

Aug. 20, 1946.

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2,406,185

IGNITION CONTROLLING MEANS

Filed May 13, 1943

2 Sheets-Sheet 1

FIG. 1

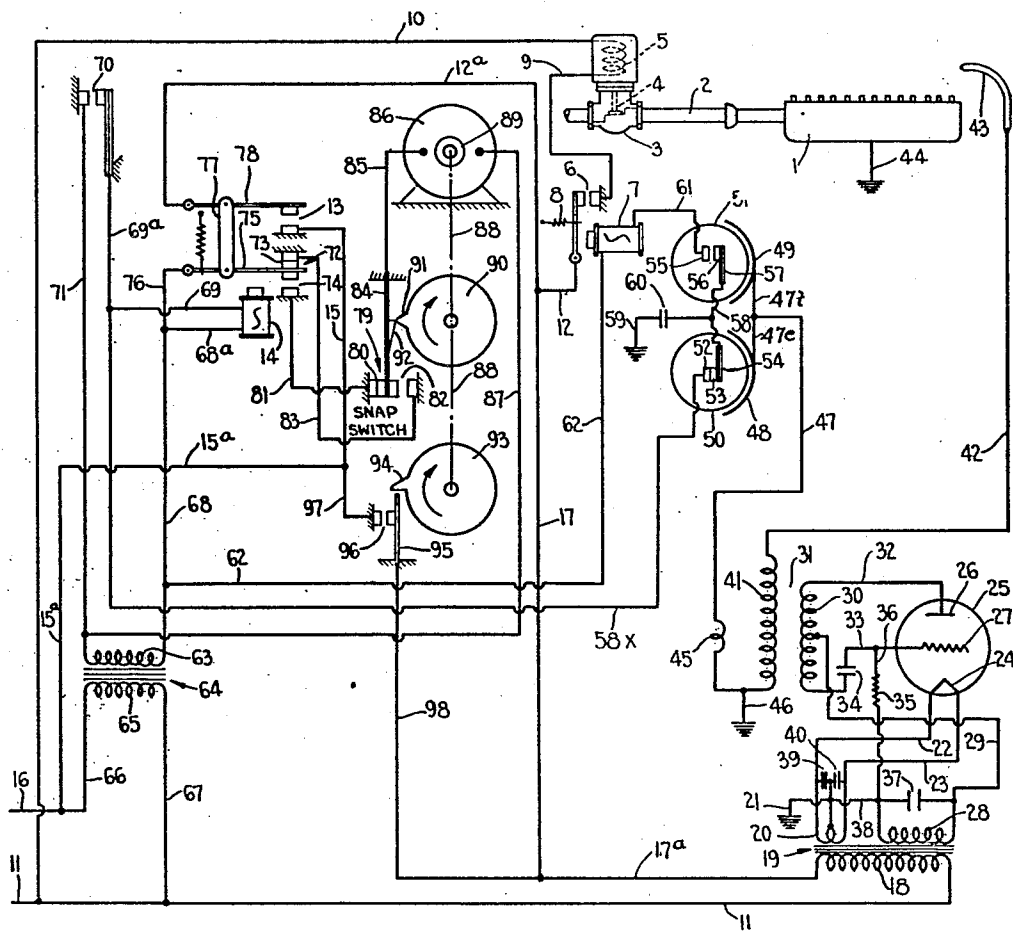
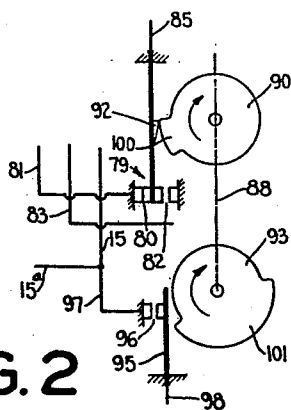


