United States Patent [19]

Masai

[11] **3,790,086**

[45] **Feb. 5, 1974**

[54] **ATOMIZING NOZZLE**

[75] Inventor: **Tadahisa Masai,** Hitachi, Japan

[73] Assignee: **Hitachi, Ltd.,** Tokyo, Japan

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[30] **Foreign Application Priority Data**

May 24, 1971 Japan 46/35757

[52] **U.S. Cl.** **239/406,** 239/426, 239/434.5

[51] **Int. Cl.** **B05b 7/10**

[58] **Field of Search** 239/403, 405, 406, 419, 419.3, 239/421, 426, 427.3, 427.5, 434.5

[56] **References Cited**

UNITED STATES PATENTS

3,608,831	9/1971	Place	239/406
3,254,846	6/1966	Schreter et al.	239/406 X
3,401,883	9/1968	Gebhardt et al.	239/406 X
3,615,051	10/1971	Gettig et al.	239/406 X

Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—Michael Y. Mar
Attorney, Agent, or Firm—Thomas E. Beall, Jr.

[57] **ABSTRACT**

The atomizing nozzle atomizes liquids such as heavy oil to be burned with the energy of a moving gas stream to make fine liquid particles and avoid the phenomena of recombination of the liquid. Gas is generally conically swirled along the front face of a nozzle end while liquid is ejected into the gas flow, in combination with means for preventing the recombination of the liquid to a liquid stream along the nozzle surface adjacent the liquid ejection ports. The recombination is particularly prevented by gas ejection downstream from the liquid ejection and the downstream projection of the recombination surface into the whirling gas flow. Further, the gas boundary layer along the liquid ejection surface is sucked off, particularly for downstream ejection, to increase the gas flow velocity adjacent the liquid ejector.

