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(54) **MODULAR DUAL VECTOR FLUID SPRAY NOZZLES**

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(21) Appl. No.: **15/499,631**

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Related U.S. Application Data

(62) Division of application No. 14/883,626, filed on Oct. 15, 2015, now Pat. No. 9,664,427, which is a division of application No. 14/013,582, filed on Aug. 29, 2013, now Pat. No. 9,631,855.

(60) Provisional application No. 61/694,262, filed on Aug. 29, 2012, provisional application No. 61/694,256, filed on Aug. 29, 2012, provisional application No. 61/694,255, filed on Aug. 29, 2012, provisional application No. 61/694,250, filed on Aug. 29, 2012.

Publication Classification

(51) **Int. Cl.**

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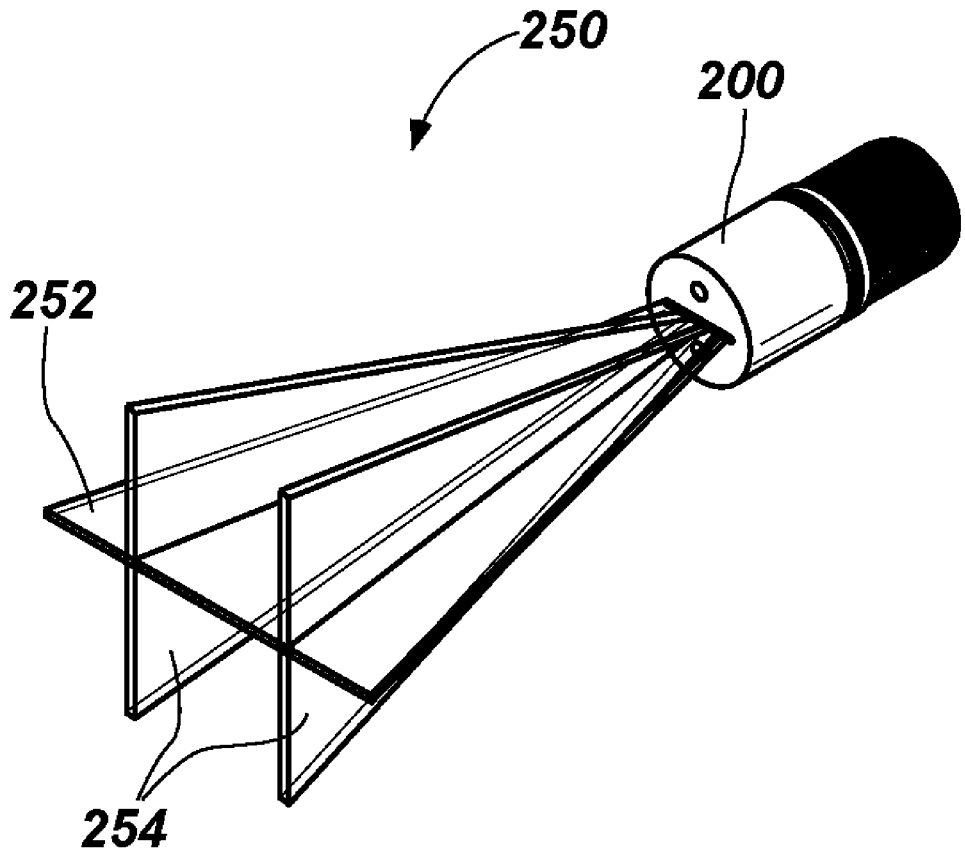
B05B 1/14	(2006.01)

(52) **U.S. Cl.**

CPC ***F25C 3/04*** (2013.01); ***B05B 1/14*** (2013.01); ***B05B 1/02*** (2013.01); ***B05B 1/044*** (2013.01)

(57) **ABSTRACT**

Various embodiments of modular dual vector fluid spray nozzles are disclosed. Embodiments of the nozzles are characterized by specially shaped fluid channels, impingement surfaces and exit orifices used to generate atomized mists of fluid under pressure. Embodiments of the nozzles are generally characterized by composite fluid spray density patterns having horizontal and vertical components, i.e., dual vector in nature. The nozzles disclosed are modular and may be easily installed or removed from a given fluid spray system, nozzle head, or fixture as dictated by any given application.



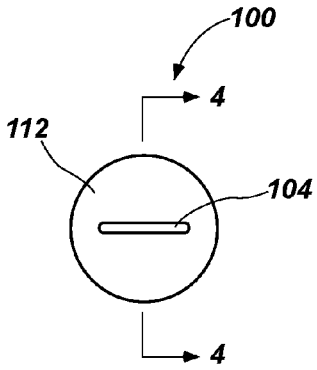


FIG. 1

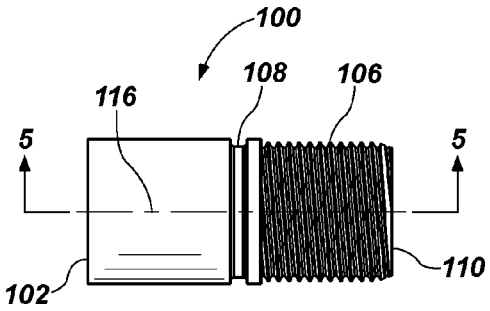
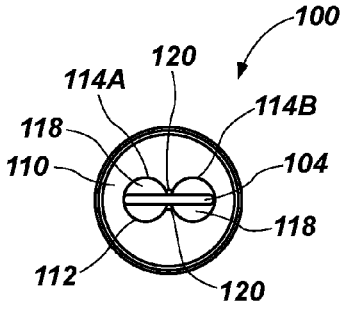


FIG. 2



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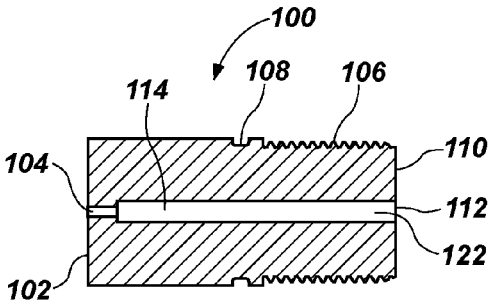

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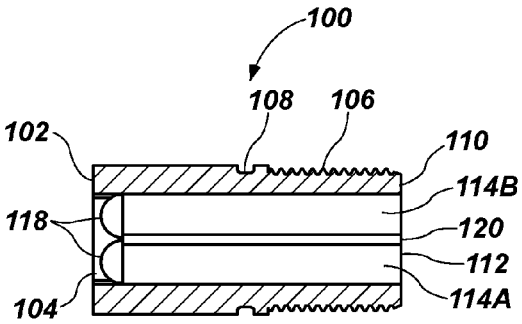

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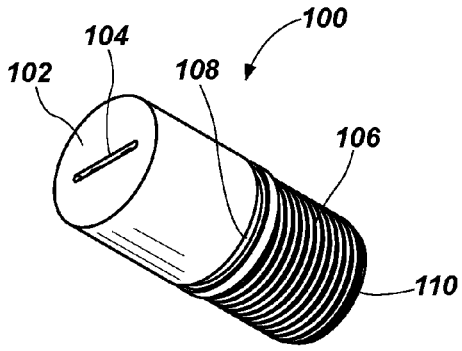

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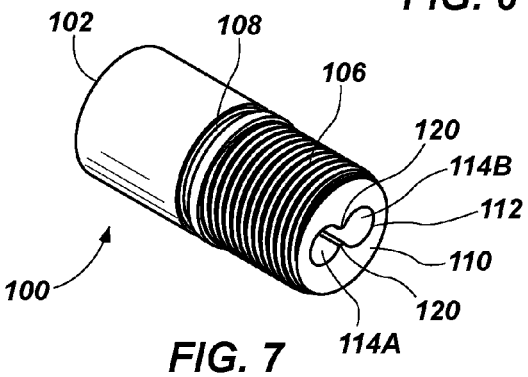

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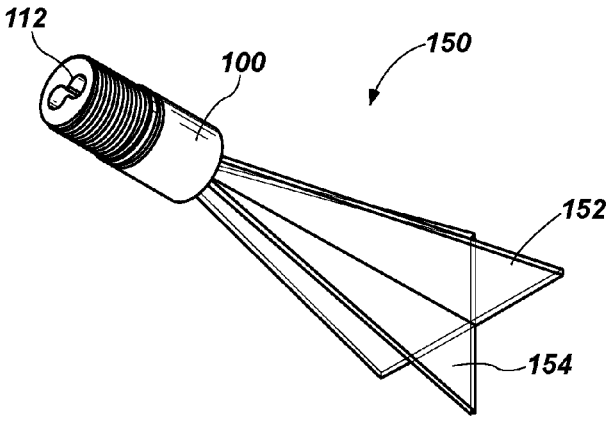
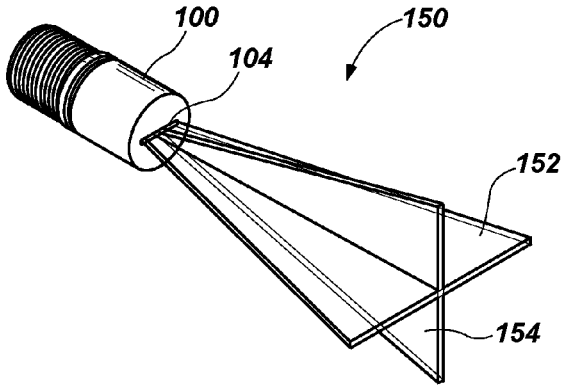


FIG. 8A



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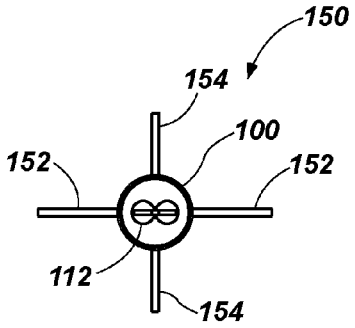

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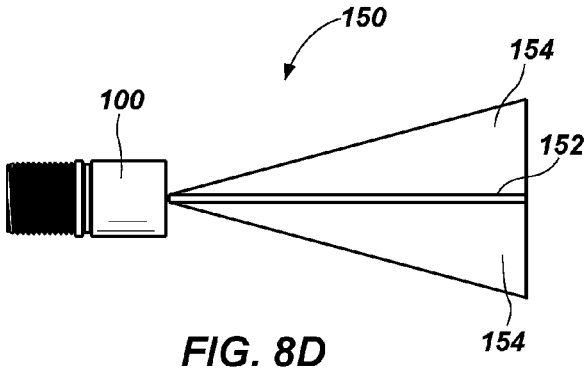

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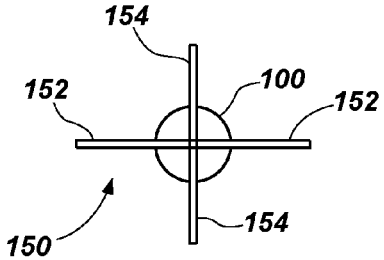

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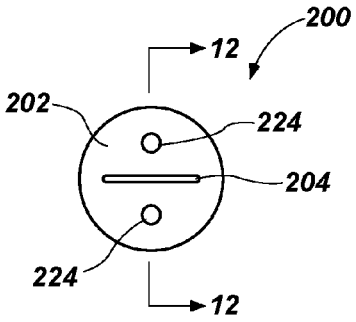

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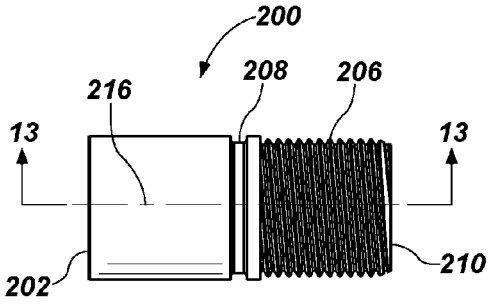

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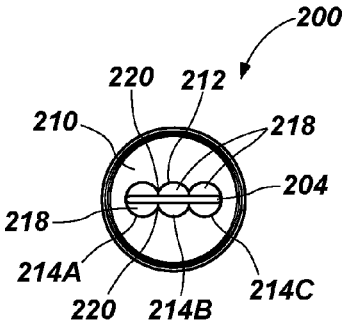

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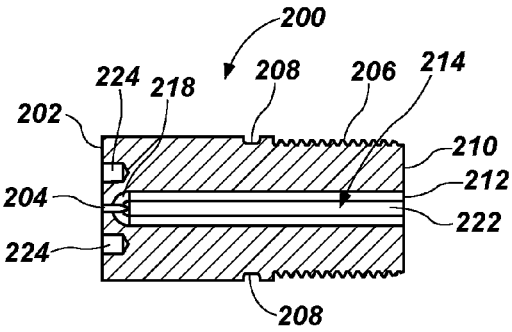

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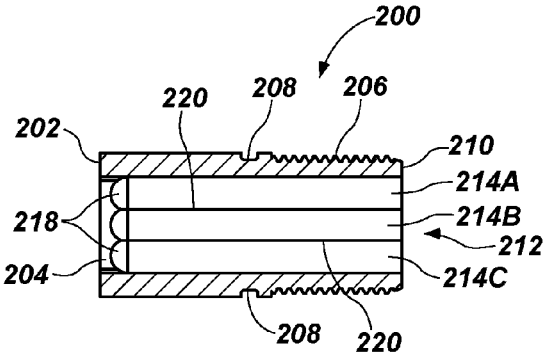

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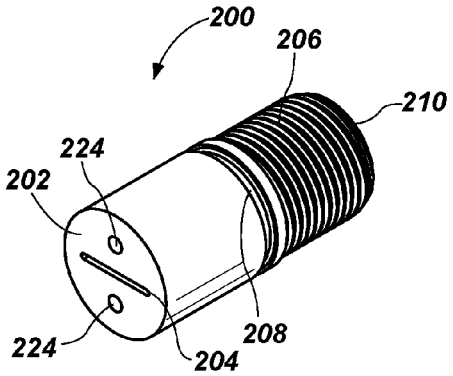

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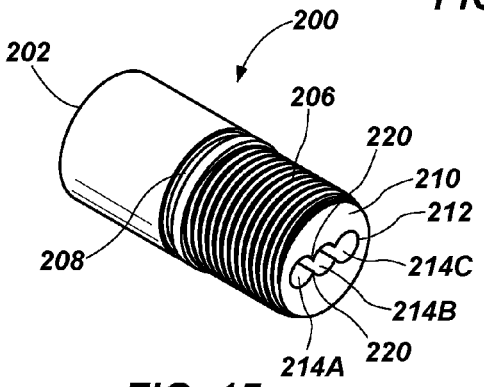

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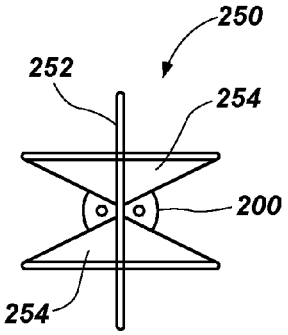

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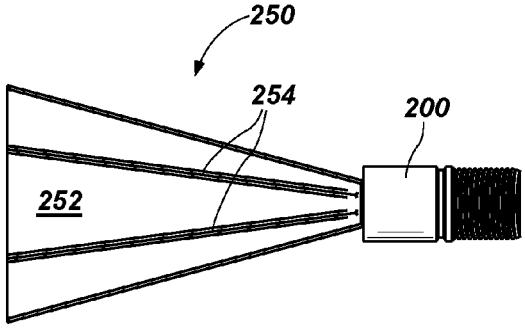

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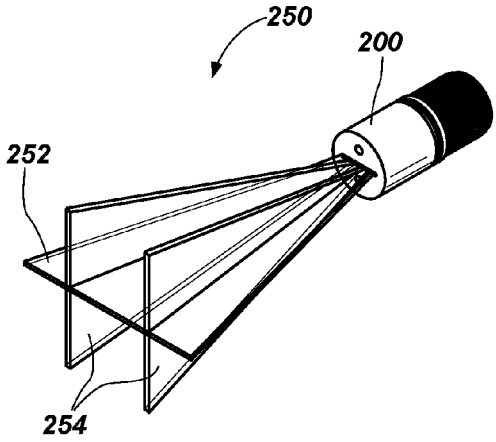