FIG. 2



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2 Sheets-Sheet 2

FIG. 3

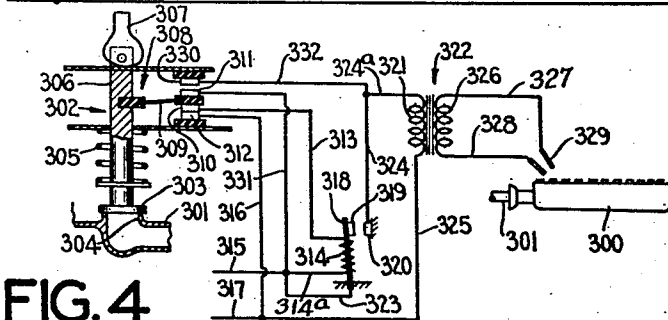
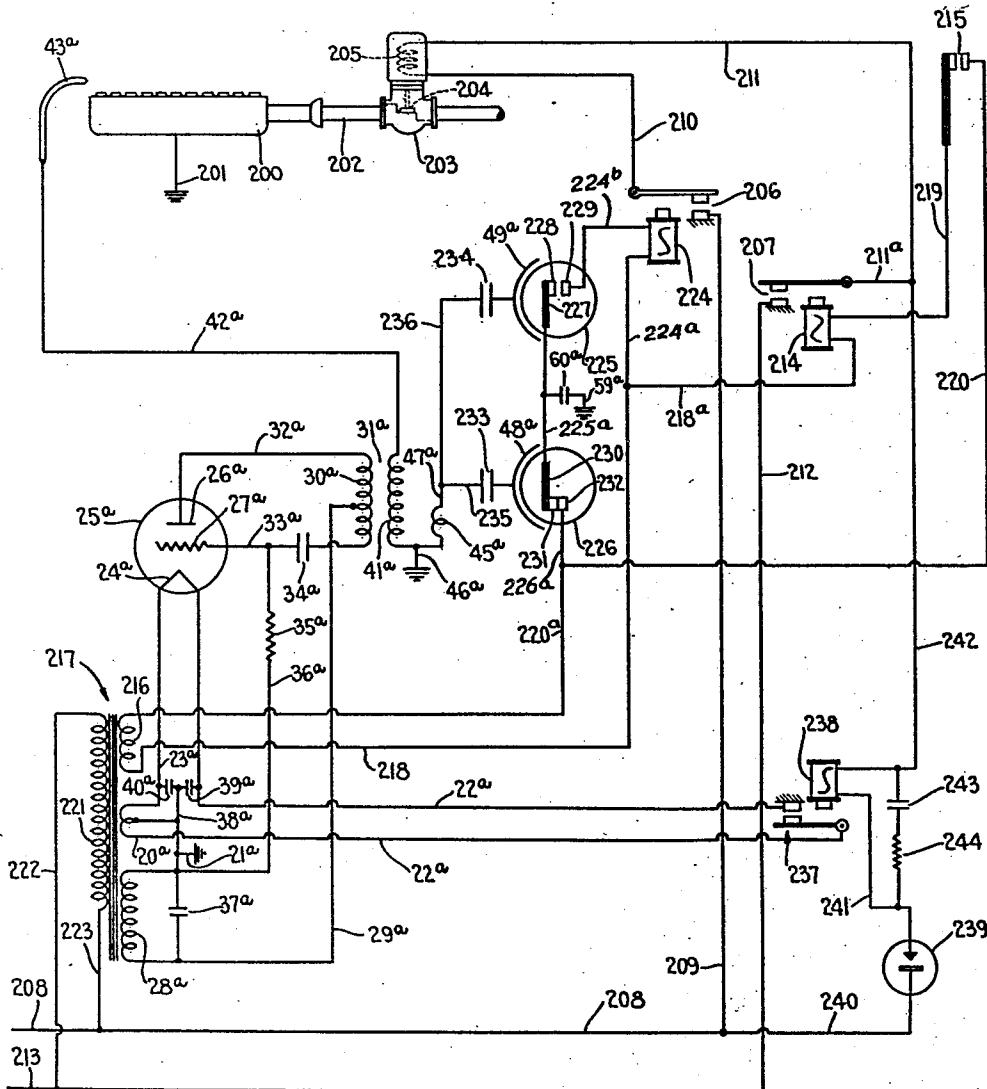


FIG. 4

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IGNITION CONTROLLING MEANS

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9 Claims. (Cl. 158—117.1)

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This invention relates to new and useful improvements in gaseous fuel burning apparatus and more particularly to means for controlling the operation of a burner igniting means.

An object of the invention is to provide a novel apparatus for controlling the operation of a gaseous fuel burner and its igniting means.

Another object is to provide a safety feature for gaseous fuel burner operation in the event of leakage of gas to the burner or failure of the burner gas supply valve to close.

Another object is to provide means by which the ignition means will be operated for a period following operation to close the gas supply valve.

The invention consists in the novel arrangement and cooperative relation of parts in the apparatus, as will be more fully described hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawings, to be taken as a part of this specification, there are fully and clearly shown several preferred embodiments of the invention, in which drawings:

Figure 1 is a diagrammatic view of a gaseous fuel burning apparatus with its control system;

Fig. 2 is a detail diagrammatic view showing a different arrangement of certain switch operating cams forming part of the controlling means of Fig. 1 and providing a different sequence of switch operation;

Fig. 3 is a diagrammatic view similar to that of Fig. 1 but having the controlling means entirely operated by relays, and

Fig. 4 is a diagrammatic view of a burner apparatus embodying the invention and having a manually operable fuel controlling valve.

Referring to the drawings by characters of reference there is in Fig. 1 a gaseous fuel burner 1 having a fuel supply pipe or conduit 2 controlled by an automatic fuel supply valve 3, preferably an electrically operated or solenoid valve. The valve 3 has a valve member 4 which is moved to open position by the magnetic force of the usual solenoid coil 5 and which is urged toward closed position by gravity or spring force upon deenergization of the coil 5. The circuit of the valve coil 5 is controlled by a relay switch 6 having a relay coil 7 and normally urged to open position by a spring 8, from the switch 6 a wire 9 leads to one end of the coil 5 which has its other end connected by a wire 10 to one of the main line wires 11 connected to a source of alternating current supply. The other side of the switch 6 is connected by a wire 12 to one end of a wire 12^a which is connected at its other end

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to one side of a normally open main switch 13 having a relay coil 14 and having its other side connected by a wire 15 to one end of a wire 15^a which is connected at its other end to the other main line wire 16 connected to the source of current. From the junction of wire 12 and wire 12^a, a wire 17 connects to one end of a wire 17^a which has its other end connected to one terminal of the primary coil 18 of the ignition controlling transformer 19, the other terminal of the transformer primary being connected to the line wire 11. The transformer secondary has a coil 20 mid-tapped to ground, as at 21, and having its ends connected by wires 22, 23 to the filament cathode 24 of an electron tube 25, having an anode 26 and a control grid 27. A transformer secondary coil 28 is connected by a wire 29 to the intermediate turn of the primary coil 30 of an air core radio frequency transformer 31. A wire 32 connects the positive terminal of the coil 30 to the plate or anode 26. The other terminal of the primary coil 30 is connected to the grid 27 by a wire 33 in which there is positioned a grid controlling condenser 34. A grid leak resistor 35 is positioned in a wire 36 which connects the grid 27 to the other side of the coil 28. A by-pass condenser 37 is connected across the terminals of the coil 28 and has a value in accordance with the frequency at which the circuit is to be operated. The middle tap of the coil 20 is connected to the wire 36 between the resistor 35 and coil 28 by a wire 38. Balancing condensers 39, 40 are connected between the mid-tap of coil 20 and the cathode lead wires 22, 23, the condensers 39, 40 and 34 and the resistor 35 having such values that the tube 25 is oscillated at predetermined radio frequency of hundreds of kilocycles. The secondary coil 41 of the ignition transformer 31 has its positive terminal connected by a conductor 42 to a spark electrode 43 which is cooperable with the burner 1 which is connected to ground, as at 44. The other end of the secondary coil 41 and the corresponding end of a coupling coil 45 are connected together and to ground, as at 46. The coil 45 has its positive terminal connected by a wire 47 to branch wires 47^e and 47^f connected respectively to the space discharge or gas ionizing electrodes 48, 49 of gas tube warp switches 50, 51 respectively. Each has a sealed glass envelope charged with an inert gas or combination of gases at a predetermined pressure such, for example, as in the Sheldon type FS4-NA gas tube warp switch used for fluorescent tube excitation. The switch 50 has normally closed contacts 52, 53 of

