

June 28, 1966

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3,258,053

AUTOMATED BURNER CONTROL

Filed May 5, 1964

3 Sheets-Sheet 1

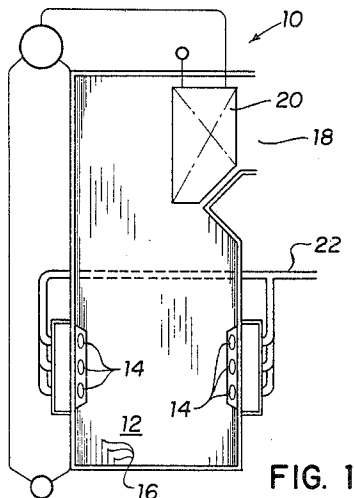


FIG. 1

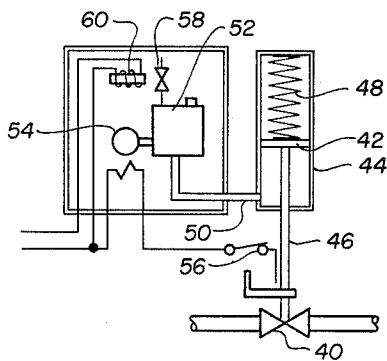


FIG. 3

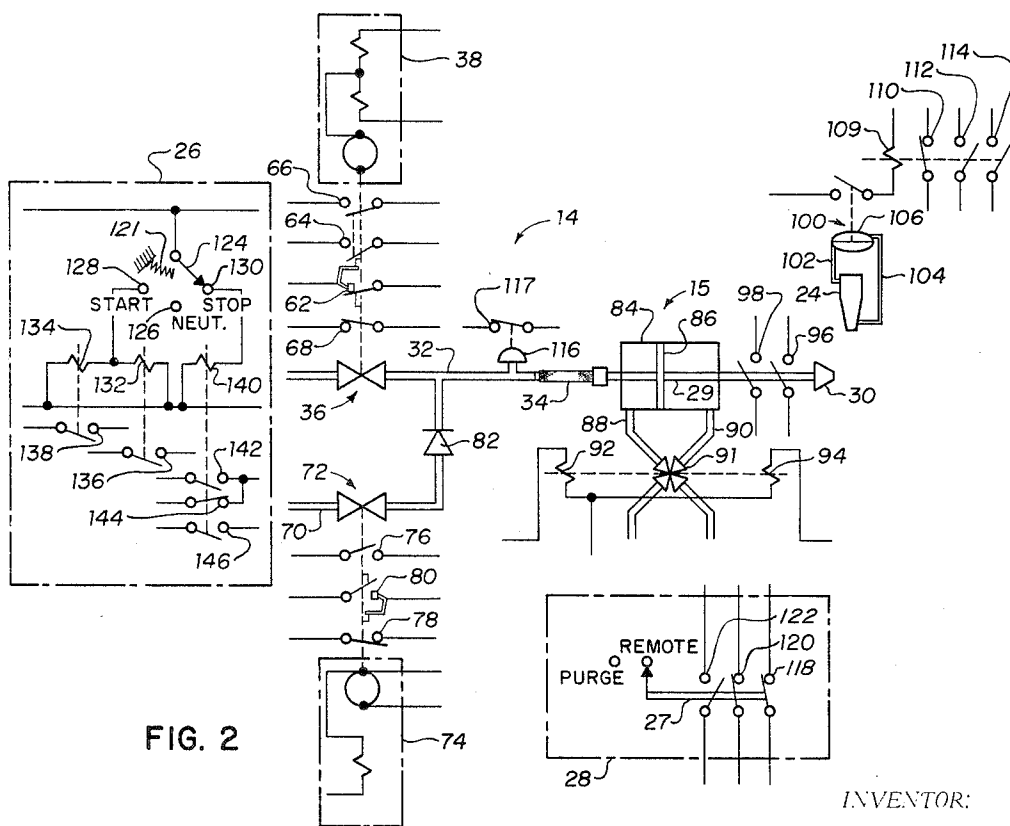


FIG. 2

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3 Sheets-Sheet 2

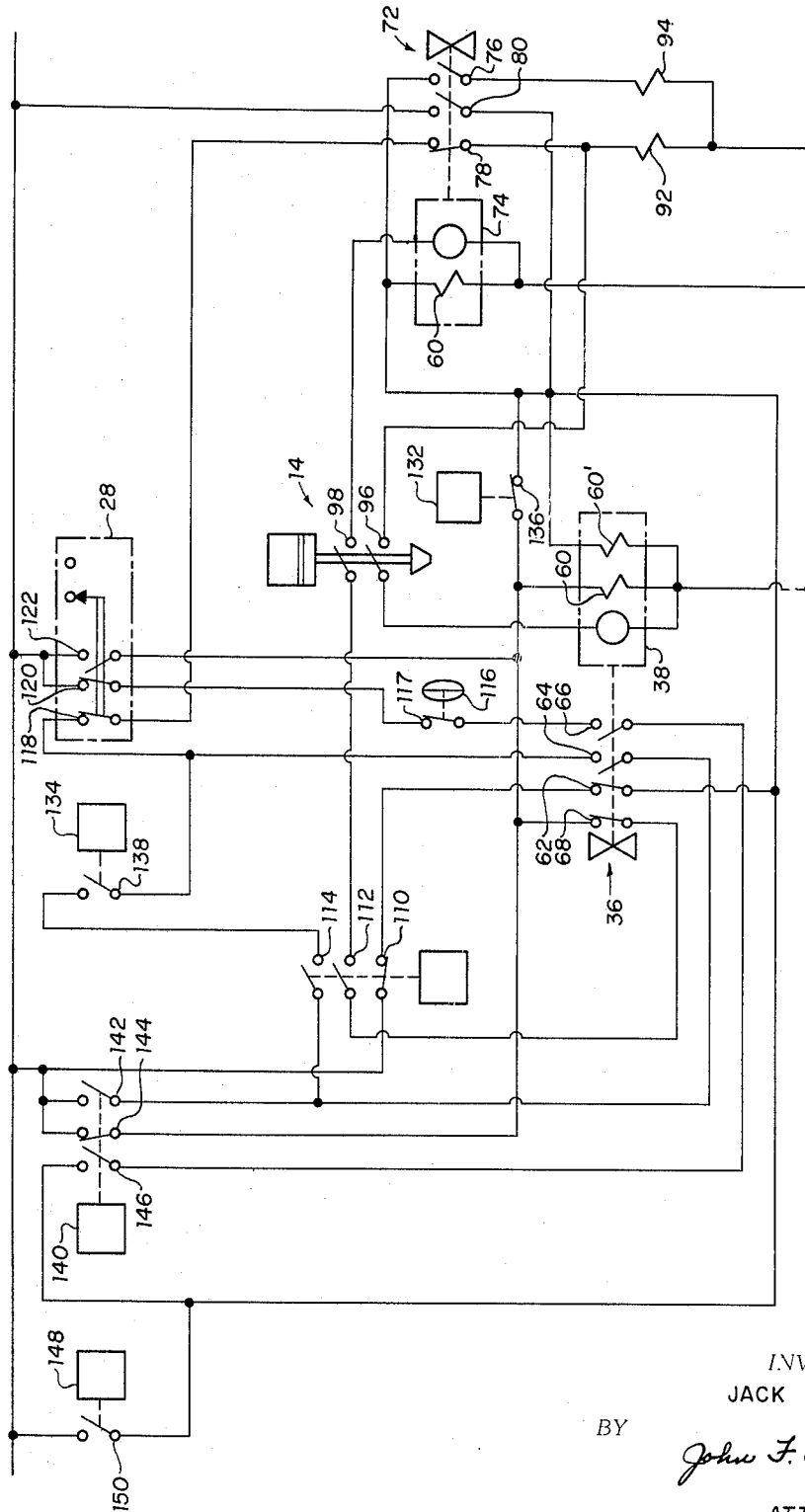


FIG. 4

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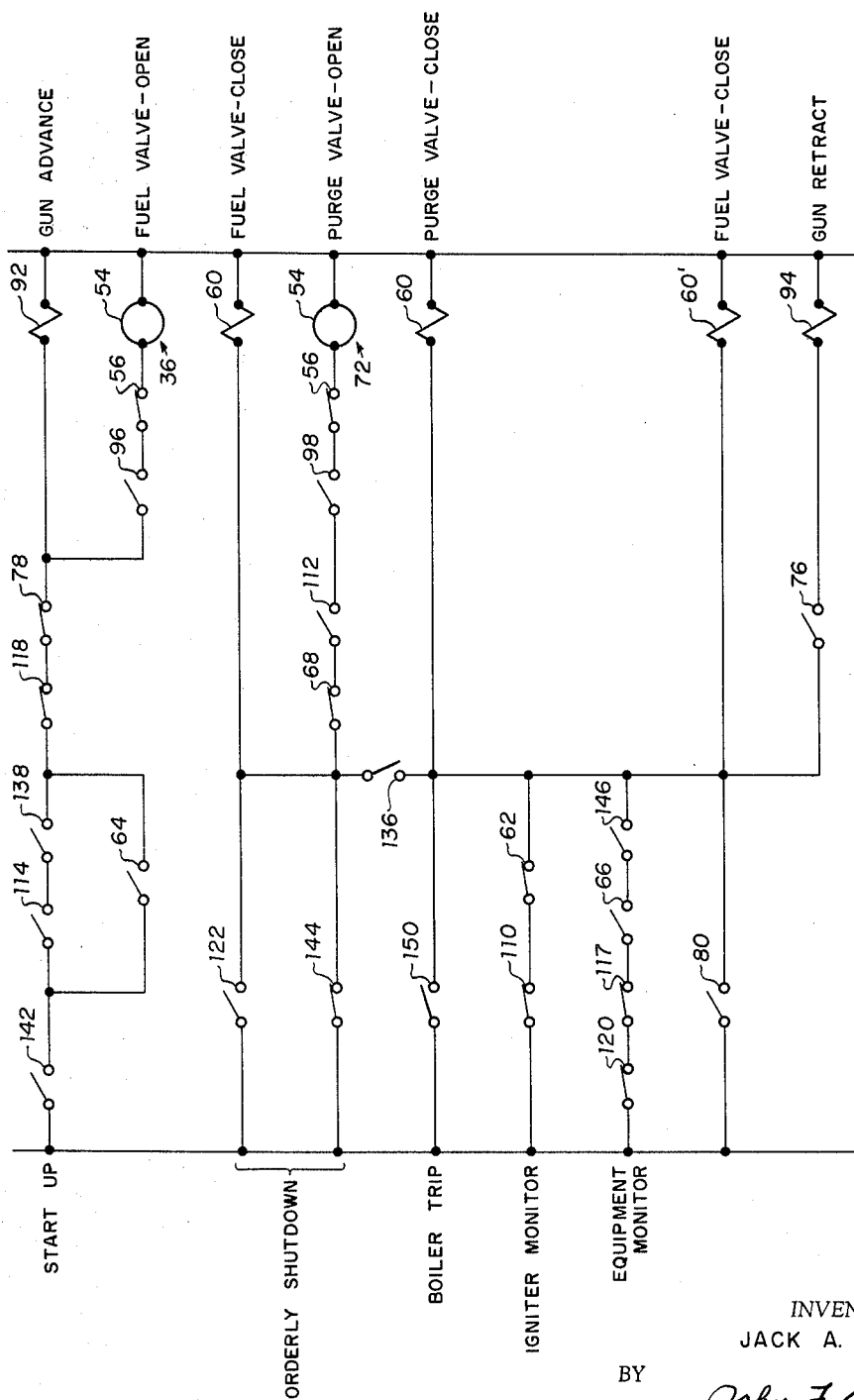
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3 Sheets-Sheet 3



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3,258,053

AUTOMATED BURNER CONTROL

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Filed May 5, 1964, Ser. No. 364,960

9 Claims. (Cl. 158-28)

This invention relates to new and useful improvements in electro-mechanical control systems suitable for burners using fluid fuel. More particularly, the invention is concerned with an electro-mechanical control system for automatically igniting, monitoring and extinguishing fuel burners of the types employed in large installations such as steam boilers which may have a multiplicity of burners in each installation.

An object of this invention is to provide an improved electro-mechanically operated system for automatically controlling the operation of a fluid fuel burner and of assuring safe operation thereof.

Another object of the invention is to provide an automatic burner control system for controlling the operation of a fluid fuel burner wherein the use of ancillary control equipment, such as timers and associated relays, is obviated.

