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(54) **FLUID SPRAY TIPS HAVING SECURING ELEMENTS FORMED IN THE FLUID SPRAY TIP BODY AND METHODS OF MANUFACTURING THEREOF**

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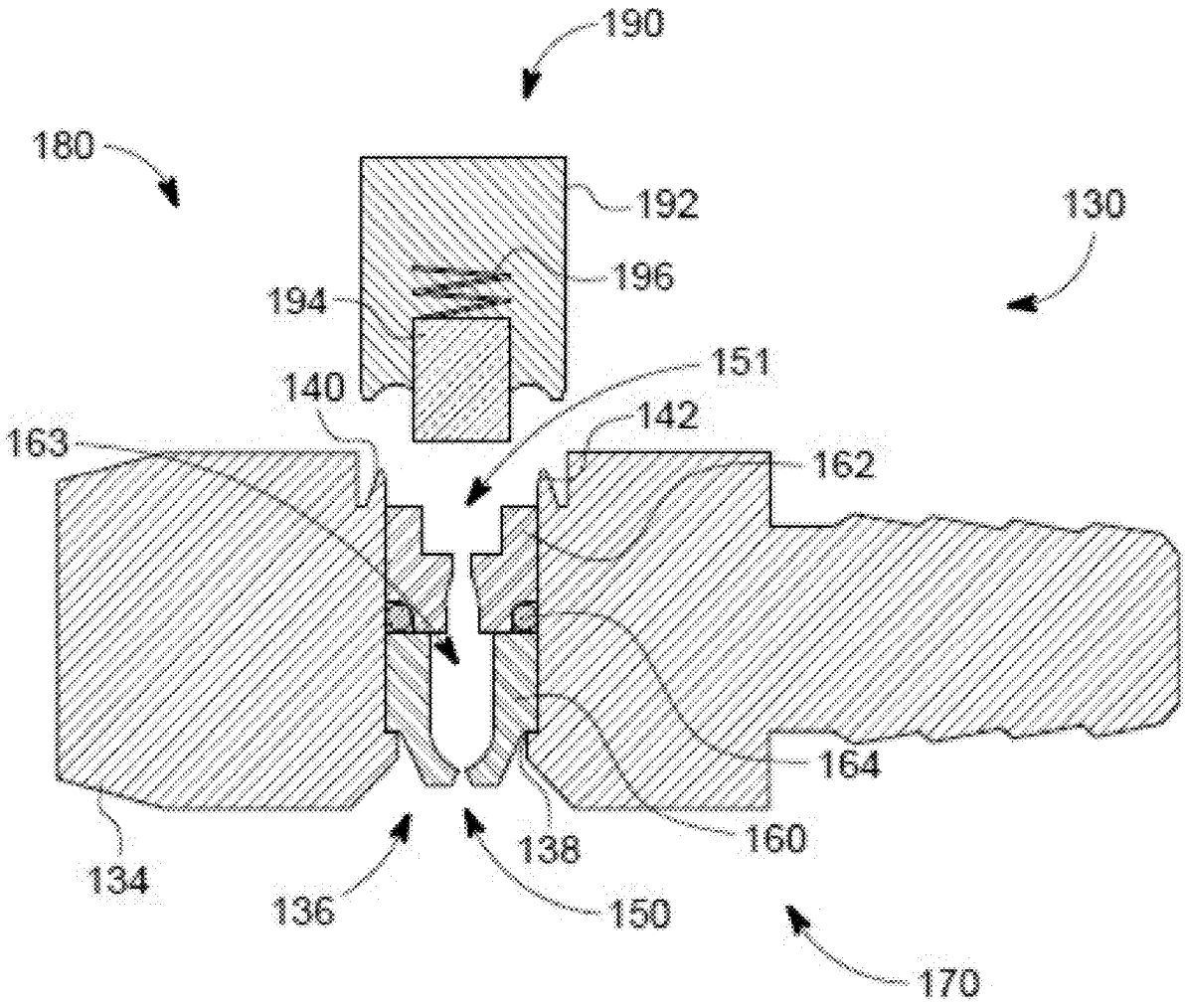
CPC ***B05B 15/658*** (2018.02); ***B05B 9/01*** (2013.01)

(57) **ABSTRACT**

A spray tip includes a tip body having a longitudinal axis and a receiving channel extending between a front and back of the tip body transverse to the longitudinal axis. The spray tip further includes a tip piece defining, at least, a first portion of a fluid channel, the fluid channel extending between an inlet and an outlet. The spray tip further includes a first securing element downstream of at least a portion of the tip piece and a second securing element upstream of the tip piece. The first securing element and the second securing element securing at least the tip piece within the receiving channel.



