This Invention relates to a submerged combustion system and more particularly to a system for the control of submerged combustion burners. The expression "submerged combustion" is used herein to describe combustion beneath the surface of the liquid in direct contact with the liquid and is to be distinguished from the older methods of heating liquids which involve the transfer of the heat from the products of combustion through a metal wall, as, for example, in a steam boiler.

One of the objects of the invention is to provide a submerged combustion system, including a submerged combustion burner, means for supplying fuel thereto, ignition means for the fuel and motor actuated timer means controlled by the temperature of the liquid to be heated for automatically regulating the fuel supply means and the ignition means.

Another object of the invention is to provide a submerged combustion system including a submerged combustion burner, means for supplying pilot fuel thereto, means for supplying main fuel thereto and motor actuated timer means controlled by the temperature of the liquid which is being heated by the burner for automatically regulating the pilot fuel supply means, the main fuel supply means and the ignition means.

Another object of the invention is to provide a submerged combustion system including a submerged combustion burner, means for supplying pilot fuel thereto, means for supplying main fuel thereto and motor actuated timer means controlled by the temperature of the liquid which is being heated by the burner for automatically regulating the pilot fuel supply means, the main fuel supply means and the ignition means.

Still another object of the invention is to provide a new and improved submerged combustion system of the type described, including means to maintain the operation of the pilot fuel supply means for a period after ignition independently of the timer operation.

Still a further object of the invention is to provide a submerged combustion system of the type described including means independent of the timer means to prevent the operation of the main fuel supply means, or both the main fuel supply means and the pilot fuel supply means when the gas pressure is below a predetermined minimum.

An additional object of the invention is to provide a new and improved submerged combustion system of the type described including means to prevent the operation of the main fuel supply means upon failure of operation of the pilot fuel supply means.

Other objects and advantages of the invention will be apparent by reference to the following description in conjunction with the accompanying drawings in which:

Figure 1 represents a general layout of one type of submerged combustion burner system which may be employed in the practice of the invention:

Figure 2 represents a simplified wiring diagram comprising various circuits utilized in the operation of the submerged burner system shown in Figure 1;

Figures 3 to 8, inclusive, represent diagrammatically the operation of the motor actuated timer means employed to control the submerged combustion burner system in accordance with the preferred embodiment of the invention.

Referring to Figure 1, the submerged combustion system shown therein comprises a submerged combustion burner, generally shown at 2, which is disposed in a suitable tank 4 containing a liquid 6. As shown, the outer casing 8 of the burner 2 preferably extends downwardly along the inside wall of the tank 4 and branches out at the bottom as an L-shaped member in which the base of the L is formed by the conduit 10. The combustion gases are discharged directly into the liquid 6 through the holes 12, and the discharge of these gases serves to agitate the liquid. Other modifications of the L shape may be used, the principal ones, however, all involving some form of an L shape, such as for example, a U-shape, which is the equivalent of two L’s, with the base of one opposite to the base of the other, or a T-shape which is equivalent to two L’s with the sides coinciding and the bases of the L’s extending in opposite directions. The present invention is not concerned specifically with the form of the submerged burner itself. Various types of burners may be used, such as described, for example, in See et al., U. S. Patent 2,118,479.

The principal elements of the burner illustrated in Figure 1, in addition to those previously described, comprise an outer passageway 14 through which the main supply of fuel is introduced, an intermediate passageway 16 through which the main supply of air is introduced, and an inner passageway 18 where the pilot fuel and air are supplied and ignited by means of an igniter indicated at 20. The main fuel and air supplies pass through a burner plate 22 provided with suitable holes and are ignited by the pilot flame passing downwardly through the inner passageway 18, thereby causing the main combustion to take place at or beyond the burner plate 22 in direct contact with the liquid 6.

As will be understood, the air and fuel must be
supplied at pressures great enough to overcome the head of the liquid. The air is supplied in the system shown in Fig. 1 by means of a blower generally illustrated at 24. The air is taken into the blower through an air cleaner 26, from which it passes through conduit 28 into the blower and is then forced through conduit 30 and a conduit 35. From conduit 35 a minor proportion of the air is forced through conduit 38 and is referred to herein as the pilot air supply. Most of the air, however, continues through conduit 40 and is introduced into the passageway 16 of the burner 2. The pilot air flows through pilot air control valve 42, a measuring orifice 44, and through the pilot air line into the burner head wherein it passes around the pilot tube 44 and thence into the pilot manifold 18. Shut off cocks 48 are provided on each side of measuring orifice 44 so that a manometer can be easily connected when desired in order to determine the pilot air flow.