Another object of the invention is to provide an automatic burner control system in which the sequence of operations on startup of the burner is to first, establish sufficient ignition energy at the igniter torch capable of igniting fuel supplied to the burner; then, only after the igniter torch has indicated that it has sufficient ignition energy, to automatically advance the burner from its retracted, inoperative position to its position of operation within the furnace chamber; and then to supply fuel to the burner only after the burner is in operative position and sensing apparatus throughout the unit indicate that conditions within the furnace chamber are such as can safely accommodate the admission of fuel.

A further object of the invention is to provide an automatic burner control system including means to monitor the burner operation and to terminate such operation when conditions indicate a malfunction in the fuel supply line such as a broken burner nozzle, a ruptured fuel line or the like.

Still another object of the invention is to provide an automatic burner control system in which the sequence of operations during the course of a normal orderly shutdown is to first, terminate the fuel supply to the burners, then purge the burners with steam only after the fuel supply valve is closed and thereafter to retract the burners from their operative to their inoperative position.

Another object of the invention is to provide a control system in which the purge portion of the burner shutdown cycle is eliminated in the event that furnace conditions indicate the necessity of effecting a "boiler trip" wherein the fuel addition to the furnace that accompanies a burner purge would be undesirable.

Yet another object of the invention is to provide an automatic burner control system wherein means are provided to effect an abrupt termination of the burner purge cycle when it is desired to immediately reinstate the burner into operation.

With the aforementioned objects in view, the invention comprises an arrangement, construction and combination of the elements of the inventive organization in such a manner as to attain the results desired as hereinafter more particularly set forth in the following detailed description of the illustrative embodiment, such embodiment being shown by the accompanying drawings wherein:

FIGURE 1 is a graphical illustration of a steam generator capable of employing the instant invention;

FIGURE 2 is a schematic illustration of a typical automatically operated burner arrangement according to the invention;

FIGURE 3 is a diagrammatic representation of an automatically operated supply valve of the type contemplated for use in the instant invention;

FIGURE 4 is a conventional wiring diagram illustrating the burner control apparatus connected to operate the components of the fuel burner unit; and,

FIGURE 5 is a simplified schematic electrical diagram intended to facilitate an understanding of the operation of the instant invention.

Referring now to FIGURE 1 there is shown in diagrammatic form an elevational section of a vapor generator 10 having a furnace chamber 12 in which the present invention is adapted to operate. A plurality of main burners 14 are arranged in the four corners of the chamber 12 for discharging and burning streams of fuel supplied thereto through a main fuel supply line 22 in the furnace chamber. In the illustrated embodiment there are three elevations of burners each consisting of burners 14 located at each of the four corners of the furnace chamber 12 and adapted to fire in a direction tangential to an imaginary firing circle (not shown). The walls of the furnace chamber 12 are lined with vapor generating tubes 16 which are in heat exchange relation with combustion gases rising within the furnace chamber 12. The arrangement is such that after traversing the furnace chamber 12 the gases enter a horizontal gas outlet passage 18 that may contain a superheater 20. The gas outlet passage 18 may be followed by a vertical down-draft gas passage (not shown) in which additional heat absorbing surfaces such as an economizer and an air heater may be disposed.

Generally, the operation of a vapor generator such as that shown comprises admitting feedwater to the tubes 16 while at the same time admitting fuel through supply line 22 to burners 14. The fuel emanating from burners 14 is consumed in the furnace chamber 12 creating hot combustion gases that flow through the furnace and out the gas outlet passage 18 whereby heat is extracted from the gases by the feedwater thus transforming the feedwater into vapor. The amount of vapor created in the generator can be controlled by the number of burners 14 placed in operation. Therefore, in the illustrated arrangement, the burner elevations are adapted to be operated either singly or together depending on the desired generator output.

Referring now to FIGURES 2, 4 and 5, FIGURE 2 is intended to illustrate the physical inter-relationship of the various component elements of a single burner 14 arrangement in accordance with the teachings of the present invention. FIGURE 4 is a conventional wiring diagram and illustrates the electrical inter-relationship of the elements. FIGURE 5 is a simplified schematic of the circuitry contained in FIGURE 4 intended to facilitate an understand of the sequence of the operations employed.

For the sake of brevity the description that follows is directed toward a single burner 14 and its associated equipment; however, it is to be understood that the description applies to all burners in the unit.

Going now to FIGURE 2 there is shown a typical burner 14, its associated igniter 24, a remote operational control 26 desirably located in the central control room of a power plant or other installation employing large furnaces, and a local control 28 desirably located in close proximity to its associated burner. The remote operational control 26 is operative to control the operations of all of the oil guns in a single elevation of which there may

be as many as four or more. The local control 28 is effective to remove individual oil guns from remote operation for maintenance or other purposes.

As best shown in FIGURE 2 the burner 14 comprises an oil gun 15 of the expansible-retractible type and includes a barrel 29 and nozzle 30 through which fuel, in the form of oil, may be supplied for combustion in the furnace chamber 12. The oil gun 15 is operatively connected to a fuel line 32, such connection including a flexible portion 34 to accommodate linear extension and retraction of the gun to and from its operative position within the furnace chamber. A fuel supply valve 36 is positioned within the fuel line 32 to control the admission of fuel to the gun 15. The valve 36 has an operator 38 which imparts to it slow opening and rapid closing characteristics. Valve 36 is illustrated in greater detail in FIGURE 3 where it is shown as including a valve body 40 connected to the fuel line 32 and operator 38 that comprises a hydraulically operated piston 42 which is operable within a cylinder 44 to actuate a valve stem 46 to an open position against the force of a spring 48 by means of fluid pressure admitted to the cylinder. Fluid is supplied to the underside of the piston 42 through inlet line 50 by means of a pump 52 driven by an electric motor 54. A normally closed limit switch 56 is positioned in the power supply line to the motor 54 and functions to discontinue operation of the motor once the valve stem has reached its uppermost or full-open position. By de-energizing the motor 54 the limit switch 56 stops the operation of pump 52; however, the valve remains open due to the fluid pressure that is retained within the cylinder 44 by the pressure relief valve 58 operated by solenoid 60. The solenoid 60 is actuated to close the valve 36, it being operational to open the pressure relief valve 58 thereby releasing the fluid pressure from beneath the piston 42 whereby the valve stem 46 is caused to rapidly descend under the force of spring 48. The fuel supply valve shown is so arranged that opening thereof is effected within about 15 seconds while closure is accomplished in less than one second.

