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NOZZLE

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Fig. 1

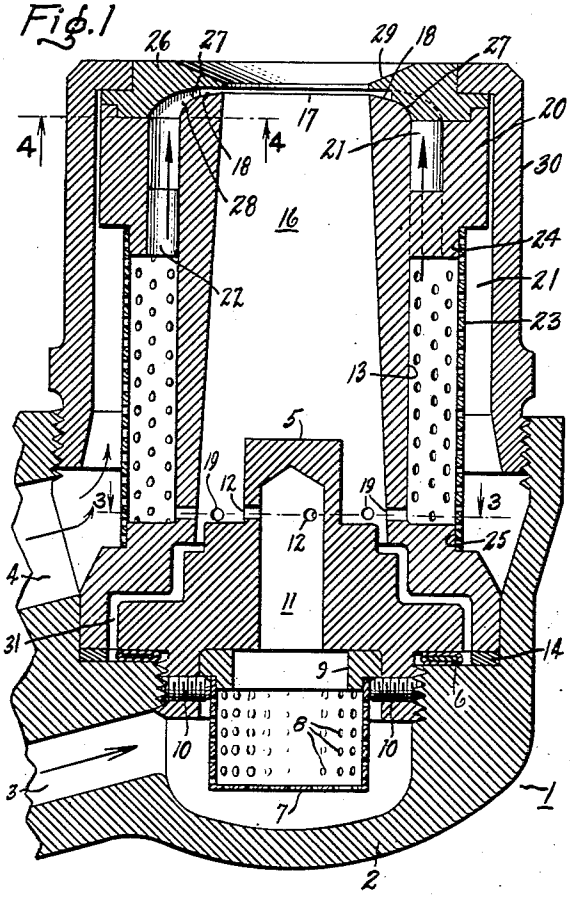


Fig. 2

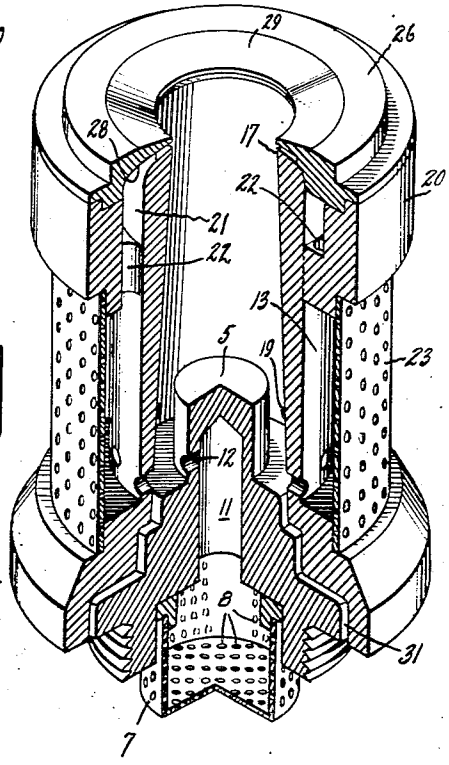


Fig. 4

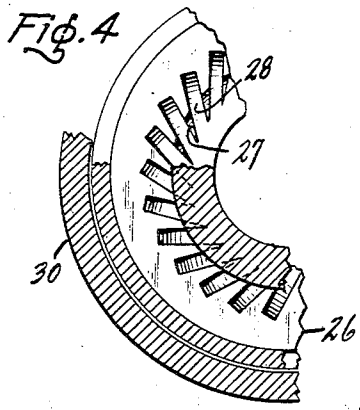


Fig. 5

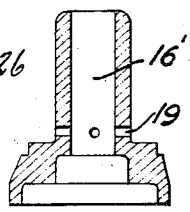
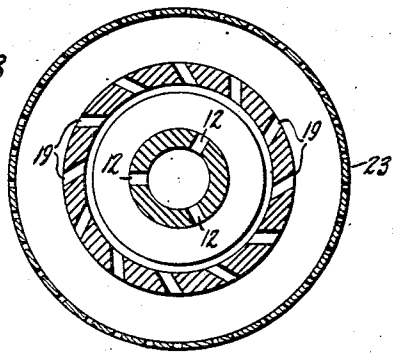


Fig. 3



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NOZZLE

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4 Claims. (Cl. 299—114)

Our invention relates to nozzles. More particularly, our invention relates to a nozzle of the vortex type which is particularly suitable for spraying relatively heavy or viscous liquids.