15 Claims, 15 Drawing Figures

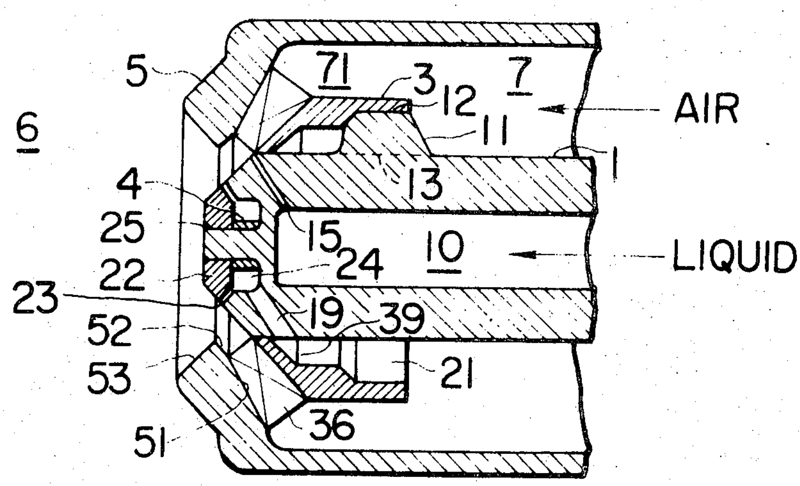


FIG. 1

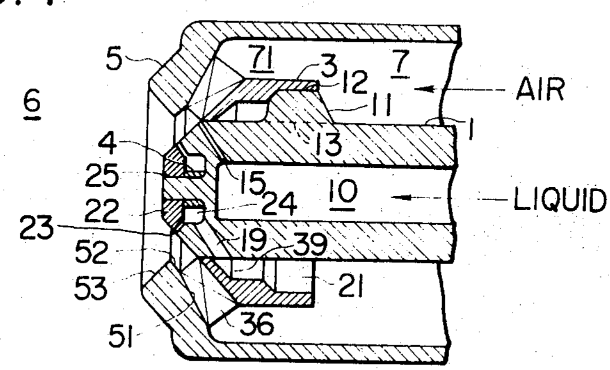


FIG. 2

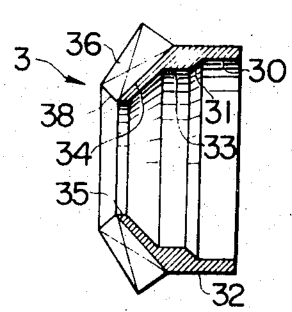


FIG. 3

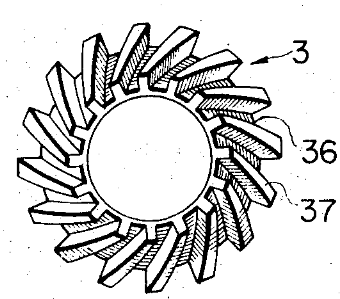


FIG. 4

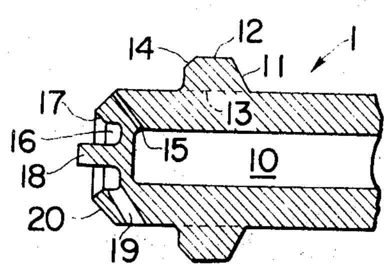


FIG. 5

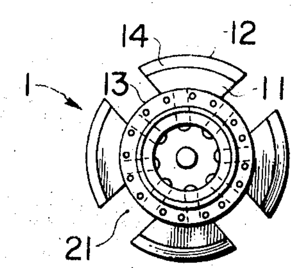


FIG. 6

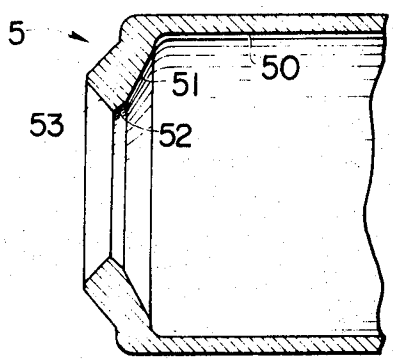


FIG. 7

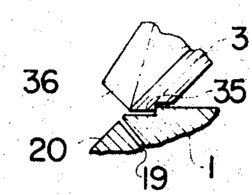


FIG. 8

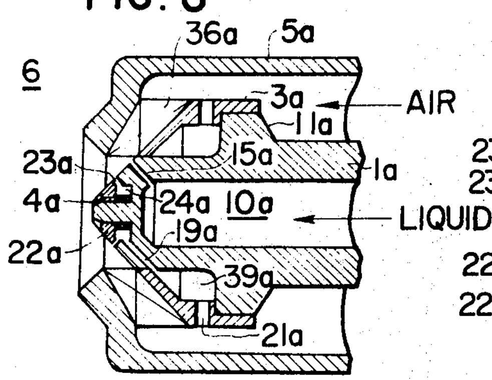


FIG. 9

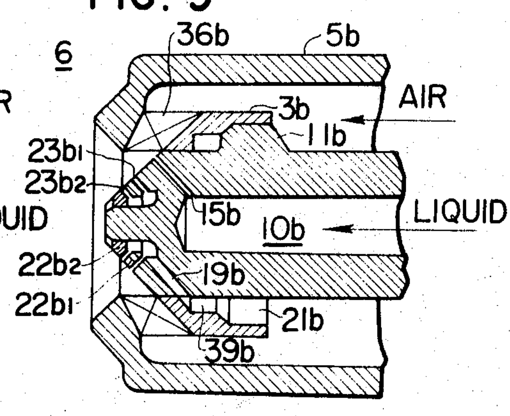


FIG. 10

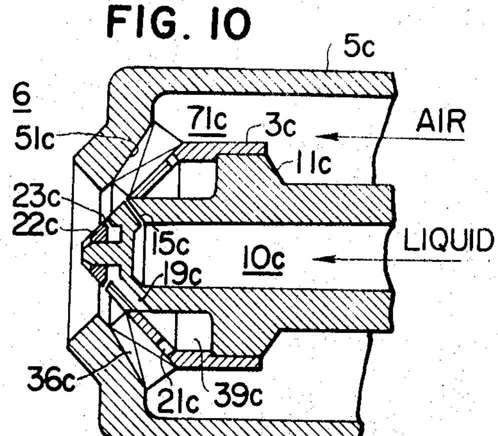


FIG. 11

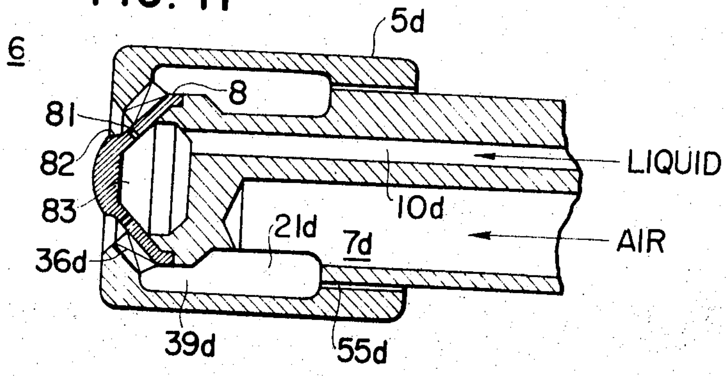


FIG. 12

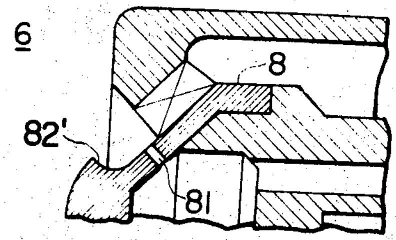


FIG. 13

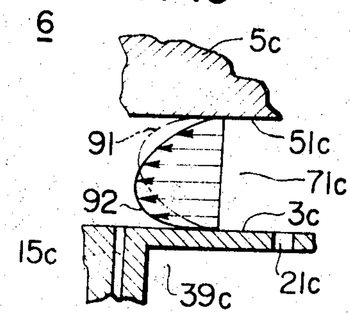


FIG. 14

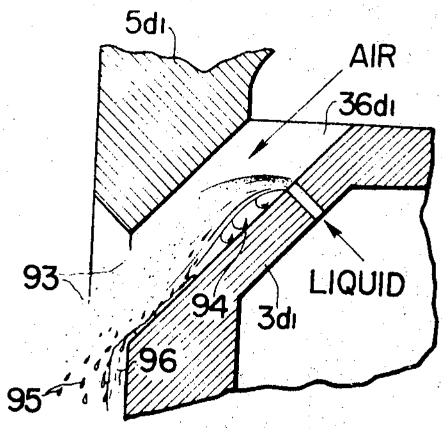
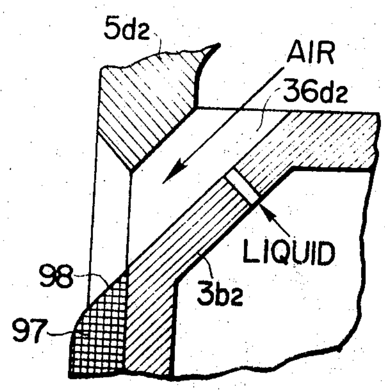


FIG. 15



ATOMIZING NOZZLE

BACKGROUND OF THE INVENTION

There are many applications wherein it is desirable to atomize liquid in fine particles within a moving gas stream, particularly with atomizing nozzles used in combustors. It is known to whirl the gas stream, particularly along a conical path and eject liquid into the whirling stream of gas. Particularly with heavy liquids, such as fuel oils used for combustion and furnaces, there is a problem that the liquid will recombine after ejection and flow along the surface adjacent the liquid ejector. This will produce incomplete combustion with resulting inefficiency and increased air pollution, as well as the buildup of carbon at the front of the nozzle. Thus, the recombination phenomena will adversely affect the atomizing characteristics of a nozzle. This is a particular problem when the ratio between the pressure of the gas and the pressure of the interior of the furnace or other area in which the atomized liquid is to be projected is small; thus, the kinetic energy of the gas is therefore relatively low so that the atomization of the liquid will be greatly influenced by the secondary growths of liquid droplets resulting from the recombination phenomena.

SUMMARY OF THE INVENTION

It is an object of the present invention to avoid the recombination phenomena mentioned above or to greatly reduce its effects.

According to the present invention, an atomizing nozzle will produce fine and uniform liquid particles to prevent emission of incomplete combustion components such as hydrocarbons and carbon monoxide to the atmosphere. Further, the nozzle will provide a wide variable range for the amount of ejecting liquid which can be atomized in stable, fine particles.