A bypass governor 50 controls the gas supply so that its pressure is the same as that of the air supply and also permits the compressed gas to flow to the high pressure or exhaust side of the gas compressor 52 through the governor back to the low pressure or intake side via conduit 54 when the solution or liquid is at the proper temperature and the gas control valves, heretofore described, are in closed position so as to stop any gas flow to the burner. The equalization of pressure between the gas and air supply is maintained by pressure equalizing lines 56 and 58. In case the gas pressure is sufficiently high so that a gas compressor is not required, it will be understood that a different type of governor may be used and that the bypass arrangement 54 will not be necessary. A gas strainer 60 is provided and should be periodically washed and cleaned. If gas is available at a pressure sufficiently high to overcome the resistance due to the head of solution in the tank 4, the gas main is connected directly to the governor 50.

From the governor 50 the gas is passed through a gas supply pipe 62 and one part, the pilot gas, passes through a conduit 64 controlled by a solenoid actuated valve 66, the other part, which forms the main gas supply, passing through conduit 68 controlled by a solenoid actuated valve 70. Conduit 68 is provided with a measuring orifice 72 to control the flow of gas and may be provided on either side of said orifice with suitable cocks, not shown, similar to cocks 48 to which a manometer may be attached to determine the gas pressure. A manually controlled valve 74 is also provided to control the main gas flow. The main gas supply flows through conduit 68 and enters the passageway 14, from which it passes through the burner plate 22 for combustion with the main air supply flowing through the annular passageway 16.

The pilot fuel supply flows through conduit 64, manually controlled pilot gas control valve 76, measuring orifice 78, and is conducted to the igniter 20 through pilot gas tube 44. It will be understood that the igniter may be above the liquid level, as shown, at the liquid level, or below it. A sight port is provided at 80 to view the changes in level as desired. A pair of cocks 82 are provided for a manometer which can be used if necessary to determine the gas flow through the conduit 64.

The igniter 20 consists of a wire which becomes red hot when held by a source of electrical energy supplied through a conductor 84. The conductor 84 is preferably run through the inside of the pilot air supply conduit 88 which it enters at point 90, through a suitable packing box or connection chamber 90, the latter being connected to a cable 92 carrying the conductor 84. The cable 92 in turn is connected to a suitable step-down transformer generally indicated at 94. The step-down transformer 94 receives the current from a high voltage line and reduces it as shown in Figure 2. Also shown in Fig. 1 is a constant current transformer 56, which preferably consists of a 3-pillar laminated iron core with a stationary low voltage secondary coil below, and a floating 110 volt primary coil above, both of which are mounted around the conductor 84 and are designed to change the current in the secondary circuit when any variation in line voltage within 25% above or below normal changes the position of the primary coil but will not change the secondary ignition current. An additional step-down transformer 32 is supplied for the timer control circuit. A control box 36 houses transformer 32 and most of the control elements which will be described more fully hereinafter with reference to Figure 2. The operation of the system is also controlled in response to the temperature of the liquid 8 by means of a thermostat element 100 connected through a line 102 and capable of actuating a switch 104, which in turn closes a circuit to initiate a cycle of operations in the manner hereinafter described. The controlling push buttons are generally indicated at 106, 108, the adjustment for the thermostat control at 109, the high voltage line carrying the source of electrical energy at 110, and the line carrying the source of electrical energy to the compressors 24 and 52 at 112.

The burner system previously described is controlled electrically in a manner which may be best understood by reference to Figure 2. As shown in Fig. 2, a source of electrical energy (of any type which is required to drive the motor 114) is passed through the lines or conductors 116, 118, and 120 to a motor 114 which serves to drive the blower 24, or both the blower 24 and the gas compressor 52 if a compressor is necessary. The motor is started by pressing the start button indicated at 106 which serves to energize a solenoid M, of a relay switch 111, thus closing and holding closed the contacts A, B, C, of said relay switch. An overload relay OL is provided to protect the motor from overloading and to break the circuit through the solenoid M by breaking the contacts OL when an overload occurs, otherwise the contacts OL are normally closed as illustrated. The motor control circuit thus extends from one side of the secondary winding of the transformer 32 through a fuse F, the normally closed stop switch 108, the start switch 106, the solenoid M of relay switch 111, the overload switch OLS, and thence to the other side of the secondary winding of the transformer 32, through a return conductor C which is preferably grounded. Thus, it will be seen that when the starter button at 106 is pressed the motor 114 runs continuously, thereby driving the air compressor and the gas compressor and causing a constant volume of air to be blown into the burner thereby continuously agitating the liquid 6 regardless of whether the fuel has been ignited or the liquid is being heated.

