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(54) **Title:** SYSTEM WITH SWIRLER NOZZLE HAVING REPLACEABLE CONSTITUENT INJECTION STEM

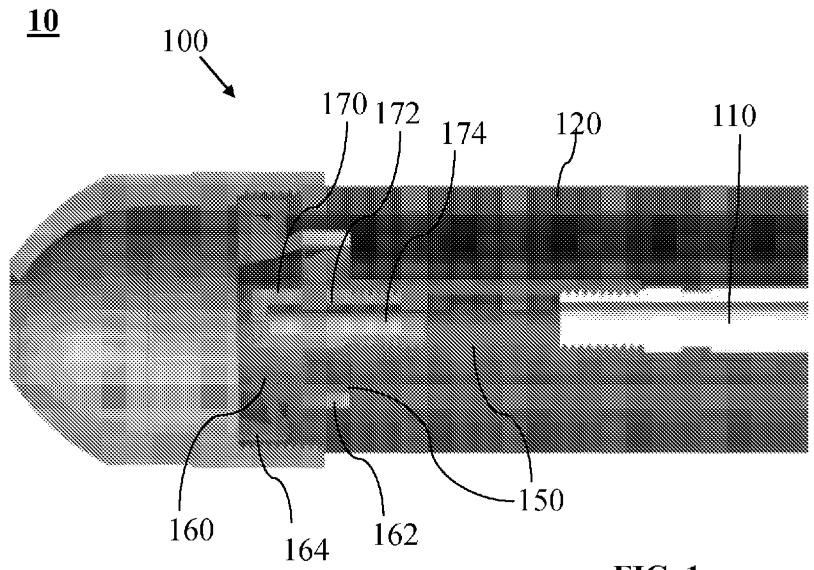

FIG. 1

(57) **Abstract:** The present disclosure discloses a system (10). The system (10) includes a constituent pipe (110), an atomizing air pipe (120) placed around the constituent pipe (110), and a swirler nozzle (150) connected to the atomizing air pipe (120). The swirler nozzle (150) includes a swirler structure (160) and a replaceable constituent injection stem (170). The constituent injection stem (170) is connected to the constituent pipe (110) and includes one or more (orifices184) or passages (184T).

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[Continued on next page]

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SYSTEM WITH SWIRLER NOZZLE HAVING REPLACEABLE CONSTITUENT INJECTION STEM

PRIORITY STATEMENT

[001] The present application is a cognate application claiming priority from Indian provisional patent application number **201941018396** filed on **8 May 2019**, **201941038037** filed on **20 September 2019, 201941038036** filed on **20 September 2019,** and **201941047743** filed on **22 November 2019,** the entire contents of which are hereby incorporated herein by reference.

FIELD OF THE INVENTION

[002] The present disclosure relates to a system having a swirler nozzle for converting constituent into an atomised spray. More particularly, the present disclosure relates to a system having a replaceable constituent injection stem for atomizer nozzles.

BACKGROUND

[003] Atomization is a vital technology used for various applications including dust suppression, spray coating, perfume spray, combustion, spray cooling and spray drying in many industries, such as food, chemicals, ceramic, detergent industry and so on. Atomization is a process of disintegration of a liquid into small droplets. A flow of atomized liquid is called spray. A device that atomizes a fluid and sprays it is called an atomizer. Usually, the atomizer comprises of a nozzle for spraying out the liquid through it.

[004] There are several air-assisted atomizer nozzles available in the market, which are used for spraying liquids in a finely divided or atomized state. Such air-assisted atomizer nozzles are used in industrial burners, gas turbines, rocket engines, cold spray nozzles, etc. For atomization of a liquid fuel or any other liquid, primarily the liquid is injected into a mixing chamber of the nozzle assembly from a fuel supply line and atomizing air is supplied into the mixing chamber from an atomizing air supply line. The interaction of the atomizing air and the fuel inside the mixing chamber among other factors facilitates breakage of the injected fuel into tiny droplets through shearing action thus atomizing the fuel and spraying out from the nozzle through an exit orifice.

[005] There are different kinds of spray patterns that can be produced using atomizing air with fuel mixture such as hollow cone and solid cone. For example, in the solid cone spray with a narrow spray angle, the injected fuel comes out axially from the orifices of the fuel supply line and wherein the injected fuel meets the incoming atomizing air at a short angle (20-30 degrees).

In the furnace burners that are currently used, non-uniform distribution of the fuel droplets in a spray cause the formation of local hotspots leading to the formation of NOx.

[006] Currently, different nozzles are made for different spray patterns and flame geometries. Therefore, when the spray pattern needs to be changed, the entire nozzle has to be replaced, and hence the conventional nozzles are not flexible in operations. An inventory of different nozzles with different spray patterns has to be maintained, which may be expensive. To overcome at least some of the above-mentioned problems there exists a need for designs that enable a nozzle to form different spray patterns without changing the entire nozzle assembly.

BRIEF DESCRIPTION OF THE INVENTION

[007] This summary is provided to introduce a selection of concepts in a simple manner that is further described in the detailed description of the disclosure. This summary is not intended to identify key or essential inventive concepts of the subject matter nor is it intended for determining the scope of the disclosure.

[008] In some embodiments of the present disclosure, a replaceable constituent injection stem is disclosed. The replaceable constituent injection stem is a detachable piece that contains the required orifices for liquid or gas injection. Additionally, the fuel injection stem may contain passages that might be utilized in providing swirl to the injected fluid. Such replaceable constituent injection stem as inventory for only one set of swirlers could be easily maintained for different flame geometries that may be required for processing different products in the furnaces. This would help reduce inventory maintenance costs of the company. Different constituent injection stems can be screwed onto the swirler to produce different spray patterns. Moreover, such kind of a constituent injection stem can be easily replaceable, and would be easier to clean compared to a nozzle wherein the injection stem and the swirler are integrated permanently. This can help minimize the inventory maintenance cost and overall spray nozzle lifecycle cost.

[009] In one aspect, a system is disclosed. The system includes a constituent pipe, an atomizing air pipe placed around the constituent pipe, and a swirler nozzle that is in contact with the atomizer air pipe. The swirler nozzle includes a swirler structure and a replaceable constituent injection stem. The swirler structure is connected to the constituent pipe. The constituent injection stem includes one or more orifices or passages connected to the swirler structure.

[0010] To further clarify advantages and features of the present disclosure, a more particular description of the disclosure will be rendered by reference to specific embodiments thereof, which is illustrated in the appended figures. It is to be appreciated that these figures depict only typical embodiments of the disclosure and are therefore not to be considered limiting of its scope.

The disclosure will be described and explained with additional specificity and detail with the accompanying figures.

BRIEF DESCRIPTION OF THE FIGURES

[0011] The disclosure will be described and explained with additional specificity and detail with the accompanying figures in which:

[0012] FIG. 1 illustrates a system, in accordance with one embodiment of the present disclosure;

[0013] FIG. 2 illustrates a swirler structure having vanes, in accordance with one embodiment of the present disclosure;

[0014] FIG. 3A illustrates a swirler structure having helical passages, in accordance with one embodiment of the present disclosure;

[0015] FIG. 3B illustrates a swirler structure having coplanar primary and secondary swirlers, in accordance with one embodiment of the present disclosure;

[0016] FIG. 4 illustrates a swirler structure having helical passages in the primary swirler and vanes in the secondary swirler, in accordance with one embodiment of the present disclosure;

[0017] FIG. 5 illustrates a replaceable constituent injection stem, in accordance with one embodiment of the present disclosure;

[0018] FIG. 6 illustrates an isometric view of the replaceable constituent injection stem with an orifice, in accordance with one embodiment of the present disclosure;

[0019] FIG. 7A illustrates an isometric view of the replaceable constituent injection stem with orifices meant for radial and axial fluid injection, in accordance with one embodiment of the present disclosure;

[0020] FIG. 7B illustrates a side view of the replaceable constituent injection stem with orifices meant for radial and axial fluid injection, in accordance with one embodiment of the present disclosure;

[0021] FIG. 8A illustrates an isometric view of the replaceable constituent injection stem with helical passages meant for injecting fluid in a swirling pattern, in accordance with one embodiment of the present disclosure;

[0022] FIG. 8B illustrates a side view of the replaceable constituent injection stem with helical passages meant for injecting fluid in a swirling pattern, in accordance with one embodiment of the present disclosure;

[0023] FIG. 9A illustrates an isometric view of the replaceable constituent injection stem with orifices meant for radial injection integrated with a dual swirler structure, in accordance with one embodiment of the present disclosure;

[0024] FIG. 9B illustrates an isometric view of the replaceable constituent injection stem with orifices meant for axial injection integrated with a dual coplanar swirler structure, in accordance with one embodiment of the present disclosure;

[0025] FIG. 10 illustrates an isometric view of the replaceable constituent injection stem with helical passages meant for injecting fluid in a swirling pattern integrated with a dual swirler structure, in accordance with one embodiment of the present disclosure;

[0026] FIG. 11 illustrates an exploded view of a dual swirl based airblast atomizer, in accordance with one embodiment of the present disclosure;

[0027] FIG. 12 illustrates a perspective view of the dual swirl based airblast atomizer, in accordance with one embodiment of the present disclosure;

[0028] FIG. 13A illustrates an isometric sectional view of the dual swirl based airblast atomizer, in accordance with one embodiment of the present disclosure;

[0029] FIG. 13B illustrates a side sectional view of the dual swirl based airblast atomizer, in accordance with one embodiment of the present disclosure; and

[0030] FIG. 14 illustrates a general overview of a set-up of an industrial burner in accordance with an embodiment of the present disclosure;

[0031] FIG. 15 illustrates a schematic view of a burner, in accordance with an embodiment of the present disclosure;

[0032] FIG. 16 illustrates a general overview of a convergent-divergent nozzle air cap wherein the air cap acts like an air-liquid mixing chamber, in accordance with an embodiment of the present disclosure;

[0033] FIG. 17 illustrates a schematic view of an atomizing air pipe centralizer (centralized within a combustion air pipe) that includes dual swirl vanes, in accordance with an embodiment of the present disclosure;

[0034] FIG. 18 illustrates an overview of a combustion air pipe in combination with an atomizing air pipe, a fuel pipe and a dual shear nozzle in accordance with an embodiment of the present disclosure; and

[0035] FIG. 19 illustrates an overview of a holder and a socket that connect the atomizing air pipe to the combustion air pipe, in accordance with an exemplary embodiment of the present disclosure.

[0036] Further, skilled artisans will appreciate that elements in the figures are illustrated for simplicity and may not have necessarily been drawn to scale. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the figures by conventional symbols, and the figures may show only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the figures with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION

[0037] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiment illustrated in the figures and specific language will be used to describe them. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Such alterations and further modifications to the disclosure, and such further applications of the principles of the disclosure as described herein being contemplated as would normally occur to one skilled in the art to which the disclosure relates are deemed to be a part of this disclosure.

