

March 5, 1963

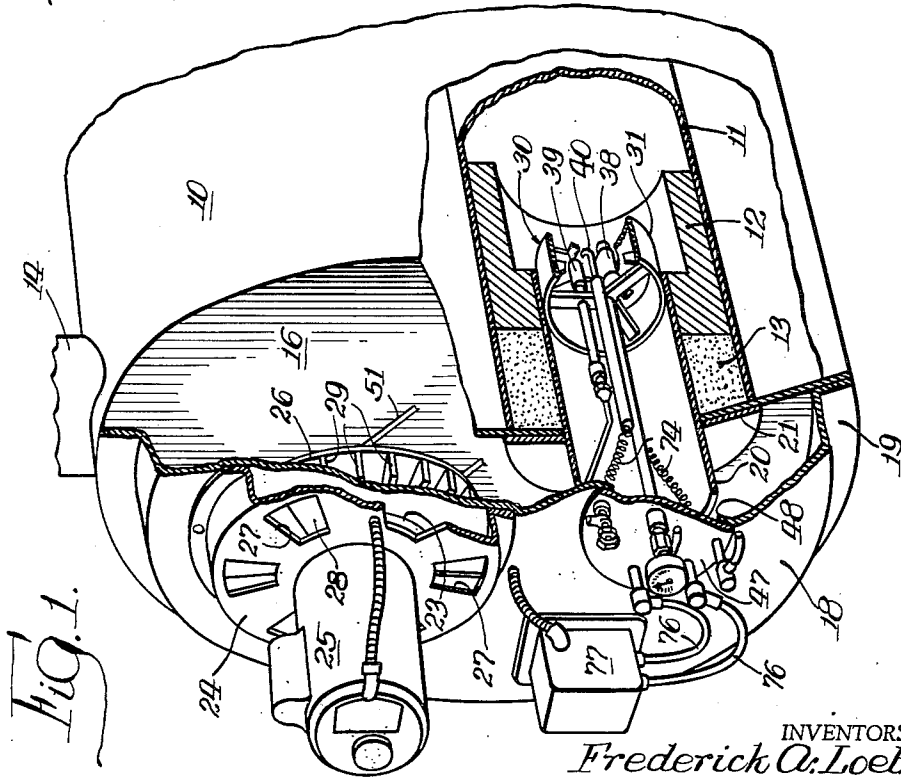
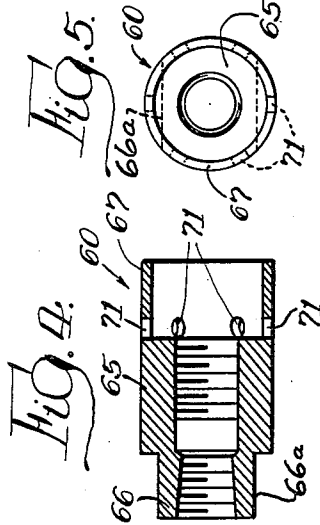
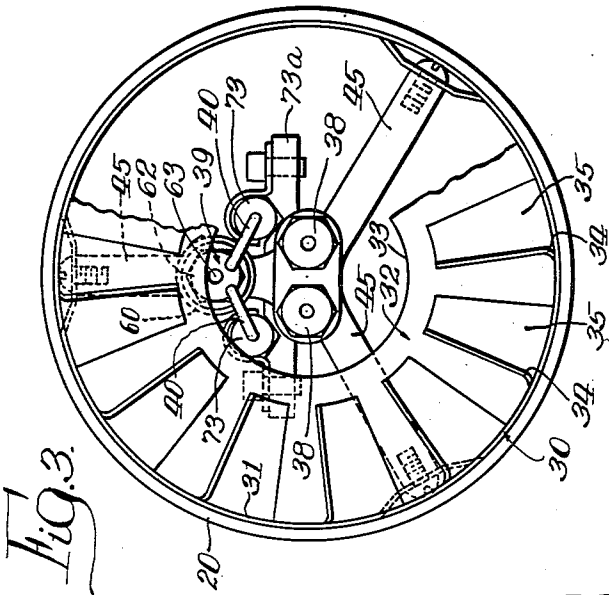
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3,079,981