As shown in Figure 2, the lines L1 and L2 have takeoffs to the transformer 32 which transforms the current from the 110 volt line to 110 volt circuits. The 110 volt circuits are grounded at G, and one side of the line passes through the starter button at 106, and the holding switch
contacts M′, which remains closed to maintain the circuit through coil M even after the start button opens when released after being pressed down to start the system in operation. The timer circuit also passes through the manually operable off and on switch 118, which is normally closed and the thermostatic switch 104, which is closed if the temperature of the liquid is below the thermostat setting. From the thermostat 104 the current passes through a conductor c and to a motor actuated timer generally indicated at 120 in Figure 2. The invention is not limited to the use of any particular motor actuated timer but may be illustrated by reference to a timer of the type described in U.S. Patent 2,175,864. The principal elements of this type of timer are shown diagrammatically in Figures 3 to 8. These Figures 3 to 8 also show the various positions of the various elements of the timer at different stages of the submerged combustion control operation, and the various positions of said elements, together with the operation thereof, will be described hereinafter.

The current flowing through conductor c energizes the timer motor 122 in a manner which will be hereinafter described and the other side of the line returns to the transformer 32 through the grounded conductor c. As will be observed, a portion of the current from the conductor c is connected through a coil G which operates a clutch associated with the timer 120, as hereinafter described.

Another circuit may be traced from the thermostat switch 104 through conductor c, contacts T1 of timer 120, contacts ISR of relay switch 1SR, conductor c, the coil of a control relay 2CR, and thence through the grounded conductor c to complete the circuit.

Also, as shown in Figure 2 a return circuit may be traced from thermostat switch 104 through conductor c, contacts T1 of timer 120, contacts ISR of relay switch 1SR, conductor c, the coil of a control relay 2CR, and thence through the coil of control relay 2CR directly to the return side of the circuit, or through conductor c and the coil of solenoid actuated pilot gas valve 66 to the return side of the circuit comprising the conductor c.

Another circuit may be traced from thermostat switch 104 through conductor c, timer contacts T1, contacts 2CR of control relay 2CR, contacts P1 and P2 of gas pressure safety switches, which are normally closed, as shown in Figure 1, in the gas supply line 34, conductor c, and the coil of solenoid actuated main gas valve 70 to the conductor c comprising the return side of the circuit.

Another circuit may be traced from the thermostat switch 104 through conductor c, timer contacts T1, conductor c, and the coil of a control relay 1CR to the return conductor c.

Fuses are provided at various places in the various circuits at P1, P2, P3, P4, P5 and P6 for safety purposes, as will be readily understood. Certain other devices and safety precautions may be provided without departing from the invention. For example, pressure switches like the switches P1 and P2 may also be placed in the conductor ahead of the pilot gas valve 66 thereby to stop the flow of gas to the pilot valve in the event that the gas pressure is too low.

As will be observed from Figure 2, the gas pressure safety switches P1 and P2 are normally closed and the same is true with respect to the contact OLV of the overload relay OL. If the gas pressure is too low, contacts P1 and P2 will open, breaking the circuit through the main gas valve 70 and causing the latter to close. If the motor 114 burns out, the overload will cause contacts OLV to open, breaking the circuit through the coil M and shutting down the entire apparatus. All of the other contacts are shown in a normally open position, which is the position they occupy when the apparatus is entirely out of operation. However, it will be understood that after the push button 106 has been pressed to start the system in operation the contacts M′, M′′, and M will be closed by the coil M and will remain closed until the “stop” button at 106 is pressed or until the circuit is broken through the coil M in some other manner, as by operation of the overload relay OL, as previously explained.

