# United States Patent [19]

**Velie**

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[54] **FUEL BURNER FOR LIQUID AND GASEOUS FUELS**


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[ * ] Notice: The portion of the term of this patent subsequent to Nov. 12, 1991, has been disclaimed.


[22] Filed: **Feb. 12, 1974**

[21] Appl. No.: **441,837**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 282,694, Aug. 22, 1972, Pat. No. 3,847,537.

[52] **U.S. Cl.** ..... **431/285;** 431/90; 431/347

[51] **Int. Cl.**[2] ..... **F23D 11/10**

[58] **Field of Search**.... 431/278, 280, 284, 285–347, 431/DIG. 21, DIG. 22; 239/416.5, 423, 424



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[57] **ABSTRACT**

A fuel burner system comprises an air-atomizing fuel nozzle, an air compressor, liquid and gaseous fuel sources and a valve in the delivery line from the liquid and gaseous fuel reservoirs to the nozzle to select the type of fuel (i.e. liquid or gaseous) delivered to the nozzle in accordance with one aspect of the disclosure. The liquid fuel source may be a reservoir which is pressurized by the air compressor to deliver the fuel to the air atomizing nozzle. In addition, the vacuum side of the air compressor may be periodically connected to the fuel reservoir through suitable valving to provide an automatic reservoir refilling capability. The air compressor then acts not only to supply atomization (primary) air, but also to deliver liquid fuel to the nozzle during the liquid fuel burning cycle, and to draw liquid fuel from a remote liquid fuel supply source during the liquid fuel reservoir refilling cycle. A flame spreader is employed in combination with the air-atomizing nozzle according to another aspect of the disclosure to stabilize and shape the flame. The position and diameter of the flame spreader are set to provide optimum fuel burning characteristics.


