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(54) Title: FLUID DISPENSING APPARATUS AND METHOD OF MANUFACTURE

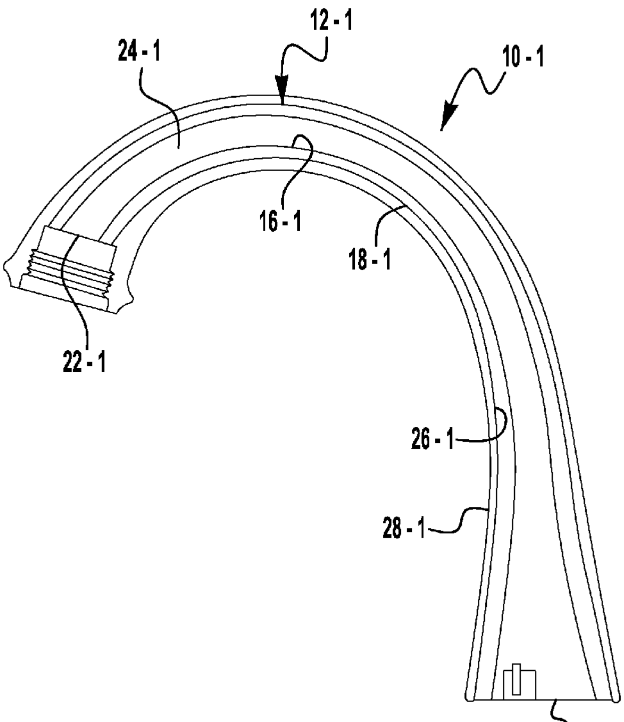

FIG. 1E

(57) Abstract: The present invention provides a fluid dispensing apparatus and a method of manufacturing a fluid dispensing apparatus. The fluid dispensing apparatus comprises a core and a shell. The core is formed from a metal alloy. The core metal alloy has a melting point. The core has an inner surface and an outer surface. The core has an inlet and an outlet. The core has a passageway extending from the inlet to the outlet. The shell is formed from a metal alloy. The shell metal alloy has a melting point. The shell is cast around the outer surface of the core. The melting point of the core metal alloy is approximately the same as the melting point of the shell metal alloy.

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FLUID DISPENSING APPARATUS AND METHOD OF MANUFACTURE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 61/824,745, filed May 17, 2013, the entire disclosure of which is hereby incorporated by reference.

FIELD

[0002] The present invention relates generally to a fluid dispensing apparatus and a method of manufacturing a fluid dispensing apparatus.

BACKGROUND

[0003] Fluid dispensing apparatuses, such as faucets and soap dispensers, are well known. Such fluid dispensing apparatuses are used in residential and commercial applications, such as in kitchens, bathrooms, and various other locations.

[0004] Fluid dispensing apparatuses are manufactured using many different techniques. One of these techniques is casting. The manufacture of fluid dispensing apparatuses using casting poses many difficulties.

SUMMARY

[0005] The present invention provides a fluid dispensing apparatus. In an exemplary embodiment, the fluid dispensing apparatus comprises a core and a shell. The core is formed from a metal alloy. The core metal alloy has a melting point. The core has an inner surface and an outer surface. The core has an inlet and an outlet. The core has a passageway extending from the inlet to the outlet. The shell is formed from a metal alloy. The shell metal alloy has a melting point. The shell is cast around the outer surface of the core. The melting point of the core metal alloy is approximately the same as the melting point of the shell metal alloy.

[0006] In another exemplary embodiment, the fluid dispensing apparatus comprises a core and a shell. The core is formed from a metal alloy. The core metal alloy has a ductility. The core includes a unitary bent tube. The core has an inner surface and an outer surface. The core has an inlet and an outlet. The core has a passageway extending from the inlet to the outlet. The shell is formed from a metal alloy. The shell is cast around the outer surface of the core. The ductility of the core metal alloy enables the tube to be bent.

[0007] The present invention provides a method of manufacturing a fluid dispensing apparatus. In an exemplary embodiment, the method comprises the steps of forming a core and casting a shell. The core is formed from a metal alloy. The core metal alloy has a melting point. The core has an inner surface and an outer surface. The core has an inlet and an outlet. The core has a passageway extending from the inlet to the outlet. The shell is cast around the outer surface of the core. The shell is formed from a metal alloy. The shell metal alloy has a melting point. The melting point of the core metal alloy is approximately the same as the melting point of the shell metal alloy.