The thermostat switch 104 is shown with the contacts normally closed which assumes that the liquid to be heated is below the temperature desired at the time the start button 106 is pressed. The timer contacts T and T′ are shown as normally open, but it should be understood, as will be hereinafter explained, that just as soon as coil G is energized, as shown in Fig. 4, the timer mechanism is released and contacts T and T′ assume a closed position, thereby causing the timer motor 122 to be energized and at the same time energizing the coil of the control relay 1CR. The coil G is energized from the secondary winding of the transformer 32, upon closure of the start switch 106, provided that the thermal switch 104 and the main switch 118 are in closed position. After being thus initially energized by the closure of the start switch 106, the coil G will be maintained in energized condition through the closure of switch contacts M′, until said contacts open as a result of the operation of the stop switch 106.

When the coil of the control relay 1CR is energized it closes the contacts 1CR and 1CR′ thereby energizing the pilot igniter 20 by causing the transformers 94 and 96 to be energized, which in turn causes a flow of electrical energy to the hot wire igniter 20. Thus, the igniter transformer circuit can not be energized prior to the energization of the timer motor 122, and hence the opening of the gas valve 66 and 70 will be prevented until the igniter is operating.

As will be observed, the energization of the igniter transformer circuit also causes the coil of series relay ISR to be energized, whereby closing contacts ISR. At such time the timer motor 122 is in operation, and after a predetermined interval will close contacts T1, as shown in Fig. 5. If the ignition transformer circuit, for any reason, has not previously been energized, relay contacts ISR will be open and nothing can happen in the circuit controlled by the contacts T1. Thus, the series relay ISR provides means to prevent the operation of the pilot fuel supply means and subsequent operation of the main fuel supply means if there has been a failure in the electrical system of the igniter. If the igniter is operating satisfactorily, however, the contacts ISR will be closed and the circuit through the coil of control relay 1CR will be energized upon the closing of the timer contacts T1 by the timer motor. At the same time the circuit through the conductors 0, 0′, and the solenoid of pilot gas valve 66 will be energized, opening the pilot gas valve and permitting a flow of pilot gas past the igniter 20 which will then light the main burner of the apparatus. It will be understood that the timer motor is set to allow a predetermined time interval between the energization of the igniter circuit and the closing of
the timer contacts T1 to energize the pilot gas valve circuit.

As soon as control relay 2CR is energized it will close the contacts 2CR; in the pilot gas valve circuit and after a predetermined interval, when timer contacts T1 are closed by further operation of the timer motor 122, as shown in Fig. 6, the solenoid of the main gas valve 70 will be energized, thereby permitting free flow of the main gas supply to the burner, as previously described. The pilot gas valve also continues to remain open and both gas valves will remain open until the circuit is broken through their respective solenoids, which may be accomplished either by opening the thermostat switch contacts 104, or by the manual switch 118, or by opening the timer contacts T1, or by opening the gas pressure safety switches P1 and P2. Since it is essential that the system should remain in operation until the liquid reaches a desired temperature and, to this end, that the main gas valve shall remain open, contacts T2 should remain closed even though the timer motor contacts T be opened by the timer motor to disable the same. Before the timer motor is stopped, however, the timer contacts T3 are opened, as shown in Fig. 7, so that the coil of control relay 1CR is de-energized and the ignition system is thereby de-energized by the opening of relay contacts 1CR1 and 1CR2. The relay ISR also becomes de-energized, thus opening relay contacts ISR, and restoring a part of the circuit through the pilot gas valve to its initial position. The opening of the contacts T1 to de-energize the ignition circuit may be accomplished either prior to or simultaneously with the opening of the motor contacts T. However, after the timer motor 122 is stopped, with the timer contacts T3 closed, the apparatus will continue to supply gas to the burner for combustion beneath the surface of the liquid so long as the thermostat calls for heat. When the thermostat switch 104 opens, the fuel supply system will automatically shut down because the solenoid valves 66 and 70, respectively, of the pilot fuel supply means and the main fuel supply means, will both be de-energized. The clutch coil G of the timer motor is also de-energized and the timer mechanism is reset to its initial position by a suitable spring in which energy has been stored by the operation of the timer motor, as hereinafter explained. As a result, all of the timer contacts T, T1, T2, and T3 will be returned to their original open positions when the switch 104 opens. When the thermostat switch is again closed, due to a falling temperature in the liquid, the operation will be repeated. If it is desired merely to run the blower motor 114 and to disconnect the burner, this may be accomplished by opening switch 118. Normally, however, the system will remain energized and the burner operation will be subject to the opening and closing of the thermostat switch 104.

