGS. 1 and 2 that cam switch **53** is shorted out by flame relay contact **33** whenever the flame relay coil **30** is energized. At time t_{15} (which for FIGS. 1 and 2 might be assumed to be 15 seconds later than time t_0 cam switches **52** and **53** reopen leaving valve V under control of the flame relay, and leaving T, C and I de-energized unless the flame relay drops out to cause recycling. When C is de-energized the cam returns under the influence of the spring without disturbing the cam switches as already explained.

Any tripping of the safety switch **20** will de-energize the flame detector amplifier **28** and all the low voltage circuits and provide an alarm through device **23**, but otherwise the equipment is powered in such manner that final equipment energization is dependent upon flame detection but with all timing operations (except post purge) dependent upon clutch control of cam switches.

FIG. 2.—Operation: Failure to Ignite

During startup the master relay **43** powers the blower, ignition, clutch and timer. From time t_5 to t_{15} a trial for ignition is made. Upon failing to ignite, the timer continues until stopped by the cam limit switch **54** at a full limit position where the cam will remain because held by the clutch and motor gearing until a time t_x when the safety switch trips and opens the low voltage circuits. Until this happens the blower B continues purging gases to leave the system in safe condition for making another trial when the safety switch is reset by the button **57**, as hereinafter explained.

Thermistor **40** is in the circuit to give a short delay each time relay **43** is operated (in order to allow a safety check on the flame relay, for example if a power failure has occurred) but this feature could be omitted. Basically the low voltage circuit is a bridge with the coil **18** of the safety switch **20** in the center. If the thermostat **45** is closed and the master relay **43** has operated and the flame relay has pulled in, the bridge will be balanced and no current will flow through **18**. But if the flame relay does not close, current will continue in coil **18** until the time (fixed by the selection of components of the bridge circuit) when tripping occurs. Furthermore, any fault in the circuit which causes bridge unbalance will ultimately trip safety switch **20**. This de-energizes all of the equipment except the alarm which is then energized. A button **57** may be provided so that the safety switch can be manually reset in order to make a new try.

FIG. 2.—Operation: Flame Failure After Igniting

It will be observed that with the arrangement described, if there is any flame failure during firing the flame relay **31** will drop out, recycling the system in normal manner. Whenever flame is established, firing will continue normally, but if a flame is not established a lock-out occurs. During normal operation furnace firing continues with heat demand, and at the end of heat demand thermostat **44** opens to de-energize master relay **43** and this in turn de-energizes fuel valve V and blower B.

FIG. 3

A modification is shown in FIG. 3 where the arrangement is the same as in FIG. 2 except that the clutch C is powered directly from the M.R. contact **47**. This means that whenever the master relay is pulled in the clutch is energized and thus the timer cam is held at the t_{15} position all during firing. This prevents recycling in the event of flame failure.

FIG. 4

Another modification is shown in FIG. 4 where the blower is again connected across the line from the master relay contact **47**, but where a pilot fuel valve solenoid P is connected in parallel with the ignition I to be energized only by the cam switch **52** (from time t_5 to t_{15}) and not independently by the flame relay. The main valve V is controlled by the flame relay contact **33** alone while the timer motor and clutch are under the influence of both the normally closed F.R. contact **35** and one of the cam switches (in this case **53**). Thus the master relay contact **47** first powers the blower, timer and clutch. At time t_5 cam switch **52** powers the pilot solenoid and ignition while cam switch **53** maintains the timer and clutch when the flame relay pulls in. Operation of the flame relay will also energize V to open the main fuel supply. At time t_{15} the ignition is cut off (and the pilot solenoid de-energized) and the timer and clutch are de-energized. The cam then returns to zero and remains there during firing.

FIG. 4.—Failure to Ignite

If there is a failure to ignite during startup with the arrangement of FIG. 4, the cam is driven to the limit and lock-out occurs when the safety switch trips. Such failure of pilot to ignite also prevents trial for main flame inasmuch as the contact **33** never closes. Although the flame detector may normally see both pilot and main flame, so that if the pilot lights the flame relay will pull in, the pilot is eventually turned off as the cam contact **52** opens and if at that time the main flame is not yet established the flame relay will drop out, the main fuel valve will be turned off, the cam drives to limit, and lockout occurs.

FIG. 4.—Flame Failure After Igniting

If there is a flame failure during firing the flame relay drops out and re-initiates a normal starting cycle. If ignition does not take place during the first recycle, lock-out occurs as described above under the heading "FIG. 4—Failure to Ignite."

