

[54] **DUCT BURNER FOR OPERATION WITH LIQUID OR GASEOUS FUELS**

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[58] Field of Search **239/399, 424, 427.3**

[56] **References Cited**

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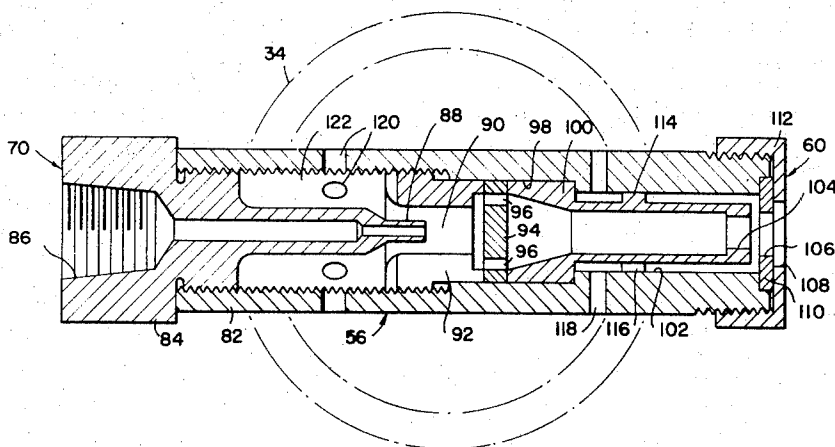
