Sept. 20, 1960 G. E. ANDREWS ET AL 2,953,196

SAFETY CONTROL APPARATUS FOR FUEL BURNERS

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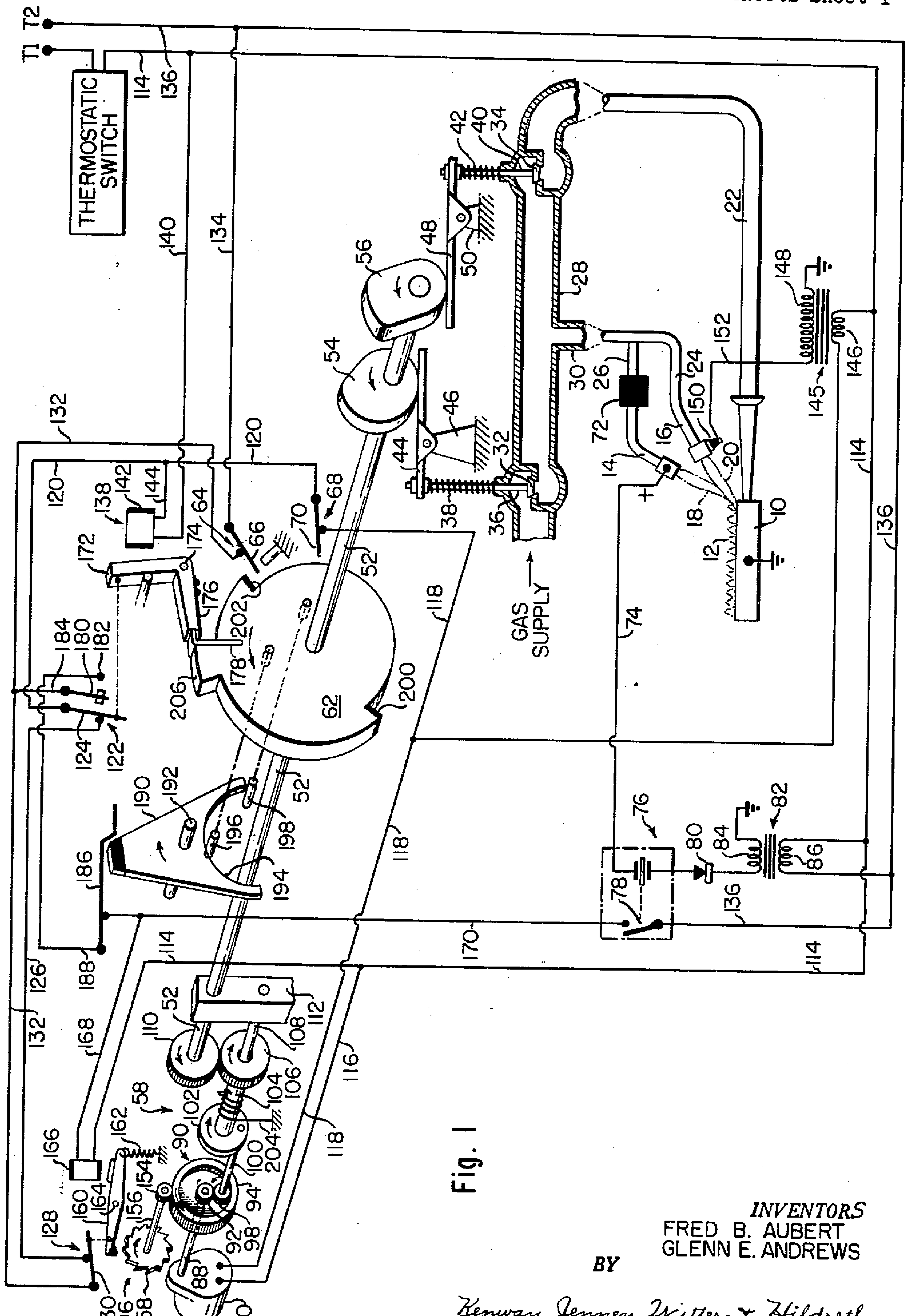