BURNER APPARATUS

Filed Sept. 6, 1957

3 Sheets-Sheet 1



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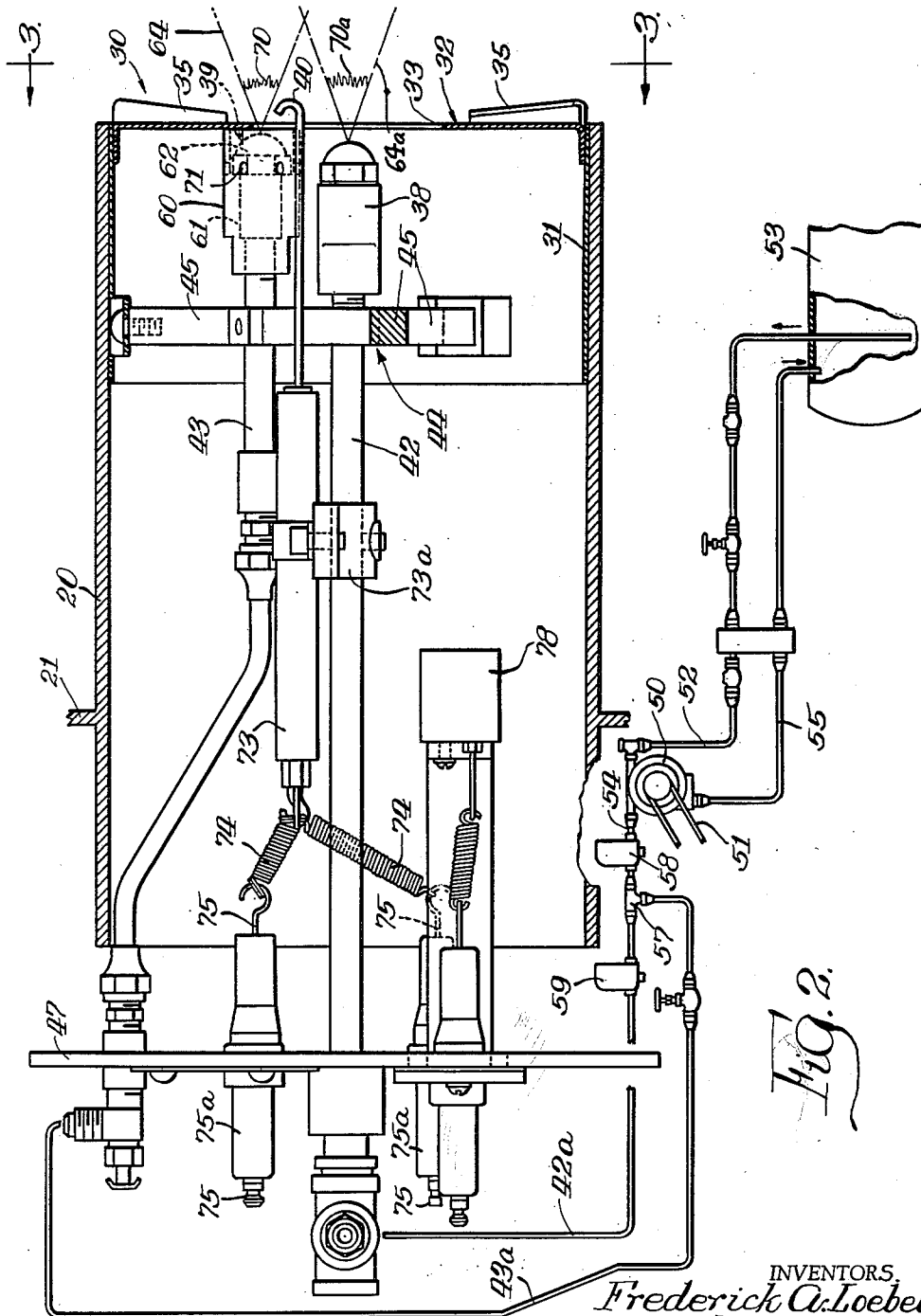
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BURNER APPARATUS

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3 Sheets-Sheet 2



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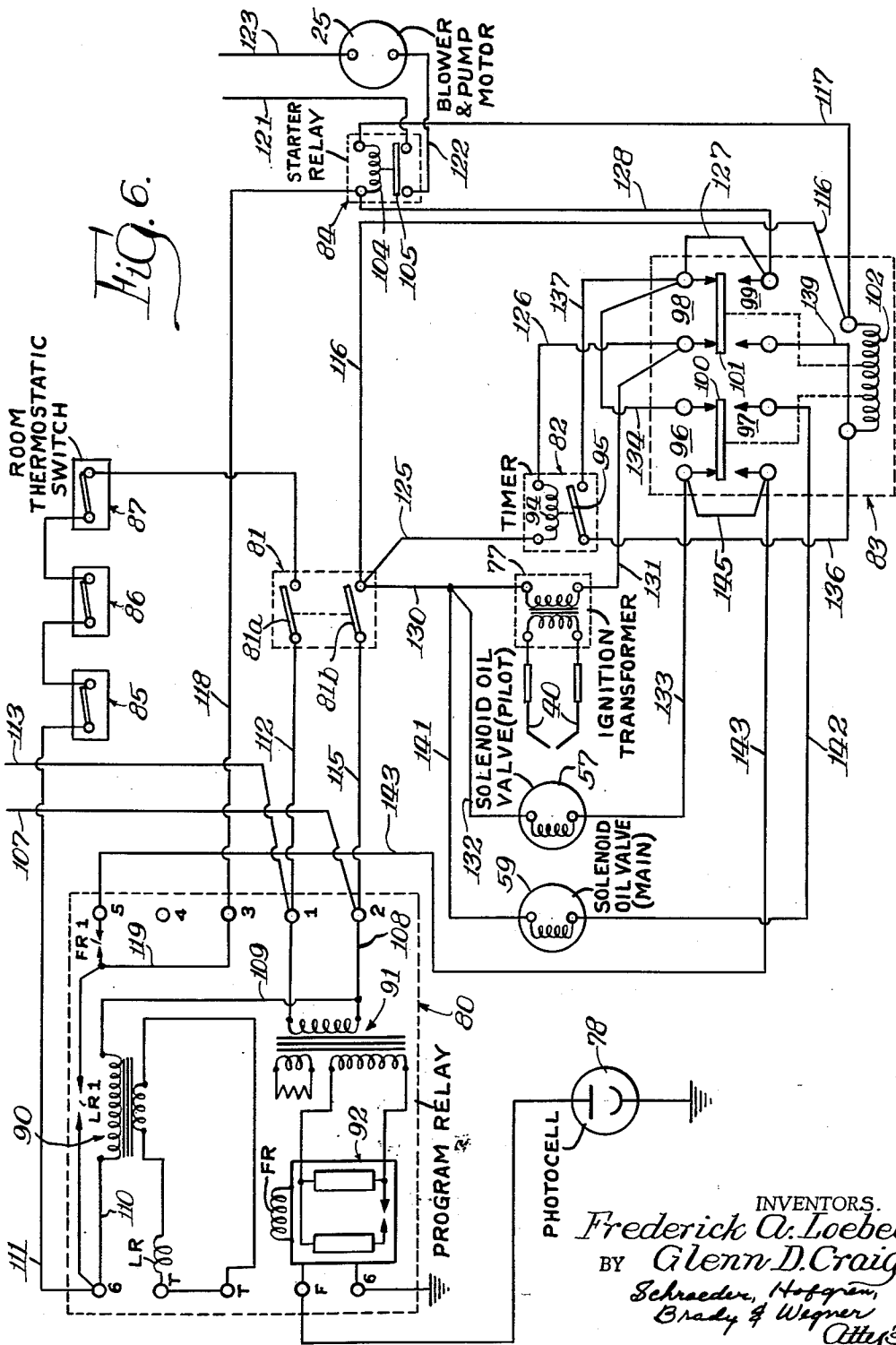
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BURNER APPARATUS

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3,079,981

BURNER APPARATUS

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6 Claims. (Cl. 158—28)

This invention relates to burner apparatus, and more particularly to apparatus for burning oil which is atomized and must be intimately mixed with air in quantities calculated to promote clean and quiet ignition and efficient combustion.