The atomizing nozzle is characterized by having gas passages that will whirl the gas, an ejector for ejecting the liquid into the gas flow thus produced to form a gas, liquid mixture, and downstream means to swerve or divert the flow direction of the mixture of the gas and liquid, particularly back into the mainstream of gas flow. This may be accomplished by air ejectors downstream from the liquid ejectors and surface abutments downstream from the liquid ejectors, both of which will divert the flow of mixture away from the surface immediately downstream from the liquid ejector to direct the mixture back into the main stream of the gas flow.

The atomizer nozzle according to the present invention is particularly suitable for atomizing liquid fuel of low quality and high viscosity, such as heavy oil.

BRIEF DESCRIPTION OF THE DRAWING

Further objects, features and advantages of the present invention will become more clear from the following detailed description of the drawing, wherein:

FIG. 1 is a longitudinal cross-sectional view taken from the flow access of an atomizing nozzle according to one embodiment of the present invention;

FIG. 2 is a longitudinal cross-sectional view of the gas swirler of the embodiment according to FIG. 1;

FIG. 3 is a front view of the swirler shown in FIG. 2;

FIG. 4 is a longitudinal cross-sectional view of the nozzle body in FIG. 1;

FIG. 5 is a front view of the nozzle body shown in FIG. 4;

FIG. 6 is a longitudinal cross-sectional view of the cap of FIG. 1;

FIG. 7 is a partial cross-sectional view showing a detail of a variation for the joints between the gas swirler and the nozzle body for forming a gas seal;

FIG. 8 is a longitudinal cross-sectional view through another embodiment of the present invention;

FIG. 9 is a longitudinal cross-sectional view of still a further embodiment of the present invention;

FIG. 10 is a longitudinal cross-sectional view of another embodiment of the present invention;

FIG. 11 is a longitudinal cross-sectional view of a still further embodiment of the present invention;

FIG. 12 is a variation of the embodiment according to FIG. 11;

FIG. 13 is a somewhat schematic view showing the gas flow within the gas passages of the atomizing nozzle shown in FIG. 10;

FIG. 14 is a partial longitudinal cross-sectional view of a known atomizing nozzle showing the liquid recombination phenomena; and

FIG. 15 is a longitudinal cross-sectional view of the known nozzle according to FIG. 14 after it has been in use, showing the buildup of carbon resulting from the recombination phenomena.