FIG. 5

Another modification is shown in FIG. 5 where M.R. **47** again powers the blower and through a single cam operated contact **52** powers the pilot solenoid (P) and ignition (I). The flame relay contact **33** controls the main valve (V) while the clutch (C), and timer (T) in series with limit switch **54**, are connected across the line formed by the contact **47**. At time t_5 the pilot solenoid and the ignition are powered and when flame is established, FR **33** closes turning on the main fuel. At time t_{15} the pilot and ignition are turned off, the cam drives to limit and is held thereby the clutch during the remainder of the heating cycle (that is until a time t_{xx}

when the thermostat 45 opens to de-energize the master relay).

If there is a failure to ignite during startup, the result is the same as for the embodiment of FIG. 4.

If there is a flame failure during firing with the arrangement of FIG. 5 the flame relay drops out and lock-out occurs as the safety switch trips. There is no recycling.

FIG. 6

Another modification is illustrated in FIG. 6 where the arrangement is assumed the same as in FIG. 5 except the second cam switch 53 is connected in series with flame relay contact 33 in the line of the valve V. With such an arrangement the master relay powers the blower, the timer, and the clutch and at time t_5 the pilot and the ignition are energized through the cam contact 52. If a fuel valve delay is desired, contact 53 may be displaced a required number of degrees around the cam from the contact 52. This establishes what might be thought of as a new time t_7 when contact 53 closes and the main fuel flows if the pilot has been proved. At a time t_{15} cam contact 52 opens and the ignition is turned off. The cam drives to limit and the clutch holds throughout the firing cycle although the timer motor is de-energized by limit switch 54 when this limit is reached. With the arrangement of FIG. 6 if there is a failure to ignite during startup the result is the same as for FIG. 4 except that the trial for main flame occurs from time t_7 to t_{15}. If there is a flame failure during firing, the result with the arrangement of FIG. 6 is the same as that of the arrangement of FIG. 5.

FIG. 7

In the modification of FIG. 7 the arrangement is the same as in FIG. 5 except that an extra contact 48 on M.R. 43 (see FIG. 1) is connected to separately energize circuits to C, and through 33 to V, and through 52 to P and I, and an additional cam switch 70 is connected in parallel across master relay contact 47 to operate as a post purge contact. This cam switch 70 is arranged to be operated by a cam directly on the motor or gear shaft (rather than through the clutch) and, unlike the limit switch 54 which is arranged to open at the limit of cam travel the cam switch 70 is assumed set to close at a time t_1 (shortly after initiation of the cam control timing cycle) and to stay closed throughout the timing cycle. At time t_5 contact 52 closes to energize the pilot solenoid and the ignition and then, as the flame relay pulls-in, valve V is energized to turn on the main fuel if the pilot is proved. The cam then drives to limit which is set to satisfy the post purge timing requirement. After the heat demand ends, the master relay drops out, the cam 51 (FIG. 1) returns to zero, and the timer starts up again without the clutch energized. Thus cam 70 maintains the blower until the timing cycle is complete, allowing purging of gases.

FIG. 7.—Failure to Ignite

If the pilot fails to ignite, the cam drives to limit and the master relay drops out when safety lock-out occurs. But the usual post purge cycle carries through. If the main flame fails to establish, the ignition is turned off, the flame relay is de-energized, contact 33 opens, and the cycle described immediately above occurs. Trial for main flame occurs from time t_5 to t_{15}.

FIG. 7.—Flame Failure After Ignition

If there is a flame failure during firing, the flame relay drops out. This turns off the main fuel and de-energizes the master relay but the post purge cycle follows. There is no recycling.

FIG. 8

Another modification is illustrated in FIG. 8 where the connections are assumed the same as in FIG. 7 except that an additional timer cam operated contact 53 is arranged in series with flame relay contact 33 and valve V. Here again, as for FIG. 6, it may be assumed that the contact 53 is displaced from contact 52 on the periphery of the cam 51 and it may be assumed that the cam 53 is arranged to remain closed slightly beyond the cam limit so that the fuel valve circuit remains "hot" during normal firing.

Summary of Operation

A summary of typical operation and advantages for the various embodiments is illustrated in the following table.