which the movable contact 53 is carried by a bimetal blade or strip 54. The switch 51 has normally open contacts 55, 56, of which the contact 56 is carried by a bimetal blade or strip 57. The bimetal strips 54, 57 are connected together by a wire 58 which is connected to ground, as at 59, through a condenser 60. The envelopes of switches 50 and 51 are charged with different gases or gas mixtures or at different pressures, as is well understood in the art, such that the gas in the tube or envelope of switch 50 will ionize sufficiently to operatively heat the arm 54 at a higher voltage on the electrode 48 than the voltage necessary on the electrode 49 to operatively heat the arm 57 of the tube 51. The fixed contact 55 is connected by a wire 61 to one terminal of the relay coil 7, having its other terminal connected by a wire 62 to one terminal of the secondary coil 63 of a step down low voltage transformer 64 having its primary coil 65 connected across the line wires 16 and 11 by wires 66, 67. From the transformer secondary coil 63 and wire 62, a wire 68 connects to one end of a wire 68^a which has its other end connected to one terminal of the relay coil 14 having its other terminal connected by a lead wire 69 to one end of a wire 69^a having its other end connected to a main or dominant switch 70, such as a room thermostat. From the other side of the switch 70 a wire 71 connects back to the transformer secondary coil 63.

Operated by the relay coil 14 is a timer motor relay switch 72 having normally closed contacts 73 and normally opened contacts 74. The switch arm 75 of the switch 72 is connected by a wire 76 to the junction of the wire 68^a with the wire 68 leading from the transformer secondary coil 63. The arm 75 is mechanically connected by a link 77 to the operating arm 78 of the main relay switch 13 so that the switches 72 and 13 are movable in unison. The switch 72 is in series-parallel circuit with a timer motor snap switch 79 having normally closed contacts 80, of which the fixed contact is connected by a wire 81 to the fixed one of switch contacts 74 and having normally opened contacts 82, of which the fixed contact is connected by a wire 83 to the fixed one of contacts 73. The switch operating arm 84 having the movable contacts of switch 79 is connected by a wire 85 to one terminal of a timer motor 86 having its other terminal connected by a wire 87 back to the transformer secondary coil 63. The timer motor 86 rotates a drive shaft 88 through reduction gearing 89. Fixed on the shaft 88 there is an operating cam wheel 90 having a cam 91 cooperable with a follower 92 mounted on the switch operating arm 84. The cam 91 is normally positioned as shown in Fig. 1 in which it is engaging the follower 92 to hold the switch contacts 80 in closed position. The shaft is rotated at a speed of about one revolution in three minutes and the cam 91 is designed so that substantially immediately after starting of rotation of the wheel 90, the follower 92 will drop off the cam 91, so that the snap switch contacts 82 will be closed (preparatory to restarting the motor 86 after the burner 1 has been stopped) and the contacts 80 will be opened to stop the motor 86. It may be noted that because the wheel 90 takes about three minutes for complete rotation, substantially this time will elapse after the motor 86 is again started by another circuit hereafter described and before the snap switch 79 is again moved back to the position of Fig. 1 with its contacts 80 in closed position. Also mounted on the

shaft 88 there is a cam wheel 93 having a cam 94 cooperable with the flexible blade 95 of a normally open ignition controlling cam switch 96. The switch 96 has its fixed contact connected by a wire 97 to the junction of the wire 15^a with the wire 15 and has its movable contact connected by a wire 98 to the junction of the wire 17^a with the wire 17. The cam 94 is so designed that it engages the switch arm 95 substantially adjacent the termination of a revolution from its starting position and closes the switch 96 for a short period prior to the opening of snap switch contacts 82, the cam 94 moving on into the position of Fig. 1 at the time of opening of the switch contacts 82.