Vortex nozzles for spraying liquids are well known and have in the past taken varied forms in their production of a vortex or swirling mixed spray of liquid and air or oxidizer. A nozzle of this type typically comprises means for producing a swirling mass of air or oxidizer in a vortex chamber. The liquid is injected into the air vortex where it is atomized by the swirling air, the mixed air and liquid being discharged from the nozzle in the form of a cone. While such a nozzle is generally suitable for liquids of lower viscosity, it has been found that it is incapable of providing requisite atomization for the heavier liquids such as Bunker C oil and the like even when the latter are pre-heated. It has also been found that prior art nozzles are unsuited where a relatively narrow spray of high energy content is required. A relatively narrow spray is particularly important in combustors in which a wide fuel-air spray tends to cause the walls of the combustor to overheat and produces undesirable coking or carbon deposits because of spray and flame impingement.

An object of our invention is to provide a nozzle of the vortex type which will efficiently atomize relatively heavy or viscous liquids.

Another object of our invention is to provide such a nozzle which will produce a relatively narrow spray.

According to our invention there is provided a central vortex chamber into which primary air is angularly introduced to produce a swirling mass or vortex of air. Liquid such as fuel oil is introduced into the vortex chamber, the air causing the liquid to spread out on the chamber wall in a thin, downstream progressing film. It is also necessary that the length of this vortex chamber be at least two or three times its diameter in order that a thin, uniform film of relatively viscous fluid may be formed on the wall thereof. Preferably the vortex chamber is tapered slightly inwardly in a downstream direction so that the air vortex increases in rotational speed thus further tending to enhance the formation of a thin liquid film which is uniform in character. The fact that the liquid is introduced and formed into a uniform thin film at a relatively cool point remote from the high temperature at the face of the nozzle enables it, in the case of fuel, more readily to become atomized by the secondary air without coking or carbonization. Secondary air is fed into an annular chamber which surrounds and is concentric with the central vortex chamber and has its outlet directed perpendicular or substantially perpendicular to the outlet of the central vortex chamber. Means are provided in the secondary air chamber just upstream of its outlet to impart a swirl to the secondary air with minimum pressure losses. By shaping the secondary air flow passages in an aerodynamically suitable way, a maximum of kinetic energy is imparted to the air jet issuing from the nozzle. The swirling vortex of high velocity secondary air thus impinges upon the liquid film and primary air vortex atomizing the liquid and producing a relatively narrow spray with a high tangential velocity.

The features of our invention which we believe to be novel are set forth with particularity in the claims appended hereto. Our invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a general elevational view in cross-section of our invention. Fig. 2 is a perspective cut-away view of a portion of our nozzle. Fig. 3 is a cross-sectional plan view of our nozzle taken along the line 3—3 of Fig. 1, and Fig. 4 is a view of our nozzle taken along the line 4—4 of Fig. 1. Fig. 5 is a sectional view at a reduced scale of a modified form of the vortex chamber of Figs. 1 and 2.

Referring to Fig. 1, there is shown a nozzle 1 having a base 2 which receives the remaining component parts of the nozzle and is provided with a liquid feed conduit 3 and air feed conduit 4. Fitted into the base 2 is a liquid injector 5 which is fixed to the base in any convenient manner as by the threading shown. A metal bound gasket 6 provides a seal between the base 2 and liquid injector 5. The single simple metal gasket insures trouble free operation for longer periods of time at low pressures than conventional high pressure nozzles having gaskets which deteriorate with heat or fuel contact. Fixed to the lower end of injector 5 is a screen 7 comprising a screen or filtering portion 8 and a rim 9, which latter is held in place by set screws 10. A central conduit 11 in the fuel injector serves to transmit liquid to holes 12 defined by the injector body which permit passage of fuel to be introduced into the vortex chamber. These holes are typically directed in a generally radial direction although their orientation can be changed as desired. These holes may be relatively large so that the fuel can be introduced at low pressures thereby improving pump life.