**27 Claims, 6 Drawing Figures**

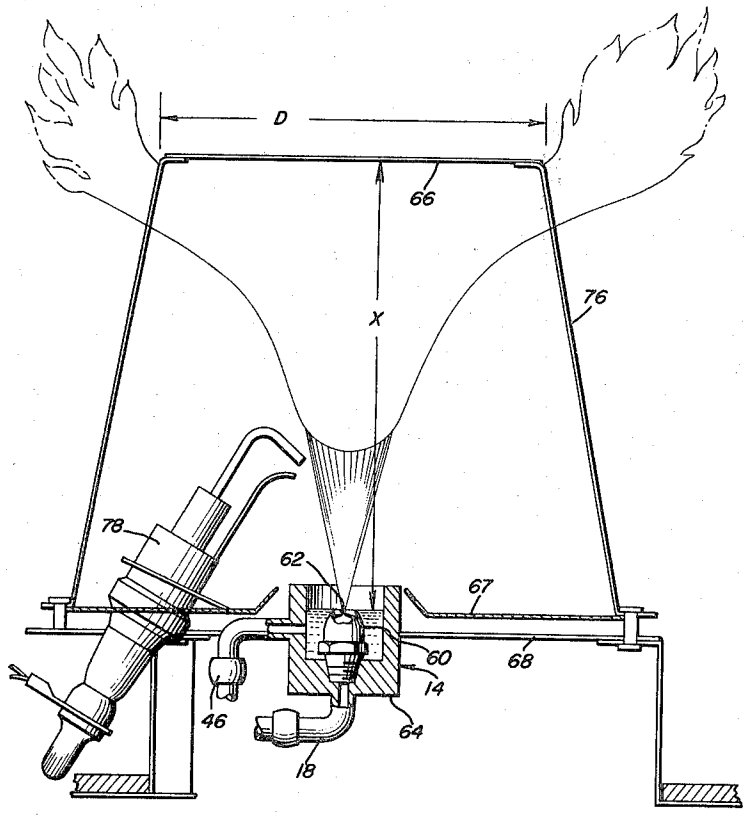


Fig. 1

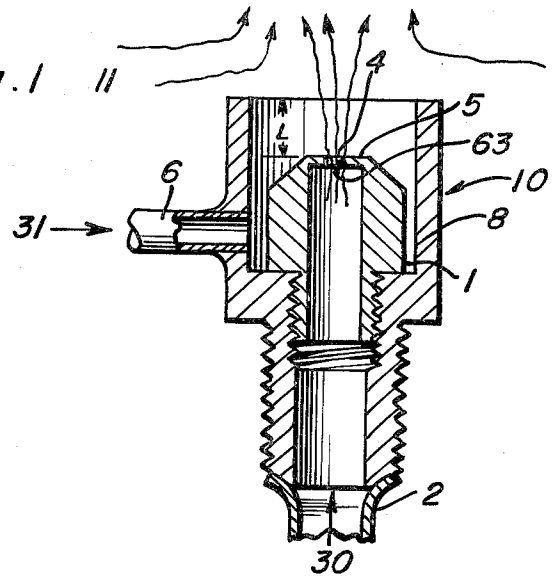



Fig. 2

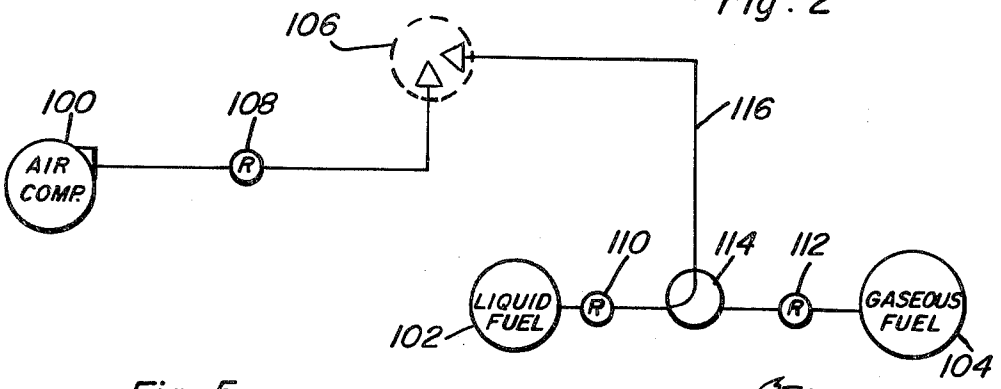



Fig. 5

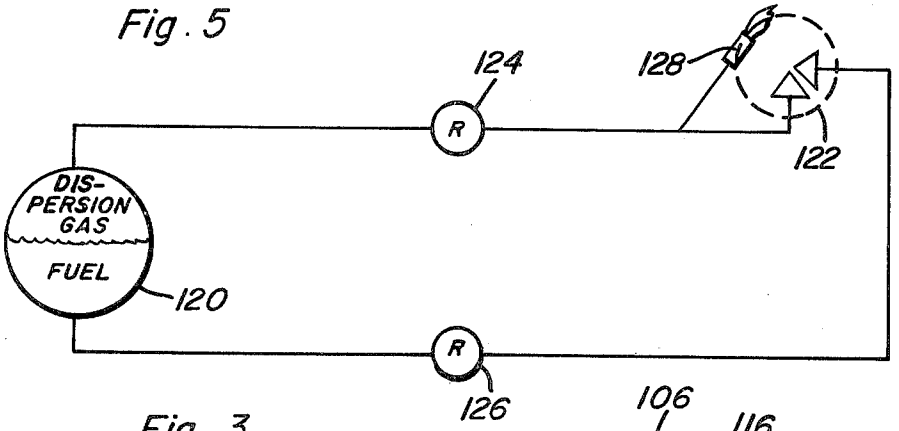
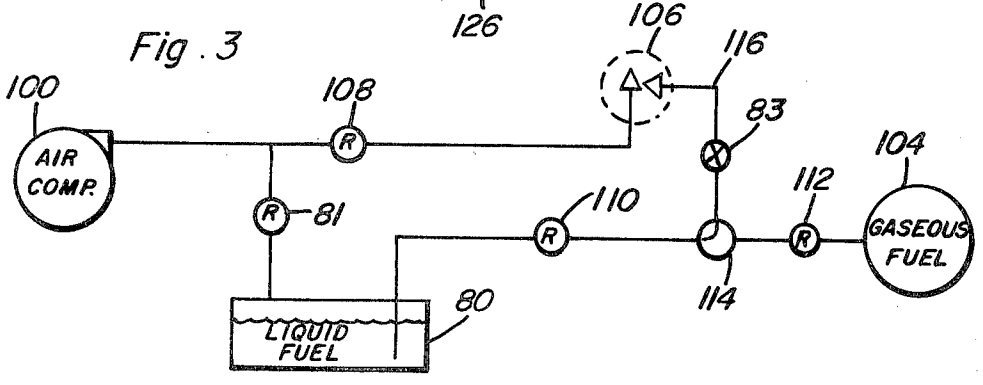