Fig. 1

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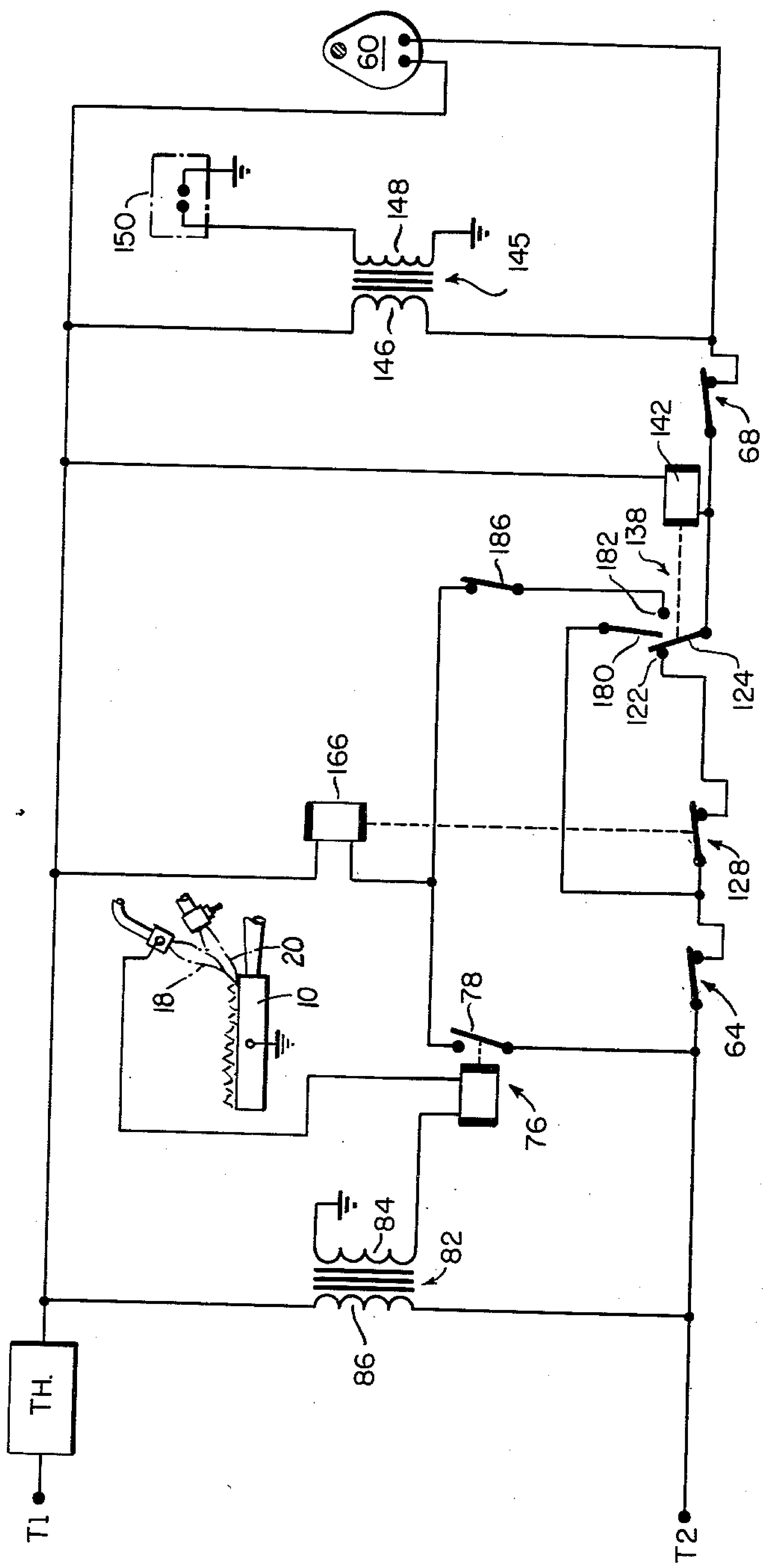
Fig. 2



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SAFETY CONTROL APPARATUS FOR FUEL BURNERS

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17 Claims. (Cl. 158—128)

This invention relates to electrical control apparatus for use with either oil or gas burners, and more particularly to control apparatus employing mutually impinging flames as a path for the flow of electrical energy.

At the outset, attention is invited to copending application Serial No. 368,708, filed July 17, 1953, now Patent No. 2,755,852 in the names of Glenn E. Andrews and Fred B. Aubert wherein the use of impinging flames as a path for electrical energy is fully described. As is therein stated, it has long been appreciated that a flame will conduct electrical energy. The use of a single flame, however, has been found unsatisfactory, for the electrical behavior of flames of different gases vary widely. The unsatisfactory performance of a single flame has been overcome by the use of mutually impinging flames as a path for electrical current, for it has been discovered that the type of fuel employed in no way affects satisfactory operation.

The primary object of this invention is to provide simple and fully automatic safety control apparatus for a fuel burner system.

Another object of this invention is to avoid the use of relatively expensive, extremely sensitive auxiliary equipment in the control of a burner system of the above character.

Another object of this invention is to obtain complete shut-down and lock-out of the system upon flame failure at either or both of the impinging pilot burners.

In accomplishing these and other objects, there is provided as one important feature electro-mechanical means for shutting down and locking out the system upon flame failure at the pilot burners.

Another feature of this invention is the provision of mechanical actuating means for the main burner and pilot burners including a master cam about which the electrical control circuits operate to insure safe operation of the system.

Still another feature of this invention is the provision of a false flame detector switch for preventing opening of a main burner fuel supply valve when a circuit is detected through the pilot burner flames before the flames would be created in normal operation.

These and other objects and features of the invention will be best understood and appreciated from the following detailed description read in the light of the accompanying drawing wherein:

Fig. 1 is a view in perspective of the apparatus comprising this invention, and

Fig. 2 is a schematic diagram of the control circuits of this invention.

Proceeding now with the presentation of the general organization of the invention, the device embodying this invention is arranged to control the supply of fuel to a main burner **10** employed to produce a flame as suggested at **12**. A pair of pilot burners **14** and **16** positioned adjacent the main burner **10** for igniting the same are adapted to produce mutually impinging flames **18** and **20**. Fuel conduits **22**, **24** and **26**, each connected at one end to

the main fuel supply line **28** are connected respectively at their opposite ends to the main burner **10**, the pilot burner **16** and the pilot burner **14**, providing a source of fuel to each of the said burners.

Positioned in the main fuel line **28** ahead of a tap off **30** for the pilot burners **14** and **16** is a mechanically operated valve **32** particularly situated to control the supply of fuel to the pilot burners, while downstream of the tap off **30** in the main fuel line **28** is a second mechanically operated valve **34** in a position to control the flow of fuel to the main burner. Valves **32** and **34** are provided respectively with valve stems **36** and **40** about which are placed tension springs **38** and **42** for biasing each of the said valves to a closed position. Connected to the free end of valve stem **36** is an actuating lever **44** pivotally mounted on block **46**, and a similar actuating lever **48**, pivotally mounted on a block **50** is connected to the free end of the valve stem **40**. The exertion of a downward force against the free end of either of the levers will operate to actuate the valve served by that lever to an open position against the bias of the spring.