Surrounding and extending beyond the liquid injector 5 and also fitting into base 2 is a generally cylindrical part or sleeve 13 provided with spacer 14 at its lower end. A leakage path 31 is left between parts 5 and 13 in order that if fuel should leak through gasket 6, it will enter the vortex chamber 16 harmlessly rather than passing into the air space 4, clogging screen 23 or slots 28. The inner wall of part 13 defines a cylindrically shaped central vortex chamber. The vortex chamber may be a true cylinder as shown at 16' in Fig. 5, or preferably as shown at 16 in Fig. 1, the vortex chamber is tapered inward gradually toward its outlet 17 or downstream portion. The outer wall of sleeve 13 is rounded inwardly as shown at 18 for reasons which will become apparent hereinafter. Holes or ports 19 for the injection of air into the vortex chamber 16 are provided through the wall of part 13 at its base or upstream end opposite or approximately opposite liquid injector holes 12. As best shown in Fig. 3, these holes are canted or tangentially arranged to cause air issuing therefrom to form a vortex or swirl in vortex chamber 16, the air causing liquid introduced from holes 12 to form a thin, continuous film on the inner wall of the vortex chamber. Mounted around the upper portion of part 13 is a ring-like collar 20 unitary therewith or securely fixed thereto as by sweating or other usual means. The downstream inner portion of collar 20 is shaped to form an annulus 21 between it and the outer wall of sleeve 13 as shown. The upstream inner portion of the collar 20 adjacent part 13 is provided with a plurality of holes 22 which are typically cylindrical. The purposes of these holes 22 is evenly to distribute air fed into them, and to serve as a structural connection between the collar 20 and part 13. A cylindrical air screen or filter 23 is

mounted on and extends between shoulder **24** of collar **20** and shoulder **25** of sleeve **13**. This screen serves to filter air fed from conduit **4** to protect the air holes **19** and the air passages from large dirt particles in the air fed through conduit **4**.

In order to impart a vortex motion to secondary air passing through annulus **21**, a deflector plate **26** is mounted downstream of and in contact with collar **20**. The upstream side of plate **26** has an arcuate surface **27** which mates with the curved downstream outer surface **18** of sleeve **13** except for tangentially arranged or canted slots or grooves **28** which also have a smooth arcuate base to minimize pressure loss and are spaced from sleeve **13** to provide channels for the passage of secondary air. As will be noted, plate **26** is closely spaced from the outlet **17** of central vortex chamber **16** so that air issuing therefrom will have a relatively high velocity. The edge of plate **26** at its outlet is also relatively sharp as shown. The secondary air outlet is directed perpendicular or substantially perpendicular to the outlet of vortex chamber **16**. The downstream portion **29** of plate **26** is dished or flared outwardly. A cap **30** suitably shaped and threaded or otherwise fixed to base **2** serves to hold plate **26** and the other parts of the nozzle in place.

In operation air is fed through conduit **4** in the desired amount. This air passes through and is filtered by screen **23**. A portion of the air hereinafter known as primary air passes through holes or ports **19** into vortex chamber **16**. Since, as pointed out above, ports **19** are canted or are at an angle to the radius of the vortex chamber, the air passing therethrough forms a downstream progressing vortex or whirling mass. Meanwhile liquid is fed through conduit **3** in desired amount and is filtered by screen **7** in passing into the chamber or conduit **11** in the fuel injector. From this chamber the liquid is fed through radially disposed holes **12**. Upon entering the upstream portion of vortex chamber **16**, the liquid is picked up by the whirling streams of air issuing from ports **19**, causing the liquid to form a thin, continuous film which clings to the inner wall of the vortex chamber and proceeds downstream. The downstream tapering character of the vortex chamber enhances the formation of a thin, continuous uniform film of liquid on the vortex chamber wall. It is not necessary that liquid be introduced into the vortex chamber in forceful jets or streams. A mere flowing of the liquid under low pressure is sufficient. Neither are the sizes of holes **12** critical.

As pointed out above, a portion of the air entering conduit **4** passes through ports **19** as primary air. The rest of the entering air, known as secondary air, proceeds downstream outside the vortex chamber. As this secondary air enters holes **22**, its flow is evenly distributed. The air then enters the annulus **21** and thence passes through grooves **28** which, while maintaining a smooth flow, impart a vortex motion to the air of the same direction of rotation as the primary air. As the air passes through grooves **28**, the passageway is also gradually restricted so that the secondary air issues from its outlet as a high energy vortex. Inasmuch as its outlet is just beyond the vortex-producing grooves **28**, there is little or no turbulence in this secondary air as it issues. Upon issuing, the secondary air impinges upon the vortex of primary air and upon the thin film of liquid as it breaks away from the wall of the central vortex chamber effectively atomizing the liquid and counteracting the tendency of the liquid to spread under action of the primary air. Thus a relatively narrow spray is achieved. The relatively sharp edge of plate **26** at the secondary air outlet prevents any tendency of the liquid to reform a film thereon or to form large liquid droplets.

There is provided by our invention a nozzle for atomizing liquids which produces a relatively narrow spray of the order of about 20–60 degrees included angle which is most useful where a wider spray cannot be tolerated.