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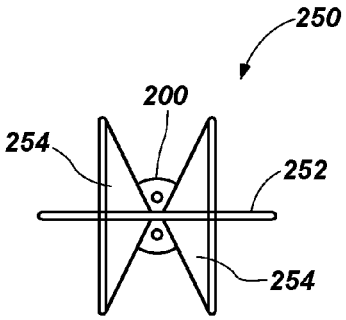

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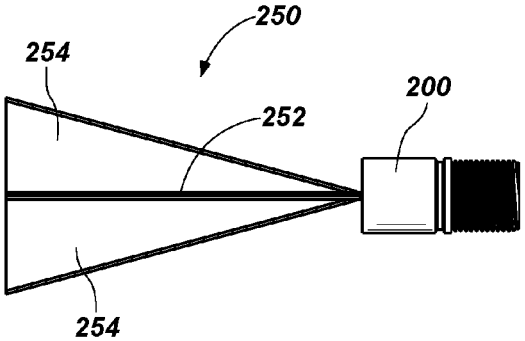

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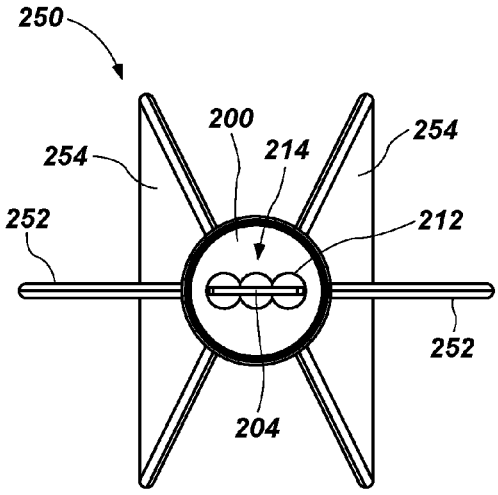

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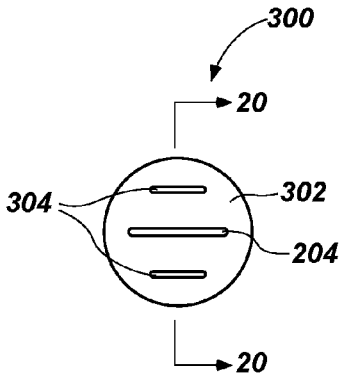

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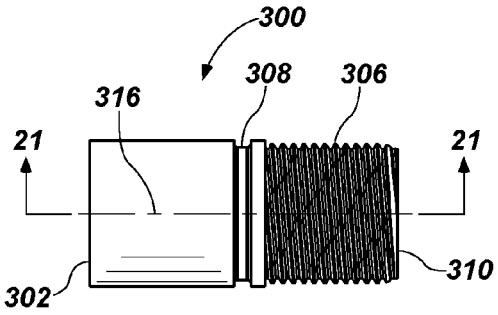

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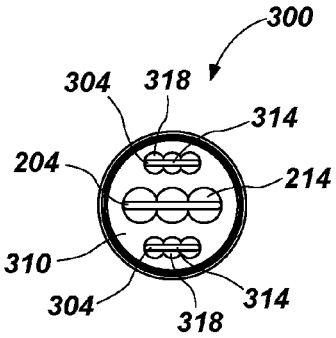

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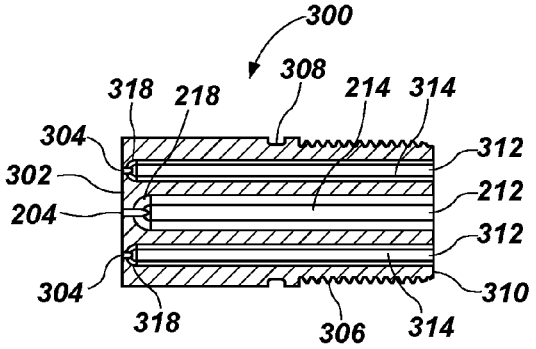

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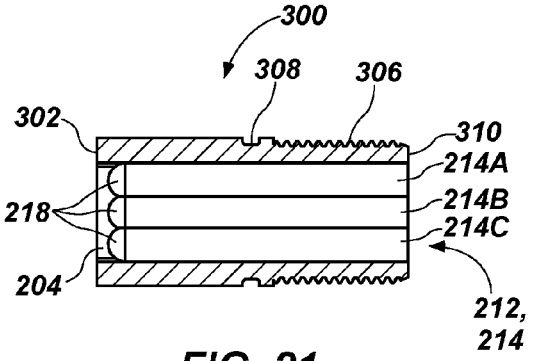

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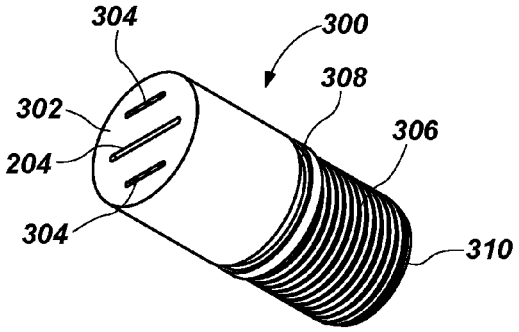

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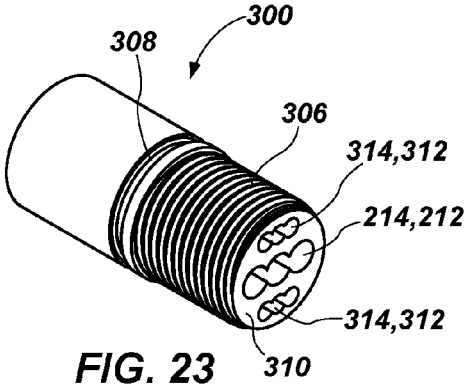

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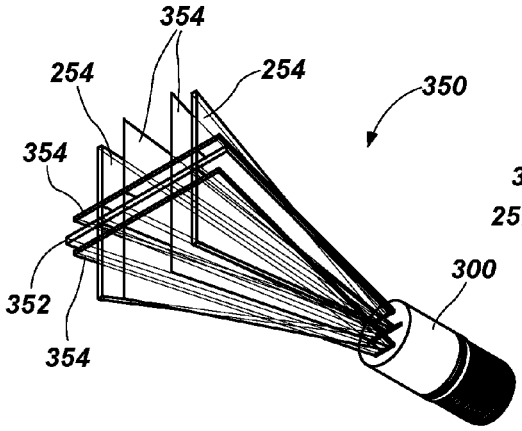

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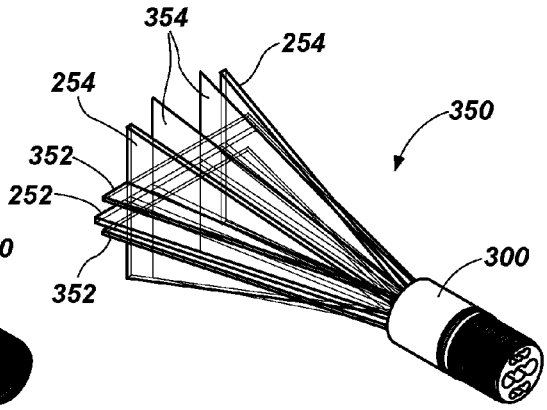

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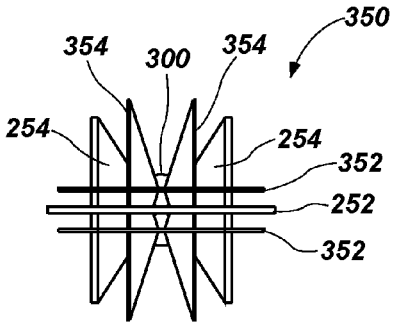

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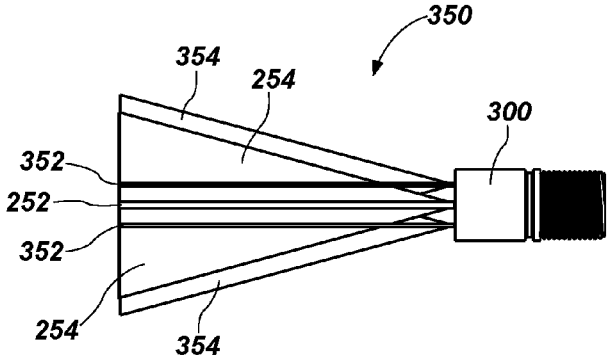

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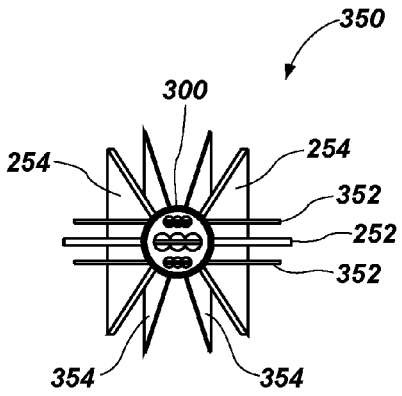

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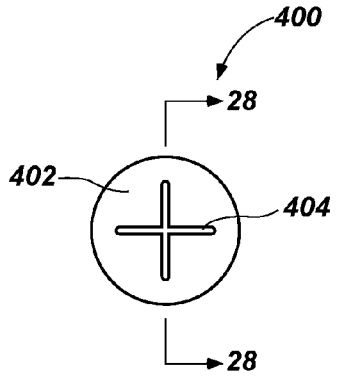

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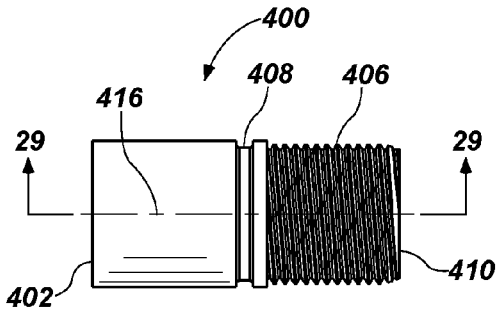
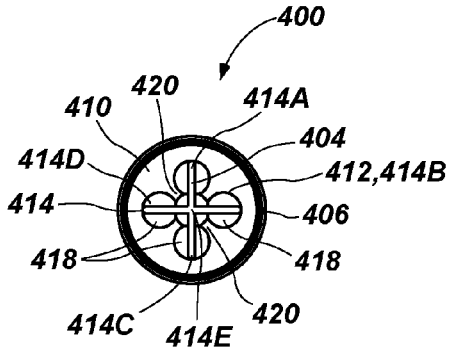


FIG. 26



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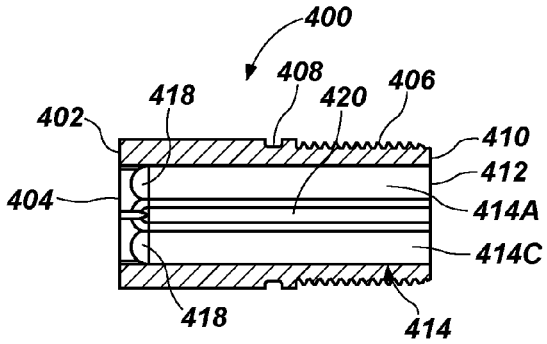

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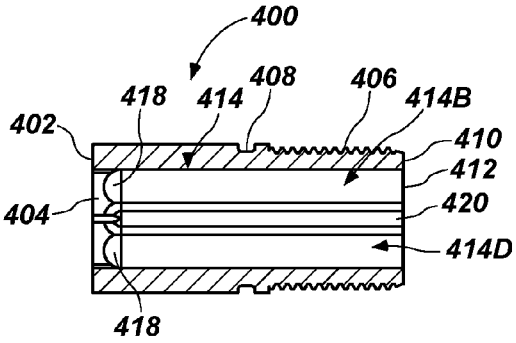

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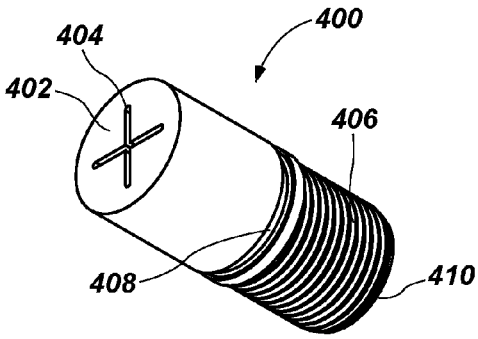
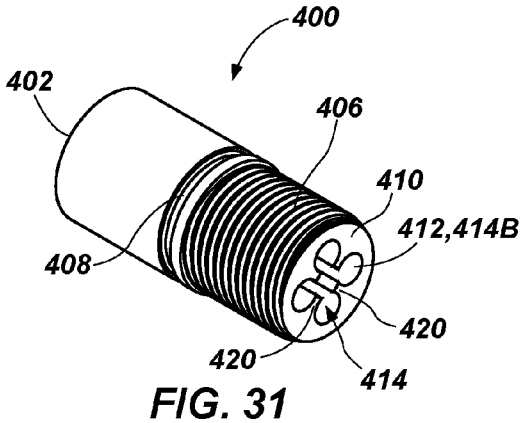


FIG. 30



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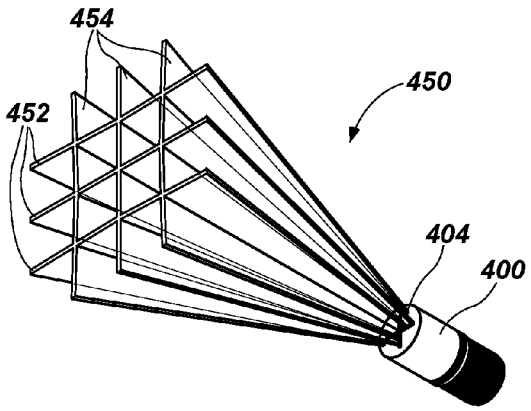
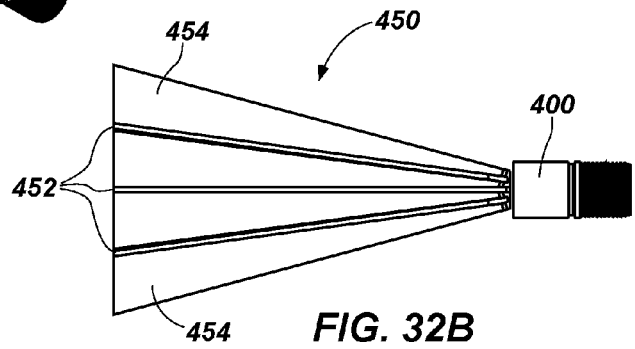


FIG. 32A



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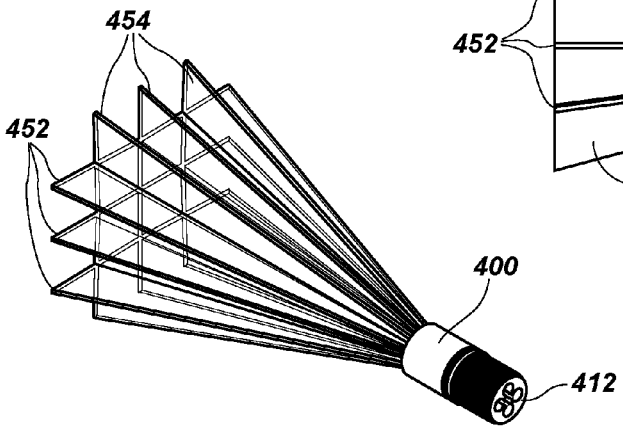

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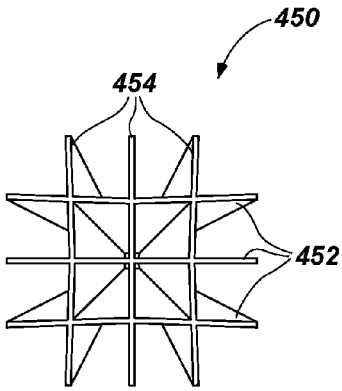