The electrically powered fuel control mechanism employed to operate the valves for the main and pilot burners will now be described in detail. An eccentric cam **54** positioned immediately above the free end of lever **44** when rotated in the direction of the arrow will urge the lever to pivot about its fulcrum in a clockwise direction, actuating the valve **32** to open position permitting the flow of fuel to the pilot burners **14** and **16**. A second cam **56** positioned immediately above the actuating lever **48** when rotated in the direction of the arrow will move the lever in a counterclockwise direction, opening the valve **34** against the bias of the spring **42**. The cams **54** and **56** mounted on a shaft **52** are driven by a motor **60** through a series of gears generally designated by numeral **58**. The motor **60** through a shaft **88** immediately driven thereby serves to rotate an inner gear **92** of a planetary gear **90**. A ring gear **94**, coaxial and coplanar with the inner gear **92** is also carried by the shaft **88** but is free to rotate independently of the shaft's rotation. Operatively connecting the inner gear **92** to the ring gear **94** is a planet gear **98** engaging the inner teeth of the ring gear and the teeth of the inner gear.

A clutch mechanism designated by the numeral **96** is provided to control the movement of the ring gear **94** by engaging or releasing the same. Apparatus governing the particular function performed by the clutch will be described in detail below. Assuming that the clutch **96** is holding the ring gear in a non-rotatable position, motor **60** through shaft **88** will rotate the inner gear **92** in a clockwise direction, thereby causing the planet gear **98** to travel about the axis of the shaft **88** in a clockwise direction within the ring gear. A shaft **100** axially carried by the planet gear will then turn a crank **102** in a clockwise direction. A crank shaft **104** in turn will rotate the tangential gear **106** in a clockwise direction, resulting in rotation of shaft **52** by means of tangential gear **110** in a counterclockwise direction as indicated by the arrows. A support rod **108** fixed to a frame **112** merely aids in supporting and aligning the system. It is noted also that the shaft **52** passes through the frame **112** to axially position the gear **110** and the actuating cams **54** and **56**. The counterclockwise rotation of the main shaft **52** will rotate the actuating cams in the manner above described, thereby opening first the valve **32** and later the valve **34**, for as is clearly evident in the drawing, cam **54** leads cam **56** in counterclockwise rotation.

Having thus described the sequence of operation of the series of gears **58** in a condition wherein clutch **96** engages the ring gear **94** in a non-rotatable position, the operation of these gears will now be described in the event clutch **96** releases the ring gear. The inner gear

92 driven by shaft 88 will continue to rotate in a clockwise direction. The planet gear 98, however, will merely rotate on the shaft 100 without traveling along its path about the axis of the shaft 88 within the ring gear. The ring gear 94 will be caused to rotate in a counter-clockwise direction by the rotation of the planet 98, thereby rotating the outer gear 154 of the clutch 96. As is indicated in the drawing, the ratchet 158 will be rotated in a clockwise direction by a clutch shaft 156 connected to the gear 154.

The function performed by clutch 96, that is, whether it holds the ring gear 94 in non-rotatable position or releases the ring gear for rotation, is determined by the position of a clutch lever 160. The clutch lever 160 mounted for pivotal movement about a fulcrum 164 is biased in the position illustrated by a spring 162. In this position ratchet 158 is free to rotate, permitting the same action on the part of ring gear 94. An electromagnet 166 positioned adjacent the clutch lever is adapted when energized to move the lever against its bias to engage the teeth of the ratchet 158. In this position, the ratchet is held against clockwise rotation and consequently the ring gear 94 is held against counter-clockwise movement.

Having thus described the electrically powered fuel control mechanism, attention is directed to apparatus for detecting the presence of flame at the pilot burners. During normal running operation of the system the flame detecting apparatus to be described will control a running or operating circuit for the electromagnet 166, ultimately determining the position of the clutch lever 160 which controls the rotation of ring gear 94. The heart of the flame detecting apparatus resides in a relay 76 including a switch 78 forming part of the operating circuit of the electromagnet. Relay 76 is energized through a circuit including the pilot burner flames 18 and 20 and may be traced through the following elements: from ground through the secondary 84 of a transformer 82, a rectifier 80, the relay 76, a lead 74, pilot burner 14, the flames 18 and 20, main burner 10 and back to ground. An insulating block 72 interrupting the fuel conduit 26 merely serves to shield the pilot burner 14 from ground, necessitating the completion of this circuit through the pilot burner flames. Therefore, in the absence of flames 18 and 20, the circuit energizing the relay 76 is open, and the switch 78 will break the running circuit of electromagnet 166.

Having described the function performed by the flame detector, namely, the controlling of switch 78 to provide a running circuit for the electromagnet 166, the inactivating or shut-down apparatus functioning as a result of flame failure at the pilot burner causing de-energization of the electromagnet will now be described. As stated above, flame failure at the pilot burner results in release of ring gear 94. A torsion spring 204 wound about the crank shaft 104 will drive the gearing 58 when the ring gear is released, turning cams 54 and 56 in a clockwise direction to close the valves 32 and 34. A master cam 62 mounted on shaft 52 for rotation therewith will also rotate in a clockwise direction under the influence of the torsion spring 204. A shoulder 202 on the master cam will open a normally closed lock-out or inactivating switch 64 by engagement of a switch blade 66. The lock-out switch 64 upon opening serves as an inactivating means for the motor 60 and a delay relay mechanism 138, later to be described.