[0008] In another exemplary embodiment, the method comprises the steps of forming a core and casting a shell. The core is formed from a metal alloy. The core metal alloy has a ductility. The core is formed by bending a unitary tube. The core has an inner surface and an outer surface. The core has an inlet and an outlet. The core has a passageway extending from the inlet to the outlet. The shell is cast around the outer surface of the core. The shell is formed from a metal alloy. The ductility of the core metal alloy enables the tube to be bent.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figures 1a-1e are views of a faucet including a core and a shell according to a first exemplary embodiment of the present invention, the core including a first core half and a second core half - Figure 1a is a view of the first core half and the second core half prior to assembly, Figure 1b is a view of the assembled core, Figure 1c is a view of the core and the shell after the shell has been die cast around the core, Figure 1d is a view of the faucet after finishing, and Figure 1e is a view of a cross-section of the faucet after finishing;

[0010] Figures 2a-2e are views of a soap dispenser including a core and a shell according to a second exemplary embodiment of the present invention, the core including a first core half and a second core half - Figure 2a is a view of the first core half and the second core half prior to assembly, Figure 2b is a view of the assembled core, Figure 2c is a view of the core and the shell after the shell has been die cast around the core, Figure 2d is a view of the soap dispenser after finishing, and Figure 2e is a view of a cross-section of the soap dispenser after finishing;

[0011] Figures 3a-3e are views of a faucet including a core and a shell according to a third exemplary embodiment of the present invention, the core including a first core half and a second core half - Figure 3a is a view of the first core half and the second core half prior to assembly, Figure 3b is a view of the assembled core, Figure 3c is a view of the core and the shell after the shell has been die cast around the core, Figure 3d is a view of the faucet after finishing, and Figure 3e is a view of a cross-section of the faucet after finishing;

[0012] Figures 4a-4d are views of a faucet including a core and a shell according to a fourth exemplary embodiment of the present invention, the core including a bent tube - Figure 4a is a view of the bent tube, Figure 4b is a view of the core and the shell after the shell has been die cast around the core, Figure 4c is a view of the faucet after finishing, and Figure 4d is a view of a cross-section of the faucet after finishing;

[0013] Figures 5a-5b are views of a soap dispenser including a core, a shell, and a liner according to a fifth exemplary embodiment of the present invention - Figure 5a is a view of the soap dispenser after finishing and Figure 5b is a view of a cross-section of the soap dispenser after finishing;

[0014] Figure 6 is a view of a cross-section of portions of a core according to an exemplary embodiment of the present invention, the core including a first core half and a second core half, the first core half including a groove and the second core half including a tongue; and

[0015] Figure 7 is a view of a cross-section of a portion of a core and a shell according to an exemplary embodiment of the present invention, the core having voids and the shell being free from voids.

DETAILED DESCRIPTION

[0016] The present invention provides a fluid dispensing apparatus and a method of manufacturing a fluid dispensing apparatus. In an exemplary embodiment, the fluid dispensing apparatus is a faucet. However, one of ordinary skill in the art will appreciate that the fluid dispensing apparatus could be a showerhead, a handheld shower, a body spray, a side spray, or any other plumbing fixture fitting. In another exemplary embodiment, the fluid dispensing apparatus is a soap dispenser.

[0017] Throughout the detailed description and the drawings, each similar component of the fluid dispensing apparatus will be referred to using the same reference number with the suffix "-X" indicating a generic embodiment of the component of the fluid dispensing apparatus and the suffix "-#" indicating a specific embodiment of the component of the fluid dispensing apparatus.

[0018] Exemplary embodiments of a fluid dispensing apparatus 10-X are illustrated in Figures 1a-1e, 2a-2e, 3a-3e, 4a-4d, and 5a-5b. In the exemplary embodiments, the fluid dispensing apparatus 10-X includes a core 12-X and a shell 14-X.

[0019] The core 12-X is formed from a metal alloy. The core 12-X has an inner surface 16-X and an outer surface 18-X. The core 12-X has an inlet 20-X and an outlet 22-X. The core 12-X has a passageway 24-X extending from the inlet 20-X to the outlet 22-X.

[0020] The shell 14-X is formed from a metal alloy. The shell 14-X is cast around the outer surface 18-X of the core 12-X. In exemplary embodiments, the shell 14-X is cast using pressure die casting or low pressure permanent mold casting. The shell 14-X has an inner surface 26-X and an outer surface 28-X.

[0021] In an exemplary embodiment, the fluid dispensing apparatus 10-X includes a liner 30-X. The liner 30-X is operable to prevent fluid flowing through the passageway 24-X of the core 12-X from contacting the inner surface 16-X of the core 12-X. In an exemplary embodiment, the liner 30-X is formed from a flexible material. In an exemplary embodiment, the liner is formed from a non-metal. In an exemplary embodiment, the liner 30-X is operable to be inserted in the passageway 24-X of the core 12-X. In an exemplary embodiment, the liner 30-X is operable to be applied to the inner surface 16-X of the core 12-X.

[0022] The core metal alloy has a melting point, and the shell metal alloy has a melting point. In an exemplary embodiment, the melting point of the core metal alloy is approximately the same as the melting point of the shell metal alloy.

[0023] Although the core metal alloy and the shell metal alloy have been described as having a melting point, one of ordinary skill in the art will appreciate that the melting point is not a discrete temperature, but includes a range of temperatures between a solidus and a liquidus. The solidus is the temperature below which a substance is completely solid. The liquidus is the temperature above which a substance is completely liquid. The melting range of temperatures between the solidus and the liquidus are the temperatures at which a substance is a mixture of solid and liquid. A melting point of one metal alloy is approximately the same as the melting point of another metal alloy if the melting range of the one metal alloy overlaps the melting range of the other metal alloy.

[0024] In an exemplary embodiment, the solidus of the core 12-X is within fifty degrees Fahrenheit (50°F) of the solidus of the shell 14-X.

