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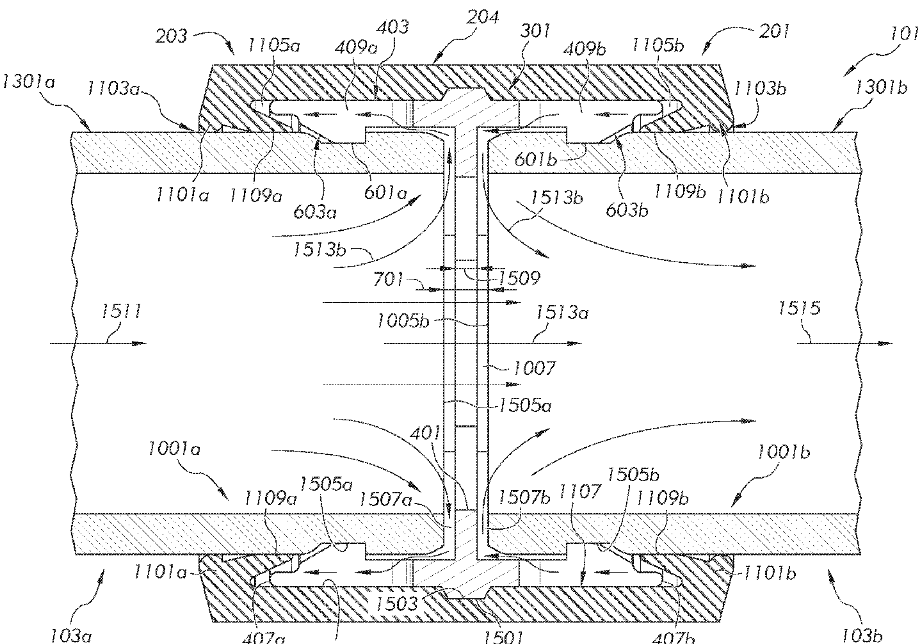

FIG. 15

(57) Abstract: Pipe apparatus can include a coupling device with a seal circumscribing a central axis. The seal further includes a first circumferential pocket at least partially defined by a first and second circumferential flange. A fluid guide device positioned at least partially within the first circumferential pocket includes a plurality of segments that are radially arranged to circumscribe the central axis. The fluid guide device at least partially defines a fluid path. Methods can include using the coupling device to couple a first end portion of a first pipe segment to a second end portion of a second pipe segment. Methods of using the pipe apparatus can include passing fluid through the fluid path to cool the seal.

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PIPE APPARATUS, COUPLING DEVICES, AND METHODS

FIELD

[0001] The present disclosure relates generally to pipe apparatus, coupling devices, and methods and, more particularly, to pipe apparatus, coupling devices and methods to provide for fluid cooled coupling devices.

BACKGROUND

[0002] In some environments, liquid delivery systems must be designed to withstand high temperature conditions while operating. For example, a fire sprinkling system is required to deliver liquid (e.g., water) to extremely hot areas in order to extinguish the fires. Such liquid delivery systems are typically fabricated from pipe segments that are joined together when installing the piping system.

[0003] It is known to provide metal coupling devices for joining metal pipe segments. Such metal coupling devices are inexpensive to install since they can be used to quickly mechanically join the pipe segments in an efficient, cost-effective manner. Furthermore, the mechanical coupling can be easily disassembled, thereby allowing subsequent replacement of a pipe segment, or other maintenance, without damaging the liquid delivery system. However, the rubber seals typically used to provide a liquid-tight connection between pipe segments may degrade and fail in a high temperature environment.

[0004] It is also known to use heat resistant polymeric pipe segments provide the liquid delivery system. For example, the polymeric pipe segments may comprise chlorinated polyvinyl chloride designed to operate during high temperature conditions. Mechanical couplings can be used to join the pipe segments. However, the polymeric pipe segments may soften too much to maintain the proper mechanical connection between pipe segments. The pipe segments can be permanently attached to one another, for example, with hot air welding, fusion welding, or a solvent cement process. However, such joining techniques are labor intensive and therefore an expensive option for joining the pipe segments. Furthermore, such joining techniques permanently join the pipe segments; therefore complicating subsequent maintenance or disassembly without damaging the liquid delivery system.

[0005] There is a desire for coupling devices that allows removable and fast coupling of segments while withstanding a high temperature operating environment.

SUMMARY

[0006] Aspects of the disclosure provide a pipe apparatus with pipe segments that can be quickly coupled and decoupled from one another with a mechanical coupling device. The mechanical coupling device is designed to allow the seal to survive high temperature operating conditions while coupling pipe segments comprising metal or other heat-resistant materials. The mechanical coupling device can comprise features that encourage a portion of liquid flowing through the pipe segments to travel within a fluid path that cools the seal in use. The fluid-cooled seal and/or other features of the disclosure help permit use of high-temperature resistant pipe segments (e.g., metal pipe segments) that can maintain structural integrity of the joint between the pipe segments while also allowing the seal to be maintained at an acceptable temperature in a high temperature environment that would otherwise damage the seal and cause failure of the fluid tight seal at the joint between the pipe segments.

[0007] Some example embodiments of the disclosure are described below with the understanding that any of the embodiments may be used alone or in combination with one another.

[0008] Embodiment 1. A pipe apparatus comprises a first pipe segment comprising a first end portion comprising a first outer circumferential edge and a second pipe segment comprising a second end portion comprising a second outer circumferential edge facing the first outer circumferential edge. The first outer circumferential edge is spaced from the second outer circumferential edge to define a circumferential gap between the first outer circumferential edge and the second outer circumferential edge. A seal circumscribes the circumferential gap. The seal comprises a first circumferential flange engaging the first end portion of the first pipe segment and a second circumferential flange engaging the second end portion of the second pipe segment. The pipe apparatus further comprises a first circumferential pocket defined between an interior surface of the seal, the first end portion, and the second end portion. A fluid guide device is positioned at least partially within the first circumferential pocket. The fluid guide device comprises a plurality of segments that are radially arranged to circumscribe the first end portion and the second end portion. The fluid guide device further comprises a first axial end positioned over the first end portion and a second axial end positioned over the second end portion. The fluid guide device at least partially defines a fluid path extending from the circumferential gap through an area defined between the fluid guide device and the interior surface of the seal.

[0009] Embodiment 2. The pipe apparatus of embodiment 1, wherein the fluid guide device comprises a circumferential guide flange extending at least partially into the circumferential gap between the first outer circumferential edge and the second outer circumferential edge. An axial width of the circumferential guide flange is less than an axial width of the circumferential gap.

[0010] Embodiment 3. The pipe apparatus of embodiment 2, wherein the circumferential guide flange is spaced from the first outer circumferential edge and the second outer circumferential edge.

[0011] Embodiment 4. The pipe apparatus of any one of embodiments 1-3, further comprising a first tongue and groove connection axially locking the fluid guide device to the first end portion and a second tongue and groove connection axially locking the fluid guide device to the second end portion.

[0012] Embodiment 5. The pipe apparatus of any one of embodiments 1-4, further comprising a third tongue and groove connection axially locking the seal to the fluid guide device.

[0013] Embodiment 6. The pipe apparatus of any one of embodiments 1-5, wherein an outer surface of the fluid guide device further comprises at least one blind channel extending from the first axial end to the second axial end, wherein the area comprises the blind channel.

[0014] Embodiment 7. The pipe apparatus of any one of embodiments 1-6, wherein the fluid guide device further comprises at least one first through channel extending from the first axial end toward the second axial end, wherein an axial length of the first through channel is less than an axial length of the fluid guide device.

[0015] Embodiment 8. The pipe apparatus of embodiment 7, wherein the axial length of the first through channel is less than or equal to half the axial length of the fluid guide device.

[0016] Embodiment 9. The pipe apparatus of any one of embodiments 7-8, wherein the fluid guide device further comprises at least one second through channel extending from the second axial end toward the first axial end, wherein an axial length of the second through channel is less than the axial length of the fluid guide device.

[0017] Embodiment 10. The pipe apparatus of embodiment 9, wherein the axial length of the second through channel is less than or equal to half the axial length of the fluid guide device.

[0018] Embodiment 11. The pipe apparatus of any one of embodiments 1-10, further comprising a housing comprising a second circumferential pocket, wherein the seal is positioned within the second circumferential pocket.

[0019] Embodiment 12. The pipe apparatus of embodiment 11, further comprising a heat shield at least partially circumscribing the housing, the heat shield spaced from the housing to define a chamber between the heat shield and the housing.

[0020] Embodiment 13. A method of using the pipe apparatus of embodiment 1 comprising passing an upstream quantity of fluid through an interior of the first pipe segment in a first axial direction of the first pipe segment. The method further comprises passing a first portion of the first upstream quantity of fluid through an interior of the second pipe segment in a second axial direction of the second pipe segment. The method further comprises cooling the seal by passing a second portion of the first upstream quantity of fluid through the area; and then passing the second portion of the first upstream quantity of fluid through the interior of the second pipe segment.

[0021] Embodiment 14. The method of embodiment 13, further comprising driving the second portion of the first upstream quantity of fluid through the area with a pressure drop.

[0022] Embodiment 15. A pipe apparatus comprises a first pipe segment comprising a first end portion comprising a first outer circumferential edge. The pipe apparatus further comprises a second pipe segment. The second pipe segment comprises a second end portion comprising a second outer circumferential edge facing the first outer circumferential edge. The first outer circumferential edge is spaced from the second outer circumferential edge to define a circumferential gap between the first outer circumferential edge and the second outer circumferential edge. A seal circumscribes the circumferential gap. The seal comprises a first circumferential flange engaging the first end portion of the first pipe segment and a second circumferential flange engaging the second end portion of the second pipe segment. The pipe apparatus further comprises a first circumferential pocket defined between an interior surface of the seal, the first end portion, and the second end portion. The pipe apparatus still further comprises a fluid guide device positioned at least partially within the first circumferential pocket. The fluid guide device comprises a circumferential guide flange extending at least partially into the circumferential gap between the first outer circumferential edge and the second outer circumferential edge. An axial width of the circumferential guide flange is less than an axial width of the circumferential gap. The circumferential guide flange is spaced from the first outer circumferential edge to define a fluid inlet port, and the circumferential guide flange is spaced from the second outer circumferential edge to define a fluid outlet port. The fluid guide device at least partially defines a fluid path extending from the fluid inlet port through an area defined between the fluid guide device and the interior surface of the seal, and from the area to the fluid outlet port.

[0023] Embodiment 16. A method of using the pipe apparatus of embodiment 15 comprises passing an upstream quantity of fluid through an interior of the first pipe segment in a first axial direction of the first pipe segment. The method further comprises passing a first portion of the first upstream quantity of fluid through an interior of the second pipe segment in a second axial direction of the second pipe segment. The method still further comprises passing a second portion of the first upstream quantity of fluid through the fluid inlet port, then through the area to cool the seal, and then through the fluid outlet port; and then passing the second portion of the first upstream quantity of fluid through the interior of the second pipe segment.

[0024] Embodiment 17. The method of embodiment 16, wherein the area comprises at least one blind channel of an outer surface of the fluid guide device and the passing the second portion of the first upstream quantity of fluid through the area comprises passing the second portion of the first upstream quantity of fluid through the blind channel from a first axial end of the fluid guide device to a second axial end of the fluid guide device.

[0025] Embodiment 18. The method of embodiment 17, wherein after the second portion of the first upstream quantity of fluid passes through the fluid inlet port and prior to passing through the blind channel, the second portion of the first upstream quantity of fluid then passes through at least one first through channel of the fluid guide device extending from the first axial end toward the second axial end. A length of the first through channel is less than an axial length of the fluid guide device.

[0026] Embodiment 19. The method of any one of embodiments 16-18, further comprising driving the second portion of the first upstream quantity of fluid through the area with a pressure drop between the fluid inlet port and the fluid outlet port.

[0027] Embodiment 20. A coupling device comprises a seal circumscribing a central axis of the coupling device. The seal comprises a first circumferential flange extending toward the central axis and a second circumferential flange extending toward the central axis. The seal further comprises a first circumferential pocket at least partially defined by an interior surface of the seal, the first circumferential flange, and the second circumferential flange. The coupling device further comprises a fluid guide device positioned at least partially within the first circumferential pocket. The fluid guide device comprises a plurality of segments that are radially arranged to circumscribe the central axis. The fluid guide device at least partially defines a fluid path extending through an area defined between the fluid guide device and the interior surface of the seal.

[0028] Embodiment 21. The coupling device of embodiment 20, wherein the seal biases the plurality of segments together in a constricted configuration.

[0029] Embodiment 22. The coupling device of any one of embodiments 20-21, wherein the fluid guide device comprises a circumferential guide flange extending toward the central axis and circumscribing the central axis.

[0030] Embodiment 23. The coupling device of any one of embodiments 20-22, further comprising a tongue and groove connection axially locking the seal to the fluid guide device.

[0031] Embodiment 24. The coupling device of any one of embodiments 20-23, wherein an outer surface of the fluid guide device further comprises at least one blind channel extending from a first axial end of the fluid guide device to a second axial end of the fluid guide device, wherein the area comprises the blind channel.

[0032] Embodiment 25. The coupling device of any one of embodiments 20-23, wherein the fluid guide device further comprises at least one first through channel extending from a first axial end of the fluid guide device toward a second axial end of the fluid guide device. An axial length of the first through channel is less than an axial length of the fluid guide device.

[0033] Embodiment 26. The coupling device of embodiment 25, wherein the axial length of the first through channel is less than or equal to half the axial length of the fluid guide device.

[0034] Embodiment 27. The coupling device of any one of embodiments 25-26, wherein the fluid guide device further comprises at least one second through channel extending from the second axial end toward the first axial end, wherein an axial length of the second through channel is less than the axial length of the fluid guide device.

[0035] Embodiment 28. The coupling device of embodiment 27, wherein the axial length of the second through channel is less than or equal to half the axial length of the fluid guide device.

[0036] Embodiment 29. The coupling device of any one of embodiments 25-28, wherein an outer surface of the fluid guide device further comprises at least one blind channel extending from the first axial end to the second axial end, wherein the area comprises the blind channel.

[0037] Embodiment 30. A method of assembling a pipe apparatus comprising the coupling device of claim 20 comprises inserting a first outer circumferential edge of a first end portion of a first pipe segment into a first axial opening of the seal. The first circumferential flange seals against an outer peripheral surface of the first end portion. The method further comprises axially locking the first end portion of the first pipe segment to the fluid guide device. The method further comprises inserting a second outer circumferential edge of a second end portion of a second pipe segment into a second axial opening of the seal. The second circumferential flange seals against an outer peripheral surface of the second end portion. The method still further comprises axially locking the second end portion of the second pipe segment to the fluid guide device. The first outer circumferential edge faces the second outer circumferential edge and a gap is maintained between the first outer circumferential edge and the second outer circumferential edge.

[0038] Embodiment 31. The method of embodiment 30, wherein a circumferential guide flange of the fluid guide device extends into the gap.

[0039] Embodiment 32. The method of embodiment 31, wherein the circumferential guide flange is spaced from the first outer circumferential edge and the second outer circumferential edge.

[0040] Embodiment 33. The method of any one of embodiments 30-32, wherein the axially locking the first end portion of the first pipe segment to the fluid guide device comprises engaging a tongue of one of the first end portion or the fluid guide device with a groove of another of the first end portion or the fluid guide device.