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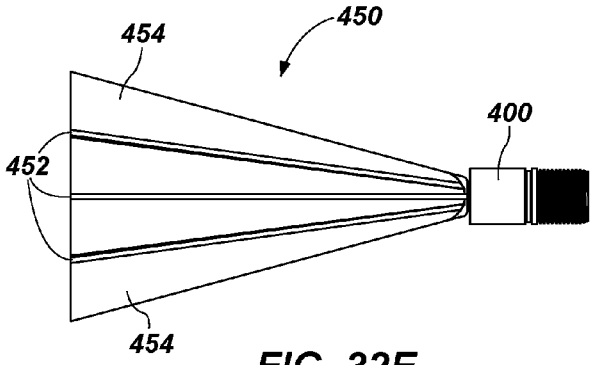

FIG. 32E

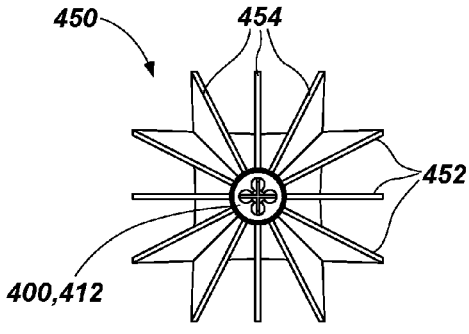

FIG. 32F

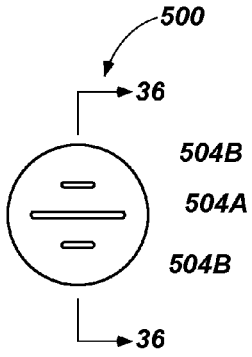

FIG. 33

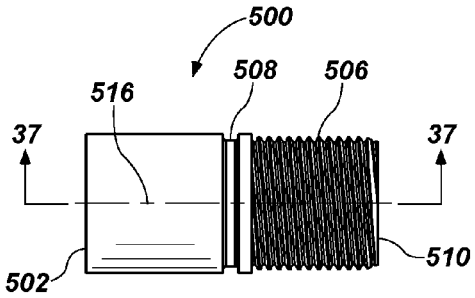

FIG. 34

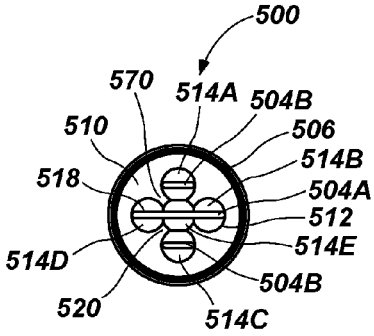

FIG. 35

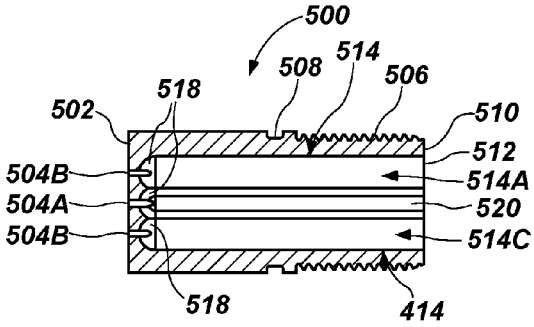

FIG. 36

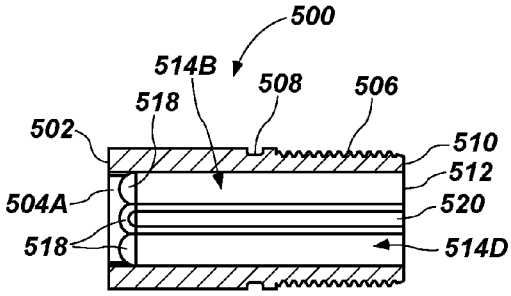

FIG. 37

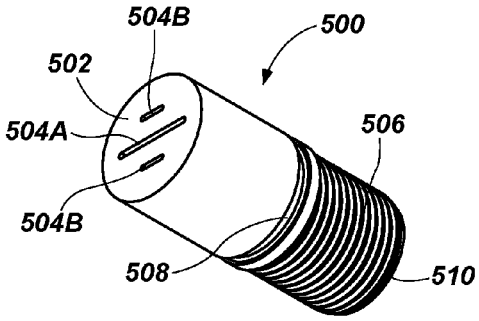

FIG. 38

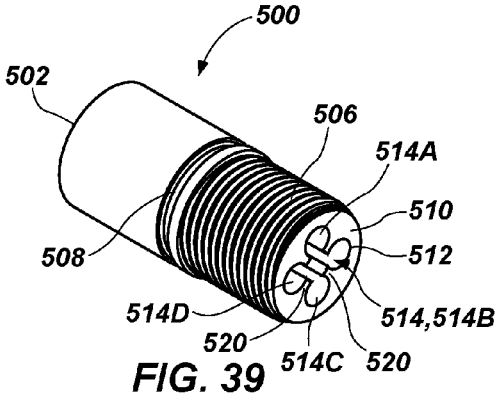

FIG. 39

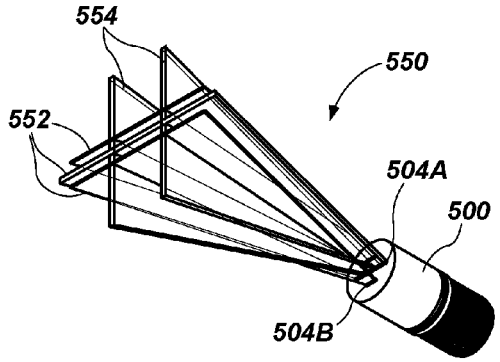

FIG. 40A

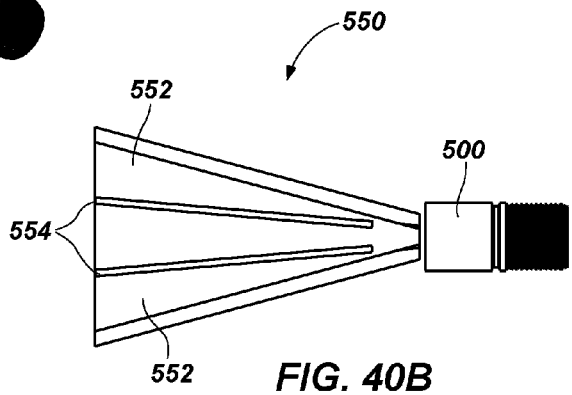

FIG. 40B

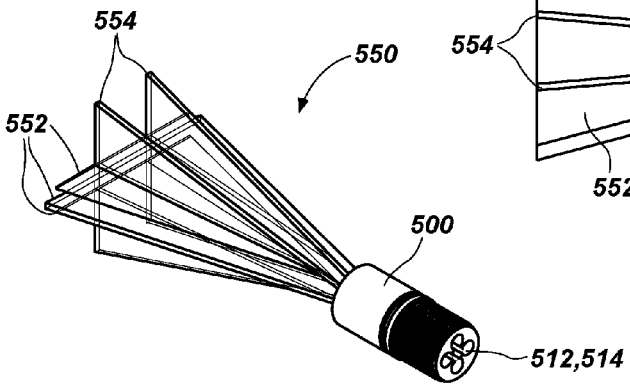

FIG. 40C

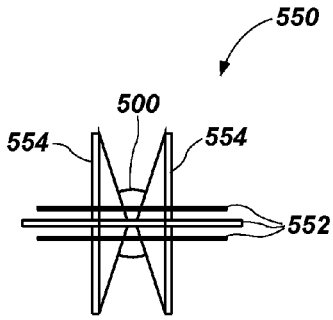

FIG. 40D

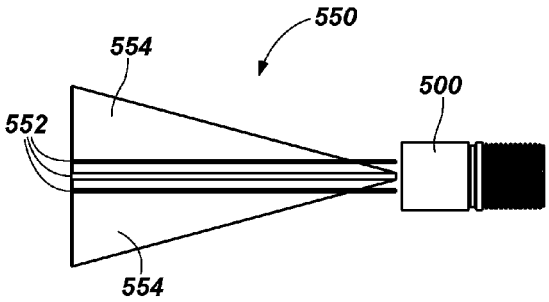

FIG. 40E

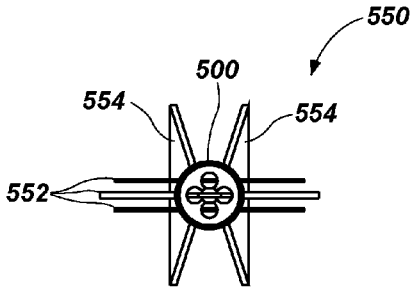

FIG. 40F

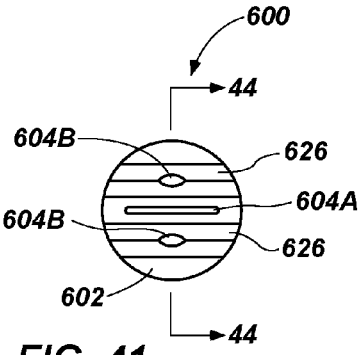

FIG. 41

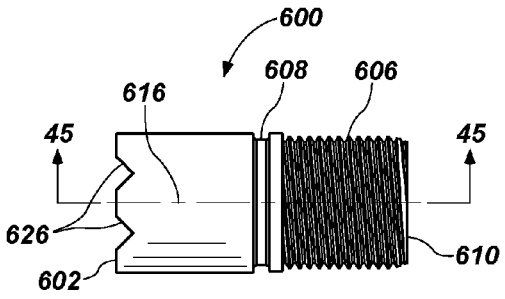

FIG. 42

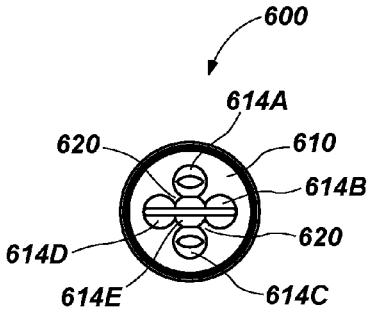

FIG. 43

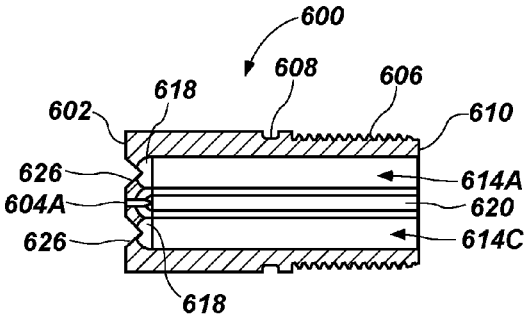

FIG. 44

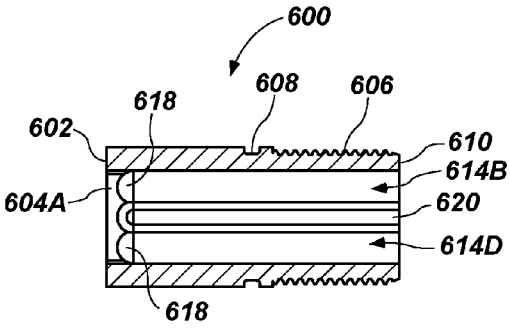

FIG. 45

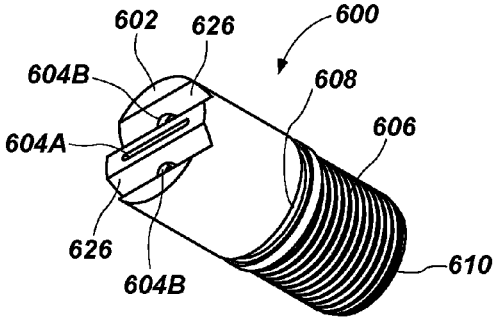

FIG. 46

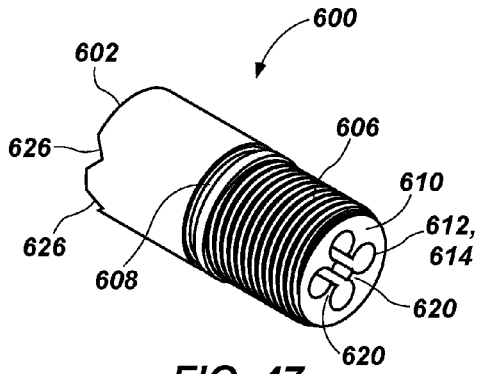

FIG. 47

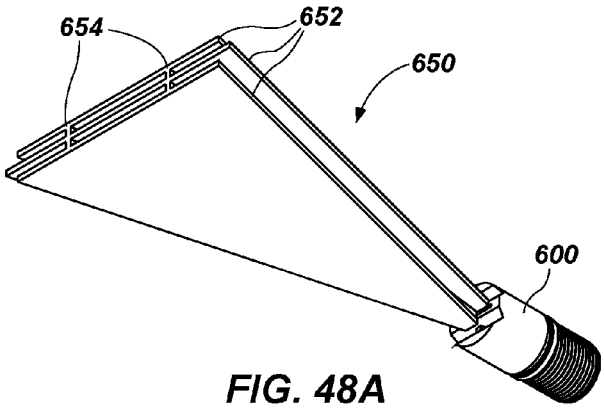

FIG. 48A

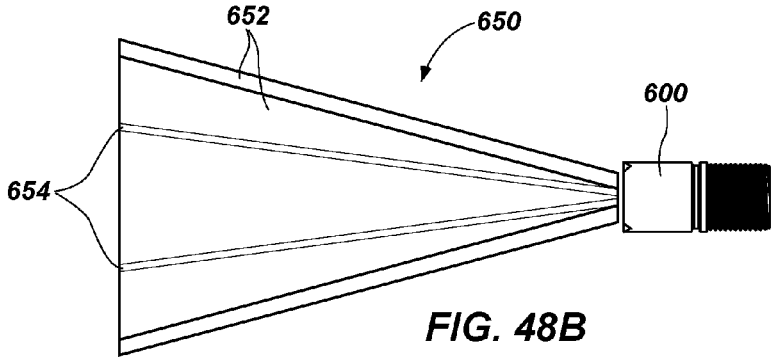

FIG. 48B

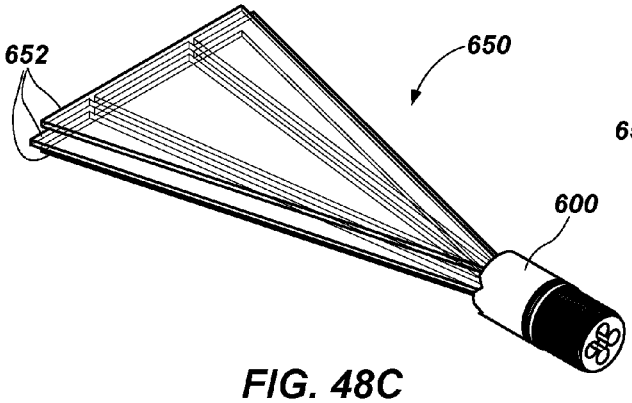

FIG. 48C

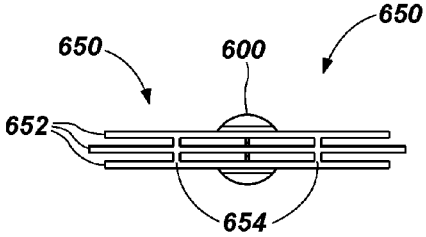

FIG. 48D

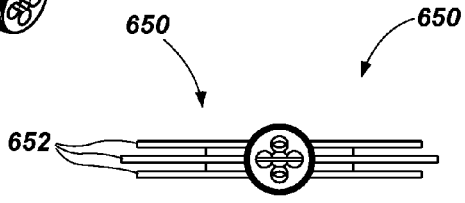

FIG. 48F

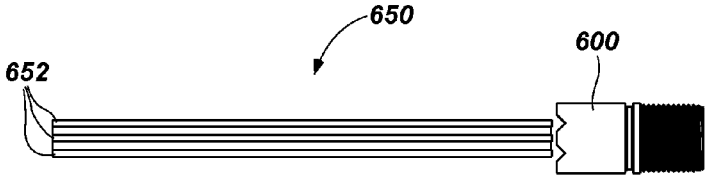

FIG. 48E

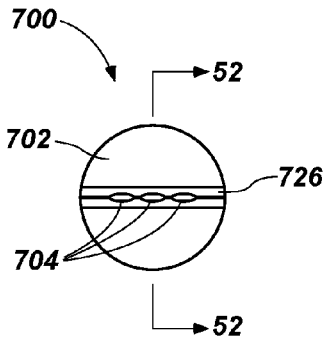

FIG. 49

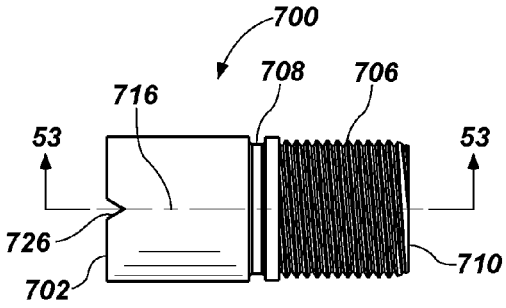

FIG. 50

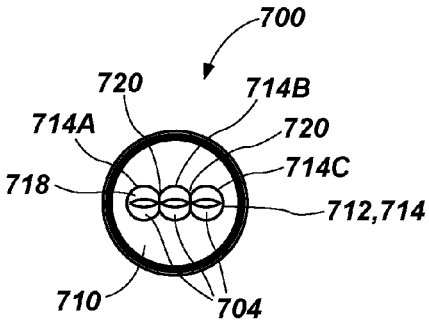

FIG. 51

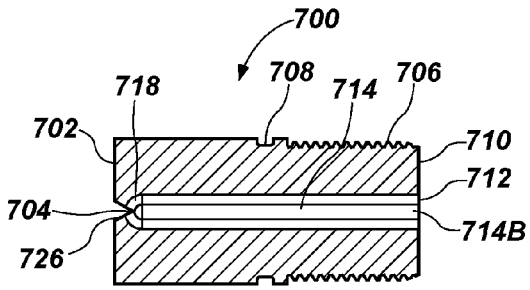

FIG. 52

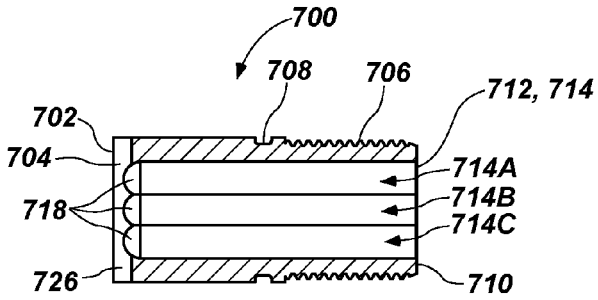

FIG. 53

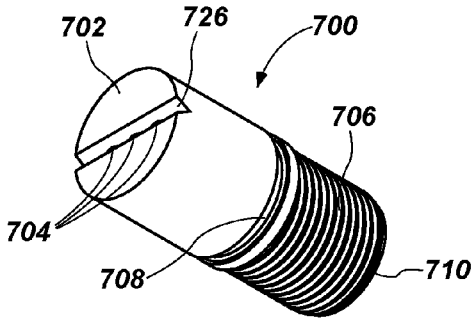

FIG. 54

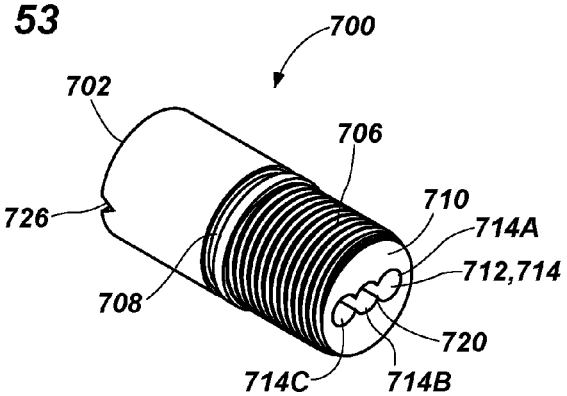

FIG. 55

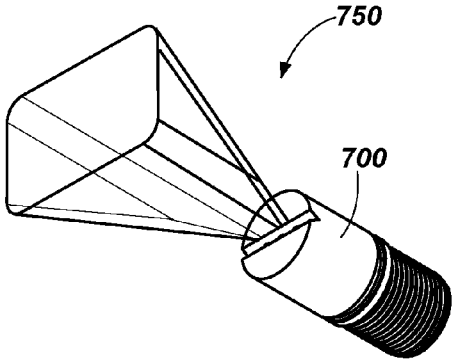

FIG. 56A

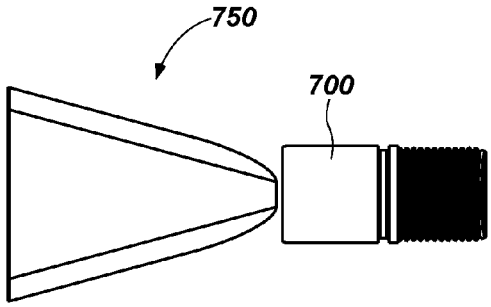

FIG. 56B

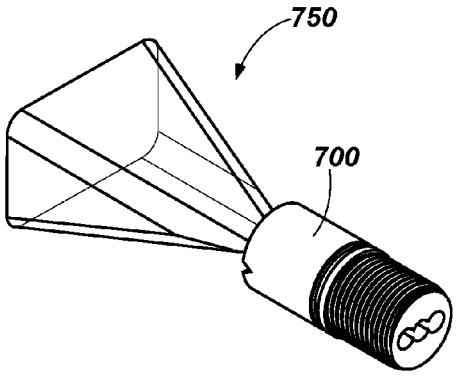

FIG. 56C

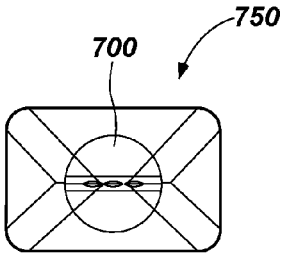

FIG. 56D

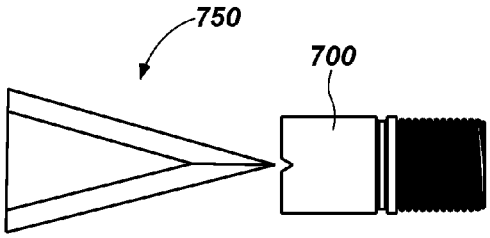

FIG. 56E

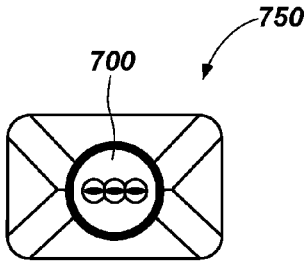

FIG. 56F

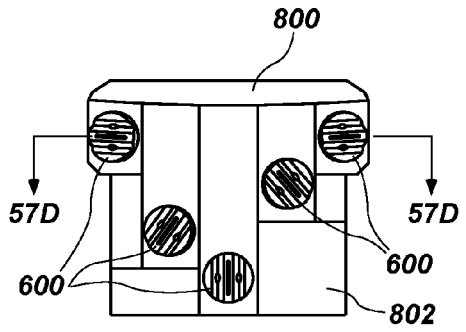

FIG. 57A

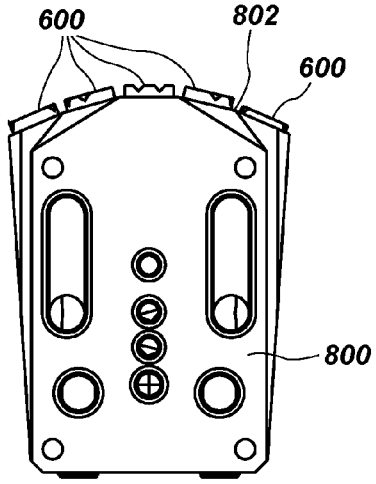

FIG. 57B

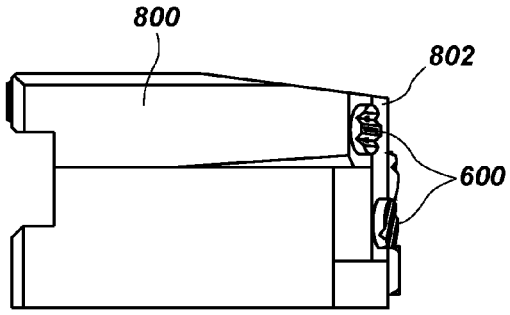

FIG. 57C

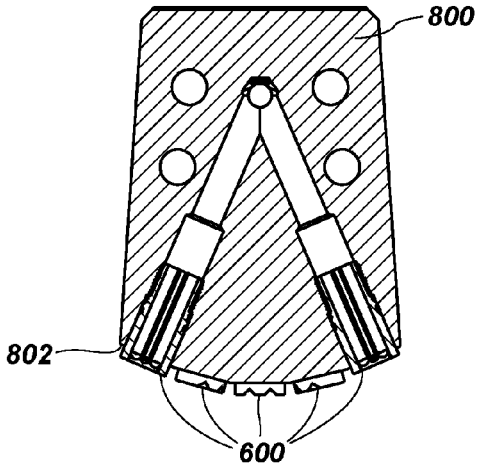

FIG. 57D

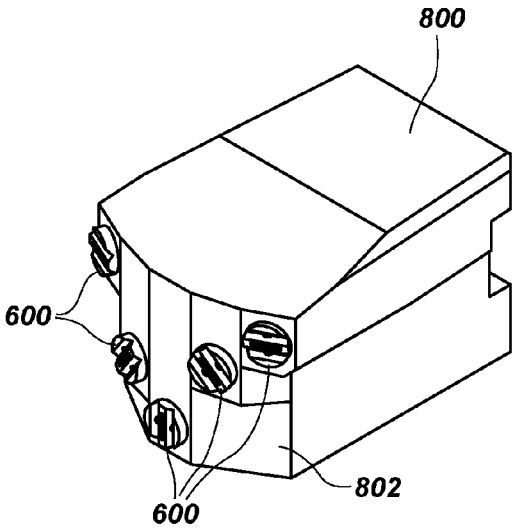

FIG. 57E

MODULAR DUAL VECTOR FLUID SPRAY NOZZLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. Divisional patent application claims priority to U.S. patent application Ser. No. 14/883,626, filed on Oct. 15, 2015, titled: "SINGLE AND MULTI-STEP SNOW-MAKING GUNS", pending, which claims priority to U.S. Nonprovisional patent application Ser. No. 14/013,582, filed, Aug. 29, 2013, titled: MODULAR DUAL VECTOR FLUID NOZZLES, issued, Apr. 25, 2017 as U.S. Pat. No. 9,631,855, which in turn claims benefit of U.S. Provisional Patent Application No. 61/694,262, filed, Aug. 29, 2012, titled: MODULAR DUAL VECTOR FLUID SPRAY NOZZLES, expired, Aug. 29, 2013 and U.S. Provisional Patent Application No. 61/694,255, filed, Aug. 29, 2012, titled: SIX-STEP SNOW-MAKING GUN, expired, Aug. 29, 2013 and U.S. Provisional Patent Application No. 61/694,250, filed, Aug. 29, 2012, titled: FOUR-STEP SNOW-MAKING GUN, expired, Aug. 29, 2013 and U.S. Provisional Patent Application No. 61/694,256, filed, Aug. 29, 2012, titled: SINGLE-STEP SNOW-MAKING GUN, expired, Aug. 29, 2013.

[0002] This U.S. Divisional patent application is further related to U.S. Non-provisional patent application Ser. No. 14/011,544, filed on Aug. 27, 2013, titled: "FLAT JET FLUID NOZZLES WITH FLUTED IMPINGEMENT SURFACES", issued on Jul. 21, 2015 as U.S. Pat. No. 9,085,003, which is a Continuation of U.S. patent application Ser. No. 12/998,141, filed on Mar. 22, 2011, titled: FLAT JET FLUID NOZZLES WITH ADJUSTABLE DROPLET SIZE INCLUDING FIXED OR VARIABLE SPRAY ANGLE, issued on Sep. 17, 2013 as U.S. Pat. No. 8,534,577, which is a National Stage of International Patent Application No. PCT/US2009/005345 filed on Sep. 25, 2009, titled: FLAT JET FLUID NOZZLES WITH ADJUSTABLE DROPLET SIZE INCLUDING FIXED OR VARIABLE SPRAY ANGLE, now expired, which in turn claims benefit and priority to Australian Provisional Patent Application No. 2008904999, filed on Sep. 25, 2008, titled: "PLUMES", also expired. The contents of all of the aforementioned patent applications are expressly incorporated by reference, for all purposes, as if fully set forth herein.

BACKGROUND OF THE INVENTION

Field of the Invention