Provided in the system are a starting circuit and a running circuit for the motor 60. The starting circuit may be traced from a terminal T1, a thermostatic switch, a lead 114, a lead 116, the motor 60, a lead 118, a cycle limiting switch 68, a lead 120, a relay switch 122 controlled by the delay relay mechanism 138, a lead 126, a biased closed switch 128 controlled by the clutch lever 160, a lead 132, the lock-out switch 64, a lead 134, and a lead 136 to a terminal T2. The running circuit for the motor 60 avoids the switches 122 and 128 by completing the current path from the lead 120 through switch blade 124, a second switch blade 180, a lead 184 to the lead 132. It is noted, however, that both the running circuit and the starting circuit for the motor 60 include the lock-out switch 64, and together they form a power circuit having start-up switching means by which the circuits are selectively controlled.

The particular function performed by switch 128 will now be set forth. It has been indicated that the switch 128 is under the immediate control of the clutch lever 160 which in turn is operated by the electromagnet 166. Should a short circuit exist across the gap separating the pilot burner 14 from either the main burner 10 or the pilot burner 16 completing the flame detector circuit, immediately upon closing of the thermostatic switch the relay 76 will become energized, closing switch 78 and energizing the electromagnet 166, whereupon the clutch lever 160 will move against the bias of the spring 162 to open the switch 128. Switch 128 thus serves as means for opening the power circuit to motor 60. If the motor 60 at this time is under the control of its starting circuit, the opening of switch 128 will deenergize it. In other words, the existence of either flames at the pilot burner or a short circuit across the flame path before flames would be present in the course of normal operation will cause a false flame indication to be relayed to the motor, shutting it down. In this operation the electromagnet 166 serves as an actuator which controls the engagement of the clutch lever 160 and the opening of the switch 128.

The delay relay 138 serves to close the running circuit for the motor after a predetermined time when the false flame test has been performed, through switch blades 124 and 180 to form a parallel running circuit that by-passes the starting circuit through switch 128. The running circuit accordingly provides means overriding the opening of the starting circuit at switch 128. Additionally, the delay relay 138 completes a starting circuit for the clutch 96 enabling the pilot burner valve to open. This circuit may be considered to send a substitute flame signal to electromagnet 166 after the false flame test has been made in order that a flame may then be created at the pilot burners in the normal sequence of operation. The starting circuit for the electromagnet may be traced from the terminal T1, through the thermostat, the lead 114, to the electromagnet and back to the terminal T2 through a lead 168, a lead 170, switch blade 186, a lead 188, a fixed contact 182, the switch blade 180, the leads 184 and 132, the lock-out switch 64 and the leads 134 and 136.

Before proceeding to a detailed description of the operation of the invention, a group of elements serving as a program control will be described. The master cam 62, previously noted in conjunction with the lock-out switch 64, through a pair of pins 196 and 198 controls the movement of a rocker 190. The rocker in turn serves as an actuator for the switch 186 whose normal position is that illustrated in the drawing. Before such time as the pilot burners are ignited, switch 186 remains closed to complete the circuit for the substitute flame signal. After ignition of the pilot burners, however, it is desired to have the electromagnet 166 under the control of the flame detector. To discontinue the starting circuit for the electromagnet, the rocker 190 moves in a clockwise direction about its fulcrum 192 to lift the blade of switch 186 away from its fixed contact. A semi-circular recess in the base of the rocker is eccentrically disposed about the axis of the shaft 52 and the pin 196 will engage the margin of the recess to actuate the rocker when the master cam 62 is rotated in a counterclockwise direction. The pin 196 carried by the master cam 62, however, is positioned to actuate the rocker only after the shaft 52 has rotated sufficiently to cause the cam 54 to open the valve controlling the flow of fuel to the pilot burner.

Having described in detail the major segments of this invention, a detailed description of the operation will now be presented. As illustrated, the valves 32 and 34 are closed, preventing the flow of fuel to the pilot burners and main burner, and the control apparatus is in a position to start through its ignition cycle upon a demand for heat from a conventional thermostatic switch.

Figure 2 has been presented to facilitate tracing of the various circuits. It is believed that the schematic diagram will be particularly helpful as an aid in the understanding of the operation of this invention which follows.

Assuming that a demand for heat occurs closing the thermostatic switch, the motor 60 will become energized through its starting circuit comprising terminal T1, the electrical leads 114 and 116, the motor 60, the lead 118, the fixed contact of the normally closed cycle limiting snapswitch 68, the switch blade 70, the lead 120, the normally closed relay switch 122, the lead 126, a fixed contact of a biased closed switch 128, a switch blade 130, the lead 132, the fixed contact of the lock-out switch 64, the switch blade 66, and the leads 134 and 136 to terminal T2. At the same time, the delay relay 138 will become energized through a circuit parallel to the motor circuit just described. Starting from terminal T1, this circuit may be traced through the thermostatic switch, the leads 114 and 140, the coil 142 of the delay relay 138, the leads 144 and 120, the switch 122, the lead 126, the switch 128, the lead 132, the lock-out switch 64, the lead 134, and back to terminal T2 through lead 136.

Connected in parallel with the motor 60 and the delay relay coil 142 and energized therewith are the primary 86 of the transformer 82 and the primary 146 of an ignition transformer 145. An electrical igniter 150 mounted on pilot burner 16 is energized through a lead 152 connected to one end of the secondary 148 of the transformer 145. The other end of the secondary 148 is grounded, while the pilot burner 16 serves as ground for the igniter. Having also energized the primary of transformer 82, it will be seen that the presence of a flame at the pilot burners would close the flame detector relay circuit passing therethrough, thereby closing the switch 78 of the relay 76. If for any reason the flame detector relay circuit is completed, as for example due to a short circuit across the gap from the pilot burner 14 to the main burner 10, switch 78 would close, immediately energizing the electromagnet 166 through the circuit 114, the electromagnet 166, a lead 168, a lead 170, the switch blade 78 and the lead 136. The blade 130 of switch 128 coupled to the clutch lever 160 would immediately open, thereby de-energizing the motor and the relay coil 142. Because under normal conditions neither a flame nor a short circuit would be present at the gap between the pilot burner 14 and the main burner 10, the preceding would not occur. However, if either condition did exist, the switch 128 serves as a false flame detection indicator, and ensures safe operation by preventing ignition of the main burner in case of such a contingency.