Also associated with the fuel supply valve 36 are a plurality of limit switches which are actuated in response to movement of the valve stem 46. One of the limit switches contains normally closed contact 62 which is so associated with the valve as to remain closed until the valve is fully open. Another limit switch contains contact 64 which is normally open and closes when the valve is fully open. Contact 66 is associated with the valve in such a manner as to be open until the valve is about 70% open on its opening cycle from whence it remains closed through the remainder of the opening cycle and also through the closing cycle until the valve is fully closed. 68 is a contact associated with another limit switch which is open at all times except when the valve is fully closed.

Additionally provided in the system is a burner purging device for expurgating the oil gun 15 and fuel line 32 prior to retracting the gun from its operative position in order to remove any unburned fuel from these members to prevent solidification thereof upon cooling which would otherwise disrupt future operation of the oil gun. The purging arrangement includes a line 70 connected to a source (not shown) of steam or other purging medium and an automatically operated purge valve 72 having an operator 74. The purge valve 72 and operator 74 are substantially the same as the fuel supply valve 36 and operator 38 shown in FIGURE 2. The purge valve operator 74 is arranged to impart an opening time of the purge valve of sixty seconds and a closing time of about one second. Associated with the purge valve 72 are a multiplicity of limit switches which actuate contacts 76, 78 and 80. Contact 76 is normally open and is closed when the purge valve is fully open. Contact 78 is normally closed and opens when the purge valve begins to open. Contact 80 is arranged so as to close when the purge valve 72 is fully open and remains closed until the

valve becomes fully closed after purging of the system is completed.

A check valve 82 is interposed in the purge line 70 downstream of the purge valve 72. Its function is to assist in preventing fuel backup from the fuel line 32 into the purge line 70.

The oil gun 15 is arranged to be automatically extended or retracted to or from its operable position within the furnace chamber 12 by a pneumatic operator which includes a cylinder 84 and a piston 86 attached to the barrel 29 of the gun. The cylinder 84 is fluidly connected to a source of pneumatic power (not shown) by air lines 88 and 90 and a dual solenoid operated four-way valve 91, the solenoid 92 being actuable to admit pneumatic fluid to the cylinder 84 behind piston 86 thereby to effect extension of the burner to its operable position and solenoid 94 being operable to admit air ahead of the piston in order to effect retraction of the burner. Also associated with the burner are limit switches including normally open contacts 96 and 98 which are each closed when the nozzle 30 is fully extended and thus in operable position.

The igniter torch 24 associated with each burner 14 is operated by a separate source of fuel supply (not shown) and is actuated to initiate combustion of the fuel that issues from the burner nozzle 30. In the instant arrangement an igniter monitor 100 is operably associated with the igniter torch 24 to indicate the torch's ability to supply sufficient ignition energy to ignite the fuel that issues from its associated gun 15. The contemplated igniter monitor 100 is as described in detail in U.S. Patent No. 3,123,027 to Livingston. It comprises essentially a pair of pressure taps 102 and 104 which, in association with a pressure differentiating chamber 106, measure the pressure differential existing within the torch 24 at spaced points therealong. This pressure differential is indicative of the amount of ignition energy the igniter is capable of delivering in order to ignite the fuel issuing from burner 14. The arrangement is such that when a predetermined pressure differential is evidenced within the chamber 106 an associated contact 108 is closed actuating a relay 109 to close its associated contacts 112 and 114 and open contact 110.

The oil guns 15 contemplated for use in the illustrated embodiment are of the mechanical atomizing type. This type of oil gun requires a relatively high fuel pressure to force oil at a high velocity through the nozzle such that it will be atomized for burning within the furnace. If the fuel pressure drops below that required for atomization due to a broken burner tip, ruptured fuel line or the like atomization cannot occur and ignition of the fuel becomes difficult, if not impossible, thereby creating a hazardous condition in the furnace. To alleviate the problem in the instant system means are provided to terminate operation of the affected burner whenever the pressure of the fuel flowing to the burner falls below that required for atomization. This means includes a fuel pressure actuated switch 116 interposed in the fuel supply line 32 between the supply valve 36 and the oil gun 15 operable to indicate the absence of suitable fuel pressure in the line. The pressure switch 116 operates contact 117 which is normally closed and is arranged such that it opens when the pressure in the fuel line rises to that required for atomization of the fuel supplied to the burner 14, thereby permitting the fuel supply valve 36 to open as is described in detail hereinafter.

The local control 28 associated with each individual oil gun 15 is intended to enable a worker to remove the associated burner from service for purposes of maintenance or the like. This control 28 may include a manually operated switch 27 having two operable positions indicated as "Purge" and "Remote" and three associated contacts 118, 120 and 122. With the control in the "Remote" position the burners and their associated components are operable under remote vapor generator con-

trol system, and when the switch associated with an individual burner 14 is moved to the "Purge" position a normal orderly shutdown of the burner is effected. Such a shutdown, as described later, includes a termination of fuel flow to the burner followed by a purge of the oil gun 15 and thereafter retraction of the gun from its operable to its retracted position. After the oil gun 15 is retracted it can be manually removed from its mounting for inspection or maintenance.