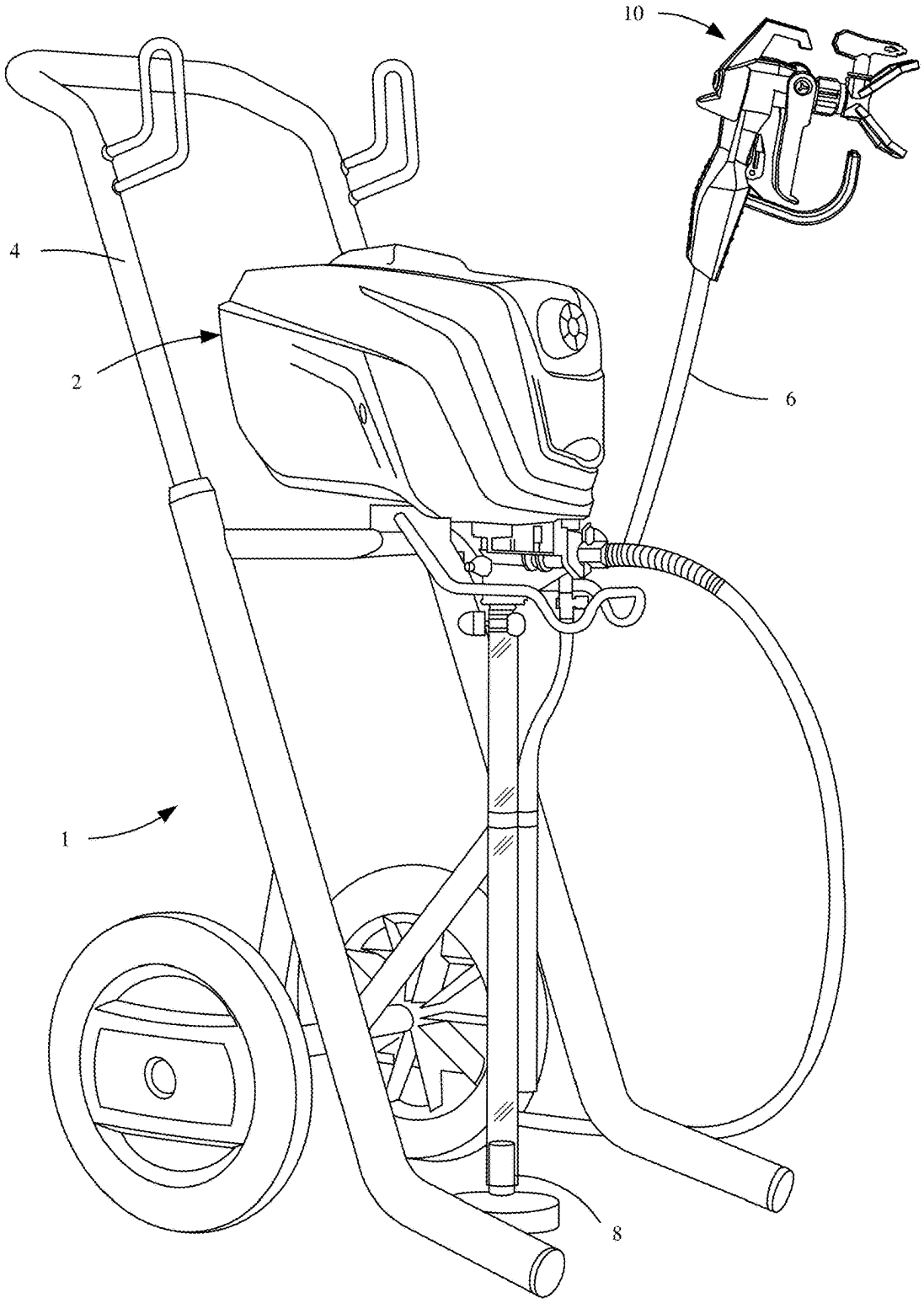


FIG. 1

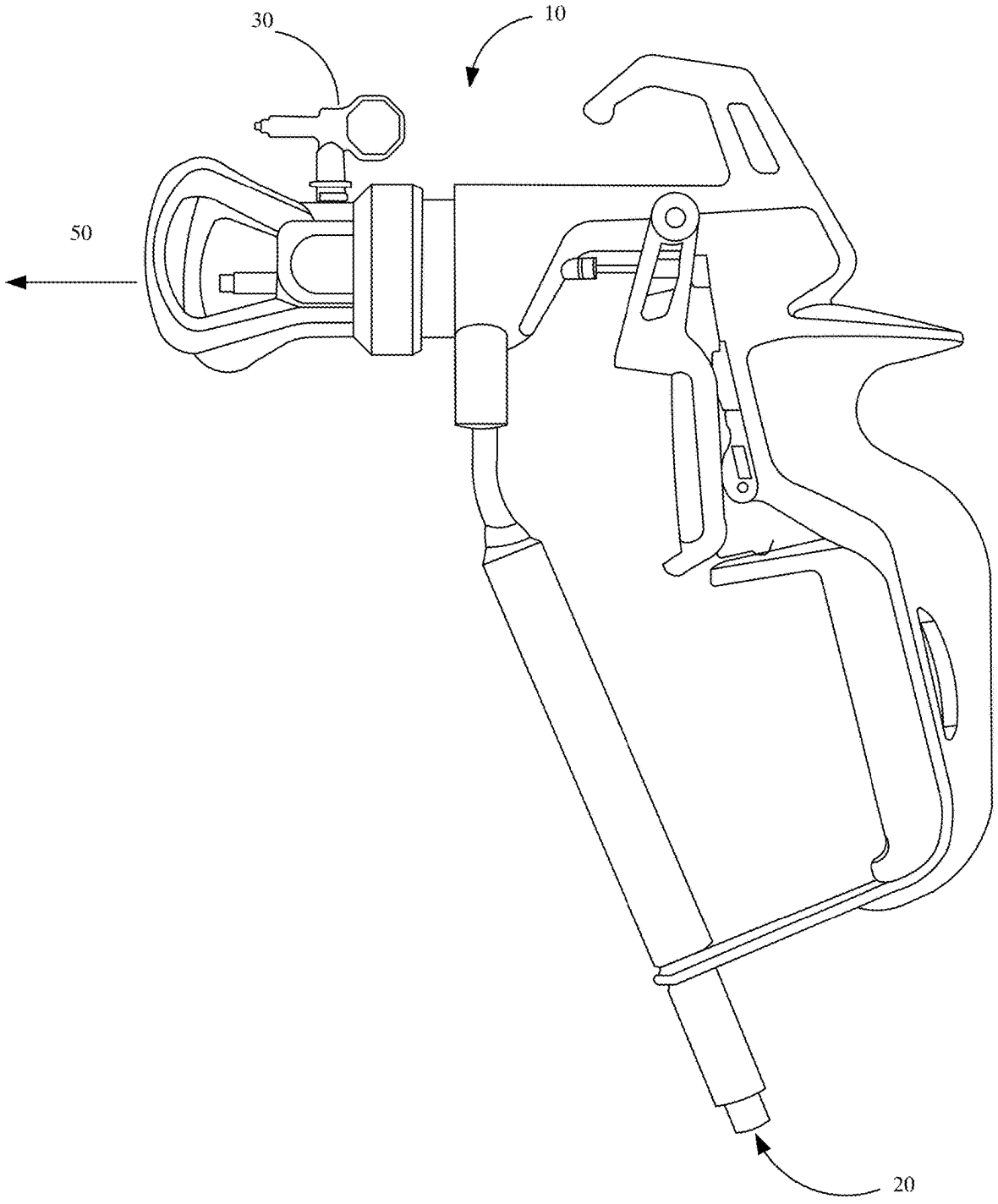


FIG. 2

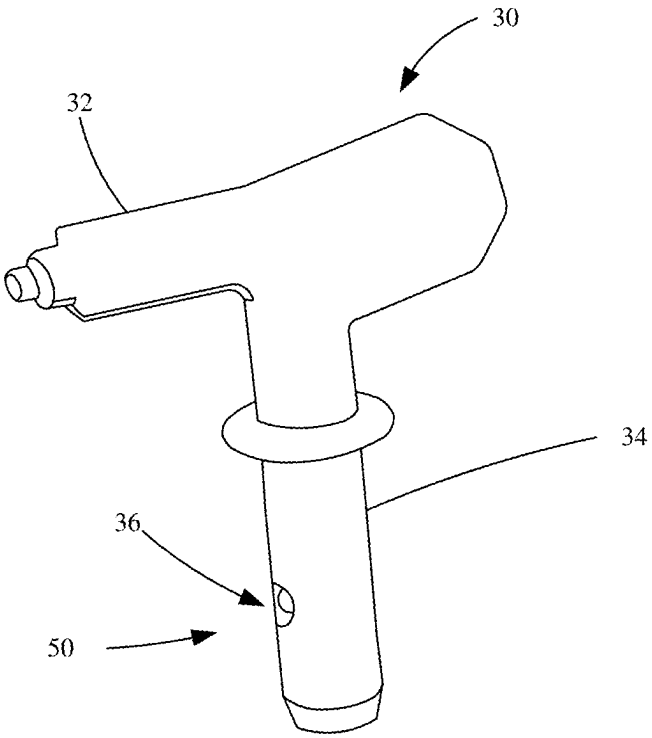


FIG. 3

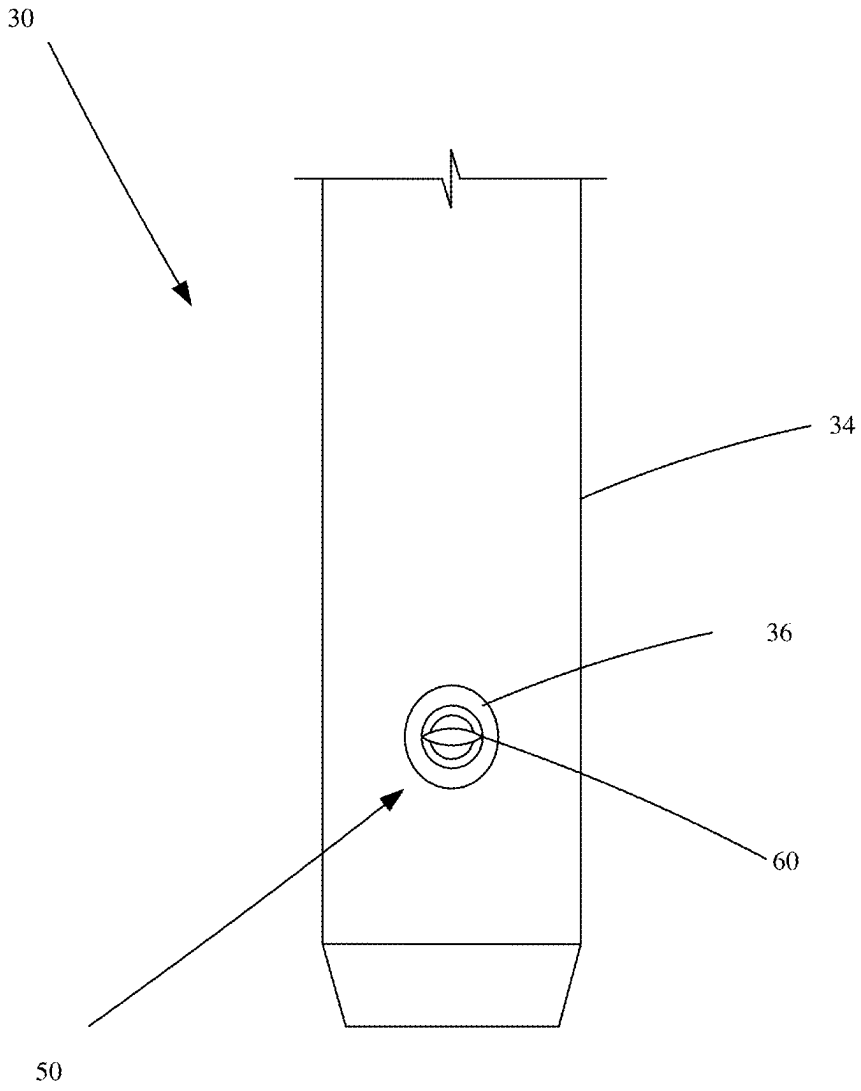


FIG. 4

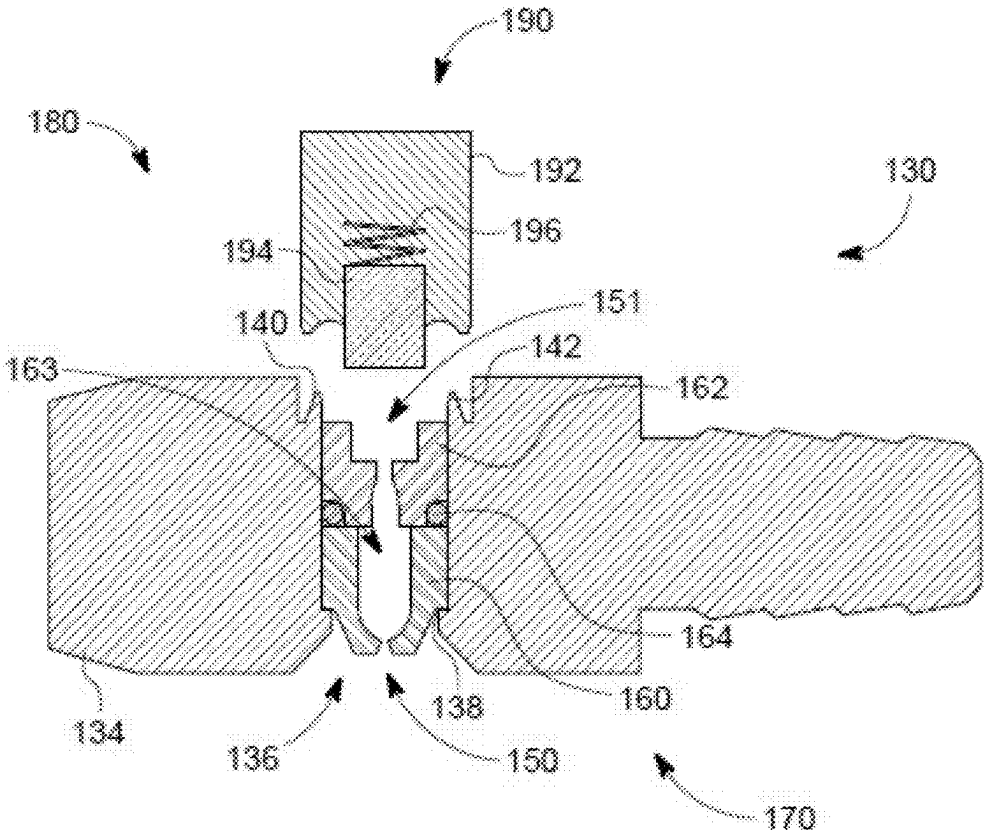

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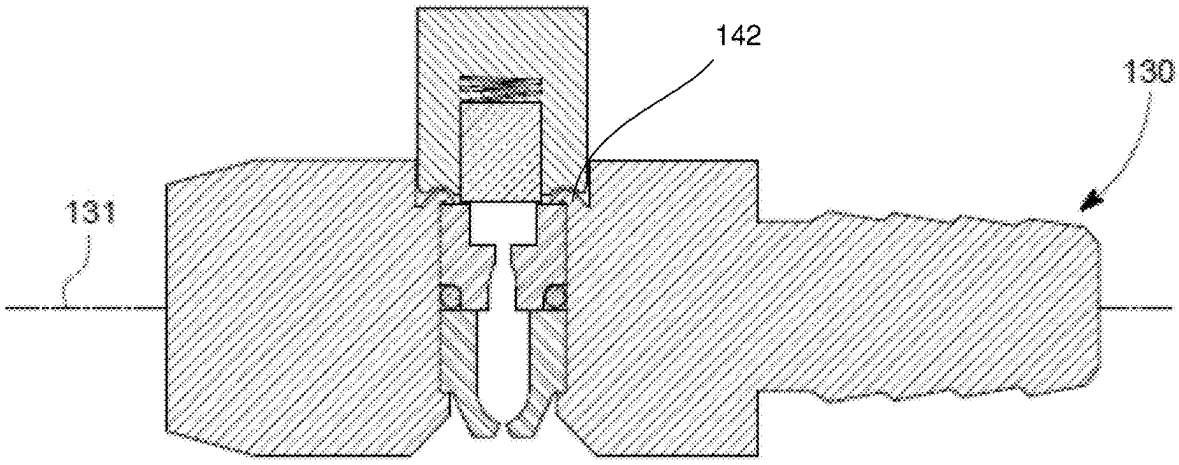
FIG. 5A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130
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FIG. 5B

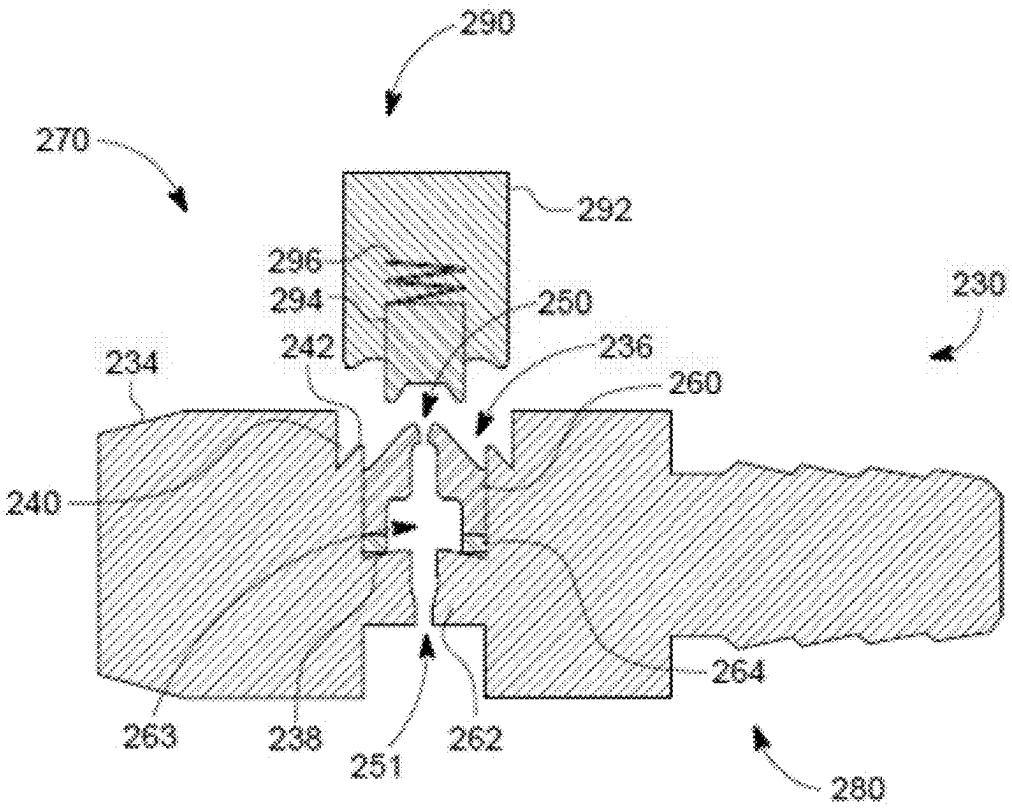
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FIG. 6A

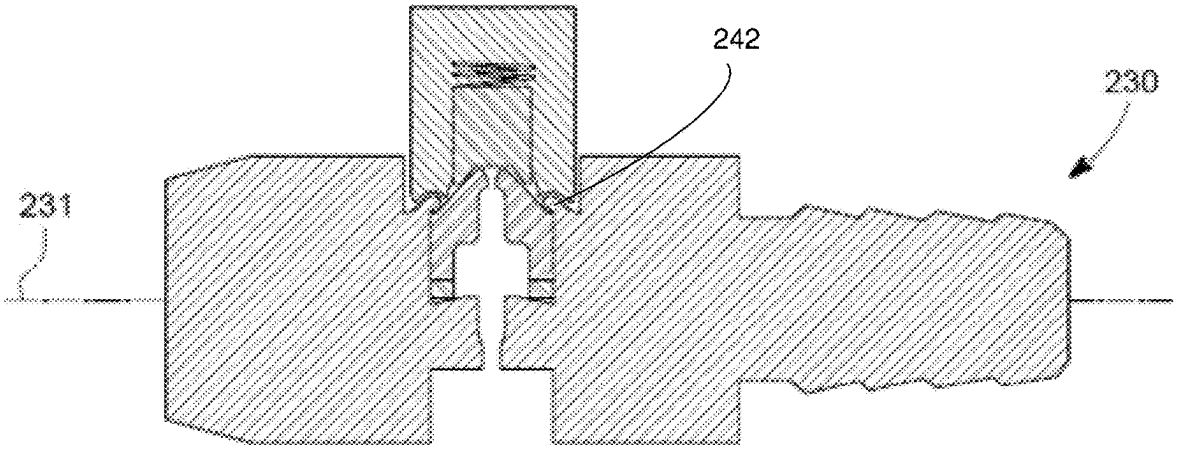
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FIG. 6B

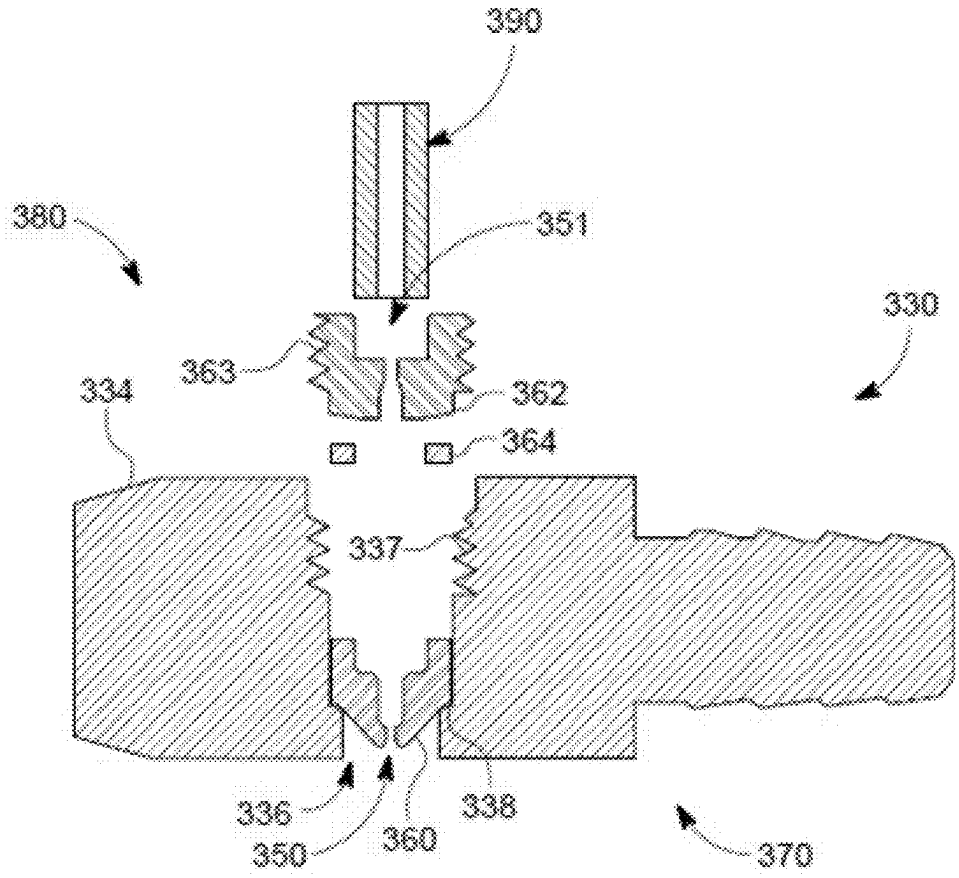
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FIG. 7A

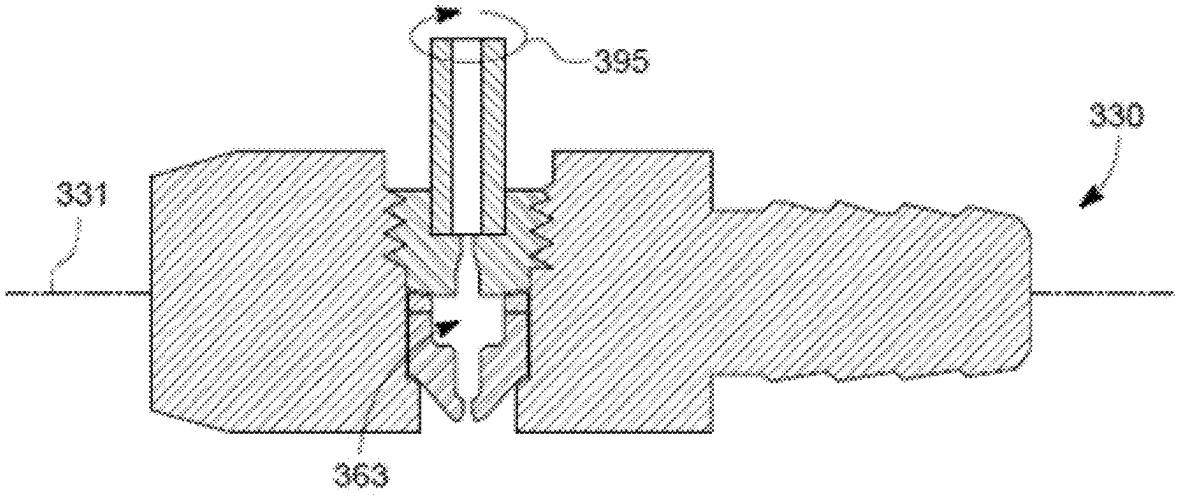
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FIG. 7B

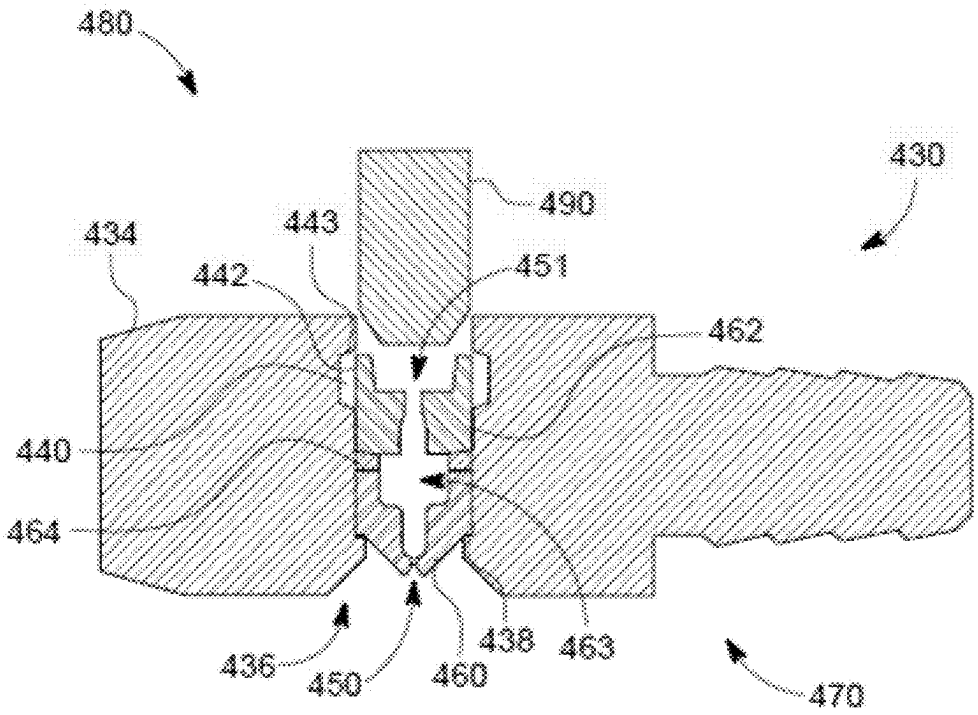
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FIG. 8A

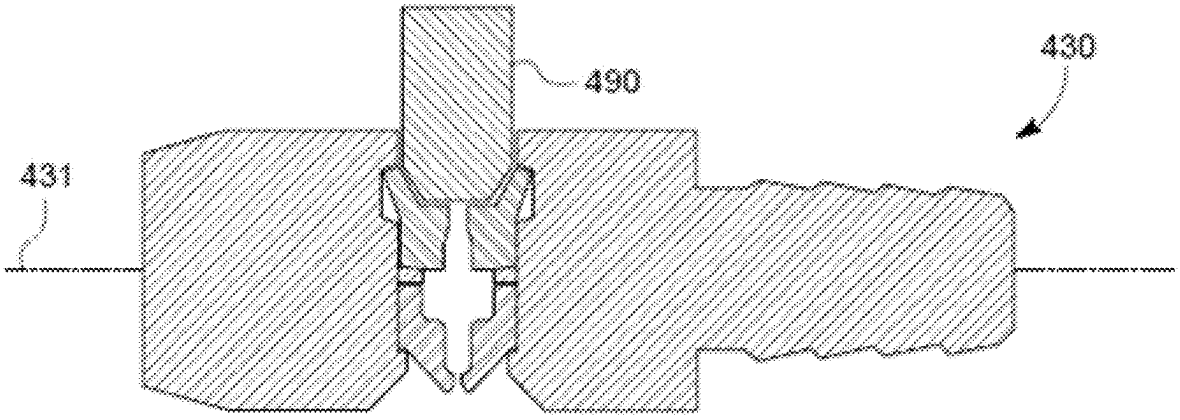
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FIG. 8B

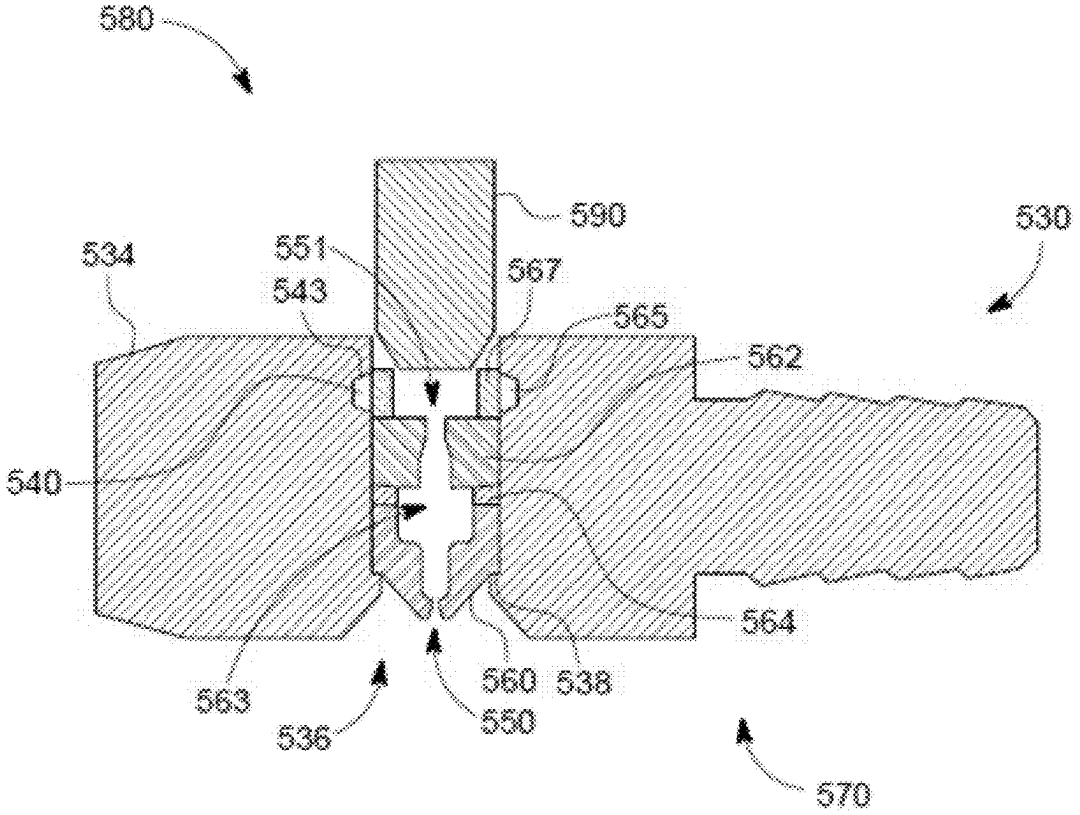
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FIG. 9A