The timer mechanism employed in combination with the other elements, as previously described, does not per se form a part of this invention and it will be understood that various types of timer mechanisms may be employed in the practice of the invention. As an example of a timer mechanism which may be used, reference is made to U.S. Patent 2,175,004 which discloses such a mechanism although not in a combination of this type. For the sake of clarity, the details of said mechanism will not be given here except so far as is necessary to understand the application of this mechanism to the present invention. The operation of the timer mechanism is illustrated herein in Figures 3 to 6, inclusive, and may be described as follows.

Preferably the elements of the timer mechanism include a timer motor 122, a latching device LA, a spring S connected to the latching device, a clutch CL, a clutch spring S1, the clutch coil G previously referred to, a third spring S2, four sets of contacts T, T1, T2, and T3, also previously referred to, and means to open and close said contacts represented by the cam elements C, C1, C2, C1, C2, C3, and C4 against which the contacts are biased by means of a suitable spring, not shown. A stop ST is also provided to limit the movement of the latch mechanism LA. The cam elements C to C4 have been represented as being carried by a shaft SH, which is driven by the timer motor 122 through the clutch CL.

In Figure 3 the timer mechanism is shown with the timer motor de-energized. In this position the spring S holds the latch bar LA against the stop ST and the stops S hold the contacts T1, T2, and T3 away from each other irrespective of the positions of the cams C to C4. In this position, as previously explained, the clutch coil G is also de-energized, and as shown the clutch is held open by spring S1. The spring S2 is in its normal uncoupled position with respect to the drum or pulley D. When the clutch coil G is energized in the manner previously explained with respect to Figure 2 it moves the bar B against the pressure of spring S1 to cause the clutch CL to engage and simultaneously unlatches the latch bar LA, moving it against the pressure of the spring S1 and causing the stops S to disengage and permit the contacts T1, T2, and T3 to assume their normally biased positions against the cams C to C4, as illustrated in Figure 4. Since the cams C to C4 are so positioned that the contacts T1, T2, and T3 are then closed, the timer motor will start immediately upon the closing of contacts T3 and will begin to drive the shaft SH through the clutch CL and store energy in the spring S2 by winding it around the drum D, as shown, or in any other suitable manner. The driving of the shaft SH will cause a rotation or other movement of the cam surfaces C to C4, and as these cams move to various positions the contacts will be opened or closed in the manner previously explained with reference to Figure 2.

As shown in Figure 5, the next operation of the timer is the closing of contacts T1 which causes the opening of the pilot gas solenoid valve 66 in the manner previously explained. At this point contacts T, T1, and T2 are all closed but contacts T3 which control the main gas supply are still open, thus giving an opportunity for the pilot gas to ignite ahead of the main gas.

The next step is the closing of contacts T3 which is illustrated in Figure 6 wherein all of the contacts are closed. The closing of contacts T3 opens the main gas valve 70 and places the burner in full operation until the thermostat
switch 104 opens (Figure 2) and breaks the motor
circuit through conductors c1 and c2.

While the burner is in full operation the igni-
tion system is no longer necessary, so that the
contacts T1 controlling the ignition system may
be opened as shown in Figure 7. Finally, after the
burner has been placed in full operation, it
is also necessary to stop the operation of the timer
motor in order to keep the contacts T1 and T2
closed, and this is accomplished by opening the
motor contacts T1, so that when the burner is in
full operation the various elements of the timer
will assume the positions shown in Figure 6. In
the positions shown in Figure 6 the clutch coil C
is still energized but the timer motor 122 is no
longer running. The clutch is strong enough to
hold the shaft SH against the tendency of the
spring S5 to restore to its initial position. The
latching bar LA is still held in unlatched position due
to the fact that the coil G is still energized. As
soon as the coil G is de-energized by the opening of
the thermostat switch 104 (Figure 2) the clutch
CL will disengage due to the spring S1 and the
latching bar LA will simultaneously move to the
left, locking the contacts T1, T1, T2, and T3 away
from the cams C to C’ thereby permitting the
spring S8 to restore to its initial position and at
the same time move the shaft SH to cause the
cams C to C’ to restore to their initial positions,
as shown in Figure 1. As soon as the ther-
mostat calls for heat, the cycle is repeated in the
manner already described.