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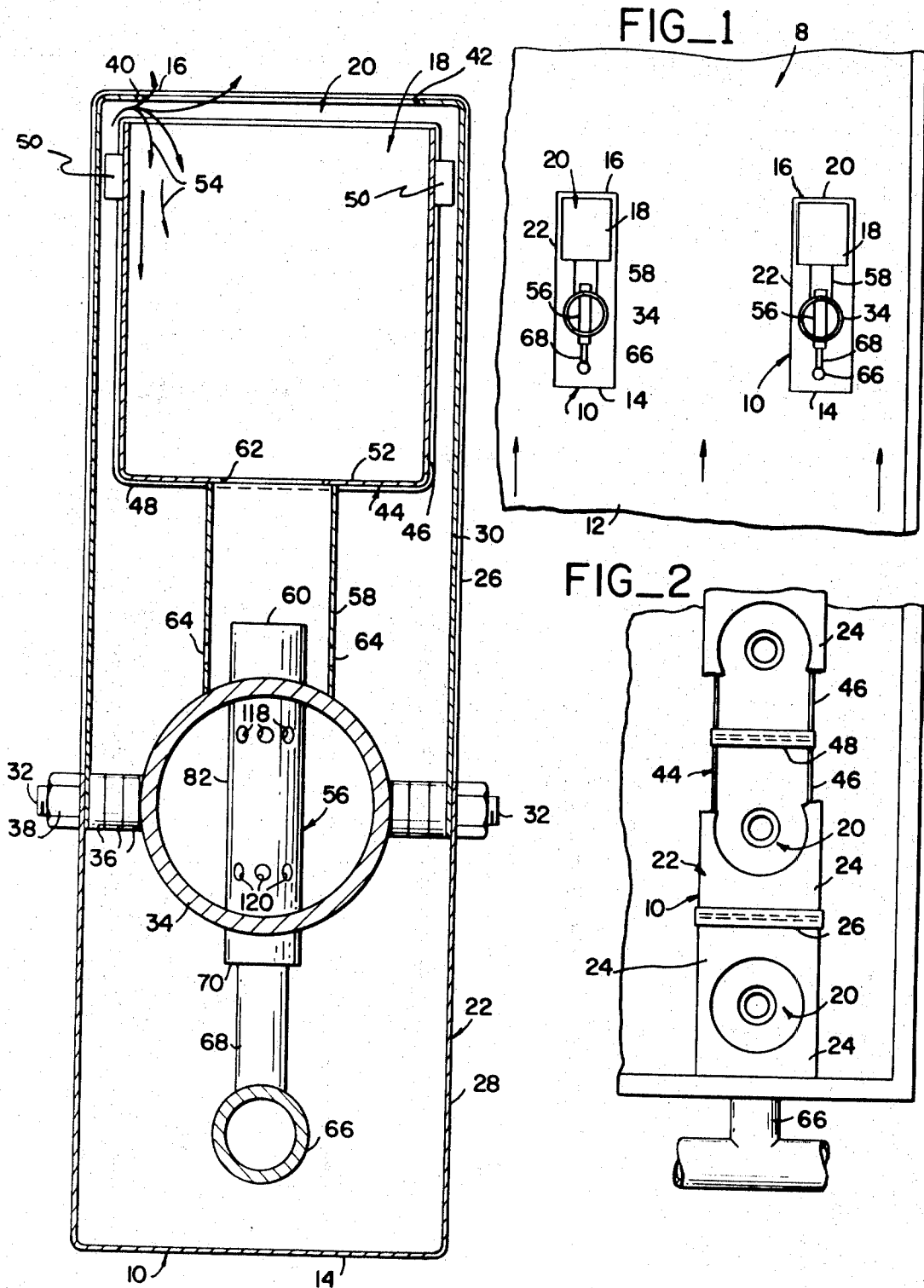
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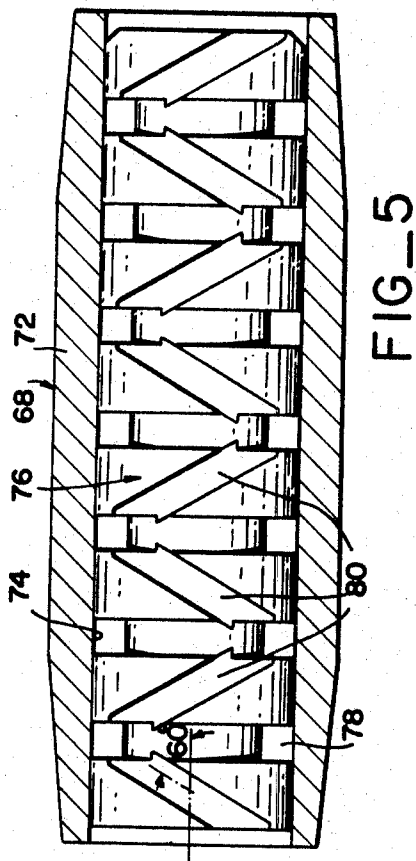
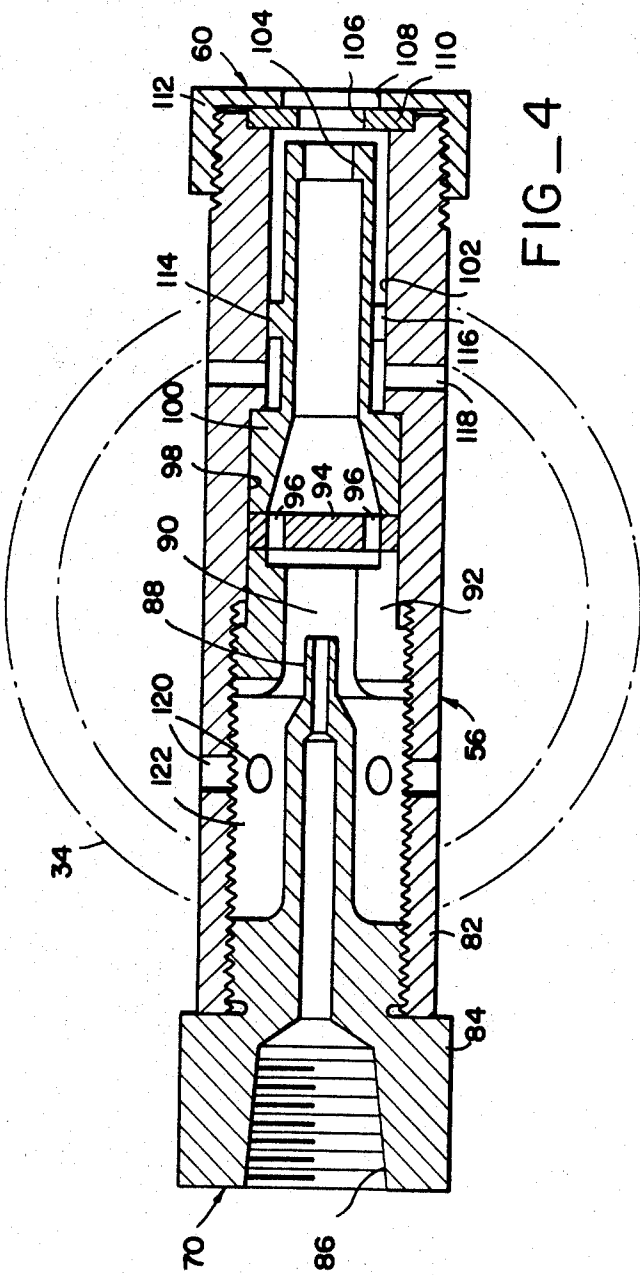
[57] **ABSTRACT**