Proceeding further through the normal cycle of operation, initially upon energization of motor 60, the shaft 52 will not rotate because the clutch 96 is not holding the ring gear 94 in a non-rotatable condition and the energy supplied by motor 60 will be dissipated through rotation of the ratchet 158. However, the current supplied to the delay relay coil 142 will attract a stop lever 172 which is pivotally mounted for movement about an axis 174 and forms a return stop for the master cam 62. Carried by the lever 172 is a leaf spring 176 which engages the underside of an L-shaped projection 178 fixed to the master cam 62. Although the master cam remains in the position illustrated, for shaft 52 has not begun to rotate, the flexibility of the leaf spring 176 permits the lever 172 to pivot about its axis under the control of the coil 142. The switch blade 124 coupled to the lever 172 will move to the right opening the switch 122, and an instant later make contact with the switch blade 180 and the fixed contact 182. The closing of these contacts will create a running circuit for the motor 60 and a holding circuit for the relay coil 142. The holding circuit for the relay coil 142 may be traced from the terminal T1, the thermostatic switch, the leads 114 and 140, the coil 142, the leads 144 and 120, the blades 124 and 180, the leads 184 and 132, the lock-out switch 64, the lead 134 and back to terminal T2 through the lead 136. The running circuit for the motor 60 may be traced from terminal T1 through the thermostatic switch, the leads 114 and 116, the motor 60, the lead 118, a cycle limiting switch 68, the lead 120, the blade 124, the blade 180, a lead 184, the lead 132, the lock-out switch 64, the lead 134 and back to terminal T2 through the lead 136.

Contact having been made between switch blade 180 and the fixed contact 182 by energization of the relay 138, a starting circuit is also established for electromagnet 166 from terminal T1, through the thermostatic switch, the lead 114, the electromagnet 166, the lead 168, the lead 170, the snap switch 186, a lead 188, the fixed contact 182, the blade 180, the leads 184 and 132, the lock-out switch 64, the lead 134 and back to terminal T2 through the lead 136. The energization of electromagnet 166 will cause the clutch lever 160 to rotate about its fulcrum engaging the ratchet 158 of clutch 96, thereby holding the ring gear 94 in a non-rotatable position. At the same time the switch 128 coupled for movement with the clutch lever 160 will open. The running circuit for the motor and the holding circuit for the delay relay having been established, however, switch 128 no longer is needed for continued operation.

The restriction against movement of the ring gear 94 resulting from engagement by the clutch 96 will now cause shaft 52 to rotate as described in detail above. The master cam 62 and the actuating cams 54 and 56 will be caused to rotate in a counterclockwise direction, the L-shaped projection 178 carried by the master cam releasing the leaf spring 176 as it moves away.

When the cam 54 has turned counterclockwise through approximately five degrees, valve 36 will be opened by actuation of the lever 44, and fuel will flow to the pilot burners 14 and 16. The electrical igniter 150 having become energized upon closing of the thermostatic switch, a flame will result at each of the pilot burners, completing the flame detector relay circuit, thereby energizing relay 76, closing the switch 78. The closing of the switch 78 will provide a holding circuit for the electromagnet 166 which may be traced from the terminal T1 through the thermostatic switch, the lead 114, the electromagnet 166, the leads 168 and 170, the switch 78 and the lead 136 to the terminal T2.

The rocker 190 pivotally mounted for movement about a fulcrum 192 is juxtaposed to the snap switch 186. The pair of pins 196 and 198 carried by the master cam 62 are adapted to rock the member 190 as the master cam is rotated. Immediately after the cam 54 opens the valve 32, the master cam will reach a position wherein the pin 196 will engage the side of the recess 194, causing the rocker 190 to move in a clockwise direction about its fulcrum, opening the snap switch 186 as described above. Thereafter the electromagnet 166 will be energized by means of its holding circuit completed through the switch 78 of the relay 76.

Further counterclockwise rotation of the shaft 52 (somewhat more than 80° from the starting position illustrated) will cause cam 56 to open the valve 34 by means of the actuating lever 48. The flames 18 and 20 of the pilot burners will then ignite the main burner 10. Additional rotation of the cam 62 will move its shoulder 200 against a blade 70, opening the cycle limiting switch 68 to break the running circuit of the motor 60 and the circuit for the igniter. The system will then be in its fully operating condition. Electromagnet 166 and the coil 142 will remain energized through their holding circuits, and barring failure of the pilot burners or power failure in the lines, the main burner will remain ignited as long as the thermostatic switch calls for heat.

Assume now that the pilot burners 14 and 16 are extinguished due to any abnormal condition, such as a reduction of fuel pressure in the line. The flame detector circuit will be broken de-energizing the electromagnet 166. Consequently the clutch 96 will release the ring gear 94 and under the influence of the torsion spring 204 the master cam 62 will rotate in a clockwise direction. The L-shaped projection 178 and the rise 206 of the cam 62 will pass under the leaf spring 176 and the lever 172, thereby permitting the shoulder 202 on the master cam to open the lock-out switch 64. During this clockwise rotation of the master cam, the pin 198 will engage the wall of the recess 194 on the rocker 190, turning the rocker in a counterclockwise direction, permitting snap switch 186 to close under its own bias.