It will be understood that the description of
the timer mechanism is merely for the purpose
of illustration and that the elements thereof do
not necessarily have the appearance of the illus-
trative elements used in Figures 3 to 6. Thus, the
cams C to C’ are not in fact cam wheels in the
specific apparatus described in U. S. Patent No.
2,175,664, but instead perform the function of
the plate (82). Nevertheless, the cams could re-
place the plate and have been used in order to
clarify the description.

It will be understood that the positions of the
cams C to C’ shown in Figures 3 to 8 are ap-
proximate for the purpose of illustration only and
may be varied to suit the particular desired tim-
ing relationship. Thus, the cams may be varied
not only as to the cam surface but as to the
size of the cams.

The invention is of importance because it pro-
vides a new and improved submerged combus-
tion system in which the operating parts are rel-
avely simple and in which the operation is safe
and satisfactory. Systems of this type may be
used for many purposes, for example, in heating
pickling baths for steel pickling operations, for
evaporation, water softening, and for other pur-
poses to which submerged combustion is appli-
cable.

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

1. A submerged combustion system comprising
a liquid submerged combustion burner; fuel sup-
ply means for delivering fuel to the burner, in-
cluding fuel supply conduit means and electrically
operated flow control means; ignition means
for igniting the fuel; electrical control means
adapted for connection with a suitable source of
energizing power, for operating said flow control
means and said ignition means in a predetermined
time delayed sequence; said electrical control
means comprising an operating circuit for said
flow control means including a control switch
for controlling the operation of said flow control
means, a control circuit including an igniter timing
switch for operating said ignition means, timer means operable initially to close said igniter
timing switch, relay means operable by said timer
means following closure of said igniter timing
switch to thereafter close said control switch, and
thermally responsive switch means responsive
to the temperature of the liquid to be heated
for selectively rendering said electrical control
means operative or inoperative.

2. A submerged combustion system as set forth
in claim 1 wherein said electrical control means
includes an additional timing switch operable by
said timer means to energize said operating cir-
cuit after a predetermined time-delay interval
following closure of said igniter timer switch.

3. A submerged combustion system as set forth
in claim 1 wherein said electrical control means
includes an additional timing switch operable by
said timer means to energize said operating cir-
cuit after a predetermined time-delay interval
following closure of said igniter timing switch, a
driving motor selectively clutchable with said
timing means to drive the same, said timing
means being operable to stop said motor, after
said operating circuit has been energized, with
the timing means in cocked position maintain-
ing said operating circuit, and means operable to
release said timer means for return from cocked
position upon failure of the fuel supply.

4. A submerged combustion system as set forth
in claim 1 wherein said electrical control means
includes an additional timing switch operable by
said timer means to energize said operating cir-
cuit after a predetermined time-delay interval
following closure of said igniter timing switch, a
driving motor selectively clutchable with said
timing means to drive the same, said timing
means being operable to stop said motor after
said operating circuit has been energized, with
the timing means in cocked position maintaining
said operating circuit, and means operable to
release said timer means for return from cocked
position upon failure of the fuel supply.
adapted to open when pressure of the fuel supply falls below a predetermined value.

7. A submerged combustion system, as set forth in claim 1, including safety switch means in said operating circuit and actuated in response to the operation of said ignition means to prevent operation of said relay means in the event of failure of the ignition means to function.

8. A submerged combustion system comprising a liquid submerged combustion burner, pilot fuel supply means and main fuel supply means for delivering pilot fuel and main fuel to the burner, including pilot fuel and main fuel supply conduit means, and electrically operated pilot and main fuel flow control means operatively associated, respectively, with said pilot and main fuel supply conduit means; ignition means for igniting the fuel supplied at said burner; electrical control means for operating said pilot and main fuel flow control means and said ignition means in a predetermined time delayed sequence, said electrical control means comprising an operating circuit for said pilot fuel flow control means, said operating circuit including a control switch for controlling the operation of said pilot fuel flow control means, an operating circuit for said main fuel flow control means, said last named operating circuit including a control switch for controlling the operation of said main fuel flow control means, timer means operable to close a plurality of timing switches, respectively, in a predetermined sequential order, control circuit means including a first of said timing switches for operating said ignition means, circuit control means for controlling the main fuel control means and including a third of said timing switches, and means responsive to energization of said ignition means for preparing the pilot circuit control means, said first, second, and third switches being actuated in sequence, whereby upon operation of the timer means the ignition means, pilot fuel supply means and main fuel supply means are sequentially operated.

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