It is a general object of the invention to provide a new and improved burner apparatus of the type described.

One of the principal problems in manufacturing commercial and industrial oil burners lies in providing for satisfactory ignition of the fuel. In order to achieve continuous efficient combustion of fuel oil over extended periods of operation, the fuel must be intimately mixed with a proper amount of air for supporting combustion, usually about 20% in excess of stoichiometric quantity. Intimate mixing of the atomized oil and the combustion air is attained by imparting turbulence to the combustion air, and introducing the atomized oil into the turbulent air stream, after which combustion occurs in a concentrated area, usually near the point of fuel injection.

The air turbulence necessary for intimate mixing of the fuel and air must occur in an orderly, controlled manner so that there is a uniformity of air supply to all sections of the combustion chamber. In order to achieve uniform distribution of the air, a diffuser means is employed in the air supply duct to the combustion chamber which is designed to impart a swirling motion to the air to provide the proper degree of turbulence for satisfactory mixing of oil and air. In passing through the diffuser, the air is subjected to a drop in static pressure which increases the air velocity. The absolute value of the required velocity of air flowing to the combustion chamber depends upon the volume of air involved. Generally, as the volume decreases, more turbulence and higher velocities are required. In burner apparatus of the type described herein the air velocity at the diffuser exit is in the range of about 4,000 to 6,000 feet per minute and while the air pressure drop across the diffuser and the resulting increase in velocity promote efficient combustion, the high velocity of the air makes it extremely difficult to ignite the rapidly moving mixture of oil and air.

In some burners, the problems of ignition are minimized by providing for a continuous operation, reducing the firing rate to a low fire or pilot fire when there is no call for heat, and increasing the firing rate to high fire operation when there is a call for heat. However, where economy of operation is an important factor, continuous burner operation is undesirable, and it is preferable to utilize an "on-off" operation wherein the burner is completely shutdown when there is no call for heat and is reignited when there is a call for heat.

In burners of the capacity here under consideration, having a firing rate of from approximately 6 to 15 gallons per hour, where burner operation is confined to "on-off" operation, there are several common practices of igniting the oil and air mixture. One of these methods is to fully open the oil supply valve instantaneously with the starting of the blower motor. This arrangement allows the full quantity of oil to flow to the combustion chamber before the motor and the blower have come up to full speed. Since ignition must be attempted as soon as fuel flow begins, the air is insufficient for complete combustion during the motor speed-up period (say for example, 5 to 10 seconds), and there results heavy smoking during

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the burner starting. In addition to the smoke nuisance, ignition in this manner causes rapid sooting and fouling of the heat transfer surfaces, thus requiring frequent shutdown for cleaning.

Another practice employed in igniting the fuel for "on-off" operation may be described as step firing. This practice involves the use of multiple fuel nozzles controlled by valves which must be opened at pre-set intervals during the fan speed-up period. The timing control for such valves must be extremely accurate and is quite intricate, because if the valves open prematurely heavy smoking results due to an excessive quantity of oil being ignited with insufficient air, and if any valve opens too late there may be sufficient combustion air flowing to extinguish the previously lighted nozzle or nozzles. In any case, the adjustments in a burner arrangement of this type are critical.

With the above and other considerations in mind, it is a broad object of this invention to provide a new and improved burner apparatus of the type described wherein ignition is easily achieved in a smooth and clean fashion so as to eliminate smoking, without the necessity of intricate controls requiring accurate adjustments which are critical for proper burner operation.

Another object is to provide a new and improved two stage burner apparatus including a pilot burner nozzle and one or more main burner nozzles wherein oil is supplied to the pilot nozzle immediately on starting the blower, when the blower supplies sufficient air for combustion at the pilot nozzle, and wherein the pilot burner is shielded for stable firing during full air flow sufficient for combustion at the pilot and the main burner nozzles, so that fuel flow to the main burner nozzles may be delayed until after the blower attains full speed.

A further object is to provide a new and improved shielded pilot nozzle structure for use in the main stream of air flowing to a combustion chamber, including a shield for protecting the pilot nozzle discharge from disruption in an air flow sufficient to support main burner firing.

It is also an object of the invention to provide a new and improved electric circuitry for automatically effecting burner ignition in a burner apparatus of the character described.

Another object is to provide, in a burner apparatus of the type described, a circuit for obtaining a novel sequence of operations wherein the blower means for supplying air to the combustion chamber, the means for supplying fuel to the pilot or first stage burner, and the ignition means for lighting the pilot burner are all set in operation simultaneously and function to immediately supply fuel to the pilot burner, to immediately supply air in sufficient quantities to support combustion at the pilot burner, and to immediately light the pilot burner to obtain a smooth clean ignition with a relatively small quantity of fuel involved, and wherein supply of fuel to the main burner is delayed until such time as the blower means has attained speed sufficient to supply air in quantities necessary for combustion at both burners.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary perspective view, partly broken away, of a boiler structure including a burner apparatus embodying the principles of the present invention;

FIG. 2 is an enlarged longitudinal vertical section taken through the burner tube of the burner apparatus illustrated in FIG. 1, with parts in elevation, and including a diagrammatic showing of the fluid circuits for supplying fuel to the burner nozzles;

FIG. 3 is an end elevational view of the structure illustrated in FIG. 2, taken at about the line 3—3 of FIG. 2;

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FIG. 4 is an enlarged longitudinal sectional view through the pilot burner shield;

FIG. 5 is a right end elevational view of the shield illustrated in FIG. 4; and

FIG. 6 is an electric circuit diagram for controlling operation of the burner apparatus illustrated in the preceding figures.