DETAILED DESCRIPTION OF THE INVENTION

While the present invention relates to a nozzle wherein any type of gas may be used for atomizing any type of liquid, it has particular utility and the preferred embodiments are specifically directed to the atomization of liquid fuel with air for combustion.

DETAILED DESCRIPTION OF THE DRAWING

Only the forward portion of the atomizing nozzle according to the first embodiment is shown in FIG. 1. The nozzle body **1**, which is shown alone in FIG. **4**, carries on its downstream end a spacer collar or sleeve **4** and a nozzle tip **22**; the collar **4** determines the axial position of the tip **22**. A gas swirler, more clearly shown alone in FIGS. 2 and 3, is concentrically mounted on the nozzle body and in turn is surrounded or enclosed by a cap **5**, which is shown alone in FIG. **6**.

The predominately cylindrical nozzle body **1** is provided with a central passage **10** for conducting liquid from a source liquid under pressure to be atomized, which source is not shown in the drawing. The nozzle body further has a plurality of peripherally spaced projections **11**, which extend radially outwardly from its otherwise cylindrical outer surface. The outermost portions of the projections **11** are provided with screw threads so that the gas swirler **3** may be threaded thereon, with the internal threads **30** of the gas swirler **3** engaging the external threads of the projections **11** on the nozzle body **1**. This construction forms a plurality of peripherally spaced openings or gas passages **21** defined by adjacent projections **11**, the internal surface of the swirler **3**, and the external surfaces **13** of the body **1** between projections **11**. These gas passages **21** communicate with an annular gas chamber **39** formed between the nozzle body **1** and the forward or down stream portion of the interior of the gas swirler **3**. The annular chamber **39** feeds gas under pressure to an annular gas reservoir **24** in the central portion **16** of the downstream end of the nozzle body **1** by means of a plurality of gas passages **19** formed in the nozzle body **1**. The annular gas reservoir **24** is defined by the central portion **16** of the nozzle body, the spacer collar or sleeve **4** that is telescopically assembled on the boss **18** of the nozzle body formed in the center of the central portion **16**, and the tip **22** that is fixed to the boss **18** by means of welding or the like **25.** In this manner, a gap or annular space **23** is formed between the conical face **17** of the down stream end of the nozzle body **1** and a correspondingly shaped face on the tip **22.** The size of the gap or space **23** is determined by the axial length of the collar or spacer sleeve **4,** and this space **23** functions as a gas ejecting port communicating with and receiving gas under pressure from the gas reservoir **24.**

The outer tapered face **34** of the gas swirler **3** is provided with a plurality of radial and inclined veins, with respect to the axis of the nozzle, which axis lies within the plane of FIG. **1** and is further the axis of symetry for most of the nozzle portions. These vanes **36,** which may be of any conventional design form a plurality of gas passages that will eject gas in cooperation with the tapered face **51** of the cap **5,** which ejected gas will be conically swirled as it moves axially to the left or downstream as shown in FIG. **1.** In the case where the ratio between the pressure of the furnace interior **6** or the other space into which the gas-liquid atomized mixture is to be projected, and the high pressure of the gas is below the critical pressure ratio (1.893 for air, 1.833 for super heated steam, and 1,732 for dry saturated steam), the cross section, in the flow direction, for the gas passages between adjacent vanes **36** of the swirler **3** will be made tapered so as to obtain the maximum flow velocity in the vicinity of the outlet of the vane part. In the case where the critical pressure ratio is exceeded, the gas passage cross-section between adjacent veins **36** will be made preferably convergent, at least for its downstream portion, to obtain the maximum flow velocity at the outlet or the vicinity of the outlet of the vanes **36,** the theory of which is known in nozzle design for subsonic and supersonic gas flow. These design criteria are highly desirable to obtain the maximum conversion of gas pressure into gas velocity to raise the atomization efficiency of the nozzle. Of course, it is recognized that the present invention may be employed with a nozzle wherein the flow cross-section between the gas swirler vanes **36** may be uniform throughout its flow direction, that is unchanged, when such is necessary due to restrictions in working or construction. Further, rounded corners are very effective for the construction of these parts to prevent a contracted flow from occurring at the inlet of the vanes **36** of the swirler **3.**

Immediately downstream of the downstream outlet end **38** of the vanes **36,** there are plurality of liquid ejecting ports or holes **15** provided in the outer surface of the nozzle body **1,** which ports **15** communicate with the high pressure liquid within the central passage **10.** The previously described gas ejection port **23** is located further downstream from the liquid ejecting ports **15,** and projects through the same outer surface of the nozzle body **1.**