[0003] The present invention relates generally to fluid spray nozzles. More particularly, this invention relates to modular dual vector fluid spray nozzles useful for any kind of fluid spraying application, e.g., and not by way of limitation, snowmaking, fire-suppression, fire-fighting, paint and solvent spraying.

Description of Related Art

[0004] Nozzles for converting fluids, such as water, under pressure into atomized mists, or plumes of vapor, are well known in the art. Nozzles find use in many applications, for example, irrigation, landscape watering, fire-fighting, and even solvent and paint spraying. Nozzles are also used in snowmaking equipment to provide atomized mists of water droplets of a size suitable for projection through a cold atmosphere to be frozen into snow for artificial snowmaking at ski resorts. Conventional nozzles are known to provide fluid mist jets of a particular shape of spray pattern, for example conical mist spray patterns are commonly used for garden hose nozzles. Nozzles that provide a flat jet (fan shaped) have proved particularly useful with regard to snowmaking, fire-fighting and irrigation. However, the density of spray achieved by flat jet nozzles is largely along a plane formed by the orifice and direction of trajectory, thus limiting the fluid density along directions away from this plane of trajectory.

[0005] There is a need for improved fluid spray nozzles having fluid trajectories in cross-planes. It would also be useful to have such improved nozzles that are modular without moving parts for ease of servicing and replacement within a fluid spray system. Such improved nozzles may provide greater control over the following nozzle spray variables: fluid flow rate, droplet size formed at ejection orifice, spray pattern and spray angle.

SUMMARY OF THE INVENTION

[0006] Various embodiments of dual vector fluid nozzles are disclosed. A particular embodiment of a fluid nozzle may include an integral cylindrical housing including a fluid channel having a fluid channel axis disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to a slotted orifice at a distal end. The embodiment of the fluid channel may further include a plurality of cylindrical sub-channels, each of the plurality of sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the slotted orifice. The embodiment of the fluid channel may further include each of the cylindrical sub-channels formed by a bore hole beginning from the proximate end of the cylindrical housing and ending in opposed hemispherical impingement surfaces at the slotted orifice.

[0007] Another embodiment of a fluid nozzle is disclosed. The fluid nozzle may include an integral cylindrical housing including a fluid channel disposed therein having a fluid channel axis disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to a cross-slotted orifice at a distal end. The embodiment of a fluid channel may further include a plurality of cylindrical sub-channels, each of the plurality of sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the cross-slotted orifice. The embodiment of a fluid channel may further include each of the cylindrical sub-channels formed by a bore hole beginning from the proximate end of the cylindrical housing and ending in opposed semi-spherical impingement surfaces at the cross-slotted orifice.

[0008] Still another embodiment of a fluid nozzle is disclosed. The fluid nozzle may include an integral cylindrical housing including a fluid channel having a fluid channel axis disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to a main slotted orifice at a distal end. The fluid channel may further include a plurality of cylindrical sub-channels, each of the plurality of sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the main slotted orifice or one of two secondary slotted orifices, the two secondary slotted orifices formed in the distal end of the housing and disposed parallel to, and on opposite sides of, the main slotted orifice. The fluid channel

may further include each of the cylindrical sub-channels formed by boring a hole beginning from the proximate end of the cylindrical housing and ending in opposed hemispherical impingement surfaces at one of the main or secondary slotted orifices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The following drawings illustrate exemplary embodiments for practicing the invention. Like reference numerals refer to like parts in different views or embodiments of the present invention in the drawings.

[0010] FIG. **1** is a front view of dual sub-chambered embodiment of a fluid nozzle, according to the present invention.

[0011] FIG. **2** is a right-side view of the embodiment shown in FIG. **1**, according to the present invention.

[0012] FIG. **3** is a rear view of the embodiment shown in FIGS. **1-2**, according to the present invention.