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms, and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention will be pointed out in the appended claims.

Referring now to the drawings, as illustrated, the invention is embodied in a horizontal fire tube boiler which includes a horizontally disposed cylindrical boiler shell 10 which may be supported in any suitable manner. A horizontally disposed fire tube 11 of suitable metal material is supported in the lower portion of the boiler shell and provides a combustion chamber. Near the front end of the boiler, in the combustion zone, the fire tube 11 is lined for a portion of its length with a suitable dry oven refractory material 12, and forwardly of the refractory 12 is lined with a suitable insulating refractory material 13. Combustion occurs in the fire tube in the vicinity of refractory 12, and boilers of the type illustrated conventionally include suitable structure forming multiple passes through the boiler from combustion gases which ultimately pass from the boiler shell through an exhaust stack 14.

At the front end of the boiler, the shell 10 is closed by an inner front boiler door 16 in the form of a circular plate which may be secured in any suitable manner to the shell. In addition to the inner door 16, the front of the boiler shell is closed by an outer dish-shaped door 18 of generally cylindrical configuration and including a radially outwardly turned flange 19 which abuts the inner door and which may be supported in any suitable manner. Doors 16 and 18 together form an air plenum chamber into which air is drawn from atmosphere and from which air is discharged to the combustion chamber.

A burner tube 20 of cylindrical configuration is fitted in suitable openings provided in the inner door 16, the refractory 13 and the refractory 12. One end of the burner tube extends into and opens into the plenum chamber formed between the doors 16 and 18, and the other end of the burner tube extends to and opens into the combustion chamber formed in the refractory 12 and the fire tube 11. The burner tube may be secured in place as illustrated by means of an integral outwardly extending flange 21 secured to the inner door 16 by any suitable means. The tube 20 functions as a housing for burner apparatus and also functions as an air duct for conducting combustion air from the air plenum chamber to the combustion chamber.

The upper portion of the outer door 18 is formed with a circular air inlet opening 23 through which air is drawn into the plenum chamber. A dish-shaped fan motor support 24 is suitably secured to the outer door concentrically with the air inlet opening 23 and carries a fan motor 25 having a drive shaft on which a fan wheel 26 is secured. The motor support 24 is formed with a plurality of air inlet openings 27 concentrically arranged about the fan motor and controlled by an adjustable damper means 28 for regulating the size of the openings 27. Operation of the motor 25 causes rotation of the fan wheel 26, drawing combustion air from atmosphere through the motor support openings 27 and the inner opening 23 into the central portion of the fan wheel, to be directed radially of the fan wheel between the fan blades 29 into the plenum chamber.

An air diffuser 30 is positioned in the end of the burner

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tube 20 adjacent the combustion chamber and includes a cylindrical side wall portion 31 which is fitted in the burner tube. At the end of the cylinder wall 31, adjacent the combustion chamber, the diffuser is formed with a diffuser plate 32 which extends transversely across the duct or passage provided by the cylindrical wall 31 and the burner tube 20. The diffuser plate is formed with a concentric central opening 33 and, outwardly of the central opening, is formed with radially extending openings 34, and adjacent the openings 34, with louvers or baffles 35. In flowing from the plenum chamber to the combustion chamber, air passes through the diffuser, and the diffuser functions to impart a swirling motion to the air to distribute the air uniformly over the combustion zone to insure efficient combustion of fuel in the combustion chamber. In passing through the diffuser, an air pressure drop is encountered, resulting in an increase in air velocity which promotes efficient combustion. Air velocity at the diffuser exit in the burner chosen for illustration is in the range of 4,000 to 6,000 feet per minute.

As best seen in FIGS. 2 and 3, the burner apparatus includes a pair of main burner nozzles 38 which are centrally located in the burner tube 20 and centrally of the central opening 33 in the diffuser plate, with the tips of the nozzles displaced slightly inwardly from the end of the burner tube adjacent the combustion chamber. Positioned centrally between the main burner nozzles 38 and thereabove, there is provided a pilot burner nozzle 39 which is utilized for igniting fuel discharged from the main burner nozzles. Fuel discharged from the pilot nozzle 39 is ignited by suitable ignition means including a pair of ignition electrodes 40 disposed slightly below the tip of the pilot nozzle and one slightly to each side of the nozzle.

The main burner nozzles 38 are supported on the end of a main burner fuel supply pipe 42, and the pilot burner nozzle is supported on the end of a pilot fuel supply pipe 43. The fuel supply pipes 42 and 43 are in turn supported on a spider structure 44 through which the pipes pass. The spider includes three equally spaced radially extending legs 45 which project outwardly from a central hub portion and have their outer ends secured to the cylindrical wall 31 of the diffuser. The fuel supply pipes 42 and 43 extend from the nozzles to a mounting plate or closure member 47, through the member 47, and are suitably secured thereto so that the plate 47 functions as a support for the pipes. The plate 47 in turn may be removably secured by any suitable means to the outside of the outer boiler door 18 and fits over an opening 48 in the outer door which permits removal of the burner nozzles on removal of the plate 47. Externally of the plate 47, the fuel lines 42 and 43 connect respectively with supply conduits 42a and 43a in turn connected with a fuel supply system.

Referring to the fluid fuel circuit diagram of FIG. 2, the means for supplying fuel to the main burner nozzles and the pilot burner nozzle includes a pump 50 which may desirably be mounted on the outside of the outer boiler door 18, and which is connected to be driven by a belt-drive 51 from the shaft of the fan wheel 26 to the drive shaft of the pump. The pump 50 draws fuel oil through an intake line 52 from a reservoir 53, and discharges fuel under pressure to a delivery line 54. The pump 50 is of a standard manufacture, and includes a pressure regulating valve incorporated therein which blocks the flow of fuel from the pump to the delivery line 54 until a pressure of approximately 80 pounds per square inch has been attained within the pump, whereupon the valve opens to permit flow to the delivery line. The pressure necessary to open the pressure regulating valve is normally attained within about 1 second after the drive motor 25 starts, and will thereafter function to supply oil to the atomizing nozzles at an oil atomizing pressure, normally about 100 pounds per square inch. Fuel pumped in excess of that required at the burner

nozzles is relieved through a relief valve incorporated in the pump, and returns to the reservoir 53 through a return line 55.