[0038] It will be understood by those skilled in the art that the foregoing general description and the following detailed description are exemplary and explanatory of the disclosure and are not intended to be restrictive thereof.

[0039] In the present disclosure, relational terms such as first and second, and the like, may be used to distinguish one entity from the other, without necessarily implying any actual relationship or order between such entities.

[0040] The terms "comprises", "comprising", or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a process or method that comprises a list of steps does not include only those steps but may include other steps not expressly listed or inherent to such a process or a method. Similarly, one or more elements or structures or components preceded by "comprises... a" does not, without more constraints, preclude the existence of other elements, other structures, other components, additional devices, additional elements, additional structures, or additional components. Appearances of the phrase “in an embodiment”, “in another embodiment” and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[0041] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. The components, methods, and examples provided herein are illustrative only and not intended to be limiting.

[0042] The subject disclosure is directed to a system. The system may be a standalone atomizer used for cold sprays and fuel injection in gas turbines, rocket engines or the system may be an industrial furnace burner or any utility that includes an atomizer. The atomizer includes an atomizer nozzle having a replaceable constituent injection stem for injecting fluids. Embodiments of the present disclosure will be described below in detail with reference to the accompanying figures.

[0043] FIG.1 illustrates a system 10 comprising an atomizer 100. The atomizer 100 includes a constituent pipe 110, an atomizing air pipe 120, and a swirler nozzle 150. The constituent pipe

110 is configured for the flow of a constituent to the swirler nozzle 150 to be sprayed by the swirler nozzle. The constituent may be any liquid, gas, a mixture of two or more liquids, a mixture of two or more gases, a mixture of one or more liquids and one or more gases, a mixture of solid particles and one or more liquids, or a mixture of solid particles and one or more gases that is intended to be sprayed using the system 10. In some embodiments, the constituent is a liquid or gaseous fuel to be sprayed for burning in a burner system. In some other embodiments, the constituent is a mixture of fine solid particles and a liquid, where the constituent is sprayed for the purpose of spray drying the solid particles. In some other embodiments, one or more gases are sprayed as fuel for a burner.

[0044] The atomizing air pipe 120 is a pipe that is configured to pass the atomizing air or any gas that is used for atomizing the constituent passing through the swirler nozzle 150. The atomizing air pipe 120 is connected to the swirler nozzle 150 and passes the atomizing air through the swirler nozzle 150.

[0045] The swirler nozzle 150 includes a swirler structure 160 and a replaceable constituent injection stem 170. The swirler structure 160 is connected to the constituent pipe 110 either directly or indirectly such that the constituent flowing through the constituent pipe 110 passes through the replaceable injection stem 170 to the swirler structure 160. The constituent injection stem 170 defines one or more orifices or passages over the body. The orifices or passages, one or more in number, work as injection channels for the constituent injection stem. For example, the constituent liquid or the gas is injected through one or more orifices or passages of the constituent injection stem 170 to the swirler structure 160.

[0046] The constituent injection stem 170 has a capability to fit with different kind of nozzles. In other words the constituent injector may be easily replaceable with different pattern of nozzles. The nozzle patterns include different geometries defining a plurality of swirlers. These swirlers are designed on the nozzle for imparting swirl to the atomizing air and hence known as the swirler nozzle 150.

[0047] The swirler structure 160 of the swirler nozzle 150 may be a single swirler structure or a double (dual) swirler structure. In some embodiments, the swirler structure 160 is a dual swirler structure having a primary swirler 162 and a secondary swirler 164 and having vanes, passages, or combination of vanes and passages. The vanes or passages are designed in one or more angles. In some embodiments, the vanes are designed in an angle to the axis of the swirler nozzle. The angles of the vanes play a substantial role in defining the spray pattern of the nozzle.

[0048] The primary swirler 162 and the secondary swirler 164 both may include a plurality of vanes, passages, or a combination thereof. In some embodiments, the primary swirler 162 includes vanes, passages, or a combination of vanes and passages. In some embodiments, the secondary swirler 164 includes vanes, passages, or a combination of vanes and passages, dependent or independent of the structure of the primary swirler 162. In some embodiments, the structure of the primary swirler 162 includes vanes, secondary swirler 164 includes passages, or vice versa. In some embodiments, the primary swirler 162 includes primary vanes and the secondary swirler 164 comprises secondary vanes as shown in the swirler structure 160 in FIG. 2. The atomizing air flowing through the atomizing air pipe 120 and the nozzle swirl vanes 166 and 168 of the primary swirler 162 and the secondary swirler 164 respectively turns the constituent sprayed into small droplets through shearing action.

[0049] In some embodiments, the swirl vanes 166, 168 on the primary swirler 162 and the secondary swirler 164 are designed to have angles in a same direction such that the atomizing air flowing through the atomizing air pipe 120 encounters swirl vanes 166, 168 to swirl the air in one direction. Alternatively, in some embodiments, the swirl vanes 166, 168 are configured in the nozzle structure 160 such that the swirl of the air is in either direction, enabling breakdown of the injected constituent into small droplets. In these embodiments, the air encounters the vanes 166, 168 in a counter-direction to each other such that one part of the atomizing air swirls in a counter direction to another part of the air.

[0050] A combination of the swirling of the nozzle vanes in both directions enables breakdown of the liquid constituent droplets that are sprayed inside the swirler nozzle 150. In case of liquid fuel injection, the combination of the swirling of the nozzle vanes in both directions enables uniform mixing of the atomizing air and the fuel droplets. The mixing enables complete and uniform burning of the liquid fuel, thus minimizing the formation of soot and NOx. In another aspect of having gaseous fuel, a thorough and uniform mixing between the atomizing air and the gaseous fuel is carried out. The uniform mixing results in the prevention of localized hotspots during combustion, thereby minimizing the formation of NOx.

[0051] The swirler structure 160 may also have passages instead of, or in addition to, the vanes. The passages may be the grooves or channels in the swirlers that supplies the atomizing air to the swirler nozzle 150. The passages may have any shape, size and numbers that is beneficial for the efficiency of the atomizing of the constituent. In some embodiments, the primary swirler 162 and the secondary swirler 164 have helical passages 169 as shown in FIG. 3A and 3B.

[0052] FIG. 3A illustrates a swirler structure 160 having dual shear helical slot passages that includes a primary swirler 162 and a secondary swirler 164. The primary swirler 162 is housed inside the secondary swirler 164. The swirler structure 160 may be assembled in the atomizing air pipe 120. In some embodiments, the swirler structure 160 further includes a support O-ring 165. The primary swirler 162 and a secondary swirler 164 may be coplanar to each other or may be designed to be in different radial planes. FIG. 3B illustrates a swirler structure 160 having coplanar primary swirler 162 and secondary swirler 164 structures.

[0053] When the atomizing air is passed through the primary swirler 162, the air shears the constituent and breaks the constituent sheet or jet into ligaments and droplets. The droplets and air mix properly, at the venturi of the primary swirler 162. Further, when the atomizing air is passed through the secondary swirler 164, in counter direction, the swirling air interacts with the premixed fluid, so that further mixing takes place and the droplets breakup into even smaller droplets.

[0054] In one aspect of the present disclosure, the passages of the primary swirler 162 and the secondary swirler 164 may be in helical shape or tangential or inclined or straight or at a certain angle to impart different degrees of swirl to the atomizing air. In addition, width, depth and number of slots may also be changed based on the required output.

[0055] The swirler structure 160 may also have a combination of vanes and passages. For example, the swirler structure 160 may have vanes in the primary swirler 162 and helical passages in the secondary swirler 164 or the helical passages in the primary swirler 162 and the vanes 164 in the secondary swirler. FIG.4 illustrates a swirler structure 160 having a primary swirler 162 with helical passages in the outer periphery and a secondary swirler 164 having vanes. The direction of the helical passages and the vanes can be varied. In one embodiment, the direction of the vanes in the secondary swirler 164 is counter to the direction of the helical passages in the primary swirler 162. A combination of vanes and passages in a single swirler can also be envisaged for increasing effectiveness of the swirler structure 160.

[0056] The replaceable constituent injection stem 170 has one or more orifices in the end that joins with the swirler structure 160. The one or more orifices of the replaceable constituent injection stem may include an axial orifice, a lateral orifice, an angular orifice, helical passage or any combinations of axial, lateral, and / or angular orifices.

[0057] FIG.5 illustrates an exemplary constituent injection stem 170 in accordance with an embodiment of the present disclosure. As shown, the constituent injection stem 170 includes a body 172. The structure or shape of the body 172 may be cylindrical or cuboidal or any other shapes. In other words, the body 172 of the constituent injection stem 170 may be a small piece of a pipe. The body 172 of the stem 170 is formed hollow that defines a bore 174. Further, the body 172 includes a first end 176 and a second end 178. The first end 176 includes a screwdriver or spanner slot 180 and the second end 178 includes threads 182 on the body 172 of the constituent injection stem 170. The threads 182 may be on an outer periphery or inner periphery of the constituent injection stem. The constituent injection stem 170 defines one or more orifices or slots 184 over the body 172. The one or more orifices 184 work as injection channels for the constituent injection stem 170. For example, the liquid or the gas is injected through the plurality of orifices 184 to a swirler nozzle.

[0058] One or more embodiments define arrangements of one or more orifices or passages 184 over the body 172 of the constituent injection stem 170 in one or more axis as described below with the help of FIGs 6-8B.

[0059] Referring to FIG. 6, in the embodiment, the orifice 184 is formed at the first end 176 of the body 172 for injecting fluid radially. For example, when the constituent (liquid or gas) is injected through the orifice 184 (formed at the first end 176 of the body 172), the constituent enters radially into the nozzle.

[0060] In another embodiment as shown in FIGs 7A and 7B, the one or more orifices 184 are formed on the body 172 for injecting fluid in one or more axis (such as radial and axial). In such an embodiment, the first orifice 184-a is formed at the first end 176 of the body 172, whereas the second orifice 184-b is formed at just below the screwdriver slot 180 of the first end 176. The fluid is injected radially through the first orifice 184-a, whereas, the fluid is injected axially through the second orifice 184-b. In further embodiment as shown in FIGs 8A and 8B, the one or more orifices 184 are formed tangentially on the first end 176 of the body 172. The fluid is injected tangentially through the helical passages 184T.