The lock-out switch 64 will maintain the system in its shut down position. To start the control apparatus through its ignition cycle after lock-out has occurred, the master cam 62 must be manually rotated in a counterclockwise direction to the position illustrated in Fig. 1, permitting lever 172 to move away from the coil 142. Until the lever is so moved, the lock-out switch must be held in its open position to prevent energization of the delay relay 138. After the system has been returned to the condition illustrated in the drawing, ignition of the main burner will be under the control of the thermostatic switch.

Barring the occurrence of an abnormal condition of the type just described, the system will operate under the control of the thermostat without manual attention. Upon cessation of a demand for heat the thermostatic switch will open and the lever 172 will return to the position illustrated. The lever 172 will then be in a position to intercept the master cam in its clockwise rotation under the influence of the torsion spring 204 before the lock-out switch 64 is opened. Subsequent closure of the thermostatic switch will automatically start the apparatus through its cycle.

From the foregoing detailed description of this invention it will be seen that in addition to the objects specifically recited in the introductory portion of the specification numerous other advantages are achieved through a device of this character. Some of these will be discussed in the following paragraphs.

Inspection of the control apparatus discloses that upon a demand for heat which closes the thermostatic switch, the false flame test is immediately made. A short circuit across the path of the pilot burner flames will cause the relay 76 to become energized, closing switch 78. The electromagnet 166 will attract the clutch lever 160 opening switch 128 before the delay relay 138 has become energized and the starting circuit for the motor 60 is broken by switch 128 before the running circuit for the motor 60 is completed through switch blades 124 and 180. Therefore, when an attempt is made to institute operation the apparatus will remain totally inactive until any existing short circuit across the gap between the pilot burners and main burner is eliminated. An operator observing such an abnormal condition will have to look no farther than the pilot burners to cure the defect. The test performed is positive, and is independent of other safety control mechanisms in the system.

Another feature of this invention rendering important advantages in safety is the positive means for discriminating between normal operation and failure. The flame detecting circuit which includes the pilot burners does not depend for operability upon extremely delicate and expensive flame sensing means such as thermocouples, thermopiles, photoelectric cells, etc. In the instant case, the flame itself completes the circuit for the relay 76. The

position of switch 78 is determined solely by the presence or absence of flames 18 and 20, and not by the presence or absence of a flame in addition to the proper functioning of a flame sensing element. Moreover, flame failure at the pilot burners instantaneously places in motion mechanisms provided to lock out the system. No delay is necessary to permit a heat responsive element to cool. Immediately following the opening of switch 78, the clutch lever is released in turn releasing the ratchet 158. Coil spring 204 turns the shaft 52 through gearing 58 and master cam 62 opens the lock-out switch 64. The operation just described is not negative, for the system is not merely permitted to shut down. To the contrary positive action may be observed in the control apparatus. Any breakdown may be immediately detected and remedied. In the same manner, the response to proper operation is considered positive, and the cause for improper functioning of the system may be readily located and cured.

The positive mechanical interlocking of the valves 32 and 34 by cams 54 and 56 and shaft 52 is another desirable feature. Having a common actuator not only reduces the number of elements in a system which in turn reduces the cost of the assembly, but more important it enhances the safety features and insures proper sequence of operation. The main burner valve 34 cannot be opened before the pilot burner receives fuel from the main fuel supply lines. A predetermined period of time after valve 32 permits fuel to pass to the pilot burners 14 and 16, fuel passes to the main burner, unless safety tests indicate that the main burner should not receive fuel from the line. When there no longer exists a demand for heat (the thermostatic switch opens) the main burner valve 34 closes before the pilot burners are extinguished. This sequence of operation insures against the accumulation of even a small amount of unburned fuel.

Still another feature of this invention producing distinct advantages over the prior art is worthy of special note; namely, the ability of the system to recycle immediately after the master cam has been manually reset following lock-out. In most systems presently employed, an unsafe period exists after lock-out but before the safety apparatus is restored. For example, thermocouples continue to generate power after the burner to which it responds fails, for an appreciable amount of time elapses before complete cooling occurs. Until such time as the thermocouple cools, there are no means for detecting flame failure. In the instant case all secondary conditions necessary in other control apparatus to insure safe operation after reset are eliminated.

Though we have described in great detail the specific embodiment illustrated in the drawing, it is obvious that numerous changes could be made without departing from the scope of this invention. It is our intention, therefore, that the scope of this invention not be limited by the preceding description, but only by the appended claims.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. In a combustion apparatus including a burner, igniting means for the burner, a flame detector adapted to provide a flame signal during normal operation of the burner; a control system comprising: electrically powered driving means; a fuel control valve for controlling the flow of fuel to said burner; yielding means biasing the fuel control valve to a position preventing the flow of fuel to the burner; means including a normally disengaged clutch connecting the driving means with the fuel control valve when said clutch is engaged; a power circuit to said driving means including in series from power terminals to the driving means a normally closed inactivating switch, normally closed start-up switching means including opening means for opening the power circuit and closing means overriding said opening means for closing the cir-

cuit, and a normally closed cycle limiting switch; a delay mechanism responsive to electrical energization through said start-up switching means adapted after a predetermined time interval to actuate said closing means and to provide a substitute flame signal; an actuator responsive to the flame signal and to the substitute flame signal to actuate said opening means and to engage said clutch; a program control operatively associated with the fuel control valve to terminate communication of the substitute flame signal to the actuator after the burner has ignited in normal operation, to open the cycle limiting switch after normal flow of fuel has been established, and upon release of the clutch and return of the fuel control to open the inactivating switch; and a return stop normally preventing opening of the inactivating switch, said stop being actuated by the delay mechanism.

2. The system defined by claim 1 wherein the substitute flame signal is communicated to the actuator through a second normally closed switch, and the program control opens said second normally closed switch after the burner has ignited in normal operation.