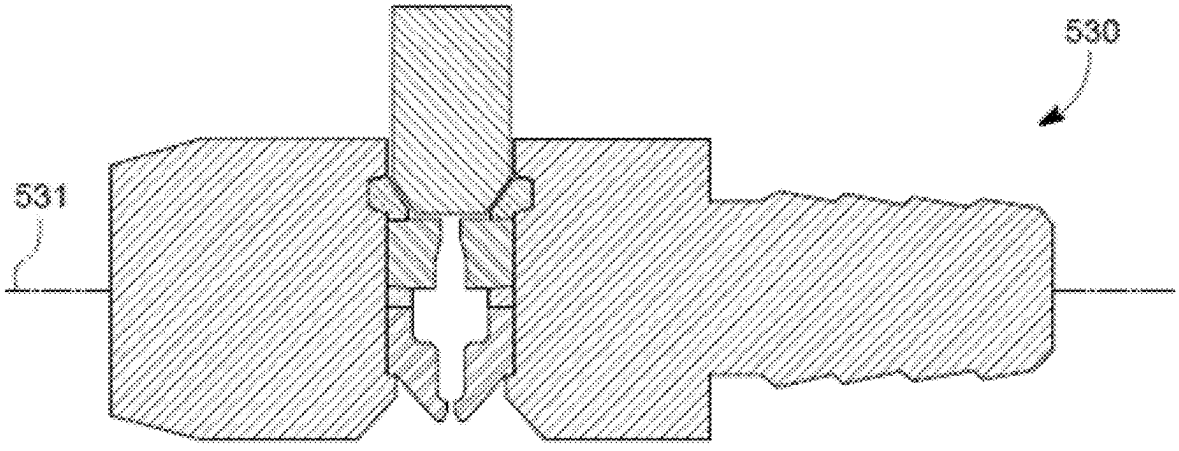
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FIG. 9B