In the operation of the embodiment according to FIG. **1,** the gas is highly compressed by means of a compressor or the like to supply high pressure gas to the gas chamber **7** between the nozzle body **1** and the cap **5,** which will feed gas through the annular passage **71** defined by the cap and the gas swirler **3** to the vanes **36.** After travelling through the vanes **36,** the gas is ejected in a conical and swirling flow with respect to the axis of the nozzle body. The liquid or fuel is supplied under pressure to the central passage **10** within nozzle body **1** to flow through the ejecting ports **15.** In this manner, the liquid flowing from the ports **15** is atomized by the velocity energy of the swirling gas immediately down stream from the outlet **38** of the vanes **36,** so that the liquid is picked up by and swirled with the gas. This swirling or vortex flow is then projected into the furnace **6** through an annular passage formed by the tapered face **53** of the cap **5** and the tapered face or surface **20** of the nozzle body **1,** which surface **20** is immediately downstream from the liquid ejecting ports **15.** The above described atomizing process is known, and the results are shown specifically in FIG. **14,** wherein it is seen that the liquid ejected to the air flow in the passage formed by an inner portion of the cap **5** ***d1*** and outer portion of the swirler or nozzle body **3*d1*** at least partially recombines downstream from the liquid ejecting port to adhere to the surface of the nozzle body downstream from the liquid ejecting port to become a liquid film, which grows in thickness as other previously atomized droplets recombine with the film; such as known as the recombination phenomena. This has been recognized by the present invention, which solves the problem by preventing the atomized liquid flow from adhering to the surface downstream of the liquid ejecting port by diverting the flow.

The above flow diversion for the prevention of the recombination phenomena is accomplished according to the embodiment of FIG. **1** of the present invention by directing high pressure gas from the passage **7,** through the passages **21,** through the annular space **39,** through the passages **19,** through the gas reservoir **24,** and through the ejecting port **23.** The gas ejected through the port **23** into the vortex flow of mixed gas and lliquid will cause the vortex flow to swerve at its outer limits back from the nozzle axis so that the once atomized liquid will not recombine and adhere to the wall or surface downstream from the liquid ejecting ports **15,** which surface is particularly formed by the nozzle body **1** and tip **22.** Thus atomization of the liquid will be improved.

As more clearly shown in FIG. **6,** the tapered surfaces **52** and **53** at the downstream end of the cap **1** are conically formed with respect to the nozzle axis. The inner oor upstream tapered surface **23** has two functions. When the velocity and force of the liquid ejected from the liquid ejecting ports **15** is very high, there is the undesirable possibility that the liquid will completely penetrate the main flow of gas from gas swirler and completely pass by the swirler **3** before it is atomized, leading to poor overall atomization. One of the functions of the tapered surface **52** is to prevent this penetration of the ejected liquid by forming a blocking surface against which the liquid will strike to be diverted back into the gas flow. The other function of the tapered surface **52** is to keep constant the maximum flow velocity of the main gas flow passing from the vanes **36** of the swirler **3** within the region of the inner taper **52** from the outlet **38** of the vanes **36** within the vicinity of the liquid ejecting ports to improve the effectiveness of the liquid atomization. Since stream lines of the main gas flow containing liquid particles are turned outwards by the gas flow ejecting from the ejecting port **23,** the outer tapered surface portion **53** of the cap **5** is divergent in shape, in the direction of fluid flow. If the surface **53** were no so formed, there would be the possibility that the recombination phenomena of the the liquid particles would occur on such a surface as **53** without the divergent shape.

As previously mentioned, the screw threads **12** and **30** on the outer portions of the projections **11** and the inner portion of the gas swirler **3**, respectively, determine the relative position between the main gas flow from the vanes **36** of the swirler **3** and the outlet of the liquid ejecting ports **15** provided at the front of the nozzle body **1**. The screw parts may be fixed by other methods, for example, by employing hook pins or by meshing the swirler **3** and the nozzle body **1** with each other. As previously described, the surfaces **13** form the bottom or inner portions of the gas passages **21** between adjacent projections **11** on the nozzle body **1**.

In order to prevent gas leakage from the annular gas space **39**, it is desirable to make the inside diameter of a gas seal annular surface **35**, as shown in FIG. **2**, slightly smaller then the outside diameter of the adjacent portion of nozzle body **1** to form a force fit between the nozzle body **1** and the gas swirler **3**. However, since the front ends **37** of the vanes **36** are helddown by tightening of the cap **5** by screw threads or the like, not shown in FIG. **5**, the gas leakage between the nozzle body **1** and gas swirler **3** would not be considerable even with a sliding fit. If with high tolerances the taper of the front ends of the vanes **36** is made slightly smaller than the adjacent engaging taper **51** of the cap **5**, the sealing surface **35** will have an external force exerted or concentrated at the front end of the cap **5**. Thus, the gas-tight seal will be enhanced.

A variation of this gas-seal between the swirler **3** and nozzle body **1** is shown in FIG. **7**, wherein a step construction is employed for the seal surface **35** and the adjacent surface of the nozzle body **1** to form a tortuous flow path seal.