[0041] Embodiment 34. The method of embodiment 33, wherein the axially locking the second end portion of the first pipe segment to the fluid guide device comprises engaging a tongue of one of the second end portion or the fluid guide device with a groove of another of the first end portion or the fluid guide device.

[0042] Embodiment 35. The method of any one of embodiments 30-34, wherein the inserting the first outer circumferential edge of the first end portion of the first pipe segment into the first axial opening of the seal dilates a first corresponding axial end of the plurality of segments of the fluid guide device against a bias of the seal.

[0043] Embodiment 36. The method of embodiment 35, wherein the axially locking the first end portion to the fluid guide device comprises constricting the first corresponding axial end of the plurality of segments of the fluid guide device.

[0044] Embodiment 37. The method of any one of embodiments 30-36, wherein the inserting the second outer circumferential edge of the second end portion of the second pipe segment into the second axial opening of the seal dilates a corresponding second axial end of the plurality of segments of the fluid guide device against a bias of the seal.

[0045] Embodiment 38. The method of embodiment 37, wherein the axially locking the second end portion to the fluid guide device comprises constricting the corresponding second axial end of the plurality of segments of the fluid guide device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] These and other embodiments are better understood when the following detailed description is read with reference to the accompanying drawings, in which:

[0047] **FIG. 1** illustrates an upper perspective view of a pipe apparatus in accordance with aspects of the disclosure;

[0048] **FIG. 2** illustrates a further upper perspective view of a pipe apparatus in accordance with aspects of the disclosure;

[0049] **FIG. 3** illustrates an exploded view of the pipe apparatus of **FIG. 2**;

[0050] **FIG. 4** illustrates an upper perspective view of a segment of a fluid guide device illustrated in **FIG. 3**;

[0051] **FIG. 5** illustrates a side view of the segment of the fluid guide device of **FIG. 4**;

[0052] **FIG. 6** illustrates a lower perspective view of the segment of the fluid guide device illustrated in **FIG. 4**;

[0053] **FIGS. 7-8** illustrates steps in a first method of assembling the pipe apparatus of **FIG. 2**;

[0054] **FIG. 9** is a cross-section of the pipe apparatus along line 9-9 of **FIG. 8**;

[0055] **FIG. 10** is a cross-section of the pipe apparatus along line 10-10 of **FIG. 2**;

[0056] **FIGS. 11-13** illustrate steps in a second method of assembling the pipe apparatus of **FIG. 2**;

[0057] **FIG. 14** is a cross-section of the pipe apparatus along line 14-14 of **FIG. 10**;

[0058] **FIG. 15** is an enlarged view of **FIG. 10**, taken at view 15 of **FIG. 10** but with the section taken through the through channels of the segments of the fluid guide device, wherein the pipe apparatus is being used to cool the seal;

[0059] **FIG. 16** is an enlarged view of **FIG. 8**, taken at view 16 of **FIG. 8**, that illustrates the pipe apparatus being used to cool the seal, wherein the seal in the position shown in **FIG. 15** is illustrated schematically with broken lines for clarity;

[0060] **FIGS. 17-19** illustrate steps in assembling an insulating device with the pipe apparatus shown in **FIG. 2** to provide the pipe apparatus shown in **FIG. 1**; and

[0061] **FIG. 20** is a cross-section of the pipe apparatus along line 20-20 of **FIG. 1**.

DETAILED DESCRIPTION

[0062] Embodiments will now be described more fully hereinafter with reference to the accompanying drawings in which example embodiments are shown. Whenever possible, the same reference numerals are used throughout the drawings to refer to the same or like parts. However, this disclosure may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

[0063] **FIG. 1** illustrates embodiments of a pipe apparatus **101** comprising a first pipe segment **103a** and a second pipe segment **103b** and an insulating device **105** described more fully below. **FIG. 2** shows the pipe apparatus **101** without the insulating device **105** for clarity and also demonstrates embodiments of the pipe apparatus **101** that do not include the insulating device **105**. As shown in **FIG. 2**, the pipe apparatus **101** can further comprise a coupling device **201** including a seal **203** circumscribing a central axis **205** of the coupling device **201** and end portions of the pipe segments **103a, 103b**. In some embodiments, the pipe apparatus **101** can be considered the coupling device **201** alone or in combination with the portions of the pipe segments **103a, 103b**.

[0064] **FIG. 10** is a cross section of **FIG. 2** and shows the first pipe segment **103a** comprising a first end portion **1001a** and the second pipe segment **103b** comprising a second end portion **1001b**. As shown in **FIGS. 7 and 10**, the first end portion **1001a** of the first pipe segment **103a** comprises a first outer circumferential edge **1005a** and the second end portion **1001b** of the second pipe segment **103b** comprises a second outer circumferential edge **1005b**. The outer circumferential edges **1005a, 1005b** can comprise blunted edges that are rounded, tapered or flat. For example, both outer circumferential edges **1005a, 1005b** can comprise substantially flat surfaces (e.g., see **1005a** in **FIG. 3**). As shown in **FIG. 7**, the second outer circumferential edge **1005b** can face the first outer circumferential edge **1005a**. Furthermore, the first outer circumferential edge **1005a** can be spaced from the second outer circumferential edge **1005b** to define a circumferential gap **1007** between the first outer circumferential edge **1005a** and the second outer circumferential edge **1005b**. As shown in **FIG. 7**, the circumferential gap **1007** can comprise a gap width **701**. In some embodiments, the gap width **701** can be substantially constant about the pipe circumference with the outer circumferential edges **1005a, 1005b** extending parallel with one another. Providing the outer circumferential edges **1005a, 1005b** as substantially flat and parallel edges can allow the gap width **701** to be substantially constant across at least a portion of the thickness of the pipe wall and radially about the central axis **205**. Providing a substantially constant gap width **701** can allow uniform fluid flow through the gap width **701** when cooling the seal **203**.

[0065] As shown, the pipe segments **103a, 103b** can comprise circular cylindrical pipe segments although the pipe segments can comprise elliptical, polygonal, or other shaped cylindrical pipe segments in further embodiments. Furthermore, only a small portion of the pipe segments **103a, 103b** are illustrated for clarity. In some embodiments, one or both of the pipe segments can comprise a substantially straight segment traveling from one junction to the next junction. In further embodiments, one or both of pipe segments may comprise a portion of a fitting such as a tee, elbow, cross, reducer, cap, valve, adaptor, or other type of fitting. The pipe segments **103a, 103b** can comprise a wide range of materials that can maintain structural integrity under temperatures up to 850°C such as metal (e.g., steel, brass) or temperatures up to 150°C (e.g., chlorinated polyvinyl chloride).

[0066] Referring to **FIGS. 10-11**, the coupling device **201** can comprise the seal **203** circumscribing the central axis **205** of the coupling device **201**. The seal **203** can comprise a first circumferential flange **1101a** and a second circumferential flange **1101b** that each extend toward the central axis **205** and circumscribe the central axis **205**. As shown in **FIG. 11**, the first circumferential flange **1101a** and the second circumferential flange **1101b** can define a first axial opening **1103a** into the coupling device **201** and a second axial opening **1103b** into the coupling device **201**, respectively. The seal **203** can further comprise a first circumferential pocket **1105** at least partially defined by the first circumferential flange **1101a** and the second circumferential flange **1101b**. For example, the first circumferential pocket **1105** can be at least partially defined by an interior concave surface **1107** of the seal **203**, a first circumferential lip **1109a** of the first circumferential flange **1101a** that extends toward the second axial opening **1103b** of the seal **203** and a second circumferential lip **1109b** of the second circumferential flange **1101b** that extends toward the first axial opening **1103a** of the seal **203**. The seal **203** can comprise a wide range of materials. For example, the seal **203** can comprise a flexible elastomeric material that can conform to the shape of the outer surface of the pipe segments for a fluid tight fit. In some embodiments, the seal **203** can comprise EPDM rubber although other types of materials may be provided in further embodiments.

[0067] As shown in **FIG. 3**, the coupling device **201** can further comprise a fluid guide device **301**. As shown in **FIGS. 3 and 14**, the fluid guide device can comprise a plurality of segments **301a-f** that are radially arranged to circumscribe the central axis **205**. The illustrated plurality of segments **301a-f** comprises six segments that are radially arranged about the central axis **205** with the understanding that any number of two or more segments can be provided that are less than or greater than the illustrated six segments. In some embodiments, as shown, each segment of the plurality of segments **301a-f** can be identical to one another although different configurations may be provided in further embodiments.

[0068] A first segment **301a** of the plurality of segments **301a-f** is illustrated in **FIGS. 4-6** with the understanding that the description of the first segment **301a** can apply to the other segments **301b-f** that can each be identical to the first segment **301a**. As shown in **FIGS. 4-6**, the segments can each comprise an arcuate wall **501** with an inner concave surface **503** that can extend with a substantially constant radius "**R**" from the central axis **205** when installed as shown in **FIG. 14**. The segments further comprise a segment axis that is coincident with the central axis **205** when installed as shown in **FIG. 14**. As shown in **FIGS. 14-15**, a portion of inner concave surface **503** with the substantially constant radius "**R**" can extend closely along an outer peripheral surface **1301b** of the second end portion **1001b** of the second pipe segment **103b** and another portion of the inner concave surface **503** with the substantially constant radius "**R**" can extend closely along an outer peripheral surface **1301a** of the first end portion **1001a** of the first pipe segment **103a**.

[0069] As shown in **FIGS. 4-6**, the guide segments can each comprise a circumferential guide flange **401**. As shown in **FIGS. 3 and 14**, each circumferential guide flange **401** of each of the plurality of segments **301a-f** can extend toward the central axis **205** and cooperated to circumscribe the central axis **205**. As further illustrated, an outer convex surface **403** of the fluid guide device **301** can comprise at least one blind channel **405**. As shown in **FIGS. 4-5**, the outer convex surface **403** can face opposite the inner concave surface **503** of the arcuate wall **501**. In some embodiments, the outer convex surface **403** can be geometrically similar to the inner concave surface **503** such that at least a portion of the arcuate wall **501** can comprise a continuous wall thickness between the outer convex surface **403** and the inner concave surface **503**.

[0070] The fluid guide device **301** can comprise at least one blind channel. For example, as shown in **FIGS. 4-5**, the outer convex surface **403** of the arcuate wall **501** of the first segment **301a** can comprise at least one blind channel **405** extending along the segment axis from a first axial end **407a** of the first segment **301a** of the fluid guide device **301** to a second axial end **407b** of the first segment **301a** of the fluid guide device **301**. Although two blind channels **405** are illustrated per segment, in further embodiments one or more than two blind channels may be provided per segment in further embodiments. For purposes of this disclosure, a blind channel of the outer convex surface **403** of the arcuate wall **501** means a channel that does not extend through the entire thickness of the arcuate wall **501** between the inner concave surface **503** and the outer convex surface **403** of the arcuate wall **501**. In some embodiments, as shown in **FIG. 16**, the blind channels **405** can comprise linear blind channels that extend parallel relative to the central axis **205**. In further embodiments, although not shown, serpentine blind channels **405** in the shape of a sine wave or other non-linear and/or linear blind channel patterns can be incorporated in further embodiments. Providing the illustrated single pass linear blind channels can reduce flow resistance that can increase convective heat transfer from the seal **203** in some embodiments due to an increased flow rate of the fluid traveling in the blind channels. Providing serpentine or other non-linear and/or linear blind channel patterns can increase the length of time the fluid is in contact with the seal, thereby giving the fluid more time to conduct heat from the seal resulting in greater heat transfer per volume of fluid traveling through the blind channel as described more fully below.

[0071] The fluid guide device **301** can further comprise at least one through channel extending from one axial end of the fluid guide device **301** toward the other axial end of the fluid guide device **301**. For purposes of this disclosure, a through channel means a channel that extends through the entire thickness of the arcuate wall **501** between the inner concave surface **503** and the outer convex surface **403** of the arcuate wall **501**. For example, as shown in **FIGS. 4-6**, the first segment **301a** can comprise a first through channel **409a** extending from the first axial end **407a** of the first segment **301a** toward the second axial end **407b** of the first segment **301a**. As further shown in **FIGS. 4-6**, the first segment **301a** can comprise a second through channel **409b** extending from the second axial end **407b** of the first segment **301a** toward the first axial end **407a** of the first segment **301a**. As shown in **FIG. 16**, the axial length "**L2**" of the first through channel **409a** and/or the axial length "**L2**" of the second through channel **409b** can be less than the axial length "**L1**" of the fluid guide device **301**, such as less than or equal to half the axial length "**L1**" of the fluid guide device. As shown, the through channels **409a, 409b** can comprise linear through channels that run parallel relative to the central axis **205** although other nonlinear shapes or patterns may be provided in further embodiments. Furthermore, as shown, each segment **301a-f** includes a single first through channel **409a** and a single second through channel **409b**. Although not shown, in further embodiments, the at least one first through channel can comprise a plurality of first through channels and/or the at least one second through channel can comprise a plurality of second through channels.

[0072] As shown in **FIG. 11**, the fluid guide device **301** can be mounted within the seal **203**. For example, as shown in **FIG. 11**, the plurality of segments **301a-f** can be positioned at least partially within the first circumferential pocket **1105**. In some embodiments, the pipe apparatus **101** can be considered as the coupling device **201** without the pipe segments **103a, 103b**. Indeed, as shown in **FIG. 11**, the coupling device **201** can be assembled without the pipe segments **103a, 103b** wherein the coupling device (comprising the segments **301a-f** mounted within the seal **203**) can be sold separately or otherwise provided for subsequent coupling with pipe segments. The seal **203** can include features that help secure the pipe segments **103a, 103b** in place even when not connected to the pipe segments. For example, as shown in **FIG. 15**, once the plurality of segments **301a-f** are positioned at least partially within the first circumferential pocket **1105**, the first axial end **407a** of each of the segments **301a-f** can be positioned within a first inwardly facing end pocket defined between the first circumferential lip **1109a** and the interior concave surface **1107**. Likewise, the second axial end **407b** of each of the segments **301a-f** can be positioned within a second inwardly facing end pocket defined between the second circumferential lip **1109b** and the interior concave surface **1107**. Once placed, each of the segments **301a-f** are trapped in the illustrated seated position within the first circumferential pocket **1105** by way of the first and second inwardly facing end pockets. Furthermore, the coupling device **201** can comprise a tongue and groove connection axially locking the seal **203** to the fluid guide device **301**. For purposes of this application, axially locking means connecting such that a relative movement between parts in a direction of the central axis **205** of the coupling device **201** is inhibited, such as prevented. For example, as shown in **FIG. 15**, the coupling device can comprise the illustrated tongue and groove connection where a tongue **1501** of each of the segments **301a-f** is seated within a groove **1503** within the interior concave surface **1107** of the seal **203**. The tongue **1501** seated within the groove **1503** can axially lock the seal **203** to the fluid guide device **301** since relative movement between the seal **203** and fluid guide device **301** in a direction of the central axis **205** of the coupling device **201** is inhibited, such as prevented, by the tongue and groove connection. Although not shown, in further embodiments, the tongue and groove connection can include a tongue defined by the interior surface of the seal that is seated within a groove defined by each of the segments.

[0073] In some embodiments, the seal **203** can bias the plurality of segments **301a-f** together in a constricted configuration. For example, as shown in **FIG. 15**, the interior concave surface **1107** of the seal **203** can snuggly engage the outer convex surface **403** of the segments **301a-f** such that the segments are held together with corresponding side edges of adjacent pairs of the segments **301a-f** engaging one another. Although not shown, in some embodiments, the side edges of the adjacent pairs of segments **301a-f** may be keyed into one another to facilitate proper alignment. For example, a tongue of one side edge of one segment may fit into a groove of an adjacent side edge of an adjacent segment to facilitate alignment while the seal **203** biases the segments together. In some embodiments, although not required, the seal **203** can be stretched over the plurality of segments **301a-f** to radially constrict the segments together in a radially constricted orientation and force the side edges of the adjacent pairs of segments together while tension in the seal **203** facilitates maintenance of the segments in the radially constricted orientation.

[0074] Once the assembled, the circumferential guide flanges **401** of the segments **301a-f** of the fluid guide device **301** can extend towards the central axis **205** and cooperate to circumscribe the central axis **205**. In some embodiments, as shown, adjacent sides adjacent pairs of circumferential guide flanges **401** can abut one another in the constricted orientation to provide of the circumferential guide flanges **401** as a substantially continuous guide flange encircling the central axis **205**.

[0075] As discussed below and illustrated by the fluid flow arrows shown in **FIGS. 15-16**, the fluid guide device **301** at least partially defines a fluid path extending through an area defined between the fluid guide device **301** and the interior concave surface **1107** of the seal **203**. As shown in **FIG. 14**, the area can comprise the blind channels **405** that are capped by the interior concave surface **1107** of the seal **203** to define the fluid paths referenced by the arrows shown passing through the blind channels **405** in **FIG. 16**. As shown in **FIG. 16**, the blind channels **405** extend from the first axial end **407a** to the second axial end **407b** such that the fluid path can pass through the entire axial length "**L1**" and through the first and second axial ends **407a, 407b**.

[0076] **FIG. 15** illustrates the pipe apparatus **101** where the coupling device **201** couples the first end portion **1001a** of the first pipe segment **103a** to the second end portion **1001b** of the second pipe segment **103b**. Axial locking is achieved by axially locking the first end portion **1001a** of the first pipe segment **103a** to the fluid guide device **301** and axially locking the second end portion **1001b** of the second pipe segment **103b** to the fluid guide device **301**. In some embodiments, axially locking can be achieved by tongue and groove connections where a first tongue and groove connection axially locks the first end portion **1001a** to the fluid guide device **301** and a second tongue and groove connection axially locks the second end portion **1001b** to the fluid guide device **301**.

[0077] Each tongue and groove connection can comprise a tongue of one of the end portion of the pipe segment and the fluid guide device engaging a groove of another of the end portion of the pipe segment and the fluid guide device. In some embodiments, the fluid guide device comprises a groove configured to receive and engage a tongue of the end portion of the pipe segment. Alternatively, as shown **FIG. 6**, each segment **301a-f** can be provided with a first tongue **601a** and a second tongue **601b**. Each first and second tongue **601a, 601b** can comprise a ramped face **603a, 603b**. The first ramped face **603a** can ramp inwardly toward the central axis **205** in a direction from the first axial opening **1103a** toward the second axial opening **1103b**. The second ramped face **603b** can ramp inwardly toward the central axis **205** in a direction from the second axial opening **1103b** toward the first axial opening **1103a**. As shown in **FIG. 15**, the first tongue **601a** of each segment **301a-f** can be engaged with a first groove **1505a** of the first end portion **1001a** of the first pipe segment **103a** to axially lock the first pipe segment **103a** to the coupling device **201**. Likewise, the second tongue **601b** of each segment **301a-f** can be engaged with a second groove **1505b** of the second end portion **1001b** of the second pipe segment **103b** to axially lock the second pipe segment **103b** to the coupling device **201**.

[0078] A method of assembling a pipe apparatus **101** comprising the coupling device **201** described above will now be discussed with reference to **FIGS. 11-13**. As shown in **FIG. 11**, the first pipe segment **103a** can be aligned with the first axial opening **1103a**. As shown in **FIG. 12**, the first outer circumferential edge **1005a** of the first end portion **1001a** of the first pipe segment **103a** can be inserted into the first axial opening **1103a** of the seal **203** in the first inward axial direction **1201a**. The step of inserting the first outer circumferential edge **1005a** through into the first axial opening **1103a** results in the first circumferential flange **1101a** sealing against an outer peripheral surface **1301a** of the first end portion **1001a**. The method further comprises axially locking the first end portion **1001a** of the first pipe segment **103a** to the fluid guide device **301**. For example, as shown in **FIG. 12**, an outer portion **1102a** of the first outer circumferential edge **1005a** (e.g., the illustrated chamfered portion) may engage the ramped face **603a** of the first tongue **601a** wherein further inserting of the first outer circumferential edge **1005a** of the first end portion **1001a** of the first pipe segment **103a** into the first axial opening **1103a** of the seal **203** dilates a first corresponding axial end of the plurality of segments **301a-f** of the fluid guide device **301** against a bias of the seal **203**. Upon full insertion, as shown in **FIG. 13**, the first tongue **601a** drops into the first groove **1505a** by the seal **203** constricting the first corresponding axial end of the plurality of segments **301a-f** of the fluid guide device **301** to axially lock the first end portion **1001a** of the first pipe segment **103a** to the fluid guide device **301**. Once axially locked, the seal **203** can bias the first tongues **601a** to remain in the first groove **1505a** to maintain the axially locked connection. Once axially locked, as shown in **FIG. 15**, a first gap **1507a** is maintained between the first outer circumferential edge **1005a** and the circumferential guide flanges **401**.

[0079] As shown in **FIG. 12**, the second pipe segment **103b** can be aligned with the second axial opening **1103b**. As shown in **FIG. 13**, the second outer circumferential edge **1005b** of the second end portion **1001b** of the second pipe segment **103b** can be inserted into the second axial opening **1103b** of the seal **203** in the second inward axial direction **1201b**. The step of inserting the second outer circumferential edge **1005b** through into the second axial opening **1103b** results in the second circumferential flange **1101b** sealing against an outer peripheral surface **1301b** of the second end portion **1001b** as shown in **FIG. 15**. The method further comprises axially locking the second end portion **1001b** of the second pipe segment **103b** to the fluid guide device **301**. For example, as shown in **FIG. 13**, an outer portion **1102b** of the second outer circumferential edge **1005b** (e.g., the illustrated chamfered portion) may engage the ramped face **603b** of the second tongue **601b** wherein further inserting of the second outer circumferential edge **1005b** of the second end portion **1001b** of the second pipe segment **103b** into the second axial opening **1103b** of the seal **203** dilates a second corresponding axial end of the plurality of segments **301a-f** of the fluid guide device **301** against a bias of the seal **203**. Upon full insertion, as shown in **FIG. 15**, the second tongue **601b** drops into the second groove **1505b** by the seal **203** constricting the second corresponding axial end of the plurality of segments **301a-f** of the fluid guide device **301** to axially lock the second end portion **1001b** of the second pipe segment **103b** to the fluid guide device **301**. Once axially locked, the seal **203** can bias the second tongues **601b** to remain in the second groove **1505b** to maintain the axially locked connection. Once axially locked, as shown in **FIG. 15**, a second gap **1507b** is maintained between the second outer circumferential edge **1005b** and the circumferential guide flanges **401**.

[0080] Thus, once the first and second end portions **1001a, 1001b** are axially locked relative to one another by the coupling device, the circumferential gap **1007** can be maintained between the first outer circumferential edge **1005a** and the second outer circumferential edge **1005b**. Furthermore, the circumferential guide flanges **401** of the segments **301a-f** of the fluid guide device **301** can extend into the circumferential gap **1007**.

In some embodiments, the circumferential guide flanges **401** can extend over a part or the entire first and second outer circumferential edges **1005a, 1005b**. In the illustrated embodiment, the circumferential guide flanges **401** extend over the entire first and second outer circumferential edges **1005a, 1005b** and over the outer circumferential edges such that the tips of the circumferential guide flanges **401** extend within the footprint of the inner diameter of the pipe segments as shown in **FIG. 14**.

[0081] FIGS. 7-10 illustrate another method of assembling a pipe apparatus **101**. As shown in **FIG.** 7, the first outer circumferential edge **1005a** of the first pipe segment **103a** can be inserted through the interior of the seal **203**. Once fully inserted, the first circumferential flange **1101a** and the second circumferential flange **1101b** seal against the outer peripheral surface **1301a** of the first pipe segment **103a** to define the first circumferential pocket **1105** (see **FIG. 9**) between the interior concave surface **1107** and the outer peripheral surface **1301a** of the first pipe segment **103a**. Then the first and second pipe segments **103a, 103b** can be coaxially aligned with the first outer circumferential edge **1005a** of the first pipe segment **103a** being spaced from the second outer circumferential edge **1005b** of the second pipe segment **103b** to form the circumferential gap **1007** with the gap width **701**.

[0082] As shown in **FIG. 8**, the segments **301a-f** of the fluid guide device **301** can be radially arranged around the first end portion **1001a** of the first pipe segment **103a** and the second end portion **1001b** of the second pipe segment **103b**. Once radially positioned, as shown in **FIG. 9**, the first tongue **601a** of each of the segments **301a-f** are received in the first groove **1505a** of the first end portion **1001a** of the first pipe segment **103a**. Likewise, once radially positioned, as shown in **FIG. 9**, the second tongue **601b** of each of the segments **301a-f** are received in the second groove **1505b** of the second end portion **1001b** of the second pipe segment **103b**. As shown in **FIG. 10**, the seal **203** can then be moved relative to the fluid guide device **301** in the direction of arrow **901** until the fluid guide device **301** is seated within the first circumferential pocket **1105**. Once in place, as shown in **FIG. 10**, the seal **203** can bias the segments **301a-f** into the illustrated constricted orientation wherein the first and second pipe segments **103a, 103b** are locked relative to one another by way of the coupling device **201**.

[0083] Once the pipe apparatus **101** is assembled (e.g., by the method illustrated in **FIGS. 7-10** or the method illustrated in **FIGS. 11-13**), the seal **203** can circumscribe the circumferential gap **1007** (see **FIG. 10**). As further illustrated in **FIG. 15**, the first circumferential flange **1101a** can engage and seal against the outer peripheral surface **1301a**

of the first end portion **1001a** of the first pipe segment **103a**. Furthermore, the second circumferential flange **1101b** can engage and seal against the outer peripheral surface **1301b** of the second end portion **1001b** of the second pipe segment **103b**. The first circumferential pocket **1105** can be defined between the interior concave surface **1107** of the seal **203**, the outer peripheral surface **1301a** of the first end portion **1001a** of the first pipe segment **103a** and the outer peripheral surface **1301b** of the second end portion **1001b** of the second pipe segment **103b**. The fluid guide device **301** can be positioned at least partially within the first circumferential pocket **1105** with the plurality of segments **301a-f** radially arranged to circumscribe the first end portion **1001a** of the first pipe segment **103a** and the second end portion **1001b** of the second pipe segment **103b**. The fluid guide device **301** can further comprise a first axial end positioned over the first end portion **1001a** and a second axial end positioned over the second end portion **1001b** wherein the fluid guide device **301** at least partially defines a fluid path extending from the circumferential gap **1007** through the area (e.g., the blind channels **405**) defined between the fluid guide device **301** and the interior concave surface **1107** of the seal **203**.

[0084] Furthermore, once the pipe apparatus **101** is assembled, the circumferential guide flanges **401** of the fluid guide device **301** can each extend at least partially into the circumferential gap **1007** between the first outer circumferential edge **1005a** and the second outer circumferential edge **1005b**, wherein an axial width **1509** (see **FIG. 15**) of the circumferential guide flange **401** is less than the axial gap width **701** of the circumferential gap **1007**. The differences in width can provide that the circumferential guide flange **401** is spaced from the first outer circumferential edge **1005a** to define the first gap **1507a** therebetween. Furthermore, the differences in width can provide that the circumferential guide flange **401** is spaced from the second outer circumferential edge **1005b** to define the second gap **1507b** therebetween. Maintenance of the first and second gaps **1507a, 1507b** can be provided by the first tongue and groove connection (e.g., **601a, 1505a**) axially locking the fluid guide device **301** to the first end portion **1001a** and the second tongue and groove connection (e.g., **601b, 1505b**) axially locking the fluid guide device **301** to the second end portion **1001b**.

[0085] Methods of using the pipe apparatus is illustrated in **FIGS. 15-16**. The methods can comprise passing an upstream quantity of fluid **1511** through an interior of the first pipe segment **103a** in a first axial direction of the first pipe segment **103a**. The method can further comprise passing a first portion **1513a** of the first upstream quantity of fluid **1511**

through an interior of the second pipe segment **103b** in a second axial direction of the second pipe segment **103b**.

[0086] The methods can further comprise cooling the seal **203** by passing a second portion **1513b** of the first upstream quantity of fluid **1511** through the area defined between the fluid guide device **301** and the interior concave surface **1107** of the seal **203**. For example, the first gap **1507a** can define a fluid inlet port of a fluid path extending from the fluid inlet port to the first through channel **409a** of the fluid guide device **301**. The second portion **1513b** of the first upstream quantity of fluid **1511** can pass through the fluid inlet port and into the first through channel **409a**. The second portion **1513b** of the first upstream quantity of fluid **1511** can then pass through the first axial end **407a** of the fluid guide device and into a first end portion **1105a** of the first circumferential pocket **1105**. As shown in **FIG. 16**, the second portion **1513b** of the first upstream quantity of fluid **1511** can then be redirected from the first end portion **1105a** of the first circumferential pocket **1105** to pass into the blind channel **405** from the first axial end **407a** to the second axial end **407b** wherein heat is transferred by convection from the seal **203** to the second portion **1513b** of the first upstream quantity of fluid **1511**. The fluid then exits the blind channel **405** into a second end portion **1105b** of the first circumferential pocket **1105**. The second portion **1513b** of the first upstream quantity of fluid **1511** is then redirected to pass back through the second through channel **409b** and out the second gap **1507b** acting as the fluid outlet port. After passing through the fluid outlet port, the second portion **1513b** of the first upstream quantity of fluid **1511** is combined with the first portion **1513a** of the first upstream quantity of fluid **1511** into a second downstream quantity of fluid **1515** that passes through the interior of the second pipe segment **103b** in the axial direction of the second pipe segment **103b**.

[0087] Thus, the coupling device **201** can comprise a mechanical coupling that can quickly attach the end portions of pipe segments. The structural integrity of the seal can be maintained in high temperature environments since a portion of the fluid traveling through the pipe segments can be redirected to cool the seal that may otherwise degrade and fail under excessively high temperature conditions. In some embodiments, the second portion **1513b** of the first upstream quantity of fluid **1511** can be driven through the area (e.g., the blind channels **405**) with a pressure drop. For instance, a pressure drop can be provided between the fluid inlet port and the fluid outlet port to drive the second portion **1513b** of the first upstream quantity of fluid **1511** through the area.

[0088] The circumferential guide flange **401** can help redirect the portion of the fluid traveling through the pipe segments to achieve the desired convective fluid flow through the area between the seal **203** and the fluid guide device **301**. In some embodiments, the area between the seal **203** and the fluid guide device **301** can comprise the blind channel **405** capped by the interior concave surface **1107** of the seal **203**. Furthermore, as shown in **FIG. 14**, in some embodiments, the tips of the circumferential guide flanges **401** can extend within the footprint of the inner diameter of the pipe segments. Such extension of the circumferential guide flanges **401** into the footprint of the inner diameter can help generate a pressure drop between the fluid inlet port and the fluid outlet port that can help drive the second portion **1513b** of the first upstream quantity of fluid **1511** to provide a convective flow of fluid through the blind channels **405** to transfer heat from the seal **203** to the fluid flowing through blind channels **405**.

[0089] **FIGS. 17** illustrates another embodiment of a pipe apparatus **101** that may comprise a protective shroud **1701**. In some embodiments, the pipe apparatus **101** can comprise only the protective shroud **1701**. In further embodiments, the pipe apparatus **101** can comprise the protective shroud **1701** in combination with the coupling device **201** attaching the first pipe segment **103a** and the second pipe segment **103b** together as shown in **FIG. 1**.

[0090] The protective shroud **1701** can further help insulate the seal **203** to reduce heat transfer to the seal **203** from the surrounding environment. For instance, the protective shroud **1701** can comprise housing **1703** with a first housing half **1705a** defining a first cavity **1707a** and a second housing half **1705b** comprising a second cavity **1707b**. The first housing half **1705a** can comprise a first reception area **1709a** and a second reception area **1709b** that are axially aligned with the first cavity **1707a** positioned therebetween. The second housing half **1705b** can comprise a third reception area **1709c** and a fourth reception area **1709d**. In some embodiments, the reception areas **1709a-d** can comprise a shape that follows the outer peripheral surfaces **1301a, 1301b** of the pipe segments **103a, 103b**. For example, as illustrated the reception areas **1709a-d** can each comprise a semicircular concave portion. Furthermore, the first cavity **1707a** of the first housing half **1705a** and the second cavity **1707b** of the second housing half **1705b** can also comprise a shape (e.g., semicircular concave portion) that follows the outer peripheral surface **204** of the seal **203**. The housing halves can be pivotably connected at hinge **1711** such that the second housing half **1705b** may pivot relative to the first housing half **1705a** about a shroud axis **1713**. The housing can be fabricated from a wide range of materials such as steel or other metal. In further embodiments, the housing can be fabricated from an insulative material such as a high-temperature plastic or ceramic that can withstand the heat from the surrounding environment while including insulative properties that help resist heat conducting through the housing wall.

[0091] In some embodiments, the protective shroud **1701** can further include a heat shield **1715**. The heat shield **1715** can comprise a first portion **1717a** mounted to the first housing half **1705a** by stand-off pegs **1719** such that the first portion **1717a** surrounds an outer surface area of the first housing half **1705a** while being spaced from the outer surface area of the first housing half **1705a**. Likewise, the heat shield **1715** can comprise a second portion **1717b** mounted to the second housing half **1705b** by stand-off pegs **1719** such that the second portion **1717b** surrounds an outer surface area of the second housing half **1705b** while being spaced from the outer surface area of the second housing half **1705b**. The first portion **1717a** of the heat shield **715** can comprise a fifth reception area **1721a** and a sixth reception area **1721b** that are axially aligned and the second portion **1717b** of the heat shield **715** can comprise a seventh reception area **1721c** and an eighth reception area **1721d** that are axially aligned. In some embodiments, the reception areas **1721a-d** can comprise a shape that follows the outer peripheral surfaces **1301a, 1301b** of the pipe segments **103a, 103b**. For example, as illustrated the reception areas **1721a-d** can each comprise a semicircular concave portion.

[0092] Methods of mounting the coupling device **201** within the protective shroud **1701** is illustrated with respect to **FIGS. 18-20**. As shown in **FIG. 18**, the coupling device **201** can be positioned within the first cavity **1707a** of the first housing half **1705a**. As shown, the interior surface of the first cavity **1707a** can closely follow and contact the outer peripheral surface **204** of the seal **203**, the inner surface defining the first reception area **1709a** can closely follow and contact the outer peripheral surface **1301a** of the first pipe segment **103a**, and the inner surface defining the second reception area **1709b** can closely follow and contact the outer peripheral surface **1301b** of the second pipe segment **103b**. Furthermore, the inner surface defining the fifth reception area **1721a** can closely follow and contact the outer peripheral surface **1301a** of the first pipe segment **103a**, and the inner surface defining the sixth reception area **1721b** can closely follow and contact the outer peripheral surface **1301b** of the second pipe segment **103b**.

[0093] As shown in **FIG. 18**, the second housing half **1705b** together with the attached second portion **1717b** of the heat shield **1715** can be pivoted about the shroud axis **1713** in the direction **1801** from the open orientation (see **FIG. 18**) to the closed orientation (see **FIG. 19**). A pivot bolt **1803** can then be pivoted down to lock the first and second housing halves **1705a, 1705b** in the closed orientation shown in **FIGS. 19-20**. Once locked, the access panel **1901** can be pivoted from the open orientation shown in **FIG. 20** to the closed orientation shown in **FIG. 1**. Pivoting the access panel **1901** can close the access opening used when pivoting the pivot bolt **1803** and locking the first and second housing halves **1705a, 1705b** in the closed orientation. Once the first and second housing halves **1705a, 1705b** are locked in the closed orientation, the coupling device **201** can be positioned within the second cavity **1707b** of the second housing half **1705b**. The interior surface of the second cavity **1707b** can closely follow and contact the outer peripheral surface **204** of the seal **203**, the inner surface defining the third reception area **1709c** can closely follow and contact the outer peripheral surface **1301a** of the first pipe segment **103a**, and the inner surface defining the fourth reception area **1709d** can closely follow and contact the outer peripheral surface **1301b** of the second pipe segment **103b**. Furthermore, the inner surface defining the seventh reception area **1721c** can closely follow and contact the outer peripheral surface **1301a** of the first pipe segment **103a**, and the inner surface defining the eighth reception area **1721d** can closely follow and contact the outer peripheral surface **1301b** of the second pipe segment **103b**.

[0094] Referring to **FIG. 20**, once the first and second housing halves **1705a, 1705b** are locked in the closed orientation, the first cavity **1707a** of the first housing half **1705a** cooperates with the second cavity **1707b** of the second housing half **1705b** to form a second circumferential pocket with the seal **203** positioned within the second circumferential pocket. Furthermore, once the first and second housing halves **1705a, 1705b** are locked in the closed orientation, the first portion **1717a** of the heat shield **1715** and the second portion **1717b** of the heat shield cooperate to circumscribe the housing **1703** to define a chamber **2001** between the heat shield **1715** and the housing **1703**.

[0095] In operation the heat shield can provide trapped air in the chamber **2001** between the heat shield **1715** and the housing **1703** that acts as insulation to resist heat transferring from the heat shield to the housing **1703**. Furthermore, the housing **1703** can comprise a heat insulating material (e.g., ceramic) that can act to reduce heat transferring from the chamber to the seal **203**. Still further, the coupling device **201** can provide fluid cooling of the seal **203** in use. In accordance to features of the disclosure, the pipe apparatus **101** can provide mechanical coupling of pipe segments in a high-temperature environment. The mechanical coupling reduces the costs of assembling a network of pipe segments in a desired configuration. Furthermore, the mechanical coupling facilitates maintenance by allowing removal and replacement of components of the coupling device **201**, first pipe segment **103a**, or second pipe segment **103b** without destroying the pipe segments that may otherwise occur with techniques that permanently connect pipe segments together. Furthermore, the fluid cooled features of the coupling device **201** can facilitate heat transfer away from the seal to avoid failure and the protective shroud **1701** can further reduce heat transferring from a high temperature environment (e.g., a building on fire) to the seal **203**.

What is claimed is:

1. A pipe apparatus comprising:

a first pipe segment comprising a first end portion comprising a first outer circumferential edge;

a second pipe segment comprising a second end portion comprising a second outer circumferential edge facing the first outer circumferential edge, and the first outer circumferential edge is spaced from the second outer circumferential edge to define a circumferential gap between the first outer circumferential edge and the second outer circumferential edge;

a seal circumscribing the circumferential gap, the seal comprising a first circumferential flange engaging the first end portion of the first pipe segment and a second circumferential flange engaging the second end portion of the second pipe segment;

a first circumferential pocket defined between an interior surface of the seal, the first end portion, and the second end portion; and

a fluid guide device positioned at least partially within the first circumferential pocket, the fluid guide device comprising a plurality of segments that are radially arranged to circumscribe the first end portion and the second end portion, the fluid guide device further comprising a first axial end positioned over the first end portion and a second axial end positioned over the second end portion, and the fluid guide device at least partially defining a fluid path extending from the circumferential gap through an area defined between the fluid guide device and the interior surface of the seal.

2. The pipe apparatus of claim 1, wherein the fluid guide device comprises a circumferential guide flange extending at least partially into the circumferential gap between the first outer circumferential edge and the second outer circumferential edge, wherein an axial width of the circumferential guide flange is less than an axial width of the circumferential gap.

3. The pipe apparatus of claim 2, wherein the circumferential guide flange is spaced from the first outer circumferential edge and the second outer circumferential edge.

4. The pipe apparatus of any one of claims 1-3, further comprising a first tongue and groove connection axially locking the fluid guide device to the first end portion and a second tongue and groove connection axially locking the fluid guide device to the second end portion.

5. The pipe apparatus of any one of claims 1-4, further comprising a third tongue and groove connection axially locking the seal to the fluid guide device.

6. The pipe apparatus of any one of claims 1-5, wherein an outer surface of the fluid guide device further comprises at least one blind channel extending from the first axial end to the second axial end, wherein the area comprises the blind channel.

7. The pipe apparatus of any one of claims 1-6, wherein the fluid guide device further comprises at least one first through channel extending from the first axial end toward the second axial end, wherein an axial length of the first through channel is less than an axial length of the fluid guide device.

8. The pipe apparatus of claim 7, wherein the axial length of the first through channel is less than or equal to half the axial length of the fluid guide device.

9. The pipe apparatus of any one of claims 7-8, wherein the fluid guide device further comprises at least one second through channel extending from the second axial end toward the first axial end, wherein an axial length of the second through channel is less than the axial length of the fluid guide device.

10. The pipe apparatus of claim 9, wherein the axial length of the second through channel is less than or equal to half the axial length of the fluid guide device.

11. The pipe apparatus of any one of claims 1-10, further comprising a housing comprising a second circumferential pocket, wherein the seal is positioned within the second circumferential pocket.

12. The pipe apparatus of claim 11, further comprising a heat shield at least partially circumscribing the housing, the heat shield spaced from the housing to define a chamber between the heat shield and the housing.

13. A method of using the pipe apparatus of claim 1 comprising:

passing an upstream quantity of fluid through an interior of the first pipe segment in a first axial direction of the first pipe segment;

passing a first portion of the first upstream quantity of fluid through an interior of the second pipe segment in a second axial direction of the second pipe segment;

cooling the seal by passing a second portion of the first upstream quantity of fluid through the area; and then

passing the second portion of the first upstream quantity of fluid through the interior of the second pipe segment.

14. The method of claim 13, further comprising driving the second portion of the first upstream quantity of fluid through the area with a pressure drop.

15. A pipe apparatus comprising:

a first pipe segment comprising a first end portion comprising a first outer circumferential edge;

a second pipe segment comprising a second end portion comprising a second outer circumferential edge facing the first outer circumferential edge, and the first outer circumferential edge is spaced from the second outer circumferential edge to define a circumferential gap between the first outer circumferential edge and the second outer circumferential edge;

a seal circumscribing the circumferential gap, the seal comprising a first circumferential flange engaging the first end portion of the first pipe segment and a second circumferential flange engaging the second end portion of the second pipe segment;

a first circumferential pocket defined between an interior surface of the seal, the first end portion, and the second end portion; and

a fluid guide device positioned at least partially within the first circumferential pocket, the fluid guide device comprising a circumferential guide flange extending at least partially into the circumferential gap between the first outer circumferential edge and the second outer circumferential edge, wherein an axial width of the circumferential guide flange is less than an axial width of the circumferential gap, the circumferential guide flange is spaced from the first outer circumferential edge to define a fluid inlet port, and the circumferential guide flange is spaced from the second outer circumferential edge to define a fluid outlet port, wherein the fluid guide device at least partially defines a fluid path extending from the fluid inlet port through an area defined between the fluid guide device and the interior surface of the seal, and from the area to the fluid outlet port.

16. A method of using the pipe apparatus of claim 15 comprising:

passing an upstream quantity of fluid through an interior of the first pipe segment in a first axial direction of the first pipe segment;

passing a first portion of the first upstream quantity of fluid through an interior of the second pipe segment in a second axial direction of the second pipe segment;

passing a second portion of the first upstream quantity of fluid through the fluid inlet port, then through the area to cool the seal, and then through the fluid outlet port; and then passing the second portion of the first upstream quantity of fluid through the interior of the second pipe segment.

17. The method of claim 16, wherein the area comprises at least one blind channel of an outer surface of the fluid guide device and the passing the second portion of the first upstream quantity of fluid through the area comprises passing the second portion of the first upstream quantity of fluid through the blind channel from a first axial end of the fluid guide device to a second axial end of the fluid guide device.

18. The method of claim 17, wherein after the second portion of the first upstream quantity of fluid passes through the fluid inlet port and prior to passing through the blind channel, the second portion of the first upstream quantity of fluid then passes through at least one first through channel of the fluid guide device extending from the first axial end toward the second axial end, wherein a length of the first through channel is less than an axial length of the fluid guide device.

19. The method of any one of claims 16-18, further comprising driving the second portion of the first upstream quantity of fluid through the area with a pressure drop between the fluid inlet port and the fluid outlet port.

20. A coupling device comprising:

a seal circumscribing a central axis of the coupling device, the seal comprising a first circumferential flange extending toward the central axis and a second circumferential flange extending toward the central axis;

a first circumferential pocket at least partially defined by an interior surface of the seal, the first circumferential flange, and the second circumferential flange; and

a fluid guide device positioned at least partially within the first circumferential pocket, the fluid guide device comprises a plurality of segments that are radially arranged to circumscribe the central axis, and the fluid guide device at least partially defines a fluid path extending through an area defined between the fluid guide device and the interior surface of the seal.

21. The coupling device of claim 20, wherein the seal biases the plurality of segments together in a constricted configuration.

22. The coupling device of any one of claims 20-21, wherein the fluid guide device comprises a circumferential guide flange extending toward the central axis and circumscribing the central axis.

23. The coupling device of any one of claims 20-22, further comprising a tongue and groove connection axially locking the seal to the fluid guide device.

24. The coupling device of any one of claims 20-23, wherein an outer surface of the fluid guide device further comprises at least one blind channel extending from a first axial end of the fluid guide device to a second axial end of the fluid guide device, wherein the area comprises the blind channel.

25. The coupling device of any one of claims 20-23, wherein the fluid guide device further comprises at least one first through channel extending from a first axial end of the fluid guide device toward a second axial end of the fluid guide device, wherein an axial length of the first through channel is less than an axial length of the fluid guide device.

26. The coupling device of claim 25, wherein the axial length of the first through channel is less than or equal to half the axial length of the fluid guide device.

27. The coupling device of any one of claims 25-26, wherein the fluid guide device further comprises at least one second through channel extending from the second axial end toward the first axial end, wherein an axial length of the second through channel is less than the axial length of the fluid guide device.

28. The coupling device of claim 27, wherein the axial length of the second through channel is less than or equal to half the axial length of the fluid guide device.

29. The coupling device of any one of claims 25-28, wherein an outer surface of the fluid guide device further comprises at least one blind channel extending from the first axial end to the second axial end, wherein the area comprises the blind channel.

30. A method of assembling a pipe apparatus comprising the coupling device of claim 20 comprising:

inserting a first outer circumferential edge of a first end portion of a first pipe segment into a first axial opening of the seal, wherein the first circumferential flange seals against an outer peripheral surface of the first end portion;

axially locking the first end portion of the first pipe segment to the fluid guide device;

inserting a second outer circumferential edge of a second end portion of a second pipe segment into a second axial opening of the seal, wherein the second circumferential flange seals against an outer peripheral surface of the second end portion; and

axially locking the second end portion of the second pipe segment to the fluid guide device, wherein the first outer circumferential edge faces the second outer circumferential edge and a gap is maintained between the first outer circumferential edge and the second outer circumferential edge.

31. The method of claim 30, wherein a circumferential guide flange of the fluid guide device extends into the gap.

32. The method of claim 31, wherein the circumferential guide flange is spaced from the first outer circumferential edge and the second outer circumferential edge.

33. The method of any one of claims 30-32, wherein the axially locking the first end portion of the first pipe segment to the fluid guide device comprises engaging a tongue of one of the first end portion or the fluid guide device with a groove of another of the first end portion or the fluid guide device.

34. The method of claim 33, wherein the axially locking the second end portion of the first pipe segment to the fluid guide device comprises engaging a tongue of one of the second end portion or the fluid guide device with a groove of another of the first end portion or the fluid guide device.

35. The method of any one of claims 30-34, wherein the inserting the first outer circumferential edge of the first end portion of the first pipe segment into the first axial opening of the seal dilates a first corresponding axial end of the plurality of segments of the fluid guide device against a bias of the seal.

36. The method of claim 35, wherein the axially locking the first end portion to the fluid guide device comprises constricting the first corresponding axial end of the plurality of segments of the fluid guide device.

37. The method of any one of claims 30-36, wherein the inserting the second outer circumferential edge of the second end portion of the second pipe segment into the second axial opening of the seal dilates a corresponding second axial end of the plurality of segments of the fluid guide device against a bias of the seal.

38. The method of claim 37, wherein the axially locking the second end portion to the fluid guide device comprises constricting the corresponding second axial end of the plurality of segments of the fluid guide device.

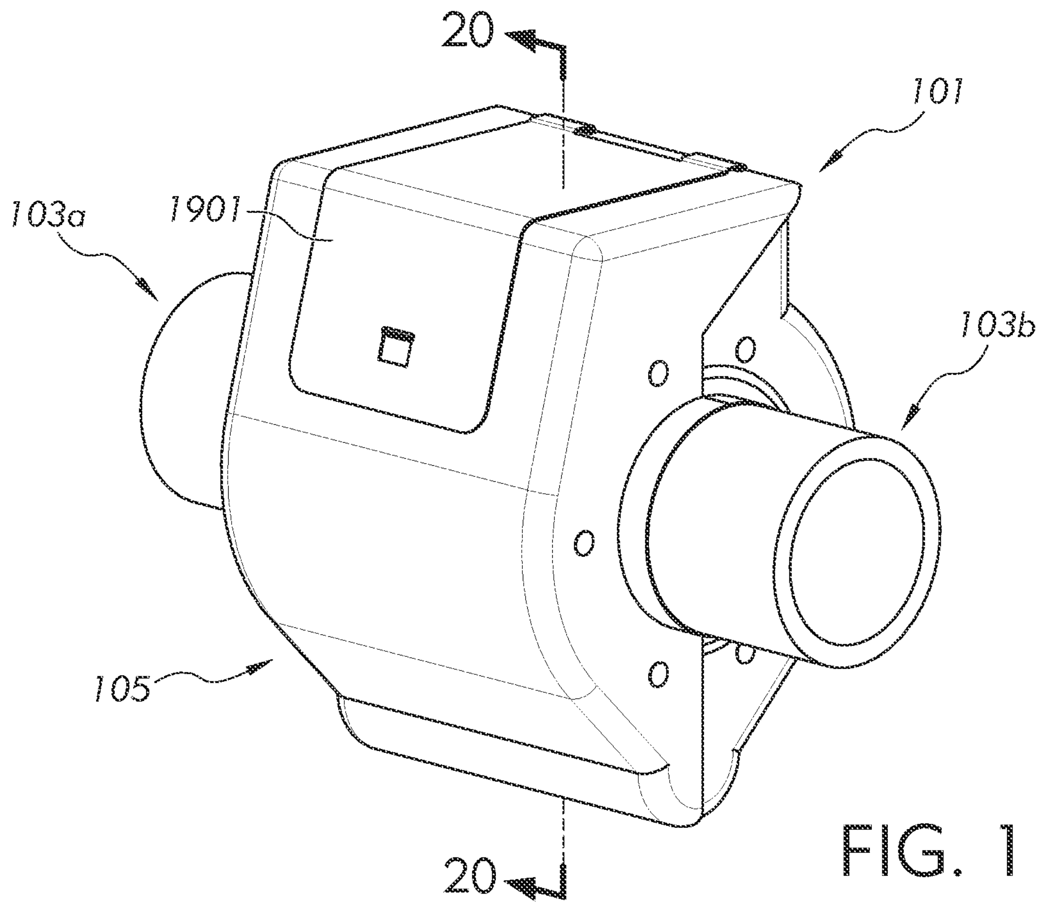

FIG. 1

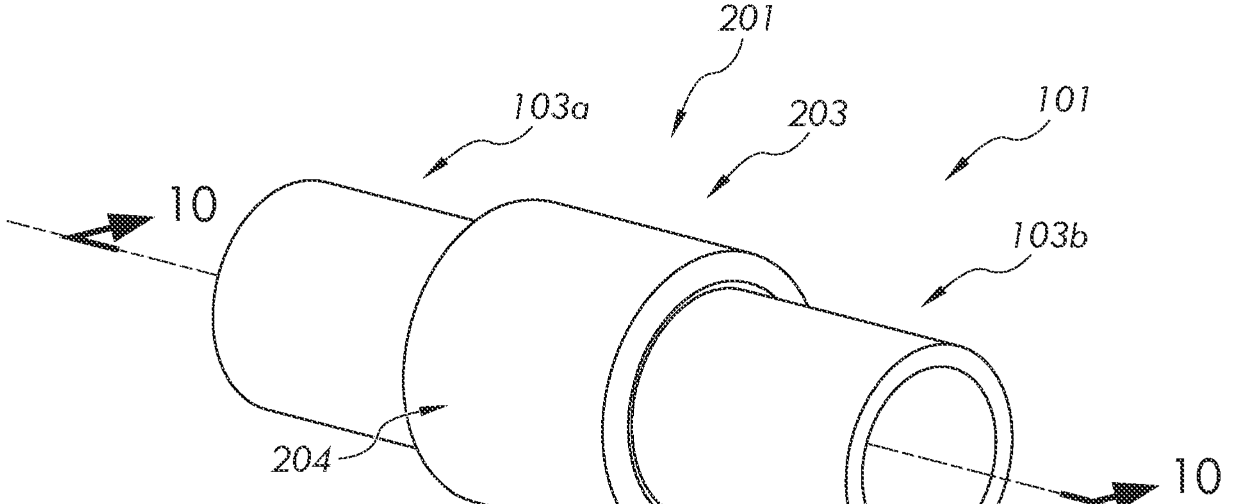

FIG. 2

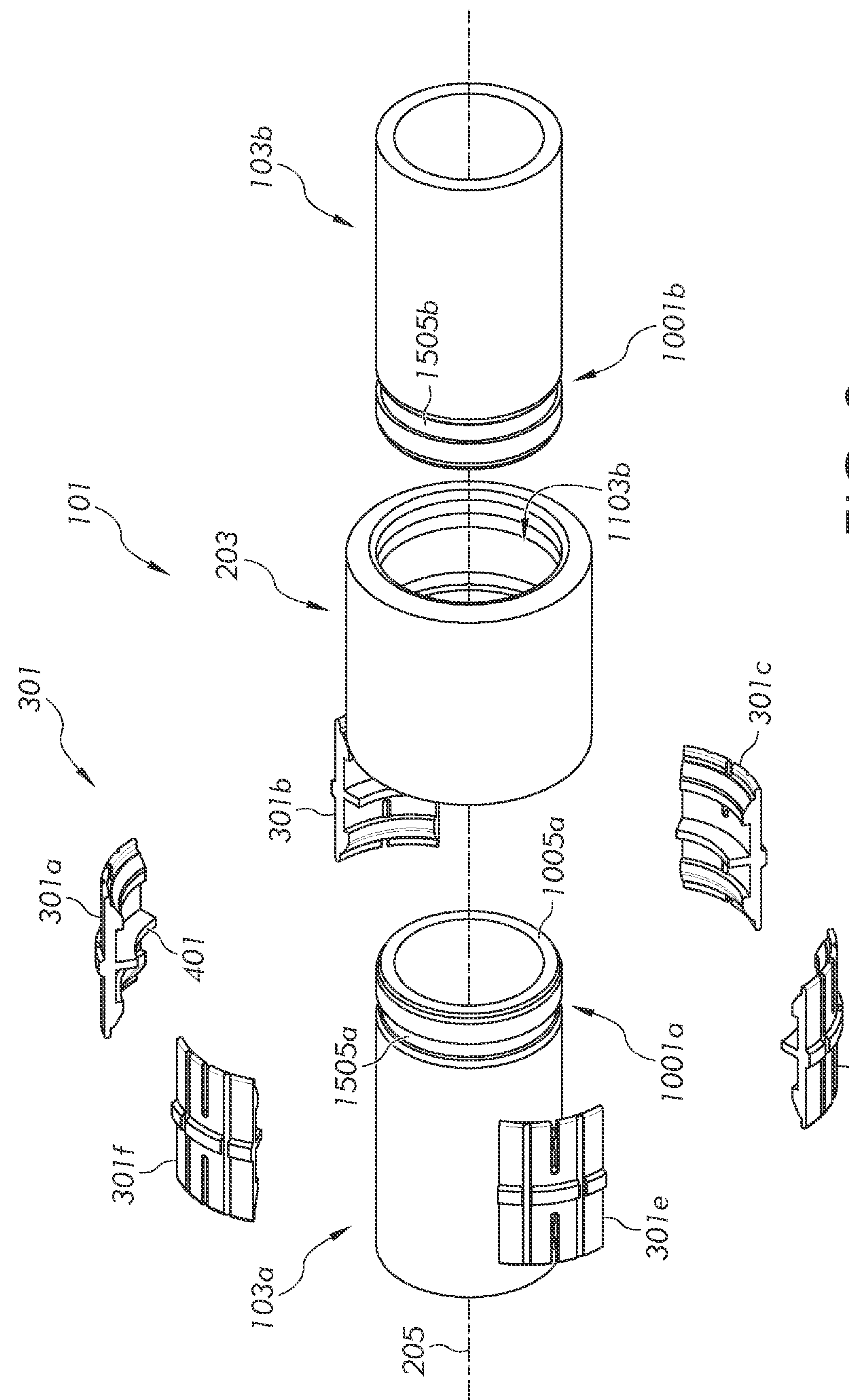
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FIG. 3

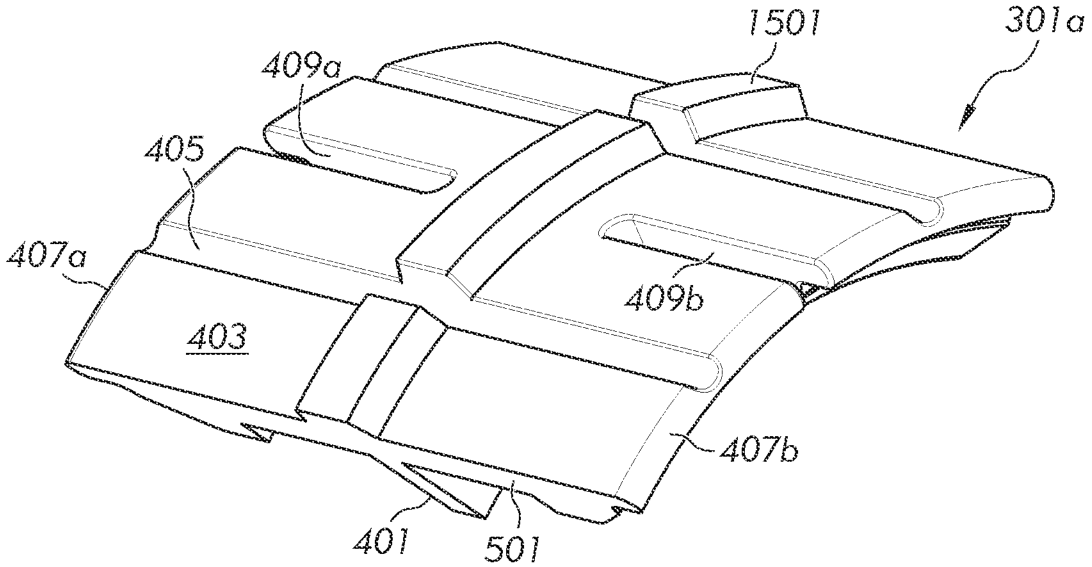
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FIG. 4

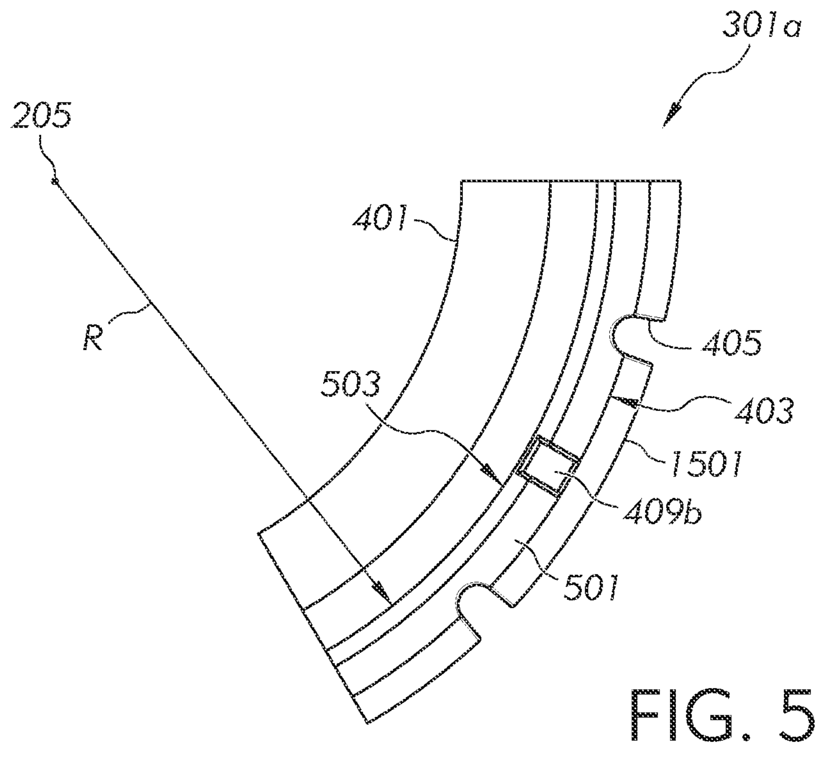
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FIG. 5

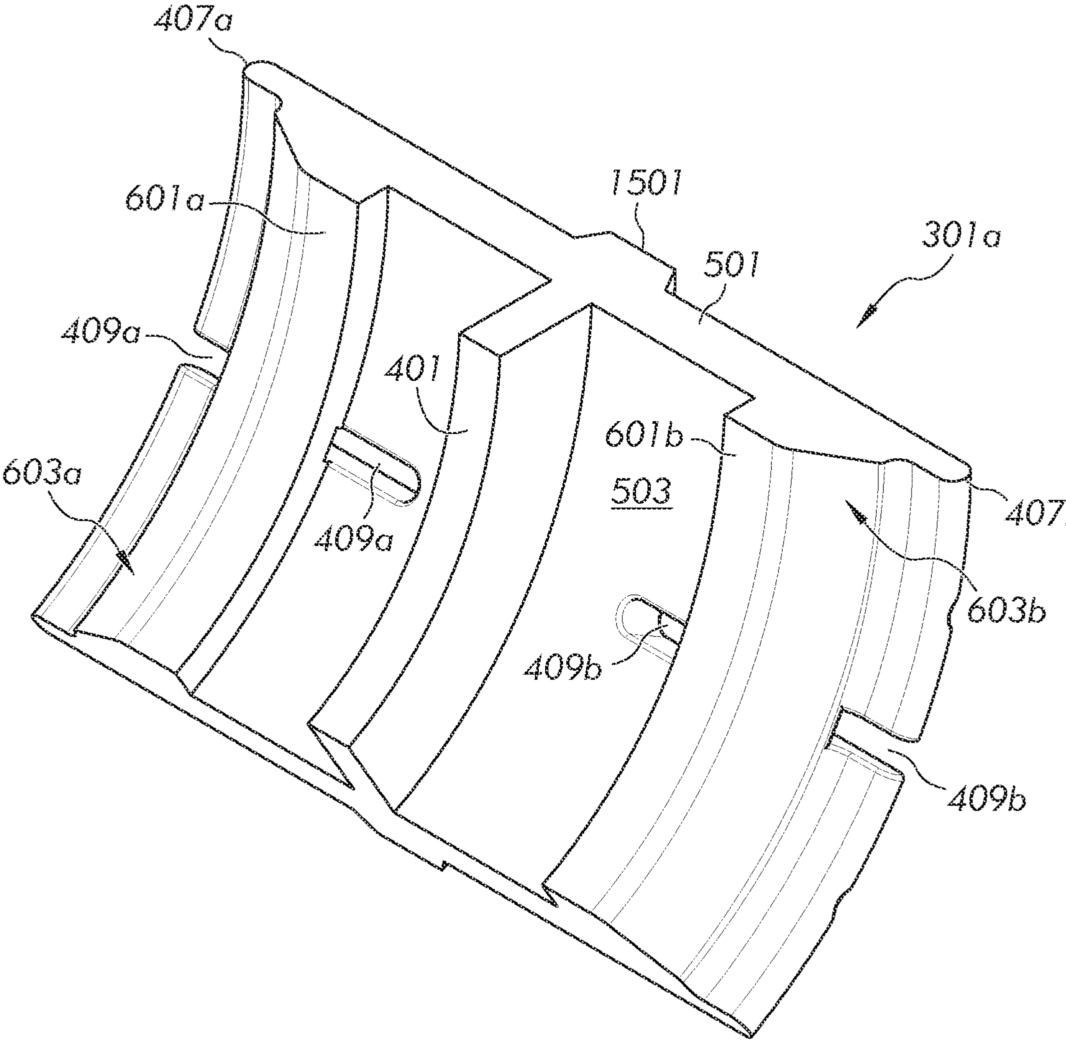
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FIG. 6

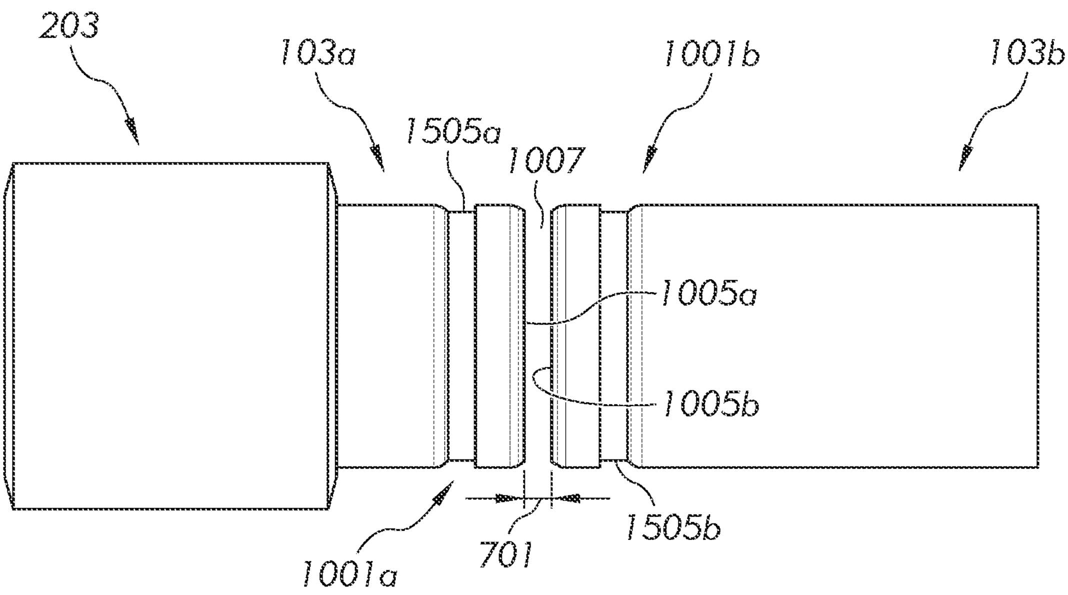
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FIG. 7

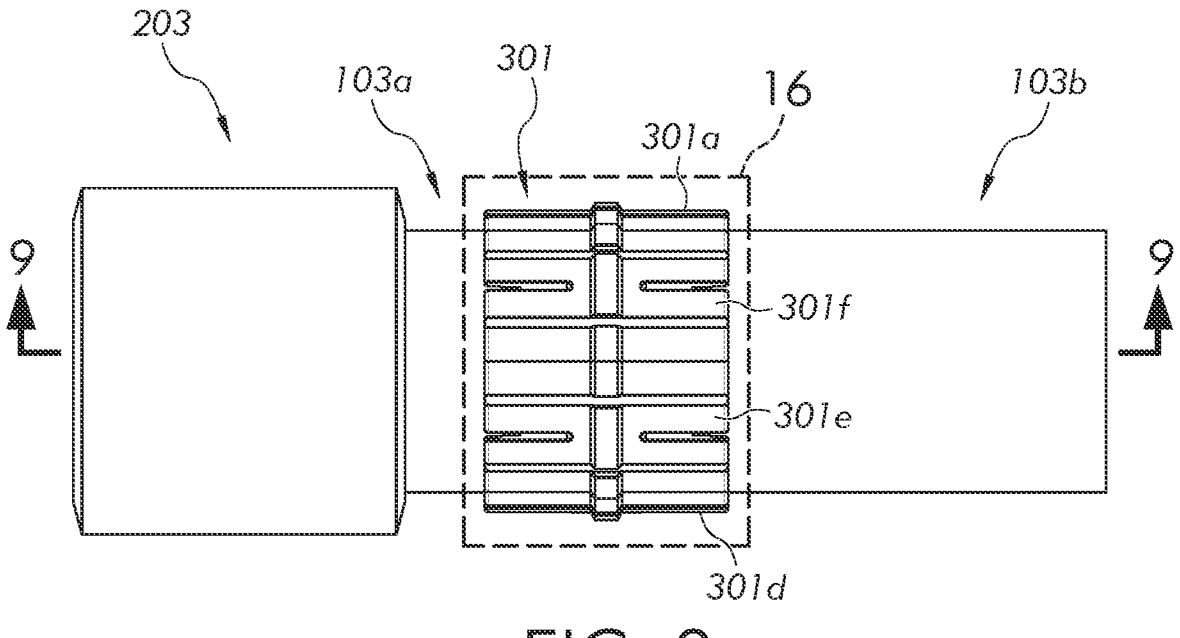
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FIG. 8

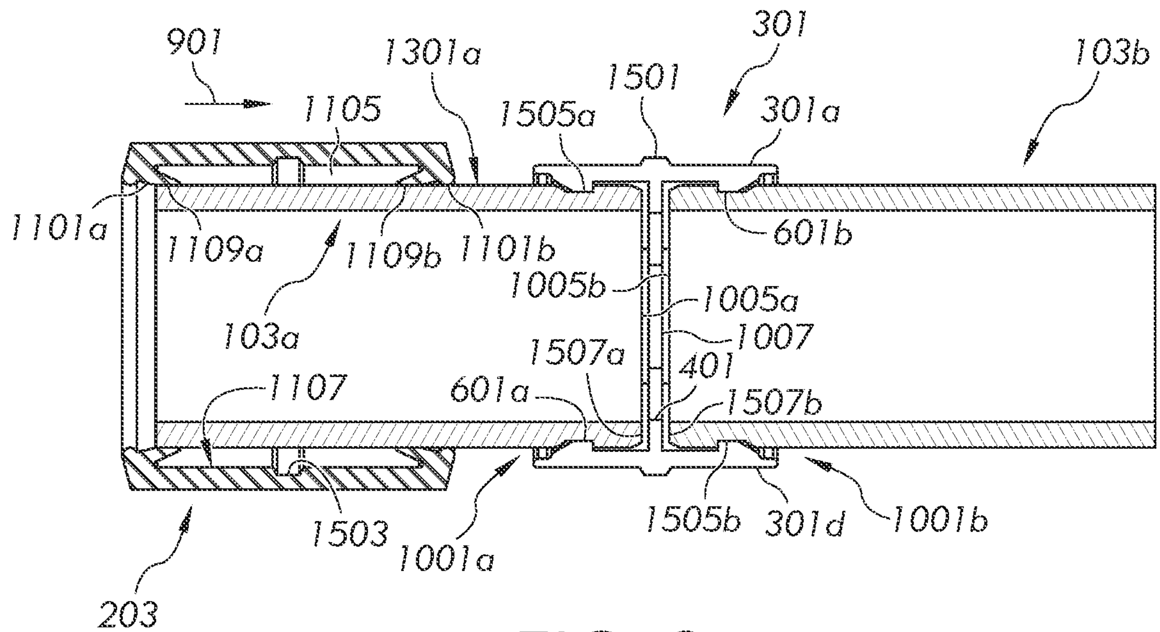
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FIG. 9

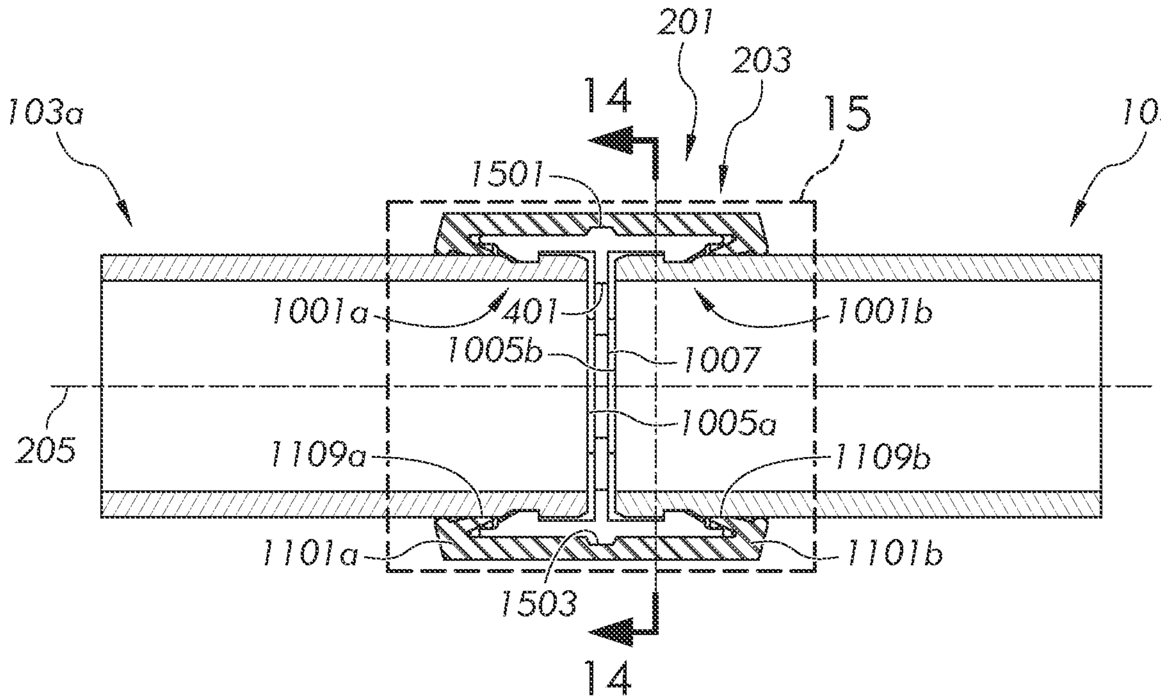
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FIG. 10

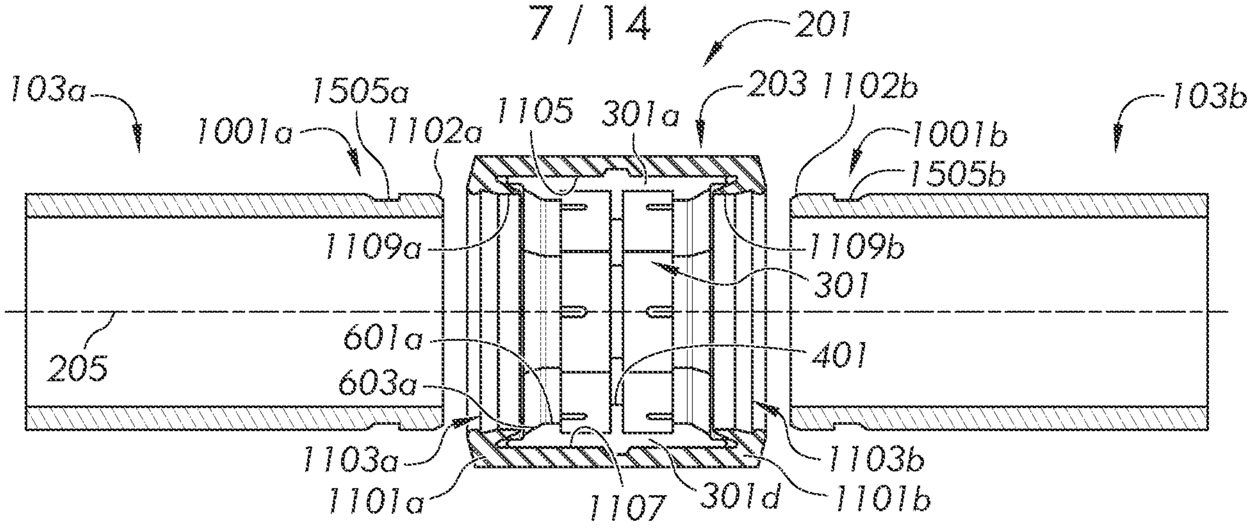

FIG. 11

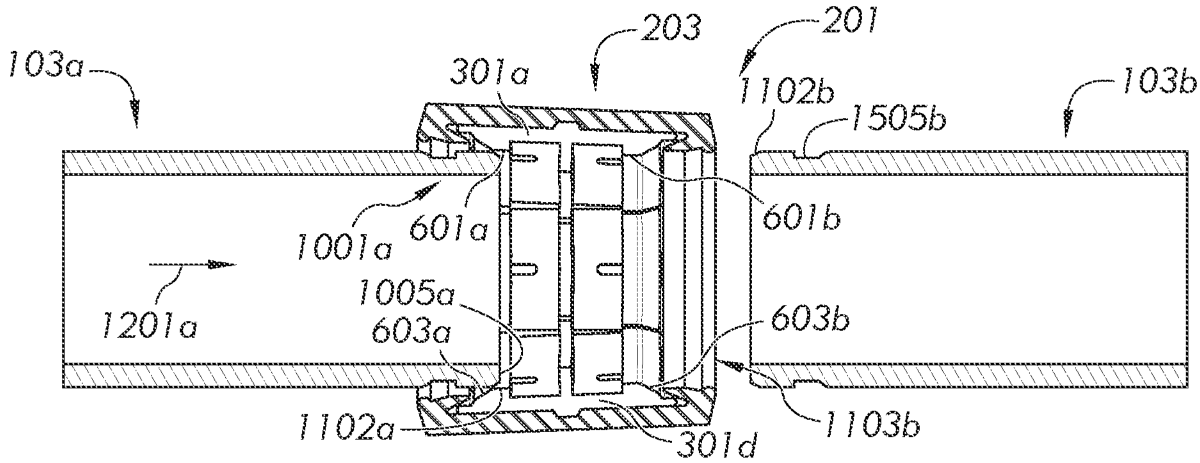

FIG. 12

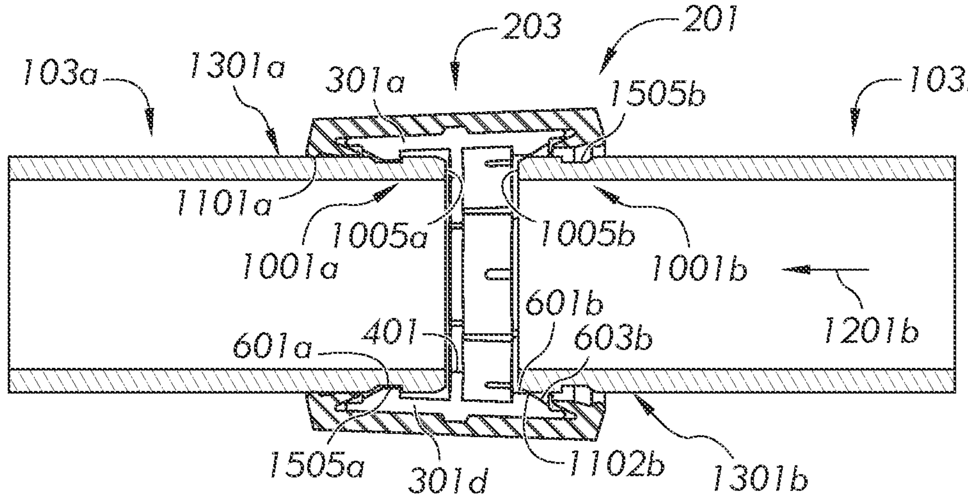

FIG. 13

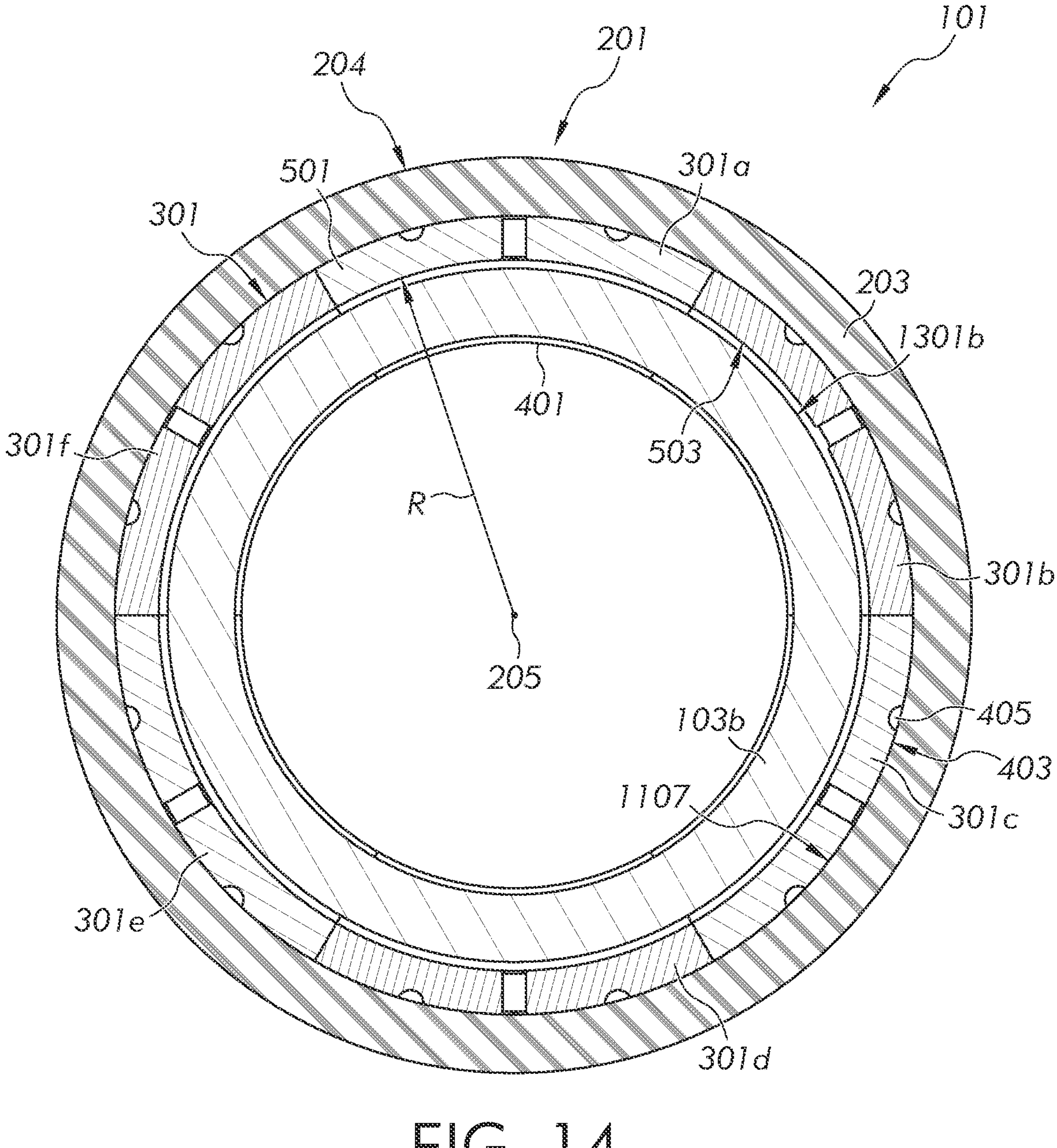
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FIG. 14

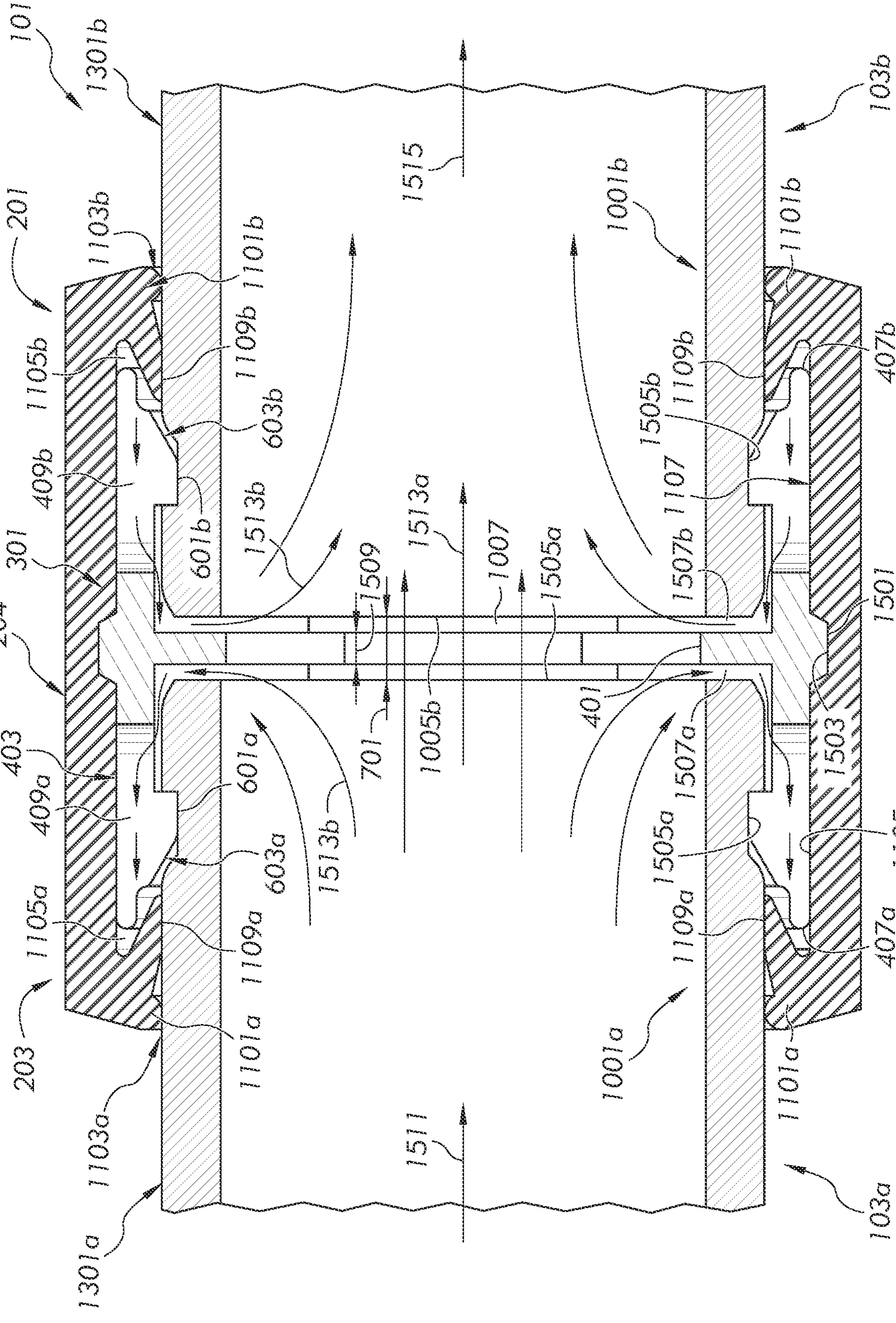
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FIG. 15

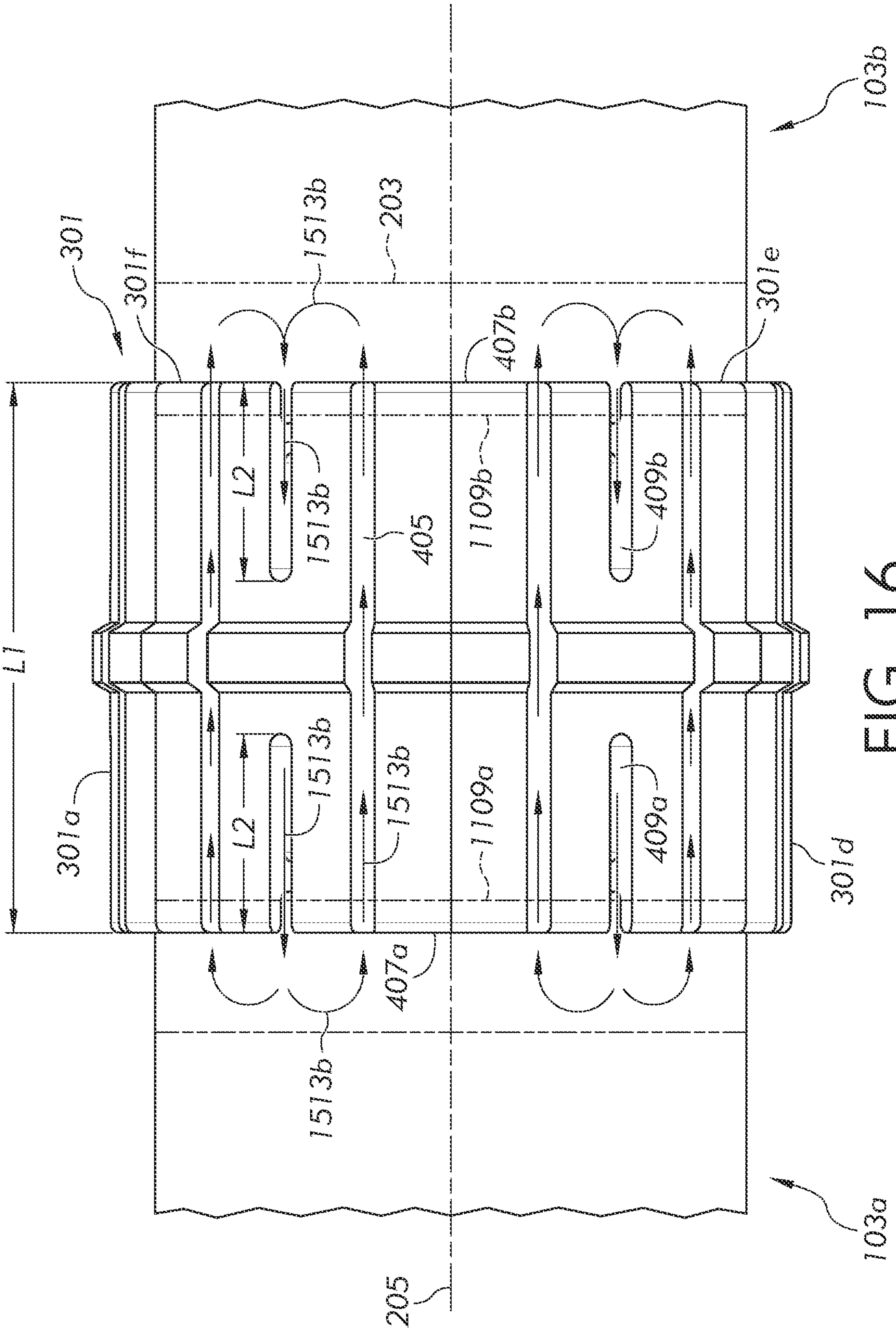
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FIG. 16

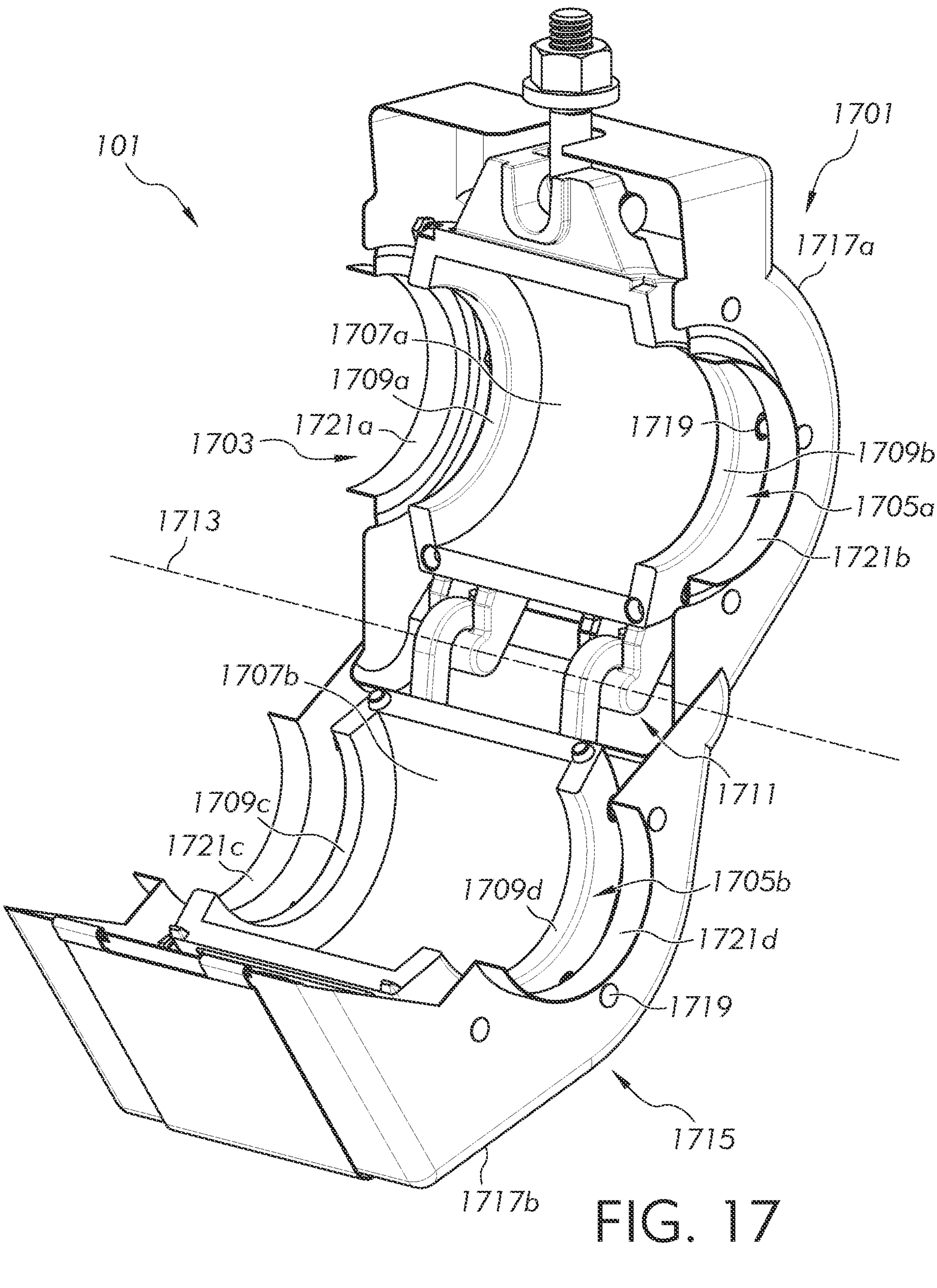
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FIG. 17

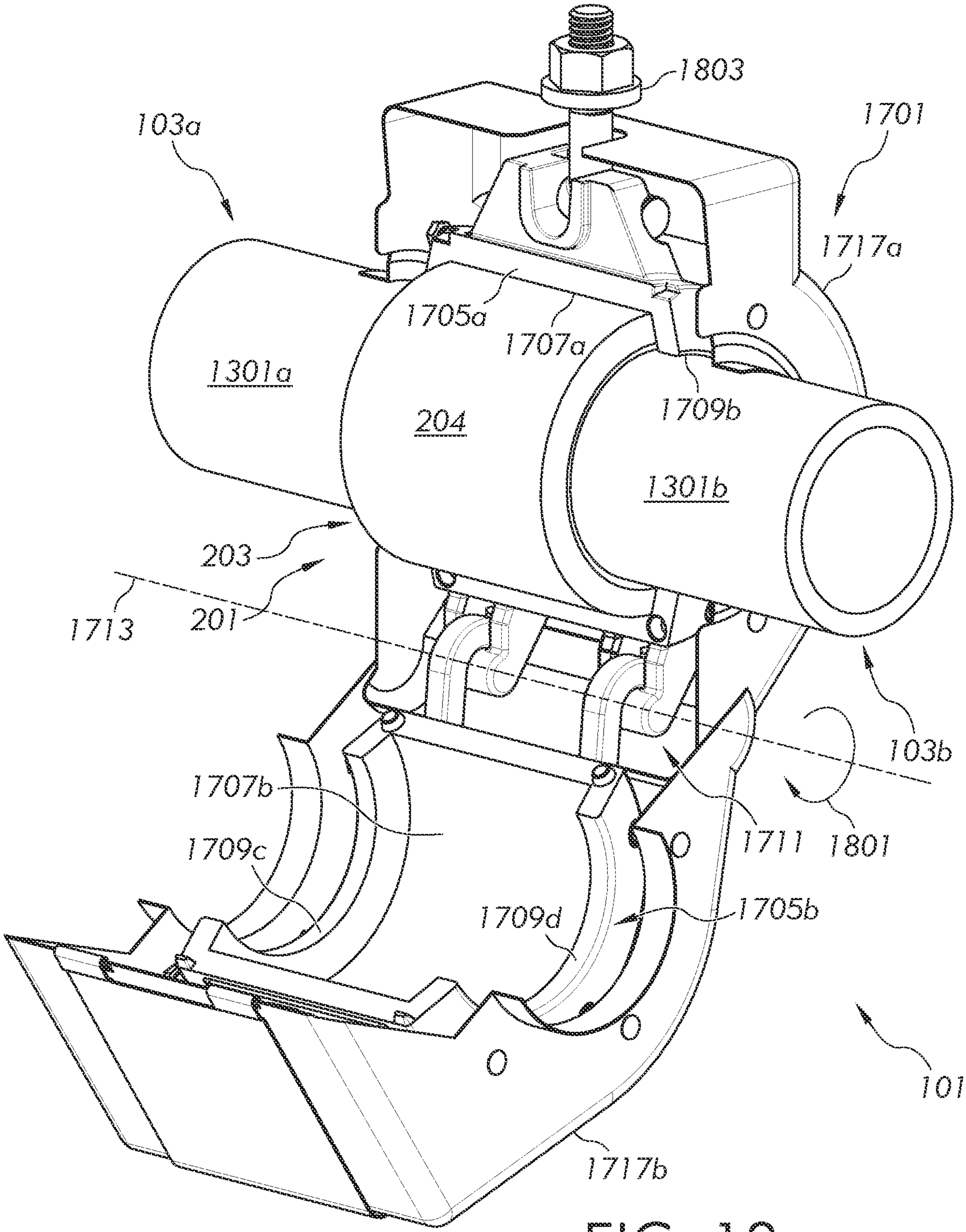
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FIG. 18

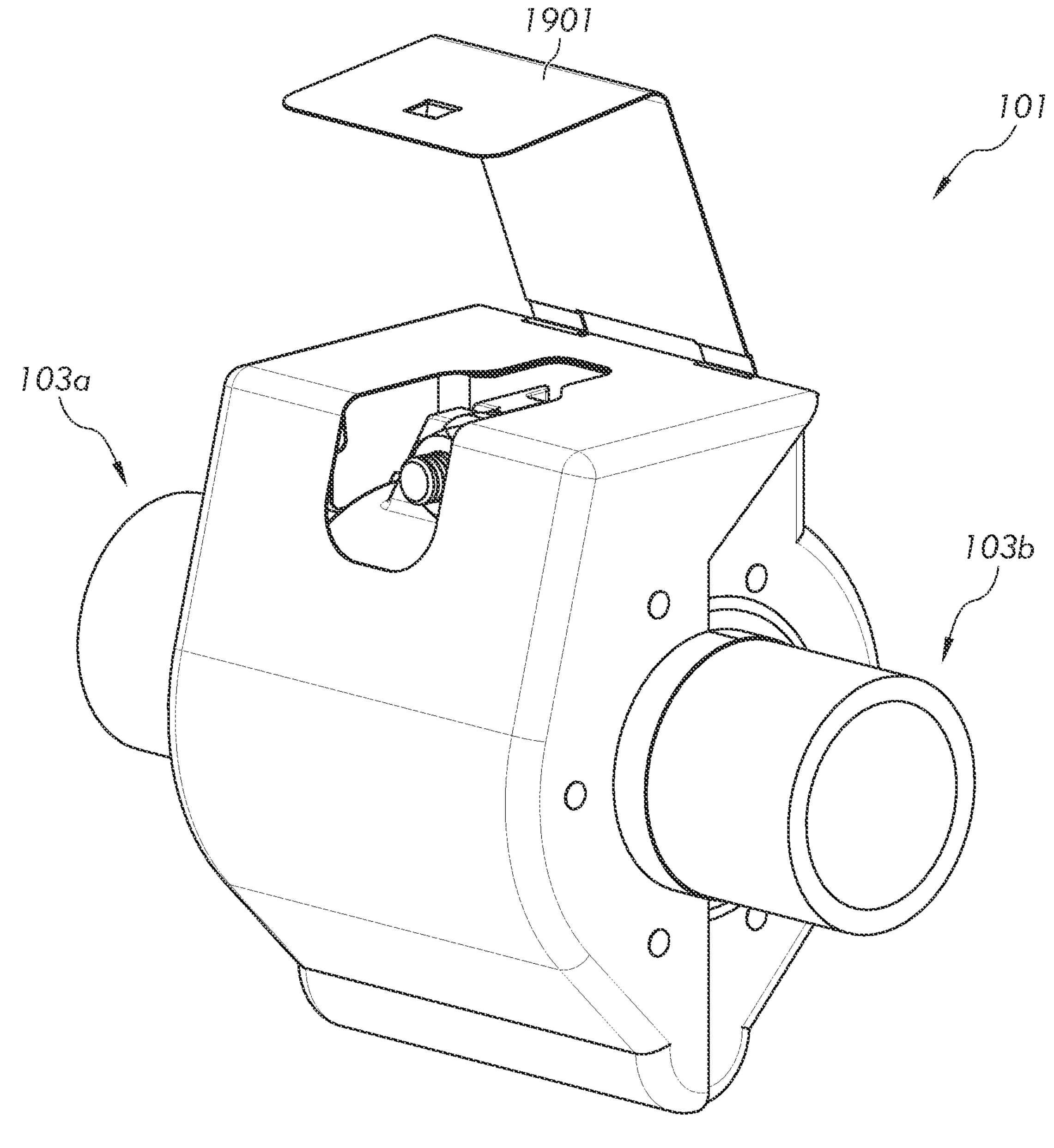

FIG. 19

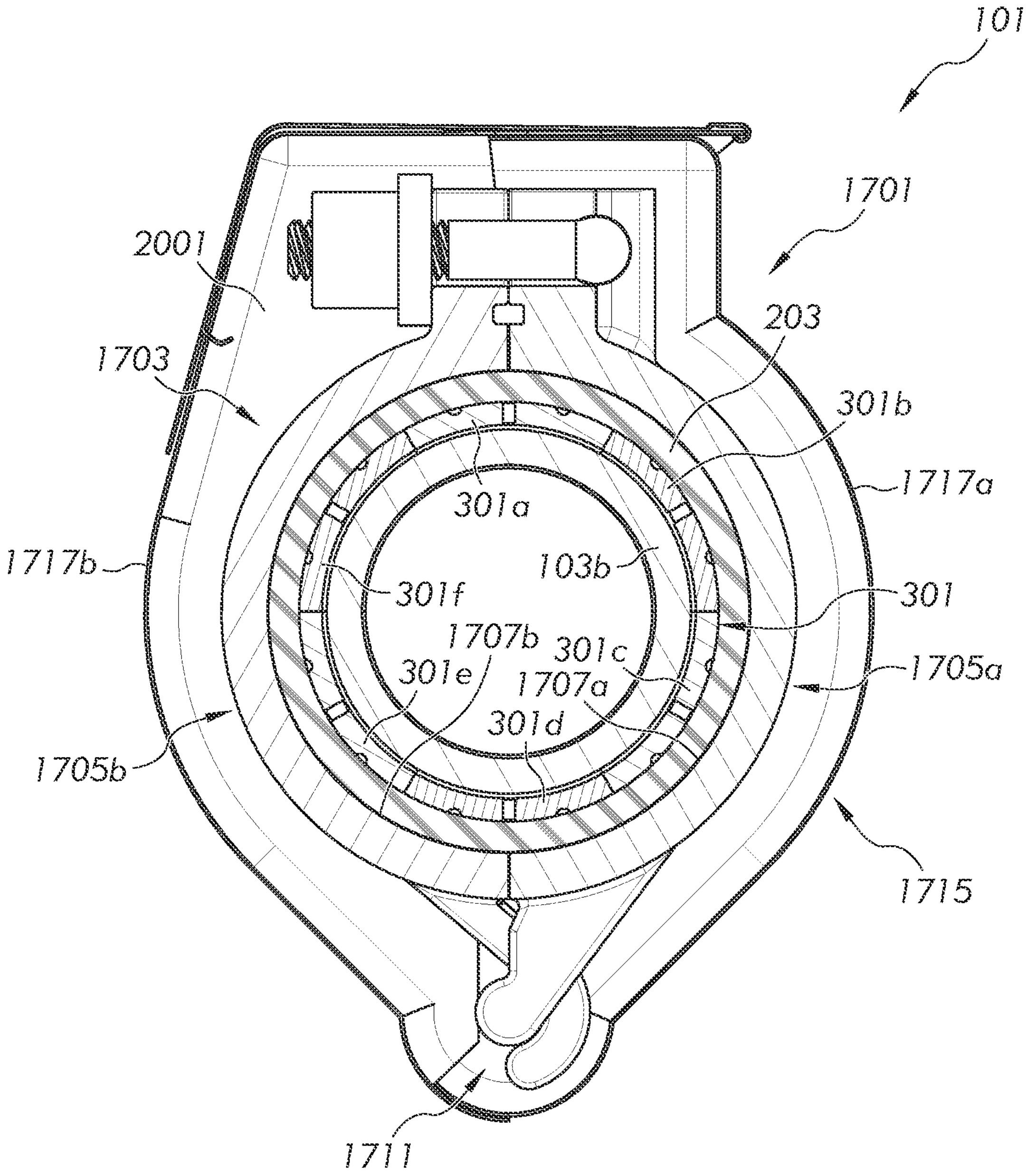
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FIG. 20