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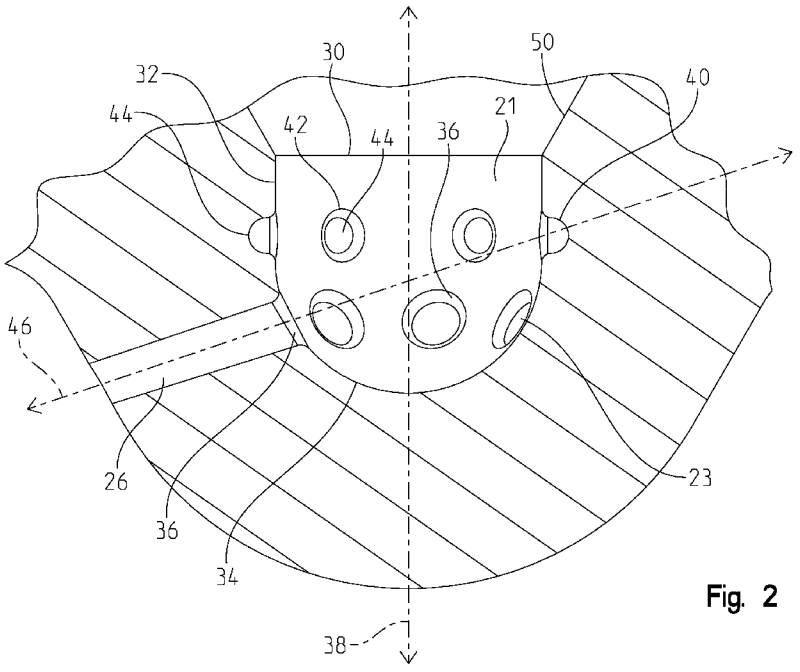


Fig. 2

(57) Abstract: A valve nozzle assembly includes a valve seat and a sac positioned below a valve body chamber. The sac includes a plurality of injection orifices operable to provide passage for fluid out of the sac, an outer wall extending between the valve seat and the orifices; and at least one dimple defined in the outer wall.

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DIMPLED NEEDLE VALVE SAC

FIELD OF THE DISCLOSURE

[0001] The present disclosure is related sac portions of a needle valve and to methods of creating the same. The present disclosure is more specifically directed to sac portions of a needle valve having interruptions in walls thereof to generate desired fuel flow therein and to methods of creating the same.

BACKGROUND

[0002] Diesel engines use high pressure in the delivery of fuel for combustion. When force is applied to fluid, vapor cavities can be produced therein. This is referred to as cavitation. The cavities often form in areas of relatively low pressure. When higher pressure is subsequently experienced in the area of a cavity, the cavity implodes and produces a shockwave. These implosions and shockwaves can produce wear on parts that experience them. Collapsing voids that implode near a metal surface can cause cyclic stress through repeated implosion. These results in surface fatigue of the metal causing a type of wear also called "cavitation."

[0003] Some diesel engines use needle valves to deliver fuel. When such needle valves are open, fuel flows therein. Accordingly, needle valves are susceptible to cavitation. Needle valves typically have an area referred to as a “sac.” Increasing the volume of the sac also leads to a decrease in the efficiency of the engine and increases the undesirable emissions produced thereby due to unburnt fuel or otherwise.

[0004] Accordingly, there exists a need for an improved method and apparatus that reduces cavitation in needle valves without significantly negatively impacting the efficiency or significantly increasing the emissions produced thereby.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a cross-sectional view of a nozzle-and-holder assembly of an injection system;

[0006] FIG. 2 is a cross-sectional view of a sac of the nozzle-and-holder assembly of Fig. 1 according to an exemplary embodiment of the present disclosure;

[0007] FIG. 3 is a flowchart showing an exemplary process for creating the nozzle and sac of Figs. 1-2 and 4; and

[0008] FIG. 4 is a cross-sectional view of another exemplary sac configuration.

DETAILED DESCRIPTION

[0009] Briefly, in one example, a valve nozzle assembly is provided. The assembly includes a valve seat and a sac positioned below a valve body chamber. The sac includes a plurality of injection orifices operable to provide passage for fluid out of the sac, an outer wall extending between the valve seat and the orifices; and at least one dimple defined in the outer wall.