An air augmented liquid or gaseous fuel burner having a hollow post mounting a plurality of fuel discharge nozzles spaced over the length of the post and a combustion chamber aligned with each discharge nozzle. An air plenum is disposed about the nozzle, the post and the combustion chamber. An upstream end of the nozzle is connected to a liquid fuel pressure reducer having relatively large cross sectional passageways for reducing the pressure of the liquid fuel supplied from a manifold. The discharge nozzle includes a liquid fuel atomizing core which employs an atomizing plate together with an air flow entering the nozzle interior through apertures in the nozzle housing from within the hollow post. For gaseous fuel operation of the burner the gas is passed through the hollow post and the bores in the nozzle housing for a discharge towards the combustion chamber. Suitable air inlets between the nozzle discharge end and the combustion chamber are provided for admixing the discharged fuel with sufficient air to sustain the growth of the jet issuing from the nozzle. The air plenum is so constructed that it induces eddy currents within the combustion chamber.

5 Claims, 5 Drawing Figures







DUCT BURNER FOR OPERATION WITH LIQUID OR GASEOUS FUELS

This is a division, of application Ser. No. 84,036, filed Oct. 26, 1970 and which is now U.S. Pat. No. 3,682,451.

BACKGROUND OF THE INVENTION

This invention relates to burners and particularly to those suited for the heating of large air or gas volumes.

Large air volumes are presently heated with so-called duct burners placed in air streams for heating the air to the desired temperature. As a result of the large air volume, which would cool the burner fuel below its flame point, duct burners are constructed so that they sustain a flame in spite of the excess air volume. Prior art duct burners were either gas or oil operated, or they employed both fuel types simultaneously. Alternative operation of prior art duct burners with liquid or gaseous fuel in an economic manner without at least a substantial increase in the initial cost of the burners was generally not possible.

SUMMARY OF THE INVENTION

The present invention provides a duct burner for the alternative use with liquid or gaseous fuel. The duct burner is efficient and employs the same burner components for both operational modes.

Briefly, the duct burner of the present invention comprises a combustion chamber disposed in a duct which has an opening facing in a downstream direction of the duct. Fuel discharging nozzle means are disposed upstream of the combustion chamber and interconnected therewith by a passage. Means disposed upstream of a fuel discharge end of the nozzle means introduces a gas stream into the interior of the nozzle means for the subsequent discharge of such gas stream through the discharge end towards the combustion chamber. Means is provided for supplying oxygen to the combustion chamber for at least partial oxidation of the gas or liquid fuel. The burner is liquid fuel operated by passing the liquid fuel through the nozzle means and atomizing it in an air flow entering the nozzle means interior through the gas stream introduction means. It is operated with gaseous fuel by passing gaseous fuel into the nozzle means interior from the gas stream introduction means.

In the preferred embodiment of the invention the mounting means for the fuel discharge nozzle comprises a hollow post that extends across the width or height of the duct in which the burner is placed and which mounts a plurality of serially arranged discharge nozzles. The nozzles comprise a housing including apertures communicating the post interior with the housing interior and an interior nozzle core which combines a liquid fuel flow with the air flow entering through the housing for atomization of the liquid fuel and subsequent discharge from the nozzle towards the combustion chamber. For gaseous fuel operation, the gas fuel is passed through the hollow post interior and the nozzle housing apertures into the nozzle interior and then discharged from the nozzle to the combustion chamber. A liquid fuel restrictor communicating an upstream nozzle end with a liquid fuel distribution manifold reduces the fuel pressure between the manifold to the nozzle by providing a plurality of relatively large cross sectional but sharply angularly inclined passage-

ways for the fuel. Heretofore often encountered clogging of restrictive, pressure reducing apertures in liquid fuel duct burners are thereby substantially reduced or eliminated. A tubular air plenum embraces the combustion chamber, the upright posts and the fuel discharge nozzle, supplies combustion air and cools the burner components during operation. A forward downstream end of the plenum includes openings for the discharge of flames from the combustion chamber into the duct. The plenum is further so constructed that eddy currents are induced at the forward end of the combustion chamber. The eddy currents recirculate burning materials from adjacent the forward discharge end of the combustion chamber towards the base thereof. The combustion of the fuel in the chamber is thereby made substantially more thorough and uniform. This substantially enhances the subsequent combustion of unburned fuel particles leaving the chamber. An increased burner efficiency and/or decreased fuel consumption is thereby obtained.