The pump delivery line 54 connects with a T-fitting 57 which in turn is connected to the branch line 42a leading to the main burner nozzles and the branch line 43a leading to the pilot nozzle. A normally closed solenoid operable valve 58 is provided in the delivery line 54 for controlling the flow of fuel to the fitting 57 and to the pilot nozzle 39. A normally closed solenoid operable valve 59 is provided in the branch conduit 42a for controlling the flow of fluid to the main burner nozzles 38.

As previously set forth, the burner apparatus illustrated is arranged to operate on an "on-off" principle only, in order to achieve low cost operation. Ignition of the fuel oil at the full firing rate, in quantities varying from 6 to 15 gallons per hour, is extremely hazardous and noisy, and has never been accomplished in a satisfactory manner. The provision of a pilot burner makes use of a small quantity of fuel which must be initially ignited, and is particularly desirable in burner apparatus operating on the "on-off" principle, provided that smooth, quiet ignition of the small quantity of fuel can be attained, and provided that smooth, quiet ignition of the remaining fuel at the full firing rate can be obtained from the pilot fire.

Accordingly, in operation, as will be described in more detail in describing the wiring diagram, the drive motor 25 for the blower and the pump 50 is energized, and within 1 second after the drive motor starts, oil begins to flow toward the pilot nozzle 39. At the same time the drive motor 25 is energized, the solenoid operated valve 58 is also energized to open the pump delivery line 54, permitting oil flow to the pilot nozzle at a pilot firing rate of about 2 gallons per hour. Simultaneously with energization of the drive motor and the valve 58, the ignition means 40 is energized. By the time fuel oil reaches the pilot nozzle 39, the blower has attained sufficient speed to supply the air necessary to support combustion of fuel issuing from the pilot nozzle. Since the ignition means is energized, a flame is immediately established at the pilot nozzle in a quiet, and safe manner.

In order to achieve a smooth ignition of the remaining fuel at the main burner nozzles with a full firing rate, it is desirable to delay the flow of fuel to the main nozzle until such time as the blower has attained a speed sufficient to deliver air to the combustion chamber in quantities necessary to support combustion at all the nozzles. If fuel flows to the main burner nozzle before the air supplied is sufficient to support combustion at these nozzles, ignition of the fuel will be accompanied by excessive smoking. Thus, opening of the solenoid operated valve 59 in the burner conduit 42a is delayed for a predetermined time after the blower starts, about 4 to 7 seconds, so that ignition of the remaining fuel at the full firing rate will be accomplished in a suitable fashion. One of the problems encountered in such an operation is that of maintaining the pilot fire, before the main burner nozzles are lighted, in an air flow greatly in excess of that required for combustion at the pilot burner, as much as 400% in excess of the air required for pilot firing.

According to the invention, a shield 60 is provided for the pilot nozzle in order to maintain stable firing at the pilot nozzle until such time as the main burners are ignited. As seen best in FIGS. 2 and 3, the pilot nozzle 39 comprises a cylindrical pilot nozzle body 61 having a rear end portion adapted to be joined to the supply pipe 43 to receive fuel oil therefrom. At the forward end of the nozzle body 61, a nozzle tip 62 is suitably affixed to the nozzle body as by being threaded therein for example, and includes a discharge orifice 63 from which fuel oil in an atomized state issues in a cone shaped spray substantially as illustrated at 64 (FIG. 2). The pilot burner nozzle 39 is positioned so that the orifice 63 is disposed

just inside the upper edge of the central opening 53 in the diffuser plate 32, as seen best in FIGS. 2 and 3.

The pilot nozzle shield 60 comprises an essentially cylindrical part including an intermediate portion 65 which is threaded on the outside of the nozzle body 61, a rear end portion 66 which is internally threaded to receive the end of the fuel supply pipe 43, and a forward end portion 67 which encircles the nozzle tip 62 in slightly spaced relation thereto. The rear end portion 66 is preferably flattened at diametrically spaced positions, as illustrated at 66a, to receive a wrench or tool. The forward open end of the shield abuts against the rear face of the diffuser plate 32 and is positioned so that an upper portion, approximately the upper half, of the open end of the shield, above the discharge orifice 63, is closed by the diffuser plate 32.

The construction and arrangement of the shield 60 is such that it shields the nozzle tip and protects the cone shaped spray issuing from the nozzle from dissipation by the main air stream at a full flow rate sufficient to support combustion at all the burner nozzles. The cone shaped spray 64 issuing from the pilot nozzle is initially ignited while the air flow is relatively low, at a value not greatly in excess of that required for pilot fire operation. Ignition occurs quietly and cleanly. Once the flame is established, and burning with a base located approximately at the position illustrated at 70 (FIG. 2) the flame will continue to burn further downstream from the base of the flame even in a more turbulent air zone after the air flow increases to a value sufficient for full firing. The shield protects at least a portion of the cone shaped spray from dissipation in the main air stream and provides a relatively quiescent air zone at the base of the pilot flame.

When fuel flow to the main burner nozzle 38 is established, these nozzles discharge atomized oil in cone shaped sprays 64a similar to the pilot nozzle discharge. These sprays intersect the burning pilot nozzle fuel and are ignited thereby to burn with bases located approximately as illustrated at 70a. Ignition of the main burners is quiet and smooth without excessive smoking. After this, the flame continues to burn fuel supplied by all the nozzles.

Shielding of the pilot nozzle in the manner described normally would cause eddy currents within the pilot nozzle shield causing a deposit of oil and soot on the nozzle tip surfaces during main burner operation. In order to prevent the deposition of soot, oil, and other extraneous matter on the nozzle tip, the nozzle shield is provided with annular series of radial openings 71 leading to the interior of the shield adjacent the nozzle tip. The openings 71 permit a uniform flow of air through the shield over the nozzle tip in quantities insufficient to support combustion at the pilot nozzle but in quantities sufficient to prevent sooting. Accordingly, the pilot nozzle burns clean and cool even during operation of the main burner nozzles.