[0010] In another example, a needle valve nozzle body nose portion is provided including: a sac defining a fluid path. The sac includes at least one injection orifice operable to receive fluid from the sac and a first portion located within the fluid path such that fluid must pass the first portion to reach the at least one injection orifice. The first portion including at least one dimple, the at least one dimple including a dimple wall that defines a first distance between the dimple wall and a central axis of the first portion, the first distance being greater than a second distance defined between a wall of a non-dimpled portion of the first portion and the central axis of the first portion.

[0011] In yet another example, a method of manufacturing a needle valve assembly is provided including: creating at least one injection orifice in a first side of a sac wall and causing a material removal element to pass through the created injection orifice such that the material removal element creates a depression in a second side of the sac wall that is opposite the first side of the sac wall.

[0012] Turning now to the drawings wherein like numerals represent like components, FIG. 1 is a diagram of an exemplary nozzle-and-holder assembly 10. This assembly is secured in a cylinder head of a diesel engine. It includes holder 12 and nozzle body 14. Nozzle body 14, together with valve stop spacer 29, is clamped on holder 12 by nozzle securing nut 27, the latter being threadedly engaged with holder 12, all as seen in FIG. 1. High-pressure tubing connects a pump high-pressure fuel delivery outlet to the inlet duct 16.

[0013] A pressure wave can deliver fuel through the inlet duct 16. The pressure wave travels through duct 16, duct 17, annular groove 11 formed in the top face of valve stop spacer 29, ducts 18, annular groove 13 formed in the top face of nozzle body 14, ducts 19, and into the annular nozzle-body cavity or chamber 20. With the nozzle 15 open, fuel flows into the sac 21 (FIG. 2) and into nozzle orifices or spray holes 23 (injection orifices) and injection begins. The valve 15 stays lifted during the time fuel is being delivered and can be closed to cease delivery. Spray holes 23, or orifices, are distributed around the sac and lead to the engine combustion chamber when the nozzle is installed.

[0014] The spray holes 23 are shown as being seven in number (only four are shown due to the view being a cross-section). Each spray hole 23 is an entrance to a spray duct 26. One of the seven spray ducts 26 is shown in the drawings. The remaining six ducts are not shown as well due to the view being a cross-section. However, additional spray holes 23 are shown that

correspond to additional spray ducts 26. It should be appreciated that having seven spray holes 23 is exemplary only. Indeed, embodiments are envisioned having any number of spray holes 23. Specifically, embodiments are envisioned having 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, or more spray holes.

[0015] With reference to Fig. 2, which corresponds to the portion within the circle "A" of FIG. 1, sac 21 illustratively includes upper boundary 30, cylindrical wall portion 32, and hemispherical bottom wall portion 34. The embodiment of sac 21 shown in Fig. 2 is generally referred to in the art as a "straight sac." This nomenclature is derived from the fact that cylindrical wall portion 32 is straight up and down. The present disclosure contemplates other known sac types being employed such as, but not limited to, conical sacs, spherical sacs, and hybrid sacs that combine elements of different sac types.

[0016] Above upper boundary 30, the internal wall of nozzle body 14 forms a needle seat 50 against which nozzle valve 15 engages when closed. Spray holes 23 are located in cylindrical wall portion 32. Spray holes 23 are illustratively round and include a first shoulder portion 36 that approximates a ring. First shoulder portion 36 defines an aperture therein that partially forms spray duct 26. Accordingly, first shoulder portion 36 provides a graduated transition from cylindrical wall portion 32 to spray duct 26. Sac 21 includes a longitudinal axis 38 about which upper boundary 30, cylindrical wall portion 32, and bottom wall portion 34 are symmetrical. However, it should be appreciated that spray holes 23 are not necessarily symmetrical about longitudinal axis 38.