Remote operational control 26 is effective to initiate startup or shutdown of an elevation of burners 14 from the control room by actuating the system controlling the oil guns and their components and by actuating the associated air register control, the latter not forming part of the instant invention. The control 26 comprises a single pole switch 124 having a "Neutral" position 126 and being adapted to close either a "Start" contact 128 or the "Stop" contact 130. The arrangement shown in FIGURE 2 is for the purpose of illustration only, since any suitable switch arrangement that will produce the desired effect can be used or, in the alternative, the initiation of the "Start" and "Stop" procedures could be effected by suitable relays operated from a computer console. In the "Start" position switch 124 is effective to simultaneously energize a pair of relays 132 and 134 by closing contact 128. Each of the relays 132 and 134 are of the time-delay type having contacts which remain closed for predetermined periods of time after the contact 128 is opened. Relay 132 is designated the "elevation igniter start pulse" relay and has an associated contact 136 which has a time-delay characteristic of 5 seconds. This contact is effective to operate the igniters 24 of all of the burners 14 in the elevation by instituting a spark in their associated igniters to ignite fuel admitted to the burners. The present arrangement is such that each igniter 24 has 5 seconds within which to be proven capable of delivering sufficient ignition energy to ignite its associated burner, this capability being proven by means of the igniter monitor 100. Relay 134 is designated the "Fuel In-Service" relay. Its associated contact 138 has a time-delay-upon-de-energization characteristic of 25 seconds. The relay 134 functions to sustain the startup operation of all of the oil guns 15 of a given elevation of burners until the fuel supply valve 36 associated with each oil gun has reached full open position at which time the burner operation becomes sealed in. The closure of contact 130 of the remote operational control 26 by placing the switch 124 in the "Stop" position effects energization of the "Normal Shutdown" relay 140. This relay includes time-delay contacts 142, 144 and 146 which will remain actuated for 5 seconds after removal of the remote operational control switch 124 from the energizing contact 130. Contacts 142 and 146 are normally closed and open when the relay 140 is energized and contact 144 is normally open and closes upon energization of the relay. The function of these contacts will be discussed hereinafter with regard to the operation of the system.

Numerical 148 shown in FIGURE 4 indicates a "Boiler Trip" relay which is operable in the over-all vapor generator control to actuate its associated contact 150 the latter being effective to immediately terminate the fuel supply to the burners upon the evidencing of conditions which would render further operation hazardous. The "Boiler Trip" relay is actuated by the existence of any one of several conditions that could adversely affect unit safety. For example, it is adapted to be operated in response to sensing devices operable to indicate loss of water circulation in the unit, total burner flame out, adverse furnace and equipment conditions prior to startup, etc. or, in the alternative, it may be operated by a manually operated switch in the control room.

The operation of the herein disclosed burner control system will be described with particular reference to FIGURE 5. For the purpose of discussion the system will be assumed to be shown in the shutdown condition with all

components inactive and all relays de-energized unless otherwise noted.

Start-up

The circuits responsible for the control of the oil guns upon start-up are those indicated as the "Gun Advance" and the "Fuel Valve-Open" circuits shown in FIGURE 5. These circuits include serially connected contacts 142, 114, 138, 118, 78 and solenoid 92 as well as contact 64 in parallel with contacts 114 and 138, and contacts 96 and 56 and motor 54 connected in parallel with solenoid 92. In order for each oil gun 15 in an elevation to be automatically operated the local control switch 27 must be in the "Remote" position thereby closing contacts 118 and 120 and opening contact 122. Contact 118 is included in the "Gun Advance" circuit and its closure indicates that the burner is intended for remote automatic operation. Thereafter, the operator moves switch 124 (shown in FIGURE 2) from "Stop" to "Start" momentarily closing contact 128. This momentary closure of the contact is due to the presence of spring 121 which returns the switch 124 to the "Neutral" position 126 thereby pulsing relays 132 and 134 and, since contact 130 is open, relay 140 is de-energized. Relay 132, being a time delay on de-energization relay that is set for 5 seconds, effects closure of contact 136, which closure will remain effective for the 5-second period after the switch 124 has been returned to the "Neutral" position. At the same time, relay 134, which is also a time delay on de-energization relay but set for 25 seconds actuation time, is actuated closing contact 138 in the "Gun Advance" circuit for the specified period. This period of time is sufficient to permit the igniters to be lighted, the burner barrels 29 to be advanced and the fuel valves 36 to open. Relay 140 being de-energized, contact 142 closes after a 5-second lapse, its closure being predicated on the fact that relay 140 is also of the time delay on de-energization type. Therefore, with the local maintenance switch 28 in the "Remote" position, remote operational control switch 124 in the "Start" position, and purge valve 72 being closed contacts 118, 138, 142 and 78 in the "Gun Advance" circuit are closed. And, if the igniter 24 associated with the burner 14 is delivering sufficient ignition energy with which to ignite its burner, contact 114 is also closed completing the circuit to the solenoid 92 thereby operating the associated four-way valve 91 to admit air to the cylinder 84 effecting extension of the oil gun 15 to its operative position within the furnace.

When the oil gun 15 is completely advanced limit switch contacts 96 and 98 are closed. Closure of contact 96 completes the circuit to motor 54 of the operator 38 of fuel supply valve 36 and the valve's opening cycle begins to admit fuel to the burner through line 32. Limit switch contact 64 closes when the fuel supply valve 36 reaches approximately 90% of its full open position shunting out contacts 114 and 138 in the "Gun Advance" circuit. When the valve 36 reaches its full open position contact 56 is opened to de-energize the motor 54; however, the valve remains open for the reasons set forth hereinabove. This serves to seal in the fuel supply valve operation thereby permitting its continued operation even though the igniter monitor relay 107 becomes de-energized opening contact 114 or after the 25-second period required for opening of the fuel valve dictated by contact 138 has lapsed. Arrangement of contact 64 in parallel relation with contacts 114 and 138 is predicated on the fact that it is assumed that the fire within the furnace is capable of sustaining combustion of the fuel issuing from the burners once the burners are fully opened and ignition energy from the igniters is not therefore required. Flame failure protection of the burners, at this point, is transferred to a control system operable to monitor the entire burner system of the unit and does not form part of this invention. This over-all control system

is as described in applicant's copending patent application Serial No. 240,797, filed November 29, 1962, now U.S. Patent No. 3,195,610, issued July 20, 1965.

Because of the instant arrangement, should the valve 36 be closed for any reason after once having been opened it cannot again be re-opened except by a subsequent actuation of the switch 124 to the "Start" position. Additionally, the arrangement is such as will automatically prevent closure of the valve 36 due to leakage of the hydraulic fluid within the valve's operator 38. This is accomplished by the presence of contacts 56 and 64 in the circuit. Should leakage occur and the valve 36 begin to close contact 56, which is open only when the valve is fully open, would close thus energizing the operator motor 54 to pump additional fluid into the cylinder 44 to return the valve to its full open position.