[0025] In an exemplary embodiment, the solidus of the core 12-X is within one hundred degrees Fahrenheit (100°F) of the liquidus of the shell 14-X.

[0026] In an exemplary embodiment, the core 12-X includes one or more core components 32-X. Each core component 32-X is cast. In exemplary embodiments, each core component 32-X is cast using pressure die casting or low pressure permanent mold casting.

[0027] In an exemplary embodiment, the core 12-X includes a unitary core component 32-X. In an exemplary embodiment, the core 12-X includes a plurality of core components 32-X. The plurality of core components 32-X are operable to be joined together to form the core 12-X. The plurality of core components 32-X are joined together using any known technique such that the shell 14-X does not penetrate the passageway 24-X of the core 12-X when the shell 14-X is cast around the core 12-X.

[0028] In an exemplary embodiment, the core 12-X is formed from a first core half 34-X and a second core half 36-X. In an exemplary embodiment, the first core half 34-X and the second core half 36-X are mirror images of each other. In an exemplary embodiment, the first core half 34-X and the second core half 36-X are not mirror images of each other.

[0029] In an exemplary embodiment, such as shown in Figure 6, the first core half 34-X includes a groove 38-X (such as groove 38-6 in first core half 34-6), and the second core half 36-X includes a tongue 40-X (such as tongue 40-6 in second core half 36-6). The groove 38-X of the first core half 34-X is operable to receive the tongue 40-X of the second core half 36-X to join together the first core half 34-X and the second core half 36-X.

[0030] In an exemplary embodiment, the core components 32-X are formed from a zinc alloy or an aluminum alloy, and the shell 14-X is formed from a zinc alloy or an aluminum alloy. Exemplary zinc alloys include Zamak 2, Zamak 3, Zamak 5, Zamak 7, ZA-8, ZA-12, ZA-27, and ACuZinc. Exemplary aluminum alloys include 242, 319, 360, 362, 380, A380, B380, 384, 390, 413, and 712.

[0031] In an exemplary embodiment, the core 12-X includes a bent tube 42-X. In an exemplary embodiment, the core 12-X is formed by bending a unitary straight tube. The core metal alloy has a ductility. In an exemplary embodiment, the ductility of the core metal alloy enables the tube 42-X to be bent. In an exemplary embodiment, the tube 42-X is hydroformed after it is bent.

[0032] In an exemplary embodiment, the tube 42-X is formed from a copper alloy or a stainless steel. Exemplary copper alloys include copper, brass, bronze, red brass, yellow brass, silicon bronze, aluminum bronze, and manganese bronze. Exemplary stainless steel include 300 series stainless steel, such as types 301, 302, 303, 304, 304L, 308, 310, 316, and 321. In an exemplary embodiment, the shell 14-X is formed from a zinc alloy or an aluminum alloy. Again, exemplary zinc alloys include Zamak 2, Zamak 3, Zamak 5, Zamak 7, ZA-8, ZA-12, ZA-27, and ACuZinc. Exemplary aluminum alloys include 242, 319, 360, 362, 380, A380, B380, 384, 390, 413, and 712.

[0033] In an exemplary embodiment, the core 12-X has a thickness t_c, and the shell 14-X has a thickness t_s. In an exemplary embodiment, around a substantial portion of the outer surface 18-X of the core 12-X, the thickness t_s of the shell 14-X is less than the thickness t_c of the core 12-X. In an exemplary embodiment, around a substantial portion of the outer surface 18-X of the core 12-X, the thickness t_s of the shell 14-X is approximately the same as the thickness t_c of the core 12-X. In an exemplary embodiment, a substantial portion means at least twenty percent (20%). In an exemplary embodiment, a substantial portion means at least thirty percent (30%). In an exemplary embodiment, a substantial portion means at least fifty percent (50%).

[0034] In an exemplary embodiment, the core 12-X has a microstructure, and the shell 14-X has a microstructure. In an exemplary embodiment, the microstructure of the shell 14-X is finer grained than the microstructure of the core 12-X.

[0035] In an exemplary embodiment, the shell 14-X has the outer surface 28-X. In an exemplary embodiment, the outer surface 28-X of the shell 14-X is substantially free from voids. Voids include porosity and planar defects, such as cracks and cold shuts. Substantially free from voids means that the outer surface 28-X is capable of being plated and passing industry standard plating quality tests. In an exemplary embodiment, such as shown in Figure 7, the core 14-7 includes voids 44-7, while the outer surface 28-7 of the shell 12-7 is free from voids.

[0036] In an exemplary embodiment, the tool (e.g., die or mold) in which the shell 14-X is formed is maintained at a temperature above room temperature, but the cast core 12-X is not preheated to the tool temperature before being placed in the tool. As a result, the temperature of the tool and the temperature of the metal alloy from which the shell 14-X is to be formed are increased above the temperatures that are suitable if the tool is empty (i.e., if there is no cast core 12-X in the tool). In an exemplary embodiment in which the core 12-X and the shell 14-X are formed from a zinc alloy, the temperature of the tool is increased by approximately forty degrees Fahrenheit (40°F), and the temperature of the zinc alloy from which the shell 14-X is to be formed is increased by approximately ten degrees Fahrenheit (10°F).