[0017] Sac 21 further includes dimples 40. Dimples 40 are illustratively localized indentations formed in cylindrical wall portion 32. It should be appreciated that in embodiments that do not employ a straight sac, dimples 40 are located above spray holes 23 and below upper

boundary 30 such that fluid entering the sac passes from above dimples 40 to below dimples 40 to get to spray holes 23. In the shown illustrative embodiment, six dimples 40 are shown. It should be appreciated that the number is illustrative. Embodiments are envisioned with many different numbers of dimples 40. Specifically, embodiments are envisioned having 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, or more dimples. Still further, while dimples 40 are shown to be regularly spaced, embodiments are envisioned where dimples 40 are irregularly spaced. Still further embodiments are envisioned where nearly every surface of sac 21 is covered by dimples 40.

[0018] Each dimple 40 illustratively has dimple shoulder portion 42 and bottom portion 44. Similar to first shoulder portion 36, dimple shoulder portion 42 provides a graduated transition from cylindrical wall portion 32. Overall, dimples 40 are areas defined in cylindrical wall portion 32 where wall is cut away to form recesses therein. These recesses have walls that define portions that are farther from longitudinal axis 38 than the cylindrical wall portion 32. While dimples 40 are shown as being generally circular and/or hemispherical dimples 40 of other sizes, shapes, and locations are also envisioned. Unlike spray holes 23 that are connected to spray ducts 26 and provide an output path from sac 21, dimples 40 have a finite depth and do not provide an egress path from sac 21.

[0019] Dimples 40 provide localized areas of increased sac volume relative to sacs 21 without dimples. Dimples 40 further provide areas of discontinuity in the walls of sac 21. While the shown dimples 40 are all located at the same height within sac 21, embodiments are envisioned where dimples 40 are positioned at multiple differing heights.

[0020] As previously noted, in operation, fuel flows into sac 21 proximate upper boundary 30, down across and through the volume proscribed by sac 21 (into cylindrical wall

portion 32, then into the volume proscribed by bottom wall portion 34), and then into spray holes/ducts 23/26.

[0021] As previously noted, while dimples 40 are shown as being generally circular and/or hemispherical, other voids within the wall of sac 21 are envisioned such that the voids result in a decrease in the likelihood of cavitation. In another embodiment, dimples 40 are ovular. In yet further embodiments, additional mutations to the sac wall are envisioned such as rings, slots, and any manner of wall permutations that impart flow characteristics that reduce cavitation. Such rings, slots, and/or other shapes can have a longitudinal axis that is generally horizontal, generally vertical, or angled.

[0022] In one embodiment, nozzle body 14 is obtained and/or formed from a block of steel, block 300, Fig. 3. The external contour is formed by casting the steel or by a cutting tool, such as a lathe. Chamber 20 and sac 21 are formed by drilling or otherwise, block 310. Spray ducts 26 are illustratively formed via Electro-static Discharge Machining (EDM) and/or electro-chemical machining (ECM), block 320. In one embodiment, dimples 40 are likewise formed via EDM and/or ECM, block 330. In one embodiment, spray ducts 26 are cut starting at the outside and proceeding towards sac 21 until sac 21 is reached and spray holes 23 are created.

[0023] In yet another embodiment, spray ducts 26 are formed via laser cutting, block 320. In one embodiment of the present disclosure, dimples 40 are aligned with spray ducts 26 such that dimples can be formed by a laser that travels through spray ducts to then cut on the opposing wall to form dimples 40, block 330. One such an alignment is shown in Fig. 2. Axis 46 is generally a longitudinal axis central to spray duct 26. As shown, axis 46 also intersects dimple 40 on the opposing portion of cylindrical wall portion 32 of sac 21. While this alignment is not necessarily present for all ducts 26 and dimples 40, embodiments are envisioned where this

is the case. One such embodiment includes six ducts 26 and six dimples 40 in sac 21. In such embodiments, it is no longer a problem for the laser to cut into a wall on the opposite side of sac 21 from which the current spray duct 26 is being formed. Rather, this is a desired feature as the cutting continues to begin forming the opposing dimple 40. Indeed, FIG. 4 shows an embodiment where all spray ducts 26 have a dimple 40 aligned therewith on an opposite wall of sac 21. In yet another embodiment, nozzle body 14 is constructed via additive machining, such as 3-D printing.