Orderly shutdown

Orderly shutdown, as distinguished from a "Boiler Trip" can be initiated either from the control board by moving remote operator control switch 124 to the "Stop" position in which case all of the burners 14 of an elevation will be shut down or it can be initiated in each individual burner 14 by moving the associated Local Maintenance Control switch 29 to the "Purge" position. An orderly or normal shutdown of the burner comprises the steps of closing the fuel supply valve 36 thereby terminating fuel flow to the associated oil gun 15, opening the purge valve 72 thereby admitting steam to the fuel line and through the gun such that unburned fuel is removed therefrom and actuating the four-way valve 91 such that air is admitted to the cylinder 84 to retract the gun.

Operation in the case of an orderly shutdown initiated at the control board is as follows. Switch 124 is moved from "Neutral" to "Stop" thereby closing contact 130 and energizing relay 140 immediately closing contacts 144 and opening contacts 142 and 146. Opening contact 146 disarms the "Equipment Monitor" circuit so that the unit will not effect a trip preventing the purge valve 72 from opening and the oil gun from retracting when the pressure in line 32 falls below the set point of the pressure switch 116. Opening of contact 142 de-energizes the "Start-Up" circuit and closure of contact 144 completes the circuit to solenoid 60 in the "Fuel Supply Valve-Close" circuit. This solenoid 60 is associated with the pressure relief valve 58 of the operator 38 of fuel supply valve 36 and effects venting of the hydraulic fluid from beneath the piston 42 permitting the valve to be rapidly closed under the force of spring 48. When the valve 36 reaches its fully closed position limit switch contact 68 associated with the valve closes arming the Purge Valve-Open circuit, contact 62 also associated with the valve having been closed immediately upon the valve's beginning its closing movement arming the Igniter Monitor circuit, and contact 66 opens. Thus, with contact 68 closed indicating that the fuel supply valve 36 is closed, contact 98 closed indicating that the oil gun 15 is advanced and contact 144 closed indicating that a normal shutdown is desired, the purge valve 72 will open as long as the igniter 24 is delivering sufficient ignition energy to consume the fuel purged from the system. This will be indicated by the closure of contact 112 associated with igniter monitor relay 107. Therefore, when all of the serially connected contacts 144, 68, 112 and 98 are closed motor 54 of the operator 74 of the purge valve 72 is energized causing the purge valve to be opened admitting steam or other purge medium to the line 32 and through oil gun 15. The characteristics of the valve 72 are such that it requires 60 seconds to reach its full open position; however, full fluid flow through the valve is achieved after 5 to 10 seconds opening time therefore effecting full flow of purge medium for approximately 50 seconds. Such flow is deemed sufficient to remove all unburned fuel from the fuel line and the gun.

When purge valve 72 reaches its full open position limit

switch contact 80 is closed thereby completing the circuit to solenoid 60 in the "Purge Valve-Close" circuit. Energization of the solenoid 60 open the pressure relief valve 58 associated with the operator 74 of the purge valve 72 effecting rapid closure of the valve under the force of spring 48. Limit switch contact 80 remains closed during the entire closure of the valve 72, opening only after the valve reaches its fully closed position thereby effecting continuity of the valve closure operation. At the same time that solenoid 60 is actuated, limit switch contact 76 is closed momentarily pulsing the solenoid 94 of the valve 91 to vent air from behind the piston 86 and to admit air ahead of the piston thereby retracting the oil gun 15. When gun 15 begins its retractive movement limit switch contact 98 is immediately opened thus preventing repetition of another cycling of the purge valve 72.

The arrangement provides a convenient means for indicating in the control room the purge status of each oil gun. Such indication can be obtained from the fact that the guns will be completely purged by the time their associated purge valves reach full open position, which condition also effects retraction of the guns from their operative position. Therefore, indicating lights can be installed on the control board to be operated by limit switches that are actuated when each gun is retracted. Since such a feature merely involves the presence of additional switches in the system and add nothing in the way of invention to the disclosed concept a complete description of the circuitry required is omitted.

The arrangement is such that should it become desirable to reinstate the elevation of burners after having removed them from service but before the purge cycle is completed this can be accomplished without having to wait for the completion of the purge cycle. All that is required is to move the Remote Operational Control switch 124 from the "Stop" to "Start" position thereby opening contact 130 to de-energize relay 140 and closing contact 128 to energize relays 132 and 134. Although relay 140 is de-energized, its associated contacts remain closed for 5 second after de-energization due to their time delay characteristic. Therefore, contact 144 remains closed for 5 seconds after the switch 124 is moved from "Stop" to "Start." At the same time, switch 124 closes contact 128 energizing relay 132 which closes contact 136. With contacts 144 and 136 closed the circuit is completed to actuate solenoid 60 associated with purge valve 72 thereby effecting rapid closure of the valve. When the purge valve 72 reaches its fully closed position contact 78 in the "Gun Advance" circuit, which has been open, is closed and the start-up procedure can proceed as described herein before.

The operation of an orderly shutdown of an individual burner by means of the Local Control 28 is as follows. The Local Maintenance Control switch 27 is moved to the "Purge" position opening contacts 118 and 120 and closing contact 122. Because contact 122 is in parallel with contact 144 as shown in FIGURE 5 the same subsequent steps are effected as were effected in the shutdown procedure described for the shutdown occasioned by the Remote Operation Control 26.

Boiler trip

When a boiler trip is occasioned for any of the reasons hereinbefore described solenoid 148 is actuated closing its associated contact 150. Closure of contact 150 completes a circuit to solenoid 60' in the operator 38 of the fuel supply valve 36 and solenoid 60 in the purge valve 72 thereby effecting rapid closure of the fuel supply valve and preventing the purge valve from opening thus preventing the addition of the fuel purged from the burners and the lines 32 to an already dangerous furnace condition. Should a boiler trip be occasioned while a burner elevation is in the process of purging, closure of contact 150 also completes a circuit to actuate solenoid 60 associated with the purge valve 72 to immediately close it. Thus means are provided to immediately close both the fuel

supply valves and the purge valves in the event of actuation of the boiler trip solenoid 148.

Individual burner trip during start-up

Flame failure protection of each individual burner during start-up is accomplished by the Igniter Monitor circuit which includes contacts 110 and 62. Contact 110 is that contact associated with the igniter monitor relay 107 and contact 62 is a limit switch contact associated with fuel supply valve 36. The former is closed when the relay 107 is de-energized indicating the presence of insufficient ignition energy to ignite the burner and limit switch contact 62 is closed as long as the fuel supply valve is not fully open. Therefore, should ignition energy be lost during start-up contact 114 in the "Gun Advance" circuit will be opened shutting off power to the operator motor 54 of valve 36 and contact 110 is closed completing the circuit to solenoid 60' which immediately closes the valve. This circuit is also operable during the course of purging of a gun at which time a source of ignition provided by the igniter 24 is required to consume the fuel purged from the burner and fuel line. Should ignition energy be lost at the igniter during this time the same circuitry is completed and the solenoid 60 associated with the purge valve 72 is actuated to immediately close the purge valve so that no further fuel will be blown into the furnace.