[0037] In a first exemplary embodiment shown in Figures 1a-1e, the faucet 10-1 includes a core 12-1 and a shell 14-1.

[0038] The core 12-1 is formed from a metal alloy, such as a zinc alloy. The core 12-1 has an inner surface 16-1 and an outer surface 18-1. The core 12-1 has an inlet 20-1 and an outlet 22-1. The core 12-1 has a passageway 24-1 extending from the inlet 20-1 to the outlet 22-1.

[0039] The shell 14-1 is formed from a metal alloy, such as a zinc alloy. The shell 14-1 is cast around the outer surface 18-1 of the core 12-1. The shell 14-1 has an inner surface 26-1 and an outer surface 28-1.

[0040] The core 12-1 includes two core components 32-1 - a first core half 34-1 and a second core half 36-1. Each core component 32-1 is cast. The first core half 34-1 and the second core half 36-1 are mirror images of each other. The first core half 34-1 and the second core half 36-1 are operable to be joined together to form the core 12-1. The first core half 34-1 and the second core half 36-1 are joined together using any known technique such that the shell 14-1 does not penetrate the passageway 24-1 of the core 12-1 when the shell 14-1 is cast around the core 12-1.

[0041] In a second exemplary embodiment shown in Figures 2a-2e, the soap dispenser 10-2 includes a core 12-2 and a shell 14-2.

[0042] The core 12-2 is formed from a metal alloy, such as a zinc alloy. The core 12-2 has an inner surface 16-2 and an outer surface 18-2. The core 12-2 has an inlet 20-2 and an outlet 22-2. The core 12-2 has a passageway 24-2 extending from the inlet 20-2 to the outlet 22-2.

[0043] The shell 14-2 is formed from a metal alloy, such as a zinc alloy. The shell 14-2 is cast around the outer surface 18-2 of the core 12-2. The shell 14-2 has an inner surface 26-2 and an outer surface 28-2.

[0044] The core 12-2 includes two core components 32-2 - a first core half 34-2 and a second core half 36-2. Each core component 32-2 is cast. The first core half 34-1 and the second core half 36-1 are mirror images of each other. The first core half 34-2 and the second core half 36-2 are operable to be joined together to form the core 12-2. The first core half 34-2 and the second core half 36-2 are joined together using any known technique such that the shell 14-2 does not penetrate the passageway 24-2 of the core 12-2 when the shell 14-2 is cast around the core 12-2.

[0045] In a third exemplary embodiment shown in Figures 3a-3e, the faucet 10-3 includes a core 12-3 and a shell 14-3.

[0046] The core 12-3 is formed from a metal alloy, such as a zinc alloy. The core 12-3 has an inner surface 16-3 and an outer surface 18-3. The core 12-3 has an inlet 20-3 and an outlet 22-3. The core 12-3 has a passageway 24-3 extending from the inlet 20-3 to the outlet 22-3.

[0047] The shell 14-3 is formed from a metal alloy, such as a zinc alloy. The shell 14-3 is cast around the outer surface 18-3 of the core 12-3. The shell 14-3 has an inner surface 26-3 and an outer surface 28-3.

[0048] The core 12-3 includes two core components 32-3. Each core component 32-3 is cast. The first core half 34-1 and the second core half 36-1 are not mirror images of each other. The two core components 32-3 are operable to be joined together to form the core 12-3. The two core components 32-3 are joined together using any known technique such that the shell 14-3 does not penetrate the passageway 24-3 of the core 12-3 when the shell 14-3 is cast around the core 12-3.

[0049] In a fourth exemplary embodiment shown in Figures 4a-4d, the faucet 10-4 includes a core 12-4 and a shell 14-4.

[0050] The core 12-4 is formed from a metal alloy, such as a copper alloy. The core 12-4 has an inner surface 16-4 and an outer surface 18-4. The core 12-4 has an inlet 20-4 and an outlet 22-4. The core 12-4 has a passageway 24-4 extending from the inlet 20-4 to the outlet 22-4.

[0051] The shell 14-4 is formed from a metal alloy, such as a zinc alloy. The shell 14-4 is cast around the outer surface 18-4 of the core 12-4. The shell 14-4 has an inner surface 26-4 and an outer surface 28-4.

[0052] The core 12-4 includes a unitary bent tube 42-4. The core 12-4 is formed by bending a unitary straight tube. The core metal alloy has a ductility. In an exemplary embodiment, the ductility of the core metal alloy enables the tube 42-4 to be bent.

[0053] In a fifth exemplary embodiment shown in Figures 5a-5b, the soap dispenser 10-5 includes a core 12-5, a shell 14-5, and a liner 30-5.

[0054] The core 12-5 is formed from a metal alloy. The core 12-5 has an inner surface 16-5 and an outer surface 18-5. The core 12-5 has an inlet 20-5 and an outlet 22-5. The core 12-5 has a passageway 24-5 extending from the inlet 20-5 to the outlet 22-5.

[0055] The shell 14-5 is formed from a metal alloy. The shell 14-5 is cast around the outer surface 18-5 of the core 12-5. The shell 14-5 has an inner surface 26-5 and an outer surface 28-5.