The duct burner of the present invention employs relatively low cost components which are simultaneously used for its liquid or gaseous fuel operation. It thus permits the operator to employ whatever fuel is most convenient, or least expensive at the time to help minimize operating costs. Moreover, the simple, rugged components assure a long and trouble-free service life of the burner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary plan view of a vertically installed duct burner constructed in accordance with the invention;

FIG. 2 is an enlarged fragmentary elevation, with parts broken away, of the duct burner illustrated in FIG. 1;

FIG. 3 is an enlarged cross sectional view of a duct burner constructed in accordance with the invention;

FIG. 4 is an enlarged cross sectional view of a liquid or gaseous fuel discharge nozzle constructed in accordance with the invention; and

FIG. 5 is an enlarged cross sectional view of an oil pressure reducing restrictor coupled with the nozzle illustrated in FIG. 4 and constructed in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 through 3, a duct burner 8 for use with liquid fuels, such as oil, or gaseous fuels, such as natural gas, is shown to comprise a plurality of horizontally spaced, vertically extending burner columns 10 disposed in side by side relation in a generally horizontal air duct 12.

Upstream end 14 of each column is closed while a forward or downstream end 16 of each column is open for the discharge of flames generated in a combustion chamber 18 through a flame discharge 20 of the chamber to thus heat the air flow in duct 12.

Each burner column 10 comprises an air plenum 22 of a generally rectangular cross section which extends over the height of duct 12 and is constructed of a plurality of relatively short plenum sections 24 arranged end to end and joined with suitable bands 26. This permits the extension and contraction of the relatively thin walled plenum without causing buckling, warping or

the like under the substantial temperature differentials encountered during operation of duct burner 8.

For assembly purposes the plenum is constructed of a U-shaped aft half 28 joined to an inverted, also U-shaped forward half 30 by laterally extending bolts 32 secured to an upstanding hollow post or pipe 34. A plurality of washers 36 enable the tightening of nuts 38 without deformation of the plenum halves while they assure correct and equal spacing between the exterior of post 34 and the plenum halves. A web 40 of the forward plenum half defining the forward end of burner column 10 includes relatively large diameter apertures 42 forming a portion of flame discharge opening 20.

Combustion chamber 18 is vertically continuous and defined by an upright U-shaped member 44 which is open on the downstream side and disposed adjacent to the forward end of air plenum 22. The U-shaped plenum member is also constructed of sections 46 which are joined end to end and interconnected by bands 48 to permit their free expansion and contraction under the encountered temperature differentials. Intermittently spaced blocks 50 are secured, e.g. welded, to exterior sides of U-shaped member 44 adjacent the forward end thereof to maintain an equal spacing between the exterior sides of the U-shaped member and the interior sides of plenum 22. This permits a free air flow in that space towards flame discharge opening 20.

During operation fuel combustion air is blown into the aft portion of plenum 22 and passes forward between the interior side of the plenum and the exterior of the combustion chamber. Chamber 18 causes a relatively high velocity hot gas-flame flow from adjacent a base 52 of the chamber through flame discharge opening 20 into the air stream in duct 12. This high velocity mixture causes low pressure areas along the interior sides of U-shaped member 44 and thus draws fresh air from the plenum towards the base along arrows 54 of FIG. 3. Good turbulence is thereby obtained in the combustion chamber, yet unburned fuel particles are returned to the base and a more uniform combustion of the air-fuel mixture in the chamber is attained. This substantially facilitates the subsequent complete combustion of the fuel when admixed with air in duct 12.

A plurality of vertically spaced fuel nozzles 56 are aligned with flame discharge openings 20, extend diametrically across hollow post 34 and are secured to that post. Pipe sections 58 are secured to post 34 concentrically with nozzles 56 and to sections 46 of U-shaped member 44 to communicate discharge ends 60 of the nozzle with the combustion chamber through fuel inlet openings 62 in base 52. The pipe sections include a plurality of circumferentially spaced air inlet apertures 64 for admixing fuel discharged by the nozzle with a sufficient amount of air to sustain the growth of the fuel jet issuing from the nozzle.

Referring to FIGS. 3 through 5, for use of the duct burner with oil or similar liquid fuels an oil supply line or manifold 66 is disposed adjacent aft end 14 of each column 10 and extends vertically within air plenum 22. An oil restrictor 68 connects each nozzle 56 with the oil supply manifold for feeding oil to an upstream or aft end 70 of the nozzle.