After the fuel supply valve 36 becomes fully opened during the start-up sequence contact 62 is opened thereby disarming this Igniter Monitor circuit. Thereafter, flame failure protection for all of the burners is undertaken by the flame failure protection control system provided for the entire unit referred to hereinbefore.

Gun integrity monitoring

The system is provided with pressure switches 116 which are intended to monitor the pressure of the fuel flowing through lines 32 to the oil guns 15. This is desirable because of the following. Where a straight mechanical atomizing burner is employed the pressure switch 116 in each line insures that the pressure of the fuel flowing through the lines is sufficient to create a fuel spray at the nozzle such that the fuel can be consumed. The pressure switch 116 also insures against the possibility of a workman closing a manually operated valve (not shown) which is normally provided upstream of the fuel supply valve in line 32. Were it not for the presence of the pressure switch 116 a workman could conceivably close the manually operated valve while the fuel supply valve 36 is open thereby removing the burner from operation and, thereafter, attempt to return the burner to operation by opening the manually operated valve with the possibility that there is no source of ignition at the igniter which would effect introduction of raw fuel to the furnace and thereby create a potentially dangerous condition. The presence of the pressure switch 116 prevents such to occur due to the fact that the pressure switch indicates a loss of fuel pressure in the line 32 when the manually operated valve is closed thereby closing the fuel supply valve 36 which cannot be thereafter re-opened until a "Start" command is initiated at the Remote Operation Control 26.

Additionally, the pressure switch 116 is effective to monitor the system and to indicate the presence of a fuel line rupture or a broken burner nozzle which would evidence themselves by a loss of pressure in the line. When such an event occurs the pressure switch would be actuated thereby effecting a rapid closure of the fuel supply valve 36 to prevent further spewing of fuel into the furnace.

The pressure switch 116 functions as follows. It operates to close contact 117 when the fuel pressure in the line falls below a predetermined value, such value being that required for atomizing the fuel supplied to the associated burner 14. The circuit in which it is employed is the "Equipment Monitor" circuit containing contacts 120, 117, 66 and 146. The circuit is armed when all of con-

tacts 120, 66 and 146 are closed. Contact 120 will be closed when the Local Control switch 28 is in the "Remote" position. Contact 66 will be closed when the fuel supply valve 36 is approximately 70% open and thereafter until it completely closes and contact 146 will be closed when the normal shutdown relay 140 is de-energized. Thereafter, with these contacts closed, closure of contact 117 will immediately effect closure of the fuel supply valve 36 by actuating the solenoid 60'. Because of the presence of contacts 120 and 146 the system can be disarmed when it is desired to effect a normal shutdown at which time the fluid pressure in line 32 would naturally fall below the set point of the pressure switch 116 due to closure of the fuel supply valve 36.

From the foregoing description, tracing a complete cycle of the operation of the apparatus of the invention, it can be seen that there has been provided an improved burner control system for automatically controlling the burners of a vapor generator during all phases of their operation. The system is simple in form and considerably less expensive than other comparable systems. Moreover, the dependability of the present system is enhanced over other systems of the prior art by the fact that the timed sequence of operation of the system's components is effected without the need of ancillary timing devices, the arrangement being such that the components themselves perform the functions heretofore provided by timing devices.

Other modifications of the present invention will be apparent to those skilled in the art, and it is therefore intended that the scope of the invention be limited solely by the scope of the appended claims.

What is claimed is:

1. A system for controlling a fuel burner arrangement having an axially movable main oil gun, an igniter torch and burner purge means comprising: a main burner fuel supply valve; a burner purge valve; an electrically actuated fuel supply valve operator adapted to open and to close said fuel supply valve upon command; an electrically actuated burner purge valve operator adapted to open and to close said burner purge valve upon command; electrically actuated oil gun moving means adapted to extend and to retract said oil gun upon command; first circuit means including means for actuating said oil gun moving means only upon said burner purge valve being closed and said igniter delivering sufficient ignition energy to ignite said oil gun, means for actuating said fuel supply valve operator to open said fuel supply valve upon said oil gun advancing to its extended position and means for locking in said fuel valve operation without igniter operation after said fuel valve is full open; second circuit means actuable upon command for terminating operation of said oil gun including means for actuating said fuel supply valve operator to close said fuel supply valve, means for actuating said purge valve operator to open said purge valve only upon said igniter delivering sufficient ignition energy to ignite the fuel expunged from said oil gun, means for actuating said purge valve operator to close said purge valve after a predetermined period of time and means for retracting said burner upon closure of said purge valve; and third circuit means independent of said first and second circuit means actuable upon command for terminating operation of said oil gun including means for actuating said fuel supply valve operator to close said fuel supply valve and means for preventing opening of said purge valve.

2. A system as set forth in claim 1 including independently operable second circuit actuating means located in close proximity to and remotely from said oil gun.

3. A system for controlling a fuel burner arrangement having an axially movable oil gun, an igniter torch and burner purge means comprising: a main burner fuel supply valve; a burner purge valve; an electrically actuated fuel supply valve operator adapted to open and to close said fuel supply valve upon command; an elec-