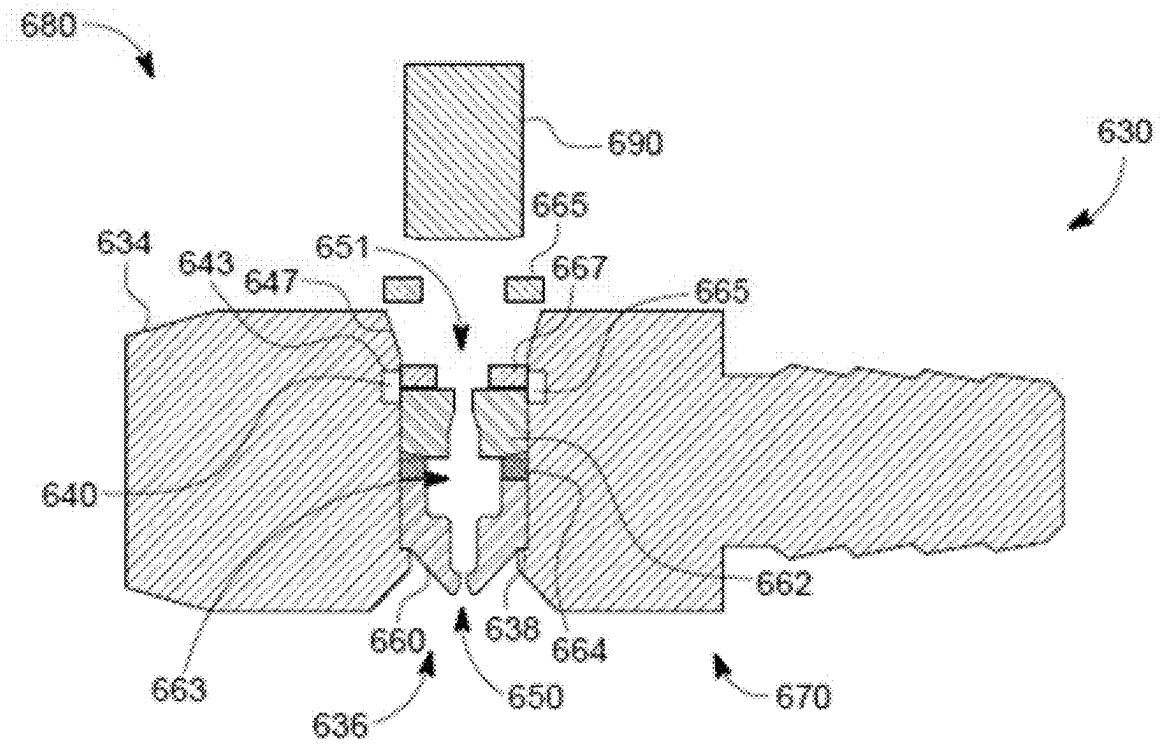

FIG. 10A

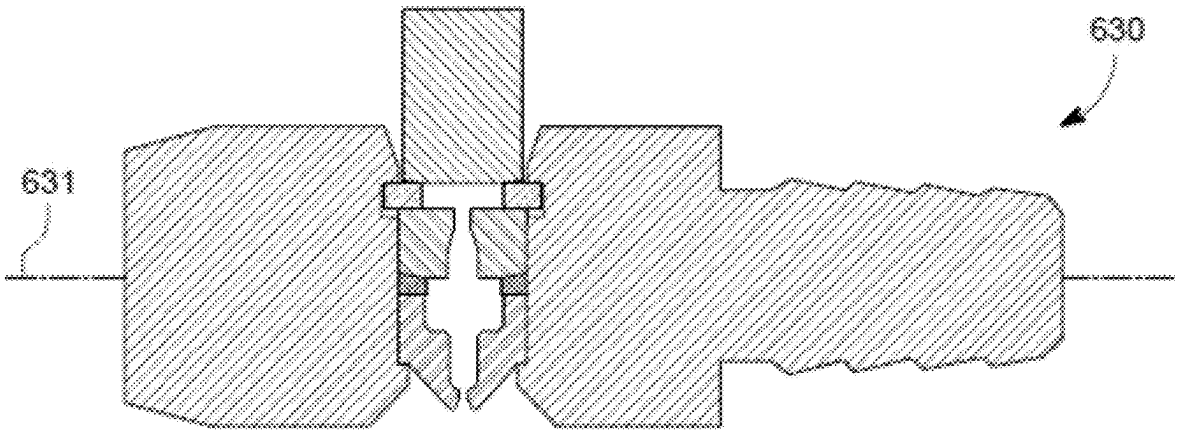

FIG. 10B

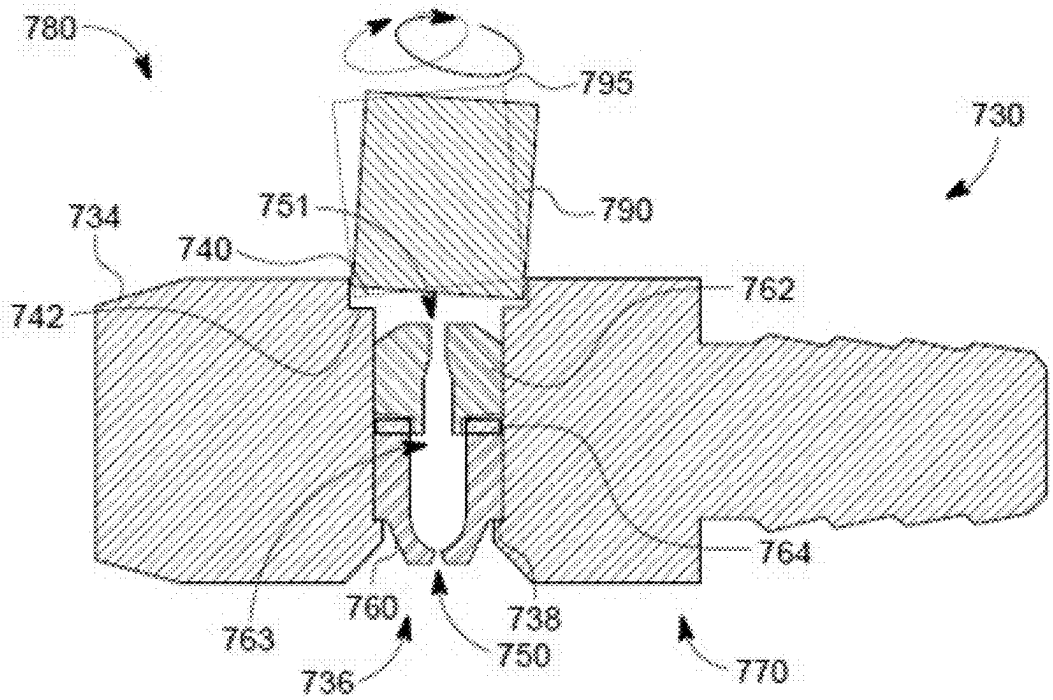

FIG. 11A

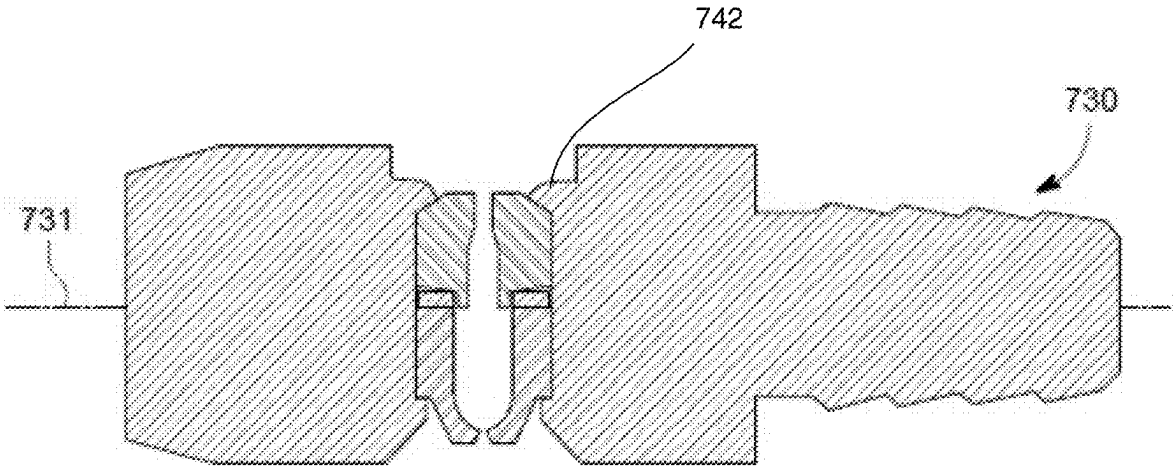

FIG. 11B

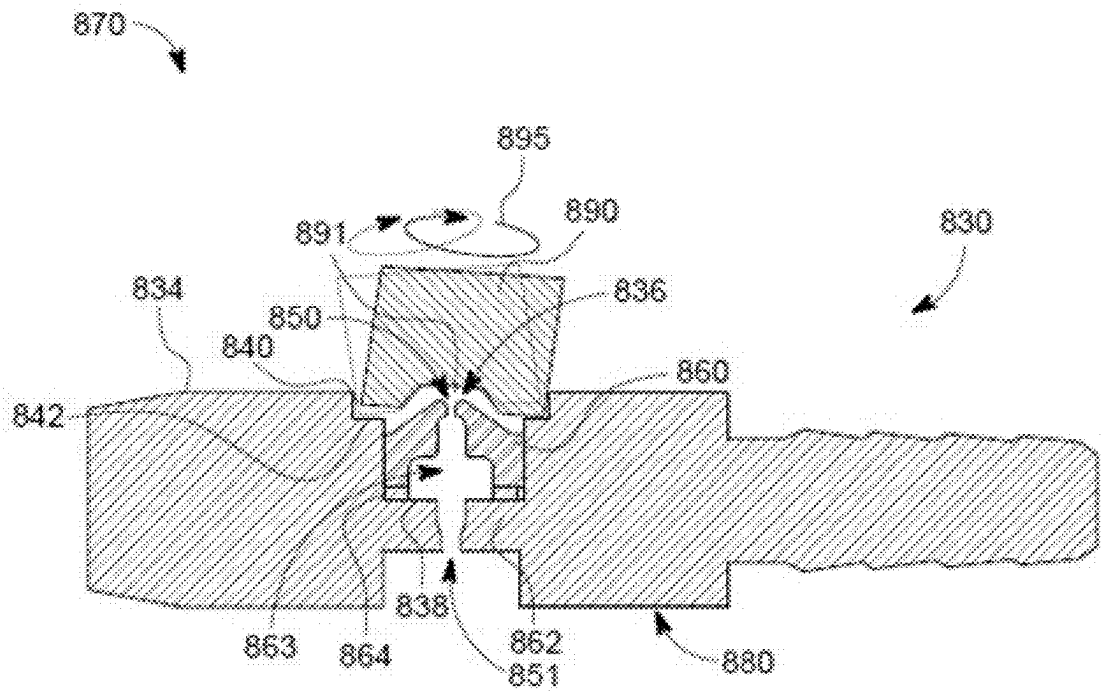

FIG. 12A

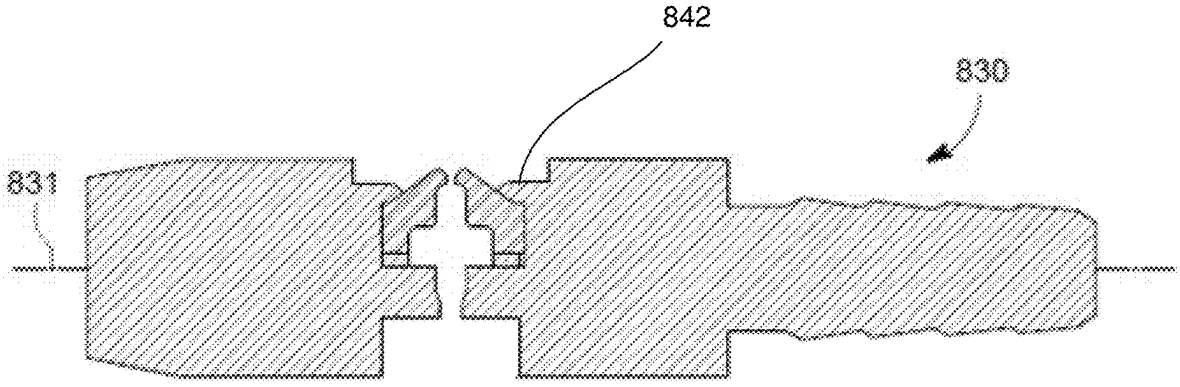

FIG. 12B

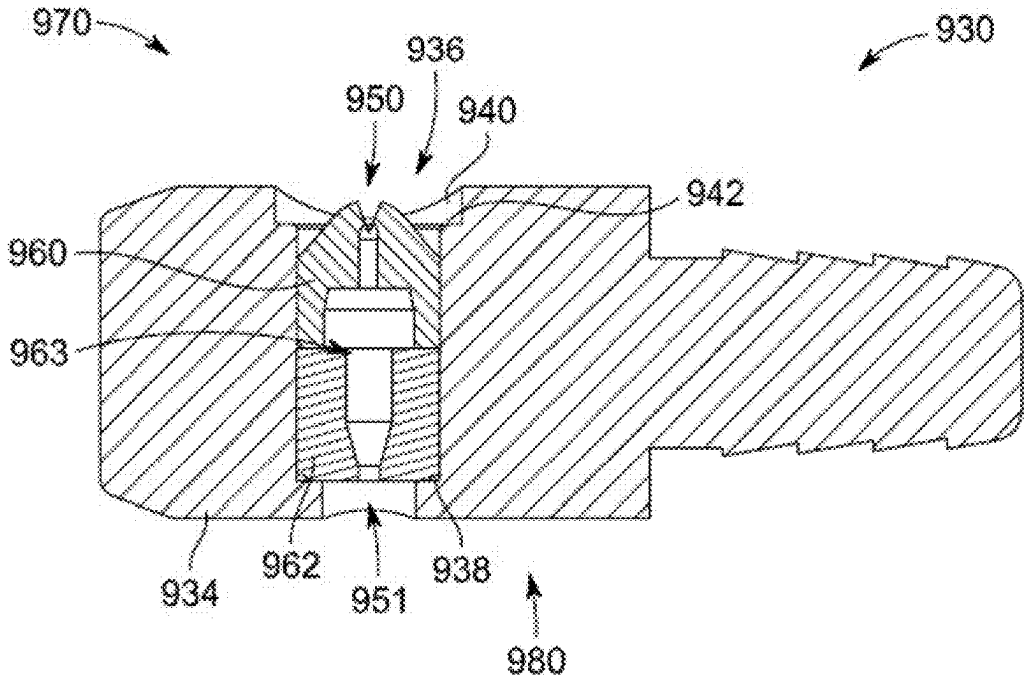

FIG. 13A

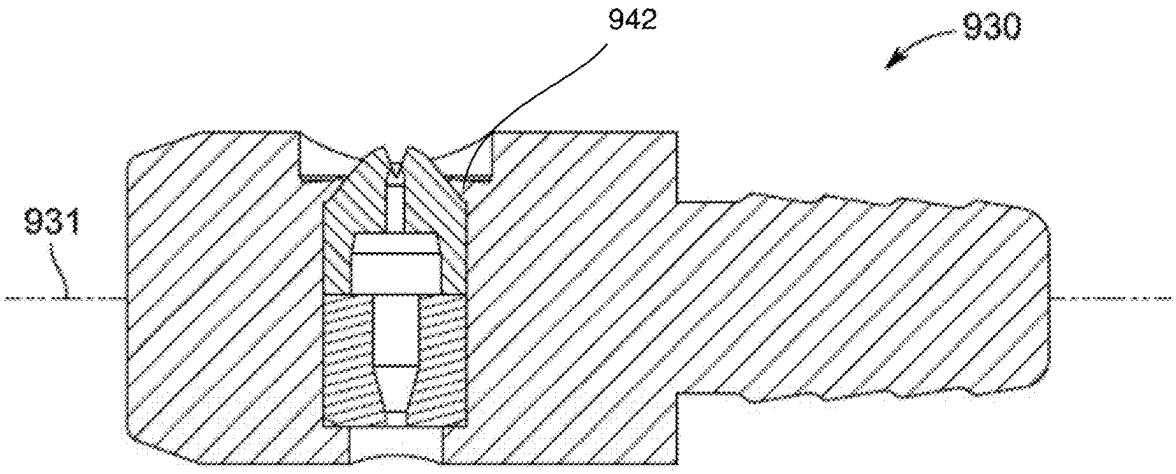

FIG. 13B

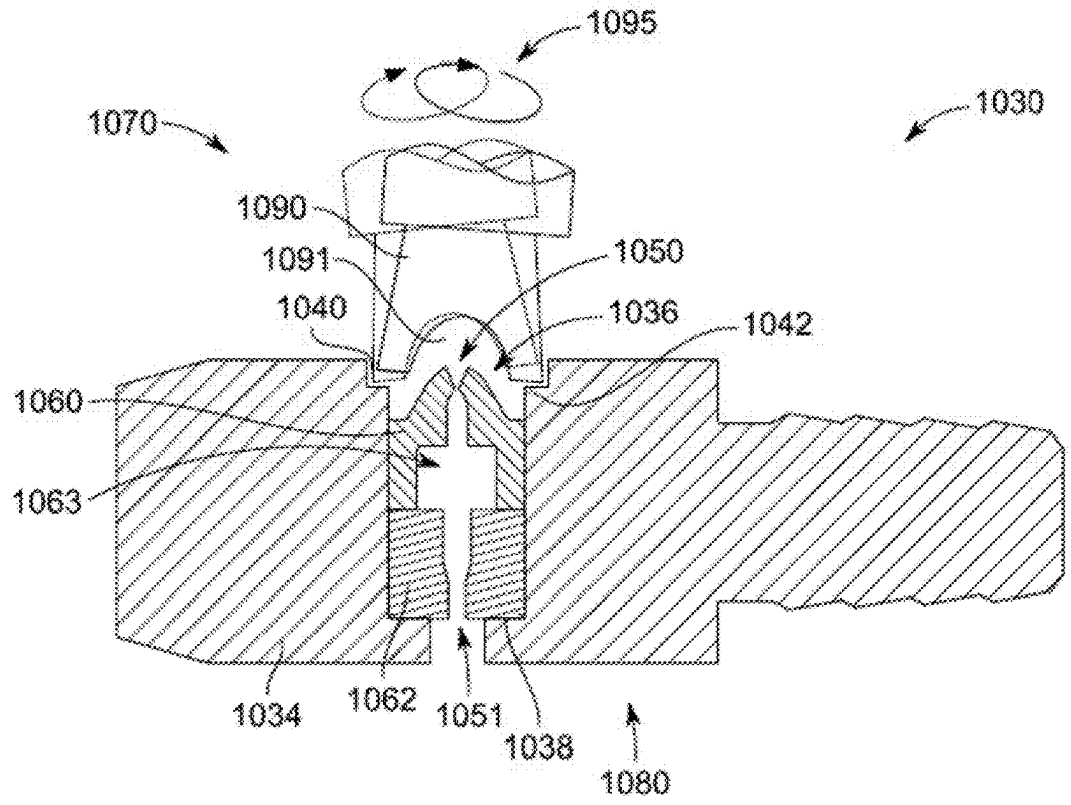

FIG. 14A

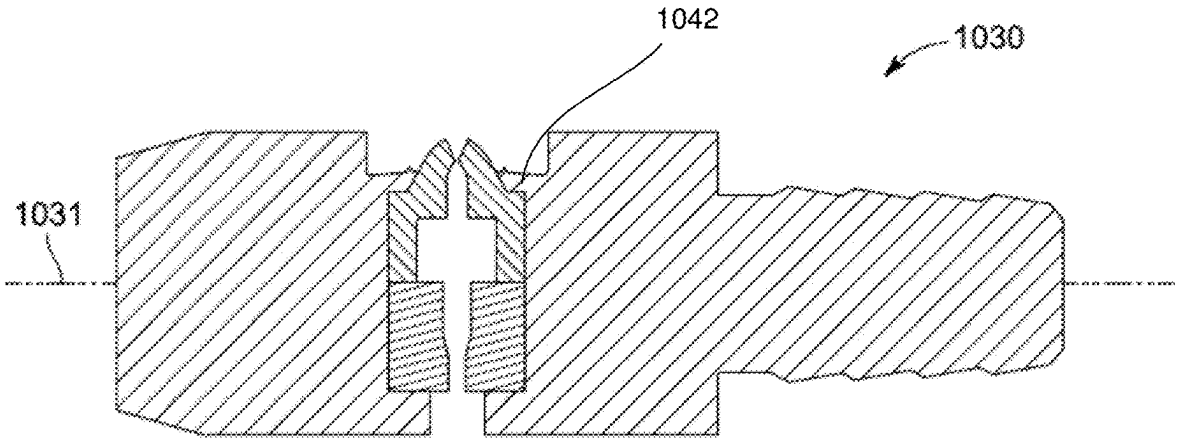

FIG. 14B

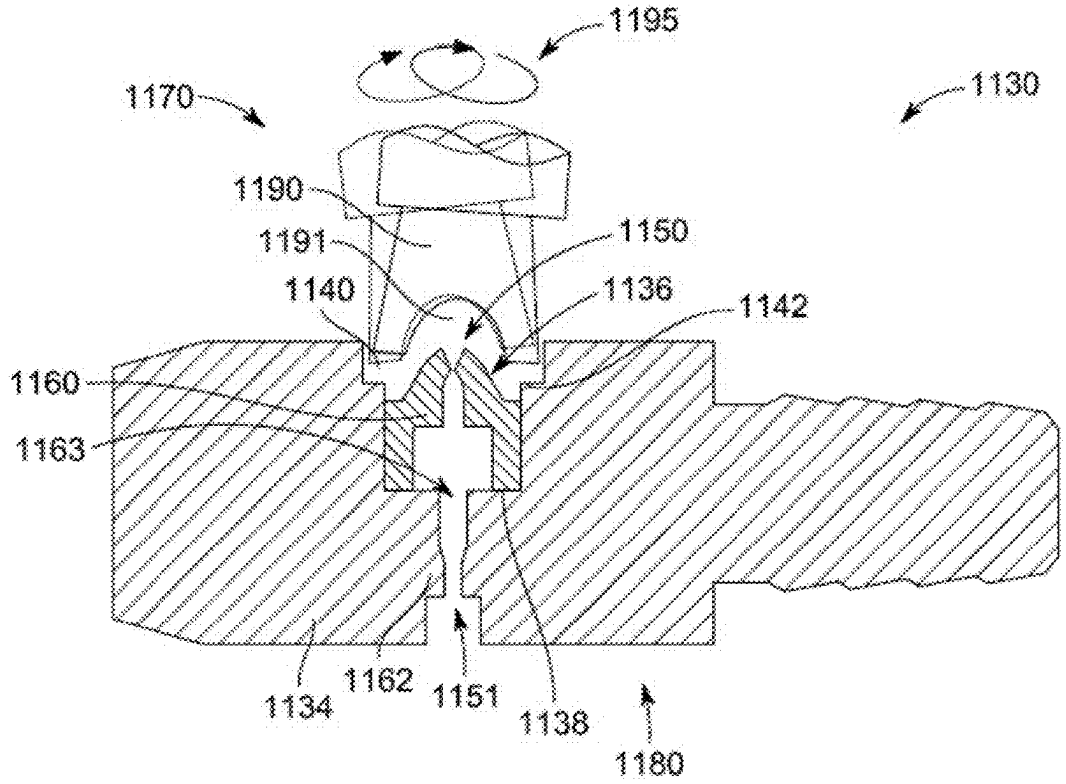

FIG. 15A

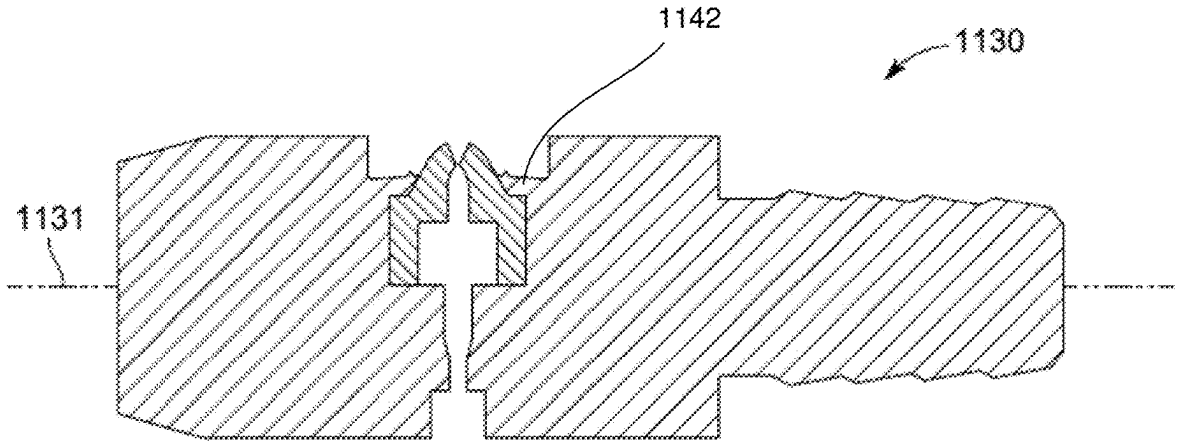

FIG. 15B

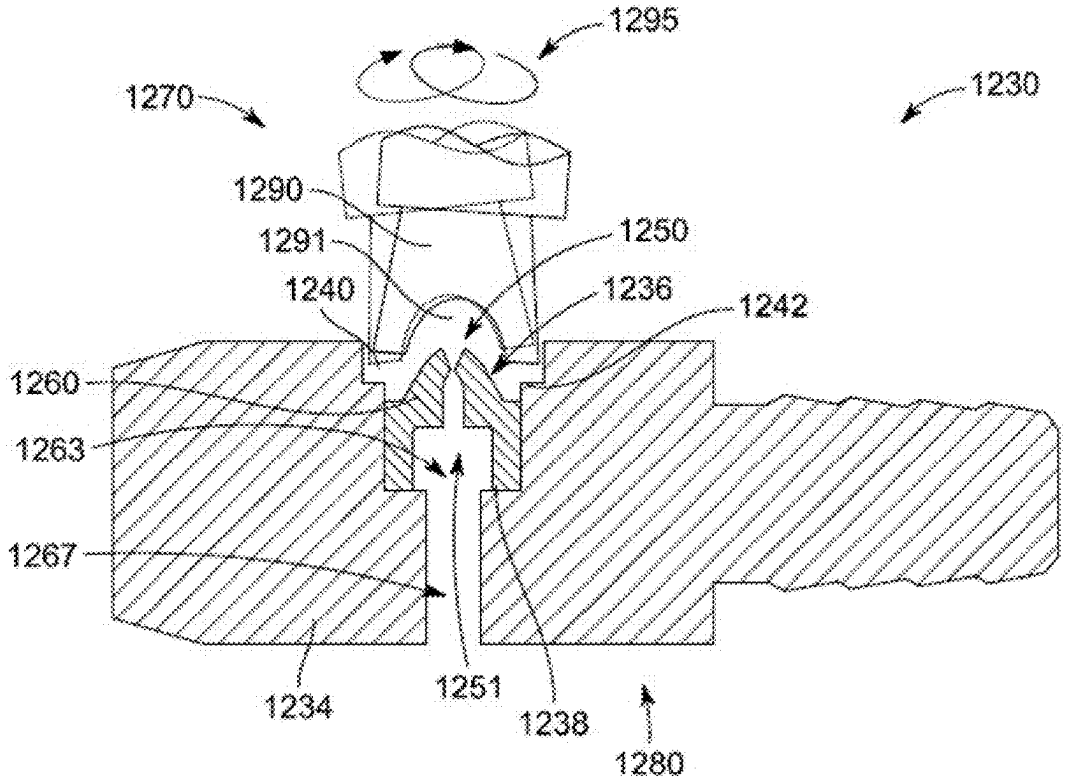

FIG. 16A

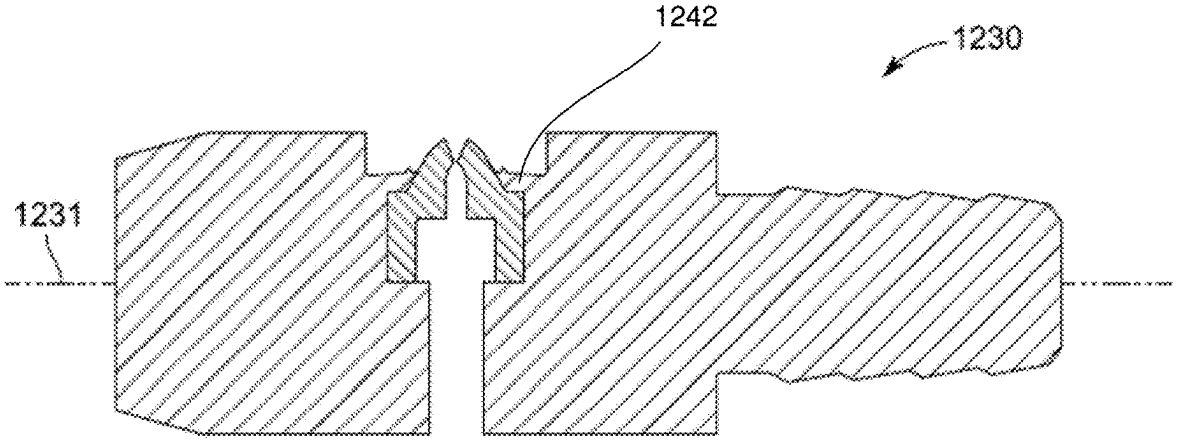

FIG. 16B

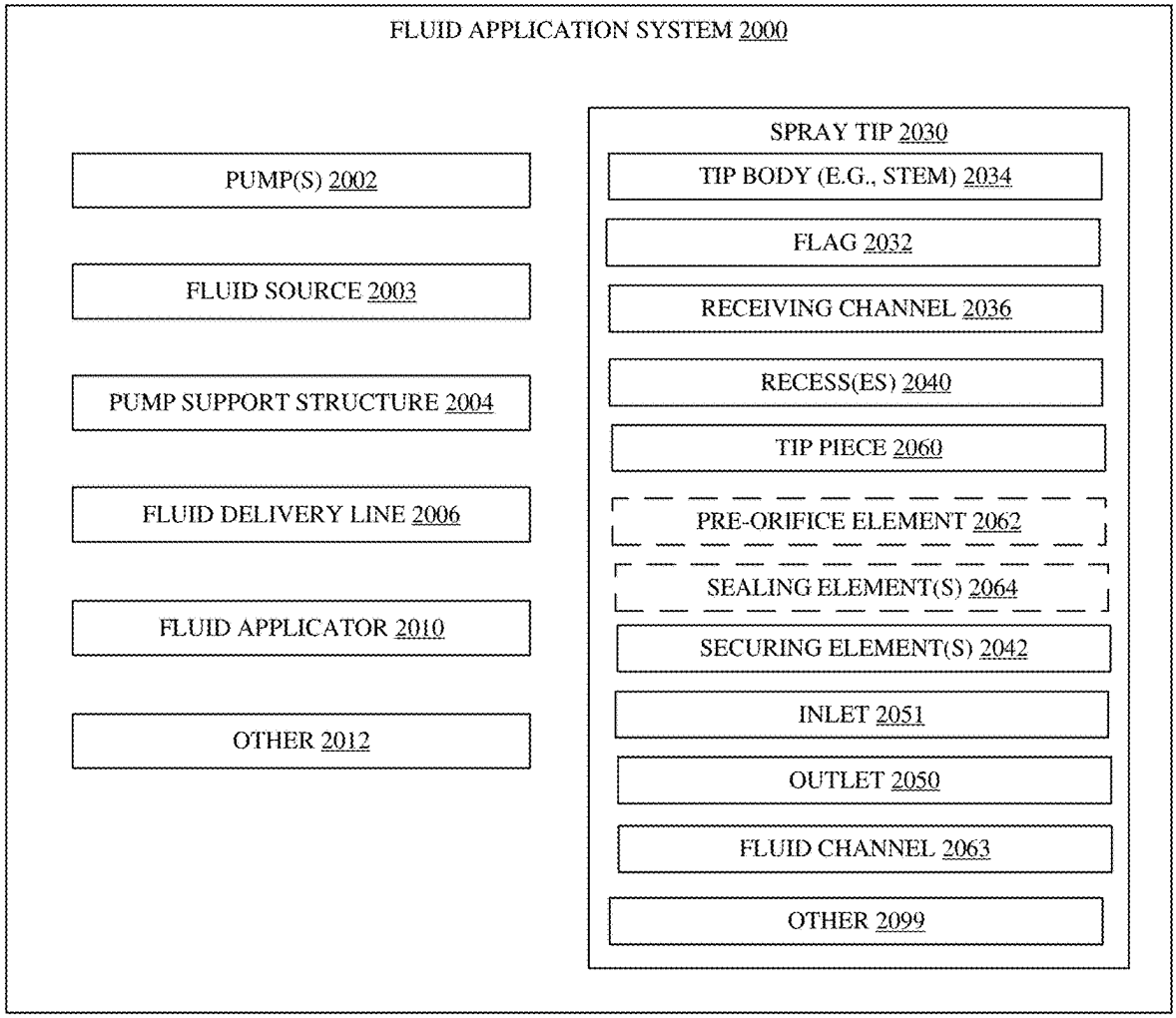
FLUID APPLICATION SYSTEM 2000
PUMP(S) 2002
FLUID SOURCE 2003
PUMP SUPPORT STRUCTURE 2004
FLUID DELIVERY LINE 2006
FLUID APPLICATOR 2010
OTHER 2012
SPRAY TIP 2030
TIP BODY (E.G., STEM) 2034
FLAG 2032
RECEIVING CHANNEL 2036
RECESS(ES) 2040
TIP PIECE 2060
PRE-ORIFICE ELEMENT 2062
SEALING ELEMENT(S) 2064
SECURING ELEMENT(S) 2042
INLET 2051
OUTLET 2050
FLUID CHANNEL 2063
OTHER 2099