[0013] FIG. **4** is vertical section view of the embodiment shown in FIGS. **1-3** as indicated in FIG. **1**, according to the present invention.

[0014] FIG. **5** is horizontal section view of the embodiment shown in FIGS. **1-4** as indicated in FIG. **2**, according to the present invention.

[0015] FIG. **6** is a front perspective view of the embodiment shown in FIGS. **1-5**, according to the present invention.

[0016] FIG. **7** is a rear perspective view of the embodiment shown in FIGS. **1-6**, according to the present invention.

[0017] FIGS. **8**A-**8**E are rear perspective, front perspective, rear, side and front views, respectively, of an exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **1-7**, according to the present invention.

[0018] FIG. **9** is a front view of triple sub-chambered embodiment of a fluid nozzle, according to the present invention.

[0019] FIG. **10** is a right-side view of the embodiment shown in FIG. **9**, according to the present invention.

[0020] FIG. **11** is a rear view of the embodiment shown in FIGS. **9-10**, according to the present invention.

[0021] FIG. **12** is vertical section view of the embodiment shown in FIGS. **9-11** as indicated in FIG. **9**, according to the present invention.

[0022] FIG. **13** is horizontal section view of the embodiment shown in FIGS. **9-12** as indicated in FIG. **10**, according to the present invention.

[0023] FIG. **14** is a front perspective view of the embodiment shown in FIGS. **9-13**, according to the present invention.

[0024] FIG. **15** is a rear perspective view of the embodiment shown in FIGS. **9-14**, according to the present invention.

[0025] FIGS. **16**A-**16**F are rotated front, top, front perspective, front, side and rear views, respectively, of an exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **9-15**, according to the present invention.

[0026] FIG. **17** is a front view of triple-chambered embodiment of a fluid nozzle, according to the present invention.

[0027] FIG. **18** is a right-side view of the embodiment shown in FIG. **17**, according to the present invention.

[0028] FIG. **19** is a rear view of the embodiment shown in FIGS. **17-18**, according to the present invention.

[0029] FIG. **20** is vertical section view of the embodiment shown in FIGS. **17-19** as indicated in FIG. **17**, according to the present invention.

[0030] FIG. **21** is horizontal section view of the embodiment shown in FIGS. **17-20** as indicated in FIG. **18**, according to the present invention.

[0031] FIG. **22** is a front perspective view of the embodiment shown in FIGS. **17-21**, according to the present invention.

[0032] FIG. **23** is a rear perspective view of the embodiment shown in FIGS. **17-22**, according to the present invention.

[0033] FIGS. **24**A-**24**E are front perspective, rear perspective, front, side and rear views, respectively, of an exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **17-23**, according to the present invention.

[0034] FIG. **25** is a front view of cross-slotted, quintuple sub-chambered embodiment of a fluid nozzle, according to the present invention.

[0035] FIG. **26** is a right-side view of the embodiment shown in FIG. **25**, according to the present invention.

[0036] FIG. **27** is a rear view of the embodiment shown in FIGS. **25-26**, according to the present invention.

[0037] FIG. **28** is vertical section view of the embodiment shown in FIGS. **25-27** as indicated in FIG. **25**, according to the present invention.

[0038] FIG. **29** is horizontal section view of the embodiment shown in FIGS. **25-28** as indicated in FIG. **26**, according to the present invention.

[0039] FIG. **30** is a front perspective view of the embodiment shown in FIGS. **25-29**, according to the present invention.

[0040] FIG. **31** is a rear perspective view of the embodiment shown in FIGS. **25-30**, according to the present invention.

[0041] FIGS. **32**A-**32**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **25-31**, according to the present invention.

[0042] FIG. **33** is a front view of triple-slotted, quintuple sub-chambered embodiment of a fluid nozzle, according to the present invention.

[0043] FIG. **34** is a right-side view of the embodiment shown in FIG. **33**, according to the present invention.

[0044] FIG. **35** is a rear view of the embodiment shown in FIGS. **33-34**, according to the present invention.

[0045] FIG. **36** is vertical section view of the embodiment shown in FIGS. **33-35** as indicated in FIG. **33**, according to the present invention.

[0046] FIG. **37** is horizontal section view of the embodiment shown in FIGS. **33-36** as indicated in FIG. **34**, according to the present invention.

[0047] FIG. **38** is a front perspective view of the embodiment shown in FIGS. **33-37**, according to the present invention.

[0048] FIG. **39** is a rear perspective view of the embodiment shown in FIGS. **33-38**, according to the present invention.

[0049] FIGS. **40**A-**40**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an

exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **33-39**, according to the present invention.

[0050] FIG. **41** is a front view of single-slotted, quintuple sub-chambered, dual flat jet embodiment of a fluid nozzle, according to the present invention.

[0051] FIG. **42** is a right-side view of the embodiment shown in FIG. **41**, according to the present invention.

[0052] FIG. **43** is a rear view of the embodiment shown in FIGS. **41-42**, according to the present invention.

[0053] FIG. **44** is vertical section view of the embodiment shown in FIGS. **41-43** as indicated in FIG. **41**, according to the present invention.

[0054] FIG. **45** is horizontal section view of the embodiment shown in FIGS. **41-44** as indicated in FIG. **42**, according to the present invention.

[0055] FIG. **46** is a front perspective view of the embodiment shown in FIGS. **41-45**, according to the present invention.

[0056] FIG. **47** is a rear perspective view of the embodiment shown in FIGS. **41-46**, according to the present invention.

[0057] FIGS. **48**A-**48**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **41-47**, according to the present invention.

[0058] FIG. **49** is a front view of single-slotted, quintuple sub-chambered, dual flat jet embodiment of a fluid nozzle, according to the present invention.

[0059] FIG. **50** is a right-side view of the embodiment shown in FIG. **49**, according to the present invention.

[0060] FIG. **51** is a rear view of the embodiment shown in FIGS. **49-50**, according to the present invention.

[0061] FIG. **52** is vertical section view of the embodiment shown in FIGS. **49-51** as indicated in FIG. **49**, according to the present invention.

[0062] FIG. **53** is horizontal section view of the embodiment shown in FIGS. **49-52** as indicated in FIG. **50**, according to the present invention.

[0063] FIG. **54** is a front perspective view of the embodiment shown in FIGS. **49-53**, according to the present invention.

[0064] FIG. **55** is a rear perspective view of the embodiment shown in FIGS. **49-54**, according to the present invention.

[0065] FIGS. **56**A-**56**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary peak spray density pattern achieved by the embodiment of a fluid nozzle shown in FIGS. **49-55**, according to the present invention.

[0066] FIGS. **57**A-**57**E are front, bottom, left, cross-section and perspective views of a modular nozzle head, according to the present invention.

DETAILED DESCRIPTION

[0067] Various embodiments of dual vector fluid spray nozzles are disclosed herein. The novel nozzles are useful in any application where the conversion of a bulk fluid is desired to be atomized and sprayed. A non-exhaustive list of such applications may include: (1) the conversion of bulk water into fine atomized water particles for projection into a cold atmosphere with or without nucleation particles for the formation of artificial snow, (2) the conversion of bulk water into fine atomized water particles for projection onto burning objects for fire-fighting, fire control and fire suppression, (3) the conversion of bulk water into fine atomized water particles for projection into the atmosphere on restaurant patios for evaporative cooling, (4) the conversion of bulk oil into fine atomized oil mists for spraying onto mechanical parts for lubrication and corrosion control, and (5) the conversion of bulk solvent into fine atomized solvent particle spray mists for use in cleaning objects of any sort, (6) the conversion of bulk paint into fine atomized paint sprays for coating objects of any sort. One of ordinary skill in the art and given this disclosure will readily comprehend the vast number of possible applications for the nozzle technology disclosed herein. The application of this nozzle technology to such other possible, but not expressly disclosed, applications falls within the scope and spirit of this invention and its claims.

[0068] The various embodiments of dual vector fluid spray nozzles disclosed herein may be used with any suitable nozzle head, fluid delivery apparatus or fixture. Importantly, the technology disclosed herein is not limited to the type of nozzle head, fluid delivery apparatus, fixture or even the type of fluid used in the fluid spray nozzles. However, generally speaking, fluids which have low viscosity and can be readily formed into fine atomized particles are generally preferred fluids for use with the novel dual vector fluid spray nozzles disclosed herein.

[0069] The exemplary embodiments of dual vector fluid spray nozzles disclosed herein may be formed of any suitable material, e.g., and not by way of limitation, aluminum, stainless steel, titanium, brass or any other hard material that can be shaped as disclosed herein and withstand high pressure fluids passing through their intake ports, fluid chambers and exit orifices without, breaking, bending or flexing. The exemplary embodiments of dual vector fluid spray nozzles shown in the drawings will be described first, followed by more general embodiments and variations described subsequently.

[0070] Reference will now be made to FIGS. **1-7** of the drawings, which illustrate various views of an embodiment of a dual sub-chambered fluid nozzle **100**. From FIGS. **1-7**, it can be seen that nozzle **100** is generally cylindrical in nature. More particularly, FIG. **1** is a front view of an embodiment of a dual sub-chambered fluid nozzle **100**, according to the present invention. The cross-section of face **102** of nozzle **100** may be generally circular as shown in FIG. **1**. However, other cross-sectional variations of face **102** are contemplated, e.g., and not by way of limitation, square, pentagonal, hexagonal, octagonal, etc. Such other cross-sections may be particularly useful during installation and removal of the nozzle **100** from its fixture or nozzle head (see, e.g., **800**, FIGS. **57**A-**57**E.) For example, and not by way of limitation, square, hexagonal and octagonal shaped cross-sections may readily mate with wrenches or other tools used to install and remove the nozzles **100** from a fixture (not shown). FIG. **1** further illustrates a slotted orifice **104** in the face **102** of nozzle **100**.

[0071] FIG. **2** is a right-side view of the embodiment of nozzle **100** shown in FIG. **1**, according to the present invention. FIG. **2** shows threading **106** located along the intake port end **110** of nozzle **100** that is configured to mate with an opening or socket (not shown) in a suitable fixture, e.g., a water nozzle head (also not shown). FIG. **2** also illustrates a circular sealing groove **108** located circumfer-

entially around nozzle **100** and located between the face **102** and intake port end **110**. Circular sealing groove **108** is configured to receive an O-ring (not shown) used to form a water tight seal between the nozzle **100** and the fixture (not shown) to which the nozzle **100** is mated. Threading **106** is located between circular sealing groove **108** and intake port end **110**.

[0072] FIG. **3** is a rear view of the embodiment of nozzle **100** shown in FIGS. **1-2**, according to the present invention. From the rear view of nozzle **100**, as shown in FIG. **3**, the outline of the intake port **112** shows both of the dual sub-chambers **114**A and **114**B that are bored into the nozzle **100**. The dual sub-chambers **114**A and **114**B may be formed parallel to one another by boring into nozzle **100** from the intake port end **110** in a direction parallel to the longitudinal axis **116** shown in dashed line in FIG. **2** and ending before reaching face **102** (FIGS. **1** and **2**). Each of the dual sub-chambers **114**A and **114**B may be formed using a hemispherical boring tool that forms a hemispherical impingement surface (best shown in FIG. **5** at reference **118** as discussed below) adjacent to the slotted orifice **104**. The intersection of the dual sub-chambers **114**A and **114**B are opposing ridges **120** that are located between the dual sub-chambers **114**A and **114**B.

[0073] FIG. **4** is vertical cross-section view, as indicated in FIG. **1**, of the embodiment of nozzle **100** shown in FIGS. **1-3**, according to the present invention. FIG. **4** illustrates the threading **106** and circular sealing groove **108** shown in FIG. **2**. FIG. **4** further illustrates a gap **122** between the opposing ridges **120** shown in FIG. **3** formed, e.g., by removing or boring along the longitudinal axis **116** with a smaller diameter boring tool (drill bit) than use to form the dual sub-chambers **114**A and **114**B. The gap **122** begins at the intake port end **110** and ends at the slotted orifice **104** before reaching the face **102**. Fluid chamber **114** comprises the combination of the dual sub-chambers **114**A and **114**B.

[0074] FIG. **5** is horizontal cross-section view as indicated in FIG. **2** of the embodiment of a nozzle **100** shown in FIGS. **1-4**, according to the present invention. FIG. **5** illustrates the generally cylindrical shape of the dual sub-chambers **114**A and **114**B and the hemispherical impingement surfaces **118** of the dual sub-chambers **114**A and **114**B adjacent to the slotted orifice **104**. FIG. **5** also illustrates the threading **106** and circular sealing groove **108** of nozzle **100**.

[0075] FIG. **6** is a front perspective view of the embodiment of a nozzle **100** shown in FIGS. **1-5**, according to the present invention. The face **102**, slotted orifice **104**, circular sealing groove **108**, threading **106** and intake port end **110** of nozzle **100** are shown in FIG. **6**.

[0076] FIG. **7** is a rear perspective view of the embodiment of a nozzle **100** shown in FIGS. **1-6**, according to the present invention. The intake port **112** formed in intake port end **110**, opposing ridges **120** between the dual sub-chambers **114**A and **114**B, threading **106**, circular sealing groove **108** and face **102** of nozzle **100** are also shown in FIG. **7**.

[0077] Operation and fluid flow of nozzle **100** is described as follows: Pressurized fluid enters into the intake port **112** from a fixture or nozzle head (not shown) to which the nozzle **100** has been mated via threading **106**. The fluid entering the intake port **112** then runs through the dual sub-chambers **114**A and **114**B toward the hemispherical impingement surfaces **118**, where the laminar flow of the fluid is forced to impinge from above and below the slotted orifice **104** before exiting at high velocity as atomized fluid particles as a mist or cloud. Each of the dual sub-chambers **114**A and **114**B generates a flat jet spray pattern independently and along the plane of the slotted orifice **104**. However, a particularly novel and unique feature of this dual sub-chambered nozzle **100** configuration is the interaction of the two independent flat jet fluid sprays which impinge against each other outside of the slotted orifice **104** and generate a vertical component to the spray pattern in addition to the horizontal component, the combination of which is referred to herein as a "dual vector" spray pattern.

[0078] This dual vector spray pattern is illustrated in FIGS. **8**A-**8**E. More particularly, FIGS. **8**A-**8**E are rear perspective, front perspective, rear, side and front views, respectively, of an exemplary composite peak spray density pattern **150** achieved by the embodiment of a dual sub-chambered fluid nozzle **100** shown in FIGS. **1-7**, according to the present invention. As noted above, the dual sub-chambers **114**A and **114**B each generate a horizontal fluid spray pattern **152** in a plane containing the slotted orifice **104**. Whereas, the interaction of the two independent flat jet fluid sprays adjacent to each other, which impinge against each other outside of the slotted orifice **104**, generate a vertical component or vertical fluid spray pattern **204**. The combination of the horizontal **152** and vertical **154** spray patterns is referred to herein as a "dual vector" spray pattern, which is believed to be unique and nonobvious in the art. Generally speaking, the dual vectored fluid nozzles disclosed herein, e.g., nozzle **100**, have an exemplary composite peak spray density pattern **150** that is comprised of horizontal **152** and vertical **154** spray patterns that diverge radially in a direction away from the exit orifice.

[0079] The peak spray density patterns herein are all shown truncated after leaving the slotted orifice in order to illustrate horizontal and vertical (perpendicular) dual vector peak density spray patterns. It will be understood that the spray patterns will eventually disperse in atmosphere and form more random cloud or mist patterns the further away from the exit orifice. This is because the dual vector peak density spray patterns will eventually be acted upon by ambient air turbulence, friction against ambient air molecules or other objects, or disturbed by other forces that may act upon the fluid jets after exiting the nozzle.

[0080] Though the terms horizontal and vertical are used herein, it will be readily apparent to one of ordinary skill in the art that a horizontal spray pattern **152** may not necessarily coincide with gravitational horizontal. The same can be said for the vertical spray pattern **154** not necessarily coinciding with gravitational vertical. The key relationship between the horizontal **152** and vertical **154** spray patterns is that their peak spray densities are oriented perpendicular to one another as illustrated in FIGS. **8**A-**8**E.

