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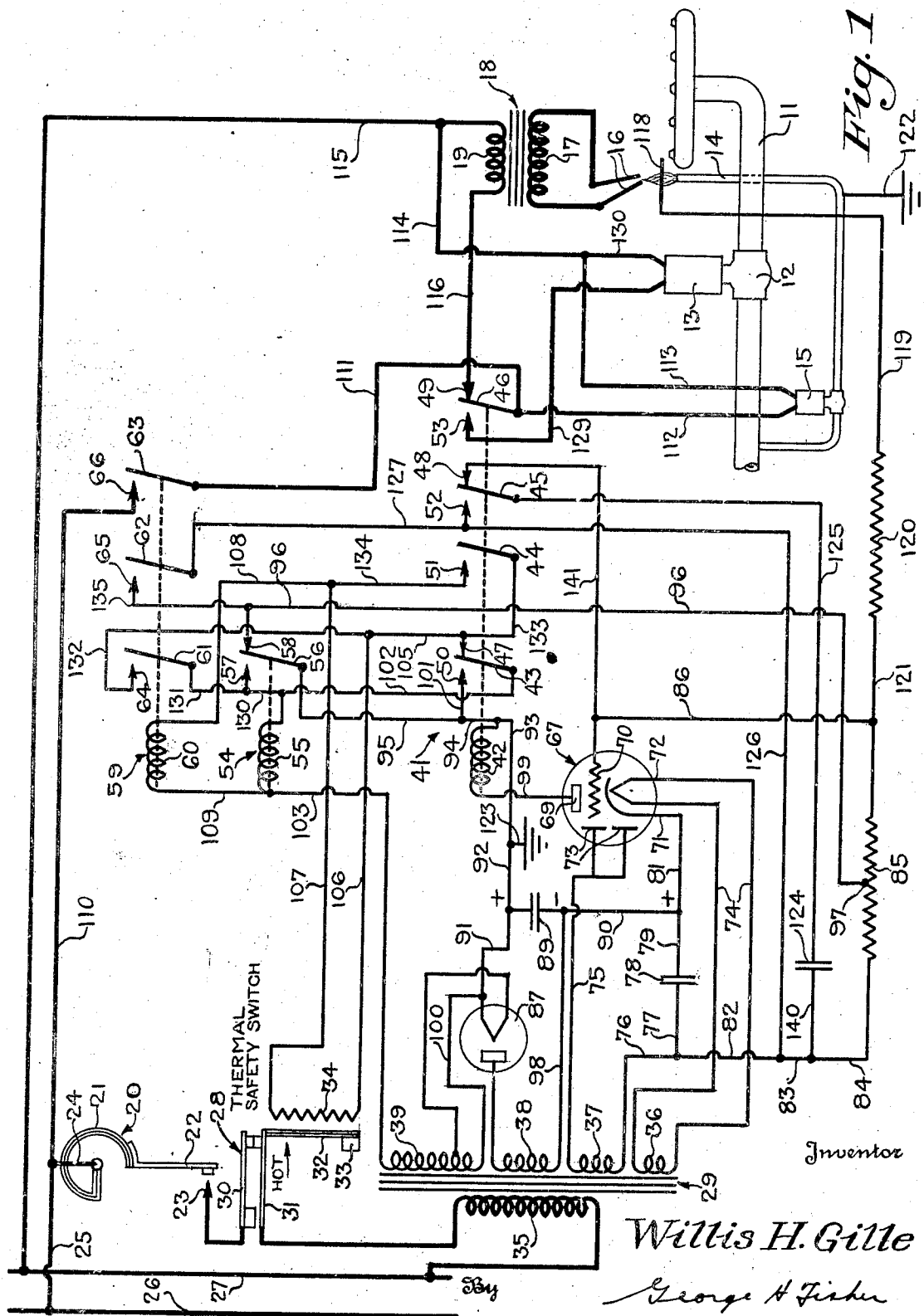
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2,170,497

FUEL COMBUSTION CONTROL SYSTEM

Filed Jan. 29, 1936

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

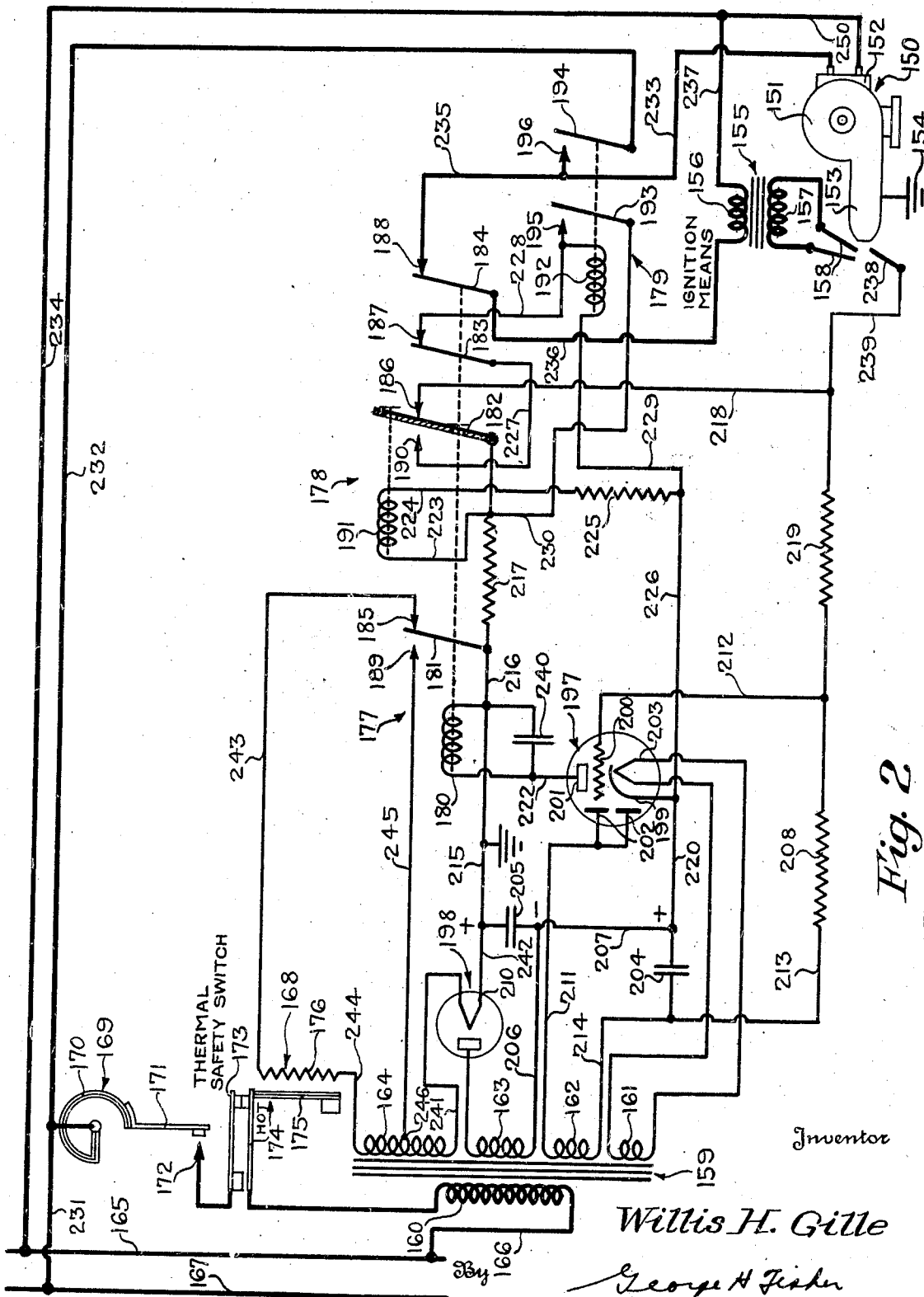


Fig. 2

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FUEL COMBUSTION CONTROL SYSTEM