The operation of the apparatus or system of Fig. 1 is as follows. When the dominant switch or room thermostat 70 is closed in calling for heat or operation of the burner 1, the relay coil 14 will be energized, assuming that the main line circuit of wires 11 and 16 has been completed. The circuit of the relay coil is as follows, from the transformer secondary coil 63 through lead wire 68 and wire 68^a to the coil 14 and thence through wire 69 and 69^a to the closed switch 70 and back to the other terminal of transformer coil 63 through wire 71. The coil 14 will attract the arms 75 and 78, thereby to close the main relay switch 13 and to operate the timer motor relay switch 72, breaking circuit at the contacts 73 and making circuit at the contacts 74. This relay switch operation will cause the substantially simultaneous energization of the timer motor 86 through the now closed contacts 74 and of the ignition controlling transformer 19 through the now closed switch 13. The circuit through the closed switch 13 will be as follows, from the main line wire 16 through the wire 15^a and the wire 15 to the stationary contact of the switch 13 and thence through its switch arm 78, lead wires 12^a, 17 and 17^a to one terminal of the primary coil 18 of the transformer 19 and thence from the other terminal of coil 18 back to the source of current supply through the main line wire 11. The circuit of the motor 86 which was completed by a closure of contacts 74 is as follows, from the transformer secondary coil 63 through wires 68 and 76 and arm 75 to the closed contacts 74 and thence through wire 81 to the closed contacts 80 of the snap switch 79 and thence through the snap switch arm 84 and wire 85 to one terminal of the motor 86, and from the other terminal of the motor 86 through wire 87 back to the other terminal of the transformer coil 63. The energization of motor 86 will rotate the cam wheels 90 and 93 in a clockwise direction, as shown by the arrows, and shortly after the start of rotation of the wheel 90, the cam 91 will move out of holding relation to the follower 92 so that the switch arm 84 will operate with a snap action to open the contacts 80 and to close the contacts 82, thereby stopping the timer motor 86. This operation of closing the contacts 82 is preparatory to reenergization of the motor 86 upon reclosure of the timer relay switch contacts 73. The wheel 93 will not perform any function during this initial operation of the motor 86.

When the ignition controlling transformer coil 18 is energized by closure of the switch 13, the network of the electron tube 25 will be energized to oscillate the tube 25 at predetermined radio frequency, as above noted. There will thus be set up in the coil 41 of the ignition transformer 31, due to the spacing of the coils 30 and 41 and the ratio of their coil turns, which may be one

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to ten, a radio frequency voltage preferably above 50,000 v. and at micro amperage. This radio frequency voltage at micro amperage is supplied by the conductor 42 to the spark electrode 43, with the result that there will be a discharge of flowing spark streams from the electrode 43 to the burner 1. It is preferable to employ a transformer 31 which will provide a voltage of say 250,000 v. at the electrode 43, so that the discharging spark streams will be of considerable length. Assuming that the electrode 43 is properly positioned relative to the burner 1, that is, such that the burner 1 is intermediate the length of the discharging spark streams from the electrode 43, then the frequency and voltage in the coil 41 will be such that the coupling coil 45 will deliver frequency and voltage of sufficient values to the space discharge electrode 49 to ionize the gas in the tube 51 and create sufficient heat on the bimetal switch actuator 57 to close the contacts 55, 56. This will result in the energization of the valve controlling relay coil 7 by the following circuit, from the transformer secondary coil 63 through wire 62 to the coil 7 and thence through wire 61, closed contacts 55, 56, wire 58, closed contacts 52, 53 of warp switch 50, wires 58^a and 69^a to the dominant switch 70 and thence through wire 71 back to the transformer coil 63. Energization of coil 7 will close the contacts of the valve relay switch 6, thereby energizing the solenoid valve coil 5 as follows, from main line wire 16 through wire 15^a and wire 15 to the closed switch 13 and thence through switch arm 78, wire 12^a and wire 12 to the closed relay switch 6 and thence through wire 9 to the coil 5 and thence through wire 10 to the main line wire 11. Current flow through the coil 5 will open and hold open the valve member 4 of the gas valve 3 so that the fuel will be supplied to the burner 1 to be ignited by the spark streams discharging from the electrode 43. The warp switch 51 serves not only as the control switch for operating the relay switch 6 upon the occurrence of ignition but also serves as a safety switch to prevent operation of the gas valve 3 in the event of short circuiting of the conductor 42 or electrode 43, or in the event of a positioning of the electrode 43 too close to the burner 1, such that the length of the spark streams is very short. In either of these events of short circuiting or short spark streams, the values of the voltage and frequency applied to the discharge electrode 49 will be insufficient to ionize the gas sufficiently in the tube 51 to cause resulting closure of the switch contacts 55, 56. The gas tube warp switch 50 is a safety means to prevent opening of the gas valve 3 in the event of spacing of the electrode 43 so far away from the burner 1 that the discharged spark streams from the electrode 43 will not impinge on the burner in bunched spark streams. When the electrode 43 is so positioned at too great a distance from the burner 1, then the values of the voltage and frequency applied to the discharge electrode 49 will be increased and be sufficient to ionize the gas in the tube 50 sufficiently to heat the bimetal actuator 54 which will therefore separate the contacts 52, 53 so as to break the circuit of the relay coil 7.

When it is desired to stop operation of the burner 1, the dominant switch 70 is operated to open position which will break the circuits of relay coils 7 and 14 which are in parallel with each other, but both of which are in series circuit with the switch 70. Deenergization of coils