trically actuated burner purge valve operator adapted to open and to close said burner purge valve upon command; electrically actuated burner moving means adapted to extend and to retract said oil gun upon command; first sensing means associated with said igniter torch actuated upon detecting the presence of sufficient ignition energy in the igniter torch to ignite said oil gun; second sensing means for determining the operative position of said fuel supply valve; third sensing means for determining the operative position of said purge valve; fourth sensing means for determining the position of said oil gun; first circuit means adapted to actuate said oil gun moving means to an extended position including in series contacts that are closed upon actuation of said first sensing means, contacts that are closed when said third sensing means indicates closure of said burner purge valve and actuation means associated with said oil gun moving means, said circuit further including contacts associated with said fuel supply valve operator closed upon said oil gun reaching its extended position to open said fuel supply valve and contacts connected in parallel with said first sensing means contacts adapted to close when said fuel supply valve is substantially full open; second circuit means adapted to terminate operation of said oil gun including contact means closed upon command connected in series with said fuel supply valve operator to close said valve, said circuit further including in series contacts that are closed upon actuation of said first sensing means, contacts that are closed when said second sensing means indicates closure of said fuel supply valve and actuation means associated with said purge valve operator to open said purge valve; contacts that are closed when said third sensing means indicates full open position of said purge valve connected in series with actuation means associated with said purge valve operator to close said purge valve; and contacts associated with said third sensing means that are closed when said purge valve is closed connected in series with actuation means for said oil gun moving means to retract said oil gun; and third circuit means adapted to terminate operation of said oil gun and prevent burner purge including contact means for initiating a command signal when closed connected in series with said fuel supply valve operator to close said valve and said purge valve operator to close said purge valve, the operators for said fuel supply valve and said burner purge valve being connected in parallel.

4. The system as recited in claim 3 wherein said third circuit includes contact means operatively associated with boiler trip control means actuated to a closed position by a boiler trip command.

5. The system as recited in claim 3 wherein said third circuit includes means for monitoring said igniter torch during startup comprising serially connected contacts associated with said first sensing means and said second sensing means, said first sensing means contacts being closed when said first sensing means is deactuated, said second sensing means contacts being closed when said fuel supply valve is not substantially full open and time delay contacts for arming said serially connected contacts for a predetermined period of time substantially equal to the time required for the fuel supply valve to reach full open position.

6. The system as recited in claim 3 wherein said third circuit includes means for monitoring the operation of said oil gun comprising serially connected contact means, said contact means including contacts adapted to close when the pressure downstream of said fuel supply valve is below that required for fuel atomization and contacts open only when said fuel supply valve is between closed and substantially full open on its opening cycle.

7. A system for controlling a fuel burner arrangement having an axially movable oil gun, an igniter torch and burner purge means comprising: a main burner fuel supply valve; a burner purge valve; an electrically actuated fuel supply valve operator adapted to open and to close

said fuel supply valve upon command; an electrically actuated burner purge valve operator adapted to open and to close said burner purge valve upon command; electrically actuated oil gun moving means adapted to extend and to retract said oil gun upon command; first sensing means associated with said igniter torch actuated upon detecting the presence of sufficient ignition energy in the igniter torch to ignite said oil gun; second sensing means for determining the operative position of said fuel supply valve; third sensing means for determining the operative position of said purge valve; fourth sensing means for determining the position of said oil gun; first circuit means adapted to actuate said oil gun moving means to an extended position including in series contacts that are closed upon actuation of said first sensing means, contacts that are closed when said third sensing means indicates closure of said burner purge valve and actuation means associated with said oil gun moving means, said circuit further including contacts associated with said fuel supply valve operator closed upon said oil gun reaching its extended position to open said fuel supply valve and contacts connected in parallel with said first sensing means contacts adapted to close when said fuel supply valve is substantially full open; second circuit means adapted to terminate operation of said oil gun including means for closing said fuel supply valve means for thereafter actuating said burner purge means and means for retracting the oil gun from operative position; and third circuit means adapted to terminate operation of said oil gun including means for closing said fuel supply valve and means for preventing the actuation of said burner purge means.

8. A system for controlling a fuel burner arrangement having an axially movable oil gun, an igniter torch and burner purge means comprising: a main burner fuel supply valve; a burner purge valve; an electrically actuated fuel supply valve operator adapted to open and to close said fuel supply valve upon command; an electrically actuated burner purge valve operator adapted to open and to close said burner purge valve upon command; electrically actuated oil gun moving means adapted to extend and to retract said oil gun upon command; first sensing means associated with said igniter torch actuated upon detecting the presence of sufficient ignition energy in the igniter torch to ignite said oil gun; second sensing means for determining the operative position of said fuel supply valve; third sensing means for determining the operative position of said purge valve; fourth sensing means for determining the position of said oil gun; first circuit means adapted to actuate said oil gun including means for advancing said oil gun to an operative position, means for opening said fuel supply valve and means for locking in said fuel supply valve operation; second circuit means adapted to terminate operation of said oil gun including contact means closed upon command connected in series with said fuel supply valve operator to close said valve, said circuit further including in series contacts that are closed upon actuation of said first sensing means, contacts that are closed when said second sensing means indicates closure of said fuel supply valve and actuation means associated with said purge valve operator to open said purge valve; contacts that are closed when said third sensing means indicates full open position of said purge valve connected in series with actuation means associated with said purge valve operator to close said purge valve; and contacts associated with said third sensing means that are closed when said purge valve is closed connected in series with actuation means for said burner moving means to retract said oil gun; and third circuit means adapted to terminate operation of said oil gun including means for closing said fuel supply valve and means for preventing actuation of said burner purge means.

9. A system for controlling a fuel burner arrangement having an axially movable oil gun, an igniter torch and burner purge means comprising: a main burner fuel sup-

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ply valve; a burner purge valve; an electrically actuated fuel supply valve operator adapted to open and to close said fuel supply valve upon command; an electrically actuated burner purge valve operator adapted to open and to close said burner purge valve upon command; electrically actuated oil gun moving means adapted to extend and to retract said oil gun upon command; first sensing means associated with said igniter torch actuated upon detecting the presence of sufficient ignition energy to ignite said oil gun; second sensing means for determining the operative position of said fuel supply valve; third sensing means for determining the operative position of said purge valve; fourth sensing means for determining the position of said oil gun; first circuit means operable when said first sensing means indicates the presence of sufficient ignition energy to ignite said gun adapted to actuate said oil gun including means for advancing said oil gun to an operative position, means for opening said fuel supply valve and means for locking in said fuel supply valve operation; second circuit means adapted to terminate operation of said oil gun and effect purge thereof including means for closing said fuel supply valve,

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means for actuating said burner purge means when said second sensing means indicates that said fuel supply valve is closed and means for retracting said oil gun from operative position when said third sensing means indicates that said purge valve is closed; third circuit means adapted to terminate operation of said oil gun and to prevent purge thereof including means operable upon command for simultaneously actuating said fuel supply valve operator and said purge valve operator to close said valves when said fourth sensing means indicates that said oil gun is in its extended position.

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