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My invention relates to an improved fuel combustion control system and more particularly to such a control system having means for automatically igniting the fuel. In this type of control system it is common to provide a thermal safety switch which is operative to interrupt the operation of the system after a predetermined period of time if combustion has not taken place. If combustion does take place within the predetermined period of time, as is normally the case, the thermal safety switch is deenergized so as to be inoperative. Various means have been employed for checking the presence of combustion preparatory to deenergization of the thermal safety switch. One such means comprises an electrode which is located in the presence of the flame of the burner and which is so connected in the system as to provide a conductive path of relatively low resistance to ground upon the presence of a flame so as to change the grid bias on a discharge device controlling the thermal safety switch. Since otherwise the means for checking the combustion would permit the system to continue in operation when a condition simulating combustion is present, such as a low resistance path between the electrode and ground arising by reason of carbonization, it is desirable that some means be provided for preventing the fuel supplying and ignition means from being turned on in the event that such a condition should arise.

An object of the present invention is to provide a system of the class previously described wherein the switching means controlling the starting of ignition and the supplying of fuel to the burner is not operated until a second switching means has been operated in a manner which is impossible in the event of conditions simulating those of combustion prior to the establishment of combustion producing conditions.

A further object of the present invention is to provide such a system wherein a thermionic space discharge device controls a means for checking combustion and in which provision is made for preventing the means controlling combustion producing conditions from being energized until the thermionic element of the space discharge device has become sufficiently heated.

A further object of this invention is to provide a fuel combustion control system having means for deenergizing the ignition means in which provision is made for delaying the action of said ignition deenergizing means for a predetermined period of time after combustion has taken place, while permitting immediate reener-

gization of the ignition means in the event of flame failure.

A further object of the present invention is to provide a relay circuit controlled by a grid controlled space discharge device in which provision is made for delaying the action of the relay by the introduction of a condenser in the grid circuit of said device, and in which means is provided for disconnecting and discharging said condenser upon energization of said relay.

Further objects of the invention will be apparent from the accompanying specification, claims and drawings, of which:

Figure 1 is a schematic view of one form of my control system, and of which:

Figure 2 is a schematic view of a modified form thereof.

Referring to Figure 1 of the drawings, a gas burner is designated by the reference numeral 11. The flow of gas to the burner is controlled by a valve 12 which is preferably an electrically operated valve of any suitable type. The operating means for this valve is designated by the reference numeral 13. A pilot burner 14 is provided which pilot burner is controlled by an electrically operated valve 15 of any suitable construction. Means are provided for igniting the pilot flame. This means comprises a pair of electrodes 16 which are connected to the opposite terminals of a secondary 17 of a step-up transformer 18 having in addition to said secondary a line voltage primary 19.

The operation of my control system is controlled by means of a thermostat 20. The thermostat comprises in the usual manner a bimetallic element 21 a contact blade 22 and a stationary contact 23. The bimetallic element 21 is connected through conductors 24 and 25 with line wire 26. The opposite contact 23 is connected to the other line wire 27 through a thermal safety switch 28 and the primary 35 of a transformer 29.

The thermal safety switch 28 is preferably of the form disclosed in the patent to F. S. Denison, No. 1,958,081, issued May 8, 1934. As shown schematically in the drawings, this switch comprises two switch arms 30 and 31, the first of which is rigidly mounted and the second of which is movably mounted. Switch arm 31 is held in engagement with switch arm 30 through a bimetallic element 32 which is rigidly secured at its lower end to a block 33. A heater 34 is located in proximity to the bimetallic element 32. As indicated by the legend on the drawings, the bimetallic element 32 is adapted to be deflected toward the right upon being heated. The heater

34 furnishes sufficient heat so that if it remains energized for a predetermined period of time it will heat the bimetallic element 32 sufficiently to cause it to be deflected to the right from under switch arm 31 allowing the same to drop downwardly and cause separation of switch arms 30 and 31 thus breaking the circuit controlled thereby. When such separation has taken place, the switch arms 30 and 31 cannot be returned to their original position without manual operation thereof. It will be seen that the thermal safety switch acts as a timing switch, opening the controlled circuit after a predetermined period of time if the heater 34 which constitutes timer energizing means remains energized.

The transformer 29 supplies power for the operation of my control system. This transformer is a combination step-up and step-down transformer and comprises a line voltage primary 35, a low voltage secondary 36, high voltage secondaries 37 and 38 and a low voltage secondary 39.

Three relays are employed in my control system. A first relay 41 comprises a relay coil 42 operatively associated with four relay arms 43, 44, 45 and 46. These relay arms are biased towards the right and when the relay coil is deenergized the arms 43, 45 and 46 are in engagement with contacts 47, 48 and 49, respectively. When the relay coil is energized arms 43, 44, 45 and 46 are in engagement with contacts 50, 51, 52 and 53, respectively. Relay 41 is primarily employed to check the operation of the system before permitting the other relays to be brought into operation and after combustion has been established to bring about the desired running conditions. All of the relay switch arms except switch arm 46 are employed in the controlling circuits while switch arm 46 controls the load circuits which energize the burner apparatus.

A second relay 54 comprises a relay coil 55 associated with a relay arm 56 which is adapted to engage with either of two contacts 57 or 58. Switch arm 56 is similarly biased towards the right and when the coil is deenergized is in engagement with contact 58. When the coil is energized arm 56 is moved into engagement with contact 57. Relay 54 serves primarily to cause relay 41 to be deenergized after its initial checking operation and to bring the elements of the system to a position wherein combustion producing conditions can be established.

A third relay 59 comprises a relay coil 60 which has associated therewith three switch arms 61, 62 and 63. These arms are adapted to be moved into engagement with contacts 64, 65 and 66 upon energization of said coil. Relay 59 functions to bring about the conditions necessary for combustion, the switch arm 63 functioning as a load switch. Relay coils 55 and 60 of relays 54 and 59, respectively, are energized through secondary 39, while relay coil 42 of relay 41 is a direct current relay and is located in the plate circuit of a vacuum tube 67.

The vacuum tube 67 is of the well-known duplex-diode-triode type which functions both as a rectifier to supply a source of direct current for grid biasing purposes and as an amplifier. The tube comprises the usual plate 69, a grid 70, a cathode 71, a cathode heater 72 and a pair of diodes 73. The cathode heater 72 is connected through conductors 74 with the secondary 36 of transformer 29. The secondary 37 is connected in a circuit including the cathode and the two diodes. The two diodes 73 are connected to-

gether since it is not necessary in the present case to have full wave rectification. A junction of the two diodes is connected through conductor 75 to one terminal of the secondary 37. The other terminal of secondary 37 is connected through conductor 76 to a conductor 77 which in turn is connected to one terminal of a condenser 78. The other terminal of the condenser is connected through conductors 79 and 81 with the cathode 71. Thus the condenser 78 has impressed across its terminals a pulsating direct voltage produced by the diode unit, the pulsations of which are filtered out by the condenser. It will be noted that the cathode 71 is connected to the positive side of the condenser. The negative side thereof is connected through conductors 82, 83 and 84, a resistor 85 and conductor 86 with the grid 70. The tendency, accordingly, of the voltage produced through the rectifying action of the diode 73 and cathode 71 is to bias the grid 70 negatively.