Fig. 3



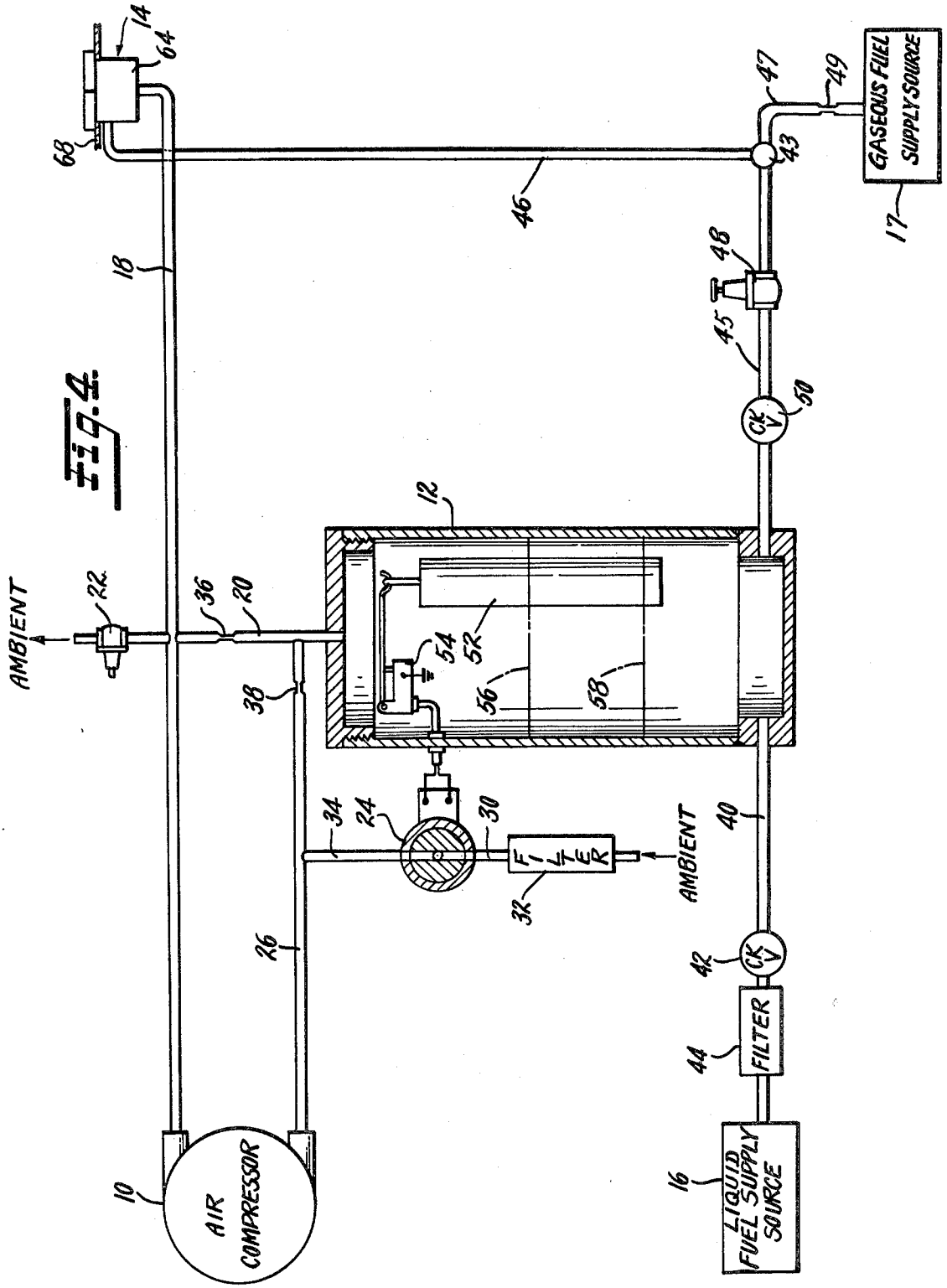
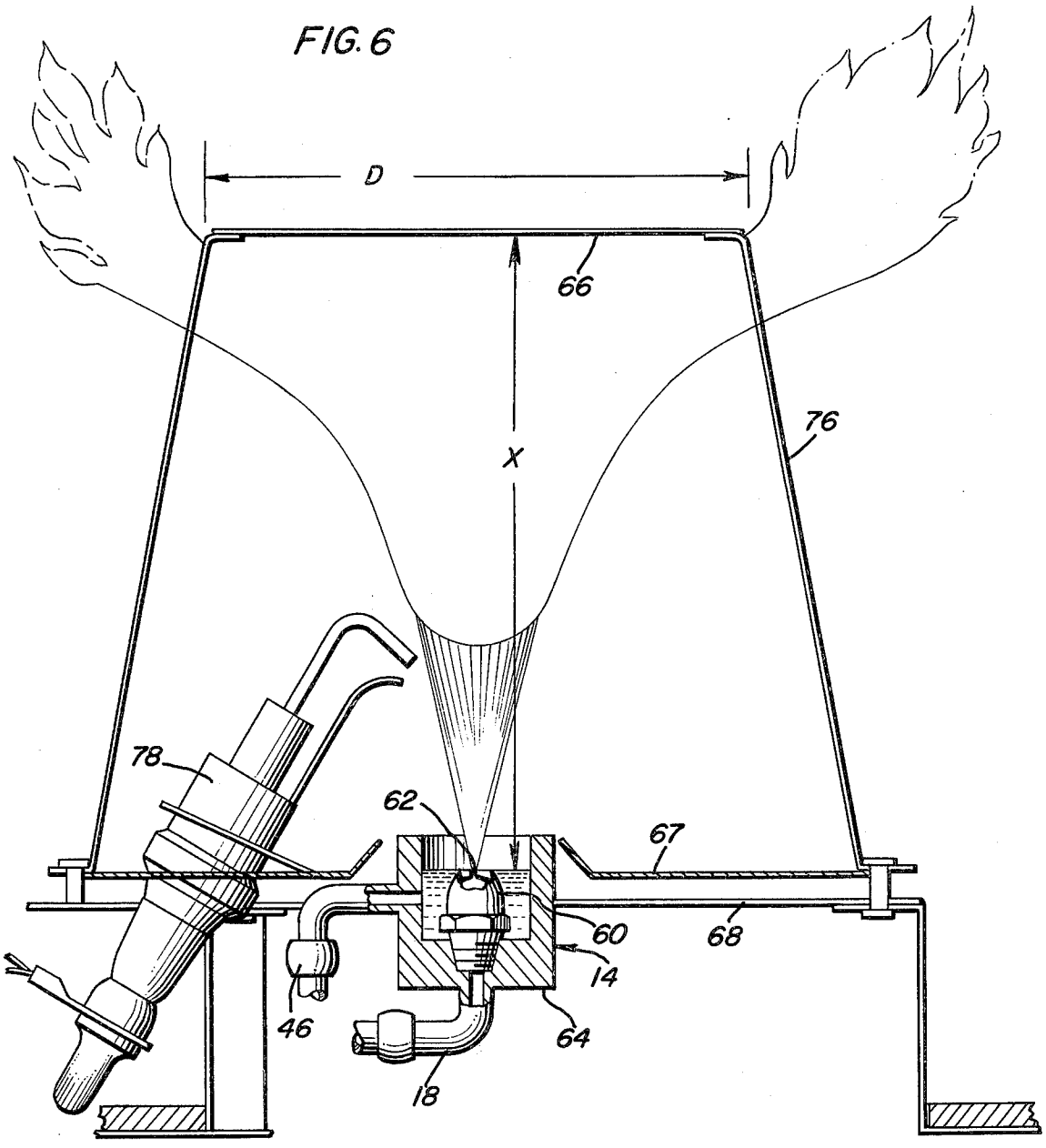