[0024] The above detailed description and the examples described therein have been presented for the purposes of illustration and description only and not for limitation. For example, the operations described may be done in any suitable manner. The method steps may be done in any suitable order still providing the described operation and results. It is therefore contemplated that the present embodiments cover any and all modifications, variations or equivalents that fall within the spirit and scope of the basic underlying principles disclosed above and claimed herein.

WHAT IS CLAIMED IS:

1. A valve nozzle assembly including:

a valve seat; and

a sac positioned below a valve body chamber, the sac including:

at least one injection orifices operable to provide passage for fluid out of the sac,

an outer wall extending between the valve seat and the orifices; and

at least one dimple defined in the outer wall.

2. The assembly of claim 1, wherein the outer wall includes a central axis and each dimple is a first part of the outer wall that is farther away from the central axis relative to the majority of the outer wall thereby increasing the volume of the sac.

3. The assembly of claim 1, wherein at least one of the dimples is intersected by a longitudinal axis of one of the plurality of injection orifices.

4. The assembly of claim 1, wherein the dimple is operable to decrease cavitation of fluids flowing through the assembly.

5. The assembly of claim 1, wherein the dimple includes a hemispherical portion.

6. The assembly of claim 1, wherein the dimple provides a discontinuity in the outer wall.

7. The assembly of claim 1, wherein the valve is part of a diesel engine.

8. The assembly of claim 1, wherein the dimple does not provide a path for egress from the sac.

9. The assembly of claim 1, wherein the sac is a straight sac.

10. The assembly of claim 1, wherein the sac is a conical sac.

11. The assembly of claim 1, wherein the sac is a spherical sac.

12. The assembly of claim 1, wherein the sac is a hybrid sac.

13. The assembly of claim 1, wherein the dimples form a regular pattern in the sac.

14. The assembly of claim 1, wherein the dimples from an irregular pattern in the sac.

15. A needle valve nozzle body nose portion including:

a sac defining a fluid path including:

at least one injection orifice operable to receive fluid from the sac; and

a first portion located within the fluid path such that fluid must pass the first portion to reach the at least one injection orifice; the first portion including at least one dimple, the at least one dimple including a dimple wall that defines a first distance between the dimple wall and a central axis of the first portion, the first distance being greater than a second distance defined between a wall of a non-dimpled portion of the first portion and the central axis of the first portion.

16. The nose portion of claim 15, wherein the dimple is round in cross-section.

17. The nose portion of claim 15, wherein the dimple is operable to decrease cavitation of fluids flowing through the assembly.

18. A method of manufacturing a needle valve assembly including:

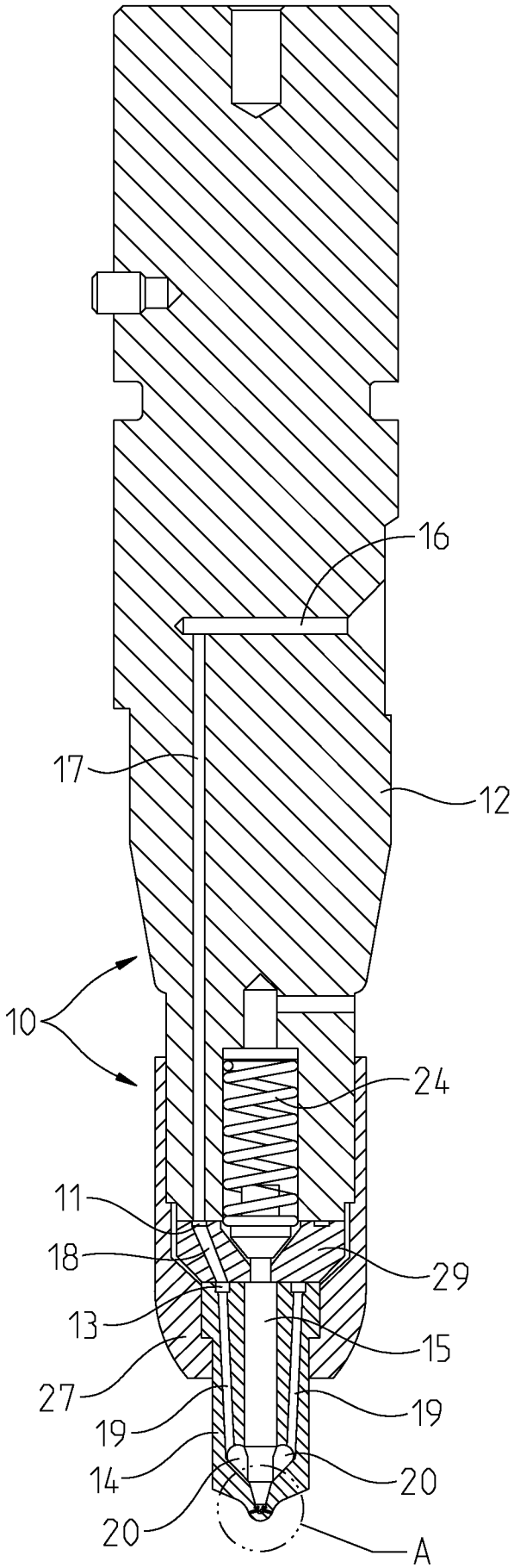
creating at least one injection orifice in a first side of a sac wall, and