3. The system defined by claim 2 wherein the program control comprises a master cam driven in conjunction with the fuel control valve, said cam operating said second normally closed switch after the flow of fuel has started, said cycle limiting switch when the fuel control valve is open, and said inactivating switch upon closing of the fuel control valve; and said return stop comprises an abutment engageable with said cam normally preventing operation of the inactivating switch.

4. In a combustion apparatus including a burner, igniting means for the burner, a detector adapted to provide an electrical energizing signal when a flame is present at the burner: a control system comprising electrically powered driving means; fuel control mechanism controlling the flow of fuel to the burner; means including a normally disengaged clutch connecting the driving means with the fuel control mechanism to permit operation of the burner; a power circuit to the driving means normally closed on demand for heat, an actuator adapted to open said power circuit and actuating said clutch delay mechanism responsive to energization through said power circuit overridingly closing said power circuit a time interval after energization through said power circuit, means establishing an auxiliary circuit to energize said actuator a time interval after energization through said power circuit, means opening said auxiliary circuit after the burner has ignited in normal operation and means establishing a holding circuit for maintaining said actuator energized after opening of said auxiliary circuit, said holding circuit being responsive to an energizing signal from said detector whereby continued operation is controlled by an energizing signal from the flame detector.

5. In a combustion apparatus including a burner, igniting means for the burner, a detector adapted to provide a signal when a flame is present at the burner: a control system comprising electrically powered drive means; fuel control mechanism yieldingly biased to shutdown position controlling the flow of fuel to the burner; means including a normally disengaged clutch connecting the driving means with the fuel control mechanism to permit operation of the burner; a power circuit to said driving means including in series from power terminals to the driving means a normally closed in activating switch, normally closed startup switching means including opening means for opening the power circuit and closing means overriding said opening means for closing the power circuit, and a normally closed cycle limiting switch; an actuator adapted to actuate said opening means and to engage said clutch; delay mechanism responsive to electrical energization through said startup switching means adapted after a time interval to actuate said closing means; means establishing an auxiliary energizing circuit to said actuator a time interval after energization through said startup means; a program control operatively associated with the fuel control mechanism to open said auxiliary circuit after the burner has ignited in normal operation, to open the cycle limiting switch after normal flow of fuel has been established and upon disengagement of the clutch and return of the fuel control mechanism to open the inactivating switch; a return stop normally preventing opening of the inactivating switch; means responding to energization through said startup switching means releasing said return stop, and means establishing a holding circuit for maintaining said actuator energized after opening of said auxiliary circuit, said holding circuit being responsive to an energizing signal from said detector whereby continued operation is controlled by said detector.

6. In a combustion apparatus including a burner, igniting means for the burner, a detector adapted to provide a signal when a flame is present at the burner; a control system comprising electrically powered drive means; fuel control mechanism yieldingly biased to shutdown position controlling the flow of fuel to the burner; means including a normally disengaged clutch connecting the driving means with the fuel control mechanism to permit operation of the burner; a power circuit to said driving means including in series from power terminals to the driving means a normally closed inactivating switch, normally closed startup switching means including opening means for opening the power circuit and closing means overriding said opening means for closing the power circuit, and a normally closed cycle limiting switch; an actuator adapted to actuate said opening means and to engage said clutch; delay mechanism responsive to electrical energization through said startup switching means adapted after a time interval to actuate said closing means and to establish an auxiliary energizing circuit to said actuator; a program control operatively associated with the fuel control mechanism to open said auxiliary circuit after the burner has ignited in normal operation, to open the cycle limiting switch after normal flow of fuel has been established and upon disengagement of the clutch and return of the fuel control mechanism to open the inactivating switch; a return stop normally preventing opening of the inactivating switch; means responding to energization through said startup switching means releasing said return stop, and means establishing a holding circuit for said actuator after opening of said auxiliary circuit, said holding circuit being responsive to an energizing signal from said detector whereby continued operation is controlled by said detector.

7. In a combustion system including a burner, igniting means for the burner, and a detector adapted to provide a flame signal during normal operation of the burner: a control system comprising electrically powered driving means; a movable element adapted to be driven by said driving means to control the flow of fuel to said burner, means including a normally disengaged clutch connecting said driving means with said movable element, yielding means biasing said movable element to its shutdown position, electrically operable clutch actuating means, means responsive to a demand for heat for initially energizing said clutch actuating means for a burner starting period, and means responsive to a signal from said detector maintaining said clutch actuating means energized during normal burner operation.

8. In a combustion system including a burner, igniting means for the burner, and a detector adapted to provide a flame signal during normal operation of the burner: a control system comprising electrically powered driving means; a movable element adapted to be driven by said driving means to control the flow of fuel to said burner, means including a normally disengaged clutch connecting said driving means with said movable element, yielding means biasing said movable element to its shutdown position, electrically operated clutch actuating means, a clutch actuating circuit for said actuating means including

a normally open switch means to hold said normally open switch closed in response to a flame signal, means including an auxiliary circuit for initially energizing said actuating means, including a normally closed switch, and means operatively associated with said movable element opening said normally closed switch when the burner has ignited in normal operation.

9. In a combustion system including a burner, igniting means for the burner, a fuel valve controlling the flow of fuel to said burner, and a detector providing a signal when a flame is present at the burner: a control system comprising electrically powered driving means, a movable element having means for opening the fuel valve, means including a normally disengaged clutch connecting said driving means with said movable element, yielding means biasing said movable element to a position where the fuel valve is closed, electrically operable clutch actuating means, means responsive to a demand for heat for initially energizing said clutch actuating means for a burner starting period, and means responsive to a signal from said detector maintaining said clutch actuating means energized during normal burner operation.