A second vacuum tube 87 is employed which tube is a conventional two-electrode half-wave rectifier, having a filament cathode which is energized by a portion of secondary 39, as indicated in the drawings. The output of secondary 38 is rectified through this tube and is connected across the terminals of a filtering condenser 89, one end of secondary 38 being connected to one terminal of condenser 89 and the other terminal of the secondary 38 being connected to the other terminal of the condenser through the tube 87. The negative side of the condenser 89 is connected through conductor 90 with the positive side of condenser 78 which is connected through conductor 81 with the cathode 71. The positive terminal of condenser 89 is, under certain conditions, connected through various relay arms and contacts, to be presently described, to the grid 70. Thus the tendency of the power supplied by secondary 38 and rectifier 87 is to raise the potential of the grid with respect to the cathode. It will thus be seen that two power supplies are provided, which are connected in series and one of which is connected so as to bias the grid negatively and the other of which, when connected to the grid, is connected so as to tend to reduce said bias.

When the temperature of the space to be controlled falls below the value it is desired to maintain, the bimetallic element 21 of thermostat 20 will be effective to cause contact arm 22 to move into engagement with contact 23. This will close the circuit to the primary 35 of transformer 29 causing energization of the secondaries of the transformer. Energization of secondary 37 as soon as the cathode of tube 67 becomes heated causes a voltage to be applied across the terminals of condenser 78 which, because of the connections previously described, causes a negative biasing voltage to be applied to the grid 70 of tube 67. Energization of secondary 38 causes a voltage to be applied across the terminals of condenser 89, as soon as the cathode of tube 87 becomes heated. As previously pointed out, the negative terminal of the condenser 89 is connected together with the positive terminal of condenser 78 to the cathode 71. With the various relays in the position shown, the grid 70 is connected to the positive side of condenser 89 through the following circuit: from grid 70, through conductor 86, the right-hand portion of resistance 85, conductor 96, contact 58, switch arm 56, conductors 95, 94, 93 and 92 to the positive terminal of condenser 89. The result of this

connection of grid 70 to the positive terminal of the condenser 89 across which is applied the rectified output of secondary 38 is that the grid is subjected to a positive voltage which reduces the negative biasing action of the previous power supply sufficiently to cause a current to flow between plate 69 and cathode 71 through the following plate circuit: from the positive terminal of condenser 89, through conductors 92 and 93, relay coil 42, conductor 99, plate 69, cathode 71, conductors 81 and 90 to the negative side of condenser 89.

This flow of current through the plate circuit including relay coil 42 is effective to cause energization thereof and to cause relay arms 43, 44, 45 and 46 to move into engagement with contacts 50, 51, 52 and 53, respectively. The movement of arm 43 into engagement with contact 50 establishes the following circuit through relay coil 55 of relay 54: from the lower terminal of secondary 39, through conductors 100, 91, 92, 93, 94 and 101, contact 50, switch arm 43, conductor 102, relay coil 55 and conductor 103, to the other terminal of secondary 39. The establishment of this energizing circuit for relay coil 55 causes the relay arm 56 to be moved into engagement with contact 57. Upon this taking place the following holding circuit is established for relay coil 55: from the lower terminal of secondary 39, through conductors 100, 91, 92, 93, 94, 95 relay arm 56, contact 57, conductor 130, relay coil 55 and conductor 103 to the other terminal of secondary 39. At the same time that relay arm 56 is moved into engagement with contact 57, it is moved out of engagement with contact 58. Since the previously traced connection between the grid 70 and the positive side of the two power supplies depended upon the engagement of switch arm 56 with contact 58 this separation of the switch arm from contact 58 interrupts this previously traced connection, so that the grid is now subjected only to the negative biasing voltage applied across condenser 78. The result is that the grid potential is now below the cut-off point so that no plate current flows through relay coil 42 with the result that relay 41 is deenergized.

Upon the relay coil 55 being energized and relay coil 42 being deenergized, the following energizing circuit is established through relay coil 60: from the lower terminal of secondary 39 through conductors 100, 91, 92, 93, 94, and 95, relay arm 56, contact 57, the conductors 130 and 102, switch arm 43, contact 47, conductors 105 and 106, heating element 34, conductors 107 and 108, relay coil 60 and conductors 109 and 103 to the other terminal of the secondary 39. The energization of relay coil 60 causes contact arms 61, 62 and 63 to be moved into engagement with contacts 64, 65 and 66, respectively. The moving into engagement of contact arm 61 with contact 64 results in the following holding circuit being established for the relay coil 60: from the lower terminal of secondary 39, through conductors 100, 91, 92, 93, 94 and 95, contact arm 56, contact 57, conductor 131, contact arm 61, contact 64, conductors 132 and 106, heating element 34, conductors 107 and 108, relay coil 60 and conductors 109 and 103 to the other terminal of secondary 39. The establishment of this holding circuit results in the energization of relay coil 60 being independent of relay coil 41 so that upon relay coil 41 becoming reenergized as subsequently takes place, relay coil 60 will remain energized. It will be noted that the energizing and holding circuits for relay coil 60 pass through the heating element

34 of the thermal safety switch so that as soon as relay coil 60 is energized the heating element of the thermal safety switch begins to heat the bimetallic element 32 thereof.

The moving into engagement of arm 63 with contact 66 results in the following circuit through the valve 15 controlling the pilot burner being established: from line wire 26, through conductors 25 and 110, load contact 66, load switch arm 63, conductor 111, conductor 112, the pilot valve actuating means, and conductors 113, 114 and 115, to the other line wire 27. The establishment of this circuit causes the valve controlling the pilot to be opened with the result that gas is fed thereto. At the same time, the following circuit through the ignition means is established: from line wire 26, through conductors 25 and 110, load contact 66, load switch arm 63, conductor 111, load switch arm 46, load contact 49, conductor 116, primary 19 of transformer 18 and through conductor 115 to the other line wire 27. The establishment of this circuit causes the energization of secondary 17 with the result that a high voltage is applied across the electrode 16 causing a spark to appear thereacross.

With the energization of the ignition means and the opening of the pilot valve, combustion should take place if conditions are proper. My control system now functions so that after a predetermined period of time after a flame has appeared at the pilot, the main gas valve will be turned on and the ignition means turned off. This is done by reenergizing relay 41 through reducing the grid bias by means of a connection between the grid and the positive side of the power supplies through the flame. The action of the means for turning on the main gas valve is delayed through a condenser connected in parallel with a portion of the grid circuit. At the same time, a portion of the resistance is cut out of the circuit between the grid and the negative terminal of the power supplies. This causes the grid to be lowered in potential so as to necessitate the presence of a path of lower resistance than previously required between the grid and the positive side of the two power supplies in order to drive the grid voltage sufficiently high to cause energization of relay coil 42. These various means will now be described in more detail.

The means for connecting the grid to the positive side of the power supplies comprises an electrode 118 which is inserted in the path of the pilot flame. This electrode is connected through a conductor 119, a protective resistance 120, conductor 121 and conductor 86 with the grid 70. The pilot supply pipe 14 is connected to ground as indicated at 122 and the positive side of the two power supplies is connected to ground as indicated at 123. The result is that upon a flame of lower resistance than the air gap appearing at the pilot by reason of the same being lighted, a path between the grid 70 and the positive side of the positive power supply is established. The resistor 120 is of comparatively low value and is inserted to prevent the grid from being subjected to too high a voltage in the event of electrode 118 being accidentally grounded.