TABULAR SUMMARY OF TYPICAL OPERATION

Dwg. Fig	1, 2	3	4	5	6	7	8
Sequence:							
t_0	B On I On	B On I On	B On	B On	B On	B On	B On
t_1							
t_5	V On	V On	I On V On*	I On V On*	I On	I On	I On
t_7					V On*	V On*	V On*
t_{15}	I Off	I Off	I Off	I Off	I Off		
t_x	B Off V Off	B Off V Off	B Off V Off	B Off V Off	B Off	B Off	B Off
t_{xx}	B Off	B Off	B Off	B Off	B Off	V Off	V Off
Advantages:							
Direct Ignition	x	x					
Fuel Valve Delay	x	x			x	x	x
Pre Ignition	x	x	x	x	x	x	x
Recycling	x		x				
Non Recycling		x		x	x	x	x
Pre Purge		x	x	x	x	x	x
Pilot Proving			x	x	x	x	x
Post Purge						x	x

Notes:
(*)—If pilot is proved.
t_x—Emergency shut-off when safety switch trips.
t_{xx}—Normal shutdown when thermostat opens.

There is thus provided arrangements of the class described capable of meeting objects as above set forth, and advantageous from many standpoints and particularly in permitting a manufacturer to produce one basic control which, with only very slight modifications readily made in the field, can be used to operate diverse installations varying from simple space heating units to furnaces and muffles as currently used for industrial processing.

While particular embodiments have been described and illustrated, various modifications may be obviously made without departing from the true spirit and scope of the invention which is defined by the appended claims to include equivalents of the specific embodiments of the invention illustrated.

We claim:

1. In a combustion control system of the type having separately electrically controlled air supply means, fuel supply means, and ignition means, and having terminal

means across which an A.C. potential may be impressed, a first switch, a transformer having a primary winding connected through said first switch across said terminal means and having a low voltage secondary winding, a thermostat switch, a master relay having a coil connected in series with said thermostat switch and at least a portion of said secondary winding and having at least one normally open contact, a flame relay having a coil arranged to be energized responsive to flame detection and having at least one normally open contact and at least one normally closed contact, means including connections for energizing the air supply means through the normally open contact of said master relay, means including connections for energizing the fuel supply means through the normally open contact of said master relay and electrically coupled in series circuit through the normally open contact of said flame relay, and means including connections for energizing the ignition means and including at least the normally open contact of said master relay, the combination of a timer motor which overheats if stalled, means including reduction gearing driven by the timer motor and through which the motor cannot be driven, means including an electric clutch driven by the gearing when the motor is energized, a cam shaft and a cam carried thereby, means operably coupling the cam shaft to be driven by the clutch from an initial position when the motor and clutch are energized, spring means for returning the cam to the initial position when the clutch is de-energized, normally open cam-operated switch means arranged to be closed and to be opened by the cam when it is driven unidirectionally by the motor, a limit switch on the cam shaft and electrically connected in series with the timer motor to prevent cam overtravel, means including connections and at least the normally open contact of said master relay for energizing the series circuit of the motor and the limit switch, means including connections and at least the normally open contact of the master relay for energizing the clutch, and means including connections through said cam operated switch means for energizing the ignition means independent of the flame relay and in timed sequence with respect to the energization of the air supply means.

2. In a combustion control system of the type having a master relay and having fuel supply, air supply and ignition electrically operated under the control of a normally open contact of the master relay, and having a flame relay with normally open and normally closed contacts, and having a unidirectional operative timer motor which overheats if stalled, the combination of means including a reducing gear driven by the motor, a cam shaft and cam and associated cam-operated switch means, a spring biasing the cam to an initial position, an electrically operated clutch operably interposed between the reducing gear and the cam shaft for alternatively holding the cam through the gears or allowing the cam to return under the influence of the spring, a limit switch arranged to be operated by the cam shaft and electrically connected in series with the timer motor for preventing overtravel of the cam, means including connections through the normally open contacts of said master relay to operate the air supply, means including connections through the normally open contact of said master relay in series with the normally closed contact of said flame relay with a branch circuit from the normally open contact of said master relay through at least a portion of the cam operated switch means for energizing the ignition and for energizing the series circuit of the limit switch and the timer motor, and means including connections through the normally open contact of said master relay in series with the normally open contact of said flame relay with a branch circuit from the normally open contact means of said master relay through at least a portion of the cam operated switch means to energize the fuel supply, and means including connections for energizing the clutch at least responsive to master relay energization.

3. In a combustion system of the type having a master relay with a normally open contact and having fuel supply control, air supply control, and ignition control all electrically operated under the control of the normally open contact of the master relay, and having a flame relay including a normally open contact and a normally closed contact, and having a unidirectionally operative timer motor which overheats if stalled, the combination of means including reducing gears driven by the motor, means including a cam shaft driven by the gears, plural cam-operated switches normally open and arranged to be temporarily closed by the cam, a spring for returning the cam shaft to an initial position, an electrically operated clutch interposed between the gearing and the cam shaft and operative to alternatively hold the cam shaft through the gears or to allow it to return under the influence of the spring, a cam-shaft operated limit switch electrically connected in series with the timer motor for preventing overtravel of the cam, means including connections through the air supply, means including connections through the normally open contact of the master relay and in series connection through one of the cam operated switches for energizing the ignition, means including connections through the normally open contact of the master relay in series connection with the normally open contact of the flame relay to operate the fuel supply, and means including connections for energizing the clutch responsive to master relay energization.