While the air passages or spaces **21**, particularly shown in FIGS. **1** and **5**, are shown as slots as in a splined shaft, these flow passages **21** may also be formed by circular axial holes perforating the swirler **3** that would extend down to the nozzle body **1** or perforating the projection **11** that would extend upwardly to the swirler **3** from the nozzle body **1**.

The engaging tapered surfaces **31** of the swirler **3** and **14** of the nozzle body **1**, for determining the axial position of the swirler **3** and nozzle body **1** may be omitted in some instances.

A second embodiment of the present invention is shown in FIG. **8** for atomizing liquid, and the above description will suffice except with respect to points of differences which will be described below. In FIG. **8**, the vanes ***36a*** are constructed differently from the vanes **36** of FIG. **1** so that the tapered surface **52** of the first embodiment is not needed in the embodiment of FIG. **8**. However, a similar result will be obtained with FIG. **8** in that the vanes extend over the direction of the liquid ejection from the liquid ports ***15a***. Further, the air passages **21** of the embodiment according to FIG. **1** are replaced by a plurality of radial air passages ***21a*** as shown in FIG. **8** passing through the swirler ***3a*** for supplying air to the annular space ***39a***. The provision of the holes or passages ***21a*** in the swirler ***3a*** is more advantageous in practice than the provision of the spaces **21** in the FIG. **1** embodiment between the projections **11**. In addition, these passages ***21a*** will deflect towards the swirler **3** the flowing direction of the main gas flow leading to the vanes ***36a*** as the gas flows through the annular space corresponding to the annular space **71** in FIG. **1**. To thus deflect the main gas flow leading to the vanes ***36a***, will produce a sharp velocity gradient of the gas flow on the side of the liquid ejecting hole ***15a*** when the gas flow is ejected from the vanes ***36a***. This will result in the excellent atomization of the liquid owing to the sharp gas velocity change at the ejection ports ***15a***. Thus, the passages ***21a*** will bleed off the boundary layer and air adjacent thereto flowing to the vanes **36** to provide a smooth redirecting of the main gas flow from the annular space corresponding to space **71** in FIG. **1** to the directional flow through the vane ***36a***.

Another embodiment of the present invention is shown in FIG. **9**, the portions of which that are similar in structure to the previously described embodiments will not be described again. The embodiment of FIG. **9** differs from the embodiment of FIG. **1** in that two annular gas ejecting ports $\mathbf{23b_1}$ and $\mathbf{23b_2}$ are provided downstream from the liquid ejecting ports ***15b***, instead of the provision of only one downstream gas ejecting port **23** as in FIG. **1**. With reference to FIG. **14**, the dimensions of the gas vortexes **94** produced downstream from the liquid ejecting ports ***15c*** vary depending not only on the diameter of the liquid ejecting ports ***15c***, but also on the flow rates of the gas and liquid, that is, the running conditions. To provide the downstream gas ejecting ports before the point at which the liquid film due to the recombination phenomena is produced, a multiplicity of gas ejecting stages, two of which are provided in the embodiment of FIG. **9**, are more preferable than a single stage as provided in FIGS. **1** and **8**. With the two-stage gas ejecting port system, in addition to an outer tip $\mathbf{22b_2}$, an inner tip $\mathbf{22b_1}$ having the downstream ejecting ports $\mathbf{22b_2}$ therein is required.

A further embodiment of the present invention is shown in FIG. **10**, which differs from the embodiment of FIG. **1** in that gas is supplied to the annular gas space ***39c*** by a plurality of gas sucking or bleed ports ***21c*** between the vanes ***36c*** and through the wall of the swirler ***3c***. This construction differs from the construction of FIG. **8**, in that the boundary layer and adjacent gases are sucked from the main gas stream as it flows between the vanes ***36c*** instead of as it flows between the swirler ***3a*** and cap ***5a*** of FIG. **8** in the space corresponding to the space **71** of FIG. **1**. In this manner, the deflecting effect of the main flow gas in the annular passage ***71c*** that was brought out with respect to the description in the embodiment of FIG. **8**, is further promoted. Thus, the boundary layer generated by the change of the flowing direction from the annular passage ***71c*** towards the liquid ejecting port ***15c*** is sucked off. FIG. 13c illustrates the difference between the velocity distribution **91** between the vanes and immediately donwstream therefrom in FIG. **1** and the veocity distribution **92** according to the embodiment of FIG. **10** due to the removal of the boundary layer by the bleed passages ***21c***. A similar result would be obtained by removal of the boundary layer with the passages ***21a*** in the embodiment of FIG. **8**. Thus, the atomization of the 2-fluid spray will be more effective, because the velocity of the gas flowing immediately adjacent or across the liquid ejecting ports ***15c*** will be higher and the velocity gradient from the wall will be greater.