A condenser 124 is connected between the grid and the negative terminal of the two power supplies. This condenser is permanently connected to the negative terminal through a conductor 140 and is connected to the grid through conductor 125, switch arm 45, contact 48 and conductor 141. Thus upon relay coil 41 being in a deenergized condition, a circuit is established between the

grid and the negative terminal of the negative power supply in parallel to the connection through resistor 85. Until the condenser becomes charged this parallel connection offers a comparatively low impedance so that the grid tends to be directly connected to the negative terminal of the power supplies. After a predetermined period of time, depending upon the capacity of condenser 124 with respect to the resistance of the rest of the grid circuit the condenser will become charged and the potential of grid 70 will be accordingly raised. With the provision of this condenser, the effect of the connection between the grid and the positive terminal of the power supply through the flame of the pilot burner is delayed until the condenser has been charged. It will be obvious that by choosing a condenser of suitable capacity, any desired time delay can be obtained. In this way, the action of ignition cut-off means can be delayed until there is a certainty that the flame is steady.

Until relay 59 is energized the connection between the grid 70 and the negative side of the two power supplies includes the entire resistance 85. As soon as relay 59 is energized, however, with the resultant moving into engagement of switch arm 62 with contact 65, the left-hand portion of resistance 85 is shunted out through the following circuit: from the left-hand terminal of resistance 85, through conductors 84, 83, 126 and 127, switch arm 62, contact 65, and conductors 135 and 96, to the mid-point 97 of resistance 85. The result of this is that until relay 59 is energized, the resistance between the grid and the negative side of the power supplies is much greater than after energization of said relay so that during the initial stages of operation of my system the grid is biased less negatively. The result of this is that if through insulation leakage or due to a low resistance between the electrode 118 and the pilot burner 14, there is a path of comparatively low resistance between the grid and the positive side of the two power supplies, which side is the grounded side, the grid bias will remain sufficiently low so that current continues to flow through relay coil 42. Since it is necessary for relay coil 42 to be deenergized before the relay coil 60 of relay 59 can be energized it is assured that relay coil 60 will not be energized in the event of excessive insulation leakage. As soon as the left-hand portion of the resistance 85 is shunted out, however, by reason of the energization of relay 59, the bias of the grid 70 is increased so that a very substantial decrease in resistance between the grid and the positive side of the system is required in order to again reduce the grid bias sufficiently to cause reenergization of relay coil 42. In this way, a check is made on the insulation resistance of the system while at the same time provision is made against a faulty check of the presence of a flame due to the grid bias being so high that the system is too sensitive. By the shunting out of a portion of the resistance 85 it is necessary that there be a material reduction in the resistance in the connection between the grid and the positive side of the two power supplies such as would occur only in the event of a flame bridging the gap between the pilot and the electrode 118. Moreover, this insures a recycling in the event of the pilot flame being extinguished since even though the electrode has become carbonized in use, the resistance between the electrode and ground will be too high to maintain the bias

sufficiently low to permit a flow of plate current through relay 41.

It will be noted that the connection between the grid and the positive side of the power supplies through relay 54 includes the right-hand portion of resistance 85. As is well known, it is extremely difficult to adequately insulate members of a relay without impeding its proper functioning. Since the high potential side of the system is grounded, it is very important that there is no leakage path of comparatively low resistance between the grid and ground. By connecting the grid to relay contact 58 through the right-hand portion of resistance 85, which has a rather large value, there is an assurance that any path between the grid and the grounded high potential side of the system will be of such high resistance as to not appreciably raise the potential of the grid.

If conditions are proper and a flame does appear, as will normally be the case, relay 41 will be energized with the result that arm 46 is moved out of engagement with contact 49 and into engagement with contact 53. The moving of arm 46 out of engagement with contact 49 causes the previously traced circuit through the primary of the ignition transformer to be interrupted with the result that the ignition means is now deenergized. At the same time, the moving into engagement of load switch arm 46 with contact 53 results in the following circuit being established to the main gas valve: from line wire 26, through conductor 25, conductor 110, load contact 66, load switch arm 63, conductor 111, load switch arm 46, load contact 53, conductor 129, the valve actuating means 13, conductors 130, 114 and 115 to the other line wire 27. This causes the main gas valve to be opened with the result that gas is admitted to the burner which gas is lighted by the pilot flame.

The reenergization of relay 41 with the resultant moving into engagement of contact arm 44 with contact 51 results in the following new holding circuit for relay coil 60 being established: from one end of the secondary 39, through conductors 100, 91, 92, 93, 94, 95, contact arm 56, contact 57, conductor 131, switch arm 61, contact 64, conductors 132, 105 and 133, switch arm 44, contact 51, conductor 134, conductor 108, relay coil 60 and conductors 109 and 103 to the other terminal of secondary 39. It will be noted that the new holding circuit for relay coil 60 just traced does not include the resistance 34 of the thermal safety switch 28 but in effect constitutes a shunt thereacross. Due to the rather high resistance of resistance 34 very little current will flow therethrough and bimetallic element 32 will not be appreciably heated thereby.

The reenergization of relay 41 also causes the engagement of arm 45 with contact 52 with the result that the condenser 124 is now connected in a circuit including conductors 140 and 126, contact 52, contact arm 45, and conductor 125. The condenser 124 will discharge immediately due to the absence of appreciable resistance in the circuit so that in the event the flame is extinguished for any reason, it is possible to immediately reenergize the ignition means, even though such a flame failure takes place almost immediately after the deenergization of the ignition means.

If for any reason the pilot burner does not become lighted, the potential of grid 70 will not be raised sufficiently to cause energization of relay coil 42. The result will be that the last traced holding circuit for relay coil 60 is not established

with the result that the current flowing there-
through must pass through the heater 34. After
a predetermined period of time this will cause the
bimetallic element 32 to be heated sufficiently to
result in a separation of switch arms 30 and 31.
The separation of the switch arms opens the cir-
cuit to the primary of transformer 29 and deen-
ergizes the entire system. As previously stated,
the switch arm 28 cannot be automatically re-
set so that it is necessary for the attendant to
investigate the condition which prevents ignition
of the pilot burner before the system can again
be put into operation.

Moreover, since it is necessary for the relay 41
to be energized and deenergized before energiza-
tion of relay 59, which controls the ignition for
the pilot fuel supply, is possible, there is an as-
surance that there will be no faulty check of the
presence of combustion due to the presence of a
low resistance path between the electrode 118 and
the pilot burner 14. If such a condition should
exist the relay 42 would not be deenergized so that
relay 59 would never be energized and the fuel
supply and the ignition means would not be
brought into operation. Moreover, there is an
assurance that there will be no delay in checking
the presence of a flame preparatory to shunting
of the thermal safety switch by reason of the
time required to heat the filaments of tubes 67
and 87. Before relay 59 can be energized it is
necessary for relay 42 to be energized and this
cannot take place until the filaments are heated.
By thus requiring energization and deenergiza-
tion of the relay 42 which ultimately is energized
to shunt out the thermal safety switch I guard in
a positive manner against a condition which
might arise through a shorted electrode wherein
the thermal safety switch would be shunted out
even though there was no combustion with the
result that the ignition and fuel supply means
would continue in operation without combustion
of the fuel being supplied taking place.

If at any time both the pilot burner and the
main burner are extinguished the conductive path
between the grid and the positive terminal of the
two power supplies will be interrupted with the
result that relay coil 42 is deenergized. This will
cause immediate reenergization of the ignition
means and closing of the main gas valve and at
the same time interrupt the last traced holding
circuit of relay coil 60. If conditions are proper
to reestablish combustion the presence of the
flame will cause reenergization of relay 41 as soon
as condenser 124 is recharged. On the other
hand, if for some reason combustion does not
take place the continued flow of current through
heater element 34 will open the thermal safety
switch and deenergize the entire system.