14
64
68
18
46
47
49
43
GASEOUS FUEL SUPPLY SOURCE
17
48
45
CK V
50
12
AMBIENT
22
36
20
54
52
56
58
38
34
24
30
FILTER
32
AMBIENT
40
26
42
CK V
44
FILTER
10
AIR COMPRESSOR
16
LIQUID FUEL SUPPLY SOURCE

FIG. 4

FIG. 6



# FUEL BURNER FOR LIQUID AND GASEOUS FUELS

## CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of application Ser. No. 282,694 filed Aug. 22, 1972 now U.S. Pat. No. 3,847,537.

## BACKGROUND OF THE INVENTION

There is an increasing interest in burners having multiple fuel capability, particularly those which can burn gaseous as well as liquid fuels. An optimum burner is one which requires the least mechanical readjustment during fuel switchover and which produces approximately the same flame pattern, cleanliness, and combustion efficiency, regardless of the fuel used.

A fuel nozzle is essential to most fuel burners and consists of a device to prepare the fuel, gaseous or liquid, for efficient combustion. Such devices have a variety of configurations, depending upon the physical characteristics of the fuel being consumed.

Almost exclusively, gaseous fuel nozzles consist of simple metering devices or orifices. Gas under its natural or supply system pressure is forced through the orifice, downstream of which is usually a tube to conduct the naturally aspirated mixture of fuel and entrapped air to a burner head. By contrast, liquid fuel nozzles typically use high fuel pressure, swirl and mechanical techniques to create a spray, which is directed into the burner where it is mixed with a forced supply of air and burned.

A disadvantage of the above gaseous and liquid fuel nozzles is that they have functionally different designs for fundamentally different processes; therefore, they are not mutually interchangeable. Increasing emphasis upon dual fuel burning appliances enhances the need for a common fuel nozzle.

In order for a nozzle to be compatible with both gas or liquid fuels, it must effectively disperse gaseous fuels, as well as atomize liquid fuels, and entrain ambient air. Experiments have shown that liquid fuels when atomized to sufficiently small drops will burn with characteristics approaching a gas. However, most of the liquid spray nozzles currently available produce a wide range of drop sizes. The importance of this can be illustrated by the fact that if only one drop in 100 is 10 times the average drop size, it contains 90 percent of the fuel spray volume, and therefore, controls the combustion process. Many pneumatic atomizers are capable of relatively small and uniform drop production, although those on the market have neglected to consider their dual fuel (gas as well as liquid) possibilities. Many are inherently capable of excellent gas dispersion. For example, when a compressed gas is expanded through an aperture it creates a region in the vicinity of its exit surface such that if fluids (liquid or gaseous) are introduced adjacent to that region, they will be drawn into the gas stream via surface tension and dispersed along with ambient air. If the fluid is a liquid, it will be concurrently shattered by the high velocity gas stream into uniformly small drops. Therefore, a pneumatic atomizer has the potential capability of accommodating both gaseous and liquid fuels as previously described. Accordingly, it is the primary objective of this invention to utilize the characteristics of the pneumatic type atomizer to provide a simple burner system which is capable of burning gaseous as well as liquid fuels.



It is a further objective of this invention to provide a burner which, in its simplest form, consists of an air-atomizing nozzle, a compressed air source, liquid and gaseous fuel sources and a means of selecting the fuel to be consumed.

It is a still further objective of this invention to define designs for liquid fuel sources, which will increase burner self sufficiency.

Yet another object of the present invention is to provide a fuel burner system in which a flame spreader is employed in combination with the atomizing nozzle to stabilize and shape the flame.

Still further objects and advantages of the present invention will become apparent upon reading the following specification and claims, taken in conjunction with the accompanying drawings.

## SUMMARY OF THE INVENTION

A simple fuel burner system is provided emphasizing a compressed gas atomizing nozzle, a source of pressurized gas for dispersion of the fuel, sources of liquid and gaseous fuels, and regulators as required for regulating the flow of pressurized gas and fuel to the air-atomizing nozzle. A valve is provided in the delivery line to the nozzle from the sources of liquid and gaseous fuel to select the type of fuel (i.e., liquid or gaseous) to be delivered to the nozzle.

In a more sophisticated version of the burner, the pressure side of the air compressor may be connected to both the air-atomizing nozzle and to the liquid reservoir to provide a fuel delivery means. Orifices or pressure regulators are provided in the line from the air compressor to the liquid fuel reservoir to control the air pressure in the liquid fuel reservoir. Additionally, the vacuum side of the air compressor may be periodically connected to the liquid fuel reservoir to provide reservoir refill capability. In this latter case, a valve is provided in the suction line of the air compressor for connecting the vacuum side of the air compressor to the liquid fuel reservoir during the refilling cycle. The valve may be operated by a mechanically actuated float switch operated by a float in the liquid fuel reservoir.

Suitable means may be optionally provided in the pressure line from the air compressor to regulate the primary air pressure to the air-atomizing nozzle. Also, a flame spreader may be employed downstream of the fuel nozzle to stabilize and shape the flame.

The overall operation of the fuel burner system and its embodiments will now be described.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 represents one embodiment of a pneumatic type atomizer illustrating important design and performance features which adapt it to multiple fuel use.