FIG. 17

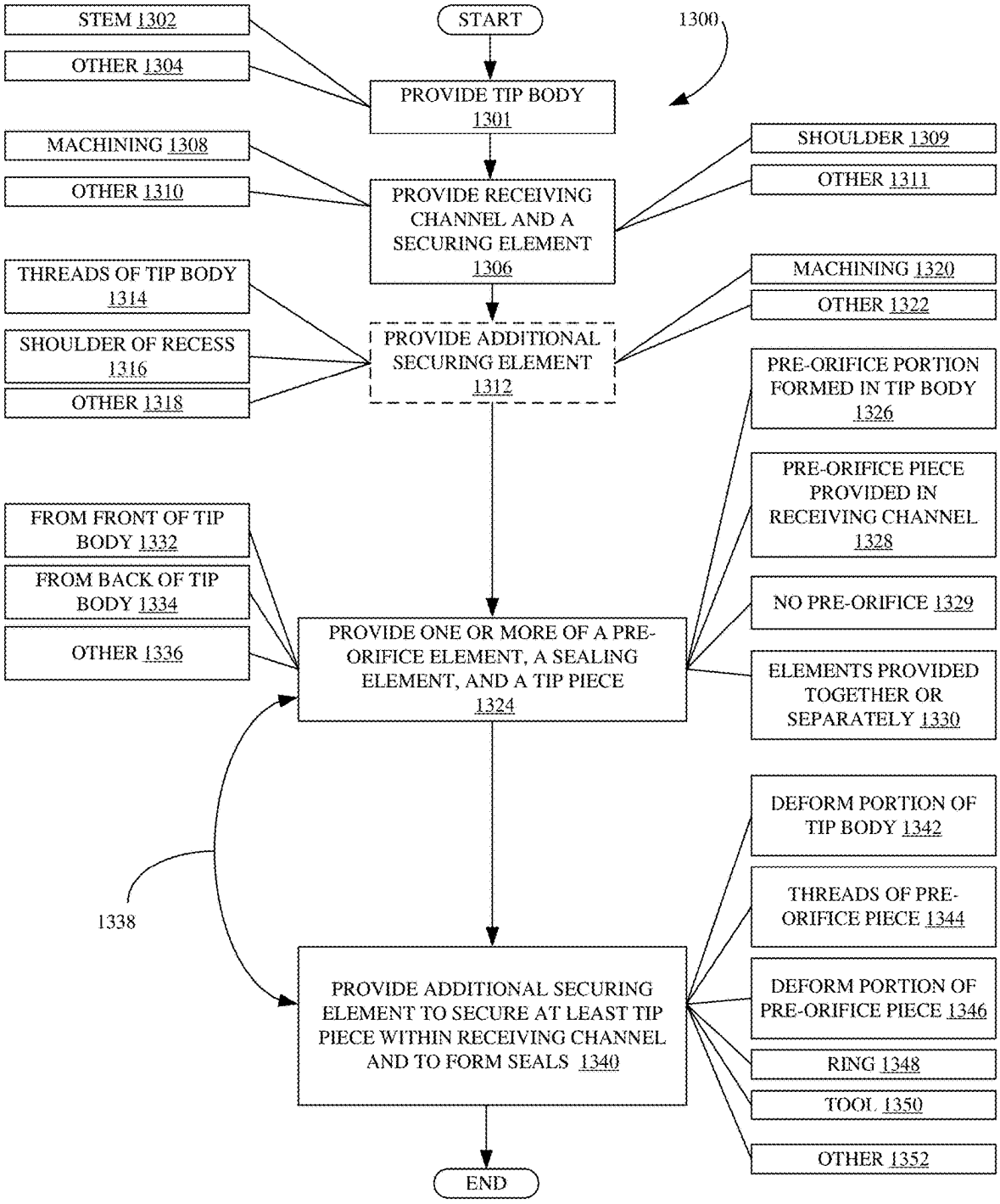
START
1300
PROVIDE TIP BODY 1301
STEM 1302
OTHER 1304
PROVIDE RECEIVING CHANNEL AND A SECURING ELEMENT 1306
MACHINING 1308
OTHER 1310
SHOULDER 1309
OTHER 1311
PROVIDE ADDITIONAL SECURING ELEMENT 1312
THREADS OF TIP BODY 1314
SHOULDER OF RECESS 1316
OTHER 1318
MACHINING 1320
OTHER 1322
PROVIDE ONE OR MORE OF A PRE-ORIFICE ELEMENT, A SEALING ELEMENT, AND A TIP PIECE 1324
FROM FRONT OF TIP BODY 1332
FROM BACK OF TIP BODY 1334
OTHER 1336
PRE-ORIFICE PORTION FORMED IN TIP BODY 1326
PRE-ORIFICE PIECE PROVIDED IN RECEIVING CHANNEL 1328
NO PRE-ORIFICE 1329
ELEMENTS PROVIDED TOGETHER OR SEPARATELY 1330
1338
PROVIDE ADDITIONAL SECURING ELEMENT TO SECURE AT LEAST TIP PIECE WITHIN RECEIVING CHANNEL AND TO FORM SEALS 1340
DEFORM PORTION OF TIP BODY 1342
THREADS OF PRE-ORIFICE PIECE 1344
DEFORM PORTION OF PRE-ORIFICE PIECE 1346
RING 1348
TOOL 1350
OTHER 1352
END

FIG. 18

FLUID SPRAY TIPS HAVING SECURING ELEMENTS FORMED IN THE FLUID SPRAY TIP BODY AND METHODS OF MANUFACTURING THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is a continuation-in-part of and claims priority of U.S. patent application Ser. No. 18/440,268, filed Feb. 13, 2024, which is based on and claims the benefit of U.S. Provisional Patent Application Ser. No. 63/486,274, filed on Feb. 22, 2023; the contents of these applications are hereby incorporated by reference in their entirety.

BACKGROUND

[0002] Spray tips are typically used in a variety of applications to break up, or atomize, a fluid material for delivery in a desired spray pattern.

[0003] While examples described herein are in the context of applying paint to a surface, it is understood that the concepts are not limited to these particular applications. As used herein, paint includes substances composed of coloring matter, or pigments, suspended in a liquid medium as well as substances that are free of coloring matter or pigment. Paint may also include preparatory coatings, such as primers, and can be opaque, transparent, or semi-transparent. Some particular examples include, but are not limited to, latex paint, oil-based paint, stain, lacquers, varnishes, inks, etc.

[0004] The discussion above is merely provided for general background information and is not intended to be used as an aid in determining the scope of the claimed subject matter.

SUMMARY

[0005] A spray tip includes a tip body having a longitudinal axis and a receiving channel extending between a front and back of the tip body transverse to the longitudinal axis. The spray tip further includes a tip piece defining, at least, a first portion of a fluid channel, the fluid channel extending between an inlet and an outlet. The spray tip further includes a first securing element downstream of at least a portion of the tip piece and a second securing element upstream of the tip piece. The first securing element and the second securing element securing at least the tip piece within the receiving channel.

[0006] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all disadvantages noted in the background.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a perspective view showing one example fluid application system.

[0008] FIG. **2** is a side view showing one example fluid applicator.

[0009] FIG. **3** is a perspective view showing one example spray tip.

[0010] FIG. **4** is a partial front view showing one example spray tip.

[0011] FIGS. **5**A and **5**B are sectional views showing one example spray tip.

[0012] FIGS. **6**A and **6**B are sectional views showing one example spray tip.

[0013] FIGS. **7**A and **7**B are sectional views showing one example spray tip.

[0014] FIGS. **8**A and **8**B are sectional views showing one example spray tip.

[0015] FIGS. **9**A and **9**B are sectional views showing one example spray tip.

[0016] FIGS. **10**A and **10**B are sectional views showing one example spray tip.

[0017] FIGS. **11**A and **11**B are sectional views showing one example spray tip.

[0018] FIGS. **12**A and **12**B are sectional views showing one example spray tip.

[0019] FIGS. **13**A and **13**B are sectional views showing one example spray tip.

[0020] FIGS. **14**A and **14**B are sectional views showing one example spray tip.

[0021] FIGS. **15**A and **15**B are sectional views showing one example spray tip.

[0022] FIGS. **16**A and **16**B are sectional views showing one example spray tip.

[0023] FIG. **17** is a block diagram showing one example fluid application system in more detail.

[0024] FIG. **18** is a flowchart showing one example method of manufacturing a spray tip.

DETAILED DESCRIPTION OF THE DRAWINGS

[0025] For the purposes of promoting an understanding of the principles of the present disclosure, reference will now be made to the examples illustrated in the drawings, and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is intended. Any alterations and further modifications to the described devices, systems, methods, and any further application of the principles of the present disclosure are fully contemplated as would normally occur to one skilled in the art to which the disclosure relates. In particular, it is fully contemplated that the features, components, and/or steps described with respect to one example may be combined with the features, components, and/or steps described with respect to other examples of the present disclosure.

[0026] In a fluid application system, a pump receives and pressurizes a fluid, delivers the pressurized fluid to an applicator, which, in turn, applies the pressurized fluid to a surface using a spray tip having a geometry selected to emit a desired spray pattern (e.g., a round pattern, a flat pattern, or a fan pattern, etc.). The fluid may comprise any fluid applied to surfaces, including, but not limited to, for example, paint, primer, lacquers, foams, textured materials, plural components, adhesive components, etc.

[0027] FIG. **1** is a perspective view showing one example fluid application system **1**. Fluid application system **1**, illustratively shown as an airless fluid spraying system (e.g., a high efficiency airless spraying system), includes pump **2** that is mounted on a cart **4** and couples to applicator **10** through fluid delivery line **6** (e.g., a hose). Pump **2** includes a fluid intake **8** that is disposed within a fluid source (e.g., a five-gallon bucket of paint). Pump **2** pumps the fluid from

the fluid source through fluid intake **8** and pumps the fluid at a given pressure to applicator **10** through fluid delivery line **6**. In one example, pump **2** can pressurize the fluid between 1500-3500 PSI.

[0028] FIG. **2** is a side view showing an example applicator **10**. Applicator **10** is used in a fluid spraying system (e.g., fluid application system **1**) to apply fluid to a surface (e.g., apply paint to a wall). The fluid enters through inlet **20**, and exits from outlet **50**, after passing through a fluid channel (not explicitly shown) within applicator **10**. Fluid inlet **20** may be coupled to a fluid delivery line, such as fluid delivery line **6**. Tip **30** is coupled to applicator **10** and has an outlet **50**. Tip **30** often is reversible (e.g., tip **30** can be rotated around its longitudinal axis such that the inlet and outlet are flipped in position (i.e., inlet facing away from applicator **10** and outlet facing towards applicator **10**)) or removable from applicator **10**. The reversibility of spray tip **30** can help with cleaning.

[0029] FIG. **3** is a perspective view showing an example spray tip **30**. Spray tip **30** includes flag **32**, tip stem **34**, and receiving channel **36**. Flag **32** can be coupled to tip stem **34** in various ways including, for example, but not by limitation, press fitting flag onto tip stem **34** or over molding flag **32** onto tip stem **34**. Flag **32** provides a convenient surface for handling spray tip **30**, particularly when spray tip **30** is installed in an applicator and can be used to indicate the directionality of spray tip **30**. Flag **32** can comprise various materials, for example, polymer. Tip stem **34** can comprise various materials, for example, metal such as stainless steel. A receiving channel **36** can be provided through tip stem **34**, such as by machining, cutting, etc. The receiving channel **36** extends a distance between a front of spray tip **30** and a rear (or back) of spray tip **30**. In some examples, the receiving channel **36** may extend from a front of spray tip **30** to a rear of spray tip **30** and yet, in other examples, the receiving channel **36** may extend some other distance. The receiving channel **36** will be shown in more detail below.

[0030] FIG. **4** is a partial front view showing example spray tip **30**. As illustrated in FIG. **4**, a tip piece **60** can be placed and retained within receiving channel **36**. As will be shown in more detail in figures below, various other items can be placed and retained within a receiving channel of a spray tip.

[0031] FIGS. **5**A-**16**B are cross-sectional views showing example spray tips. It will be understood that the spray tips illustrated in FIGS. **5**A-**16**B are example embodiments of spray tip **30** and can thus be used with a fluid applicator, such as fluid applicator **10**, and in a fluid applicator system, such as fluid application system **1**. It will be noted that the example spray tips shown in FIGS. **5**A-**16**B have their respective flags removed for convenience of illustration, but it will be understood that each of the example spray tips can include a flag, such as flag **32**.

[0032] FIGS. **5**A and **5**B (collectively referred to herein as FIG. **5**) are cross-sectional views showing example spray tip **130**. As illustrated in FIG. **5**, spray tip **130** includes tip stem **134** with a receiving channel **136** provided therein, transverse to the longitudinal axis **131** of the tip stem **134**. Receiving channel **136** extends between a front **170** of spray tip **130** and a back **180** of spray tip **130**. It can be seen in FIG. **5** that a tip piece **160**, a pre-orifice element in the form of a pre-orifice piece **162**, and a sealing element **164** are placed within receiving channel **136** from the back **180** of spray tip **130** and are retained within receiving channel **136**. The geometry of receiving channel **136** forms a shoulder **138** against which an outer surface of tip piece **160** abuts. Sealing element **164** (illustratively an O-ring) fits around pre-orifice piece **162** (a portion of pre-orifice piece **162** is disposed within a hole of sealing element **164**). Sealing element **164** abuts an outer surface of pre-orifice piece **162**, an outer surface of tip piece **160**, and a wall of receiving channel **136**. An outer surface of pre-orifice piece **162** abuts an outer surface of tip piece **160**. Tip piece **160** and pre-orifice piece **162** form a fluid channel **163** having variable geometry extending from an inlet **151** to an outlet **150**. Fluid, to be sprayed, is received though the inlet **151** and exits through the outlet **150**. A recess **140** is provided from and in to the back **180** of spray tip **130** which forms an annular projection **142**.

[0033] A swaging tool **190** is provided. Swaging tool **190** includes a swaging body **192**, a biased member **194**, and a biasing member **196**. In the illustrated example, biasing member **196** is a spring. Swaging tool **190** is pressed, from the back **180** of spray tip **130**, against spray tip **130** such that biased member **194** contacts pre-orifice portion **162**, and such that swaging body **192** fits within recess **140** and contacts annular projection **142** to deform (or crimp) annular projection **142** against pre-orifice piece **162**. Biased member **194** contacts pre-orifice portion **162** and drives pre-orifice portion **162** to and against sealing element **164** and thereby crushes sealing element **164** such that sealing element **164** forms a seal against an outer surface of pre-orifice piece **162**, a seal against an outer surface of tip piece **160**, and a seal against a wall of receiving channel **136**. The deformed annular projection **142** (shown in FIG. **5**B) and the shoulder **138** retain pre-orifice portion **162**, sealing element **164**, and tip piece **160** within receiving channel **136**.

[0034] In one example, tip piece **160** can be formed of a metal, such as carbide. In one example, pre-orifice piece **162** can be formed of a metal, such as carbide or stainless steel, such as hardened stainless steel. In one example, sealing element **164** can be formed of a polymer, such as an elastomer (e.g., rubber, etc.).

[0035] FIGS. **6**A and **6**B (collectively referred to herein as FIG. **6**) are cross-sectional views showing example spray tip **230**. As illustrated in FIG. **6**, spray tip **230** includes tip stem **234** with a receiving channel **236** provided therein, transverse to the longitudinal axis **231** of the tip stem **234**. Receiving channel **236** extends from a front **270** to a pre-orifice element in the form of a pre-orifice portion **262**. Pre-orifice portion **262** is formed within tip stem **234**, such as by machining, and includes a shoulder **238**. It can be seen in FIG. **6** that a tip piece **260** and a sealing element **264** are placed within receiving channel **236** from the front **270** of spray tip **230** and are retained within receiving channel **236**. Sealing element **264** (illustratively a gasket) abuts shoulder **238**, an outer surface of tip piece **260**, and a wall of receiving channel **236**. Tip piece **260**, pre-orifice portion **262**, and sealing element **264** form a fluid channel **263** having variable geometry extending from an inlet **251** to an outlet **250**. Fluid, to be sprayed, is received through inlet **251** and exits through outlet **250**. A recess **240** is provided from and in the front **270** of spray tip **230** which forms an annular projection **242**.

[0036] A swaging tool **290** is provided. Swaging tool **290** includes a swaging body **292**, a biased member **294**, and a biasing member **296**. In the illustrated example, biasing member **296** is a spring. Swaging tool **290** is pressed, from

the front **270** of spray tip **230**, against spray tip **230** such that biased member **294** contacts tip piece **260** and such that swaging body **292** fits within recess **240** and contacts annular projection **242** to deform (or crimp) annular projection **242** against tip piece **260**. Biased member **294** contacts tip piece **260** and drives tip piece **260** to and against sealing element **264** and thereby crushes sealing element **264** such that sealing element **264** forms a seal against an outer surface or tip piece **260**, a seal against shoulder **238**, and a seal against a wall of receiving channel **236**. The deformed annular projection **242** (shown in FIG. **6**B) and shoulder **238** retain tip piece **260** and sealing element **264** within receiving channel **236**. As can be seen in FIG. **6**, biased member **294** is shaped to accommodate a portion of tip piece **260**.

[0037] In one example, tip piece **260** can be formed of a metal, such as carbide. In one example, pre-orifice portion **262** (as well as tip stem **234**) can be formed of stainless steel, such as hardened stainless steel. In one example, sealing element **264** can be formed of a polymer, such as plastic or an elastomer (e.g., rubber, etc.).