It will be noted that I have provided means for
thoroughly testing the operation of my flame re-
sponsive ignition deenergizing circuit before es-
tablishment of combustion producing conditions.
Thus, if for any reason the tube 67 is not func-
tioning in the manner desired, relay coil 42 will
never be energized. If, on the other hand, the
tube 67 should be functioning properly but the
resistance across the flame gap should be so low
that the flame checking means might otherwise
work even in the absence of a flame, the relay
coil 42 is not initially deenergized so that it is
impossible for the power relay 60 to be energized
so as to establish combustion under these condi-
tions. Again, if the rectifier tube 87 is not func-
tioning properly, relay coil 42 will not be ener-
gized. At the same time I avoid the disadvan-

tage of certain prior devices wherein slight varia-
tions in the conductivity of the flame will cause
the system to be deenergized. It will be noted that
no matter how low the conductivity of the flame,
the system will remain in operation. While it is
true that a too high resistance across the flame
gap will cause deenergization of relay 41 and if
continued long enough deenergization of the
entire system, a large variation in resistance is
possible due to the fact that the portion of the
resistance 85 between its midpoint and terminal
84 is shunted out and the flame checking means,
is accordingly less sensitive than in the testing
period of its operation.

In Figure 2 I have shown a modified form of
my combustion control system. In this form of
my device I have shown my system as applied to
an oil burner, although it will be understood that
the same could readily be applied to any other
fluid fuel burner by obvious modifications thereof.

Referring to said figure, a fuel burner is desig-
nated by the reference numeral 150 and com-
prises a burner motor 151 driven by a motor hav-
ing a terminal box 152 and a fuel feeding nozzle
153 grounded as indicated at 154.

The means for igniting the fuel comprises a
step-up transformer 155 comprising a line voltage
primary 156 and a high voltage secondary 157.
The opposite terminals of the secondary 157 are
connected to electrodes 158 spaced apart to form
a spark gap therebetween.

A combination step-up, step-down trans-
former 159 supplies power for the operation of my
control system. This transformer comprises a
line voltage primary 160, low voltage secondaries
161 and 164 and two high voltage secondaries 162
and 163. One terminal of the primary 160 is con-
nected to line wire 165 to a conductor 166. The
other terminal is connected to line wire 167
through a thermal safety switch 168 and a ther-
mostat 169.

The thermostat 169, which may be of any form,
is shown as a conventional bimetallic thermostat
having a bimetallic element 170 to which is at-
tached a contact arm 171 adapted to engage with
a contact 172.

The thermal safety switch, which is of the same
type as a similar switch 28 in the previously de-
scribed species, consists of a pair of switch arms
173 and 174 which are held in engagement by bi-
metallic element 175. An electric heater 176 is
located in proximity to the bimetallic element.
Since the operation of this switch is the same as
switch 28 it will not be repeated here.

As in the previous form of my control system,
three relays 177, 178 and 179 are employed. Re-
lay 177 corresponds in function to relay 41 of the
previously described species and comprises a re-
lay coil 180 and switch arms 181, 182, 183 and 184.
In the deenergized position of relay coil 180,
switch arms 181, 182, 183 and 184 are in engage-
ment with contacts 185, 186, 187 and 188, respec-
tively. Energization of relay coil 180 causes dis-
engagement of the switch arms with the pre-
viously named contacts and causes switch arms
181 and 182 to be moved into engagement with
contacts 189 and 190, respectively. The switch
arm 182 is connected through a one-way con-
nection to the armature which cooperates with
relay coil 180 so that upon deenergization of re-
lay coil 180, arm 182 may still be held in en-
gagement with contact 190 by other means
without preventing the return movement of the
other switch arms. As in the previous species, all
of the switch arms except switch arm 184 are used

in the various control circuits, arm 184 being used to control the load circuit.

The relay 178 comprises a relay coil 191 which is not of sufficient strength to cause switch arm 182; with which it is associated, to be moved into engagement with contact 190 but is able to hold the arm in engagement with said contact after the engagement has been established by relay coil 180. The arm 182 is also connected through a one-way connection to the armature of coil 191 so that the coil 180 may move blade 182 into engagement with contact 90 without moving the armature of coil 191.

Relay 179, which constitutes the power relay, comprises a relay coil 192 which is associated with switch arms 193 and 194 and is adapted to move these arms into engagement with contacts 195 and 196 upon energization thereof. The switch arm 193 is employed to establish a holding circuit for the relay coil, while switch arm 194 acts to control the load circuit.

As in the preceding species two direct current power supplies are employed, one of which is obtained through the rectifying action between the diodes and the cathode of a duplex-diode-triode tube 197 and the other of which is obtained through a two-electrode rectifier 198. The duplex-diode-triode tube 197 is of the conventional type and comprises a cathode 199, a grid 200, a plate 201 and the two diodes 202. The cathode 199 is of the indirectly heated type employing a heater 203 which is energized through the secondary 161 of transformer 159. The secondary 162 is employed to furnish the alternating current rectified by the diodes 202 and cathode 199. One terminal of the secondary 162 is connected to the two diodes 202 which are shown as connected in parallel since for the present purposes it is not necessary to have full wave rectification. The other terminal of the secondary 162 is connected to one terminal of a condenser 204, the opposite terminal of which is connected to the cathode 199. Thus, there is provided across the condenser 204, a direct pulsating voltage, the pulsations of which are filtered out by the condenser.

The secondary 163 is connected to the opposite terminals of a condenser 205 through a conductor 206 and a rectifier 198. The result is that a second supply of direct current is available across the terminals of condenser 205, the pulsations of which are filtered out by the condenser. The two power supplies are connected in series through a conductor 207 which connects the negative terminal of condenser 205 with the positive terminal of condenser 204. The grid 200 is permanently connected to the negative side of the two power supplies through a resistance 208 which resistance corresponds to resistor 85 in my preferred species. As in my preferred species, a further connection is provided between the grid and the positive side of the two power supplies which connection may be either through the switch arm 182 or through the burner flame.

The secondary 164 is designed to supply current for the energization of filament 210 of the rectifier 198. Under certain conditions the secondary also supplies current to the heating element 176 of the thermal safety switch 168.

Upon the temperature in the room or other space to be heated falling below the desired value the thermostat 169 is closed causing the energization of transformer 159. Upon this taking place, the cathode 199 of the tube 197 is heated. As soon as the cathode becomes sufficiently

heated, current is passed between the diodes 202 and the cathode and causes a direct voltage to be applied across the terminals of condenser 204. At the same time the filament 210 of rectifier 198 becomes heated with the result that a voltage is impressed across the terminals of condenser 205.

Because of the previously described connections, the voltage applied across condenser 204 is effective to bias the grid negatively with respect to the cathode. As previously indicated, the negative terminal of condenser 205 is connected together with the positive terminal of condenser 204 to the cathode 199. With the parts shown in the drawings, the grid 200 is connected with the positive side of the condenser 205, which is the positive side of the two power supplies, through the following circuit: from grid 200, through conductor 212, protective resistor 219, conductor 218, contact 186, contact arm 182, resistor 217, conductor 216, and conductor 215, to the positive terminal of condenser 205. The result of this connection between the grid 200 and the positive side of the two power supplies is that the bias of grid 200 is reduced sufficiently that current flows between the plate and cathode of tube 197 through the following plate circuit: from the upper terminal of secondary 163, through the rectifier 198, conductors 242 and 215, relay coil 108, conductor 222, plate 201, cathode 199 and conductors 220, 207 and 206, back to the other terminal of secondary 163. At the same time a circuit is established through relay coil 191 as follows: from one end of secondary 163 through the rectifier 198, conductors 242, 215 and 216, resistor 217, conductor 223, relay coil 191, conductor 224, resistor 225, conductors 226, 220, 207 and 206 to the other terminal of secondary 163. It will be noted that the energization of relay coil 180 depends upon a flow of plate current through tube 197 while the energization of relay coil 191 is independent of tube 197.