A further embodiment of the present invention is shown in FIG. **11** for diverting the gas liquid atomized mixture to prevent recombination. Again, only the differences from the previously described embodiments will be described in detail. In the nozzle of FIG. **11**, the nozzle body is provided with a liquid passage **10***d* that is eccentric with respect to the nozzle axis and a gas passage **7***d*, which is similarly eccentric. The liquid passage **10***d* supplies high pressure liquid to the liquid reservoir **83** between the interior of the gas swirler **8** and the nozzle body, in front of the nozzle body. Gas swirler **8** is provided with a plurality of gas ejecting vanes **36***d* to eject the gas, such as air, to the interior of the furnace **6** in a whirling conical fashion, in combination with liquid ejected from the liquid ejecting ports **81** communicating with the liquid reservoir **83.** The central portion of the gas swirler **8** is provided with an annular surface **82** parallel with the axis of the nozzle, which surface **82** could also be formed by a portion of the nozzle body. The gas will flow from the gas passage **7***d* through the passage **21***d* to the annular gas reservoir **39***d*, where it is supplied to the vanes **36***d*. The cap **5***d* is secured to the nozzle body by means of threads or the like **55***d* to form therewith the annular gas reservoir space **39***d*. The compressed gas is ejected from the vanes **36***d* in a whirling conical path to atomize the liquid ejected from the liquid ejection ports **81.** The liquid film that would tend to appear on the outer surface of the gas swirler **8** downstream from the liquid ejecting ports **81** due to the recombination phenomena as described with respect to FIG. **14** at **96** is prevented from occurring by means of the parallel surface portion **82** at the downstream terminal end of the gas swirler **8.**

The liquid film **96** that tneds to appear in the known nozzles as shown in FIG. **14** becomes quite thick with highly viscous fuels such as heavy oil. However, it has been experimentally proved that making the boundary layer quite thin according to the embodiments of the present invention has a most desirable effect. The parallel surface portion **82** of the swirler **8** in FIG. **11** will tend to divert the gas liquid boundary layer flow from the wall of the swirler toward the main gas flow.

A similar diversion of the gas- liquid boundary layer flow is obtained according to the variation of the embodiment of FIG. **11** as shown in FIG. **12**, wherein arcuate surface **82'** at the front or terminal end of the swirler **8** will even more sharply direct the gas-liquid boundary layer flow back into the main swirling gas flow. Further, the configuration of the ejecting part may be made concave to prevent the boundary layer of the ejected flow on the side of liquid ejecting ports from being developed.

The results of the recombination phenomena for the known nozzles of FIG. **14** are shown in FIG. **15**, wherein solid carbon **97** has developed on the front central section of the nozzle with a surface **98** as an extension of the surface on which the liquid film forms. Such a buildup of carbon is prevented with the present invention.

In all of the embodiments of the present invention, it is seen that the boundary layer of relatively slow velocity fluid along the surface that has extending therethrough the liquid ejecting ports is considerably reduced in thickness as compared to the known nozzles by the various means including sucking off the boundary layer upstream of the liquid ejecting ports, blowing the boundary layer back into the main gas flow by ejecting air downstream of the liquid ejecting ports and providing a surface projection downstream of the liquid ejecting ports for turning the boundary layer back into the main gas flow. The bleeding or sucking off of the boundary layer will produce a thinner, higher velocity boundary layer as shown in FIG. **13** to improve the atomization; the gas ejection will break up the boundary layer, and the surface redirection of the boundary layer will break it up with the main gas flow, each of which will have the effect of reducing the thickness of the boundary layer and increasing the flow velocity to prevent the recombination phenomena from forming a liquid film along the surface. These various means for accomplishing the desired result may be employed singly or in combination.

While preferred embodiments and variations have been described in detail for purposes of illustration, and for the merits of their details, the broader aspects of the present invention include further embodiments, modifications and variations as determined by the spirit and scope of the following claims.

It is claimed:

1. An atomizing nozzle for atomizing liquid within a gas, comprising:

a fluid flow guide surface;

means for directing a high velocity flow of gas along said guide surface;

means for ejecting liquid under pressure through said guide surface into the gas flow at a substantial angle with respect to the gas flow direction for atomizing the liquid within the gas;

means for diverting the fluid boundary layer that is along said guide surface to increase the fluid velocity gradient, as measured from said guide surface, above what would normally be obtained without said diverting means and said diverting means further including means for ejecting gas through said guide surface downstream from said means for ejecting liquid to divert the gas-liquid boundary layer away from said guide surface toward the main gas flow.

2. The atomizing nozzle according to claim **1,** including common means for supplying gas under pressure to both said means for directing gas and said means for ejecting gas.

3. The atomizing nozzle according to claim **2,** wherein said common means includes an air passage defined at least in part by said guide surface; and bleed passage means extending into said air passage up stream from said liquid ejecting means for bleeding at least the gas boundary layer that would otherwise form along said guide surface and supplying it to said means for ejecting gas.

4. The atomizing nozzle according to claim **3,** wherein said gas directing means includes an annular array of blades to project the gas flow in a whirling cone; and said bleed passage means is upstream from said blades.