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7 and 14 will permit their respective switches 6 and 13 which are in series with the valve coil 5 to move to open position thereby deenergizing the valve coil 5 and accordingly the valve member 4 should move to closed position and cut off further flow of fuel to the burner 1. In order to avoid the possibility of explosion or of other hazard, if there is a leakage of gas at the valve 4 after the flame at the burner 1 has been extinguished, a safety means is provided for igniting the gas escaping at the burner 1. Opening of the switch 70 will break the circuit of the relay coil 14, thereby permitting the switch arm 75 to close the switch contacts 73 of the timer motor relay switch 72 so that the timer motor 86 is reenergized through the following circuit, from the transformer secondary coil 63 through wires 68, 76 and arm 75 to the closed contacts 73 and thence through lead wire 83 to the closed snap switch contacts 82 and thence through snap switch arm 84 and wire 85 to the motor 86 from which the wire 87 completes the circuit back to the transformer coil 63. Upon this reenergization of motor 86, the cam wheel 93 will again be rotated in its clockwise direction and when the above mentioned predetermined time period of say about three minutes has elapsed, then the cam 94 will engage the switch arm 95 and close the cam switch 96. This will establish a circuit to the ignition controlling transformer primary coil 18 to energize the ignition transformer 31 and cause the discharge of bunched spark streams from the electrode 43 to the burner 1, the circuit of switch 96 being as follows, from the main line wire 16 through wires 15^a and 97 to the closed switch 96 and thence through wires 98 and 17^a to one terminal of the coil 18 which, as above noted, has its other terminal connected to the main line wire 11. The switch 96 will be held closed by the cam 94 for a short time period of say 5 or 10 seconds duration but sufficient to assure the ignition of gas leakage at the burner 1. When the cam 94 leaves the switch arm 95, the arm 95, which is preferably resilient, will snap the switch 96 to open position, thereby breaking the ignition controlling circuit through the transformer primary coil 18. Subsequent to this opening of switch 96 by the cam 94, the cam 91 will be rotated to engage the follower 92 to operate the snap switch 79 to break the timer motor circuit at the contacts 82 and to remake a preparatory circuit at the contacts 80, the opening of the switch contacts 82 serving to stop the timer motor 86 in position for the start of a new cycle or period of burner operation which will be established by the closure of the dominant switch 70.

Referring to Fig. 2, the cam wheels 90 and 92 are provided with cams of different form and relative position from that of the cams 91 and 94 of Fig. 1. In Fig. 2, the wheel 90 has a cam 100 which, as in the case of the cam 91, cooperates with the follower 92, serving to position the contacts 80 of the snap switch 79 in closed position for the start of a burner cycle. This cam 100 has an extending length of cam surface so as to maintain the timer motor 86 in operation for a substantial period of time following closure of the dominant switch 70. The cam wheel 93 has a cam 101 cooperable with the switch blade 95 of the switch 96. The cam 101 is positioned when the timer motor is stopped by the opening of switch contacts 82, in a position, as in Fig. 2, such that after the timer motor 86 has been started at the beginning of burner operation, the

cam 101 will engage and close the switch 96 during the time period of the holding of switch contacts 80 in closed position by the cam 100. The cam 101 therefore serves while the main relay switch 13 is closed, to close a parallel circuit to the ignition controlling transformer secondary coil 18, see Figs. 1 and 2, as follows: From wire 15^a to wire 97 and through the now closed switch 96 and its arm 95 to the wire 98 and thence through wire 17^a to the coil 18. While the switch 96 is held closed by the cam 101 so that ignition will remain "on" when switch 13 is opened, the cam 100 moves out of holding engagement with the follower 92 so that the snap switch 79 is actuated to stop the timer motor 85 by breaking the timer motor circuit at contacts 80 and to close the timer motor preparatory circuit at the contacts 82. The cam 101 has a cam surface of sufficient length so that the switch 96 is maintained closed when the timer motor 85 is stopped by the opening of the switch contacts 80. It will therefore be apparent that when the dominant switch 70 is opened at the end of a heating period that the ignition controlling transformer secondary coil 18 will not be deenergized, the circuit to the same being maintained at switch 96 during the heating period and for a time period thereafter. Ignition at the electrode 43 will therefore continue after the solenoid valve coil 5 has been deenergized. The time period or duration of time during which the switch 96 is maintained closed after the burner is stopped can, of course, be determined by the rate of rotation of the shaft 88 and the length of the cam surface of the cam 101. The speed of rotation and length of cam surface is preferably such that ignition will be kept on at the electrode 43 for a period of say three minutes following the opening of the dominant switch 70, so that there will be ignition of any gas leakage through the closed valve member 4 when the leakage is of sufficient value to provide a combustible mixture at the burner 1. The foregoing partial description of the operation of the cams of Fig. 2, when taken in connection with the complete description of Fig. 1, will make obvious the complete operation of the system when provided with the cams as shown in Fig. 2.

Referring to the apparatus of Fig. 3 there is a gas burner 200 which is electrically grounded, as at 201, and which has a fuel supply pipe or conduit 202 controlled by an automatic gas valve 203, preferably an electrically operated or solenoid valve. The valve 203 has a valve member 204 and an electric operating coil 205. The coil 205 is controlled by a relay switch 206 and by a main relay switch 207 which are in series circuit as follows, from the main line wire 208 through wire 209 to the fixed contact of the switch 206 and thence from its movable contact through wire 210 to one terminal of the coil 205 and from the other coil terminal via wire 211 and 211^a to the movable contact of relay switch 207 and thence from the fixed contact of switch 207 by a lead wire 212 to the other main line wire 213. The coil 214 of the main relay switch 207 is controlled by a dominant switch 215 which, as in Fig. 1, may be a room thermostat, the circuit of this switch and coil being as follows, from the secondary coil 216 of a step down low voltage transformer 217 via a wire 218 to one end of a wire 218^a having its other end connected to the coil 214 and thence via a wire 219 to one contact of switch 215 having its other contact connected to a wire 220 leading to a wire 220^a which

leads back to the other end of the transformer coil 216. The transformer 217 has a primary coil 221 connected by wires 222 and 223 to the main line wires 213 and 208 respectively. The relay coil 224 of relay switch 206 is also supplied with current from the coil 216 and, as in Fig. 1, has in its circuit a normally open gas tube warp switch 225 and a normally closed gas tube warp switch 226. The switch 225 has a bimetal actuator 227 normally holding a switch contact 228 spaced from its cooperating fixed contact 229. The switch 226 as a bimetal actuator 230 normally holding its contact 231 in closed circuit making position with the fixed contact 232. The switches 225, 226 in this form of the invention of Fig. 3 contain the same charge of gas or gas mixture and at the same pressure as distinguished from the different gas charges in the switches 50, 51.