It will further be noted that the circuits just traced included resistors 208, 217, 219 and 225. The function of resistance 208 is to reduce the negative biasing effect of the connection between the grid and the negative side of the power supplies, to a value desired. Resistors 217 and 225 are solely to reduce the voltage applied to relay coils 191 and 192 to a value for which they are designed. Resistor 219 functions as a protective resistance to prevent any danger of an excessive voltage being applied to grid 200.

Upon the energization of relay coil 180, switch arm 182 is moved out of engagement with contact 186 and into engagement with contact 190. The movement of the switch arm 182 out of engagement with contact 186 results in the connection between the grid and the positive side of the two power supplies being interrupted so that the grid is connected only to the negative side of the two power supplies and accordingly is biased negatively to such an extent as to prevent flow of plate current through tube 197. This results in the deenergization of relay coil 180. In view, however, of the fact that relay coil 191 is independent of tube 197 and is able to hold switch arm 182 into engagement with contact 190, switch arm 182 does not move back into engagement with contact 186. Upon switch arm 182 being moved into engagement with contact 190, an energizing circuit for relay coil 192 is established as follows: from the secondary 163, through rectifier 198, conductors 242, 215 and 216, resistor 217, switch arm 182, contact 190, conductor 227, contact arm 183, contact 187, con-

ductor 228, relay coil 192, conductors 229, 226, 220, 207 and 206 back to the other terminal of secondary 163.

The energization of relay coil 192 causes switch arms 193 and 194 to be moved into engagement with contacts 195 and 196, respectively. The engagement of switch arm 193 with contact 195 establishes a holding circuit for relay coil 192 as follows: from one terminal of secondary 163, through the rectifier 198, conductors 242, 215 and 216, resistor 217, conductor 230, switch arm 193, contact 195, relay coil 192, and conductors 229, 226, 220, 207 and 206 back to the other terminal of secondary 163. It will be noted that this holding circuit is independent of the engagement of switch arm 183 with contact 187 so that even if relay coil 180 is now reenergized, relay coil 192 will still remain energized.

The engagement of switch arm 194 with contact 196 as a result of energization of relay coil 192 establishes the following circuit through the burner motor: from line wire 167, through conductors 231 and 232, switch arm 194, contact 196, conductor 233, the burner motor, conductors 250 and 234 to the other line wire 165. At the same time the following circuit is established through the primary of the ignition transformer: from line wire 167, through conductors 231 and 232, switch arm 194, contact 196, conductor 235, contact 188, switch arm 184, conductor 236, primary 156, conductors 237 and 234, to the other line wire 165. With the energization of the primary 156, the ignition means is placed in operation and conditions are established for combustion.

If the apparatus is functioning properly, the fuel issuing from the nozzle 153 will be ignited by the spark appearing across the electrodes 158 and a flame will appear which will bridge the gap between an electrode 238 and a burner nozzle 153. Upon this taking place, a new path is established between the grid and the positive side of the two power supplies, through conductor 212, resistor 219, conductor 239, electrode 238, and the flame gap to burner nozzle 153 which is connected to ground so as to be at the same potential as the positive side of the power supply. The result of the establishment of this new connection between the grid and the positive side of the power supply is to again raise the grid to a potential sufficiently high to cause the tube 197 to pass current. The result of this is to cause relay coil 180 to be energized again. The energization of relay coil 180 causes separation of switch arm 184 and contact 188 to interrupt the circuit through the ignition transformer to deenergize the ignition means. Since during this initial state, the flame is apt to be somewhat unsteady it is desirable, as pointed out in connection with my previous species, to somewhat delay the action of the relay which places the ignition means out of operation. In my previous species this was accomplished by the condenser connected across the portion of the grid circuit, which delayed building up of the potential of the grid. In the present case, a condenser 240 is connected across the relay coil 180 so as to effectively shunt out the relay coil 180 until the condenser 240 has become charged. The time required for charging is sufficient to permit the flame to become somewhat stable.

As indicated in the previous paragraph, the secondary 164 is employed to heat the filament 210 of rectifier 198 and also to supply current to heating element 176 during certain portions of

the operation of this system. As will be apparent from the drawings, so long as relay coil 180 is deenergized, the heating element 176 is being energized through a circuit as follows: from one terminal of secondary 164, through conductor 241, the filament 210, conductor 242, conductor 215, conductor 216, switch arm 181, contact 185, conductor 243, heating element 176 and conductor 244 to the other terminal of secondary 164. Upon energization of relay coil 180, switch arm 181 is moved out of engagement with contact 185 and into engagement with contact 189. The circuit through the heater 210 is now as follows: from one terminal of secondary 164 through conductor 241, filament 210, conductors 242, 215 and 216, switch arm 181, contact 189 and conductor 245 to an intermediate tap 246 of the secondary 164. It will be noted that under these conditions the heater element 176 is not receiving current and only a portion of the secondary 164 is connected in the circuit. The portion of the secondary 164 which is connected in the circuit under these conditions is of such value that the current flowing through the filament 210 will be of substantially the same value as when the entire secondary is connected in the circuit and the heating element 176 is included therein.

With the above described arrangements of the heating element of the thermal safety switch there are two occasions upon which the thermal safety switch is likely to be open. The first of these exists the time that the system is first energized before the relay coil 180 has become energized. It will be seen that at this stage of the operation if relay coil 180 does not become energized within a predetermined period of time for any reason whatsoever, the heater 176 will become sufficiently heated to open the thermal safety switch and deenergize the entire system. In this way the condition of the two tubes 197 and 198 and the various connections are checked before any of the relays have operated. A second occasion upon which the thermal safety switch is apt to be open is after relay 177 has first been deenergized with the resultant energization of relay 179 which establishes a combustion producing condition. If for any reason at its time combustion does not take place the grid 200 remains permanently at the lower potential so that relay coil 180 is not again reenergized. In this case also the heating element 176 will remain in the circuit sufficiently long to open the thermal safety switch.

While in the present species I have not provided a means for increasing the sensitivity of tube 197 to a reduction in the conductivity between the electrode 238 and the burner nozzle as was done in the preferred species by having a resistance of considerable magnitude which is connected between the grid and the negative terminal of the two power supplies during the initial operation of the system and which is partly cut out after establishment of combustion, it will be understood that this means could be employed with the present species in the same manner as in the previously described species where it is considered desirable. Furthermore, while I have shown a condenser connected directly across the relay coil 180 instead of across a portion of the grid circuit of the duplex-diode-triode tube as in the previously described species, it will be understood that if desired the condenser may be so connected in the present series. Another difference between the last described species and

the first described one is that the grid is not connected to the positive terminal of the power supplies through a portion of the resistor between the grid and the negative terminal of the power supplies as was done in the first described species. It is to be understood, however, that this feature may be employed in connection with the second species, if desired. Furthermore, while, in one case, my invention is applied to a gas combustion system and in another case to an oil combustion system, the invention is not limited to any particular type of fuel combustion system.