FIG. 2 represents the simplest embodiment of the invention showing the relationship of major components, including the pneumatic atomizer.

FIG. 3 shows an embodiment of FIG. 2 with a pressurized liquid fuel reservoir as a means of fuel delivery.

FIG. 4 shows an embodiment of FIG. 3 with liquid fuel refilling means for extending operation time.

FIG. 5 shows a self-contained embodiment of FIG. 2.

FIG. 6 represents the flame spreader embodiment of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, the fuel atomizer is illustrative of a configuration useful for multiple fuel operation. It consists of an open ended atomizer body **10** containing a compressible flow nozzle **1** at the terminus of an air or gas conduit **2** and so constructed that when a compressed gas **33** is expanded through the aperture **4** a region is created in the vicinity of surfaces **5** and **8** such that liquid or gaseous fuel **31** introduced through a conduit **6** adjacent to surfaces **5** and **8** is efficiently and completely dispersed along with ambient air **11.** Specific dimensions of the nozzle are important to effective performance of the nozzle using both liquid and gaseous fuels. In particular, a sharp-edged air aperture is desirable, or more specifically, one in which the thickness of the edge **63** of air aperture **4** is as thin as possible and less than the hydraulic diameter (i.e., aperture area ÷ aperture perimeter) of air aperture **4.** Furthermore, the ratio of the mean diameter of gas conduit **2** to the hydraulic diameter of air aperture **4** should be greater than approximately **10.** Some variation in the above dimensions is obviously possible without seriously affecting nozzle performance. The best hydraulic diameter for air aperture **4** appears to be between about 10 and 30 thousandths of an inch and the preferred thickness of edge **63** is about 5 thousandths of an inch. It should be noted that air aperture **4** has been greatly enlarged in FIG. **1** for the purposes of illustration. The exit area of atomizing housing **10** should be less than about 0.4 square inch for a liquid fuel dispersion rate of about 1 g.p.h. since too large of an exit area may result in excessive exposure of volatile liquid fuels to combustion heat resulting in vaporization and surface burning. At the same time, the exit area should not be so small that operation on gaseous fuel produces excessive exit velocity. The length (L) of the open end of the atomizer housing **10** above air aperture **4** should be minimized to enhance aspiration of the ambient air at the housing exit. Approximately one-fourth inch or less has been found to be acceptable for this length (L). Concurrently, the fuel inlet should be as far below the aperture end of nozzle **1** as practical to avoid surface disturbance of liquid fuel and to uniformly distribute gaseous fuels around nozzle **1** prior to dispersion. The fuel inlet conduit **6** should have as small a diameter as possible but large enough to avoid excessive gaseous fuel velocity and thus distortion of the dispersed gas. The inside conduit area should not be less than about $3 \times 10^{-4}$ in.$^2$ per cu. ft./hr. of gaseous fuel flow rate.

An open ended atomizer body is not a mandatory requirement of the pneumatic type atomizer and successful performance is possible by placing fuel conduit **6** close to surface **5** and adjacent to the aperture **4.** The broad aspect of the invention is recognition of the fact that the pneumatic type fuel atomizer configurations generally have the characteristics which make them potentially applicable to dual fuel operation. FIG. **1** serves to illustrate the design principles involved in effective use of the pneumatic type nozzle.

FIG. **2** is a schematic representation of the simplest embodiment of the present invention. Broadly speaking, the fuel burner system includes a source of pressurized gas, specifically illustrated as air compressor **100,** for dispersion of the fuel, sources of liquid and gaseous fuels, **102** and **104,** respectively, an air atomizing nozzle **106,** and regulators for regulating the flow or pressurized gas **108** and fuel **110** and **112** to the atomizing nozzle. A valve **114** is provided in the delivery line **116** from the sources of liquid and gaseous fuel to the nozzle **102** to select the type of fuel (i.e., liquid or gaseous) delivered to the nozzle.

FIG. **3** is a schematic representation of a more sophisticated burner system of FIG. **2** wherein liquid fuel reservoir **80** is pressurized by the air compressor **100.** The air pressure to reservoir **80** is regulated by pressure regulator **81** or other suitable means. The air pressure serves as a means of delivering liquid fuel to the atomizer. A valve **83** is placed in the fuel delivery line **116** to serve as a manual or automatic means of shutting off the burner.

This type of air-atomizing fuel burner system is particularly useful for portable burner applications requiring about 1.0 gallons per hour (hereinafter g.p.h.) burning rates such as construction heaters. By way of illustration, burning rates in the range of 0.1 to 1.0 g.p.h. can conveniently be provided using the burner system at primary air pressures between about 8 and 18 p.s.i.g. The air pressure in liquid fuel reservoir **80** is regulated by a simple gas pressure regulator to about 1 p.s.i.g.

FIG. **4** is a schematic representation of a more elaborate embodiment of the present invention wherein automatic fuel replenishment capability is added to the burner system of FIG. **3.** The liquid fuel refilling aspects of this system are described in more detail in my copending application Ser. No. 282,694, filed Aug. 22, **1972,** the disclosure of which is expressly incorporated herein by reference. The first major component is air compressor **100** which is of conventional design such as a reciprocating diaphragm pressure/vacuum pump and has three separate functions in the overall system. First, it supplies primary air to air-atomizing nozzle **14** to disperse the fuel. Second, it supplies air pressure to liquid fuel reservoir **12** to deliver liquid fuel to the nozzle. Third, the air compressor acts as a vacuum pump to refill liquid fuel reservoir **12** from a remote liquid fuel supply source **16** when the fuel level in the reservoir **12** reaches a predetermined low level.