[0038] FIGS. **7**A and **7**B (collectively referred to herein as FIG. **7**) are cross-sectional views showing example spray tip **330**. As illustrated in FIG. **7**, spray tip **330** includes tip stem **334** with a receiving channel **336** provided therein, transverse to the longitudinal axis **331** of the tip stem **334**. Receiving channel **336** extends between a front **370** of spray tip **330** and a back **380** of spray tip **330**. It can be seen in FIG. **7** that a tip piece **360**, a pre-orifice element in the form of a pre-orifice piece **362**, and a sealing element **364** are placed within receiving channel **336** from the back **380** of spray tip **330** and are retained within receiving channel **336**. The geometry of receiving channel **336** forms a shoulder **338** against which an outer surface of tip piece **360** abuts. Sealing element **364** (illustratively a gasket) abuts an outer surface of pre-orifice piece **362**, an outer surface of tip piece **360**, and a wall of receiving channel **336**. Tip piece **360**, pre-orifice portion **362**, and sealing element **364** form a fluid channel **363** having variable geometry extending from an inlet **351** to an outlet **350**. Fluid, to be sprayed, is received though the inlet **351** and exits through the outlet **350**. As can be seen in FIG. **7**, receiving channel **336** is provided with threads **337** and pre-orifice piece **362** is provided with threads **363**. Threads **363** and threads **337** mate.

[0039] A rotatable driving tool **390** is provided. In the illustrated example, rotatable driving tool **390** is provided, from the back **380** of spray tip **330**, and into the fluid channel of pre-orifice piece **362**. Rotatable driving tool **390**, while disposed within the fluid channel of pre-orifice piece **362**, is rotated, as indicated by arrow **395**, to drive pre-orifice piece **362** within receiving channel **336**, via threads **363** and **337**, towards sealing element **364** and to contact and crush sealing element **364** such that sealing element **364** forms a seal against an outer surface of pre-orifice piece **362**, a seal against an outer surface of tip piece **360**, and a seal against a wall of receiving channel **336**. The threaded connection between pre-orifice piece **362** and receiving channel **336** (shown in FIG. **7**B) retains pre-orifice piece **362** within receiving channel **336**. Thus, tip piece **360**, pre-orifice portion **362**, and sealing element **364** are retained within receiving channel **336** by shoulder **338** and the threaded connection between pre-orifice piece **362** and receiving channel **336** (as shown in FIG. **7**B).

[0040] In one example, tip piece **360** can be formed of a metal, such as carbide. In one example, pre-orifice piece **362** can be formed of a metal, such as stainless steel, for instance hardened stainless steel. In one example, pre-orifice piece **362** is a set screw, such as a hardened stainless steel set screw. In one example, sealing element **364** can be formed of a polymer, such as plastic or an elastomer (e.g., rubber, etc.).

[0041] FIGS. **8**A and **8**B (collectively referred to herein as FIG. **8**) are cross-sectional views showing example spray tip **430**. As illustrated in FIG. **8**, spray tip **430** includes tip stem **434** with a receiving channel **436** provided therein, transverse to the longitudinal axis **431** of the tip stem **434**. Receiving channel **436** extends between a front **470** of spray tip **430** and a back **480** of spray tip **430**. It can be seen in FIG. **8** that a tip piece **460**, a pre-orifice element in the form of a pre-orifice piece **462**, and a sealing element **464** are placed within receiving channel **436** from the back **480** of spray tip **430** and are retained within receiving channel **436**. The geometry of receiving channel **436** forms a shoulder **438** against which an outer surface of tip piece **460** abuts. Sealing element **464** (illustratively a gasket) abuts an outer surface of pre-orifice piece **462**, an outer surface of tip piece **460**, and a wall of receiving channel **436**. Tip piece **460**, pre-orifice portion **462**, and sealing element **464** form a fluid channel **463** having variable geometry extending from an inlet **451** to an outlet **450**. Fluid, to be sprayed, is received though the inlet **451** and exits through the outlet **450**. As can be seen in FIG. **8**, tip stem **434** is provided with a recess **440** that extends radially from receiving channel **436** and forms a shoulder **443**.

[0042] A press tool **490** is provided. In the illustrated example, press tool **490** is provided, from the back **480** of spray tip **430**, and into the fluid channel of pre-orifice piece **462**. Press tool **490**, while disposed within the fluid channel of pre-orifice piece **462**, is driven to press pre-orifice piece **462** towards and against sealing element **464** to crush sealing element **464** such that sealing element **464** forms a seal against an outer surface of pre-orifice piece **462**, a seal against an outer surface of tip piece **460**, and a seal against a wall of receiving channel **436**. Insertion of the press tool **490** into the fluid channel of pre-orifice piece **462** deforms a wall **442** of pre-orifice piece **462** such that pre-orifice portion **462** expands in diameter and is disposed within recess **440** and abuts shoulder **443** (as shown in FIG. **8**B). Thus, tip piece **460**, pre-orifice portion **462**, and sealing element **464** are retained within receiving channel **436** by shoulder **438** and the contact between the deformed wall **442** (shown in FIG. **8**B) of pre-orifice piece **462** and the shoulder **443**.

[0043] In one example, tip piece **460** can be formed of a metal, such as carbide. In one example, pre-orifice piece **462** can be formed of a metal, such as stainless steel. In one example, sealing element **464** can be formed of a polymer, such as plastic or an elastomer (e.g., rubber, etc.).

[0044] FIGS. **9**A and **9**B (collectively referred to herein as FIG. **9**) are cross-sectional views showing example spray tip **530**. As illustrated in FIG. **9**, spray tip **530** includes tip stem **534** with a receiving channel **536** provided therein, transverse to the longitudinal axis **531** of the tip stem **534**. Receiving channel **536** extends between a front **570** of spray tip **530** and a back **580** of spray tip **530**. It can be seen in FIG. **9** that a tip piece **560**, a pre-orifice element in the form of a pre-orifice piece **562**, a sealing element **564**, and a retaining ring **565** are placed within receiving channel **536** from the back **580** of spray tip **530** and are retained within receiving

channel **536**. The geometry of receiving channel **536** forms a shoulder **538** against which an outer surface of tip piece **560** abuts. Sealing element **564** (illustratively a gasket) abuts an outer surface of pre-orifice piece **562**, an outer surface of tip piece **560**, and a wall of receiving channel **536**. Tip piece **560**, pre-orifice portion **562**, and sealing element **564** form a fluid channel **563** having variable geometry extending from an inlet **551** to an outlet **550**. Fluid, to be sprayed, is received though the inlet **551** and exits through the outlet **550**. As can be seen in FIG. **9**, tip stem **534** is provided with a recess **540** which extends radially from receiving channel **536** and forms a shoulder **543**. Retaining ring **565**, when installed, abuts pre-orifice piece **562**.

[0045] A press tool **590** is provided. In the illustrated example, press tool **590** is provided, from the back **580** of spray tip **530**, and into a hole of retaining ring **565**. Press tool **590**, while disposed within the hole of retaining ring **565**, is driven to press retaining ring **565** towards and against pre-orifice portion **562** which drives pre-orifice portion **562** towards and against sealing element **564** to crush sealing element **564** such that sealing element **564** forms a seal against an outer surface of pre-orifice piece **562**, a seal against an outer surface of tip piece **560**, and a seal against a wall of receiving channel **536**. Insertion of the press tool **590** into the hole of retaining ring **565** deforms a wall **567** of retaining ring **565** such that retaining ring **565** expands in diameter and is disposed within recess **540** and abuts shoulder **543** (as shown in FIG. **9**B). Thus, tip piece **560**, pre-orifice portion **562**, sealing element **564**, and retaining ring **565** are retained within receiving channel **536** by shoulder **538** and the contact between the deformed wall **567** (shown in FIG. **9**B) of retaining ring **565** and the shoulder **543**.

[0046] In one example, tip piece **560** can be formed of a metal, such as carbide. In one example, pre-orifice piece **562** can be formed of a metal, such as carbide or stainless steel, such as hardened stainless steel. In one example, sealing element **564** can be formed of a polymer, such as plastic or an elastomer (e.g., rubber, etc.). In one example, retaining ring **565** can be formed of metal, such as stainless steel, for instance hardened stainless steel.

[0047] FIGS. **10**A and **10**B (collectively referred to herein as FIG. **10**) are cross-sectional views showing one example spray tip **630**. As illustrated in FIG. **10**, spray tip **630** includes tip stem **634** with a receiving channel **636** provided therein, transverse to the longitudinal axis **631** of the tip stem **634**. Receiving channel **636** extends between a front **670** of spray tip **630** and a back **680** of spray tip **630**. It can be seen in FIG. **10** that a tip piece **660**, a pre-orifice element in the form of a pre-orifice piece **662**, a sealing element **664**, and a snap ring **665** are placed within receiving channel **636** from the back **680** of spray tip **630** and are retained within receiving channel **636**. The geometry of receiving channel **636** forms a shoulder **638** against which an outer surface of tip piece **660** abuts. Sealing element **664** (illustratively a gasket) abuts an outer surface of pre-orifice piece **662**, an outer surface of tip piece **660**, and a wall of receiving channel **636**. Tip piece **660**, pre-orifice portion **662**, and sealing element **664** form a fluid channel **663** having variable geometry extending from an inlet **651** to an outlet **650**. Fluid, to be sprayed, is received though the inlet **651** and exits through the outlet **650**. As can be seen in FIG. **10**, tip stem **634** is provided with a recess **640** which extends radially from receiving channel **636** and forms a shoulder **643**. Receiving channel **636** further includes a ramp **647** which narrows as it extends from the back **680** of spray tip **630** towards the front **670** of spray tip **630**. Snap ring **665**, when installed, abuts pre-orifice piece **662**.

[0048] A press tool **690** is provided. In the illustrated example, press tool **690** is provided, from the back **680** of spray tip **630**, and into a hole of snap ring **665**. Press tool **690**, while disposed within the hole of snap ring **665**, is driven to press and drive snap ring **665** along ramp **647** towards and against pre-orifice portion **662** which drives pre-orifice portion **662** towards and against sealing element **664** to crush sealing element **664** such that sealing element **664** forms a seal against an outer surface of pre-orifice piece **662**, a seal against an outer surface of tip piece **660**, and a seal against a wall of receiving channel **636**. Driving snap ring **665** along ramp **647** progressively reduces the diameter of snap ring **665** until snap ring **665** passes ramp **647** at which point snap ring **665** snaps back to its original (or at least a wider) diameter and is thus disposed within recess **640** and abuts shoulder **643** (as shown in FIG. **10**B). Thus, tip piece **660**, pre-orifice portion **662**, sealing element **664**, and snap ring **665** are retained within receiving channel **636** by shoulder **638** and the contact between snap ring **665** and the shoulder **643**.

[0049] In one example, tip piece **660** can be formed of a metal, such as carbide. In one example, pre-orifice piece **662** can be formed of a metal, such as carbide or stainless steel, such as hardened stainless steel. In one example, sealing element **664** can be formed of a polymer, such as plastic or an elastomer (e.g., rubber, etc.). In one example, snap ring **665** can be formed of metal, such as stainless steel, for instance hardened stainless steel.

[0050] FIGS. **11**A and **11**B (collectively referred to herein as FIG. **11**) are cross-sectional views showing example spray tip **730**. As illustrated in FIG. **11**, spray tip **730** includes tip stem **734** with a receiving channel **736** provided therein, transverse to the longitudinal axis **731** of the tip stem **734**. Receiving channel **736** extends between a front **770** of spray tip **730** and a back **780** of spray tip **730**. It can be seen in FIG. **11** that a tip piece **760**, a pre-orifice element in the form of a pre-orifice piece **762**, and a sealing element **764** are placed within receiving channel **736** from the back **780** of spray tip **730** and are retained within receiving channel **736**. The geometry of receiving channel **736** forms a shoulder **738** against which an outer surface of tip piece **760** abuts. Sealing element **764** fits around pre-orifice piece **762** (a portion of pre-orifice piece **762** is disposed within a hole of sealing element **764**). Sealing element **764** comprises a ductile or elastomeric material such as a polymer (e.g., acetal, etc.) or various other ductile or elastomeric materials. Sealing element **764** abuts an outer surface of pre-orifice piece **762**, abuts an outer surface of tip piece **760**, and abuts a wall of receiving channel **736**. Tip piece **760** and pre-orifice piece **762** form a fluid channel **763** having variable geometry extending from an inlet **751** to an outlet **750**. Fluid, to be sprayed, is received though the inlet **751** and exits through the outlet **750**. A recess **740** is provided from and in the back **780** of spray tip **730** which forms an annular wall **742**.

[0051] A peen tool **790** is provided (as part of an orbital forming machine). Peen tool **790** is used, in an orbital forming process, to deform annular wall **742**. Peen tool **790** is pressed, from the back **780** of spray tip **730**, against spray tip **730** such that peen tool **790** fits within recess **740**,

contacts annular wall **742** to deform (or crimp) annular wall **742** against pre-orifice piece **762** (as shown in FIG. **11**B). Peen tool **790** is caused to actuate in a circular, or orbital, motion (as indicated by arrow **795**) to progressively collapse (deform or crimp) annular wall **742** against pre-orifice piece **762**. The deformation (or crimping) of annular wall **742** against pre-orifice piece **762** drives pre-orifice piece **762** to and against sealing element **764** and thereby crushes sealing element **764** such that sealing element **764** forms a seal against an outer surface of pre-orifice piece **762**, a seal against an outer surface of tip piece **760**, and a seal against a wall of receiving channel **736**. The deformed annular wall **742** (shown in FIG. **11**B) and the shoulder **738** retain pre-orifice piece **762**, sealing element **764**, and tip piece **760** within receiving channel **736**.

[0052] In one example, tip piece **760** can be formed of a metal, such as carbide. In one example, pre-orifice piece **762** can be formed of a metal, such as carbide or stainless steel, such as hardened stainless steel. In one example, sealing element **764** can be formed of a polymer, such as an elastomer (e.g., rubber, etc.).

[0053] FIGS. **12**A and **12**B (collectively referred to herein as FIG. **12**) are cross-sectional views showing example spray tip **830**. As illustrated in FIG. **12**, spray tip **830** includes tip stem **834** with a receiving channel **836** provided therein, transverse to the longitudinal axis **831** of the tip stem **834**. Receiving channel **836** extends between a front **870** of spray tip **830** to a pre-orifice element in the form of a pre-orifice portion **862**. Pre-orifice portion **862** is formed within tip stem **834**, such as by machining. It can be seen in FIG. **12** that a tip piece **860** and a sealing element **864** are placed within receiving channel **836** from the front **870** of spray tip **830** and are retained within receiving channel **836**. The geometry of receiving channel **836** forms a shoulder **838**. Sealing element **864** abuts shoulder **838**, an outer surface of tip piece **860**, and a wall of receiving channel **836**. Sealing element **864** comprises a ductile or elastomeric material such as a polymer (e.g., acetal, etc.) or various other ductile or elastomeric materials. Tip piece **860**. sealing element **864**, and pre-orifice portion **862** form a fluid channel **863** having variable geometry extending from an inlet **851** to an outlet **850**. Fluid, to be sprayed, is received though the inlet **851** and exits through the outlet **850**. A recess **840** is provided from and in the front **880** of spray tip **830** which forms an annular wall **842**.

[0054] A peen tool **890** is provided (as part of an orbital forming machine or other cold forming process). Peen tool **890** is similar to peen tool **790** except that peen tool **890** includes a recess **891** configured to receive a portion of tip piece **860**. Peen tool **890** is used, in an orbital forming process, to deform annular wall **842**. Peen tool **890** is pressed, from the front **870** of spray tip **830**, against spray tip **830** and against tip piece **860** such that peen tool **890** fits within recess **840**, contacts annular wall **842** to deform (or crimp) annular wall **842** against tip piece **860** (as shown in FIG. **12**B). Peen tool **890** is caused to actuate in a circular, or orbital, motion (as indicated by arrow **895**) to progressively collapse (deform or crimp) annular wall **842** against tip piece **860**. The deformation (or crimping) of annular wall **842** against tip piece **860** drives tip piece **860** to and against sealing element **864** and thereby crushes sealing element **864** such that sealing element **864** forms a seal against an outer surface of pre-orifice element **862** or shoulder **838**, a seal against an outer surface of tip piece **760**, and a seal against a wall of receiving channel **836**. The deformed annular wall **842** (shown in FIG. **12**B) and the shoulder **838** retain tip piece **860** and sealing element **864** within receiving channel **836**.

[0055] In one example, tip piece **860** can be formed of a metal, such as carbide. In one example, pre-orifice portion **862** can be formed of a metal, such as carbide or stainless steel, such as hardened stainless steel. In one example, sealing element **864** can be formed of a polymer, such as an elastomer (e.g., rubber, etc.).

[0056] FIGS. **13**A and **13**B (collectively referred to herein as FIG. **13**) are cross-sectional views showing example spray tip **930**. As illustrated in FIG. **13**, spray tip **930** includes tip stem **934** with a receiving channel **936** provided therein, transverse to the longitudinal axis **931** of the tip stem **934**. Receiving channel **936** extends from a front **970** to a back **980** of the spray tip **930**. It can be seen in FIG. **13** that a tip piece **960** and a pre-orifice element in the form of a pre-orifice piece **962** are placed within receiving channel **936** from the front **970** of spray tip **930** and are retained within receiving channel **936**. The geometry of receiving channel **936** forms a shoulder **938** against which pre-orifice piece **962** abuts. Tip piece **960** and pre-orifice piece **962** form a fluid channel **963** having variable geometry extending from an inlet **951** to an outlet **950**. Fluid, to be sprayed, is received through inlet **951** and exits through outlet **950**. A recess **940** is provided from and in the front **970** of spray tip **930** which forms an annular wall **942**.

[0057] Though not shown in FIG. **13**, a tool (e.g., swaging tool, peen tool, etc.) can be provided. The tool is pressed, from the front **970** of spray tip **930**, against spray tip **930** such that the tool (at least a portion thereof) fits within recess **940** and contacts annular wall **942** to deform (or crimp) annular wall **942** against tip piece **960** (as shown in FIG. **13**B). The deformation of annular wall **942** against tip piece **960** drives tip piece **960** to and against pre-orifice piece **962** and drives pre-orifice piece **962** to and against shoulder **938** to further secure and fit tip piece **960** and pre-orifice piece **962** within receiving channel **936** and to better form a seal between tip piece **960** and pre-orifice piece **962** and to better form seals between tip piece **960** and tip stem **934** and pre-orifice piece **962** and tip stem **934**. The deformed annular wall **942** (shown in FIG. **13**B) and shoulder **938** retain tip piece **960** and pre-orifice piece **962** within receiving channel **936**. The axial compression of the annular wall **942** is such that the deformed annular wall **942** is able to retain elements within the receiving channel **936** and to provide a seal between the tip piece **960** and the tip stem **934** (or the deformed annular wall **942** of the tip stem **934**). The tool may include one or more components shaped to accommodate a portion of tip piece **960**.