Additionally, the shield 60 serves to enclose the pilot nozzle and to protect the latter from heat radiating toward the nozzle from hot refractories on burner shutdown, and thus prevents coking of oil in the nozzle passages due to the radiating heat and thereby prevents plugging of the nozzle passages.

Additionally, the flow of air through the nozzle shield over the nozzle tip in quantities insufficient to hamper operation of the nozzle but sufficient to prevent sooting also serves to prevent sooting on the ignition electrodes 40, so that the electrodes remain clean and free of soot for extended periods of operation.

The burner apparatus illustrated and described was tested on a continuous cycle for a period of about 900 hours, during which time about 5000 ignition cycles were completed. No difficulties were encountered in burner operation, and the pilot nozzle remained free of soot and carbon.

The ignition electrodes 40 are conductive sparking ele-

ments having major portions suitably encased in insulators 73 which are held by a mounting bracket 73a in turn supported on the main burner supply pipe 42. The ends of the ignition electrodes remote from the combustion chamber are connected with suitable conductors 74 in turn connected with conductors 75 encased in insulators 75a passing through the closure plate 47. Externally of the outer door 18, the conductors 75 are connected by wiring 76 (FIG. 1) to an ignition transformer 77 supported on the door 18. The ignition transformer is connected in the electric circuit to be described.

A flame detecting photocell 78 is supported by the closure plate 47 in the burner tube 20 to detect the presence of a pilot flame as a condition precedent to the opening of the main fuel valve 59, though this forms no part of the present invention. The photocell is suitably connected in the wiring diagram to perform the desired function, as described below.

Referring now to the wiring diagram of Fig. 6, the electric circuits for obtaining operation of the burner apparatus described include the electrically operated elements previously referred to, including the blower and pump motor 25, the ignition electrodes 40, the ignition transformer 77, the solenoid operated pilot fuel valve 57, the solenoid operated main fuel valve 59, and the photocell 78. Additionally, the circuit includes a control unit 80 of conventional manufacture, sometimes described as a program relay, a manually controllable burner switch 81, a timer 82, a relay 83 controlled by the timer, and a starter relay 84 for the motor 25. Further, the circuit may include, if desired, conventional limit control switches illustrated at 85 and 86, and a room thermostatic switch 87 for automatically controlling the circuit. Alternatively, the switches 85, 86 and 87 may be omitted if desired and control maintained over the circuit through the manually operated switch 81.

The control unit 80 which per se forms no part of the present invention includes a network of wiring not entirely illustrated, but a portion of which is illustrated in order to facilitate an understanding of the circuit operation, including a transformer 90 for supplying power to a load relay LR controlling normally open switch contacts LR-1 which are closed on energization of the coil LR. Also included in the control unit is a transformer 91 for supplying power to an electronic network illustrated generally at 92 which is responsive to the photocell 78 on detection of a pilot flame to energize a flame relay FR controlling normally open switch contacts FR-1 which are closed when the flame relay is energized.

The timer 82 is a device of conventional construction which includes a timer motor having a winding illustrated at 94 which, when energized, effects operation of the timer motor and suitable means driven thereby, such as a cam, for closing a normally open switch 95 after a predetermined time delay following energization of the winding 94. On deenergization of the motor winding, the operator for the switch 95 is automatically returned to its starting position by means such as a spring.

The control relay 83 is also a unit of conventional construction, and includes 4 pairs of stationary switch contacts, the pairs being identified respectively by the reference numbers 96, 97, 98 and 99. A movable switch contact 100 is arranged for cooperation with the contacts 96 and 97, and a movable contact 101 is arranged for cooperation with the contacts 98 and 99. The movable contacts 100 and 101 are normally positioned as illustrated, and are controlled by a relay coil 102, which on energization is effective to move the movable contacts from the positions illustrated, in engagement with stationary contacts 96 and 98, to positions engaging the stationary contacts 97 and 99. The relay is of the "make before break" type in which the contacts 97 are closed by the movable contact 100 before the contacts 96 are

opened, and the contacts 99 are closed by the movable contact 101 before the contacts 98 are opened.

The starter relay 84 for the blower and the pump motor 25 includes a relay coil 104 controlling a normally open switch 105 which is closed on energization of the winding 104.

It is believed that the remaining portions of the wiring diagram will be best understood in describing the operation of the circuit. Accordingly, these will not be described in detail except as follows in the description of operation.

In operation, if the room thermostatic switch 87 is employed to control the circuit, the manually controllable burner switch 81 will normally remain closed at all times in order to permit control by the room thermostatic switch. If the room thermostatic switch is not employed, the circuit will be controlled by manually closing and opening the burner switch 81.

Assuming that the room thermostatic switch and the burner switch are both closed, a circuit will be completed from a suitable source of electric power through a wire 107, a wire 108, a wire 109, the primary winding of transformer 90, a wire 110, a wire 111, the limit switches 85 and 86, the thermostatic switch 87, the burner switch 81a, a wire 112, and a wire 113, back to the source of power to energize the transformer 90. Energization of the transformer 90 is effective to energize the load relay winding LR to close the relay switch contacts LR-1.

On closure of the switch LR-1, a circuit is completed to energize the starter relay for the motor 25, to energize the timer motor winding 94, to energize the ignition transformer 77, and to energize the pilot fuel valve 57.

The circuit for energizing the starter relay 84 can be traced from the supply line 107, a wire 115, burner switch 81b, a wire 116, a wire 117, the relay winding 104, a wire 118, a wire 119, the switch contacts LR-1, and wire 111 back to the source of power. Energization of the starter relay coil 104 is effective to complete a circuit from a source of power through a wire 121, the relay switch 105, a wire 122, the motor 25, and a wire 123 back to the source of power, to thereby energize the motor 25 for driving the blower and fuel pump.