In addition to the above modifications, it will be understood that such other changes may be made as would occur to one skilled in the art and that my invention is limited only by the scope of the appended claims.

I claim as my invention:

1. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, means for terminating operation of said fuel igniting means, and means for delaying the action of said last named means for a predetermined period of time after combustion has first taken place, said delaying means being operative upon the operation of said fuel igniting means being terminated to immediately assume the condition that it had before said fuel feeding means and fuel igniting means were brought into operation.

2. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, means for terminating operation of said fuel igniting means, energy storing means for delaying the action of said last named means for a predetermined period of time after combustion has first taken place, and means for immediately removing the energy stored up in said energy storing means upon the operation of said fuel igniting means being terminated.

3. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, electrically operated means for terminating operation of said fuel igniting means, a source of electrical energy, a circuit including a gap bridged by a flame when combustion takes place acting to connect said source of electrical energy with said last named electrically operated means, a condenser, and connections between said condenser and a portion of said circuit operative to delay the action of said means for terminating the operation of said ignition means until said condenser has become charged.

4. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, electrically operated means for terminating operation of said fuel igniting means, a source of electrical energy, a circuit including a gap bridged by a flame when combustion takes place acting to connect said source of electrical energy with said last named electrically operated means, a condenser, connections between said condenser and a portion of said circuit operative to delay the action of said means for terminating the operation of said ignition means until said condenser has become charged, and means operative upon said ignition means being rendered inoperative to immediately discharge said condenser.

5. In a burner control system, fuel feeding

means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, means including an electrical circuit for terminating the operation of said fuel igniting means, a switch in said circuit and controlling the same, a relay coil controlling said switch, an energizing circuit for said relay coil, and a condenser connected across said relay coil, said condenser being of sufficient capacity relative to the resistance of said circuit means to appreciably retard the energization of said relay upon establishment of said energizing circuit by reason of the time required to charge said condenser.

6. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, means including an electrical circuit for terminating the operation of said fuel igniting means, a switch in said circuit and controlling the same, a relay coil controlling said switch, a source of electrical energy, circuit means connecting said source of electrical energy to said relay coil, said circuit means including a grid controlled electric valve for controlling the flow of electrical energy from said source to said relay, a condenser, and connections between said condenser and said grid effective to retard the flow of current to said relay coil until said condenser has been charged.

7. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, means including an electrical circuit for terminating the operation of said fuel igniting means, a switch in said circuit and controlling the same, a relay coil controlling said switch, a source of electrical energy, circuit means connecting said source of electrical energy to said relay coil, said circuit means including a grid controlled electric valve for controlling the flow of electrical energy from said source to said relay, a condenser, connections between said condenser and said grid effective to retard the flow of current to said relay coil until said condenser has been charged, a second switch controlled by said relay coil, and means controlled by said second switch operative upon energization of said relay coil to discharge said condenser.

8. In a burner control system, a burner, igniting means for said burner, a space discharge device comprising a cathode, a grid, a main anode, and an auxiliary anode, a relay coil, a normally closed switch controlled by said coil, an energizing circuit for said ignition means controlled by said switch, a source of alternating current, connections between said source of alternating current, said cathode, said auxiliary anode and said grid to maintain a constant negative biasing voltage on said grid, rectifying means, connections between said source of alternating current, said rectifying means, said relay coil, said cathode and said main anode to maintain said main anode at a constant positive voltage with respect to said cathode, and further variable connections between said source of alternating current, said rectifying means, said cathode and said grid and including a flame gap adjacent said burner, to apply a positive biasing voltage to said grid upon the presence of a flame at said burner.

9. In a burner control system, a burner, electrically controlled fuel feeding means therefor, fuel igniting means, switching means for bringing into operation said fuel feeding means, means operative in the absence of combustion to render

inoperative said fuel feeding means a predetermined period of time after the same has been brought into operation, further switching means, said first named switching means being operative only after an initial predetermined operation of said further switching means including the movement of said switching means between two of its circuit controlling positions, and means for preventing the completion of said initial predetermined operation of said further switching means in the event of a condition simulating that of combustion.

10. In a burner control system, a burner, fuel feeding means therefor, fuel igniting means, switching means, movable between first and second circuit controlling positions, means for normally causing said switching means to move from said first to said second and back to said first controlling position, electrically operated means operative upon said switching means so moving from first to second and back to said first controlling position to bring into operation said fuel feeding means, means operative in the absence of combustion to render inoperative said fuel feeding means a predetermined period of time after the same has been brought into operation, and means for preventing said switching means from being moved back from said second to said first position in the event of conditions simulating those of combustion.

11. In a burner control system, a burner, electrically operated fuel feeding and fuel igniting means, a first relay coil, first and second relay switches closed upon energization of said relay coil, a third relay switch normally closed but opened upon energization of said relay, a second relay coil, a load switch closed upon energization of said relay coil, a source of energy, a timing switch controlling said source of energy, means for successively energizing and deenergizing said first relay coil, means operative to establish an energizing circuit for said second relay coil upon the successive closing of said first and third relay switches by reason of the successive energization and deenergization of said first relay coil, said last named energizing circuit including timer energizing means for said timer switch, an energizing circuit for said fuel feeding and said fuel igniting means controlled by said load switch, means responsive to combustion for reenergizing said first relay coil, a shunt circuit around said timer energizing means controlled by said second relay switch to deenergize said timer energizing means as the result of combustion being established, and means operative in the event of conditions simulating combustion prior to the bringing into operation of said fuel feeding and fuel igniting means to prevent the initial deenergization of said first relay coil so as to prevent said fuel feeding and fuel igniting means being brought into operation.

12. In a burner control system, a burner, fuel flow controlling means, fuel igniting means, a first relay coil, a first load switch which is normally closed but is opened upon energization of said coil, a second relay coil, a second load switch which is closed upon energization of said second coil, energizing means, an energizing circuit for said fuel flow controlling means including said energizing means and controlled by said second load switch, an energizing circuit for said fuel igniting means including said energizing means and controlled by both said first and second load switches, means for energizing said second relay coil to establish the circuit through the fuel

flow controlling means and the fuel igniting means, means operative upon the establishment of combustion to energize said first relay coil to interrupt the circuit to the fuel igniting means, and further means to energize and deenergize successively said first relay coil prior to the energization of said second relay coil in order to test the operation thereof prior to the establishment of combustion producing conditions.

13. In a burner control system, a burner, fuel flow controlling means, fuel igniting means, a first relay coil, a first load switch which is normally closed but is opened upon energization of said coil, a second relay coil, a second load switch which is closed upon energization of said second coil, energizing means, an energizing circuit for said fuel flow controlling means including said energizing means and controlled by said second load switch, an energizing circuit for said fuel igniting means including said energizing means and controlled by both said first and second load switches, means for energizing said second relay coil to establish the circuit through the fuel flow controlling means and the fuel igniting means, means operative upon the establishment of combustion to energize said first relay coil to interrupt the circuit to the fuel igniting means, and further means including a third relay coil and a control switch to energize and deenergize successively said first relay coil prior to the energization of said second relay coil in order to test the operation thereof prior to the establishment of combustion producing conditions.