[0081] Referring now to FIGS. **9-15**, an embodiment of a triple sub-chambered fluid nozzle **200** will be described. From FIGS. **9-15**, it can be seen that nozzle **200** is generally cylindrical in nature. More particularly, FIG. **9** is a front view of triple sub-chambered embodiment of a fluid nozzle **300**, according to the present invention. The cross-section of face **202** of nozzle **200** may be generally circular as shown in FIG. **9**. However, other cross-sectional variations of face **202** (like face **102** discussed above) are contemplated, e.g., and not by way of limitation, square, pentagonal, hexagonal, octagonal, etc. and considered to be within the scope of the present invention.

[0082] Such other cross-sections may be particularly useful during installation and removal of the nozzle **100** from its fixture. For example square, hexagonal and octagonal shaped cross-sections at face **202** or located circumferentially anywhere between the face **202** and circular sealing groove **208**, may readily mate with wrenches or other tools used to install and remove the nozzles **100** from a fixture (not shown). Such other cross-sections are intentionally not illustrated herein to simplify the numerous drawings. FIG. **9** further illustrates a slotted orifice **204** and pin spanner holes **224** in the face **202** of nozzle **200**. The pin spanner holes **224** shown in FIGS. **9**, **12** and **14** may be used with a pin spanner wrench or other similar tool to install or remove nozzle **200** from a nozzle head or other fixture to which is it mated using threads **206**, according to one embodiment.

[0083] FIG. **10** is a right-side view of the embodiment of fluid nozzle **200** shown in FIG. **9**, according to the present invention. FIG. **10** shows threading **206** located along the intake port end **210** of nozzle **200** that is configured to mate with an opening or socket (not shown) in a suitable fixture, e.g., a water nozzle head (also not shown). FIG. **10** also illustrates a circular sealing groove **208** located circumferentially around nozzle **200** and located between the face **202** and intake port end **210**. Circular sealing groove **208** is configured to receive an O-ring (not shown) used to form a water tight seal between the nozzle **200** and the fixture (not shown) to which the nozzle **200** is mated using threading **206**. Threading **206** may be located between circular sealing groove **108** and intake port end **110**, according to the illustrated embodiment.

[0084] FIG. **11** is a rear view of the embodiment of nozzle **200** shown in FIGS. **9-10**, according to the present invention. From the rear view of nozzle **200**, as shown in FIG. **11**, the outline of the intake port **212** shows three sub-chambers **214**A-C that may be bored into the nozzle **200** from the intake port end **210**. The triple sub-chambers **214**A-C may be formed parallel to one another by boring into nozzle **200** from the intake port end **210** in a direction parallel to the longitudinal axis **216** shown in dashed line in FIG. **10** and ending before reaching face **202** (see, e.g., FIGS. **9-10** and **12-13**). Each of the triple sub-chambers **214**A-C may be formed using a hemispherical boring tool (drill bit) that forms a hemispherical impingement surface (best shown in FIGS. **12-13** at reference **218** as discussed below) adjacent to the slotted orifice **204**. The adjacent intersections of the triple sub-chambers **214**A-C are opposing ridges **220** (two pairs) that are located between adjacent the triple sub-chambers **214**A-C.

[0085] FIG. **12** is vertical section view as indicated in FIG. **9** of the embodiment of nozzle **200** shown in FIGS. **9-11**, according to the present invention. FIG. **12** illustrates the threading **206** and circular sealing groove **208** also shown in FIGS. **10** and **13-15**. FIG. **12** further illustrates a gap **222** between the opposing ridges **220** shown in FIGS. **11** and **15**. The gap **222** begins at the intake port end **210** and ends at the slotted orifice **204** before reaching the face **202**. The fluid chamber, shown generally at arrow **214**, comprises the combination of all three of the triple sub-chambers **214**A-C.

[0086] FIG. **13** is horizontal section view as indicated in FIG. **10** of the embodiment of nozzle **200** shown in FIGS. **9-12**, according to the present invention. FIG. **13** illustrates the generally elongated cylindrical shape of the triple sub-chambers **214**A-C and the hemispherical impingement surfaces **218** of the triple sub-chambers **214**A-C adjacent to slotted orifice **204**. Opposing ridges **220** appear as lines running longitudinally in FIG. **13**. FIG. **13** also illustrates the threading **206** and circular sealing groove **208** of nozzle **200**.

[0087] FIG. **14** is a front perspective view of the embodiment of nozzle **200** shown in FIGS. **9-13**, according to the present invention. The face **202**, slotted orifice **204**, pin spanner holes **224** (two shown), circular sealing groove **208**, threading **206** and intake port end **210** of nozzle **200** are shown in FIG. **14**.

[0088] FIG. **15** is a rear perspective view of the embodiment of nozzle **200** shown in FIGS. **9-14**, according to the present invention. The intake port **212** formed in intake port end **210**, opposing ridges **220** between the triple sub-chambers **214**A-C, threading **206**, circular sealing groove **208** and face **202** of nozzle **200** are also shown in FIG. **15**.

[0089] FIGS. **16**A-**16**F are rotated front, top, front perspective, front, side and rear views, respectively, of an exemplary composite peak spray density pattern **250** achieved by the embodiment of a fluid nozzle **200** shown in FIGS. **9-15**, according to the present invention. Each of the triple sub-chambers **214**A-C will generate an independent flat jet spray pattern exiting from the slotted orifice **204** in a horizontal spray pattern **252** largely in a plane that includes the slotted orifice **204**. Further and uniquely to the embodiments of dual vectored nozzles disclosed herein, the interference caused by the intersection of those horizontally oriented spray patterns **152** will generate vertically oriented spray patterns **254**. Again, the terms horizontal and vertical are not necessarily referenced to gravitational horizontal and vertical, but are simply perpendicular relative to one another. The naming convention used herein is to associate the term horizontal with a plane including the slotted orifice **204** and vertical with spray densities that are generally perpendicular to the plane including the slotted orifice **204**. It will be understood that the nozzles disclosed herein may be oriented in any suitable direction for any suitable purpose.

[0090] Accordingly, FIGS. **16**A-F illustrate an exemplary composite dual vector spray pattern shown generally at arrow **250** and generated by nozzle **200** that is comprised of a horizontal spray pattern **252** and two vertical spray patterns **254**. Note that the vertical spray patterns **254** are oriented generally perpendicular to the horizontal spray pattern **252**. The origination of each of the two vertical spray patterns **254** corresponds to the intersections of flat jet spray patterns from adjacent sub-chambers **214**A-C. The two vertical spray patterns **254** may also roughly correspond to the two opposed pairs of ridges **220** formed within the fluid chamber, shown generally at arrow **214** in FIGS. **12** and **16**F, comprising all three sub-chambers **214**A-C.

[0091] Referring now to FIGS. **17-23**, an embodiment of a triple-chambered fluid nozzle **300** is shown in various views. Nozzle **300** shares the triple sub-chambered fluid chamber **214** structure illustrated and described with reference to nozzle **200** above. However, nozzle **300** further includes two additional triple sub-chambered fluid chambers **314**, one displaced vertically above and one displaced vertically below fluid chamber **214**, and each fluid chamber **314** having smaller dimensions than fluid chamber **214**. Since the fluid chambers **214** and **314** have generally the same structure and operation as fluid chamber **214** of nozzle **200**, the focus of the discussion below with respect to nozzle **300** will be on the distinctive new features, or differences, of the structure and resulting fluid spray patterns relative to nozzles **100** and **200** disclosed above.

[0092] FIG. **17** is a front view of an embodiment of a triple-chambered fluid nozzle **300**, according to the present invention. As shown in FIG. **17**, face **302** includes main slotted orifice **204** and two smaller slotted orifices **304**, vertically displaced above and below the main slotted orifice **204** along the dashed line indicated for the cross-sectional view in FIG. **20**. Note that unlike nozzle **200**, there are no pin spanner holes **224** formed in the face **302** of nozzle **300**, because that is where the smaller slotted orifices **304** reside.

[0093] FIG. **18** is a right-side view of the embodiment of nozzle **300** shown in FIG. **17**, according to the present invention. Like other nozzle embodiments, nozzle **300** may include threading **306** and circular sealing groove **308** located between face **302** and intake port end **310** of nozzle **300**. The view of nozzle **300** in FIG. **18** is essentially identical to the view of nozzle **200** in FIG. **10**.

[0094] FIG. **19** is a rear view of the embodiment of nozzle **300** shown in FIGS. **17-18**, according to the present invention. FIG. **19** clearly shows the three independent fluid chambers, namely the center fluid chamber **214** and the vertically disposed smaller fluid chambers **314**, each with its respective slotted orifices, **204** and **304**. Thus, nozzle **300** may be capable of independent driving of each of the three fluid chambers **214** and **314** using appropriate valving (not shown) in the fixture to which the nozzle **300** is affixed by threading **306**.

[0095] FIG. **20** is vertical section view as indicated in FIG. **17** of the embodiment of nozzle **300** shown in FIGS. **17-19**, according to the present invention. FIG. **20** illustrates each of the three fluid chambers **214** (one main fluid chamber) and **314** (two smaller fluid chambers) in cross-section. Each of the three fluid chambers **214** (one main fluid chamber) and **314** (two smaller fluid chambers) is configured to receive pressurized fluid at the intake port end **310** at each respective intake port **212** and **312**. In operation, the pressurized fluid may be driven through each of the three fluid chambers **214** (one main fluid chamber) and **314** (two smaller fluid chambers) until the laminar flow of the fluid is forced to impinge at the hemispherical impingement surfaces **218** and **318** (two smaller impingement surfaces associated with smaller fluid chambers **314**) before exiting a respective slotted orifices **204** and **304** (two smaller slotted orifices).

[0096] FIG. **21** is horizontal section view as indicated in FIG. **18** of the embodiment of nozzle **300** shown in FIGS. **17-20**, according to the present invention. Note that the view of nozzle **300** shown in FIG. **21** is essentially identical to the view of nozzle **200** shown in FIG. **13**, because they both are section views of the same triple sub-chambered fluid chamber **214**.

[0097] FIG. **22** is a front perspective view of the embodiment of nozzle **300** shown in FIGS. **17-21**, according to the present invention. The face **302**, main slotted orifice **204**, both smaller slotted orifices **304**, circular sealing groove **308**, threading **306** and intake port end **310** of nozzle **300** are shown in FIG. **22**.

[0098] FIG. **23** is a rear perspective view of the embodiment of nozzle **300** shown in FIGS. **17-22**, according to the present invention. The intake port **212** formed in intake port end **310**, and main fluid chamber **214** are essentially identical to those shown in FIG. **15**. The two smaller fluid chambers **314** having smaller intake ports **312** formed in the intake port end **310** are also shown in FIG. **23**, along with the threading **306** and circular sealing (O-ring) groove **308**.

[0099] FIGS. **24**A-**24**E are front perspective, rear perspective, front, side and rear views, respectively, of an exemplary composite peak spray density pattern **350** achieved by the embodiment of a fluid nozzle **300** shown in FIGS. **17-23**, according to the present invention. The composite peak spray density pattern **350** shown in FIGS. **24**A-**24**E include the supposition of the spray patterns originating from each of the two smaller slotted orifices **304** with the spray patterns show for the main orifice **204** illustrated in FIGS. **16**A-**16**F. Each of the fluid chambers **214** (main chamber) and **314** (two smaller chambers) will generate a single horizontal spray with two vertical spray patterns. More particularly, the vertical components of the two smaller slotted orifices **304** will be along the same two vertical planes **354** inside of the two vertical planes **254** generated by the main slotted orifice **204**, because of the smaller geometry associated with the smaller slotted orifices. Note that the horizontal components **252** (one associated with main slotted orifice **204**) and **352** (two, one each associated with each smaller slotted orifice) all fall along planes containing their respective slotted orifices **204** and **304**.

[0100] From a comparison of the spray patterns (FIGS. **16**A-**16**F) generated by nozzle **200** to the spray patterns (FIGS. **24**A-**24**E) generated by nozzle **300**, the increased fluid spray density becomes visually apparent with the more fluid chambers and slotted orifices. Thus, knowledge about the resulting spray patterns from various nozzle configurations may be configured to generate virtually unlimited fluid peak density spray patterns. Additional such combinations and configurations are shown and described below.

[0101] For example, suppose one started with the triple sub-chambered fluid chamber **214** of nozzle **200** and superimposed the same triple sub-chambered fluid chamber **214** rotated 90° about the longitudinal axis **216**. The resulting fluid chamber **414** would include a quintuple sub-chambered embodiment of a fluid nozzle with cross-slotted exit orifice according to the present invention as shown in FIGS. **25-31** and as described further below.

[0102] FIG. **25** is a front view of such a cross-slotted, quintuple sub-chambered embodiment of a fluid nozzle **400**, according to the present invention. More particularly, FIG. **25** illustrates an embodiment of a cross-slotted orifice **404** in face **402** of nozzle **400**.

[0103] FIG. **26** is a right-side view of the embodiment of nozzle **400** shown in FIG. **25**, according to the present invention. More particularly, FIG. **26** illustrates the threading **406**, located between circular sealing groove **408** and intake port end **410** (opposite face **402**). Groove **408** is configured to receive an O-ring (not shown) for sealing nozzle **400** to a fixture (not shown) using threading **406**. The longitudinal axis **416** shown in dashed line in FIG. **26** is also the section view line for FIG. **29**, described below.

[0104] FIG. **27** is a rear view of the embodiment of nozzle **400** shown in FIGS. **25-26**, according to the present invention. More particularly, FIG. **27** illustrates an embodiment of a cloverleaf intake port **412** leading into cloverleaf cross-sectioned fluid chamber **414**, comprised of five sub-chambers **414**A-E, then to hemispherical impingement surfaces **418** (five smaller circular objects) that force laminar fluid flows from internal surfaces of the fluid chamber **414** to impinge against each other before exiting as atomized fluid particles at the cross-slotted orifice **404**. Note that there are four ridges **420** between each "leaf" of the cloverleaf configuration separating the four outer sub-chambers **414**A-D.

[0105] FIG. **28** is vertical section view as indicated in FIG. **25** of the embodiment of nozzle **400** shown in FIGS. **25-27**, according to the present invention. More particularly, FIG. **28** illustrates from the intake port end **410** toward face **402** the following features: intake port **412**, two sub-chambers **414**A and **414**C separated by ridge **420**, leading to hemispherical impingement surfaces **418** adjacent to the cross-slotted exit orifice **404**. FIG. **28** also illustrates threading **406** and groove **408** in cross-section.

[0106] FIG. **29** is horizontal section view as indicated in FIG. **26** of the embodiment of nozzle **400** shown in FIGS. **25-28**, according to the present invention. The cross-section view shown in FIG. **29** appears essentially identical to the cross-section view of FIG. **28**. This is because of symmetry about the longitudinal axis **416** (FIG. **26**). More particularly, FIG. **29** illustrates two different sub-chambers, i.e., sub-chambers **414**B and **414**D separated by ridge **420**.

[0107] FIG. **30** is a front perspective view of the embodiment of nozzle **400** shown in FIGS. **25-29**, according to the present invention. More particularly, FIG. **30** illustrates the cross-slotted orifice **404** on face **402**, threading **406** located between groove **408** and intake port end **410**.

[0108] FIG. **31** is a rear perspective view of the embodiment of nozzle **400** shown in FIGS. **25-30**, according to the present invention. More particularly, FIG. **31** illustrates threading **406** located between circular sealing groove **408** and intake port end **410**, intake port **412**, cloverleaf cross-sectioned fluid chamber **414** with five sub-chambers **414**A-E and four ridges **420**.

[0109] FIGS. **32**A-**24**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary composite peak spray density pattern **450** achieved by the embodiment of a fluid nozzle **400** shown in FIGS. **25-31**, according to the present invention. The composite peak spray density pattern **450** is characterized by three horizontal spray patterns **452** and three vertical spray patterns **454**, which is generally homogeneous in both the horizontal and vertical directions.