The circuit for energizing the timer motor winding 94 can be traced from the wire 115, burner switch 81b, a wire 125, the timer motor winding 94, a wire 126, relay contacts 98 and 101, a wire 127, a wire 128, and the wire 118 back to the source of power, to thereby energize the timer motor and to begin the predetermined time delay after which the main fuel valve is opened.

The circuit for energizing the ignition transformer can be traced from the burner switch 81b, a wire 130, the primary of the ignition transformer, a wire 131, and relay contacts 98 and 101 back to the source of power.

The circuit for energizing the pilot fuel valve may be traced from the wire 130, a wire 132, the valve 57, a wire 133, relay contacts 96 and 100, a wire 134, and the wire 127 back to the source of power.

The blower and fuel pump are thereby started in operation, the pilot fuel valve is opened and the ignition transformer is energized to immediately effect the flow of fuel and air to the pilot burner nozzle and to immediately ignite the combustible mixture of fuel and air to establish a pilot flame. Oil flows to the pilot nozzle at a pilot or first stage firing rate, about 2 gallons per hour in the model illustrated.

On establishing a pilot flame, the flame is sensed by the photocell 78 and the sensing of the flame is reflected in energization of the flame relay FR which upon energization effects closure of the switch contacts FR-1 to partially complete a circuit to the main fuel valve 59.

During the time that the pilot flame is being established, and the blower is attaining a speed sufficient to supply air necessary for combustion at all the burners, the timer 82 continues to operate for a predetermined time. After

the predetermined time passes, the timer switch 95 is closed to complete a circuit energizing the relay winding 102 of the control relay 83. The circuit to the winding 102 can be traced from the wire 116, through the winding 102, a wire 136, the time switch 95, a wire 137, and the wire 127 back to the source of power. Energization of the winding effects closure of the movable relay contacts 100 and 101 with stationary contacts 97 and 99 and, later, the opening of contacts 96 and 98.

On energization of the relay winding 102, a holding circuit is completed to maintain the winding energized, and a circuit is completed to the main fuel valve 59.

The holding circuit for maintaining the winding 102 energized can be traced from the wire 116, through the winding 102, a wire 139, the relay contacts 99 and 101, and the wire 128 back to the source of power.

The circuit for energizing the main fuel valve can be traced from the wire 130, a wire 141, the valve 59, a wire 142, relay contacts 97 and 100, a wire 143, the switch contacts FR-1 and the wire 119, back to the source of power. The main fuel valve 59 is thereby opened to permit flow of fuel to the main burner nozzles 38 for ignition of this fuel by the previously established pilot flame.

After the movable switch 101 of the control relay closes the stationary contacts 99, the stationary contacts 98 are opened to break the circuit to the timer motor winding 94 and to break the circuit through the ignition transformer 77. The timer motor and the transformer are thereby deenergized. The ignition transformer remains de-energized during continued operation of the burner apparatus for economy of operation.

After the movable switch contact 100 of the control relay closes the stationary contacts 97, the stationary contacts 96 are opened, breaking the circuit therethrough to the pilot fuel valve 57. Thereafter, the pilot fuel valve is maintained energized by a circuit through the wire 133, a wire 145, the wire 143, and the flame relay contacts FR-1. In the event that a pilot flame has not been established, the pilot fuel valve will be deenergized on energization of the control relay 93, because contacts FR-1 will not have been closed.

After a flame is established at the main burner nozzles 38, as described above, the nozzles, together with the pilot nozzle 39 continue in operation until such time as the demand for heat has been satisfied, and either the thermostatic switch 87 or the manually controlled burner switch 81 is opened, whereupon burner operation is terminated.

In the event that no flame is established at the pilot burner nozzle upon completion of the pre-determined time delay provided by the timer 82, the photocell will not have sensed a pilot flame, the flame relay FR will not have been energized, the switch contacts FR-1 will not have been closed, and no circuit can be completed to the main fuel valve 59 on energization of the control relay 83 at the end of the predetermined time delay. Thus, the fuel supply to the combustion chamber through the main burner nozzles will not be initiated, and as described above, the pilot fuel valve 57 will be deenergized to stop the flow of fuel through the pilot nozzle.

In addition to the flame detection upon which main burner operation is contingent, the control unit 80 may include a safety switch (not illustrated) substantially as described in the Marshall et al. Patent 2,748,845, operative on failure of energization of the flame relay FR to also cause deenergization of the load relay LR, thereby permitting the contacts LR-1 to open and deenergize the entire electric circuit and terminate the burner operation.

We claim:

1. An oil burner apparatus, comprising, a burner tube for conducting air to a combustion chamber, an air diffuser plate across the burner tube at the forward end portion thereof having a central opening therethrough and additional openings disposed radially outward from the central opening and means adjacent the outwardly dis-

posed openings for directing air forwardly therethrough in a swirling pattern, a main oil nozzle located in the burner tube adjacent the diffuser plate and centrally of said central opening to direct atomized oil forwardly therethrough, a pilot oil nozzle located in the burner tube slightly to the rear of said diffuser plate and adjacent the edge of said central opening to direct atomized oil therethrough, and a cylindrical pilot nozzle shield surrounding the pilot nozzle, having a rear end on the nozzle body, having an open forward end around the nozzle tip, and having an upper portion of its forward edge adjacent the rear face of said diffuser plate, thereby to shield the pilot nozzle for pilot firing in the main air stream during full air flow sufficient to support main burner firing before firing of the main burner.