The second major component of the fuel burner system is liquid fuel reservoir **12** which is also of conventional design. The liquid fuel reservoir is sized to give a reasonable burning time (e.g. 10 to 15 minutes) at the desired burning rate (e.g. less than 1 g.p.h.) and to be compatible with the air compressor characteristics such that refill occurs fairly rapidly (e.g. 5 to 10 seconds). During the liquid fuel burning cycle, fuel reservoir **12** is connected to the air pressure side of air compressor **100,** and also to the fuel side of air atomizing nozzle **14.** During the liquid fuel refilling cycle, reservoir **12** is connected to the vacuum side of air compressor **100,** and also to remote liquid fuel supply source **16.**

The third major component of the fuel burner system is gaseous fuel supply source **17** which is also of conventional design. Liquid fuels which have no measurable vapor pressure at ambient conditions require a means of delivery. By contrast, most gaseous fuels (e.g., hydrogen, methane, petroleum gases) have a substantial vapor pressure which can be used for fuel delivery or the gaseous fuels can be obtained under pressure from a central delivery system. During the gaseous fuel

burning cycle, fuel supply 17 is connected to the fuel side of air-atomizing nozzle 14.

The fourth major component of the fuel burner system is "air-atomizing" nozzle 14. The term air-atomizing nozzle is used throughout the specification and claims in its generic sense as meaning a nozzle, such as the type shown in FIG. 1, in which fuel is prepared for combustion by low-pressure dispersion using a compressible gas (e.g., air) as the dispersing medium. In low-pressure atomization, primary air (gas) is delivered to the nozzle at relatively low pressure (e.g., 1 to 25 p.s.i.g.) and used to atomize fuel also delivered to the nozzle at low pressure (e.g. 1 to 4 p.s.i.g.).

The overall operation of the fuel burner system will now be described. During the liquid fuel burning cycle, suction line 26 of air compressor 100 is connected to ambient. Air compressor 100 supplies primary air through air pressure line 18 to air-atomizing nozzle 14. The pressure in air pressure line 18 is regulated by pressure regulator 22. Part of the air pressure in air pressure line 18 is bled off through air pressure line 20 to fuel reservoir 12. The pressure in fuel reservoir 12 is controlled, for a given primary air pressure by the diameter ratio of flow restriction orifice 38 to flow restriction orifice 36. At the start of the liquid fuel burning cycle, the fuel level in liquid fuel reservoir 12 is at "high" level 56, float 52 is at its uppermost position, float switch 54 is open, the solenoid-operated valve 24 is connecting the vacuum side of air compressor 100 to ambient, and valve 43 is connecting the fuel side of nozzle 14 to liquid fuel reservoir 12. The air pressure in fuel reservoir 12 forces the liquid fuel through delivery line 46 to air-atomizing nozzle 14, and the fuel flow rate is regulated by flow restrictor 48. At nozzle 14, the liquid fuel from delivery line 46 is atomized into fine particles by the primary air from air pressure line 18 and is ignited and burned in the presence of secondary air in conventional manner.

As the liquid fuel is burned at air-atomizing nozzle 14, the fuel level in liquid fuel reservoir 12 gradually drops to "low" level 58. At this level, float 52 closes float switch 54 which energizes the solenoid of valve 24 and connects the vacuum side of air compressor 100 to liquid fuel reservoir 12. The vacuum in liquid fuel reservoir 12 is controlled, for a given air compressor vacuum pressure, by the diameter ratio of flow restriction orifice 38 to flow restriction orifice 36. During the liquid fuel refilling cycle, fuel is drawn into liquid fuel reservoir 12 through liquid fuel supply line 40 from the liquid fuel supply source 16 and is simultaneously filtered by filter 44. Once the fuel in liquid fuel reservoir 12 has reached high level 56, float 52 opens float switch 54 which de-energizes the solenoid of valve 24 and reconnects the vacuum side of air compressor 100 to ambient, thus re-establishing the liquid fuel burning cycle.

During the gaseous fuel burning cycle, valve 43 is manually operated to connect the fuel side of air-atomizing nozzle 14 to gaseous fuel supply source 17. Air compressor 100 supplies primary air through air pressure line 18 to air-atomizing nozzle 14. The pressure in air pressure line 18 is regulated by pressure regulator 22. Gaseous fuel is delivered through delivery line 46 to air-atomizing nozzle 14, and the fuel flow rate is regulated by fuel flow restrictor 49. At nozzle 14, gaseous fuel from delivery line 46 is dispersed by the primary air from air pressure line 18 and is ignited and burned in the presence of secondary air.

FIG. 5 illustrates in schematic form a self-contained burner system of the present invention. In this embodiment, the dispersion gas for dispersion of the fuel is itself a gaseous fuel having significant vapor pressure at ambient conditions such as propane, butane, methane, etc. The fuel may be the dispersion gas, another gas, or a liquid fuel such as diesel fuel, kerosene, waste oil, etc. The dispersion gas and fuel may share source 120, as illustrated, or be separately contained. The dispersion gas and fuel are metered to atomizer 122 from the top and bottom of supply source 120, respectively, by regulators 124 and 126, respectively. The dispersion gas may also serve as a pilot flame 128 for the burner. No source of energy other than the pressure of the high vapor pressure dispersion gas is required for the burner's operation. Although only one source of dispersion gas has been illustrated, it will be appreciated that two sources will be required when burning both liquid and gaseous fuels.