[0110] FIGS. **33-39** illustrate yet another embodiment of a triple-slotted, quintuple sub-chambered fluid nozzle **500**, according to the present invention. Nozzle **500** employs the cloverleaf cross-sectioned fluid chamber (see **414**) configuration of nozzle **400** described above, but with a triple slotted exit orifice configuration similar to nozzle **300**.

[0111] More particularly, FIG. **33** is a front view of triple-slotted, quintuple sub-chambered embodiment of a fluid nozzle **500**, according to the present invention. FIG. **33** illustrates main slotted orifice **504**A and two vertically offset smaller slotted orifices **504**B formed in face **502**.

[0112] FIG. **34** is a right-side view of the embodiment of nozzle **500** shown in FIG. **33**, according to the present invention. More particularly, FIG. **34** illustrates threading **506**, located between circular sealing groove **508** and intake port end **510** (opposite face **502**). Groove **508** is configured to receive an O-ring (not shown) for sealing nozzle **500** to a fixture (not shown) using threading **506**. The longitudinal axis **516** shown in dashed line in FIG. **34** is also the section view line for FIG. **37**, described in further detail below.

[0113] FIG. **35** is a rear view of the embodiment of nozzle **500** shown in FIGS. **33-34**, according to the present invention. More particularly, FIG. **35** illustrates cloverleaf intake port **512** leading into the cloverleaf cross-sectioned fluid chamber **514** comprising a central sub-chamber **514**E and four sub-chambers **514**A-D in a cloverleaf cross-section configuration leading to hemispherical impingement surfaces **518**. The four sub-chambers **514**A-D divided by ridges **520**. Pressurized fluid flowing from a fixture (not shown) into intake port **512** and into chamber **514** impinges along the hemispherical impingement surfaces **518** before exiting the main slotted orifice **504**A and the two smaller slotted orifices **504**B as atomized fluid particles.

[0114] FIG. **36** is vertical section view as indicated in FIG. **33** of the embodiment of nozzle **500** shown in FIGS. **33-35**, according to the present invention. More particularly, FIG. **36** illustrates two sub-chambers **514**A and **514**B in cross-section divided by ridge **520** in nozzle **500**. FIG. **36** further illustrates the hemispherical impingement surfaces **518** adjacent the main slotted orifice **504**A and the two smaller slotted orifices **504**B.

[0115] FIG. **37** is horizontal section view of the embodiment of nozzle **500** shown in FIGS. **33-36** as indicated in FIG. **34**, according to the present invention. More particularly, FIG. **37** illustrates two sub-chambers **514**A and **514**C in cross-section divided by ridge **520**. FIG. **37** illustrates the hemispherical impingement surfaces **518** adjacent the main slotted orifice **504**A.

[0116] FIG. **38** is a front perspective view of the embodiment of nozzle **500** shown in FIGS. **33-37**, according to the present invention. More particularly, FIG. **38** illustrates main slotted orifice **504**A and two smaller slotted orifices **504**B disposed in face **502**, with threading **506** between O-ring groove **508** and intake port end **510** of nozzle embodiment **500**.

[0117] FIG. **39** is a rear perspective view of the embodiment of nozzle **500** shown in FIGS. **33-38**, according to the present invention. More particularly, FIG. **39** illustrates the cloverleaf cross-sectioned intake port **512** leading into cloverleaf cross-sectioned fluid chamber **514** of nozzle embodiment **500**. FIG. **39** further illustrates ridges between sub-chambers **514**A-D. Finally, FIG. **39** illustrates threading **506** adjacent to O-ring groove **508** of nozzle embodiment **500**.

[0118] FIGS. **40**A-**40**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary dual vector composite peak spray density pattern **550** (hereinafter "composite spray pattern **550**") achieved by the embodiment of a fluid nozzle **500** shown in FIGS. **33-39**, according to the present invention. The composite dual vector fluid spray pattern **550** generated by nozzle embodiment **500** includes three closely spaced horizontal peak spray patterns **552**, each corresponding to one of the three slotted orifices **504**A and **504**B. Composite spray pattern **550** further includes two vertically oriented peak spray patterns **554**. Composite spray pattern **550** is characterized by a dual vectored spray pattern that has particularly high density along the closely placed planes that comprise the horizontal peak spray patterns **552**.

[0119] It will be understood that additional variations in the structure of the novel nozzles disclosed herein can be used to shape the resultant composite fluid spray pattern. For example, by chamfering of opposed orifice edges, or using flattened oval cross-sectioned orifices, or both, can be employed to achieve flat jets of atomized fluid. FIGS. **41-47** illustrate a particular embodiment with these types of structural enhancements, namely, a single-slotted, quintuple sub-chambered, dual flat jet embodiment of a fluid nozzle **600**, according to the present invention.

[0120] FIG. **41** is a front view of a single-slotted, quintuple sub-chambered, dual flat jet embodiment of a fluid

nozzle **600**, according to the present invention. FIG. **41** illustrates a slotted orifice **604**A and two flattened oval cross-sectioned orifices **604**B disposed in face **602** of nozzle **600**. Note that the opposing edges of the two oval orifices **604**B are chamfered **626** along the face **602** of nozzle embodiment **600**.

[0121] FIG. **42** is a right-side view of the embodiment shown in FIG. **41**, according to the present invention. More particularly, FIG. **42** illustrates chamfers **626** formed in face **602**, circular sealing (O-ring) groove **608**, threading **606** and intake port end **610**. Longitudinal axis, shown as dashed line **616**, passes through the cylindrical axis of nozzle **600** and is also the cut-line for the section shown FIG. **45**.

[0122] FIG. **43** is a rear view of the embodiment shown in FIGS. **41-42**, according to the present invention. More particularly, FIG. **43** illustrates the clover leaf cross-sectioned intake port **612** and fluid chamber **614**. Clover leaf cross-sectioned fluid chamber **614** is of the quintuple sub-chamber **614**A-E configuration. Sub-chambers **614**A-D are divided by ridges **620**. Towards the face **602** end, there are hemispherical impingement surfaces **618** which are adjacent to the slotted orifice **604**A and the two flattened oval cross-sectioned orifices **604**B.

[0123] FIG. **44** is vertical section view of the embodiment shown in FIGS. **41-43** as indicated in FIG. **41**, according to the present invention. More particularly, FIG. **44** illustrates a cross-section through fluid chamber **614** and sub-chambers **614**A and **614**C separated by ridge **620**, of nozzle embodiment **600**. At the face **602** of nozzle embodiment **600**, chamfers **626** are shown cutting into hemispherical impingement surfaces **618** associated with sub-chambers **614**A and **614**C. FIG. **44** further illustrates a cross-section of slotted orifice **604**A, threading **606** and circular sealing (O-ring) groove **608** of nozzle embodiment **600**.

[0124] FIG. **45** is horizontal cross-section view as indicated in FIG. **42** of the embodiment shown in FIGS. **41-44**, according to the present invention. More particularly, FIG. **45** illustrates two sub-chambers **614**B and **614**D separated by ridge **620**, of nozzle embodiment **600**. The hemispherical impingement surfaces **618** are adjacent to slotted orifice **604**A on face **602** of nozzle embodiment **600**. FIG. **45** further illustrates threading **606** and circular sealing (O-ring) groove **608** of nozzle embodiment **600**.

[0125] FIG. **46** is a front perspective view of the embodiment shown in FIGS. **41-45**, according to the present invention. More particularly, FIG. **46** illustrates chamfers **626** cut into face **602** and flattened oval cross-sectioned orifices **604**B as well as slotted orifice **604**A. FIG. **46** further illustrates threading **606** and circular sealing (O-ring) groove **608** of nozzle embodiment **600**.

[0126] FIG. **47** is a rear perspective view of the embodiment shown in FIGS. **41-46**, according to the present invention. More particularly, FIG. **47** illustrates cloverleaf cross-sectioned intake port **612** and fluid chamber **614** disposed in the intake port end **610** of nozzle embodiment **600**. FIG. **47** further illustrates chamfers **626** in face **602** along with circular sealing (O-ring) groove **608** of nozzle embodiment **600**.

[0127] FIGS. **48**A-**48**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary composite peak spray density pattern **650** achieved by the embodiment of a fluid nozzle **600** shown in FIGS. **41-47**, according to the present invention. The composite spray peak density spray pattern **650** generated by nozzle embodiment **600** is characterized by three horizontal peak spray patterns **652** with two vertical peak spray patterns **654** perpendicularly transecting the horizontal patterns **652**. Accordingly, and as shown in FIGS. **48**A-**48**F, the composite peak spray density spray pattern **650** is largely horizontal with three planes of flat jets originating from the orifices **604**A and **604**B.

[0128] Yet another embodiment of a nozzle **700** may be achieved by taking the basic structure of nozzle **200** and instead of forming a slotted orifice **204**, forming a chamfer **726** in face **702** that cuts into hemispherical impingement surfaces **718** thereby forming three flattened oval cross-sectioned orifices **704**. Such an embodiment of a nozzle **700**, as shown in FIGS. **49-55** may or may not include pin spanner holes **224** (FIGS. **9**, **12** and **14**) according to two embodiments of the present invention. However, the embodiment of nozzle **700** described below and shown in FIGS. **49-55** does not include such pin spanner holes **224** (FIGS. **9**, **12** and **14**) for simplicity of illustration.

[0129] More particularly FIG. **49** is a front view of triple sub-chambered, triple flat jet embodiment of fluid nozzle **700**, according to the present invention. FIG. **49** illustrates chamfer **726** disposed in face **702** that cuts into hemispherical impingement surfaces **718** (see FIGS. **52-53**) thereby forming three flattened oval cross-sectioned orifices **704**.

[0130] FIG. **50** is a right-side view of the embodiment of the fluid nozzle **700** shown in FIG. **49**, according to the present invention. FIG. **50** illustrates chamfer **726** in face **702** of nozzle embodiment **700**. FIG. **50** further illustrates a longitudinal axis **716** (dashed line which also represents section line in FIG. **53**), threading **706** located between circular sealing (O-ring) groove **708** and intake port end **710** of nozzle embodiment **700**.

[0131] FIG. **51** is a rear view of the embodiment of the fluid nozzle **700** shown in FIGS. **49-50**, according to the present invention. FIG. **51** illustrates intake port **712** of fluid chamber **714** as viewed from intake port end **710**. Fluid chamber **714** is comprised of three sub-chambers **714**A-C separated by ridges **720** that lead to hemispherical impingement surfaces **718** adjacent to the three flattened oval cross-sectioned orifices **704** of nozzle embodiment **700**.

[0132] FIG. **52** is vertical section view as indicated in FIG. **49** of the embodiment of the fluid nozzle **700** shown in FIGS. **49-51**, according to the present invention. More particularly, FIG. **52** illustrates a cross-section of intake port **712** at intake port end **710**, leading to sub-chamber **7148** of fluid chamber **714**, which in turn leads to hemispherical impingement surfaces **718** adjacent to a flattened oval cross-sectioned orifice **704** at chamfer **726** of nozzle embodiment **700**. Cross-sections of threading **706** and circular sealing (O-ring) groove **708** are also illustrated in FIG. **52**.

[0133] FIG. **53** is horizontal section view as indicated in FIG. **50** of the embodiment of the fluid nozzle **700** shown in FIGS. **49-52**, according to the present invention. More particularly, FIG. **53** illustrates cross-section of intake port **712** at intake port end **710**, leading to all three sub-chambers **714**A-C of fluid chamber **714**, which in turn leads to hemispherical impingement surfaces **718** adjacent to chamfer **726** of nozzle embodiment **700**. Cross-sections of threading **706** and circular sealing (O-ring) groove **708** are also illustrated in FIG. **53**.

[0134] FIG. **54** is a front perspective view of the embodiment of the fluid nozzle **700** shown in FIGS. **49-53**, according to the present invention. More particularly, FIG. **54**

illustrates three flattened oval cross-sectioned orifices **704** at bottom of chamfer **726** disposed in the face **702** of nozzle embodiment **700**. FIG. **54** further illustrates threading **706** located between circular sealing (O-ring) groove **708** and intake port end **710** of nozzle embodiment **700**.

[0135] FIG. **55** is a rear perspective view of the embodiment of the fluid nozzle **700** shown in FIGS. **49-54**, according to the present invention. More particularly, FIG. **55** illustrates intake port **712** of fluid chamber **714**, comprised of all three sub-chambers **714**A-C, formed in intake port end **710** of nozzle embodiment **700**. FIG. **55** further illustrates chamfer **726** located in face **702** as well as threading **706** located between circular sealing (O-ring) groove **708** and intake port end **710** of nozzle embodiment **700**.

[0136] FIGS. **56**A-**56**F are front perspective, top, rear perspective, front, side and rear views, respectively, of an exemplary composite peak spray density pattern **750** achieved by the embodiment of a fluid nozzle **700** shown in FIGS. **49-55**, according to the present invention. Composite pattern **750** is dual vectored, but without clearly discernible horizontal and vertical peak densities.

[0137] FIGS. **57**A-**57**E are front, bottom, left, cross-section and perspective views of a modular nozzle head **800**, according to the present invention. Embodiments of the modular nozzle head **800** may be configured to receive any number of the modular dual vector fluid nozzles **100**, **200**, **300**, **400**, **500**, **600** and **700** disclosed herein. In the particular embodiment illustrated in FIGS. **57**A-**57**E, five of the nozzle embodiment **600** are shown installed in the face **802** of head **800**. Note that the rotational orientation of the nozzles **600** may be in any suitable orientation. Note further that the face **802** may be, linear, arcuate, curved, or piecewise curvilinear in cross-section, see FIG. **57**D.

[0138] It will be understood that each longitudinal axis **116**, **216**, **316**, **416**, **516**, **616** and **716** described herein may also be fluid channel axis or a sub-channel axis as well as an axis of a cylindrical housing from which the particular nozzle is formed. Though the term longitudinal axis has been used extensively herein, it will be understood that each of the sub-channels described herein may have its own sub-channel axis as the sub-channels are generally cylindrical openings. It will be further understood that the term "intake port end" may be synonymous with the term proximate end. Similarly, the term "face" may be synonymous with the term "distal end". It will be further understood that each of the nozzles **100**, **200**, **300**, **400**, **500**, **600** and **700** shown in the drawings herein is comprised of a cylindrical housing about which the novel and nonobvious features are formed on or within, other suitable housing shapes could be used consistent with the teachings of this disclosure.

[0139] Having described the embodiments of nozzles shown in the drawings and their particular structural features, variations and resulting spray patterns using particular terminology, additional embodiments of dual vector fluid spray nozzles will now be disclosed. The following embodiments may or may not correspond precisely to the illustrated embodiments, but will have structure and features that are readily apparent based on the description of the drawings as provided herein.

[0140] An embodiment of a fluid nozzle is disclosed. The fluid nozzle may include an integral cylindrical housing further including a fluid channel having a fluid channel axis, or longitudinal axis, disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to an orifice at a distal end. According to one embodiment of a fluid nozzle, the orifice may be a slotted orifice. According to an embodiment of the fluid nozzle, the fluid channel may further include a plurality of cylindrical sub-channels, each of the plurality of sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the slotted orifice. According to another embodiment of the fluid nozzle, each of the cylindrical sub-channels may be formed by a bore hole beginning from the proximate or intake port end of the cylindrical housing and ending in opposed hemispherical impingement surfaces at the slotted orifice.

[0141] According to another fluid nozzle embodiment, the integral cylindrical housing may further include external threading along an outer surface adjacent to the proximate end, the threading configured for mounting the fluid nozzle to a fluid spray system, fixture, or nozzle head (see, e.g., **800**, FIGS. **57**A-**57**E). The threading may be configured to mate with threading in a fluid spray system or fixture head, thus allowing the nozzles to be removable for servicing and replacement. One particularly useful feature of the fluid nozzles disclosed herein is that they are modular and can be replaced with identical or various configurations of nozzles **100**, **200**, **300**, **400**, **500**, **600** and **700**, for example.

[0142] According to still another fluid nozzle embodiment, the integral cylindrical housing may further comprises a circumferential, or circular sealing, groove formed within the cylindrical housing at a location between the proximate end and the distal end, or face, the groove adapted to receive an O-ring for sealing the threading.