Our nozzle having no complex moving parts to get out of adjustment is particularly useful in combustors for gas turbine installations wherein the combustor has a relatively small diameter and the use of wide sprays tends to overheat the walls of the combustor causing them to fail and to carbonize or coke excessively. The swirling of the atomized particles produced prolongs their residence in the flame zone to improve combustion performance.

While our invention is suitable for spraying any liquids, it is particularly suitable for spraying relatively heavy or viscous liquids which do not atomize readily upon merely impinging in a stream on a vortex of air or gas. By causing the liquid first to be formed into a thin, continuous and uniform film in a vortex chamber to be later acted upon by an impinging vortex of high energy secondary air, the viscous liquid is effectively atomized.

In those cases in which the liquid is a viscous fuel, the introduction of the fuel at a point relatively remote from the hot face of the nozzle obviates coking or carbonization of the fuel which occurs when the fuel exists in a stream or relatively massive form near the nozzle face or outlet.

While we have described certain specific embodiments of our invention, we wish it to be understood that we desire to protect in the following claims all changes or modifications thereto which fall within the spirit and scope of those claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A nozzle for spraying a liquid comprising a member defining a central cylindrically shaped vortex chamber with an open end and a closed end and having a smooth, continuous, imperforate side wall portion of an axial length substantially greater than its diameter, first nozzle means for introducing liquid into the closed end portion of the vortex chamber, second nozzle means for introducing primary air into the vortex chamber at the closed end thereof with a substantial tangential component whereby the liquid is caused to form a thin, continuous, uniform downstream-progressing film of liquid on the vortex chamber wall, housing means defining an annular chamber surrounding and separated from the vortex chamber for the passage of secondary atomizing air, and third annular nozzle means for directing an annular jet of secondary air transversely across the liquid film issuing from the open end of the vortex chamber.

2. A nozzle for spraying a liquid comprising a member defining a central vortex chamber with an open end and a closed end and having an imperforate cylindrically shaped side wall portion of an axial length substantially greater than its diameter, first nozzle means for introducing liquid into the closed end portion of said vortex chamber in jets directed toward said side wall, second nozzle means for introducing primary air into the vortex chamber at the closed end thereof with a tangential component whereby the liquid is caused to form a thin, continuous, uniform, downstream-progressing film of liquid on the vortex chamber wall, housing means defining an annular chamber surrounding and separated from the vortex chamber for the passage of secondary air, third nozzle means for directing a jet of secondary air transversely across the liquid film issuing from the open end of the vortex chamber, and means located immediately upstream from said third nozzle means for imparting a vortex motion to the secondary air of the same direction of rotation as the primary air.

3. A liquid spray nozzle having a member defining a central vortex chamber with a closed end and an open end and of a length at least equal to twice its diameter and having an imperforate side wall portion tapered smoothly inwardly toward the open end, first nozzle means at the upstream closed end of said chamber for introducing liquid into said vortex chamber in jets di-

rected outwardly toward said tapered side wall, and second nozzle means at the upstream end of said imperforate side wall for introducing primary atomizing air into said vortex chamber with a tangential component whereby the liquid is caused to form a thin, continuous, uniform, downstream-progressing film on the smoothly tapered side wall, housing means defining an annular chamber surrounding and separated from the vortex chamber for the passage of secondary atomizing air, third annular nozzle means communicating with said annular chamber and discharging said secondary air across the path of the liquid film issuing from the open end of the vortex chamber, and means for imparting a vortex motion to said secondary air in the third nozzle means of the same direction of rotation as said primary air, said last-mentioned means being located upstream in said annular chamber from said third nozzle means whereby a smooth, solid swirl of secondary air impinges upon the thin film of liquid and the vortex of primary air emerging from the open end of the vortex chamber.

4. A nozzle for spraying a liquid comprising a member defining a central vortex chamber with an open end and a closed end and having a smooth, continuous, imperforate side wall portion of an axial length substantially greater than its diameter, first nozzle means for introducing liquid into the closed end portion of the vortex chamber, second nozzle means for introducing primary air into the vortex chamber at the closed end thereof with a substantial tangential component whereby the liquid is caused to form a thin, continuous, uniform downstream-progressing film of liquid on the vortex chamber wall, housing means defining an annular chamber surrounding and separated from the vortex chamber for the passage of secondary atomizing air, and third annular nozzle means for directing an annular jet of secondary air transversely across the liquid film issuing from the open end of the vortex chamber.

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