[0058] In one example, tip piece **960** can be formed of a metal, such as carbide. In one example, pre-orifice piece **962** (as well as tip stem **934**) can be formed of stainless steel, such as hardened stainless steel.

[0059] FIGS. **14**A and **14**B (collectively referred to herein as FIG. **14**) are cross-sectional views showing example spray tip **1030**. As illustrated in FIG. **14**, spray tip **1030** includes tip stem **1034** with a receiving channel **1036** provided therein, transverse to the longitudinal axis **1031** of the tip stem **1034**. Receiving channel **1036** extends between a front **1070** and a back **1080** of the spray tip **1030**. It can be seen in FIG. **14** that a tip piece **1060** and a pre-orifice element in the form of a pre-orifice piece **1062** are placed

within receiving channel **1036** from the front **1070** of spray tip **1030** and are retained within receiving channel **1036**. The geometry of receiving channel **1036** forms a shoulder **1038** against which pre-orifice piece **1062** abuts. Tip piece **1060** and pre-orifice piece **1062** form a fluid channel **1063** having variable geometry extending from an inlet **1051** to an outlet **1050**. Fluid, to be sprayed, is received through inlet **1051** and exits through outlet **1050**. A recess **1040** is provided from and in the front **1070** of spray tip **1030** which forms an annular wall **1042**.

[0060] A peen tool **1090** is provided (as part of an orbital forming machine or other cold forming process). Peen tool is similar to peen tool **890** and includes a recess **1091** configured to receive a portion of tip piece **1060**. Peen tool **1090** is used, in an orbital forming process, to deform annular wall **1042**. The peen tool **1090** is pressed, from the front **1070** of spray tip **1030**, against spray tip **1030** and against tip piece **1060** such that peen tool **1090** fits within recess **1040** and contacts annular wall **1042** to deform (or crimp) annular wall **1042** against tip piece **1060** (as shown in FIG. **14**B). Peen tool **1090** is caused to actuate in a circular, or orbital, motion (as indicated by arrow **1095**) to progressively collapse (deform or crimp) annular wall **1042** against tip piece **1060**. The deformation (or crimping) of annular wall **1042** drives tip piece **1060** to and against pre-orifice piece **1062** and drives pre-orifice piece to and against shoulder **1038** to further secure and fit tip piece **1060** and pre-orifice piece **1062** within receiving channel **1036** and to better form a seal between tip piece **1060** and pre-orifice piece **1062** and to better form seals between tip piece **1060** and tip stem **1034** and pre-orifice piece **1062** and tip stem **1034**. The deformed annular wall **1042** (shown in FIG. **14**B) and shoulder **1038** retain tip piece **1060** and pre-orifice piece **1062** within receiving channel **1036**. The axial compression of the annular wall **1042** is such that the deformed annular wall **1042** is able to retain elements within the receiving channel **1036** and to provide a seal between the tip piece **1060** and the tip stem **1034** (or the deformed annular wall **1042** of the tip stem **1034**). It can be seen that peen tool **1090** includes a recess **1091** to accommodate a portion of tip piece **1060**.

[0061] In one example, tip piece **1060** can be formed of a metal, such as carbide. In one example, pre-orifice piece **1062** (as well as tip stem **1034**) can be formed of stainless steel, such as hardened stainless steel.

[0062] FIGS. **15**A and **15**B (collectively referred to herein as FIG. **15**) are cross-sectional views showing example spray tip **1130**. As illustrated in FIG. **15**, spray tip **1130** includes tip stem **1134** with a receiving channel **1136** provided therein, transverse to the longitudinal axis **1131** of the tip stem **1134**. Receiving channel **1136** extends between a front **1170** of the spray tip **1130** and a pre-orifice element in the form of a pre-orifice portion **1162**. Pre-orifice portion **1162** is formed within tip stem **1134**, such as by machining. It can be seen in FIG. **15** that a tip piece **1160** is placed within receiving channel **1136** from the front **1170** of spray tip **1130** and is retained within receiving channel **1136**. The geometry of receiving channel **1136** forms a shoulder **1138** against which tip piece **1160** abuts. Tip piece **1160** and pre-orifice portion **1162** form a fluid channel **1163** having variable geometry extending from an inlet **1151** to an outlet **1150**. Fluid, to be sprayed, is received through inlet **1151** and exits through outlet **1150**. A recess **1140** is provided from and in the front **1170** of spray tip **1130** which forms an annular wall **1142**.

[0063] A peen tool **1190** is provided (as part of an orbital forming machine or other cold forming process). Peen tool is similar to peen tool **1090** and includes a recess **1191** configured to accommodate a portion of tip piece **1160**. Peen tool **1190** is used, in an orbital forming process, to deform annular wall **1142**. The peen tool **1190** is pressed, from the front **1170** of spray tip **1130**, against spray tip **1130** such that peen tool **1190** fits within recess **1140** and contacts annular wall **1142** to deform (or crimp) annular wall **1142** against tip piece **1160** (as shown in FIG. **15**B). Peen tool **1190** is caused to actuate in a circular, or orbital, motion (as indicated by arrow **1195**) to progressively collapse (deform or crimp) annular wall **1142** against tip piece **1160**. The deformation (or crimping) of annular wall **1142** drives tip piece **1160** to and against shoulder **1138** to further secure and fit tip piece **1160** within receiving channel **1136** and to better form a seal between tip piece **1160** and tip stem **1134**. The deformed annular wall **1142** (shown in FIG. **15**B) and shoulder **1138** retain tip piece **1160** within receiving channel **1136**. The axial compression of the annular wall **1142** is such that the deformed annular wall **1142** is able to retain elements within the receiving channel **1136** and to provide a seal between the tip piece **1160** and the tip stem **1134** (or the deformed annular wall **1142** of the tip stem **1134**).

[0064] In one example, tip piece **1160** can be formed of a metal, such as carbide. In one example, pre-orifice portion **1162** (as well as tip stem **1134**) can be formed of stainless steel, such as hardened stainless steel.

[0065] FIGS. **16**A and **16**B (collectively referred to herein as FIG. **16**) are cross-sectional views showing example spray tip **1230**. As illustrated in FIG. **16**, spray tip **1230** includes tip stem **1234** with a receiving channel **1236** provided therein, transverse to the longitudinal axis **1231** of the tip stem **1234**. Receiving channel **1236** extends between a front **1270** of the spray tip **1230** and an inlet channel **1267**. Inlet channel **1267** is formed within tip stem **1234**, such as by machining. It can be seen in FIG. **16** that a tip piece **1260** is placed within receiving channel **1236** from the front **1270** of spray tip **1230** and is retained within receiving channel **1236**. The geometry of receiving channel **1236** forms a shoulder **1238** against which tip piece **1260** abuts. Tip piece **1260** forms a fluid channel **1263** having variable geometry extending from an inlet **1251** to an outlet **1250**. Fluid, to be sprayed, is received through inlet **1251** and exits through outlet **1250**. A recess **1240** is provided from and in the front **1270** of spray tip **1230** which forms an annular wall **1242**.

[0066] A peen tool **1290** is provided (as part of an orbital forming machine or other cold forming process). Peen tool is similar to peen tool **1190** and includes a recess **1291** configured to receive a portion of tip piece **1260**. Peen tool **1290** is used, in an orbital forming process, to deform annular wall **1242**. The peen tool **1290** is pressed, from the front **1270** of spray tip **1230**, against spray tip **1230** such that peen tool **1290** fits within recess **1240** and contacts annular wall **1242** to deform (or crimp) annular wall **1242** against tip piece **1260** (as shown in FIG. **16**B). Peen tool **1290** is caused to actuate in a circular, or orbital, motion (as indicated by arrow **1295**) to progressively collapse (deform or crimp) annular wall **1242** against tip piece **1260**. The deformation (or crimping) of annular wall **1242** drives tip piece **1260** to and against shoulder **1238** to further secure and fit tip piece

1260 within receiving channel **1236** and to better form a seal between tip piece **1260** and tip stem **1234**. The deformed annular wall **1242** (shown in FIG. **16**B) and shoulder **1238** retain tip piece **1260** within receiving channel **1236**. The axial compression of the annular wall **1242** is such that the deformed annular wall **1242** is able to retain elements within the receiving channel **1236** and to provide a seal between the tip piece **1260** and the tip stem **1234** (or the deformed annular wall **1242** of the tip stem **1234**).

[0067] In one example, tip piece **1260** can be formed of a metal, such as carbide. In one example, tip stem **1234** can be formed of stainless steel, such as hardened stainless steel.

[0068] FIG. **17** is a block diagram showing one example fluid application system **2000**. Fluid application system **2000** can include one or more pumps **2002**, a fluid source **2003**, a pump support structure **2004**, a fluid delivery line **2006**, a fluid applicator **2010**, a spray tip **2030**, and can include various other items **2012**, including, but not limited to, other items discussed or shown herein. One example of fluid application system is fluid application system **1**, shown in FIG. **1**.

[0069] Pumps **2002**, in one example, can be similar to pump **2**, or can be other type of pumps. A fluid source **2003** can be a fluid container, such as a paint bucket (e.g., 5-gallon paint bucket, etc.). Pump support structure **2004** can be similar to or the same as cart **4** or can be other types of pump support structures. Fluid delivery line **2006** can be similar to fluid delivery line **6** or can be another type of fluid delivery line. Fluid applicator **2010** can be similar to fluid applicator **10** or can be another type of fluid applicator. Pumps **2002** pump and pressurize fluid from fluid source **2003** and deliver the pressurized fluid to fluid applicator **2010** via fluid delivery line **2006**. The pumps **2002** can be supported by a pump support structure **2004**, such as a cart (e.g., **4**) or other pump support structure.

[0070] Spray tip **2030** is installed in fluid applicator **2010**. Spray tip **2030** can be similar to spray tip **30**, spray tip **130**, spray tip **230**, spray tip **330**, spray tip **430**, spray tip **530**, spray tip **630**, spray tip **730**, spray tip **830**, spray tip **930**, spray tip **1030**, spray tip **1130**, or spray tip **1230**, or can be another type of spray tip. Pressurized fluid is delivered through fluid applicator to spray tip **2030**. Spray tip **2030** breaks up, or atomizes, the fluid to deliver the fluid in a desired spray pattern.

[0071] Spray tip **2030** can include a tip body (e.g., stem, etc.) **2034**, a flag **2032**, a receiving channel **2036**, one or more recesses **2040**, a tip piece **2060**, one or more securing elements **2042**, an outlet **2050**, an inlet **2051**, and a fluid channel **2063**. In some examples, spray tip **2030** can also include a pre-orifice element **2062** or one or more sealing elements **1064**, or both. Spray tip **2030** can include various other items **1099** as well, including but not limited to, other items discussed or shown herein.

[0072] Tip body (or stem) **2034** can be similar to stem **34**, stem **134**, stem **234**, stem **334**, stem **434**, stem **534**, stem **634**, stem **734**, stem **834**, stem **934**, stem **1034**, stem **1134**, or stem **1234**, or can be another type of tip body (e.g., stem, etc.). Flag **2032** can be similar to flag **32** or can be another type of flag. Receiving channel **2036** can be similar to receiving channel **36**, receiving channel **136**, receiving channel **236**, receiving channel **336**, receiving channel **436**, receiving channel **536**, receiving channel **636**, receiving channel **736**, receiving channel **836**, receiving channel **936**, receiving channel **1036**, receiving channel **1136**, or receiving channel **1236**, or can be another type of receiving channel.

[0073] Recesses **2040** can be similar to recess **140**, recess **240**, recess **440**, recess **540**, recess **640**, recess **740**, recess **840**, recess **940**, recess **1040**, recess **1140**, or recess **1240**, or can be another type of recess or other types of recesses.

[0074] Tip piece **2060** can be similar to tip piece **60**, tip piece **160**, tip piece **260**, tip piece **360**, tip piece **460**, tip piece **560**, tip piece **660**, tip piece **760**, tip piece **860**, tip piece **960**, tip piece **1060**, tip piece **1160**, or tip piece **1260**, or can be another type of tip piece. Pre-orifice element **1062** can be similar to pre-orifice piece **162**, pre-orifice portion **262**, pre-orifice piece **362**, pre-orifice piece **462**, pre-orifice piece **562**, pre-orifice piece **662**, pre-orifice piece **762**, pre-orifice portion **862**, pre-orifice piece **962**, pre-orifice piece **1062**, pre-orifice portion **1162**, or can be another type of pre-orifice element. Sealing elements **2064** can be similar to sealing element **164**, sealing element **264**, sealing element **364**, sealing element **464**, sealing element **564**, sealing element **664**, sealing element **764**, or sealing element **864**, or can be another type of sealing element or other types of sealing elements.

[0075] Securing elements **2042** can be similar to shoulder **138** and deformed projections **142**, to shoulder **238** and deformed projections **242**, to mating threads **363**, mating threads **337** and shoulder **338**, to shoulder **438**, shoulder **443**, and deformed wall **442**, to shoulder **538**, shoulder **543**, and ring **565**, to shoulder **638**, shoulder **643**, and ring **665**, to shoulder **738** and deformed wall **742**, to shoulder **838** and deformed wall **842**, to shoulder **938** and deformed wall **942**, to shoulder **1038** and deformed wall **1042**, to shoulder **1138** and deformed wall **1142**, or to shoulder **1238** and deformed wall **1242**, or another type of securing element or other types of securing elements.

[0076] Outlet **2050** can be similar to outlet **50**, outlet **150**, outlet **250**, outlet **350**, outlet **450**, outlet **550**, outlet **650**, outlet **750**, outlet **850**, outlet **950**, outlet **1050**, outlet **1150**, or outlet **1250**, or another type of outlet. Inlet **2051** can be similar to inlet **151**, inlet **251**, inlet **351**, inlet **451**, inlet **551**, inlet **651**, inlet **751**, inlet **851**, inlet **951**, inlet **1051**, inlet **1151**, or inlet **1251**, or can be another type of inlet. Fluid channel **2063** can be similar to fluid channel **136**, fluid channel **236**, fluid channel **336**, fluid channel **436**, fluid channel **536**, fluid channel **636**, fluid channel **736**, fluid channel **836**, fluid channel **936**, fluid channel **1036**, fluid channel **1136**, or fluid channel **1236**, or another type of fluid channel. Fluid channel **2063** extends between inlet **2051** and outlet **2050** and can have variable geometry. In some examples, fluid channel **2063** can be stepped, or can otherwise progressively widen from an upstream end to a downstream point and then progressively narrow from the downstream point to a downstream end.

[0077] It will be understood that spray tip **2030** can be reversible (e.g., can be rotated about its longitudinal axis). That is, the spray tip can be rotated between a first operating posture (normal operation posture) in which the outlet **2050** is facing away from the applicator **2010** and inlet **2051** is facing towards the applicator **2010** and a second operating posture (cleaning operation posture) in which the outlet **2050** is facing towards the applicator **2010** and the inlet **2051** is facing away from the applicator **2010**.

[0078] FIG. **18** shows a flowchart showing one example method **1300** of manufacturing a spray tip, such as spray tip **2030**.

[0079] At block **1301** a tip body **2034** is provided. As indicated by block **1302**, the tip body **2034** can be a stem, such as stem **34**, stem **134**, stem **234**, stem **334**, stem **434**, stem **534**, stem **634**, stem **734**, stem **834**, stem **934**, stem **1034**, stem **1134**, or stem **1234**, or another type of stem. The tip body **2034** can be other types of tip bodies, as indicated by block **1304**.

[0080] At block **1306**, a receiving channel **2036** and a securing element **2042** is provided in tip body **2034**. The receiving channel **2036** can be receiving channel **36**, receiving channel **136**, receiving channel **236**, receiving channel **336**, receiving channel **436**, receiving channel **536**, receiving channel **636**, receiving channel **736**, receiving channel **836**, receiving channel **936**, receiving channel **1036**, receiving channel **1136**, or receiving channel **1236**, or another type of receiving channel. In some examples, the receiving channel **2036** is transverse to a longitudinal axis of the tip body **2034**. The securing element **2042** at block **1306** can be shoulder **138**, shoulder **238**, shoulder **338**, shoulder **438**, shoulder **538**, shoulder **638**, shoulder **738**, shoulder **838**, shoulder **938**, shoulder **1038**, shoulder **1138**, or shoulder **1238**, or can be another type of securing element. In some examples, providing the receiving channel **2036** also provides the securing element **2042** at block **1306**, for instance, the geometry of the receiving channel **2036** may define the securing element **2042** at block **1306**. As indicated by block **1308**, the receiving channel **2036** or the securing element **2042**, at block **1306**, can be provided by machining. As indicated by block **1310**, the receiving channel **2036** or the securing element **2042**, at block **1306**, can be provided in various other ways.

[0081] In some examples, an additional securing element **2042** is provided at block **1312**. As indicated by block **1314**, the additional securing element **2042** can be threads formed in the tip body **2034**. The threads can be threads **337**, or can be other threads. As indicated by block **1316**, the additional securing element **2042** can be a shoulder of a recess formed in the tip body **2034**. The shoulder of the recess can be shoulder **443** of recess **440**, shoulder **543** of recess **540**, or shoulder **643** of recess **640**, or can be another shoulder of another recess. The additional securing element **2042** can be various other securing elements, as indicated by block **1318**. As indicated by block **1320**, the additional securing element **2042** can be provided by machining. As indicated by block **1322**, the additional securing element **2042** can be provided in various other ways.

[0082] At block **1324** one or more of a pre-orifice element **2062**, a sealing element **2064**, and a tip piece **2060** is provided. For instance, in some examples, a pre-orifice element **2062**, and sealing element **2064**, and a tip piece **2060** are provided. In other examples, a pre-orifice element **2062** and a tip piece **2060** are provided. In yet other examples, a tip piece **2060** is provided.