[0143] According to yet another fluid nozzle embodiment, the integral cylindrical housing may further include means for applying rotational torque to the fluid nozzle to install or remove the fluid nozzle from a fluid spray system head. According to one such means embodiment, pin spanner holes (**224**, FIGS. **9**, **12** and **14**) may be formed in the face or distal end of the nozzle housing for mating with a pin spanner wrench. Thus, according to this particular means for applying rotational torque, two holes may be formed in the distal end of the cylindrical housing, the pin holes configured for receiving pins from a spanner wrench. According to other means embodiments, the distal end or body of cylindrical housing may be shaped to receive a square socket, hexagonal socket, octagonal socket or spanner wrench.

[0144] According to one fluid nozzle embodiment, the plurality of sub-channels may be two sub-channels. According to another fluid nozzle embodiment, the plurality of sub-channels comprises three sub-channels. According to still another fluid nozzle embodiment, the sub-channel axes of the three sub-channels may all fall in a single plane.

[0145] According to yet another fluid nozzle embodiment, a cross-section of the intake port at the proximate end may comprise a plurality of circular openings, each of the plurality of circular openings touching an adjacent circular opening and each circular opening surrounding a portion of a volume formed by sweeping the slotted orifice along the fluid channel axis from the distal end to the proximate end. Stated another way, this embodiment implies that the cross-section of the intake port is the same as the cross-section of the fluid channel. According to one fluid nozzle embodiment, each of the plurality of circular openings formed in the proximate, or intake port end, corresponds to one of the plurality of sub-channels of the nozzle fluid chamber.

[0146] According to one fluid nozzle embodiment, a spray pattern generated by pressurized fluid entering the intake port and exiting the orifice of the fluid nozzle forms a plume of fluid vapor having a horizontally oriented main plume exiting radially along a plane formed by the slotted orifice and the fluid channel axis, and having a plurality of vertically oriented plumes exiting the slotted orifice in planes oriented perpendicularly relative to the main plume. According to a particular fluid nozzle embodiment, each of the plurality of vertically oriented plumes is formed by the intersection of adjacent sub-channels. According to still another fluid nozzle embodiment, each of the plumes, vertical or horizontal, is a peak fluid vapor density along an exit trajectory plane.

[0147] According to yet another embodiment, the fluid nozzle may further include at least one secondary fluid channel may be formed in the cylindrical housing and spaced apart from, and parallel to, the fluid channel.

[0148] According to one embodiment of a fluid nozzle, the secondary fluid channel further include a plurality of secondary cylindrical sub-channels, each of the plurality of secondary cylindrical sub-channels having a secondary sub-channel axis disposed parallel to the fluid channel axis beginning from a secondary intake port formed at the proximate end and passing through a secondary slotted orifice formed in the distal end.

[0149] According to another embodiment of a fluid nozzle, each of the secondary cylindrical sub-channels may be formed by a secondary bore hole beginning from the proximate end of the cylindrical housing and ending in opposed hemispherical impingement surfaces at the second slotted orifice.

[0150] According to another embodiment of a fluid nozzle, the secondary bore hole diameters are less than the bore hole diameters of the cylindrical sub-channels forming the fluid channel. It will be understood that the scale of the fluid channels may be changed according to various embodiments of the nozzles disclosed herein.

[0151] According to one embodiment of a fluid nozzle, the at least one secondary fluid channel may include two secondary fluid channels, each secondary fluid channel may be disposed parallel to the fluid channel, but on opposed sides of the fluid channel. For example and not by way of limitation, see nozzle **300** in FIGS. **17-23**.

[0152] According to another embodiment of a fluid nozzle, a composite fluid spray pattern generated by pressurized fluid entering the intake port and exiting the orifice of the fluid nozzle forms a plume of fluid vapor having a horizontally oriented main plume exiting radially along a plane formed by the slotted orifice and the fluid channel axis, two horizontally oriented secondary plumes, each exiting radially along planes formed by respective secondary slotted orifices and the associated secondary fluid sub-channel channel axes and having a plurality of vertically oriented plumes exiting the slotted orifice and the secondary slotted orifices, each vertically oriented plume lying in a plane oriented perpendicular relative to the main plume.

[0153] Another embodiment of a fluid nozzle is disclosed. This embodiment of a fluid nozzle may include an integral cylindrical housing including a fluid channel disposed therein having a fluid channel axis disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to a cross-slotted orifice at a distal end. According to still another embodiment of a fluid nozzle, the fluid channel may further include a plurality of cylindrical sub-channels, each of the plurality of sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the cross-slotted orifice. According to still another embodiment of a fluid nozzle, each of the cylindrical sub-channels may be formed by a bore hole beginning from the proximate end of the cylindrical housing and ending in opposed semi-spherical impingement surfaces at the cross-slotted orifice.

[0154] According to one embodiment of a fluid nozzle, the plurality of cylindrical sub-channels may include a central cylindrical sub-channel and four quadrature sub-channels, the central cylindrical sub-channel sharing the fluid channel axis centered on the cross-slotted orifice, each of the four quadrature sub-channels having an axis falling on an arm of the cross-slotted orifice. One such embodiment is nozzle **400** shown in FIGS. **25-31**.

[0155] According to another embodiment of a fluid nozzle, the integral cylindrical housing may further include external threading along an outer surface adjacent the proximate end, the threading configured for mounting the fluid nozzle to a fluid spray system head or fixture. According to still another embodiment of a fluid nozzle, the integral cylindrical housing further comprises a circumferential groove formed within the housing, the groove adapted to receive an O-ring for sealing the threading.

[0156] According to yet another embodiment of a fluid nozzle, a cross-section of the intake port at the proximate end comprises a central circular opening and four quadrature circular openings, each quadrature circular opening surrounding the central circular opening at 90° intervals, each of the quadrature circular openings touching the central circular opening.

[0157] According to one embodiment of a fluid nozzle, a plume of fluid vapor generated by pressurized fluid entering the intake port and exiting the cross-slotted orifice of the fluid nozzle forms a composite spray pattern. According to one embodiment, the composite spray pattern may include intersecting horizontally and vertically oriented main plumes exiting radially along a planes formed by the cross-slotted orifice and the fluid channel axis. The composite spray pattern may further include two laterally oriented secondary plumes, each exiting radially along planar trajectories not intersecting, on opposite sides of, and at an acute angle relative to, the horizontal main plume, each horizontally oriented secondary plume lying in a respective plane oriented perpendicular relative to the vertically oriented main plume. The composite spray pattern may further include two vertically oriented secondary plumes, each exiting radially along other planar trajectories not intersecting, on opposite sides of, and at an acute angle relative to, the vertical main plume, each vertically oriented secondary plume lying in a respective plane oriented perpendicular relative to the horizontal main plume.

[0158] Still another embodiment of a fluid nozzle is disclosed. The embodiment of a fluid nozzle may include an integral cylindrical housing including a fluid channel having a fluid channel axis disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to a main slotted orifice at a distal end. According to one embodiment the fluid channel may further include a plurality of cylindrical sub-channels, each of the plurality of sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing

through the main slotted orifice or one of two secondary slotted orifices, the two secondary slotted orifices formed in the distal end of the housing and disposed parallel to, and on opposite sides of, the main slotted orifice. The embodiment of a fluid nozzle may further include each of the cylindrical sub-channels formed by boring a hole beginning from the proximate end of the cylindrical housing and ending in opposed hemispherical impingement surfaces at one of the main or secondary slotted orifices.

[0159] According to another embodiment of a fluid nozzle, the plurality of cylindrical sub-channels may include a central cylindrical sub-channel, two horizontal sub-channels and two vertical sub-channels, the central cylindrical sub-channel sharing the fluid channel axis centered on the main slotted orifice, each of the two horizontal sub-channels having an axis passing through the main slotted orifice and each of the two vertical sub-channels having an axis passing through one of the secondary slotted orifices.

[0160] According to another embodiment of a fluid nozzle, the integral cylindrical housing may further include external threading along an outer surface adjacent the proximate end, the threading configured for mounting the fluid nozzle to a fluid spray system head or fixture. According to still another embodiment of a fluid nozzle, the integral cylindrical housing may further include a circumferential groove formed within the housing, the groove adapted to receive an O-ring for sealing the threading.

[0161] According to yet another embodiment of a fluid nozzle, a cross-section of the intake port at the proximate end may include a central circular opening and two horizontally oriented circular openings and two vertically oriented circular openings, each of the horizontal and vertical circular openings surrounding the central circular opening at 90° intervals, each of the circular openings touching the central circular opening.

[0162] According to a particular embodiment of a fluid nozzle, a plume of fluid vapor generated by pressurized fluid entering the intake port and exiting the main slotted orifice and secondary slotted orifices of the fluid nozzle forms a composite spray pattern. The composite spray pattern of this embodiment may include a horizontally oriented main plume exiting radially along a plane formed by the main slotted orifice and the fluid channel axis. The composite spray pattern of this embodiment may further include two horizontally oriented secondary plumes, each exiting radially along planar trajectories not intersecting, on opposite sides of, and at parallel relative to, the horizontal main plume. The composite spray pattern of this embodiment may further include two vertically oriented secondary plumes, each exiting radially along other planar trajectories not intersecting and at an acute angle relative to one another, each vertically oriented secondary plume lying in a respective plane oriented perpendicular relative to the horizontal main plume.

[0163] The embodiments of dual vector fluid nozzles disclosed herein and their components may be formed of any suitable materials, such as aluminum, copper, stainless steel, titanium, carbon fiber composite materials and the like. The component parts may be manufactured according to methods known to those of ordinary skill in the art, including by way of example only, machining and investment casting. Assembly and finishing of nozzles according to the description herein is also within the knowledge of one of ordinary skill in the art and, thus, will not be further elaborated herein.

[0164] In understanding the scope of the present invention, the term "fluid channel" is used to describe a three-dimensional space disposed within a cylindrical housing that begins at a fluid intake port and ends at an orifice. In understanding the scope of the present invention, the term "fluid chamber" is used herein synonymously with the term "fluid channel". In understanding the scope of the present invention, the term "configured" as used herein to describe a component, section or part of a device may include any suitable mechanical hardware that is constructed or enabled to carry out the desired function. In understanding the scope of the present invention, the term "comprising" and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. The foregoing also applies to words having similar meanings such as the terms, "including", "having" and their derivatives. Also, the terms "part", "section", "portion", "member", or "element" when used in the singular can have the dual meaning of a single part or a plurality of parts. As used herein to describe the present invention, the following directional terms "forward, rearward, above, downward, vertical, horizontal, below and transverse" as well as any other similar directional terms refer to those directions relative to the front of an embodiment of a nozzle that has an orifice as described herein. Finally, terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed.

[0165] While the foregoing features of the present invention are manifested in the detailed description and illustrated embodiments of the invention, a variety of changes can be made to the configuration, design and construction of the invention to achieve those advantages. Hence, reference herein to specific details of the structure and function of the present invention is by way of example only and not by way of limitation.

What is claimed is:

1. A fluid nozzle, comprising:

an integral cylindrical housing including a fluid channel having a fluid channel axis disposed coaxially through the cylindrical housing from a fluid intake port on a proximate end to a slotted orifice at a distal end, the slotted orifice having parallel opposed edges at the distal end, an exit plane passing between, and parallel to, the parallel opposed edges;

the fluid channel further comprising three cylindrical sub-channels, each of the three sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the slotted orifice along the exit plane; and

each of the three cylindrical sub-channels is formed by a boring a hole beginning from the proximate end of the cylindrical housing and ending in opposed hemispherical impingement surfaces at the slotted orifice.

2. The fluid nozzle according to claim **1**, wherein the integral cylindrical housing further comprises external threading along an outer surface adjacent the proximate end, the threading configured for mounting the fluid nozzle to a fluid spray system head.

3. The fluid nozzle according to claim **2**, wherein the integral cylindrical housing further comprises a circumfer-

ential groove formed within the housing at a location between the proximate end and the distal end, the groove adapted to receive an O-ring for sealing the threading.

4. The fluid nozzle according to claim **1**, wherein the integral cylindrical housing further comprises means for applying rotational torque to the fluid nozzle to install or remove the fluid nozzle from a fluid spray system head.

5. The fluid nozzle according to claim **1**, wherein the means for applying rotational torque comprises two holes formed in the distal end of the housing configured for receiving pins from a spanner wrench.

6. The fluid nozzle according to claim **1**, wherein a cross-section of the intake port at the proximate end comprises three circular openings, each of the three circular openings touching an adjacent circular opening and each circular opening surrounding a portion of a volume formed by sweeping the slotted orifice along the fluid channel axis from the distal end to the proximate end.

7. The fluid nozzle according to claim **6**, wherein each of the three circular openings corresponds to one of the three sub-channels.

8. The fluid nozzle according to claim **1**, wherein a composite spray pattern generated by pressurized fluid entering the intake port and exiting the slotted orifice of the fluid nozzle forms a plume of fluid vapor having a horizontally oriented main plume exiting radially along the exit plane, and having two vertically oriented plumes exiting the slotted orifice in planes oriented perpendicularly relative to the main plume.

9. The fluid nozzle according to claim **8**, wherein each of the two vertically oriented plumes is formed by the intersection of adjacent sub-channels.

10. The fluid nozzle according to claim **8**, wherein each of the plumes, vertical or horizontal, comprises a peak fluid vapor density along an exit trajectory plane.

11. The fluid nozzle according to claim **1**, further configured for mounting into openings on a modular nozzle head of a snowmaking machine.

12. The fluid nozzle according to claim **1**, further configured for threaded engagement with openings on a modular nozzle head of a snowmaking machine.

13. The fluid nozzle according to claim **1**, wherein the nozzle is formed of a material selected from the group consisting of: aluminum, stainless steel, titanium and brass.

14. A modular dual vector fluid nozzle adaptable for use in a snowmaking machine, the nozzle comprising:

a metal cylindrical housing including an intake port disposed at a proximate end and a slotted orifice having parallel opposed edges at a distal end, a fluid channel having a fluid channel axis disposed coaxially through the cylindrical housing from the fluid intake port on the proximate end to the slotted orifice at the distal end;

the fluid channel further comprising three cylindrical sub-channels, each of the three sub-channels having a sub-channel axis parallel to the fluid channel axis beginning from the intake port and passing through the slotted orifice along an exit plane passing between, and parallel to, the parallel opposed edges of the slotted orifice; and

each of the three cylindrical sub-channels begins from the proximate end of the cylindrical housing and ends in opposed hemispherical impingement surfaces at the slotted orifice, the opposed hemispherical impingement surfaces bisected by the parallel opposed edges of the slotted orifice.

15. The fluid nozzle according to claim **14**, wherein the integral cylindrical housing further comprises external threading along an outer surface extending from the proximate end toward the distal end, the threading configured for mounting the fluid nozzle to a modular nozzle head of the snowmaking machine.

16. The fluid nozzle according to claim **14**, wherein the integral cylindrical housing further comprises a circumferential groove formed within the housing at a location between the proximate end and the distal end, the groove adapted to receive an O-ring for sealing the fluid nozzle to a modular nozzle head of the snowmaking machine.

17. The fluid nozzle according to claim **14**, wherein the integral cylindrical housing further comprises means for applying rotational torque to the fluid nozzle to install or remove the fluid nozzle from a fluid spray system head.

18. The fluid nozzle according to claim **17**, wherein the means for applying rotational torque comprises two holes formed in the distal end of the integral cylindrical housing configured for receiving pins from a spanner wrench.

19. The fluid nozzle according to claim **14**, wherein a cross-section of the intake port at the proximate end comprises three circular openings, each of the three circular openings touching an adjacent circular opening and each circular opening surrounding a portion of a volume formed by sweeping the slotted orifice along the fluid channel axis from the distal end to the proximate end.

20. The fluid nozzle according to claim **14**, wherein a composite spray pattern generated by pressurized fluid entering the intake port and exiting the slotted orifice of the fluid nozzle forms a plume of fluid vapor having a horizontally oriented main plume exiting radially along the exit plane, and having two vertically oriented plumes exiting the slotted orifice in planes oriented perpendicularly relative to the main plume, wherein each of the plumes, vertical or horizontal, comprises a peak fluid vapor density along an exit trajectory plane.

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