14. In a burner control system, a burner, fuel flow controlling means, fuel igniting means, a first relay coil, a first load switch which is normally closed but is opened upon energization of said coil, a second relay coil, a second load switch which is closed upon energization of said second coil, energizing means, an energizing circuit for said fuel flow controlling means including said energizing means and controlled by said second load switch, an energizing circuit for said fuel igniting means including said energizing means and controlled by both said first and second load switches, means for energizing said second relay coil to establish the circuit through the fuel flow controlling means and the fuel igniting means, an energizing circuit for said first relay coil, a grid controlled space discharge device controlling the flow of current through said circuit, a grid circuit for said tube including connections effective upon the presence of a flame to raise the potential of the grid sufficiently to cause the space discharge device to pass sufficient current to energize said first relay coil so as to deenergize said ignition means, and further connections in said grid circuit operative before establishment of combustion producing conditions to raise the grid potential sufficiently to cause energization of said first relay.

15. In a burner control system, a burner, fuel flow controlling means, fuel igniting means, a first relay coil, a first load switch which is normally closed but is opened upon energization of said coil, a second relay coil, a second load switch which is closed upon energization of said second coil, energizing means, an energizing circuit for said fuel flow controlling means including said energizing means and controlled by said second load switch, an energizing circuit for said fuel igniting means including said energizing means and controlled by both said first and second load switches, means for energizing said second relay coil to establish the circuit through the fuel flow

controlling means and the fuel igniting means, an energizing circuit for said first relay coil, a grid controlled space discharge device controlling the flow of current through said circuit, a grid circuit for said tube including connections effective upon the presence of a flame to raise the potential of the grid sufficiently to cause the space discharge device to pass sufficient current to energize said first relay coil so as to deenergize said ignition means, and further connections in said grid circuit operative before establishment of combustion producing conditions to raise the grid potential sufficiently to cause energization of said first relay, and further means operative upon energization of said first relay coil to interrupt said last named connections prior to establishment of combustion producing conditions.

16. In a burner control system, a burner, fuel flow controlling means, fuel igniting means, a first relay coil, a first load switch which is normally closed but is opened upon energization of said coil, a second relay coil, a second load switch which is closed upon energization of said second coil, energizing means, an energizing circuit for said fuel flow controlling means including said energizing means and controlled by said second load switch, an energizing circuit for said fuel igniting means including said energizing means and controlled by said second load switches, means for energizing said second relay coil to establish the circuit through the fuel flow controlling means and the fuel igniting means, an energizing circuit for said first relay coil, a grid controlled space discharge device controlling the flow of current through said circuit, a grid circuit for said tube including connections effective upon the presence of a flame to raise the potential of the grid sufficiently to cause the space discharge device to pass sufficient current to energize said first relay coil so as to deenergize said ignition means, and further connections in said grid circuit operative before establishment of combustion producing conditions to raise the grid potential sufficiently to cause energization of said first relay, and further means operative upon energization of said first relay coil to interrupt said last named connections to deenergize said first relay coil and to cause operation of the means for energizing said second relay coil.

17. In a fuel burner control system, a burner, fuel feeding means, fuel igniting means, means for establishing energizing circuits for said fuel feeding and said fuel igniting means to place them into operation, a space discharge device, connections to said device to provide input and output circuits, a relay in the output circuits including a switch normally open but closed upon energization of said relay coil, said energizing circuit for said fuel igniting means being controlled by said switch so that energization of said relay coil is effective to deenergize said igniting means, means operative upon the establishment of a flame adjacent said burner to vary the potential across the input circuit in a manner to cause a current flow in said output circuit sufficient to energize said relay, a condenser connected across a portion of said input circuit and adapted to delay said change in potential across said input circuit and consequently the deenergization of said igniting means until said condenser is charged, and means operative upon said relay being energized to disconnect said condenser from said input circuit and to discharge the same.

18. In a burner control system, fuel feeding means, fuel igniting means, means for bringing

into operation said fuel feeding means and said fuel igniting means, a cut-out mechanism automatically operable after a timed period to interrupt the operation of said fuel feeding means, means for rendering said cut-out mechanism inoperative, and means for delaying the action of said last named means for a predetermined period of time after combustion has first taken place, said delaying means being operative upon said cut-out mechanism being rendered inoperative to immediately assume the condition it had before said fuel feeding and fuel igniting means were brought into operation.

19. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, a cut-out mechanism automatically operable after a timed period to interrupt the operation of said fuel feeding means, means for rendering said cut-out mechanism inoperative, energy storing means for delaying the action of said last named means for a predetermined period of time after combustion has first taken place, and means for immediately removing the energy stored up in said energy storing means upon said cut-out mechanism being rendered inoperative.

20. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, an electrically operated cut-out mechanism operable after a timed period to interrupt the operation of said fuel feeding means, means including a switch for deenergizing said cut-out mechanism to render the same inoperative, a relay coil for said switch, an energizing circuit for said relay coil and a condenser connected across said relay coil, said condenser being of sufficient capacity relative to the resistance of said circuit means to appreciably retard the energization of said relay upon establishment of said energizing circuit by reason of the time required to charge said condenser.

21. In a burner control system, fuel feeding means, fuel igniting means, means for bringing into operation said fuel feeding means and said fuel igniting means, an electrically operated cut-out mechanism operable after a timed period to interrupt the operation of said fuel feeding means, means including a switch for deenergizing said cut-out mechanism to render the same inoperative, a relay coil for said switch, a source of electrical energy, circuit means connecting said source of electrical energy to said relay coil, said circuit means including a grid controlled electric valve for controlling the flow of electrical energy from said source to said relay, a condenser, and connections between said condenser and said grid effective to retard the flow of current to said relay coil until said condenser has been charged.

22. In a burner control system, a pilot burner, a main burner, an electrically operated device associated with each burner for controlling the flow of fuel to said burner, switching means for effecting the energization of the pilot burner fuel flow controlling device, means responsive to the pilot burner flame and operative upon the same assuming an igniting condition to cause the energization of the main burner fuel flow controlling device, further switching means, said first named switching means being operative only after an initial predetermined operation of said further switching means including the movement of said switching means between two of its circuit controlling positions, and means for preventing the

completion of said initial predetermined operation of said further switching means in the event of a condition simulating that of the pilot flame when in igniting condition.

5 23. In a burner control system, a pilot burner, a main burner, an electrically operated device associated with each burner for controlling the flow of fuel to said burner, first and second relays each including a relay coil and normally open
10 switching means which is closed upon energization of the relay coil, an energizing circuit for the pilot burner fuel flow controlling device controlled by the switching means of said second relay, an energizing circuit for said main burner
15 fuel flow controlling means controlled in part by the switching means of said first relay, means for energizing said second relay coil to establish the circuit through said pilot burner fuel controlling device, means responsive to the pilot
20 burner flame and operative upon the same assuming an igniting condition to energize said first relay coil to complete the circuit to said main burner fuel flow controlling device, and further means to energize and deenergize successively
25 said first relay coil prior to the energization of said second relay in order initially to test the operation of the system.

24. In a burner control system, a pilot burner, a main burner, an electrically operated device associated with each burner for controlling the flow of fuel to said burner, switching mechanism for effecting the energization of the pilot burner
5 fuel flow controlling device, means responsive to the resistance of a path including a gap bridged by the pilot flame, said means being operative upon the resistance of said path subsequent to the energization of said pilot burner fuel con-
10 trolling device assuming a value accompanying the bridging of said gap by a flame to cause the energization of said main burner fuel flow controlling device, said last named means being op-
15 erative upon the resistance of said path prior to the energization of said pilot burner fuel controlling device assuming a value lower than that normally existing when the gap is open to prevent said energization of the pilot burner fuel flow
20 controlling device, and means to decrease the sensitivity of said resistance responsive means upon the energization of said pilot burner fuel flow controlling device so as to necessitate said
25 path having a lower resistance for operation of said resistance responsive means.

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