2. An oil burner apparatus, comprising, a burner tube for conducting air to a combustion chamber, an air diffuser plate across the burner tube at the forward end portion thereof having a central opening therethrough and a series of openings disposed radially outward from the central opening and baffles adjacent the outwardly disposed openings for directing air forwardly therethrough in a swirling pattern, a main oil nozzle located in the burner tube slightly to the rear of the diffuser plate and centrally of said central opening to direct atomized oil forwardly therethrough, a pilot nozzle located in the burner tube slightly to the rear of said diffuser plate and adjacent the edge of said central opening to direct atomized oil therethrough, and a cylindrical pilot nozzle shield surrounding the pilot nozzle, closed at the rear end, having an open forward end encircling the nozzle tip, and having a portion of its forward edge abutting said diffuser plate so that a portion of the open forward end thereof is closed by the diffuser plate, the construction and arrangement of the shield serving to shield the pilot nozzle for stable pilot firing during full air flow sufficient to support combustion at both burners, said shield having a plurality of openings adjacent the nozzle tip to permit a uniform flow of air through the shield over the pilot nozzle tip to prevent deposit of oil and soot on the nozzle tip during operation of the main burner.

3. An oil burner apparatus, comprising a burner tube for conducting air to a combustion chamber, an air diffuser plate extending across the burner tube at the forward end portion thereof having a central opening therethrough and a series of radially extending openings therein and baffles adjacent the radial openings for directing air forwardly therethrough in a swirling pattern, a main oil nozzle located in the burner tube slightly to the rear of the diffuser plate and centrally of said center opening to direct atomized oil forwardly therethrough, a pilot oil nozzle located in the burner tube slightly to the rear of said diffuser plate and above the main oil nozzle to direct atomized oil through said central opening, said pilot nozzle comprising a cylindrical nozzle body adapted to be connected at the rear end to an oil supply pipe and an oil atomizing nozzle tip affixed to the forward end of the nozzle body, and a cylindrical pilot nozzle shield surrounding the pilot nozzle, having a rear end fitted on the nozzle body, having an open forward end encircling the pilot nozzle tip in slightly spaced relation thereto, and having an upper portion of its forward edge abutting the rear face of the diffuser plate to shield the pilot nozzle for pilot firing during full air flow sufficient to support combustion at both burners, said shield having a series of radial openings adjacent the nozzle tip to permit air to flow over the nozzle tip in quantities sufficient to prevent deposit of oil on the nozzle tip during operation of both burners.

4. An oil burner, comprising, a cylindrical housing forming a combustion chamber, a cylindrical burner tube having an open rear end and a forward end positioned adjacent the combustion chamber to provide an air duct for conducting air to flow in a stream from the rear end to the combustion chamber for mixture with atomized oil

to support combustion of the oil, an air diffuser plate across the burner tube at the forward end portion thereof in the air stream having a central opening therethrough and series of radially extending openings therein and baffles adjacent the radial openings for directing air forwardly therethrough in a swirling pattern, a pair of main oil atomizing nozzles located side by side in the burner tube slightly to the rear of the diffuser plate and substantially centrally of said central opening to direct atomized oil there-through, a pilot oil atomizing nozzle located above and intermediate said main nozzles slightly to the rear of the diffuser plate and positioned to direct atomized oil through said central opening adjacent the upper edge thereof, and a cylindrical pilot nozzle shield surrounding the pilot nozzle, closed at the rear end, having an open forward end encircling the pilot nozzle tip, and having an upper portion of its forward edge abutting the rear face of the diffuser plate to shield the pilot nozzle for pilot firing in the main air stream during full air flow sufficient to support combustion at the pilot and main burners.

5. An oil burner, comprising, a cylindrical housing forming a combustion chamber, a coaxial cylindrical burner tube having an open rear end and a forward end positioned adjacent one end of the combustion chamber to provide an air duct for conducting air to flow in a stream from the rear end to the combustion chamber for mixture with atomized oil to support combustion of the oil, an air diffuser plate across the forward end of the burner tube in the air stream having a central opening therethrough and an annular series of radially extending openings therein and baffles adjacent the radial openings for directing air forwardly therethrough in a swirling pattern, a pair of main oil atomizing nozzles located side by side in the burner tube slightly to the rear of the diffuser plate and substantially centrally of said central opening to direct atomized oil therethrough, a pilot oil atomizing nozzle located above and intermediate said main nozzles slightly to the rear of the diffuser plate and positioned to direct atomized oil through said central opening adjacent the upper edge thereof, said pilot nozzle comprising a cylindrical nozzle body adapted to be connected at the rear end to an oil supply pipe and an oil atomizing nozzle tip affixed to the forward end of the nozzle body, a pair of ignition electrodes positioned slightly forwardly of slightly below the pilot nozzle tip, one slightly to each side of the nozzle tip, and a cylindrical pilot nozzle shield surrounding the pilot nozzle and extending the length of the nozzle, having a rear end

fitted on the nozzle body and an open forward end encircling the nozzle tip in slightly spaced relation thereto, said shield having approximately the upper half of its forward end abutting the rear face of the diffuser plate, the construction and arrangement of the shield serving to shield the pilot nozzle for stable pilot firing in the main air stream during full air flow sufficient to support main burner operation before and during firing of the main burners, said shield having an annular series of radial openings adjacent the nozzle tip to permit an even flow of air through the shield over the pilot nozzle tip in quantities sufficient to prevent deposit of oil and soot on the nozzle tip during operation of the main burners.

6. A shielded oil atomizing pilot nozzle structure for use with a main burner nozzle in the main stream of air flowing to a combustion chamber to permit stable pilot firing during full air flow sufficient to support firing at both nozzles, comprising: a pilot nozzle for discharging atomized oil into a combustion chamber including a cylindrical nozzle body having a rear end adapted for connection with an oil supply conduit, and a nozzle tip affixed to the forward end of the nozzle body for discharging atomized oil in a cone shaped spray; and a cylindrical pilot nozzle shield surrounding the pilot nozzle and extending the length of the nozzle, having a rear end fitted on the nozzle body and an open forward end encircling the nozzle tip in slightly spaced relation thereto, to shield at least at portion of the cone shaped nozzle discharge from the main air stream, said shield having a series of radial openings therethrough adjacent the nozzle tip rearwardly of the discharge orifice therein and forwardly of the rear end fitted on the nozzle body to permit an even flow of air forwardly through the shield over the pilot nozzle tip in quantities sufficient to prevent deposit of oil and soot on the nozzle tip.

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