[0061] Referring to FIG. 9A, the constituent injection stem 170 is fitted onto the swirler structure 160 of the nozzle 150. The constituent injection stem 170 is screwed onto the swirler structure 160 utilizing a screwdriver at the screwdriver slot 180 and the threads 182, constructed on the second end 178 of the constituent injection stem 170, engaged with the swirler structure 160. As shown, the screwdriver or spanner slot 180 helps in installation or uninstallation of the constituent injection stem 170 from the swirler structure160. In the embodiment, the fluid is injected radially into the nozzle 150 through the orifice 184 (formed at the first end 176 of the body 172). Further, FIG. 9B illustrates an isometric view of the replaceable constituent injection stem 170 with orifices meant for axial injection, integrated with a dual coplanar swirler structure 160 of the swirler nozzle 150. FIG. 10 illustrates an embodiment in which the fluid is injected tangentially into the nozzle 150 through the helical passages 184T.

[0062] The bore and orifices of the constituent injection stem 170 can be easily cleaned. Further, the constituent injection stem 170 can be easily screwed onto the swirler structure 160. Since the swirler structure 160 is the expensive part of the swirler nozzle, the same swirler structure 160 can be used with different constituent injection stems to generate different spray patterns. This reduces the cost of inventory maintenance for swirler nozzles meant for different spray patterns. The orifice size (such as diameter and length) may be changed according to the fuel injection requirement. Further, the orifice position may also be changed as per requirement. Furthermore, the liquid entry and exit in the constituent injection stem may be changed.

[0063] The aspects of the constituent injection stem are that it is a liquid/gas injector that can be detached from and combined with the swirler structure of the nozzle. The constituent injection stem with the swirler structure forms a swirler nozzle. Different constituent injection stems can be mixed and matched with different swirler structures to obtain different swirler nozzles that deliver different spray patterns. The constituent injection stem is easily attachable to and detachable from swirler structures. For applications where the swirler structure can remain unchanged but various liquid injection patterns are required, the constituent injection stem can help reduce inventory maintenance costs. The inventory for the swirler structure, which is the expensive part, can be kept smaller while stocks of different constituent injection stem types can be maintained.

[0064] Further, the constituent injection stem improves the versatility of generating different spray patterns by combining different swirler structures. These swirler nozzles can be used in different applications including in atomizers for industrial furnace burners, gas turbines, rocket engines and cold sprays.

[0065] Figs. 11 to 13B illustrate the arrangement of the constituent injection stem 170 in a swirler nozzle 150 of an atomizer 100, according to some embodiments of the present disclosure. While the swirler structure 160 is illustrated as a dual swirl structure having helical passages in the primary swirler 162 and the secondary swirler 164 for the passage of atomizing air, variations such as having vanes or a combination of vanes and swirlers are also envisaged in the present description as illustrated in the earlier passages.

[0066] FIG. 11 illustrates an exploded view of a dual swirl based airblast atomizer 100, in accordance with one embodiment of the present disclosure. The dual swirl based airblast atomizer 100 comprises a nozzle air cap 130, a support O-ring 165, a primary swirler 162, a secondary swirler 164, a constituent injection stem 170, an atomizing air pipe 120 and a plurality of adapters 125A, 125B and 125C. The atomizing air pipe 120 includes a first end 122 and a second end 124, wherein the first end 122 includes a threaded profile on its outer periphery as well as inner periphery.

[0067] FIG. 12 illustrates an outside view of the dual swirl based airblast atomizer 100. The primary swirler 162, the secondary swirler 164, the support O-ring 165 and the constituent injection stem 170 are housed inside the atomizing air pipe 120, at the first end 122 of the atomizing air pipe 120 (as shown in Figs 13A and 13B). The nozzle air cap 130 includes a threaded profile on its inner surface that enables the nozzle air cap 130 to screw and engage on the outer threaded profile of the atomizing air pipe 120. The nozzle air cap 130 is assembled for providing a closed chamber for proper liquid-air mixing. The nozzle air cap 130 further includes an orifice (of pre-determined diameter) through which the liquid-air spray exits from the device 100. The support O-ring 165 includes a threaded profile on its outer diameter, i.e. on outer surface. The support O-ring 165 is screwed and engaged to the inner threaded profile of the atomizing air pipe 120. The smooth inner diameter of the O-ring 165 is engaged with the secondary counter swirler 164 in a tight fit. The tight fit is for ensuring that the secondary counter swirler 164 does not rotate due to airflow during burner operation. A notch on the secondary swirler 164 with a matching male projection on the O-ring inner diameter 165 are also made to ensure that the two components are rotationally locked to each other. The plurality of adapters 125A-125C are arranged to connect the liquid and air supply lines to the second end 124 of the atomizing air pipe 120 and the primary swirler 162. Hence, a part of atomizing air supplied to the atomizing air pipe 120 further flows through the primary swirler 162, and part of the atomizing air flows through the secondary counter swirler 164. The adapters 125A-125C act as the interface between the atomizing air pipe 120, primary swirler 162 and the fluid supply lines.

[0068] The one or more orifices of the constituent injection stem 170 work as injection channels for the constituent injection stem 170. In one aspect of the present invention, the constituent injection stem 170 includes helical passages on its outer periphery. The helical passages provide swirl to fluid when the fluid ejects into the swirler mixing chamber (comprising of the nozzle air cap 130 and the secondary counter swirler bore 164). The constituent injection stem 170 may be screwed at bore of the primary swirler 162. There is a tight fit engagement between the constituent injection stem 170 and the primary swirler 162 so that the atomizing air is passed through the helical passages only.

[0069] In some embodiments, the primary swirler 162 includes a venturi (converging bore) at the center (not shown), and helical slots at the periphery of the front end. The primary swirler 162 is fitted tightly with a second support O-ring that is part of the secondary counter swirler 164 to ensure that the atomizing air flows out through the helical passages on the primary swirler only and that there is no leakage. The helical passages provide swirl to the atomizing air. Liquid flows through the liquid supply line into the primary swirler 162 and into the constituent injection stem 170, via one of the plurality of adapters 125A-125C. The liquid exits out of the constituent injection stem 170 through the helical passages contained in the constituent injection stem 170. The secondary swirler 164 comprises helical passages at outer periphery. In some embodiments, the passages over the secondary counter swirler 164 are designed in counter/opposite direction to the direction of passage of the primary swirler 162.

[0070] In one aspect of the present disclosure, the liquid is fed into the constituent injection stem 170 through its bore, since it is screwed into the bore of the primary swirler 162. If the constituent injection stem 170 is constructed with helical passages, the flowing liquid gains a high angular velocity while ejecting through the helical passage. The liquid then emerges from the helical passage in the form of a hollow cylindrical liquid film with both tangential and axial velocity components. As described, the constituent injection stem 170 is connected to the primary swirler 162. Further, as the nozzle cap 130 is detachable, different nozzle caps having different orifice diameters and lengths may be used based on the requirements. Also the shape of the nozzle cap 130 may be changed.

[0071] Another variation to this design could be that instead of the primary and secondary swirler planes being offset from each other, they could be coplanar as shown in FIG. 3B earlier. In this embodiment, the venturi may be eliminated. Yet another variation to this design could be that instead of helical passages on the primary and secondary swirlers, either one or both of them could have vanes instead to provide swirl to the atomizing air.

[0072] In one aspect of the present disclosure, liquid and airflow between the different bores can be interchanged. Hence, in the bore where liquid is said to flow in the above descriptions, air can be supplied instead and the bore where air is said to flow in the above descriptions, liquid can be supplied instead.

[0073] In the present disclosure, due to the dual swirl action (as opposed to single swirl action of other low end nozzles); the dual swirl based airblast atomizer is effectively able to generate a highly atomized spray, at the orifice exit of the nozzle cap, at a lower atomizing air pressure, and flow rate. Conventional techniques may be used for manufacturing of the dual swirl based airblast atomizer and parts thereof. Such conventional techniques have relatively easy manufacturability capability. Further the conventional techniques are much more cost-effective solution compared to more high-end vane based nozzles that can deliver similar atomizing performance. Since different types of constituent injection stems may be assembled in the nozzle, different spray patterns may be generated as per requirements in a cost effective manner, without replacing other parts of the nozzle.

[0074] In some embodiments, the system 10 is a device or an industrial set up that includes the atomizer 100. The system may be a sprayer system, a drier system, a burner system, or any other that includes the atomizer 100.

[0075] FIG. 14 illustrates an exemplary overview of a system 10 that includes a setup of an industrial burner 20 in accordance with an exemplary embodiment of the present disclosure. In a specific embodiment, the industrial burner 20 set-up is used in combination with a furnace wall 15, a conveyor belt 16, a plurality of blocks of bricks 18, a furnace burner 20, an air heater 25 (for example, recuperator), a blower with motor 30, a fuel tank 35, a compressor 40 and a fuel pump 45. The compressor 40 may be run by an electric motor.

[0076] In an aspect, trolleys and the like may also be used interchangeably with the conveyor belt 16. In another aspect, the block of bricks (18) may be optionally interchanged with, but not limited to, metal slabs, billet, bloom, and the like. In yet another aspect, the blower 30 is used to supply combustion air, and the compressor 40 is used to supply atomizing air. In a feature of the present disclosure, the blower 30 may be used to supply atomizing air as well.

[0077] In one embodiment of the present disclosure, the furnace burner 20 is a device used for providing heat output through the combustion of liquid or gaseous fuel. Therefore, the constituent that is utilized in the atomizer here is a fuel. The heat produced by the burners 20 is utilized in furnaces and ovens for the heat treatment of metallic articles, in incinerators to burn waste, in boilers to generate steam, heat fluids, and the like.

[0078] In some embodiments of the present disclosure, inside the furnace wall 15, a mechanism for carrying a plurality of blocks of bricks 18 through a conveyor belt 16 is provided. The conveyor belt 16 is used for carrying one or more raw materials for the industries. Here, the conveyor belt 16 is used for carrying a plurality of blocks of raw bricks 18. The raw bricks 18 need to be baked in the furnace burner 20.

[0079] In the same embodiment, the furnace burner 20 includes the burner cap 199. The burner cap 199 is provided with at least one fitting for supplying the fuel and the air. Further, the burner cap 199 acts as an interface between the fuel and air supply lines and the burner lance (as shown in FIG. 15). The burner cap 199 includes one or more fittings for supplying fuel and air. The burner lance, further, includes three concentric pipes (refers to FIG. 15), the combustion air pipe, the atomizing air pipe, and the fuel pipe.

[0080] Further, the blower 30 is driven by a motor for supplying combustion air to the burner 20. The combustion air flows to the burner 20 through the combustion pipe (shown in FIG. 15). The combustion air is usually heated using a heat exchanger called recuperator (for example, air heater 25). The recuperator 25 is meant for extracting heat from flue gases.

[0081] Furthermore, the fuel tank 35 is provided for storing fuel. The fuel to be stored in the fuel tank 35 is selected from at least one of a liquid fuel or a gaseous fuel. The fuel stored is supplied to the burner 20 through the fuel pipe (shown in FIG. 15) for heating purposes. The fuel tank 35 is in turn, connected with the fuel pump 45 (only in the case of liquid fuels) for pumping the stored fuel to the fuel pipe (shown in FIG. 15).

[0082] In another embodiment of the present disclosure, the compressor 40 is provided for atomizing air. The compressor 40 supplies the atomizing air to the burner 20. The atomizing air flows through the atomizing air pipe (shown in FIG. 15) inside the burner 20. The atomizing air is used by the burner 20 to breakdown the injected fuel into fuel droplets. The breakdown into extremely fine fuel droplets, in turn, results in the high combustion efficiency of the fuel in the burner 20. The compressor 40 is utilized to deliver high pressure to the atomizing air, which enables the breakdown of the fuel droplets. The higher the atomizing air pressure, the smaller are the resultant fuel droplets. The smaller the fuel droplets generated, the better is the fuel combustion efficiency.

[0083] In an aspect of the present disclosure, the compressor 40 delivers atomizing air at a pressure of about 1 barg (10,000 pascals) and above. Alternatively, if a blower is utilized instead of a compressor, the blower generates atomizing air pressure of up to 1,000 mm water column (about 0.1 barg or about 9,807 pascals).

[0084] In another aspect of the present disclosure, the industrial burner 20 refers to the burners used in at least one of, but not limited to, industrial furnaces, incinerators, ovens, boilers, and the like for heating purposes. The heat produced in the industries may be utilized in one or more ways, for example, but not limited to, heat treatment of metallic articles, incinerating waste products, generating steam, heating fluids, and the like for meeting needs of the industries.

[0085] In yet another aspect of the present disclosure, the fuel is selected from at least one of liquid fuel or gaseous fuel, such as, but not limited to, diesel, tar, furnace oil, LPG (Liquefied

Petroleum Gas), and the like. The liquid fuel and/or the gaseous fuel are used in combination with combustion air and atomizing air for producing flames. There is no need for atomization of a gaseous fuel. Therefore, when gaseous fuels are fired in the burner, the helical passages provided in the primary swirler and the secondary swirler facilitate the uniform and comprehensive mixing between the gaseous fuel and the combustion air.

[0086] FIG. 15 illustrates a schematic view of a burner 20 in accordance with an embodiment of the present disclosure. In particular, the burner 20 includes a burner crown 22, a nozzle air cap 130, a primary swirler 162, a secondary swirler 164, a support O-ring 165, a fuel injection stem 170, an atomizing air pipe 120, a fuel pipe 110, a holder 196, a socket 198, a burner cap 199 and a combustion air pipe 190. In some embodiments, the burner includes a centralizer 194.

[0087] The burner 20 includes three concentric pipes: the combustion air pipe 190, the atomizing air pipe 120, and the fuel pipe 110. The combustion air pipe 190 is the pipe with the largest diameter and is meant for supplying combustion air to the burner 20 (shown in FIG. 14) from the blower (also known as centrifugal fan) 30. The atomizing air pipe 120 is inside the combustion air pipe 190 and is meant for supplying atomizing air to the burner 20 via the compressor 40. The fuel pipe 110 is inside the atomizing air pipe 120 and is meant for supplying fuel to the burner 20. In other words, the burner 20 is an arrangement that has the combustion air passage and burning set up over an atomizer 100 arrangement. In one embodiment of the present disclosure, the nozzle is in contact with the fuel pipe 110 at the center and to the inside diameter of the atomizing air pipe 120 at its periphery.

[0088] In the same aspect of the present disclosure, the dual shear swirler nozzle 150 includes a primary swirler 162, a secondary swirler 164 and a support O-ring 165. Also, the fuel injection stem 170 is in contact with the inside diameter of the primary swirler 162.

[0089] In one embodiment of the present disclosure, the primary swirler 162 is assembled such that the primary swirler 162 is inside the secondary swirler 164. Further, the primary swirler 162 and the secondary swirler 164 may be assembled such that the one swirler may be axially ahead or behind the other swirler. Also, in a specific embodiment, the secondary swirler 164 is in a plane with the primary swirler 162, that is, the secondary swirler 164 and the primary swirler 162 are coplanar (as shown in FIG. 3B). It is to be noted that, even though the embodiments of the disclosure are specified for two swirlers, the inclusion of more than two swirlers may also be envisaged.

[0090] The burner crown 22 is screwed onto the furnace end of the combustion pipe. It helps the hot combustion air focus into the path of the sprayed fuel droplets. This helps the combustion air impart heat onto the sprayed fuel droplets for vaporization and provides the necessary oxygen. This assists the fuel in combusting efficiently and completely. The nozzle air cap 130 is in contact with the outer diameter of the atomizing air pipe 120. In some embodiments, the nozzle air cap 130 is a convergent-divergent nozzle air cap as shown in FIG. 16. The convergent-divergent air cap 130 acts as an air-liquid mixing chamber and also controls the spray angle and in turn flame diameter. The convergent-divergent air cap 130 is particularly beneficial when large spray angle and flame diameter are desired. FIG. 16 also illustrates an overview of the nozzle 150 according to these aspects.

[0091] In some embodiments of the present disclosure, two major aspects determine the spray and flame geometries. In the first aspect, the swirl is imparted to the atomizing air through the swirl vanes in the nozzle 150, and in the second aspect, the divergent angle and the length of the divergent section of the nozzle air cap 130 determine the spray and flame geometries.

[0092] The centralizer 194 is provided in between the combustion air pipe 190 and the atomizing air pipe 120. The outer diameter of the centralizer 194 is slightly less than the inner diameter of the combustion air pipe 190 in order for the centralizer 194 to fit into the combustion air pipe 190. The centralizer 194 keeps the atomizing air pipe 120 concentric with the combustion air pipe 190.

[0093] In some embodiments, the centralizer 194 is a disc with a hole at its center for the atomizing air pipe to pass through and perforations in the rest of the body to enable passage of the combustion air. In some embodiments, the centralizer 194 includes swirl vanes. In some embodiments, the centralizer 194 includes dual swirl vanes 195 as shown in FIG. 17. The dual swirl vanes may be in same directions or in directions forming an angle with the other vanes. In some embodiments, the directions of the dual swirl vanes 195 are designed such that the vanes in the inner most side of the centralizer 194 are in a direction counter to the direction of the vanes contacting the periphery of the centralizer 194.

[0094] FIG. 18 illustrates an overview of a combustion air pipe 190 in combination with an atomizing air pipe 120, a fuel pipe 110 and a dual shear swirler nozzle in accordance with an embodiment of the present disclosure. The description of an arrangement of the combustion air pipe 190, the atomizing air pipe 120 and the fuel pipe 110 have already been explained earlier with respect to the FIG. 15.

[0095] In an embodiment of the present disclosure, the atomizing air and the fuel mixture is sprayed out through the nozzle air cap 130, wherein, the mixture encounters the heated combustion air. The combustion air flowing through the combustion air pipe 190 mixes with the sprayed fuel droplets and the atomizing air in the proper fuel-air ratio and the combustion is carried out at the exit of the nozzle air cap 130. The combustion air volume is adjusted such that the fuel to air volume ratio is appropriate. If the furnace is sufficiently hot when the burner is inserted into it through a hole in the furnace walls, the sprayed fuel catches fire automatically. Otherwise, fire-catching elements, such as a lighter, may need to be utilized to help fire the fuel.

[0096] FIG. 19 illustrates a holder 196 and socket 198 arrangement for connecting combustion air pipe 190 and atomizer air pipe 120, in accordance with an exemplary embodiment of the present disclosure. Typically, the socket 198 is housed inside the holder 196. The socket

198 interfaces with the outside of the atomizing air pipe and the holder 196. The holder 196 interfaces with the inside of the combustion air pipe 190 and the socket 198. The socket 198 along with the holder 196 form a seal between the combustion air pipe 190 and the atomizing air pipe 120. The socket 198 outer diameter seals against the holder 196 inner diameter. Specifically, the holder 196, along with the socket 198 seals against the inner diameter of the combustion air pipe 190 and against the outer diameter of the atomizing air pipe 120. The socket 198 inner diameter seals against the atomizing air pipe 120 outer diameter. Furthermore, the socket 198 enables axial movement of the atomizing air pipe 120 with respect to the combustion air pipe 190. This enables easy installment or uninstallment of the atomizing air pipe 120 as and when required, keeping the combustion air pipe 190 unaffected.

[0097] While specific language has been used to describe the disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person skilled in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein.

[0098] The figures and the foregoing description give examples of embodiments. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For example, orders of processes described herein may be changed and are not limited to the manner described herein. Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts. The scope of embodiments is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of embodiments is at least as broad as given by the following claims.

We Claim:

1. A system (10), comprising:

a constituent pipe (110);

an atomizing air pipe (120) placed around the constituent pipe (110); and

a swirler nozzle (150) in contact with atomizing air pipe (120) and comprising:

a swirler structure (160) connected to the constituent pipe (110); and

a replaceable constituent injection stem (170) comprising one or more orifices (184) or passages (184T) connected to the swirler structure (160).

2. The system (10) as claimed in claim 1, wherein the swirler structure (160) comprises a primary swirler (162) and a secondary swirler (164), both comprising vanes (166, 168), passages, or a combination thereof.

3. The system (10) as claimed in claim 2, wherein the primary swirler (162) and the secondary swirler (164) are coplanar.

4. The system (10) as claimed in claim 2, wherein the primary swirler (162) comprises primary vanes (166) and the secondary swirler (164) comprises secondary vanes (168).

5. The system (10) as claimed in claim 2, comprising helical passages (169) in the primary swirler (162) and the secondary swirler (164).

6. The system (10) as claimed in claim 5, comprising a support O-ring (165) connected to the secondary swirler (164) and the atomizing air pipe (120).

7. The system (10) as claimed in claim 2, comprising the vanes in the primary swirler (162) and helical passages (169) in the secondary swirler (164) or the helical passages in the primary swirler (162) and the vanes (168) in the secondary swirler (164).

8. The system (10) as claimed in claim 1, wherein the one or more orifices (184) of the replaceable constituent injection stem (170) comprise an axial orifice, a lateral orifice, an angular orifice, or combinations thereof.

9. The system (10) as claimed in claim 1, comprising a combustion air pipe (190) outside of the atomizing air pipe (120) and a centralizer (194) comprising swirl vanes and located in between the atomizing air pipe (120) and the combustion air pipe (190).

10. The system (10) as claimed in claim 9, wherein the centralizer (194) comprises dual swirl vanes (166, 168).

11. The system (10) as claimed in claim 1, comprising a convergent-divergent nozzle air cap (130).

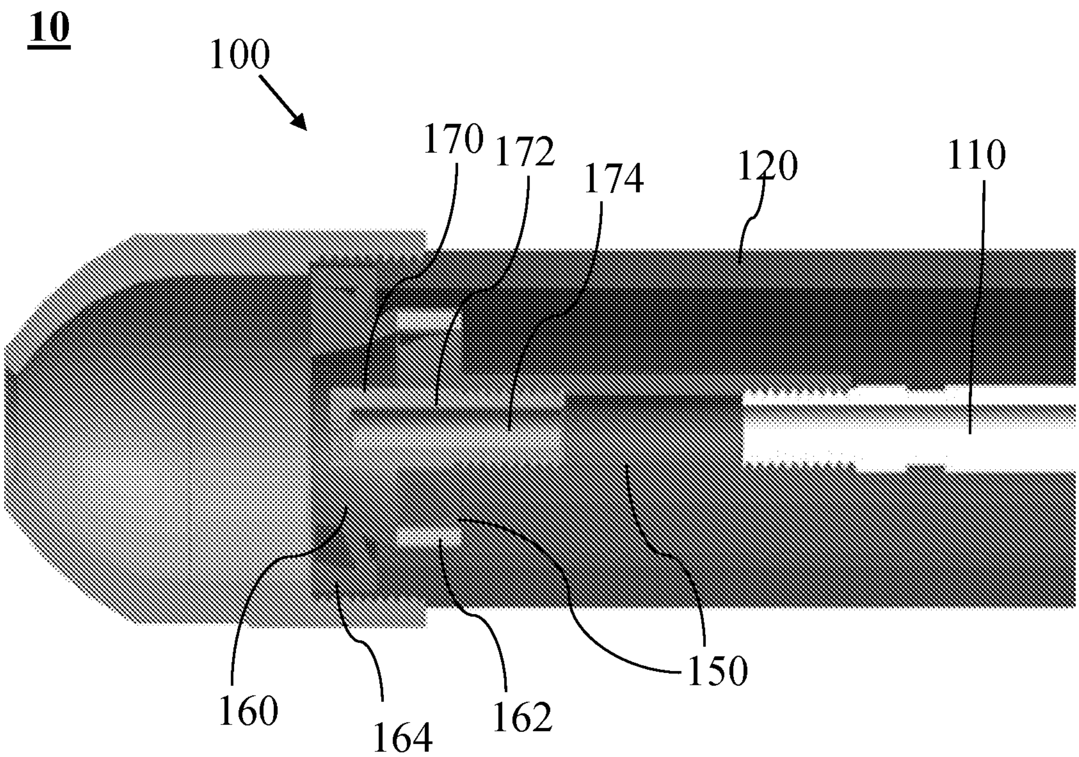

FIG. 1

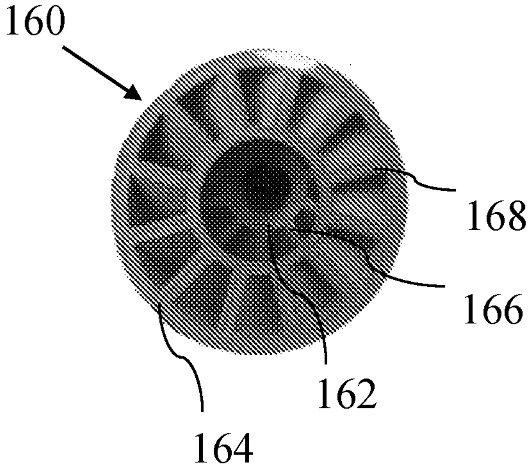

FIG. 2

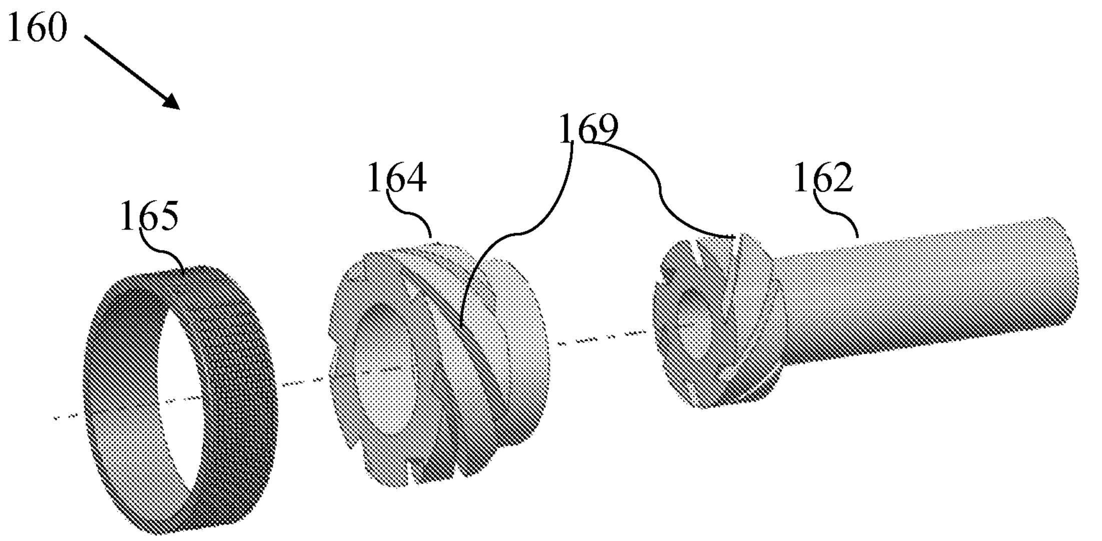

FIG. 3A

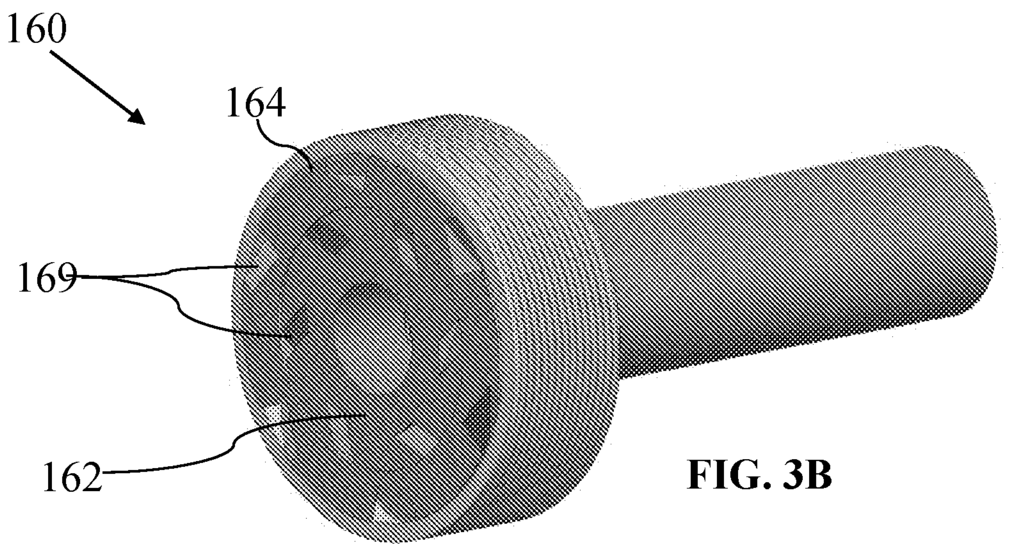

FIG. 3B

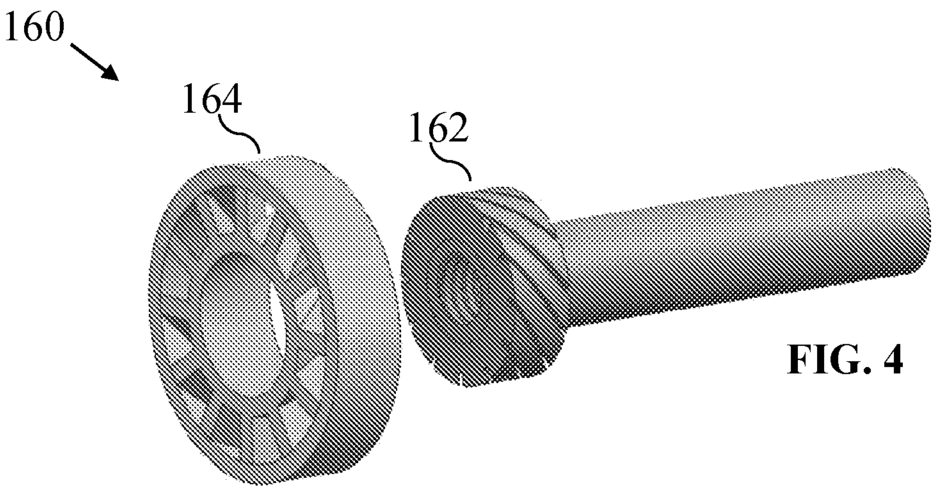

FIG. 4

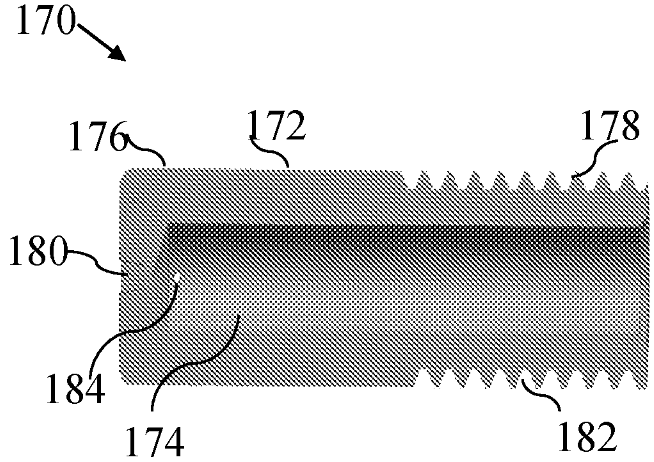

FIG. 5

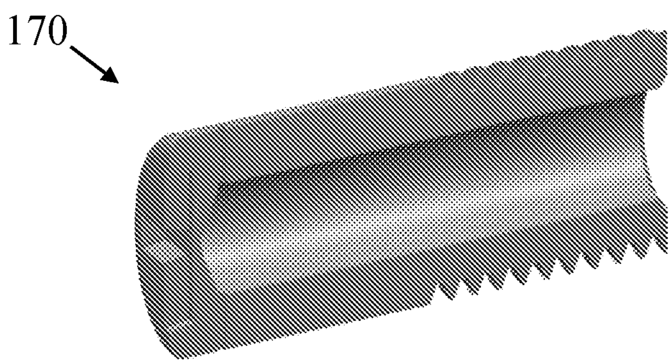

FIG. 6

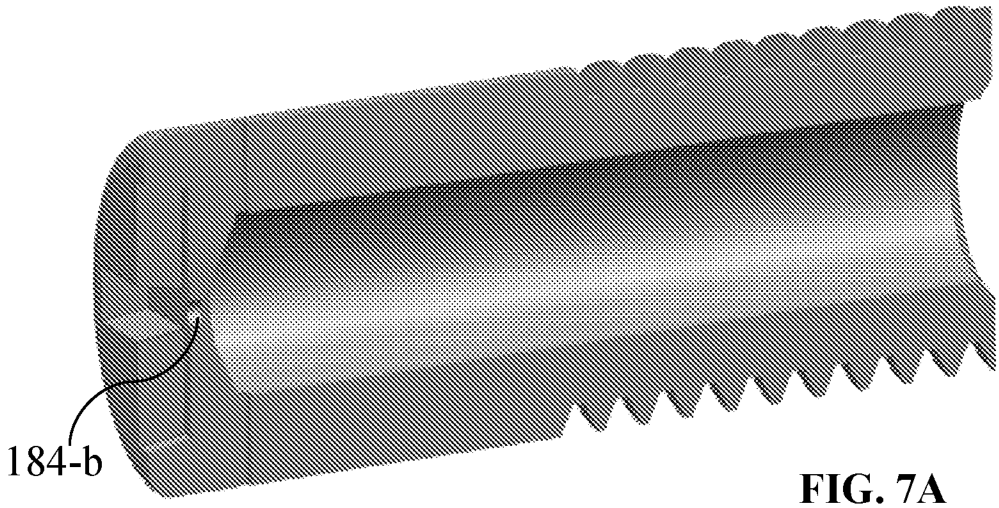

FIG. 7A

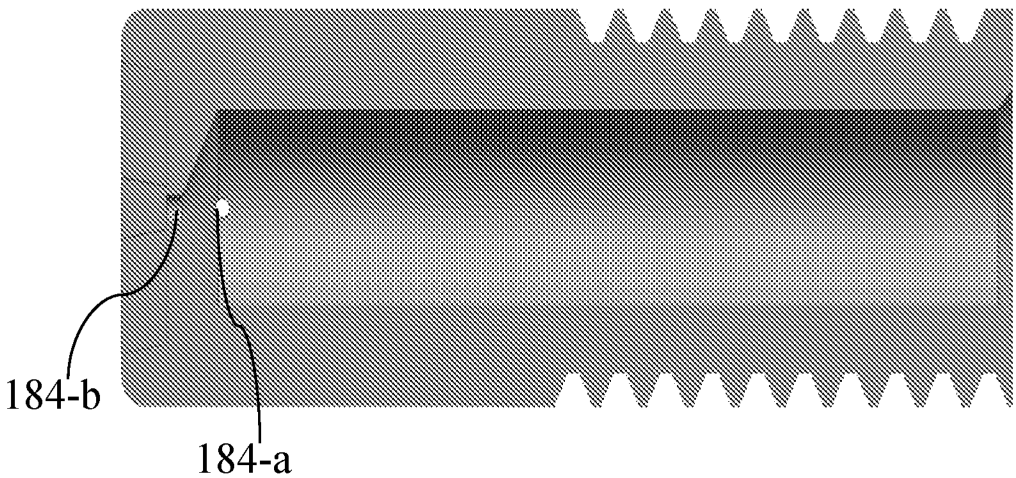

FIG. 7B

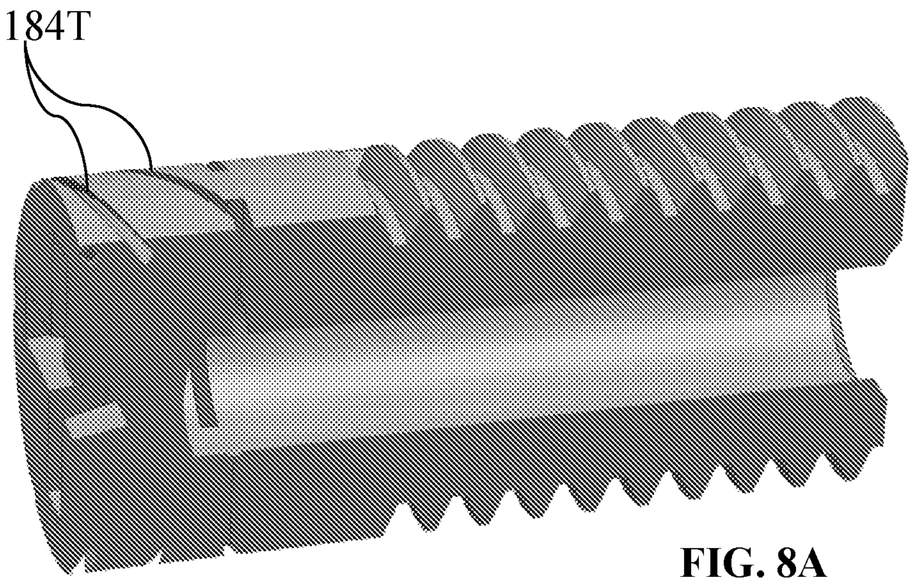

FIG. 8A

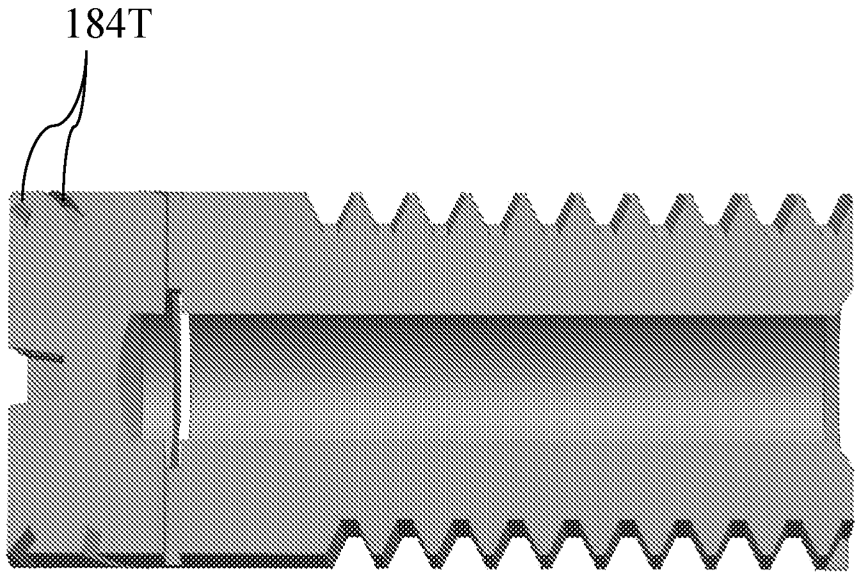

FIG. 8B

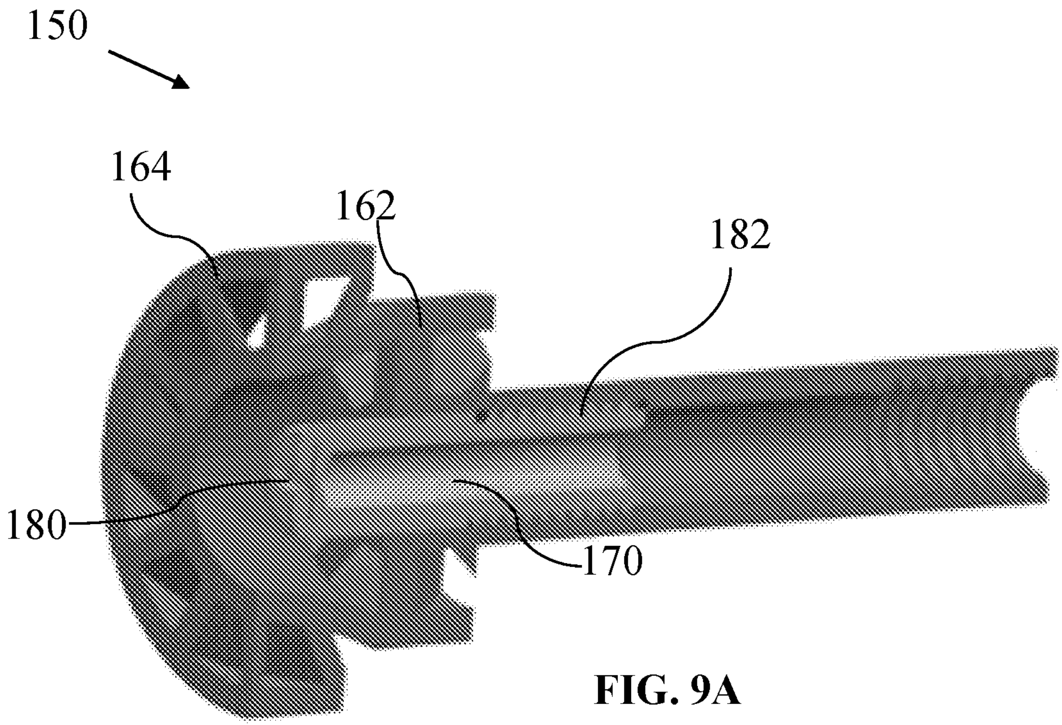

FIG. 9A

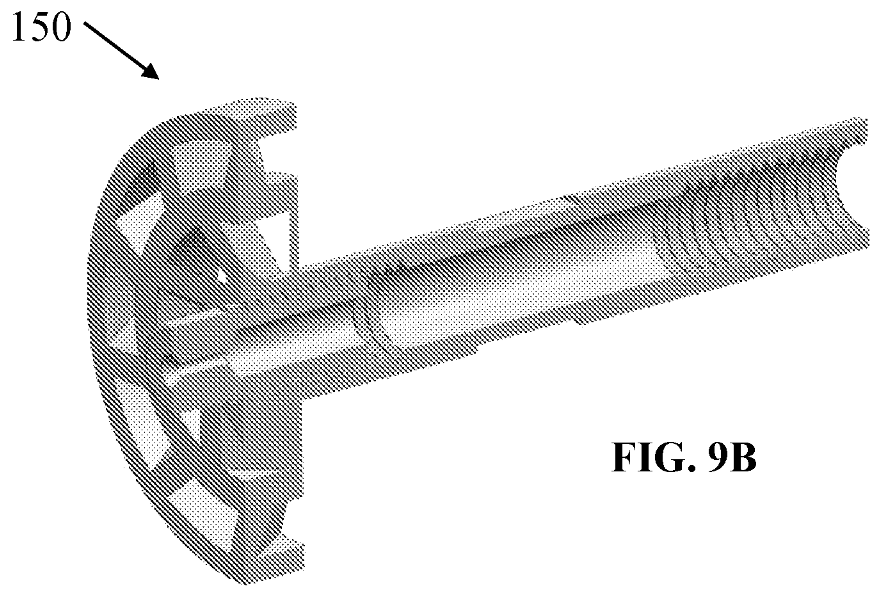

FIG. 9B

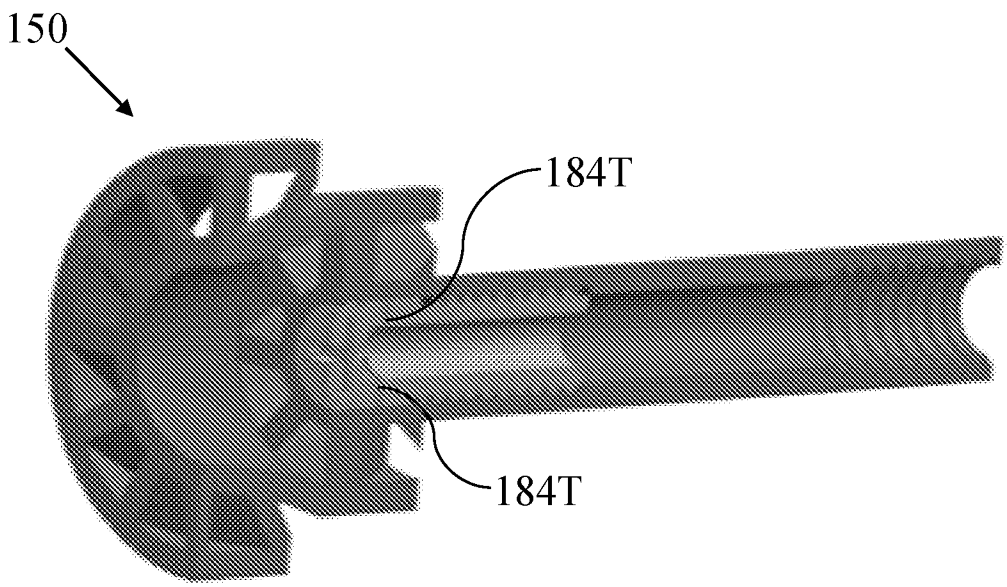
150
184T
184T

FIG. 10

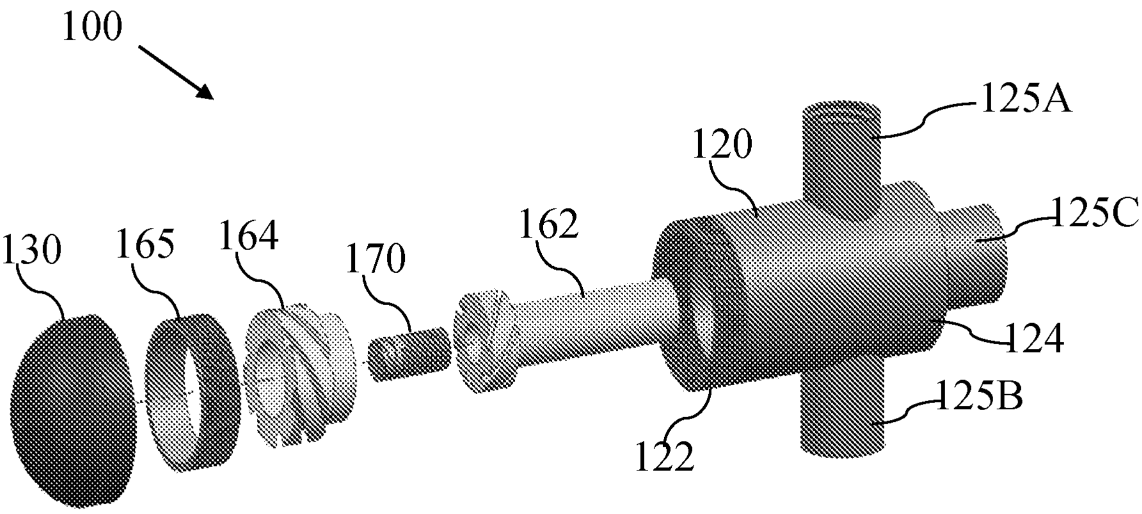
100
125A
120
125C
130
165
164
170
162
124
125B
122