The ignition means of Fig. 3 is the same as that heretofore described and shown in Fig. 1 and therefore the reference characters applied to Fig. 1, but with the suffix "a," designate like parts in the ignition means of Fig. 3. Since the switches 225, 226 are of like characteristics, the values of voltage and frequency at which they respond are controlled by condensers 233, 234, preferably having capacities of .001 microfarad and .01 microfarad respectively. The condenser 233 is connected in a wire 235 leading from the coupling coil conductor or wire 47^a to the discharge electrode 48^a of switch 226. The condenser 234 is positioned in a wire 236 leading from the wire 47^a to the discharge electrode 49^a of switch 225. The ignition means of Fig. 3 is, however, controlled by a relay switch 237 in the filament cathode circuit and interposed in the wire 22^a leading to the cathode from the 6 v. coil 20^a. The switch 237 corresponds to the switch 96 of Figs. 1 and 2. The relay coil 238 of the switch 237 has its energizing circuit controlled by the main relay switch 207 as follows. The relay coil 238 of the switch 237 is supplied with current from the main line wire 208 through a half wave rectifier 239 and has its energizing circuit controlled by the main relay switch 207. The energizing circuit for the coil 238 is as follows, from the main line wire 208 through a wire 240 to the rectifier 239 and thence via a wire 241 to the coil 238 and thence via wire 242 to the junction of the wire 211 with the wire 211^a leading to the movable contact of the switch 207. In shunt with the coil 238 there is a condenser 243 connected across the wires 241 and 242. Connected between the wire 241 and the condenser 243 there is a resistor 244 cooperable with the condenser to determine the time period of condenser discharge to the coil 238 to hold switch 237 closed following the opening of the switch 207.

The operation of this apparatus of Fig. 3 is as follows. When the dominant switch 215 is closed, the relay coil 214 will be energized to pull switch 207 to closed position, thereby completing the energizing circuit of the relay coil 238 so that the ignition controlling relay switch 237 is closed. The circuit of coil 238 is as follows: From line wire 208 to wire 240, through the half wave rectifier 239, to wire 241 and through coil 238 and wires 242, 211^a to closed switch 207 and thence through wire 212 to the other line wire 213. The closure of switch 237 energizes the circuit of the electron tube 25^a to provide the radio frequency high voltage microamperage current supply to the spark electrode 43^a, as described in connection with Fig. 1. Upon the occurrence of a proper discharge of the bunched spark streams from the electrode 43^a

to the burner 200, as described in connection with Fig. 1, the warp switch gas tube 225 will be energized to close the switch contacts 228, 229, thus completing the circuit of the gas valve relay coil 224 from transformer coil 216 via wire 218 to wire 224^a to the coil 224, thence through wire 224^b, the closed switch 225, wire 225^a closed switch 226 to the wire 226^a and thence through wire 220^a back to the transformer coil 216, so that the gas valve relay switch 206 will be closed. Upon closure of switch 206 the circuit of the coil 205 will be completed as above described, thereby opening the gas valve 203 to supply gas to the burner 200 for ignition by the discharging spark streams from the spark electrode 43^a. The switches 225 and 226 serve as safety means to prevent opening of valve 203 as was described for switches 59 and 51.

When the dominant switch 215 is opened for any reason, the circuit of the main relay switch coil 214 will be broken so that the main relay switch 207 will be opened, thereby deenergizing the valve coil 205 and breaking the energizing circuit of the ignition controlling relay coil 238. The relay switch 237 will, however, remain closed so that ignition will be maintained in order to provide ignition for any gas which may leak past the valve 204 in sufficient volume to provide a combustible mixture at the burner 200. Ignition will be maintained for a predetermined period of time following deenergization of coil 205 for movement of valve member 204 toward closed position, the time period being determined by the capacity of the condenser 243 and the value of the resistor 244 which determines the time period to drain the condenser. When the discharge from the condenser 243 is no longer capable of energizing the coil 238 sufficiently to hold the switch 237 in closed position, then the switch 237 will move to open position, thereby breaking the filament cathode circuit 22^a, 23^a to deenergize the electron tube 25^a and stop further operation of the ignition means.

Referring to Fig. 4, an apparatus or system is shown which utilizes a manually operable gas valve in lieu of the automatic valves of Figs. 1 and 3 and which utilizes any of the well known or conventional electric ignition means, although it will be apparent that the ignition means and the ignition responsive safety means of Figs. 1 and 3 might be employed. In this Fig. 4 the gaseous fuel burner 300 is supplied with gaseous fuel through a pipe or conduit 301, the flow of fuel being controlled by a manually operable valve 302 having a valve member 303 cooperable with a valve port 304. The valve member 303 is normally urged toward closed position by a helical coil compression spring 305 acting on the valve stem 306. The valve member 303 is movable to open position by a manually operable cam member 307, which may be pivotally secured to the valve stem and have its cam surface bearing on the valve bonnet, for example. Secured to the stem 306 and electrically insulated therefrom, there is a switch arm 308 having a flexible resilient portion 309 carrying contacts 310, 311 insulated from each other. The contact 310 is engageable with a fixed contact 312 during movement of the valve member 303 to closed position, the valve member 303 being permitted to have continued movement to its seat after engagement of these contacts by reason of the flexible arm portion 309. The contact 310 is connected by a lead wire 313 to one terminal of a heater coil 314 which has its other terminal connected by a wire 314^a to the main line wire 315 leading from a source of current supply. The fixed contact 312 is connected by a wire 316 to