causing a material removal element to pass through the created injection orifice such that the material removal element creates a depression in a second side of the sac wall that is opposite the first side of the sac wall.

19. The method of claim 18, wherein the material removal element is selected from the group consisting of an ECM tool, and EDM tool, and a laser beam.

20. The method of claim 18, wherein the needle valve is at least partially manufactured via additive machining.

Fig. 1



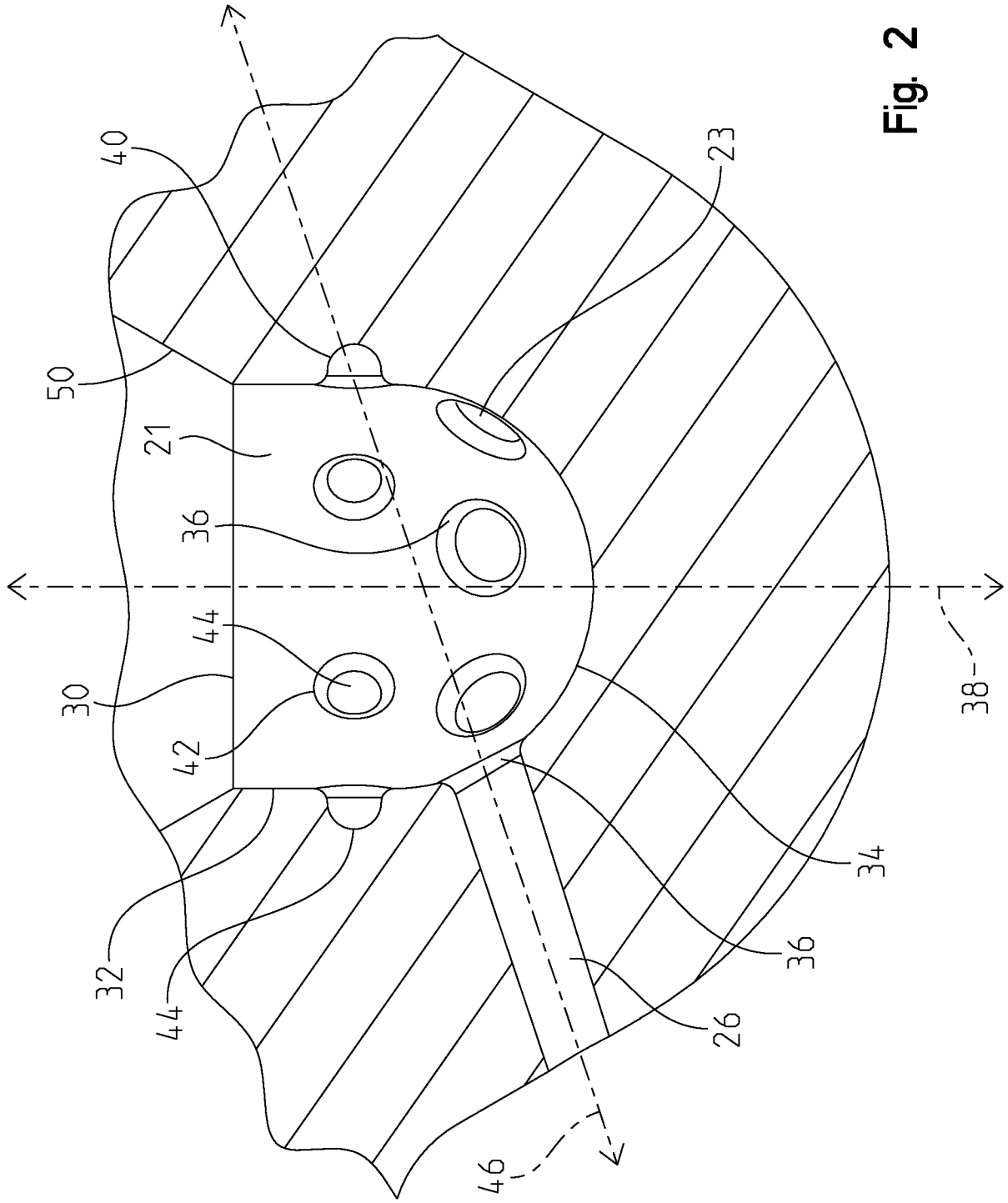


Fig. 2

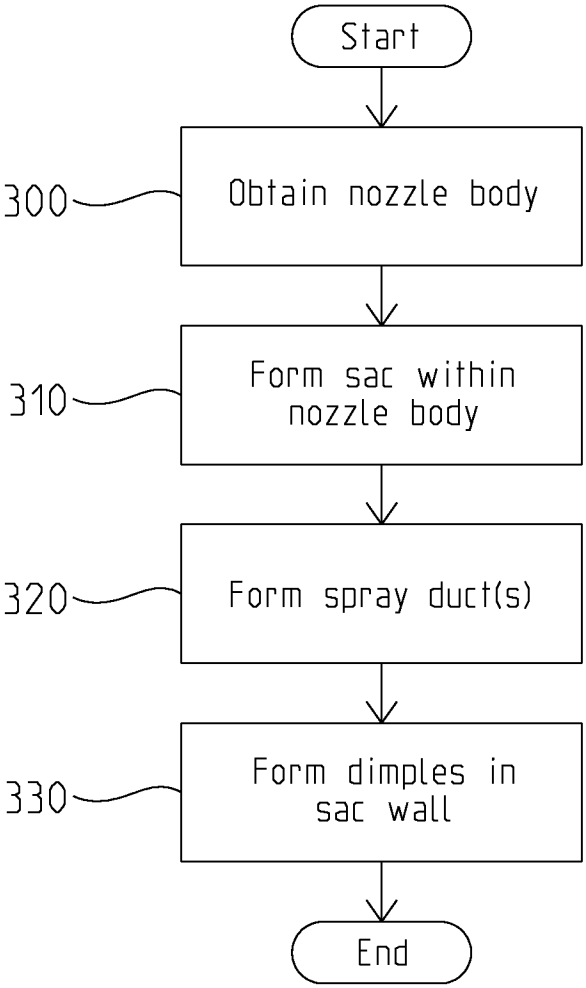
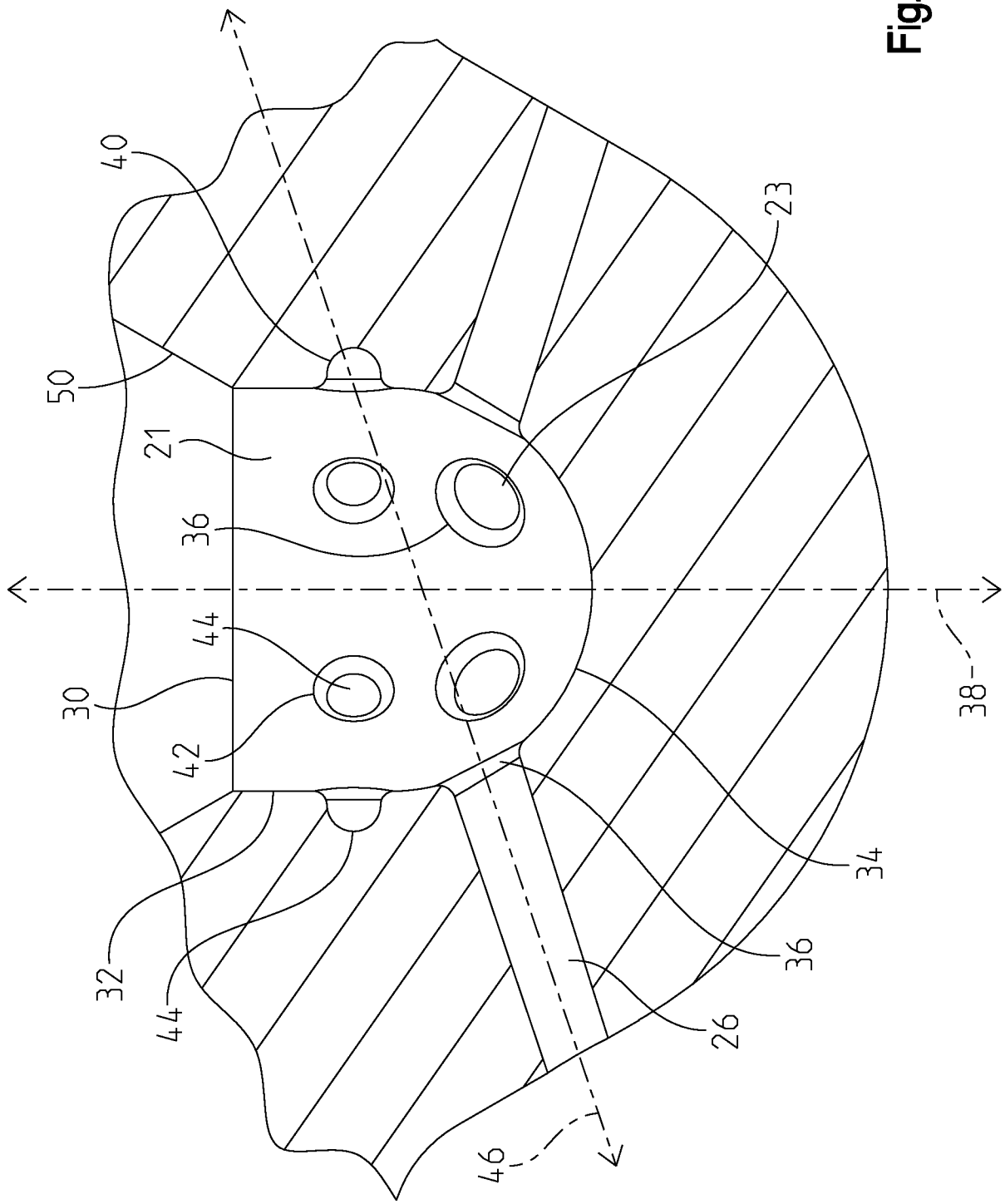

Start
300
Obtain nozzle body
310
Form sac within nozzle body
320
Form spray duct(s)
330
Form dimples in sac wall
End

Fig. 3

Fig. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/014434

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F02M 47/02 (2014.01)
USPC - 239/533.2
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)
IPC(8) - F02M 47/02, 61/00 (2014.01)
USPC - 239/005, 533.12, 533.2, 533.3. 585.1, 585.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - F02M 47/022 (2014.02)

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,880,770 B2 (JAMESON et al) 19 April 2005 (19.04.2005) entire document	1-20
Y	US 2005/0205693 A1 (TESCHNER et al) 22 September 2005 (22.09.2005) entire document	1-20
A	US 2010/0090031 A1 (HASHII et al) 15 April 2010 (15.04.2010) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 May 2014	22 MAY 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774