10. In a combustion system including a burner, igniting means for the burner, a fuel valve controlling the flow of fuel to said burner, and a detector providing a signal when a flame is present at the burner: a control system comprising electrically powered driving means, a movable element having means for opening the fuel valve, means including a normally disengaged clutch connecting said driving means with said movable element when said clutch is engaged, yielding means biasing said movable element to a position where the fuel valve is closed, clutch actuating means responsive to a signal from said detector maintaining said clutch engaged during normal burner operation, and a circuit energizing said clutch actuating means before normal burner operation is established.

11. In a combustion system including a burner, igniting means for the burner, a fuel valve controlling the flow of fuel to the burner, and a detector providing a signal when a flame is present at the burner; a control system comprising electrically powered driving means, a movable element having means for opening the fuel valve, means including a normally disengaged clutch connecting said driving means with said movable element when said clutch is engaged, yielding means biasing said movable element to a position where the fuel valve is closed, clutch actuating means responsive to a signal from said detector maintaining said clutch engaged during normal burner operation, a circuit for energizing said clutch actuating means prior to normal burner operation, and means operatively associated with said movable element opening said circuit when the burner has ignited in normal operation.

12. In a combustion system including a main burner, a pilot burner, a main burner fuel valve, a pilot burner fuel valve, igniting means for the pilot burner, and a detector providing a signal when a flame is present: a control system comprising electrically powered driving means, a movable element having means for opening first the pilot burner fuel valve and then the main burner fuel valve, means including a normally disengaged clutch connecting said driving means with said movable element when said clutch is engaged, yielding means biasing said movable element to a position where the valves are closed, electrically operable clutch actuating means, means responsive to a demand for heat for initially energizing said clutch actuating means for a burner starting period, and means responsive to a signal from said detector maintaining said clutch actuating means energized during normal burner operation.

13. In a combustion system including a main burner, a pilot burner, a main burner fuel valve, a pilot burner fuel valve, igniting means for the pilot burner, and a detector providing a signal when a flame is present: a control system comprising electrically powered driving means, a movable element having means for opening first the pilot burner fuel valve and then the main burner fuel valve, means including a normally disengaged clutch connecting said driving means with said movable element when said clutch is engaged, yielding means biasing said movable element to a position where the valves are closed, clutch actuating means responsive to a signal from said detector maintaining said clutch engaged during normal burner operation, and a circuit energizing said clutch actuating means before normal burner operation is established.

14. In a combustion system including a main burner, a pilot burner, a main burner fuel valve, a pilot burner fuel valve, igniting means for the pilot burner, and a detector providing a signal when a flame is present: a control system comprising electrically powered driving means, a movable element having means for opening first the pilot burner fuel valve and then the main burner fuel valve, means including a normally disengaged clutch connecting said driving means with said movable element when said clutch is engaged, yielding means biasing said movable element to a position where the valves are closed, clutch actuating means responsive to a signal from said detector maintaining said clutch engaged during normal burner operation, a circuit for energizing said clutch actuating means prior to normal burner operation, and means operatively associated with said movable element opening said circuit when the pilot burner has ignited in normal operation.

15. In a combustion system including a main burner, a pilot burner, a main burner fuel valve, a pilot burner fuel valve, igniting means for the pilot burner, and a detector providing a signal when a flame is present: a control system comprising electrically powered driving means, a movable shaft having cam means for opening first the pilot burner fuel valve and then the main burner fuel valve, means including a normally disengaged clutch connecting said driving means to said shaft when said clutch is engaged, yielding means biasing said shaft to a position where the valves are closed, clutch actuating means to cause said clutch to become engaged, a first energizing circuit to said actuating means including a first normally closed switch, a power circuit to said driving means including a second normally closed switch, cam means operatively associated with said movable shaft for first opening said first normally closed switch after the burners have ignited in normal operation and opening said second normally closed switch when the main burner fuel valve is open to its normally operating condition, and a second energizing circuit to said actuating means including a normally open switch closing in response to a signal from said detector.

16. In a combustion system including a burner, a fuel valve controlling the flow of fuel to the burner, and a detector providing a signal when a flame is present at the burner: a control system comprising electrically powered driving means, a movable element having means for opening the fuel valve, means including a normally disengaged clutch connecting the driving means with said movable element, yielding means biasing said movable element when said clutch is engaged to a position where the valve is closed, clutch actuating means responsive to a signal from said detector maintaining said clutch engaged during normal burner operation, start-up means for supplying power to said driving means and energizing said actuating means prior to normal burner operation, and a program control mechanism operatively associated with said movable element to inactivate said start-up means after the burner has ignited in normal operation.

17. In a combustion system including a burner, a fuel valve controlling the flow of fuel to the burner, means for igniting the burner, a detector providing a signal when a flame is present at the burner, and combustion control means sequentially operative to cause the valve to open,

ignite the burner, hold the burner open in response to a signal from the detector after the burner has ignited in normal operation, and to close the valve upon a flame failure: a burner opening and program control mechanism comprising electrically powered drive means, a movable element having means for opening the fuel valve, means including a normally disengaged clutch connecting the driving means with said movable element, yielding means biasing the movable element when said clutch is engaged to a position where the valve is closed, electrically operable clutch actuating means, means responsive to a demand for heat for initially energizing said clutch actuating means for a burner starting period, and means responsive to a signal form said detector maintaining said clutch actuating means energized during normal burner operation.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,953,196 September 20, 1960

Glenn E. Andrews et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 64, for "in activating" read -- inactivating --; column 10, line 46, for "for said actuator after" read -- for maintaining said actuator energized after --.

Signed and sealed this 6th day of June 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents