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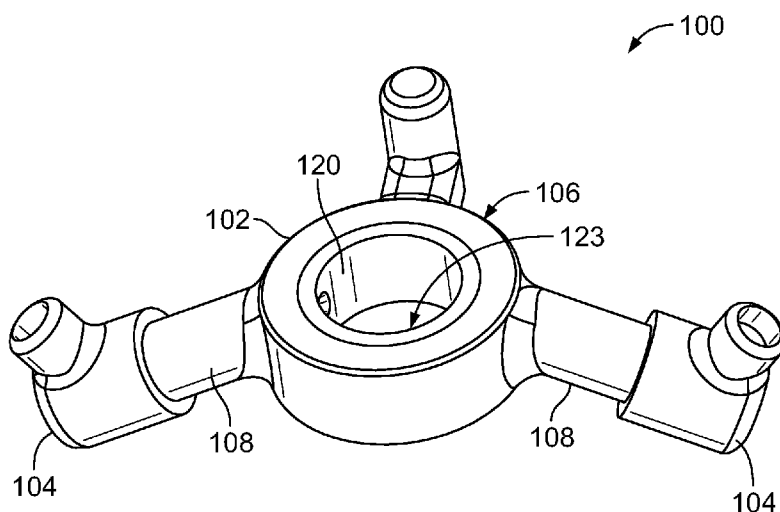


FIG. 2

(57) Abstract: A piston cooling jet assembly includes nozzle caps and a base manifold. The base manifold includes wings and a base, with each wing having a base end and a free end that extends a distance away from the base. The nozzle caps are formed as individual cap bodies. Each nozzle cap is operably coupled with the free end of each wing. The base manifold and the nozzle caps form one or more passages inside the piston cooling jet assembly to direct fluid through the piston cooling jet assembly and out of the piston cooling jet assembly in a direction towards a spray target.

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PISTON COOLING JET ASSEMBLY

RELATED APPLICATIONS

[0001] This application relates to and claims priority benefits from U.S. Provisional Patent Application No. 62/468,042, entitled “Piston Cooling Jet Assembly,” filed March 7, 2017, which is hereby incorporated by reference in its entirety.

FIELD OF EMBODIMENTS OF THE DISCLOSURE

[0002] Embodiments of the present disclosure generally relate to piston cooling jets for engines.

BACKGROUND

[0001] Piston cooling jets may be mounted to an engine crankcase proximate to a crankshaft. Each piston cooling jet may be fastened to the crankcase with a banjo bolt. The banjo bolt extends into an oil chamber in the crankcase, thereby allowing pressurized oil to flow into the piston cooling jet and spray upwards onto a bottom side of a piston during engine operation. Such cooling is often used with high compression and/or turbocharged engines. Figure 1 illustrates a known piston cooling jet 10. As shown, the piston cooling jet 10 is a unitary piece of metal. It has been found that forming the piston cooling jet is expensive, due to the cost of the material for the metal component. Further, machining operations used to drill small channels in nozzles of the piston cooling jet are complex.

SUMMARY OF EMBODIMENTS OF THE DISCLOSURE

[0002] A need exists for a versatile piston cooling jet that allows for various configurations and orientations of outlet nozzles. A need exists for a versatile assembly having components that may be repurposed or retrofitted with new or existing assemblies. A need exists for a piston cooling jet assembly that is easy to manufacture and reduces overall part mass.

[0003] With those needs in mind, certain embodiments of the present disclosure provide a piston cooling jet assembly that includes a base manifold and nozzle caps. The base manifold includes wings and a base, with each wing having a base end and a free end that extends a distance away from the base. The nozzle caps are formed as individual cap bodies. Each nozzle cap is operably coupled with the free end of each wing. The base manifold and the nozzle caps form one or more passages inside the piston cooling jet assembly to direct fluid through the piston cooling jet assembly and out of the piston cooling jet assembly in a direction towards a spray target.

[0004] In at least one embodiment, the piston cooling jet assembly also includes a compression limiter that is retained within the base of the base manifold. The compression limiter may be removably secured to the base manifold.

[0005] In at least one embodiment, the base manifold, the nozzle caps, and the compression limiter form the one or more passages inside the piston cooling jet assembly.

[0006] One or more of the base manifold, the nozzle caps, or the compression limiter may be formed of plastic.

[0007] One or more of the nozzle caps may be retrofitted to the base manifold.

[0008] Each of the nozzle caps also include an inlet passage and an outlet passage. The inlet passage is elongated along and encompasses an inlet axis that extends in a first direction. The outlet passage is elongated and encompasses an outlet axis that extends in different, second direction. The inlet passage is also fluidly coupled with the outlet passage.

[0009] The nozzle caps are also configured to direct the fluid out of the piston cooling jet assembly through the outlet passage of each nozzle cap in a direction away from the piston cooling jet assembly.

[0010] Each of the wings also includes a wing passage that is elongated along and encompasses a wing axis that extends in a third direction. The inlet axis and the wing

axis are parallel, and the outlet axis and the wing axis are not parallel. Each wing is also configured to direct the fluid through the wing passage to each nozzle cap.

[0011] One or more of the nozzle caps may be ultrasonically welded to the base manifold.

[0012] Each of the nozzle caps may be removably coupled to the base manifold.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0013] Figure 1 illustrates a known piston cooling jet.

[0014] Figure 2 illustrates a top perspective view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0015] Figure 3 illustrates a bottom perspective bottom view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0016] Figure 4 illustrates a perspective bottom exploded view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0017] Figure 5 illustrates a perspective side view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0018] Figure 6 illustrates a perspective side view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0019] Figure 7 illustrates a perspective side view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0020] Figure 8 illustrates a cross-sectional view of a nozzle cap, according to an embodiment of the present disclosure.

[0021] Figure 9 illustrates a cross-sectional view of a base manifold, according to an embodiment of the present disclosure.

[0022] Figure 10 illustrates ultrasonic weld joints that secure nozzle caps to a base manifold, according to an embodiment of the present disclosure.

[0023] Figure 11 illustrates a perspective view of a nozzle cap, according to an embodiment of the present disclosure.

[0024] Figure 12 illustrates a bottom perspective view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0025] Figure 13 illustrates a partial perspective translucent view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0026] Figure 14 illustrates a partial perspective exploded view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0027] Figure 15 illustrates a partial cross-sectional exploded view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0028] Figure 16 illustrates a cross-sectional view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0029] Figure 17 illustrates a partial cross-sectional view of a piston cooling jet assembly, according to an embodiment of the present disclosure.

[0030] Before the embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The disclosure is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of "including" and "comprising" and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE DISCLOSURE

[0031] Embodiments of the present disclosure provide a piston cooling jet assembly that includes a base manifold, one or more nozzle caps, and optionally, a compression limiter secured to the base manifold. The piston cooling jet assembly may be

fastened to a crankcase and configured to allow pressurized oil to flow through the piston cooling jet assembly and out of the piston cooling jet assembly in a direction towards a spray target. In at least one embodiment, the piston cooling jet assembly provides a modular assembly that allows internal passages to be efficiently formed in the nozzle caps and the base manifold. Additionally, the modular assembly of the piston cooling jet assembly may provide for various different configurations and orientations of outlet nozzles of the one or more nozzle caps.

[0032] The base manifold, nozzle caps, and compression limiter may all be coupled together (such as through press-fit connections, welded joints, or the like) to form the piston cooling jet assembly that allows for various spray patterns and/or spray target locations.

[0033] Figure 2 illustrates a top perspective view of a piston cooling jet assembly 100, according to an embodiment of the present disclosure. Figure 3 illustrates a bottom perspective bottom view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure. Figure 4 illustrates a perspective bottom exploded view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure.

[0034] Referring to Figures 2-4, the piston cooling jet assembly 100 includes a base manifold 102, a plurality of nozzle caps 104, and optionally, a compression limiter 120 secured within a central passage 123 of the base manifold 102. The base manifold 102 includes a base 106 and plural wings 108. The base 106 and the wings 108 of the base manifold 102 are formed as a unitary body, but may be formed as individual components that may be attached together by any attachment method such as by welding, fastening, adhering, or the like. Each of the wings 108 includes a base end 110 and a free end 112. The base end 110 is disposed proximate the base 106, and the free ends 112 are disposed a distance 114 away from the base 106.

[0035] In one or more embodiment, the base 106 may include a mating surface 132 that extends into the central passage 123. The base 106 also includes a notch 136 that

extends into the central passage 123. The compression limiter 120 includes a body 124 and a lip 125 that extends a distance away from the body 124. The lip 125 includes a mating surface 128 that is configured to mate with the mating surface 132 of the base 106 when the compression limiter 120 is secured inside the central passage 123 of the base manifold 102. Additionally, the lip 125 of the compression limiter 120 includes a notch 134 that protrudes into the lip 125. For example, the notch 134 of the compression limiter 120 is sized and shaped to receive the notch 136 of the base manifold 102, such that the notches 134, 136 align and orient the compression limiter 120 inside the central passage 123 of the base manifold 102. The compression limiter 120 removably secures to the central passage 123 of the base manifold 102, such as by a press-fit connection, a snapable connection, or the like. Optionally, the compression limiter 120 may secure to the base manifold 102 by a non-removable means, such as by welding.

[0036] The nozzle caps 104 are formed as individual cap bodies. Each of the nozzle caps 104 include a mating end 142 and a free end 144. The mating ends 142 of the nozzle caps 104 are operably coupled with the free ends 112 of the wings 108. Each of the nozzle caps 104 also includes an outlet end 154. For example, fluid (e.g., pressurized oil) is configured to be directed through plural passages 122 of the compression limiter 120, through a wing passage 148 of each of the wings 108, through the nozzle caps 104 and out of the piston cooling jet assembly 100 in a direction away from the piston cooling jet assembly 100. The fluid may be directed towards one or more spray targets.

[0037] The piston cooling jet assembly 100 provides a modular assembly that allows for various different configurations and orientations of outlet nozzles. The components of the piston cooling jet assembly 100 may be formed of plastic, thereby reducing overall mass and cost. In at least one embodiment, the base manifold 102 may be formed of metal, while the other components are formed of plastic. Alternatively, at least two or more of the components may be formed of metal.

[0038] The nozzle caps 104 may be molded separately from the base manifold 102. As such, simpler tooling may be used to form the nozzle caps 104 and the base manifold 102.

[0039] Various spray patterns and spray target locations may be achieved by changing orientations, lengths, and outlet angles of the nozzle caps 104 without modifying the base manifold 102. In one example, Figure 5 illustrates a perspective side view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure. As shown in Figure 5, a longer nozzle cap 504, relative to the nozzle cap 104 of Figure 2, may be used. For example, a distance 502 between a mating end 542 and a free end 544 of the nozzle cap 504 is greater (e.g., longer) than a distance between the mating end 142 and the free end 144 of the nozzle cap 104 of Figure 2. The longer nozzle cap provides a widened spray pattern. Optionally, the distance 502 may be shorter than the distance between the mating and free ends 142, 144 of the nozzle cap 104 of Figure 2. A shorter nozzle cap may provide a narrowed spray pattern.

[0040] In one example, Figure 6 illustrates a perspective side view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure. As shown in Figure 6, a nozzle cap 604 has an outlet angle 610 that is different than an outlet angle of the nozzle cap 104 of Figure 2. For example, the outlet angle 610 between an inlet axis 612 and an outlet axis 614 of the nozzle cap 604 is substantially 90 degrees. Alternatively, the outlet angle of the nozzle cap 104 illustrated in Figure 2 is greater than 90 degrees. Optionally, the outlet angle may have any angular value. The different outlet angle 610 may be used in order to change a target spray location of the fluid that is directed out of the nozzle cap 604 in a direction away from the piston cooling jet assembly 100.

[0041] In one example, Figure 7 illustrates a perspective side view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure. As shown in Figure 7, the nozzle caps 704 may be rotated to provide different target spray locations.

[0042] The two nozzle caps 504 of Figure 5 are illustrated as both having substantially the same distances 502 between the mating ends 542 and the free ends 544 that are greater than the distance between the mating ends 142 and the free ends 144 of the nozzle caps 104 of Figure 4. Similarly, the two nozzle caps 604 of Figure 6 both have substantially the same outlet angle, and the two nozzle caps 704 of Figure 7 are illustrated as both having the same rotated configuration. Additionally or alternatively, one or more

of the nozzle caps of the piston cooling jet assembly 100 may have any uniform and/or unique configuration. For example, a first nozzle cap may extend a first distance 502, and a different, second nozzle cap may extend a second distance that is different than the first distance 502 (not shown). Optionally, one or more of the nozzle caps may have any orientations, lengths, and/or outlet angle that is unique to or substantially the same as the orientation, length, and/or outlet angle of any other nozzle cap.

[0043] Figure 8 illustrates a cross-sectional view of a Section 8-8 of the nozzle cap 104 of Figure 4, according to an embodiment of the present disclosure. The nozzle cap 104 includes an inlet passage 140 and an outlet passage 150. The inlet passage 140 is elongated along and encompasses an inlet axis 240 that extends in a first direction 242. The inlet passage 140 is an open passage that is open at the mating end 142 of the cap 104 and extends in a direction towards the free end 144. The outlet passage 150 is elongated along and encompasses an outlet axis 250 that extends in a second direction 252. The outlet passage 150 is an open passage that is open at the outlet end 154 of the cap 104. The inlet passage 140 is fluidly coupled with the outlet passage 150. For example, the fluid is directed into the inlet passage 140 from the base manifold 102, and directed out of the nozzle cap 104 through the outlet passage 150. Optionally, the nozzle caps 104 may include two or more inlet passages 140 and/or two or more outlet passages 150 that may direct fluid in any direction out of and away from the piston cooling jet assembly 100.

[0044] The nozzle cap 104 includes an outlet angle 810 between the inlet axis 240 and the outlet axis 250. As illustrated and described with Figure 6, the outlet angle 810 may have any angular value in order to direct the fluid in a direction towards a target spray location.

[0045] Figure 9 illustrates a cross-sectional view of a Section 9-9 of the base manifold 102 of Figure 4, according to an embodiment of the present disclosure. Each of the wings 108 include a wing passage 148 that is elongated along and encompasses a wing axis 248 of each wing and extend in a third direction 254. The wing passage 148 is an open passage that is open at and extends between the base end 110 and the free end 112 of each of the wings 108. The wing passage 148 is fluidly coupled with the inlet passage 140

of the nozzle cap 104 when the nozzle cap 104 is coupled with the base manifold 102. For example, the fluid is directed into each of the wing passages 148 from the passages 122 of the compression limiter 120, directed into the inlet passage 140 of the nozzle cap 104, and directed out of the nozzle cap 104 through the outlet passage 150.

[0046] The multi-piece design of the piston cooling jet assembly 100 allows for plural internal passages to be efficiently formed in each of the nozzle caps 104 and the base manifold 102. The plural internal passages may have orientations or configurations other than shown. As shown in Figures 2 through 9, the wing axis 248 of each wing 108 and the inlet axis 240 of each nozzle cap 104 may be substantially parallel. Additionally, the wing axis 248 of each wing 108 and the outlet axis 250 of each nozzle cap 104 may not be parallel. Optionally, the wing axis 248 and the inlet axis 240 may not be parallel, the wing axis 248 and the outlet axis 250 may be substantially perpendicular, or the wing axis 248 and the outlet axis 250 may not be perpendicular.

[0047] Figure 10 illustrates ultrasonic weld joints 1002 that secure the nozzle caps 104 to the base manifold 102, according to an embodiment of the present disclosure. Additionally, the compression limiter 120 is press fit into the central passage 123 of the base manifold 102 to form the piston cooling jet assembly 100. The fluid 1004 is directed into each of the wing passages 148 from the passages 122 of the compression limiter 120, directed into the inlet passage 140 of the nozzle cap 104, and directed out of the nozzle cap 104 through the outlet passage 150 of the nozzle cap 104.

[0048] Figure 11 illustrates a perspective view of a nozzle cap 1104, according to an embodiment of the present disclosure. The nozzle cap 1104 may include an ultrasonic weld feature 1112 at a mating end 1142 of the cap 1104. The ultrasonic weld feature 1112 includes a recessed 1114 “tongue and groove” weld feature that is configured to contain ultrasonic weld melt flow. The recess 1114 prevents undesired material from flowing into an inlet passage 1140 during a welding process.

[0049] The tongue and groove feature on the nozzle cap 1104 may be flat at the bottom. An arm of the base manifold may include an annular energy director having a

triangular profile (not shown). The triangular energy director may be consumed during the ultrasonic welding process. The material of the energy director may form filler material during the welding process.

[0050] Figure 12 illustrates a bottom perspective view of a piston cooling jet assembly 1200, according to an embodiment of the present disclosure. Figure 13 illustrates a partial perspective translucent view of the piston cooling jet assembly 1200, according to an embodiment of the present disclosure. Figure 14 illustrates a partial perspective exploded view of the piston cooling jet assembly 1200, according to an embodiment of the present disclosure. Figure 15 illustrates a partial cross-sectional exploded view of the piston cooling jet assembly 1200, according to an embodiment of the present disclosure.

[0051] Referring the Figures 12 through 15, the piston cooling jet assembly 1200 includes a base manifold 1202, nozzle caps 1204, and, optionally, a compression limiter 1220 secured within a central passage 1223 of the base manifold 1202. Each of the nozzle caps 1204 includes a cap alignment feature 1260 at a mating end 1242 of each cap 1204. The cap alignment feature 1260 extends a distance away from the mating end 1242 of each cap 1204. Additionally, each wing 1208 of the base manifold 1202 includes a wing alignment feature 1258 that is shaped and sized in order to receive the cap alignment feature 1260 inside the wing alignment feature 1258. As shown in Figures 12 through 15, the cap and the wing alignment features 1260, 1258 are hexagonal, however the alignment features 1260, 1258 may be any alternative shape. Optionally, the wing alignment feature 1258 may extend a distance away from the free end 1212 of the wing, and the cap alignment feature 1260 may receive the wing alignment feature 1258 inside the mating end 1242 of the cap 1204.

[0052] The nozzle caps 1204 removably secure to the free ends 1212 of the wings 1208 of the base manifold 1202, such as by a press-fit connection, a snapable connection, or the like. For example, new or different nozzle caps 1204 may be retrofitted to the base manifold 1202 after the base manifold 1202 has been used in order to replace different nozzle caps 104. For example, one or more nozzle caps having varying orientations, lengths, and/or outlet angles may be removably coupled with the base

manifold 1202 in order to direct the fluid out of the base manifold 1202 and in a direction towards a spray target. Optionally, the nozzle caps 1204 may secure to the base manifold 1202 by a non-removable means, such as by ultrasonic welding, or the like.

[0053] An inlet passage 1240 extends through the alignment feature 1260 through the nozzle cap 1204 such that the fluid may be directed out of the base manifold 1202 through a wing passage 1248 and into the inlet passage 1240 of the nozzle cap 1204.

[0054] Figure 16 illustrates a cross-sectional view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure. Figure 17 illustrates a partial cross-sectional view of the piston cooling jet assembly 100, according to an embodiment of the present disclosure. It has been found that as a nozzle outlet length 1702 of the outlet passage 150 increases, a spray pattern narrows. Conversely, a shorter nozzle outlet length 1702 produces a wider spray pattern. By varying the length of the outlet passage 150, various spray patterns may be achieved.

[0055] While various spatial and directional terms, such as top, bottom, lower, mid, lateral, horizontal, vertical, front and the like may be used to describe embodiments of the present disclosure, it is understood that such terms are merely used with respect to the orientations shown in the drawings. The orientations may be inverted, rotated, or otherwise changed, such that an upper portion is a lower portion, and vice versa, horizontal becomes vertical, and the like.

[0056] Variations and modifications of the foregoing are within the scope of the present disclosure. It is understood that the embodiments disclosed and defined herein extend to all alternative combinations of two or more of the individual features mentioned or evident from the text and/or drawings. All of these different combinations constitute various alternative aspects of the present disclosure. The embodiments described herein explain the best modes known for practicing the disclosure and will enable others skilled in the art to utilize the disclosure. The claims are to be construed to include alternative embodiments to the extent permitted by the prior art.

[0057] To the extent used in the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, to the extent used in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112(f), unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

[0058] Various features of the disclosure are set forth in the following claims.

CLAIMS

1. A piston cooling jet assembly, comprising:

a base manifold comprising one or more wings and a base, each of the one or more wings comprising a base end and a free end, wherein the free end of each wing extends a distance away from the base; and

nozzle caps formed as individual cap bodies, each nozzle cap configured to be operably coupled to the free end of each wing,

wherein the base manifold and the nozzle caps are configured to form one or more passages inside the piston cooling jet assembly to direct fluid through the piston cooling jet assembly and out of the piston cooling jet assembly in a direction towards a spray target.

2. The piston cooling jet assembly of claim 1, further comprising a compression limiter, wherein the compression limiter is configured to be retained within the base of the base manifold.

3. The piston cooling jet assembly of claim 2, wherein the compression limiter is removably secured to the base manifold.

4. The piston cooling jet assembly of claim 2, wherein the base manifold, the nozzle caps, and the compression limiter are configured to form the one or more passages inside the piston cooling jet assembly.

5. The piston cooling jet assembly of claim 2, wherein one or more of the base manifold, the nozzle caps, or the compression limiter are formed of plastic.

6. The piston cooling jet assembly of claim 1, wherein the nozzle caps are configured to be retrofitted to the base manifold.

7. The piston cooling jet assembly of claim 1, each of the nozzle caps further comprising an inlet passage and an outlet passage, wherein the inlet passage is elongated along and encompasses an inlet axis that extends in a first direction and the outlet passage is elongated along and encompasses an outlet axis that extends in a different, second direction.

8. The piston cooling jet assembly of claim 7, wherein the inlet passage is fluidly coupled with the outlet passage.

9. The piston cooling jet assembly of claim 7, wherein the nozzle caps are configured to direct the fluid out of the piston cooling jet assembly through the outlet passage of each nozzle cap in a direction away from the piston cooling jet assembly.

10. The piston cooling jet assembly of claim 7, each of the one or more wings further comprising a wing passage that is elongated along and encompasses a wing axis that extends in a third direction, wherein the inlet axis and the wing axis are parallel.

11. The piston cooling jet assembly of claim 7, each of the one or more wings further comprising a wing passage that is elongated along and encompasses a wing axis that extends in a third direction, wherein the outlet axis and the wing axis are not parallel.

12. The piston cooling jet assembly of claim 1, each of the one or more wings further comprising a wing passage, wherein each wing is configured to direct the fluid through the wing passage to each nozzle cap.

13. The piston cooling jet assembly of claim 1, wherein the nozzle caps are configured to be ultrasonically welded to the base manifold.

14. The piston cooling jet assembly of claim 1, wherein each of the nozzle caps is removably coupled to the base manifold.

15. A piston cooling jet assembly, comprising:

a base manifold comprising one or more wings and a base, each of the one or more wings comprising a base end and a free end, wherein the free end of each wing extends a distance away from the base;

nozzle caps formed as individual cap bodies, each nozzle cap configured to be operably coupled with the free end of each wing; and

a compression limiter, wherein the compression limiter is configured to be retained within the base of the base manifold,

wherein the base manifold, the compression limiter, and the nozzle caps are configured to form one or more passages inside the piston cooling jet assembly to direct fluid through the piston cooling jet assembly and out of the piston cooling jet assembly in a direction towards a spray target,

wherein the compression limiter is removably secured to the base manifold,

wherein the base manifold, the nozzle caps, and the compression limiter are configured to form one or more passages inside the piston cooling jet assembly,

wherein each of the nozzle caps comprises an inlet passage and an outlet passage, wherein the inlet passage is elongated along and encompasses an inlet axis that extends in a first direction and the outlet passage is elongated along and encompasses an outlet axis that extends in a different, second direction,

wherein the inlet passage is fluidly coupled with the outlet passage, and

wherein each of the one or more wings comprises a wing passage that is elongated along and encompasses a wing axis that extends in a third direction, wherein the inlet axis and the wing axis are parallel.

16. The piston cooling jet assembly of claim 15, wherein one or more of the base manifold, the nozzle caps, or the compression limiter are formed of plastic.

17. The piston cooling jet assembly of claim 15, wherein the nozzle caps are configured to be retrofitted to the base manifold.

18. The piston cooling jet assembly of claim 15, wherein the nozzle caps are configured to direct the fluid out of the piston cooling jet assembly through the outlet passage of each nozzle cap in a direction away from the piston cooling jet assembly.

19. The piston cooling jet assembly of claim 15, wherein the nozzle caps are configured to be ultrasonically welded to the base manifold.

20. The piston cooling jet assembly of claim 15, wherein each of the nozzle caps is removably coupled to the base manifold.

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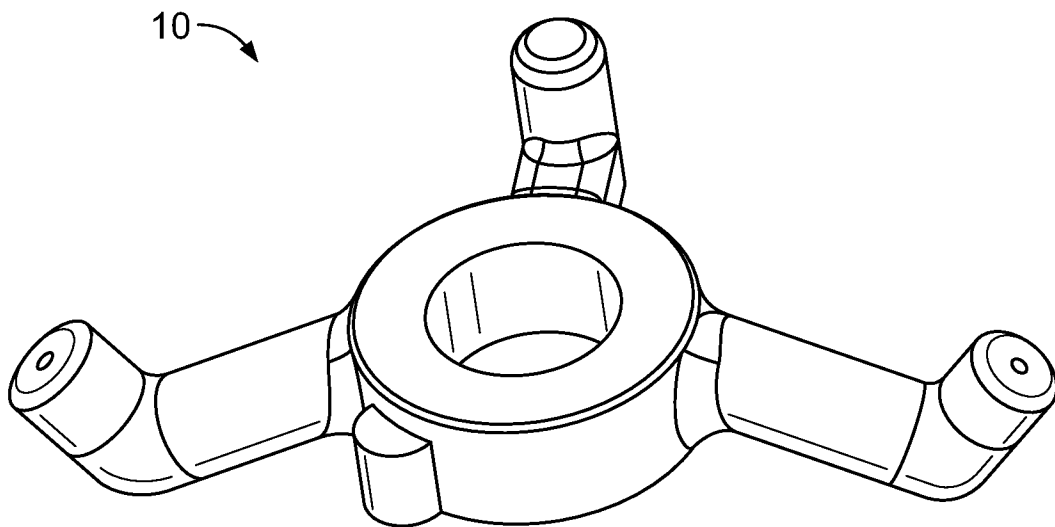


FIG. 1
(Prior Art)

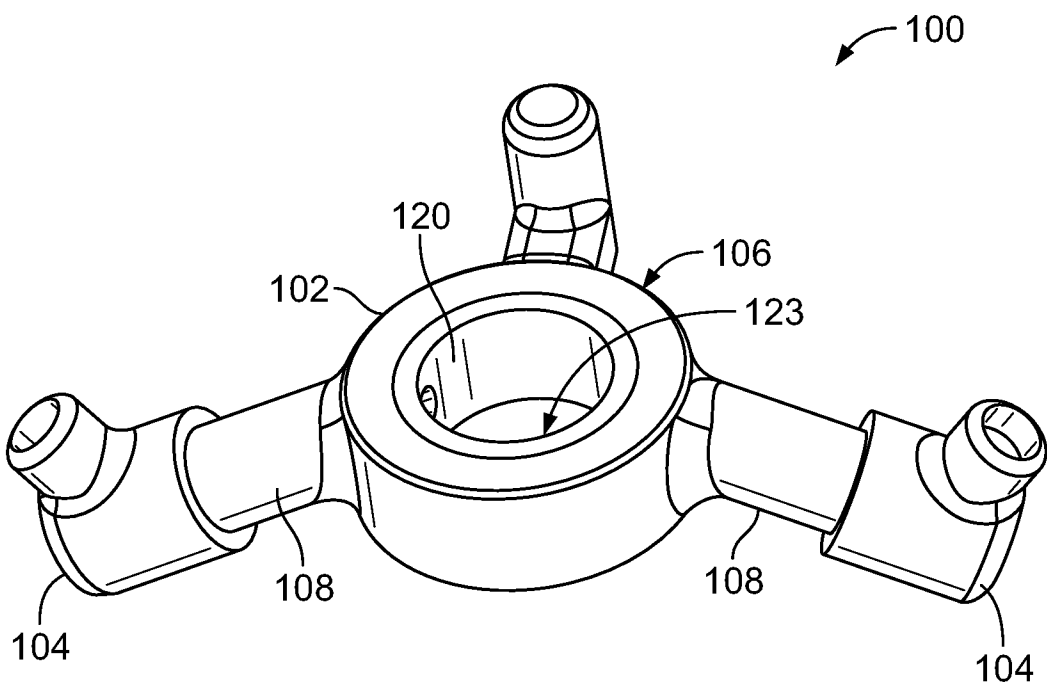


FIG. 2

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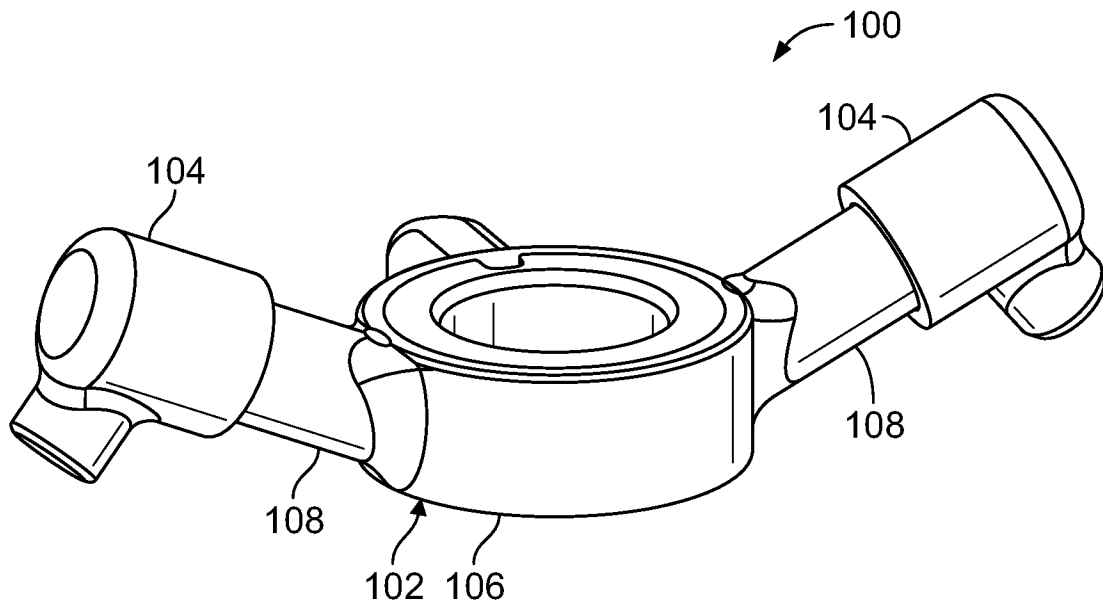


FIG. 3

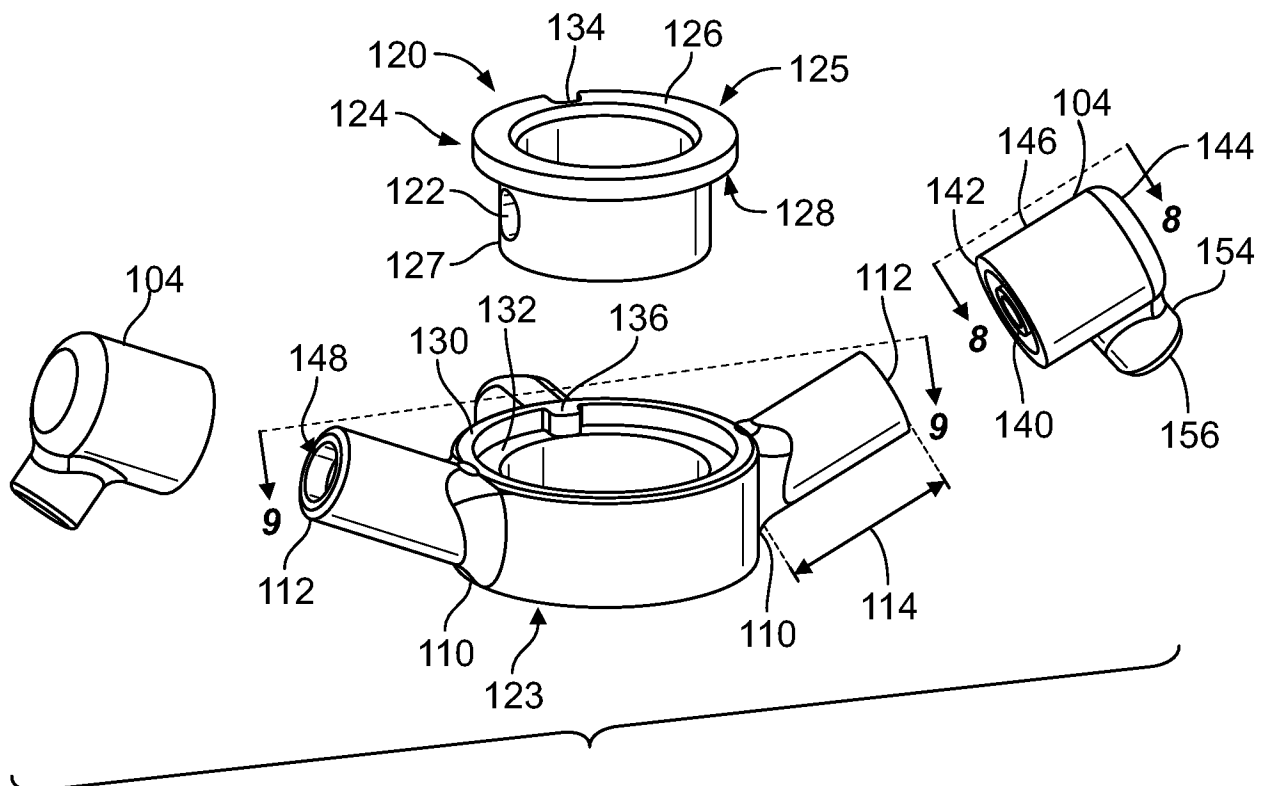


FIG. 4

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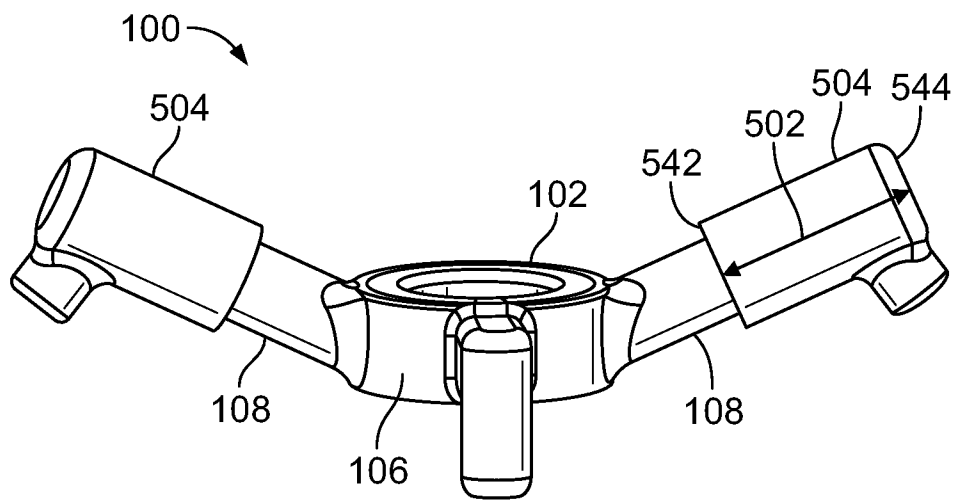


FIG. 5

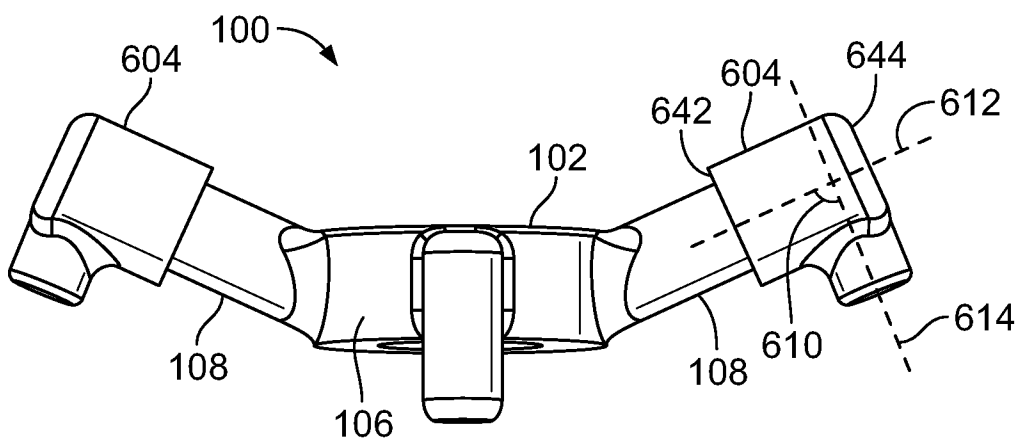


FIG. 6

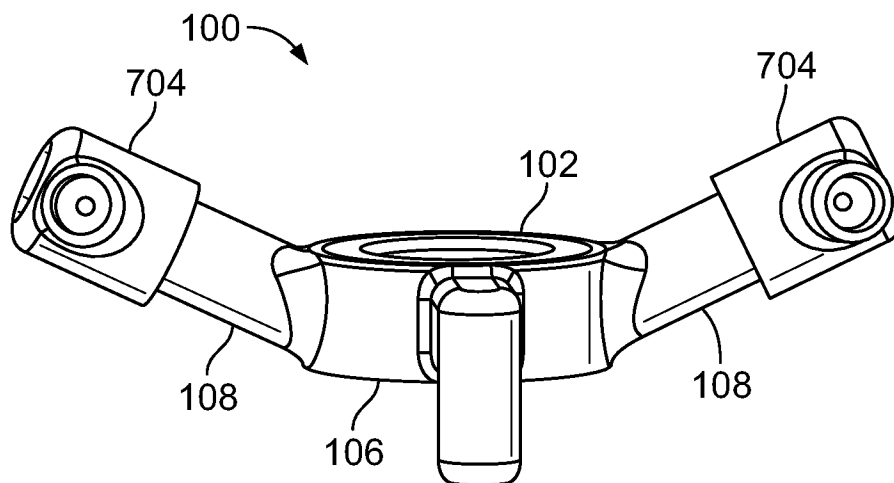


FIG. 7

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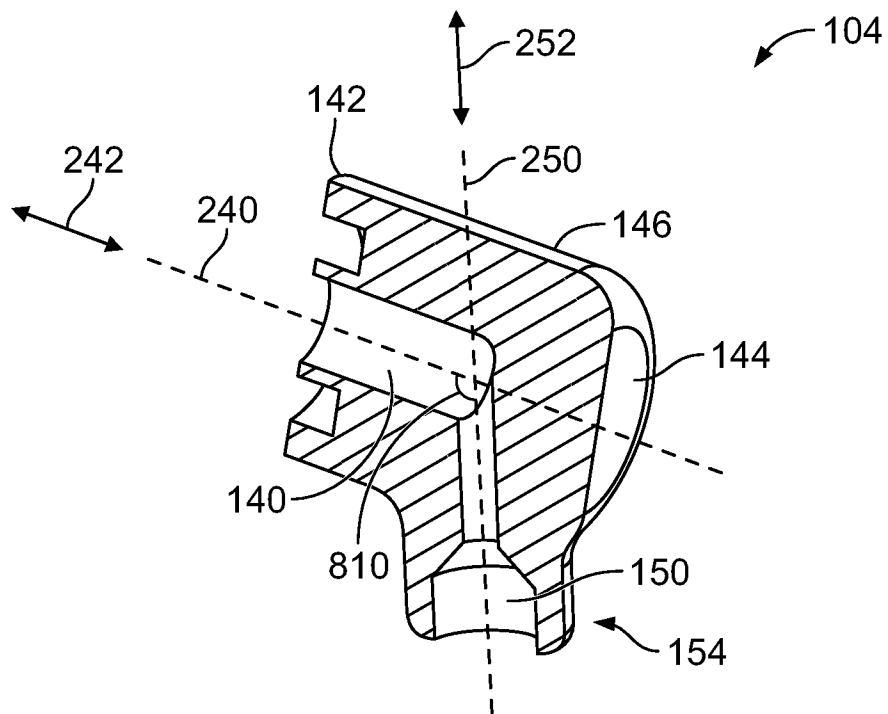


FIG. 8

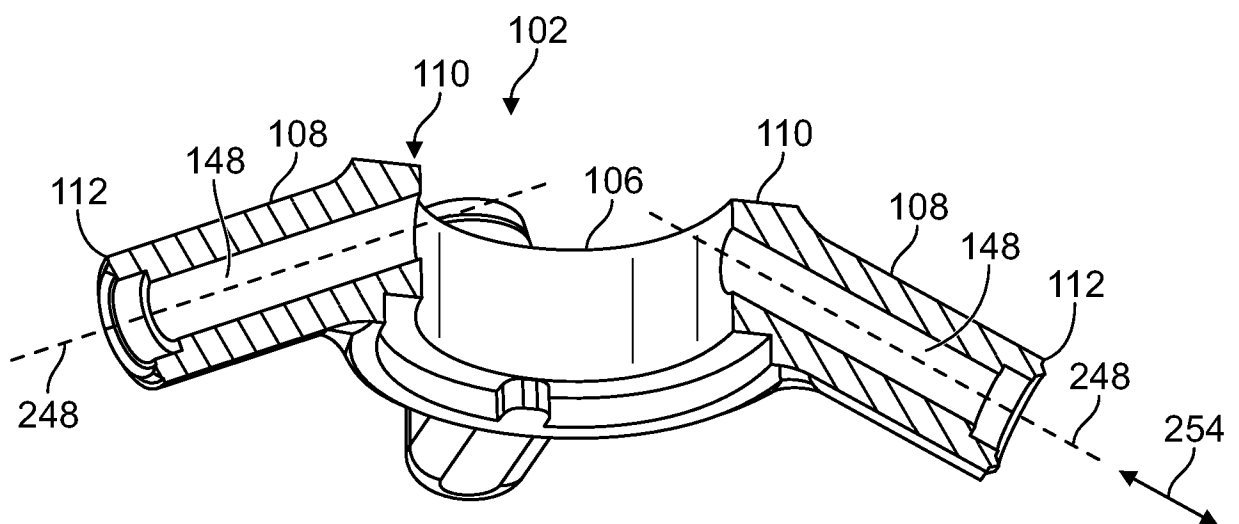


FIG. 9

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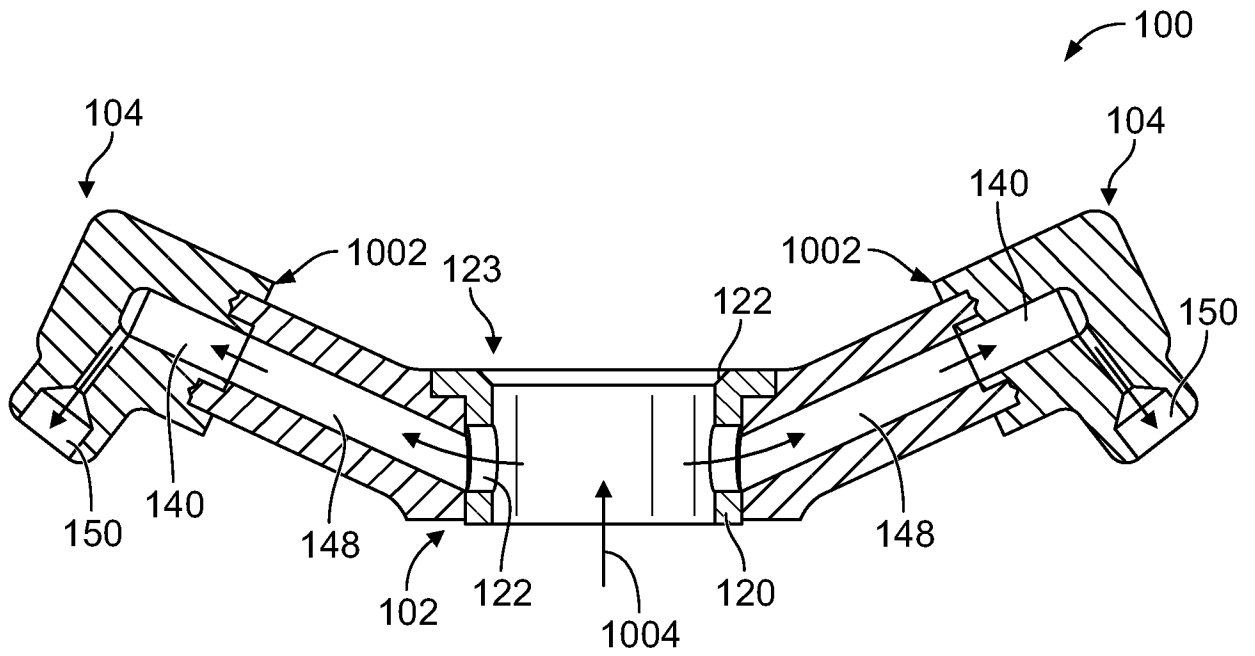


FIG. 10

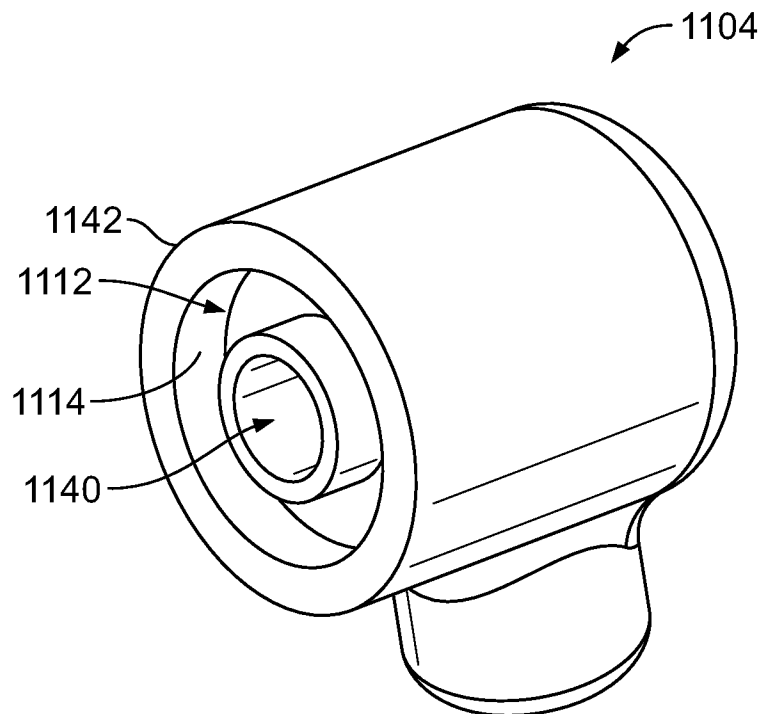


FIG. 11

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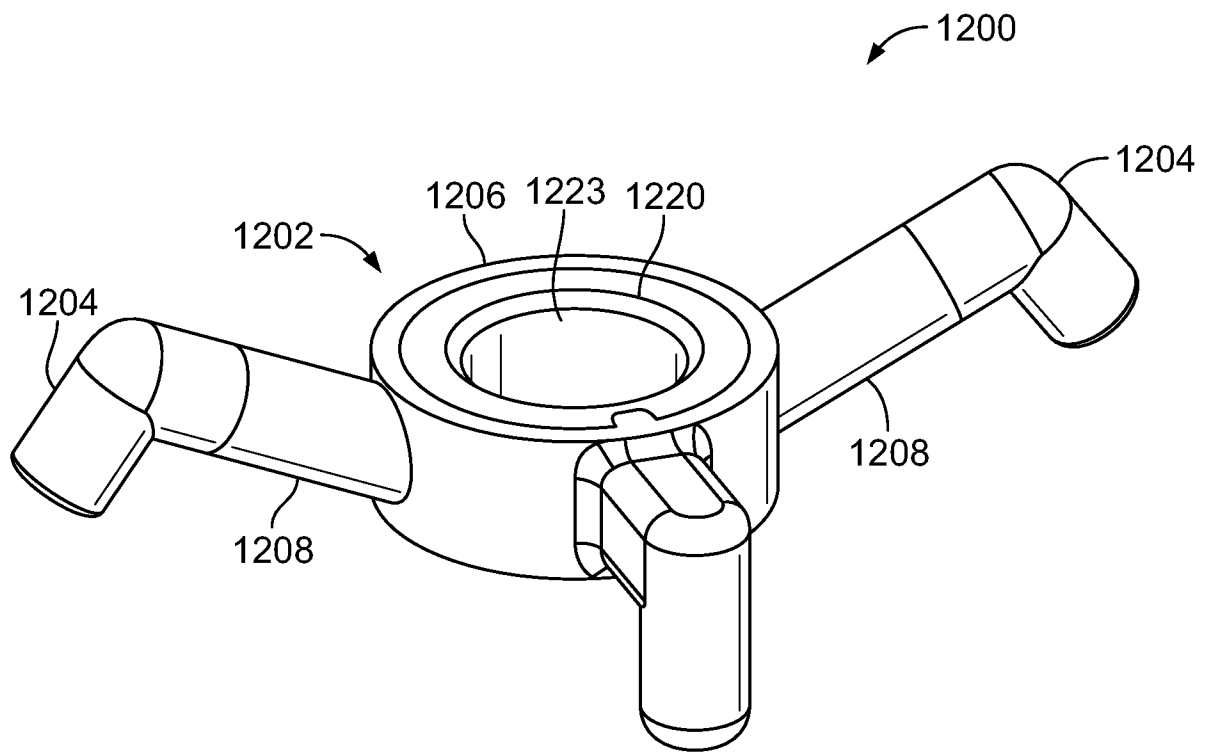


FIG. 12

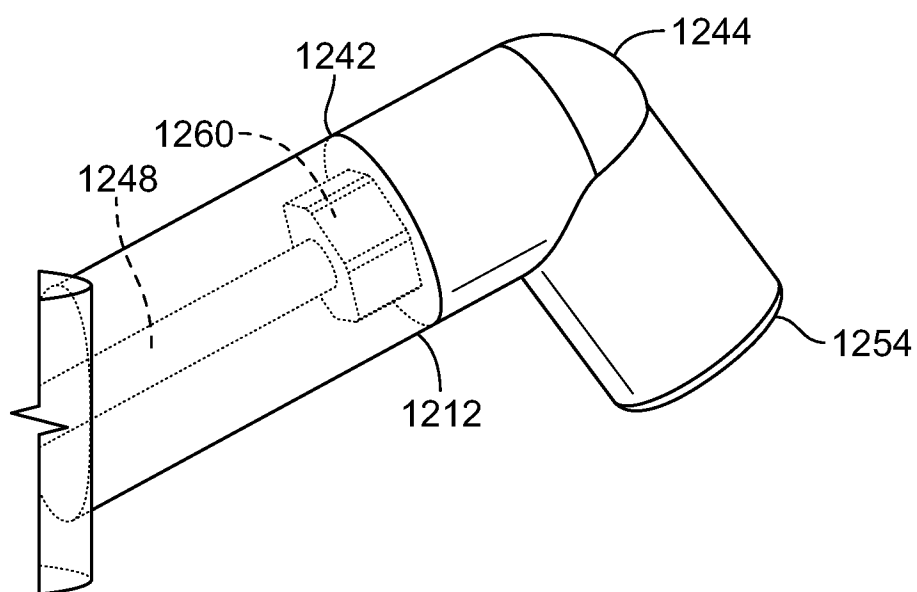


FIG. 13

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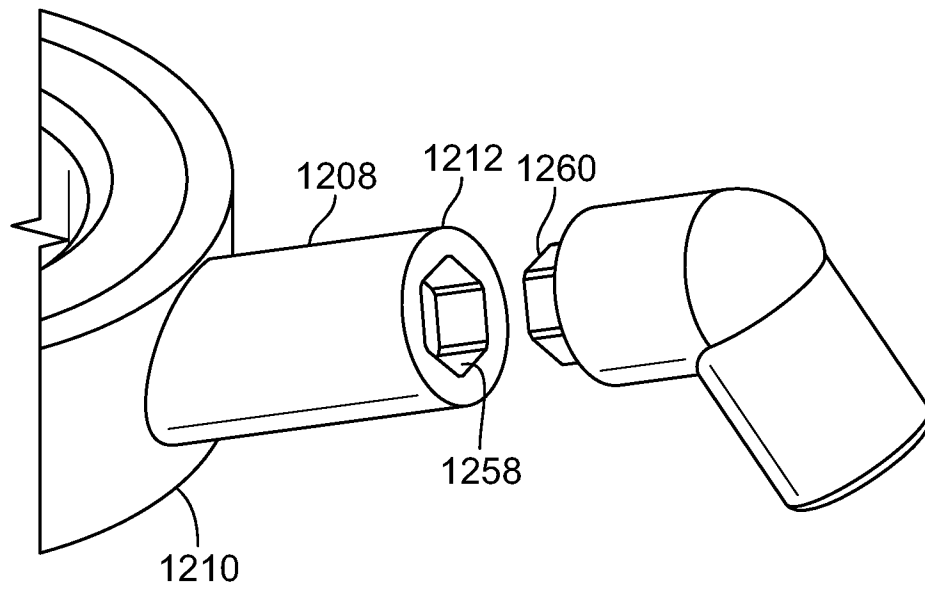


FIG. 14

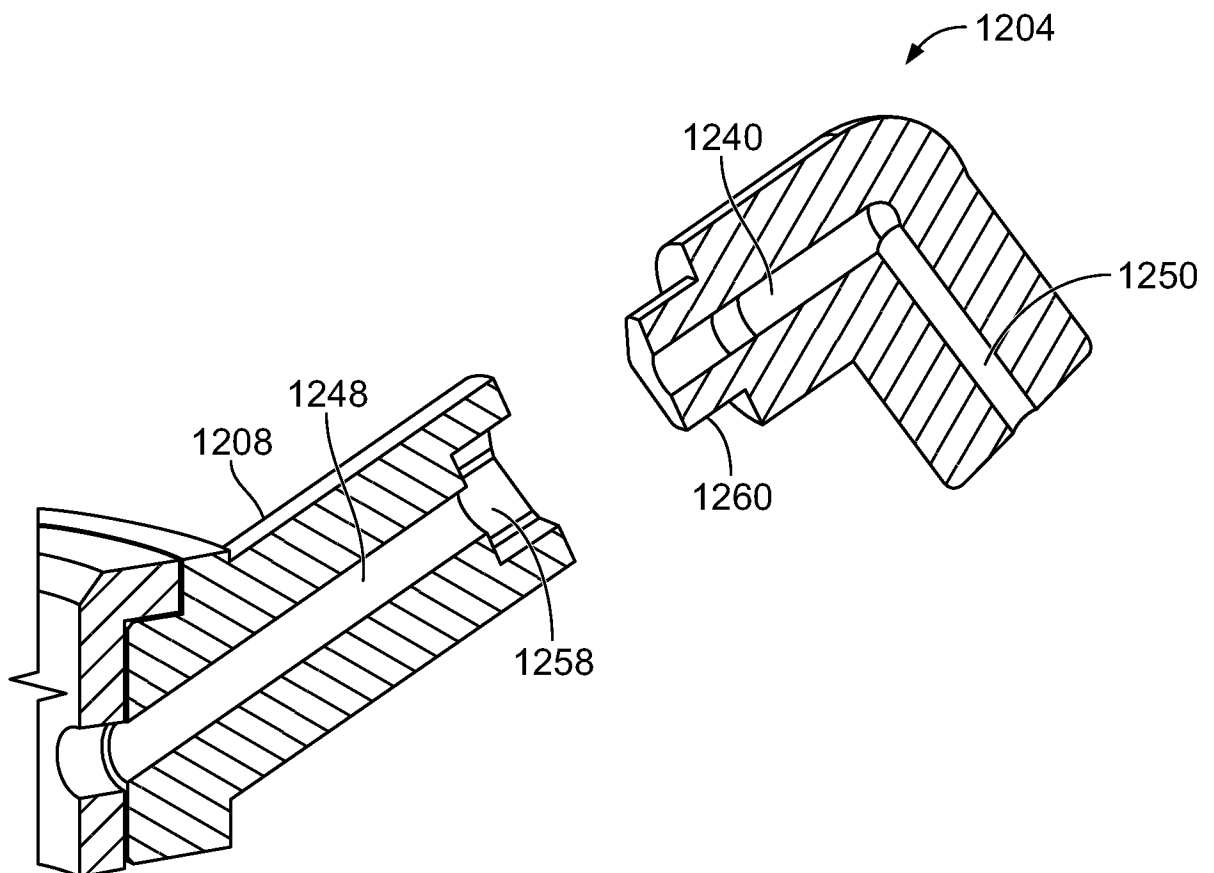


FIG. 15

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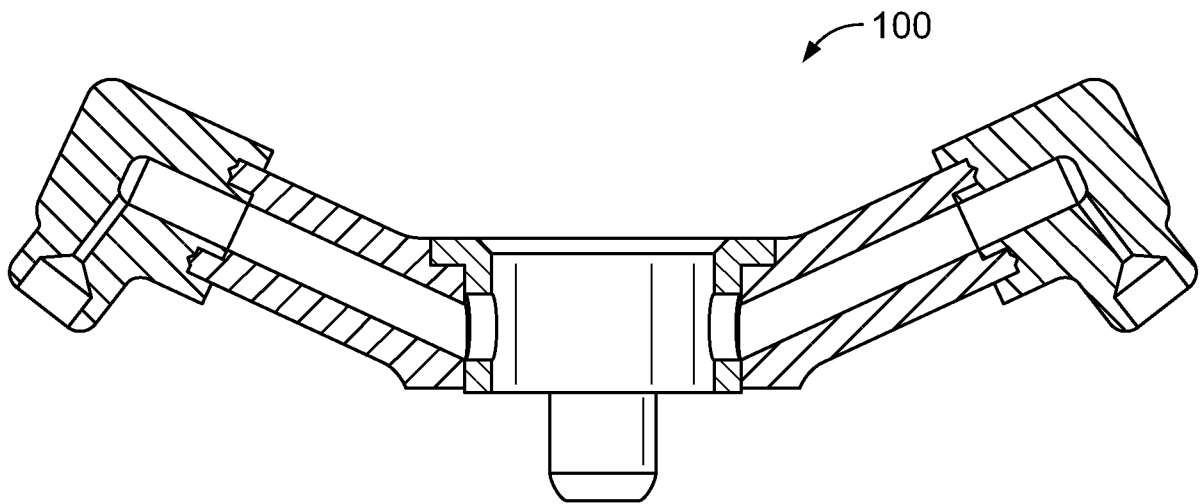


FIG. 16

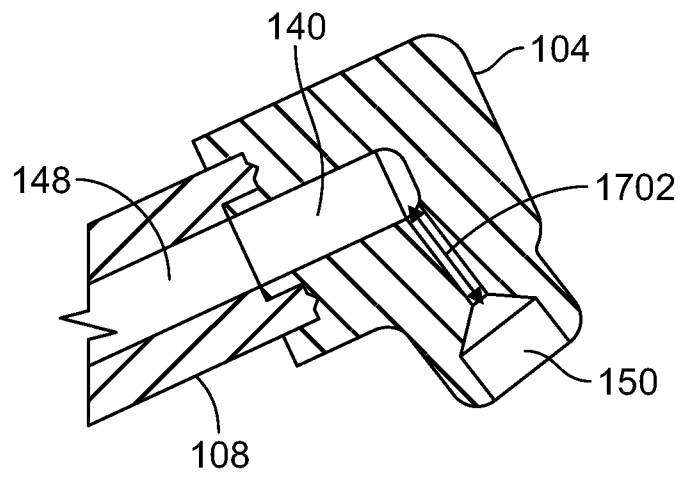


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/019865

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01P3/08 F01M1/08
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01P F01M

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/040520 A1 (BONTAZ CHRISTOPHE [FR] ET AL) 4 March 2004 (2004-03-04) paragraphs [0036], [0037], [0038], [0044], [0045], [0047], [0055] - [0058] -----	1-20
X	GB 1 309 983 A (TATRA NP) 14 March 1973 (1973-03-14) page 1, line 52 - line 88 -----	1-20
X	US 2 788 773 A (SIEGFRIED MEURER) 16 April 1957 (1957-04-16) figure 2 -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

17 April 2018

Date of mailing of the international search report

24/04/2018

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Coniglio, Carlo

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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