[0056] The liner 30-5 is operable to prevent fluid flowing through the passageway 24-5 from contacting the inner surface 16-5 of the core 12-5. The liner 30-X is formed from a flexible material. In an exemplary embodiment, the liner is formed from a non-metal. The liner 30-5 is operable to be inserted in the passageway 24-5 of the core 12-5.

[0057] In the illustrated embodiments, the core 12-X includes structure that extends outside of the shell 14-X before finishing of the fluid dispensing apparatus 10-X. This structure is used to place and retain the core 12-X in the tool and is removed during finishing of the fluid dispensing apparatus 10-X.

[0058] One of ordinary skill in the art will now appreciate that the present invention provides a fluid dispensing apparatus and a method of manufacturing a fluid dispensing apparatus. Although the present invention has been shown and described with reference to particular embodiments, equivalent alterations and modifications will occur to those skilled in the art upon reading and understanding this specification. The present invention includes all such equivalent alterations and modifications and is limited only by the scope of the following claims in light of their full scope of equivalents.

What is claimed is:

1. A fluid dispensing apparatus, comprising:

a core, the core being formed from a metal alloy, the core metal alloy having a melting point, the core having an inner surface and an outer surface, the core having an inlet and an outlet, the core having a passageway extending from the inlet to the outlet; and

a shell, the shell being formed from a metal alloy, the shell metal alloy having a melting point, the shell being cast around the outer surface of the core;

wherein the melting point of the core metal alloy is approximately the same as the melting point of the shell metal alloy.

2. The fluid dispensing apparatus of claim 1, wherein

the solidus of the core is within fifty degrees Fahrenheit of the solidus of the shell.

3. The fluid dispensing apparatus of claim 1, wherein

the solidus of the core is within one hundred degrees Fahrenheit of the liquidus of the shell.

4. The fluid dispensing apparatus of claim 1, further including:

a liner, the liner being formed from a flexible material, the liner being operable to prevent fluid flowing through the passageway of the core from contacting the inner surface of the core.

5. The fluid dispensing apparatus of claim 1, wherein:

the core has a thickness;

the shell has a thickness; and

around a substantial portion of the outer surface of the core, the thickness of the shell is less than the thickness of the core.

6. The fluid dispensing apparatus of claim 1, wherein:

the shell has an outer surface; and

the outer surface of the shell is substantially free from voids.

7. The fluid dispensing apparatus of claim 1, wherein:

the core includes a plurality of cast core components joined together to form the core.

8. The fluid dispensing apparatus of claim 7, wherein:

the core includes a first core half and a second core half joined together to form the core.

9. The fluid dispensing apparatus of claim 8, wherein:

the first core half includes a groove;

the second core half includes a tongue; and

the groove of the first core half is operable to receive the tongue of the second core half to join together the first core half and the second core half.

10. The fluid dispensing apparatus of claim 1, wherein:

the core metal alloy is a zinc alloy; and

the shell metal alloy is a zinc alloy.

11. A fluid dispensing apparatus, comprising:

a core, the core being formed from a metal alloy, the core metal alloy having a ductility, the core including a unitary bent tube, the core having an inner surface and an outer surface, the core having an inlet and an outlet, the core having a passageway extending from the inlet to the outlet; and

a shell, the shell being formed from a metal alloy, the shell being cast around the outer surface of the core;

wherein the ductility of the core metal alloy enables the tube to be bent.

12. The fluid dispensing apparatus of claim 11, wherein:

the shell has an outer surface; and

the outer surface of the shell is substantially free from voids.

13. The fluid dispensing apparatus of claim 11, wherein:

the core metal alloy is a copper alloy; and

the shell metal alloy is a zinc alloy.

14. A method of manufacturing a fluid dispensing apparatus, comprising the steps of:

forming a core, the core being formed from a metal alloy, the core metal alloy having a melting point, the core having an inner surface and an outer surface, the core having an inlet and an outlet, the core having a passageway extending from the inlet to the outlet; and

casting a shell around the outer surface of the core, the shell being formed from a metal alloy, the shell metal alloy having a melting point;

wherein the melting point of the core metal alloy is approximately the same as the melting point of the shell metal alloy.

15. The method of claim 14, wherein

the solidus of the core is within fifty degrees Fahrenheit of the solidus of the shell.

16. The method of claim 14, wherein

the solidus of the core is within one hundred degrees Fahrenheit of the liquidus of the shell.

17. The method of claim 14, further including the step of:

providing a liner in the passageway of the core, the liner being formed from a flexible material, the liner being operable to prevent fluid flowing through the passageway of the core from contacting the inner surface of the core.

18. The method of claim 14, wherein:

the core has a thickness;

the shell has a thickness; and

around a substantial portion of the outer surface of the core, the thickness of the shell is less than the thickness of the core.

19. The method of claim 14, wherein:

the shell has an outer surface; and

the outer surface of the shell is substantially free from voids.

20. The method of claim 14, wherein:

the step of forming the core includes the steps of casting a plurality of core components and joining together the plurality of core components.