the other main line wire 317 so that when the contacts 310 and 312 are engaged, then the coil 314 will be energized. The coil 314 is in heat exchange relation and operable to heat a thermostatic element 318, preferably a bimetal operating arm or blade rigidly secured to a base at one end and at its other end carrying a switch contact 319. The blade 318, when cold, or when it has cooled following deenergization of coil 314, warps to the right facing Fig. 4 so as to move the contact 319 into engagement with a fixed contact 320, thereby closing the circuit of the primary coil 321 of an ignition transformer 322, the circuit being as follows, from the main line wire 315 through a wire 323 to the blade 318 and contact 319 and from the contact 320 through a wire 324 to a wire 324^a connected to one terminal of the coil 321 and thence via a wire 325 to the main line wire 317. The secondary coil 326 of the ignition transformer is connected by wires 327, 328 to the spark ignition electrodes 329 positioned in cooperative relation with the burner 300 to ignite the gas discharging therefrom when the valve member 303 is opened. The contact 311 is cooperable with a contact 330 and is engageable therewith upon the valve member 303 reaching substantially full open position by operation of the cam member 307. When the contacts 311 and 330 are engaged with each other, a circuit will be established to the transformer primary coil 321 as follows, from main line wire 315 through wire 331 to contact 311 and from contact 330 through wire 332 to the wire 324^a leading to the coil 321 and thence via wire 325 to the main line wire 317.

The operation of this apparatus of Fig. 4 is as follows. During the stand-by period when no heat is desired from the burner 300, so that the valve member 303 is closed, the coil 314 will be heated by reason of closure of contacts 310, 312 so that the transformer 322 will be deenergized by reason of the open circuit at the contacts 319, 320. When the cam 307 is manually operated to open the valve 303, the contact 311 will engage the contact 330, thereby closing the circuit to the transformer 322 as above described, so that ignition sparks at the electrodes 329 will ignite the gas at the burner 300. When it is desired to stop further operation of the burner 300, the cam 307 is moved to the position of Fig. 4 which will break the circuit to the transformer 322 at the contacts 311, 330 but the circuit to the transformer primary coil 321 will be maintained through the closed warp switch contacts 319, 320 so that ignition sparks at the electrodes 329 will continue and ignition will be maintained. Therefore, if the closing movement of the valve 303 extinguished the flame at the burner 300, but the valve member 303 failed to close off gas flow through the port 304 to the pipe 301 so that gas flow of ignitable proportions continued to feed to the burner 300, then the continued ignition will ignite the gas leakage to the burner 300. The period of continued ignition is controlled by the heating of the blade 318, the coil 314 being energized by closure of contacts 310, 312 as the valve member 303 moved toward closed position. Therefore, a predetermined time after movement of valve member 303 toward closed position and closure of contacts 310, 312, the blade 318 will have been heated sufficiently by the coil 314 to move contact 319 away from contact 320 and thereby break the circuit to the transformer primary coil 321. This predetermined time period for breaking of circuit at contacts 319, 320 is sufficient to assure that ignition will be maintained on long enough to ignite any leakage mix-

ture at the burner 300 following extinguishment of the flame by closing movement of the valve member 303.

From the foregoing it will be apparent that there is provided a safety means to eliminate the hazard of gas leakage following presumed closure of the burner controlling gas valve and that the danger of collecting an explosive gas mixture in the burner combustion chamber is overcome.

What is claimed and is desired to be secured by Letters Patent of the United States is:

1. A burner control apparatus comprising a gaseous fuel burner, means to supply fuel to said burner, an electrically operable valve controlling the supply of fuel through said means to said burner and normally biased to closed position, a spark discharge electrode for igniting the fuel supplied to said burner, means including a pair of relay switches in series circuit and controlling the energization of said valve, means to supply electrical energy to said electrode, means including one of said relay switches controlling the operation of said energy supply means, means including a main control switch controlling said one relay switch, means responsive to predetermined operation of said energy supply means for controlling the other of said relay switches, and time interval control means operable, when preconditioned, to control operation of said energy supply means to supply electrical energy to said electrode for a predetermined period, said interval control means being preconditioned upon closure of said main switch and being rendered effective to perform its controlling operation by opening of said main switch.

2. A burner control apparatus, comprising a gaseous fuel burner, means to supply fuel to said burner, an electrically operable valve normally biased to closed position and movable to closed position upon deenergization and controlling fuel flow through said supply means to said burner, ignition means for said burner, a circuit for said valve, a relay switch having an energizing circuit and controlling deenergization of said ignition means, a main switch operable to open said energizing circuit and the circuit of said valve, and means to supply current to said relay switch upon opening of said energizing circuit by said main switch thereby to hold said relay switch energized.

3. A burner control apparatus, comprising a gaseous fuel burner, means to supply fuel to said burner, an electrically operable valve normally biased to closed position and movable to closed position upon deenergization and controlling fuel flow through said supply means to said burner, ignition means for said burner, a circuit for said valve, a relay switch having an energizing circuit and controlling deenergization of said ignition means, a main switch operable to open said energizing circuit and the circuit of said valve, and a condenser having a controlled discharge and in shunt with the coil of said relay switch to supply current to said relay switch upon opening of said energizing circuit by said main switch thereby to hold said relay switch energized.