Turning now to another aspect of the present invention, FIG. 6 illustrates the air-atomizing nozzle and flame spreader combination of the present invention. The air-atomizing nozzle and flame spreader combination of FIG. 6 is ideally suited for use in the overall air-atomizing fuel burner system of FIGS. 2, 3 or 4, and, accordingly, will be described as part of these systems. It should be understood, however, that the air-atomizing nozzle and flame spreader combination in accordance with this aspect of the invention and can be used with other primary air and fuel supply systems and that the air-atomizing nozzle described can be used without the flame spreader.

Flame spreader 66 can be formed from any conventional material such as stainless steel or ceramics. Flame spreader 66 is generally disc-shaped and typically has a flat, planar or convex flame engaging surface. The exact shape and materials of construction of the flame spreader 66, however, do not form part of the present invention. The flame spreader has been found to be particularly useful in fuel burner systems employing low fuel burning rates in the range between 0 and 1.5 g.p.h.

Flame spreader 66 may be supported relative to air-atomizing nozzle 14 by simple legs 76 as illustrated in FIG. 6. Air-atomizing nozzle 14 is supported by burner base 68. Above the burner base 68 and attached to it is an optional flame shield 67. Ignitor 78 is attached to burner base 68 and is of conventional design, such as a high voltage spark ignitor.

During operation, primary air disperses the fuel into fine particles or a mist as it expands through air aperture 62 of nozzle head 60. These fine particles or mist are mixed with secondary air which is drawn into the system above the atomizer by natural aspiration. The sprayed fuel is ignited by ignitor 78 and the resulting flame directed perpendicular to flame spreader 66. At flame spreader 66, the flame is stabilized and shaped, the upper surface of flame shield 67 acts as a radiation shield.

Flame spreader 66 should be positioned perpendicular to air-atomizing nozzle 14 and approximately centered (i.e., within about 0.25 inch) on the nozzle. For optimum combustion, flame spreader 66 should be in the gaseous or hydroxyl type combustion zone. This zone is downstream from the drop vaporization zone

and upstream from the yellow flame or carbonaceous combustion zone. If flame spreader **66** is too far into the drop vaporization zone, deposits from liquid vaporization and cracking will form on its surface. On the other hand, if flame spreader **66** is too large or too far into the yellow flame or carbonaceous zone, carbon will collect on its surface.

Since increasing the fuel spray rate increases the flame length, flame spreader **66** should be moved further away from air-atomizing nozzle **14** as the fuel spray is increased. By way of illustration, adequate combustion has been found to occur when the axial separation distance (X) between nozzle head **60** and flame spreader **66** is between about 1.5 and 5 inches for low burning rates of between about 0.05 and 1.5 g.p.h., respectively. For optimum burning characteristics for most burner applications, it has been found best to use a ratio of flame spreader diameter (D) to axial separation distance (X) of about 1. The ignitor **78** location is not critical; however, it should be on the fringe of the spray and about 1.0 to 2.5 inches downstream from the air-atomizing nozzle for most applications.

To illustrate the present invention, the air-atomizing fuel burner system of FIG. **3** was employed in combination with the flame spreader and air-atomizing combination of FIG. **6.** Referring to FIG. **6,** the flame spreader diameter (D) and axial separation distance (X) between air-atomizing nozzle **62** and flame spreader **66** were 4 and 4.5 inches, respectively. Flame spreader **66** was made of 309 stainless steel, and of conventional disc-shaped design with a flat, planar, flame engaging surface. It was positioned perpendicular to air-atomizing nozzle **14** with its center within 0.25 inch of the center of spray of air-atomizing nozzle **14.** Nozzle head **60** had an air aperture **62** size of 0.032 inch diameter with an edge thickness of about 5 thousandths of an inch. Referring to FIG. **3,** the air pressure in the pressure line from air compressor **100** was 15 p.s.i.g. An air pressure regulator **81** maintained the pressure in liquid fuel reservoir **102** at 1.25 p.s.i.g. which provided fuel delivery to air-atomizing nozzle **106.** The liquid fuel burning rate was 0.80 g.p.h. Propane was used as the gaseous fuel and was contained in gaseous fuel supply source **104** under normal vapor pressure. The propane pressure downstream of fuel pressure regulator **112** was 3.5 p.s.i.g. The propane fuel burning rate was 1.2 g.p.h. Three-way valve **114** was used to select the type of fuel (i.e., liquid or gaseous) supplied to air-atomizing nozzle **106.**

The invention in its broader aspects is not limited to the specific details shown and described, and departures may be made from such details without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

**1.** An air-atomizing fuel burner system comprising air-atomizing nozzle means for using primary gas under pressure to disperse fuel, means for delivering liquid fuel to said air-atomizing nozzle means, means for delivering gaseous fuel to said air-atomizing nozzle means, means for selecting the type of fuel delivered to said air-atomizing nozzle means, and means for delivering primary gas under pressure to said air-atomizing nozzle means to disperse said fuel so that the dispersed fuel can be ignited in the presence of secondary air to produce a combustion flame.

**2.** The air-atomizing fuel burner system of claim **1** in which said primary gas is air and said primary gas delivery means includes air compressor means.