[0083] In one example, as indicated by block **1326**, providing the pre-orifice element **2062** can comprise forming (e.g., by machining, etc.) the pre-orifice element **2062** in the tip body **2034**, such as the example pre-orifice portion **262** in the tip stem **234** in FIG. **6**, the example pre-orifice portion **862** in the tip stem **834** in FIG. **12**, or the example pre-orifice portion **1162** in the tip stem **1134** in FIG. **15**. In such examples, providing the sealing element **2064** or providing the tip piece **2060**, or both, can comprise placing the sealing element **2064** or the tip piece **2060**, or both, into the receiving channel **2036** (from the front of the tip body as indicated by block **1332**). In such examples, the tip piece **2060** is upstream of the pre-orifice element **2062** or the sealing element **2064** (or at least a portion of the tip piece **2060** is upstream of the sealing element **2064**), or both. In examples, at block **1326**, where a sealing element **2064** is provided, the sealing element **2064** is upstream of the pre-orifice element **2062**, or at least a portion of the pre-orifice element **2062**. At block **1326**, the pre-orifice element **2062**, or at least a portion of the pre-orifice element **2062**, is upstream of the receiving channel **2036**.

[0084] In one example, as indicated by block **1328**, providing the pre-orifice element **2062** can comprise placing the pre-orifice element **2062** in the receiving channel **2036**, such as the example pre-orifice pieces **162**, **362**, **462**, **562**, **662**, **762**, **962**, and **1062** in FIGS. **5** and **7-11**, and **13-14**, respectively. In such examples, providing can comprise placing the sealing element **2064** or the tip piece **2060**, or both, into the receiving channel **2036** (from the front of the tip body as indicated by block **1332** or from the back of the tip body as indicated by block **1334**). In such examples, the tip piece **2060** is upstream of the pre-orifice element **2062** or the tip piece **2060** is upstream of the pre-orifice element **2062** and the tip piece **2060**, or at least a portion of the tip piece **2060**, is upstream of the sealing element **2064**. In examples where a sealing element **2064** is provided, the sealing element **2064** is upstream of the pre-orifice element **2062**, or at least a portion of the pre-orifice element **2062**. For instance, in some examples, the sealing element **2064** may be disposed around the pre-orifice element **2062** such that a portion of the pre-orifice element **2062** is disposed in a hole of the sealing element **2064**. In such examples, the pre-orifice element **2062**, or at least a portion of the pre-orifice element **2062**, is downstream, at least partially, of the sealing element **2064**.

[0085] In some examples, no pre-orifice element **2062** is provided, as indicated by block **1329**. For instance, instead another element may be provided in the tip **2030** (e.g., tip body **2034**), such as an inlet channel. One example of an inlet channel is inlet channel **1267** in FIG. **16**. Other elements, including other types of inlet channels, can be provided.

[0086] In some examples, two or more of the pre-orifice element **2062**, the sealing element **2064**, and the tip piece **2060** may be provided together (e.g., placed in the receiving channel **2036** together), as indicated by block **1330**. For instance, the sealing element **2064** and the pre-orifice element **2062** can, in some examples, be provided together (e.g., placed in the receiving channel **2036** together). For instance, the sealing element **2064** may be fit around a portion of the pre-orifice element **1062** and then the sealing element **2064** and the pre-orifice element **2062** may be provided together (e.g., placed in the receiving channel **2036** together). For instance, in the examples shown in FIGS. **5** and **11**, the sealing element **2064** and the pre-orifice element **2062** may be provided together (e.g., placed in the receiving channel **2036** together). Of course, in some instances, the sealing element **2064** and the pre-orifice element **2062** need not be provided together. For instance, the sealing element **2064** and the pre-orifice element **2062** need not be provided together in the examples shown in FIGS. **5** and **11**.

[0087] In some examples, the pre-orifice element **2062** (if provided at all), the sealing element **2064** (if provided at all), and the tip piece **2060** may be provided separately. For instance, in the examples shown in FIGS. **6-10** and **12**, the pre-orifice element **2062**, the sealing element **2064**, and the tip piece **2060** may be provided separately. Of course, as will be noted, in some examples (e.g., FIG. **16**) only a tip piece **2060** is provided. In some examples (FIGS. **13-15**), only a tip piece **2060** and a pre-orifice element **2062** are provided. It will be noted that while the examples shown in FIGS. **13-16** do not include a sealing element **2064**, in some instances, a sealing element **2064** may additionally be provided (e.g., at least partially, between the pre-orifice element **2062** and the tip piece **2060** or at least partially between the tip piece **2060** and another element (e.g., securing element **2042**)) in the examples shown in FIGS. **13-16**.

[0088] The pre-orifice element **2062** (if provided at all), the sealing element **2064** (if provided at all), and the tip piece **2060** may be provided in various other ways, as indicated by block **1336**.

[0089] At block **1340** an additional securing element **2042** is provided to secure at least tip piece **2060** within receiving channel **2036** and to form seals. Of course, in some examples, the additional securing element **2042** is provided to secure the tip piece **2060** as well as the pre-orifice element **2062** or a sealing element **2064**, or both, within receiving channel **2036** and to form seals. In some examples, the additional securing element **2042** is provided to secure the pre-orifice element **2062**, the sealing element **2064**, and the tip piece **2060** in the receiving channel **2036**, such as in the examples shown in FIGS. **5** and **7-11** (e.g., examples where the pre-orifice element **2062** is a pre-orifice piece, such as pre-orifice piece **162**, pre-orifice piece **362**, pre-orifice piece **462**, pre-orifice piece **562**, pre-orifice piece **662**, or pre-orifice piece **762**, respectively). In some examples, the additional securing element **2042** is provided to secure the pre-orifice element **2062** and the tip piece **2060** in the receiving channel **2036**, such as the examples shown in FIGS. **13-14** (e.g., examples where the pre-orifice element **2062** is a pre-orifice piece, such as pre-orifice piece **962** or pre-orifice piece **1062**). In some examples, the additional securing element **2042** is provided to secure only the tip piece **2060** and the sealing element **2064** in the receiving channel **2036**, such as in the examples shown in FIG. **6** and FIG. **12** (e.g., examples where the pre-orifice element **2062** is a pre-orifice portion formed in the tip body **2034**, such as pre-orifice portion **262** and pre-orifice portion **862**, respectively). In some examples, the additional securing element **2042** is provided to secure only the tip piece **2060** in the receiving channel **2036**, such as in the example shown in FIGS. **15-16** (e.g., examples where there is no sealing element **2064** and the pre-orifice element **2062** is a pre-orifice portion formed in the tip body **2034**, such as pre-orifice portion **1162** or examples where there is no sealing element **2064** and no pre-orifice element **2062** (e.g., FIG. **16**)). In examples in which a sealing element **2064** is provided, providing the additional securing element **2042** causes the formation of seals.

[0090] For example, providing the additional securing element **2042** can cause the formation of seals by causing compression of sealing element **2064** (e.g., by driving movement of the tip piece **2060** or the pre-orifice element **2062** to reduce the distance between the tip piece **2060** and the pre-orifice element **2062**). The seals can include two or more of a seal between sealing element **2064** and pre-orifice element **2062**, a seal between sealing element **2064** and tip piece **2060**, and a seal between sealing element **2064** and tip body **2034**.

[0091] Additionally, or alternatively, providing the additional securing element can cause the formation of seals between the tip piece **2060** and the pre-orifice element **2062** (e.g., by causing compression of tip piece **2060** or the pre-orifice element **2062** to reduce the distance between the tip piece **2060** and the pre-orifice element **2062**). The seals can include two or more of a seal between tip piece **2060** and the pre-orifice element **2062**, a seal between the tip piece **2060** and the tip body **2034**, and a seal between the pre-orifice element **2062** and the tip body **2034**.

[0092] In some examples, providing the additional securing element can cause the formation of seals between tip piece **2060** and the tip body **2034** (e.g., by causing compression of tip piece **2060** to reduce the distance between the tip piece and the tip body **2034**).

[0093] In some examples, providing the additional securing element **2042** at block **1340** can comprise deforming a portion of the tip body **2034**, as indicated by block **1342**, such as in the examples of deformed projections **142** and **242** shown in FIGS. **5** and **6**, respectively, and in the examples of deformed walls **742**, **842**, **942**, **1042**, **1142**, and **1242** shown in FIGS. **11** **12**, **13**, **14**, **15**, and **16** respectively. Deforming a portion of the tip body **2034** can include a forming process such as a radial forming process, an orbital forming, a cold forming process, or various other forming processes and may include use of a tool, such as, but not limited to, one of the tools shown herein and described again at block **1350**.

[0094] In some examples, as indicated by block **1344**, providing the additional securing element **2042** at block **1340** can comprise providing threads of a pre-orifice element **2062**, such as in the example of threads **363** of pre-orifice piece **336** shown in FIG. **6**. In such an example, the threads of the pre-orifice element **2062** are mated with threads of the tip body **2034** (e.g., threads **337**) such as those provided at block **1314**. The pre-orifice element **2062** is thus threadably coupled to the tip body **2034** and acts as an additional securing element **2042** to secure pre-orifice portion **2062**, tip piece **2060**, and, if included, sealing element **2064** in the receiving channel **2036**. Thus, providing the pre-orifice portion **2062** and the additional sealing element **2042** at block **1340** can occur together as indicated by arrow **1338**.

[0095] In some examples, providing the additional securing element **2042** at block **1340** can comprise deforming a portion of the pre-orifice element **2062**, as indicated by block **1346**, such as in the example of deformed wall **442** shown in FIG. **8**. In such an example, the deformed portion of pre-orifice element **2062** may be deformed to be disposed within a recess (e.g., recess **440**) of the tip body **2034** and to be disposed against another securing element **2042**, such as a shoulder of the tip body **2034** (e.g., shoulder **443**) such as the shoulder of the recess provided at block **1316**.

[0096] In some examples, providing the additional securing element **2042** at block **1340** can comprise providing a ring, as indicated by block **1348**, such as in the example of ring **565** and ring **665** show in FIGS. **9** and **10**, respectively. In one example, the ring (e.g., ring **565**) is moveable between a first diameter and a second diameter. The ring is caused to compress to the first, smaller diameter, until

aligned with a recess (e.g., recess **540**) wherein the ring will snap back to its second, larger diameter, to be disposed in the recess and disposed against another securing element **2042**, such as a shoulder of the tip body (e.g., shoulder **543**) such as the shoulder of the recess provided at block **1316**. In another example, a portion (e.g., wall **667**) of the ring (e.g., ring **665**) is deformed to be disposed with a recess (e.g., recess **640**) of the tip body **2034** and to be disposed against another securing element **2042**, such as a shoulder of the tip body **2034** (e.g., shoulder **643**) such as the shoulder of the recess provided at block **1316**.

[0097] Providing the additional securing element **2042** at block **1340** can include the use of a tool, as indicated by block **1350**, such as a swaging tool (e.g., swaging tool **190** or swaging tool **290**), a rotatable driving tool (e.g., rotatable driving tool **390**), a press tool (e.g., press tool **490**, press tool **590**, or press tool **690**), a peen tool (e.g., peen tool **790**, peen tool **890**, peen tool **1090**, peen tool **1190**, or peen tool **1290**), or another type of tool.

[0098] Providing the additional securing element **2060** to secure at least the tip piece **2060** (and in some examples also the sealing element **2064** or the pre-orifice element **2062**, or both) within the receiving channel **2036** and to form seals at block **1340** can be done in various other ways, as indicated by block **1352**.

[0099] As can be seen, a spray tip can include a tip body (e.g., tip stem, etc.) having a longitudinal axis and a receiving channel, formed in the tip stem transverse to the longitudinal axis. The spray tip can further include a tip piece disposed within the receiving channel. In some examples, the tip piece further includes a sealing element disposed within the receiving channel and upstream of the tip piece or a pre-orifice element upstream of the tip piece, or both. The spray tip can also include a fluid channel of variable geometry extending between an upstream end and a downstream end (e.g., between an upstream end of the pre-orifice element and a downstream end of the tip piece or between an upstream end of the tip piece and a downstream end of the tip piece). The spray tip can further include a first securing element downstream of the tip piece, or at least a portion of the tip piece. In some example, the first securing element can also be downstream of a sealing element or downstream of a pre-orifice element, or both. The spray piece can further include a second securing element upstream of the tip piece. In some examples, the second securing element can be downstream of a sealing element, or at least a portion of the sealing element, or upstream of a pre-orifice element, or both In one example, a sealing element forms a portion of the fluid channel. In one example, the first securing element comprises a shoulder of the tip body defined by the receiving channel. In one example, the first securing element comprises a deformed portion of the tip body. In one example, the second securing element comprises a shoulder of the tip body defined by the receiving channel. In one example, the second securing element comprises a deformed portion of the tip body. In one example, the second securing element comprises a ring. In one example, the second securing element comprises threads of the pre-orifice element and threads of the tip body. In one example, the second securing element comprises a deformed portion of the pre-orifice element. In one example, the tip body includes a recess extending radially from the receiving channel, the recess configured to receive the second securing element. In one example, the recess includes a shoulder. In one example, the second securing element abuts the shoulder of the recess. In one example, the pre-orifice element comprises hardened stainless steel. In one example, the receiving channel includes threads and the pre-orifice element includes threads, the threads of the pre-orifice element and the threads of the receiving channel being configured to mate. In one example, the pre-orifice element comprises a set screw. In one example, the pre-orifice element is configured to receive a press tool to deform the portion of the pre-orifice element to form the second securing element. In one example, the pre-orifice element is configured to receive a rotatable drive tool. In one example, the pre-orifice element is configured to receive a biased element of a swaging tool. In one example, the tip piece is configured to receive a biased element of a swaging tool. In one example, the tip body is configured to receive a swaging tool to deform the portion of the tip body to form the first securing element. In one example, the tip body is configured to receive a swaging tool to deform the portion of the tip body to form the second securing element. In one example, the second securing element is configured to receive a press tool to cause the second securing element (e.g., ring, portion of pre-orifice element) to be disposed in a recess and to abut a shoulder of the recess. In one example, the tip body is configured to receive a peen tool to deform the portion of the tip body to form the second securing element. In one example, the, the tip body is configured to receive a peen tool to deform the portion of the tip body to form the first securing element.

[0100] Although the present invention has been described with reference to preferred examples, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

[0101] Additionally, while a particular order of steps has been described for the sake of illustration, it is to be understood that some or all of these steps can be performed in any number of orders.

[0102] It should also be noted that the different examples described herein can be combined in different ways. That is, parts of one or more examples can be combined with parts of one or more other examples. All of this is contemplated herein.

What is claimed is:

1. A spray tip comprising:

a tip body having a longitudinal axis;

a receiving channel extending between a front and a back of the tip body transverse to the longitudinal axis;

a tip piece defining, at least, a first portion of a fluid channel, the fluid channel extending from an inlet to an outlet;

a first securing element downstream of at least a portion of the tip piece; and

a second securing element upstream of the tip piece, wherein the first securing element and the second securing element secure at least the tip piece within the receiving channel.

2. The spray tip of claim **1** and further comprising a pre-orifice element, wherein the pre-orifice element comprises a pre-orifice piece, the pre-orifice piece disposed in the receiving channel upstream of the tip piece and defining a second portion of the fluid channel, and wherein the first securing element and the second securing element secure the tip piece and the pre-orifice piece in the receiving channel.

3. The spray tip of claim 2, wherein the first securing element compresses the tip piece against the pre-orifice piece.

4. The spray tip of claim 1 and further comprising a pre-orifice element, wherein the pre-orifice element comprises a pre-orifice portion formed in the tip body and upstream of the receiving channel and defines a second portion of the fluid channel.

5. The spray tip of claim 1, wherein the second securing element comprises a shoulder of the tip body.

6. The spray tip of claim 5, wherein the first securing element compresses the tip piece against the second securing element.

7. The spray tip of claim 6 and further comprising a fluid inlet extending between the back of the tip body and the receiving channel.

8. The spray tip of claim 1, wherein the first securing element comprises a deformed portion of the tip body.

9. A fluid application system comprising:

a fluid applicator;

a fluid delivery line coupled to the fluid applicator;

a pump configured to deliver fluid from a fluid source through the fluid delivery line to the fluid applicator; and

a reversible spray tip coupled to the fluid applicator, the spray tip comprising:

a tip body having a longitudinal axis;

a receiving channel extending between a front and a back of the tip body transverse to the longitudinal axis;

a tip piece defining, at least, a first portion of a fluid channel, the fluid channel extending from an inlet to an outlet;

a first securing element downstream of at least a portion of the tip piece; and

a second securing element upstream of the tip piece, wherein the first securing element and the second securing element secure at least the tip piece within the receiving channel.

10. The fluid applicator of claim 1, wherein the reversible spray tip further comprises a pre-orifice element, wherein the pre-orifice element comprises a pre-orifice piece, the pre-orifice piece disposed in the receiving channel upstream of the tip piece and defining a second portion of the fluid channel, and wherein the first securing element and the second securing element secure the tip piece and the pre-orifice piece in the receiving channel.

11. The fluid applicator of claim 10, wherein the first securing element compresses the tip piece against the pre-orifice piece.

12. The fluid applicator of claim 9, wherein the reversible spray tip further comprises a pre-orifice element, wherein the pre-orifice element comprises a pre-orifice portion formed in the tip body and upstream of the receiving channel and defines a second portion of the fluid channel.

13. The fluid applicator of claim 9, wherein the second securing element comprises a shoulder of the tip body.

14. The fluid applicator of claim 13, wherein the first securing element compresses the tip piece against the second securing element.

15. The fluid applicator of claim 14, wherein the reversible spray tip further comprises a fluid inlet extending between the back of the tip body and the receiving channel.

16. The fluid applicator of claim 9, wherein the first securing element comprises a deformed portion of the tip body.

17. A method of manufacturing a spray tip comprising:

providing a tip body having a longitudinal axis;

providing a receiving channel in the tip body transverse to the longitudinal axis, wherein providing the receiving channel provides a securing element;

providing a tip piece, wherein providing the tip piece comprises providing the tip piece within the receiving channel; and

providing an additional securing element, wherein providing the additional securing element drives movement of at least the tip piece to form a seal.

18. The method of claim 17, wherein providing the additional securing element comprises deforming a portion of the tip body.

19. The method of claim 17 and further comprising:

providing a pre-orifice element, wherein providing the pre-orifice element comprises providing the pre-orifice element within the receiving channel upstream of the tip piece; and

wherein providing the additional securing element drives the tip piece against the pre-orifice element.

20. The method of claim 17 and further comprising:

providing a pre-orifice element, wherein providing the pre-orifice element comprising forming the pre-orifice element in the tip body, the pre-orifice element upstream of the receiving channel; and

wherein providing the additional securing element drives the tip piece against the securing element.

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