Oil pressure restrictors 68 are interposed to reduce the pressure of oil entering nozzle 56 from the pressure prevailing in supply manifold 66. This is necessary since duct burners of the type under consideration have heights of as much as 16 feet or more. There is, there-

fore, a substantial static pressure drop in the supply manifold. When the burner is operated for low heat output, which requires a corresponding reduction of the oil pressure in manifold 66, there might be insufficient pressure in the manifold to supply the upper nozzles with any oil whatsoever. Oil pressure reducing devices are therefore used so that the pressure in the supply manifold can substantially exceed the desired oil pressure at the upstream entrance to the nozzle.

In the past such oil restrictors comprised orifice plates having a small diameter aperture through which the oil had to pass in order to reach the nozzle. The required apertures were so small that they tended to clog easily. To prevent such clogging of the nozzle oil supply the restrictor of the present invention comprises an outer pipe 72 having a cylindrical interior surface 74 and, disposed within the pipe, a snugly fitting oil pressure reducing core 76. The core extends over substantially the full length of the pipe and includes a plurality of axially spaced annular grooves 78. Passageways 80 are inclined with respect to the axis of core 76, preferably at an angle of about 60° and they alternately extend in opposite directions so that the passageways terminating at any given annular groove extend non-parallel away from that groove. Thus, the annular grooves and the passageways define a continuous yet tortuous path for the oil for an upstream end of restrictor 68 to the downstream end thereof adjacent nozzle intake 70. The nonlinear path and the many directional changes the oil must follow to travel over the length of the restrictor causes a substantial pressure drop. With a restrictor of a length of only 1½ inch, a diameter for core 76 of only three-eighths inch, seven spaced apart annular grooves 78 and passageways 80 extending between the annular grooves and inclined 60° from the axis of the core, and groove and passageway widths and depths of one-sixteenth inch an oil pressure drop of about 50 psi was obtained at a flow rate of about 10 gallons per hour of diesel oil. None of the passageways or annular grooves have transverse directions less than one-sixteenth inch thus virtually eliminating the heretofore troublesome clogging of oil pressure reduction devices.

Referring now particularly to FIGS. 3 and 4, nozzle 56 comprises a cylindrical outer housing 82 having a greater length than the diameter of tubular post 34. The upstream end 70 of nozzle is defined by a pipe plug 84 including an interior pipe thread 86 for connection to an exterior pipe thread (not shown) on restrictor 68 and including a forwardly extending, relatively small diameter fuel discharge tube 88 terminating about midway between ends of nozzle 56. The forward end of tube 88 extends into a rearwardly and outwardly flaring, cylindrical fuel-air mixing chamber 90 defined by a sleeve 92 threaded into the interior of housing 82. A liquid fuel atomizing whirl plate 94 includes a plurality of circumferentially arranged apertures 96 and is restrained to an interior cylindrical portion 98 of housing 82 by the forward end of sleeve 92 and an aft end of an atomized fuel flow tube 100 fitted interiorly of the housing and extending forwardly to adjacent nozzle discharge 60 within stepped down, cylindrical housing in portion 102.

The downstream end of flow tube 100 has an exit aperture 104 aligned with apertures 106 and 108 and an orifice plate 110 and an end cap 112, respectively. The exterior of flow tube 100 is radially spaced from cylindrical housing end portion 102 and is supported therein

by a plurality of circumferentially outwardly extending lugs 114 integrally constructed with the flow tube and defining between them passageways 116. It will also be noted that the downstream end of flow tube 100 is spaced from the inner side of orifice plate 110 to thus provide a continuous flow passage from radially outwardly extending, relatively small diameter apertures 118 in housing 82, through passageways 116 and to aperture 106 in the orifice plate.

The nozzle housing includes a plurality of outwardly extending, relatively large diameter second apertures 120 which communicate the housing exterior with the annular space 122 between the housing and the exterior of tube 88 defined by pipe plug 84. This annular space communicates with the outwardly flaring fuel mixing chamber 90.