**3.** The air-atomizing fuel burner of claim **2** and further comprising fuel reservoir means for storing liquid fuel, means for delivering liquid fuel from said liquid fuel reservoir means to said air-atomizing nozzle means, means for delivering a portion of said air under pressure from said air compressor means to said liquid fuel reservoir means.

**4.** The air-atomizing fuel burner system of claim **3** in which said means for delivering a portion of the air under pressure from said air compressor means to said liquid fuel reservoir means includes air flow restriction or regulation means for controlling the pressure of air to said liquid fuel reservoir means.

**5.** The air-atomizing fuel burner system of claim **3** in which said means for delivering liquid fuel to said air-atomizing nozzle means from said liquid fuel reservoir means includes a fuel flow restriction means for metering the flow of liquid fuel to said air-atomizing means.

**6.** The air-atomizing fuel burner system of claim **3** and further comprising means for supplying liquid fuel to said fuel reservoir means from a remote fuel supply source, and means for connecting the vacuum side of said air compressor means to ambient during the liquid fuel burning cycle of said air-atomizing nozzle means and to said liquid fuel reservoir during the liquid fuel reservoir refilling cycle.

**7.** The air-atomizing fuel burner system of claim **6** in which said means for connecting the vacuum side of said air compressor means to said liquid fuel reservoir means includes means for restricting the flow of air from said liquid fuel reservoir means.

**8.** The air-atomizing fuel burner system of claim **6** in which said means for connecting the vacuum side of said air compressor means to said liquid fuel reservoir means includes means responsive to the fuel level in said liquid fuel reservoir and a valve pilot operated by said responsive means.

**9.** The air-atomizing fuel burner system of claim **2** in which said means for supplying air under pressure to said air-atomizing nozzle means from said air-compressor means includes means for regulating the air pressure supplied to said air-atomizing nozzle means.

**10.** The air-atomizing fuel burner system of claim **2** and further comprising flame spreader means located downstream of said air-atomizing nozzle means for stabilizing and shaping said flame.

**11.** The air-atomizing fuel burner system of claim **10** in which the ratio of flame spreader diameter to separation distance between said flame spreader and air-atomizing nozzle is about **1.**

**12.** The air-atomizing fuel burner system of claim **10** in which said flame spreader is located in the gaseous or hydroxyl type combustion zone in said combustion flame.

**13.** The air-atomizing fuel burner system of claim **10** in which the location of said flame spreader relative to said air-atomizing nozzle is based on the fuel burning rate.

**14.** The air-atomizing fuel burner system of claim **13** in which said flame spreader is moved further downstream from said air-atomizing nozzle as the fuel burning rate increases.

**15.** The air-atomizing fuel burner system of claim **10** in which said flame spreader is between about 1.5 and

5 inches downstream from said air-atomizing nozzle means.

**16.** The air-atomizing fuel burner system of claim **2** in which said means for delivering gaseous fuel to said air-atomizing nozzle means includes means for regulating the flow of gaseous fuel to said air-atomizing nozzle means.

**17.** The air-atomizing fuel burner system of claim **16** in which said means for regulating the flow of gaseous fuel to said air-atomizing nozzle means is a gaseous fuel pressure regulator.

**18.** The air-atomizing fuel burner system of claim **2** in which said means for controlling the type of fuel delivered to said air-atomizing nozzle means comprises a three-way valve.

**19.** The air-atomizing fuel burner system of claim **2** in which said air-atomizing nozzle means comprises an air aperture having an edge with a thickness approximately equal to or less than the hydraulic diameter of said air aperture.

**20.** The air-atomizing fuel burner system of claim **18** in which said hydraulic diameter is about 10 to 30 mils.

**21.** The air-atomizing fuel burner system of claim **1** and further comprising means for igniting the dispersed fuel in the presence of said secondary air to produce said combustion flame.

**22.** An air-atomizing fuel burner system comprising air-atomizing nozzle means for using primary gas under pressure to disperse fuel, means for delivering fuel to said air-atomizing nozzle means, means for delivering primary gas under pressure to said air-atomizing nozzle means to disperse said fuel so that the dispersed fuel can be ignited in the presence of secondary air to produce a combustion flame, and flame spreader means located downstream of said air-atomizing nozzle means for stabilizing and shaping said flame, said flame spreader means being located in the gaseous or hydroxyl-type combustion zone of said combustion flame.

**23.** The air-atomizing fuel burner system of claim **22** in which the ratio of flame spreader diameter to separation distance between said flame spreader and air-atomizing nozzle means is about 1.

**24.** The air-atomizing fuel burner system of claim **22** in which said flame spreader is between about 1.5 and 5 inches downstream from said air-atomizing nozzle.

**25.** A low pressure air-atomizing fuel burner system comprising air-atomizing nozzle means for using primary air to atomize fuel, means for delivering fuel under low pressure to said air-atomizing nozzle means, means for delivering primary air to said air-atomizing nozzle means to disperse said fuel so that the dispersed fuel can be ignited in the presence of secondary air to produce a combustion flame, and flame spreader means located downstream of said air-atomizing nozzle means for stabilizing and shaping said flame, said flame spreader means being located in the gaseous or hydroxyl-type combustion zone of said combustion flame.

**26.** The air-atomizing fuel burner system of claim **25** in which said primary air and said fuel are each delivered to said air-atomizing nozzle means at a pressure of about 1 to 15 psi.

**27.** The air atomizing fuel burner system of claim **25** in which said fuel is delivered to said air-atomizing nozzle means at a pressure of about 1 to 4 psi.

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