4. A burner control apparatus, comprising a gaseous fuel burner, means to supply fuel to said burner, an electrically operable valve normally biased to closed position and controlling fuel flow through said supply means to said burner, electric ignition means for said burner, a timer motor, means including a dominant switch and a normally open main relay switch controlling both

said valve and said ignition means, means including a normally open valve-operating relay switch controlling said valve only, means including a double throw timer motor relay switch, means including a double throw snap-acting timer motor switch, said timer switches being in series-parallel circuit with said motor, said timer motor relay switch having normally closed contacts in series circuit with normally open contacts of said snap-acting timer motor switch, said timer motor relay switch having normally open contacts in series circuit with normally closed contacts of said snap-acting timer motor switch, a cam operable by said motor and acting normally to hold closed said normally closed snap-acting switch contacts, said dominant switch being operable on closure to close said main relay switch and to close said open timer motor relay switch contacts so that said ignition means and said timer motor are energized, means operable upon occurrence of ignition to close said valve-operating relay switch, said cam being so constructed and arranged that upon movement by said motor, said cam actuates said snap-acting switch to close said normally open snap-acting switch contacts preparatory to restarting said timer motor and to open said normally closed snap-acting switch contacts thereby to stop said timer motor, said dominant switch acting when opened to open said main relay switch and to reclose said normally closed timer relay switch contacts thereby to reenergize said timer motor, a normally open cam switch controlling said ignition means only, and a cam driven by said timer motor and operable to close said cam switch, said last-named cam being so constructed and arranged relative to said first-named cam as to open said cam switch to deenergize said ignition means during reenergization of said timer motor, said first-named cam acting to operate said snap-acting switch to stop said timer motor subsequent to opening of said cam switch.

5. A burner control apparatus, comprising a gaseous fuel burner, a conduit for supplying fuel to said burner, an electrically operable valve controlling fuel flow through said conduit to said burner and normally biased to closed position, electric ignition means for said burner, a timer motor, means including a normally open main relay switch controlling both said valve and said ignition means, a normally open valve-operating relay switch controlling said valve only, a double throw timer motor relay switch, a double throw snap-acting timer motor switch, said timer switches being in series-parallel circuit with said motor, said timer motor relay switch having normally closed contacts in series circuit with normally open contacts of said snap-acting timer motor switch, said timer motor relay switch having normally open contacts in series circuit with normally closed contacts of said snap-acting timer motor switch, a cam operable by said motor and acting normally to hold closed said normally closed snap-acting switch contacts, a dominant switch operable on closure to close said main relay switch and to close said open timer motor relay switch contacts so that said ignition means and said timer motor are energized, means operable upon occurrence of ignition to close said valve-operating relay switch, said cam being so constructed and arranged that upon movement by said motor, said cam actuates said snap-acting switch to close said normally open snap-acting switch contacts preparatory to restarting said motor and to open said normally closed snap-

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acting switch contacts thereby to stop said timer motor, said dominant switch acting when opened to open said main relay switch thereby to de-energize said valve and said ignition means and acting to reclose said normally closed timer relay switch contacts thereby to reenergize said timer motor, a normally open cam switch controlling said ignition means only, and a time delay cam driven by said timer motor and operable subsequent to said reenergization of said timer motor first to close and then to open said cam switch to provide a period of operation of said ignition means, said first-named cam acting to operate said snap-acting switch to stop said timer motor subsequent to opening of said cam switch.

6. A burner controlling apparatus comprising a gaseous fuel burner, means for supplying fuel to said burner, an electromagnetic valve, normally biased to closed position, for controlling the supply of fuel through said supply means, electrical control means for controlling said valve to open position at times, electric ignition means for the fuel supplied to said burner, means operable to energize said ignition means, means responsive to a thermal change in one direction for energizing said electrical control means and for controlling said operable means, and means including said electrical control means and responsive to said thermal responsive means when a desired temperature is reached in the opposite direction for energizing said ignition means for a predetermined period, said last-named means including means to delay the energization of said ignition means by said last-named means.

7. A burner controlling apparatus comprising a gaseous fuel burner, means for supplying fuel to said burner, an electrically operable valve, normally biased to closed position, for controlling the supply of fuel through said supply means, electrical control means for controlling said valve to open position at times, electric ignition means for the fuel supplied to said burner, means operable to energize said ignition means, an electric switch, means responsive to closure of said switch for energizing said electrical control means and for controlling said operable means, and means including said electrical control means and responsive to opening of said switch for energizing said ignition means for a predetermined period, said last-named means including means to delay the energization of said ignition means by said last-named means.

8. A burner controlling apparatus comprising

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a gaseous fuel burner, a conduit for supplying fuel to the burner, an electrically operable valve, normally biased to closed position, controlling flow through said conduit, electric ignition means for the fuel supplied to said burner, means including a dominant switch operable when closed to energize said ignition means, means to energize said valve and responsive to operation of said ignition means, a timer motor, means to start said timer motor upon closure of said dominant switch, means operable by said timer motor to stop said timer motor upon predetermined running of said timer motor and to close a preparatory circuit for restarting said timer motor, means to complete said preparatory circuit upon opening of said dominant switch, cam means driven by said timer motor, and means operated by said cam means upon predetermined running of said timer motor to reenergize said ignition means.

9. A burner controlling apparatus, comprising a gaseous fuel burner, a conduit for supplying fuel to the burner, an electrically operable valve, normally biased to closed position, controlling flow through said conduit, electric ignition means for the fuel supplied to the burner and having a controlling circuit, means including a dominant switch operable when closed to energize said ignition means circuit, a timer motor, parallel control circuits for said motor, a first double throw switch having normally closed contacts in one of said control circuits and open contacts in the other of said control circuits, a second double throw switch having closed contacts in said other of said control circuits and open contacts in said one of said control circuits, means operable on closure of said dominant switch to open said first switch closed contacts and to close said first switch open contacts to start said motor, a cam driven by said motor and operable upon predetermined motor running to open said second switch closed contacts to stop said motor and to close said second switch open contacts preparatory to reclosure of said first switch normally closed contacts upon opening of said dominant switch, a second controlling circuit for energizing said electric ignition means and having a switch, and a cam driven by said motor upon restarting by the opening of said dominant switch and operable upon predetermined motor running to open said last-named switch to stop said ignition means.

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