In operation low pressure liquid fuel, preferably pressurized to only about 5 psi above ambient pressure, is introduced into nozzle 56 and flows through tube 88 into mixing space 90. At the same time low pressure air is flowed through second apertures 120 and annular space 122 towards the mixing chamber. Both the fuel and the air are directed through apertures 96 in whirl plate 94 and are spun into flow tube 100 so that the liquid fuel is atomized in the air flow from apertures 120. The atomized liquid fuel-air mixture flows along tube 100, through tube aperture 104 and is then discharged from the nozzle through apertures 106, 108 in orifice plate 110 and end cap 112, respectively. Pressurized air is also flowed through first apertures 118 and past passageways 116 around the end of flow tube 100 and hence out through the apertures in the orifice plate and the end cap. This air flow provides a cushion between the atomized liquid fuel-air mixture flow and prevents contact between the fuel droplets that flow and components of the nozzle. The collection of fuel on nozzle components and the clogging of spaces or passageways with collected fuel, or the dripping of the nozzle, both of which substantially decrease the nozzle efficiency, are thus prevented.

Referring now to FIGS. 1 through 5, nozzle 56 is installed in holes (not shown) of post 34 so that the discharge end 60 of the nozzle is disposed within pipe section 58 and upstream intake end 70 of the nozzle projects past the opposite side of the tubular post. Restrictor 68 is connected to the nozzle intake end and to an appropriate opening in oil supply manifold 66. For operation of duct burner 8 with liquid fuel the lower end of the tubular post 44 and the air plenum 22 are connected to a source of pressurized air (not separately shown) and fuel supply manifold 66 is pressurized for a discharge of an atomized fuel-air mixture by nozzle 56 by virtue of the admixture of the liquid fuel in the nozzle with pressurized air entering the nozzle interior through apertures 118 and 120 in housing 82. Additional air is supplied to the atomized fuel-air mixture through pipe section apertures 64. The mixture is then introduced into the combustion chamber 18 and suitably ignited. The air flow in plenum 22 past the forward end of U-shaped member 44 of the combustion chamber induces the above referred eddy currents for a uniform combustion of the mixture.

To switch to gaseous fuel operation liquid fuel supply manifold 66 is suitably turned off through the closing

of proper valving (not shown) and simultaneously therewith or thereafter the lower end of tubular post 34 is connected to a source of pressurized gaseous fuel such as natural gas. The interior of the tubular post is further sealed from its exterior. Pressurized gas enters nozzle 56 through apertures 118 and 120, while no fuel enters the nozzle from its aft end 70. Alternatively, a liquid-gaseous fuel mixture can be formed in the nozzle by continuing the liquid fuel supply while gaseous fuel is passed through the tubular post. This can also be employed to maintain a continuous flame while switching from liquid to gaseous fuel, or vice versa, by temporarily feeding both fuels through the nozzle while the tubular post is switched from a gas to an air supply or vice versa. For gaseous fuel operation the gas is admixed in pipe section 58 with air entering from plenum 22 through apertures 64 in the pipe section. The mixture travels forward into the combustion chamber where it is ignited as previously described.

I claim:

1. An atomizing nozzle comprising an elongate housing having upstream and downstream ends and a substantially cylindrical interior, an orifice plate at the downstream end, means disposed in the housing interior for discharging liquid fuel towards the orifice plate, means for combining the discharged liquid fuel with a flow of air entering the housing from the housing exterior adjacent the liquid fuel discharge, an atomizer plate disposed downstream of the interior discharge member for atomizing the liquid fuel in the air flow, aperture means in said atomizer plate adjacent its outer periphery for whirling said fuel and air, means for passing the atomized liquid flow towards the orifice plate, and means for enveloping the atomized liquid fuel flow in a coaxial air flow surrounding the atomized liquid fuel flow when it passes the orifice plate to prevent contact between the liquid fuel flow and the nozzle and to thereby prevent the formation of liquid fuel droplets on the nozzle.

2. A nozzle according to claim 1, including means for introducing a liquid fuel flow into the nozzle, and pressure reducing means between the nozzle means and a liquid fuel supply conduit.

3. A nozzle according to claim 2 wherein the pressure reducing means comprises means defining a plurality of angularly disposed, relatively large cross section passageways causing a substantial pressure drop between an upstream and a downstream end of the passageways.

4. A nozzle according to claim 3 wherein the passageway defining means comprises a tubular member, and a snugly fitting core member disposed interiorly of the tubular member and having a plurality of axially spaced annular spaces and a plurality of inclined grooves interconnecting the annular spaces, grooves terminating at the same annular space extending nonparallel away from the annular space.

5. A nozzle according to claim 4, wherein the grooves extending from a given annular space have an angular inclination with respect to each other of no more than about 90°.

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