FIG. 11

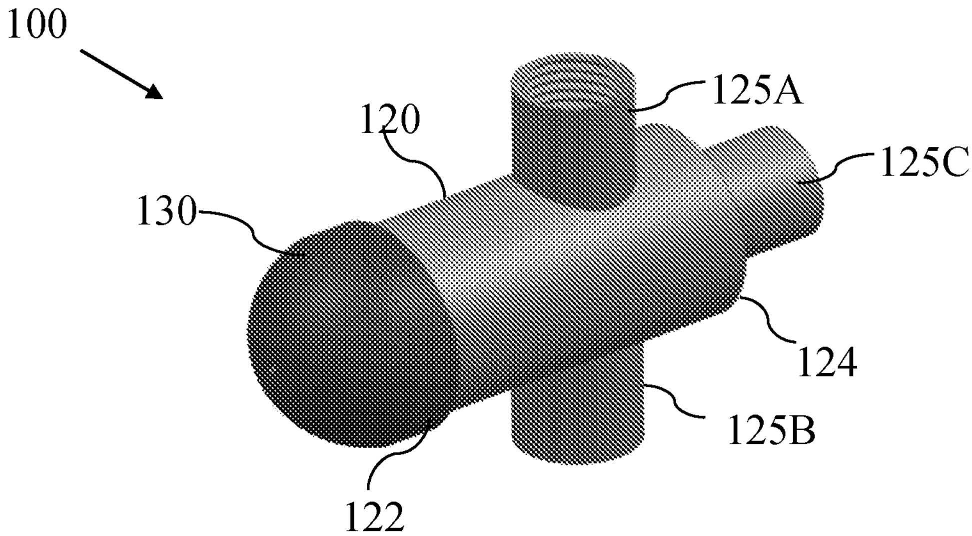

FIG. 12

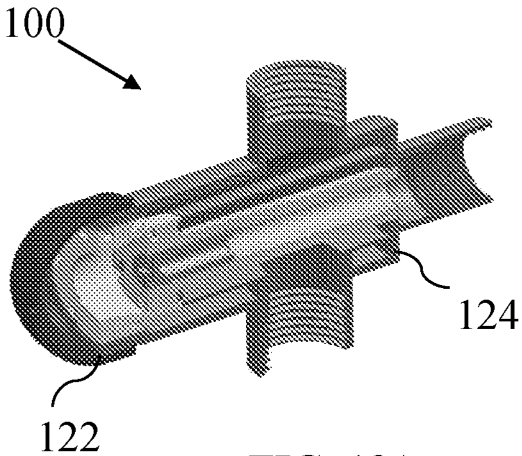

FIG. 13A

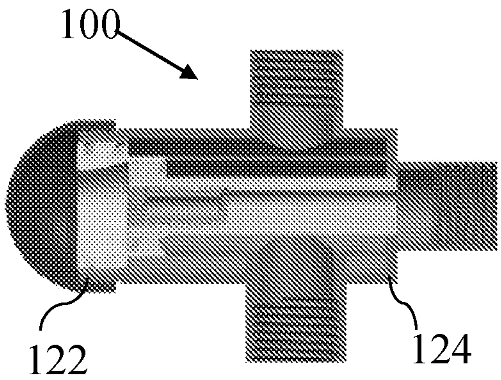

FIG. 13B

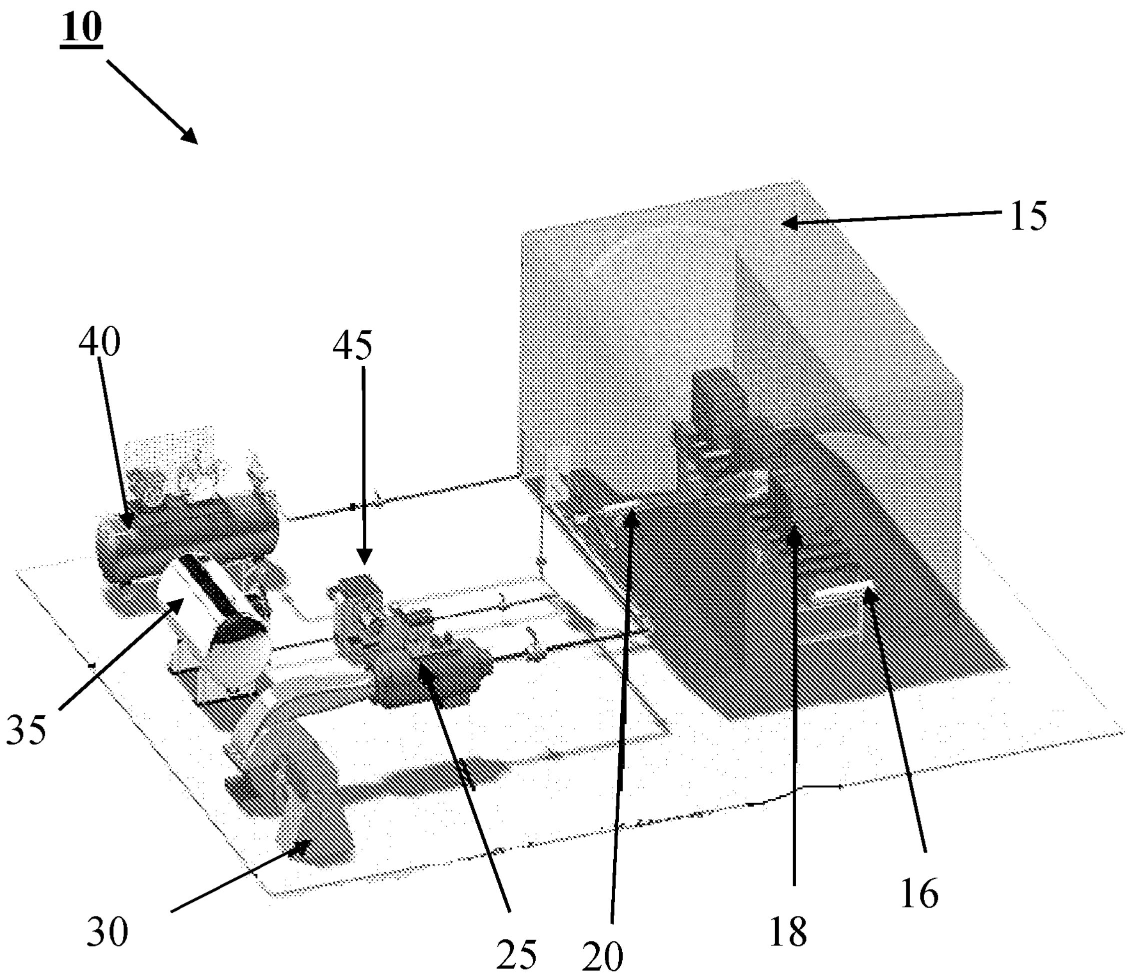

FIG. 14

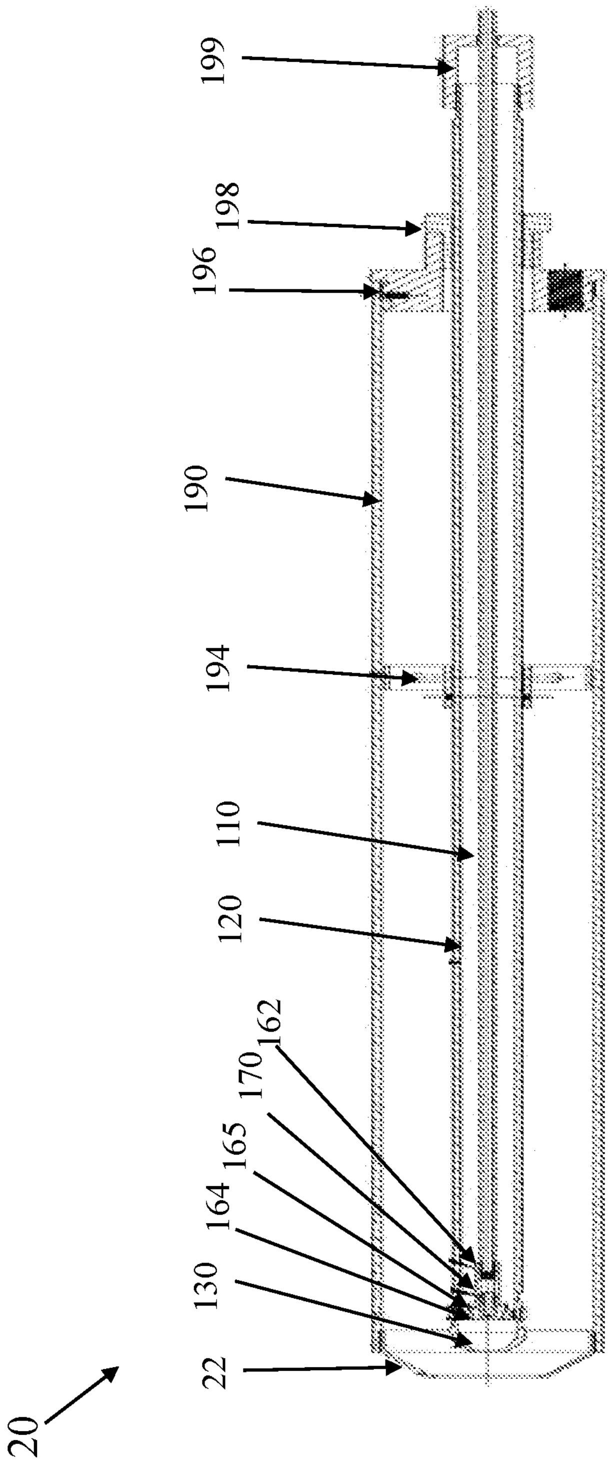

FIG. 15

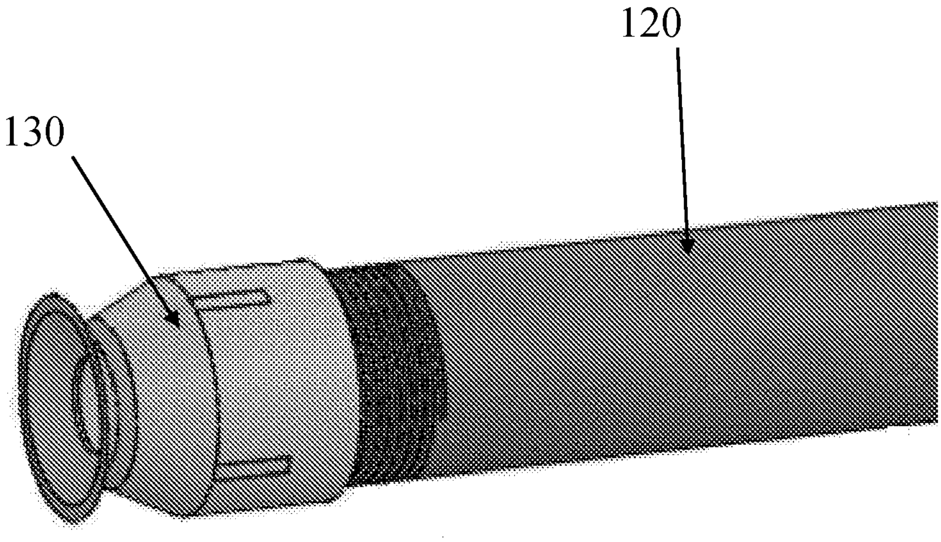

FIG. 16

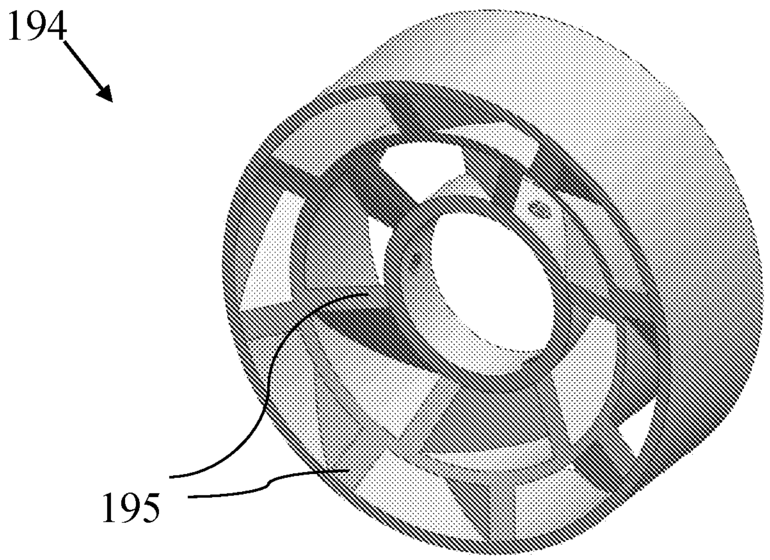

FIG. 17

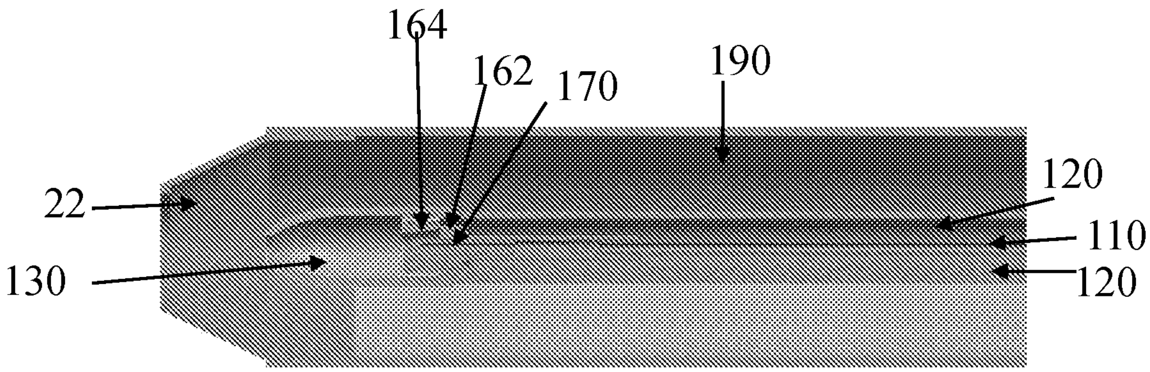

FIG. 18

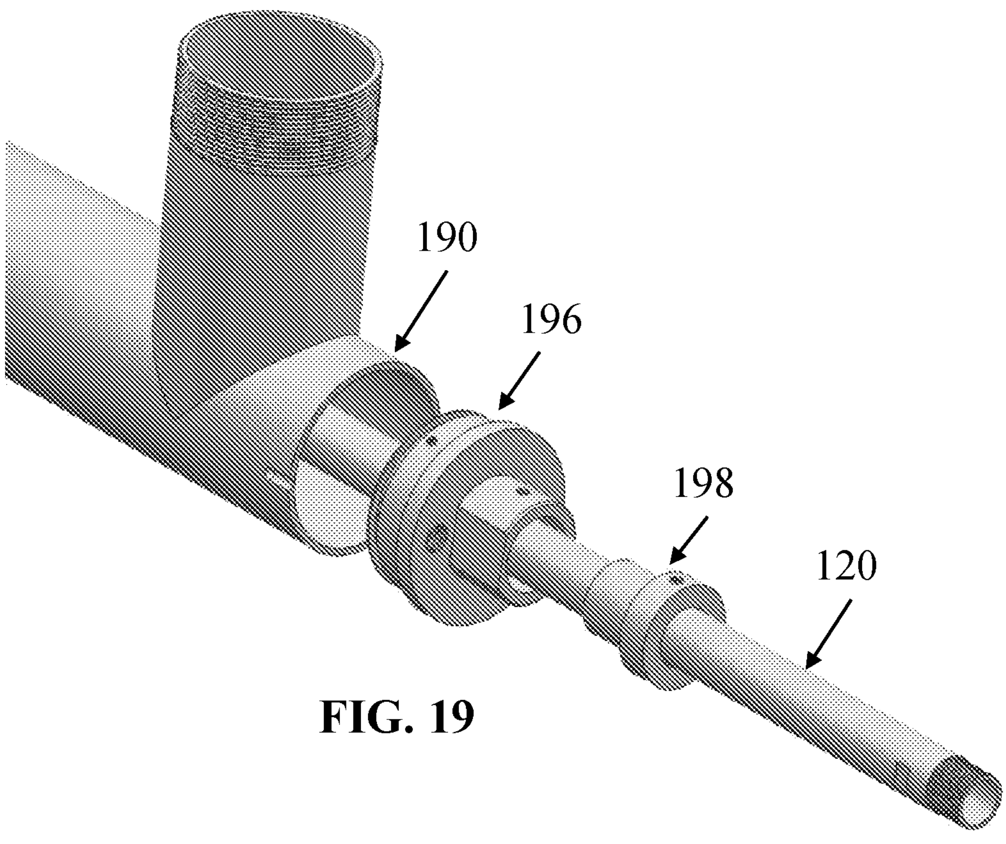

FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2020/050413

A. CLASSIFICATION OF SUBJECT MATTER
F02M61/18,F02C7/236,B05B7/12,F23R3/14 Version=2020.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02M, F02C, B05B, F23R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

TotalPatent One, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US4216652A (GENERAL MOTORS CORP) 12 AUGUST 1980 (12.08.1980) abstract, (column 2: lines 28-30); (column 4: lines 28-29, 39-40)	1-11
A	US2010314470 (A1) (STANADYNE CORPORATION) 16 DECEMBER 2010 (16.12.2010) abstract, (para 0023: lines 1-2)	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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