4. The combination as in claim 3 further characterized by the clutch being connected in parallel with the ignition, the series circuit of timer motor and limit switch being connected in parallel with the ignition, there being means including a branch circuit to operate the fuel supply through one of the cam operated switches independently of energization of the flame relay, and there being means including a branch circuit for energizing the ignition, the clutch, and the series circuit of the limit switch and timer motor through the normally closed flame relay contact independently of operation of the cam switches, thereby to provide direct ignition, fuel valve delay, pre-ignition and recycling.

5. The combination as in claim 3 further characterized by the clutch being connected to be energized directly by the normally open contact of the master relay, the series circuit of timer motor and limit switch being connected in parallel with the ignition and thereby energized from one of the cam operated switches but with the ignition and series circuit of limit switch and timer motor also arranged for energization through a branch circuit including the normally closed flame relay contact to energize the same independently of operation of the cam switches, and there being means including a branch circuit to operate the fuel supply through one of the cam operated switches independently of energization of the flame relay, thereby to provide direct ignition, fuel valve delay, pre-ignition, non-recycling and prepurge.

6. The combination as in claim 3 further characterized by there being connections to operate the air supply directly through the normally open contact of the master relay, a pilot fuel supply control means, the pilot fuel supply control means being connected in parallel with the ignition, the series circuit of the limit switch and timer motor being placed in parallel with the clutch and these circuits together being arranged for alternative energization through the normally open cam contacts, thereby to provide pre-ignition, recycling, prepurge and pilot proving.

7. The combination as in claim 3 further characterized by there being connections to operate the air supply directly through the normally opened contact of the master relay, a pilot fuel supply control means, the pilot fuel supply control means being connected in parallel with the ignition, the timer motor and limit switch being connected in parallel with the clutch and these two circuits being connected in parallel with the air supply means.

thereby to provide pre-ignition, non-recycling, prepurge and pilot proving.

8. The combination as in claim 3 further characterized by the air supply means, the clutch, and the series circuit of limit switch and timer motor all being connected for energization directly by the normally open contact of the master relay, and a pilot fuel supply control means connected in parallel with the control, thereby to provide fuel valve delay, pre-ignition, non-recycling, prepurge and pilot proving.

9. The combination as in claim 3 further characterized by the series circuit of limit switch and timer motor being connected in parallel with the air supply means, and means connecting said series parallel circuit for energization directly by the normally open contact of the master relay, an additional limit switch adapted to be actuated by the timer motor and electrically arranged in parallel around the normally open contact of the master relay, a second normally open contact of the master relay connected to isolate the circuit for fuel valve, ignition and clutch with respect to closing of said second limit switch around the first normally open contact of the master relay, and pilot fuel supply control means connected in parallel with the ignition, thereby to provide fuel valve delay, pre-ignition, non-recycling, prepurge and pilot proving, and post-purge.

10. The combination as in claim 3 further characterized by the series circuit of limit switch and timer motor being connected in parallel with the air supply means, and means connecting said series parallel circuit for energization directly by the normally open contact of the master relay, an additional limit switch actuated by the timer motor and electrically arranged in parallel around the normally open contact of the master relay, a second normally open contact of the master relay connected to isolate the circuit for fuel valve, ignition and clutch with respect to closing of said second limit switch around the first normally open contact of the master relay, pilot fuel supply control means connected in parallel with the ignition, with the main fuel valve controlled through the series circuit of said second normally open contact of the master relay, one of the cam contacts and the normally open contact of the flame relay, thereby to provide fuel valve delay, pre-ignition, non-recycling, prepurge, pilot proving and post-purge.

References Cited in the file of this patent

UNITED STATES PATENTS

1,986,032	Townsend	Jan. 1, 1935
2,618,323	Aubert	Nov. 18, 1952
2,655,207	Outterson	Oct. 13, 1953
2,655,208	Outterson	Oct. 13, 1953
2,673,603	Outterson	Mar. 30, 1954
2,685,918	Marquardt	Aug. 10, 1954
2,851,095	Aubert	Sept. 9, 1958