5. The atomizing nozzle according to claim **3,** wherein said gas directing means includes an annular array of blades to project the gas in a whirling cone; and said bleed passage means is between said blades.

6. The atomizing nozzle according to claim **2,** including a nozzle body having a central downstream conical surface forming at least in part said guide surface, a downstream opening annular recess concentrically inwardly of said conical surface, and a downstream projecting central member at least in part forming said annular recess; said nozzle body further having a second conical surface oppositely directed from said first-mentioned conical surface and extending between said first-mentioned conical surface and said annular recess; a spacer sleeve surrounding said projecting member within said annular recess for only a portion of the axial extent of said projecting member; and a nozzle tip surrounding the remaining portion of said projecting member and tightly abutting said spacer sleeve; said nozzle tip having a conical surface complementary to and spaced from said nozzle body second conical surface to form therebetween an annular passage extending from said annular recess through said guide surface; and said common means including said annular recess.

7. The atomizing nozzle according to claim **6,** wherein said gas directing means includes a generally annular gas whirler mounted on said nozzle body to form therebetween an annular gas chamber, and having an annuar array of blades to project the gas flow in a whirling cone terminating at least closely adjacent said first mentioned nozzle body conical surface; a cap member surrounding said annular array of blades and being outwardly spaced from the remainder of said gas whirler and said nozzle body to form therebetween a main gas passage leading to the downstream end of said blades, which gas passage forms in part said common means; said common means further including gas passage means extending between said main gas passage and said annular gas chamber.

8. The atomizing nozzle according to claim **7,** including a high pressure liquid passage within said nozzle body for supplying liquid to said liquid ejecting means.

9. The atomizing nozzle according to claim **7,** including threaded means between said gas whirler and said nozzle body; said gas whirler and nozzle body having complementary seal surfaces immediately adjacent the downstream end of said blades and upstream from said liquid ejecting means, and said seal surfaces having an interference fit and extending generally parallel to the axis of said threaded means.

10. The atomizing nozzle according to claim **7,** wherein said gas whirler and nozzle body have complementary stepped seal surfaces forming a tortuous fluid path therebetween and immediately adjacent the downstream end of said blades and immediately upstream of said liquid ejecting means to isolate said annular gas chamber from the flow immediately upstream of said liquid ejecting means.

11. The atomizing nozzle according to claim **6,** including a generally annular gas passage at least in part formed by at least one of said nozzle body and nozzle tip to form a second means for ejecting gas through said guide surface downstream from said means for ejecting liquid and spaced from said first-mentioned means for ejecting gas in the direction of main gas flow.

12. An atomizing nozzle for atomizing liquid within a gas, comprising:

a fluid flow guide surface;

means for directing a high velocity flow of gas along said guide surface;

means for ejecting liquid under pressure through said guide surface into the gas flow at a substantial angle with respect to the gas flow direction for atomizing the liquid within the gas;

means for diverting the fluid boundary layer that is along said guide surface to increase the fluid velocity gradient, as measured from said guide surface, above what would normally be obtained without said diverting means; an air passage, at least partially defined by said guide surface, for supplying air under pressure to said means for directing gas; said means for diverting including bleed passage means extending into said gas passage for removing at least a substantial portion of the adjacent gas boundary layer upstream from said means for ejecting liquid, which boundary layer would otherwise flow along said guide surface immediately across said means for ejecting liquid.

13. The atomizing nozzle according to claim **12,** wherein said gas directing means includes an annular array of blades to project the gas flow in a whirling cone along said guide surface upstream from said liquid ejecting means; said bleed passage means removing the boundary layer upstream of said blades.

14. The atomizing nozzle according to claim **12,** wherein said gas directing means includes an annular array of blades to project the gas flow in a whirling cone along said guide surface upstream from said means for ejecting liquid; and said bleed passage means extending between said blades.

15. An atomizing nozzle for atomizing liquid within a gas, comprising:

a fluid flow guide surface;

means for directing a high velocity flow of gas along said guide surface;

means for ejecting liquid under pressure through said guide surface into the gas flow at a substantial angle with respect to the gas flow direction for atomizing the liquid within the gas;

means for divering the fluid boundary layer that is along said guide surface to increase the fluid velocity gradient, as measured from said guide surface, above what would normally be obtained without said diverting means; said diverting means including a projection from said guide surface downstream of said liquid ejecting means for changing the direction of the fluid boundary layer moving along said surface to direct it toward the main gas flow to be broken up thereby and to decrease the angle between the fluid boundary layer flow and the direction of flow for the liquid ejected by said liquid ejecting means; said gas directing means including an annular array of blades forming an annular flow of main gas, and said liquid ejecting means being annular and projecting said liquid in an annular path having an axis of symmetry substantially concentric with the axis of symmetry of the main gas flow annular path; and said projection means having an annular surface generally parallel to said axes, and at its upstream end angularly joining said guide surface.

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