21. The method of claim 20, wherein:

the step of forming the core includes the steps of forming a first core half, forming a second core half, and joining together the first core half and the second core half.

22. The method of claim 21, wherein:

the step of forming the first core half includes the step of forming a groove in the first core half;

the step of forming the second core half includes the step of forming a tongue in the second core half; and

the step of joining together the first core half and the second core half includes the step of inserting the groove of the first core half into the tongue of the second core half.

23. The method of claim 14, wherein:

the core metal alloy is a zinc alloy; and

the shell metal alloy is a zinc alloy.

24. A method of manufacturing a fluid dispensing apparatus, comprising the steps of:

forming a core, the core being formed from a metal alloy, the core metal alloy having a ductility, the core being formed by bending a unitary tube, the core having an inner surface and an outer surface, the core having an inlet and an outlet, the core having a passageway extending from the inlet to the outlet; and

casting a shell around the outer surface of the core, the shell being formed from a metal alloy;

wherein the ductility of the core metal alloy enables the tube to be bent.

25. The method of claim 24, wherein:

the shell has an outer surface; and

the outer surface of the shell is substantially free from voids.

26. The method of claim 24, wherein:

the core metal alloy is a copper alloy; and

the shell metal alloy is a zinc alloy.

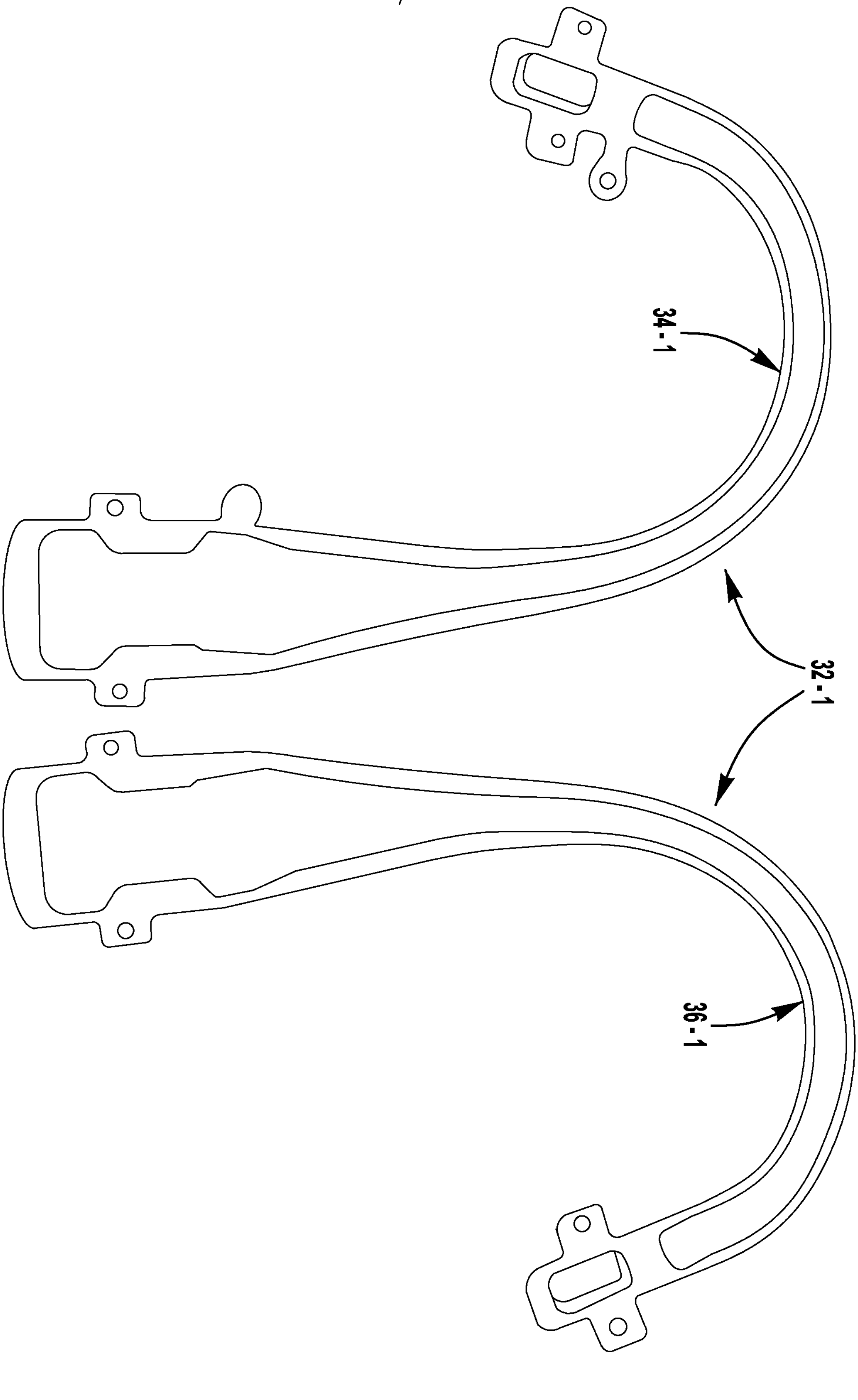


FIG. 1A

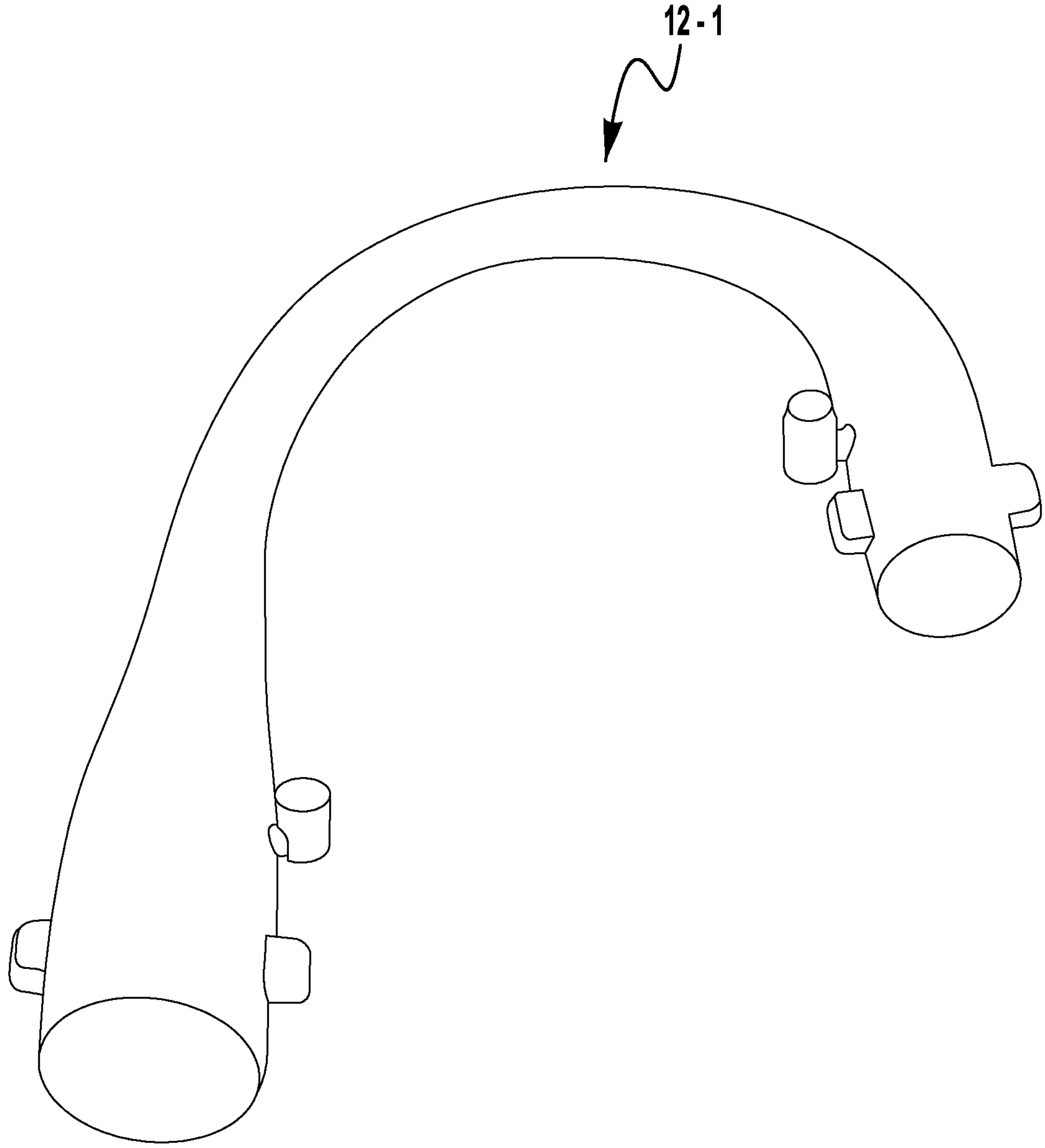


FIG. 1B

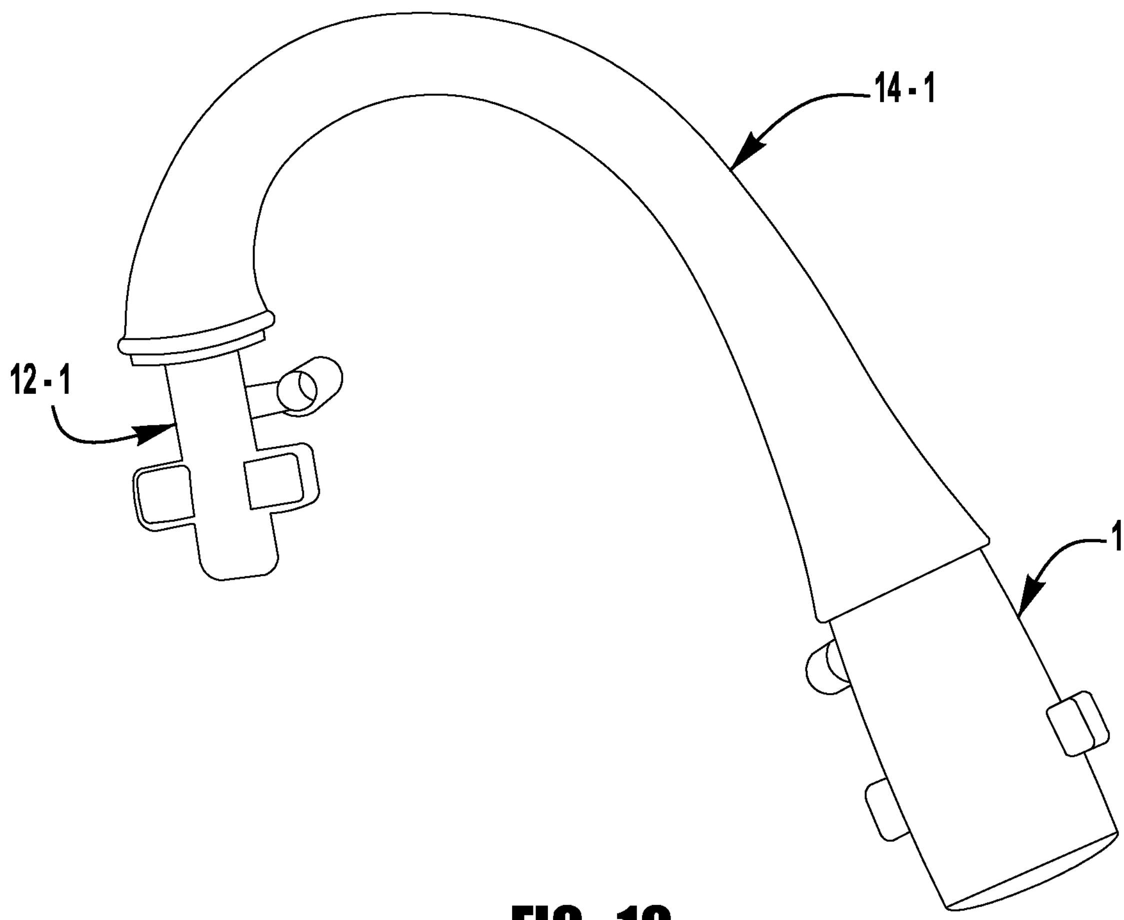


FIG. 1C

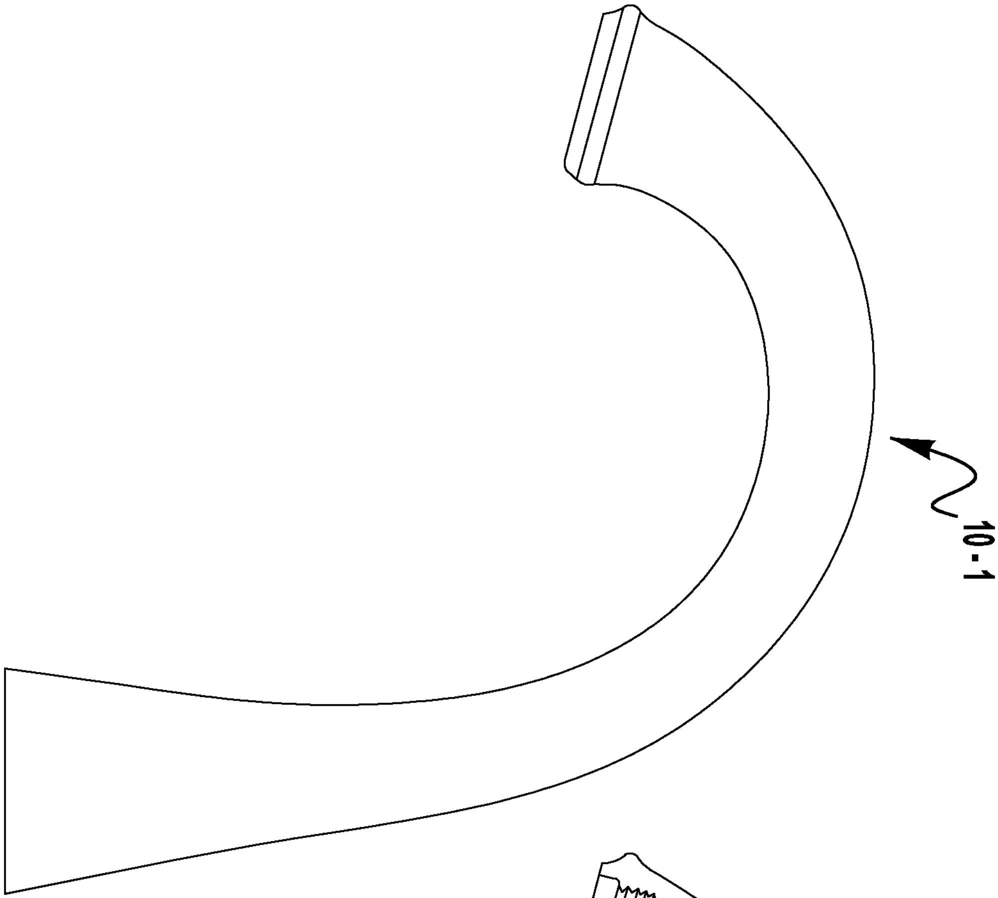


FIG. 1D

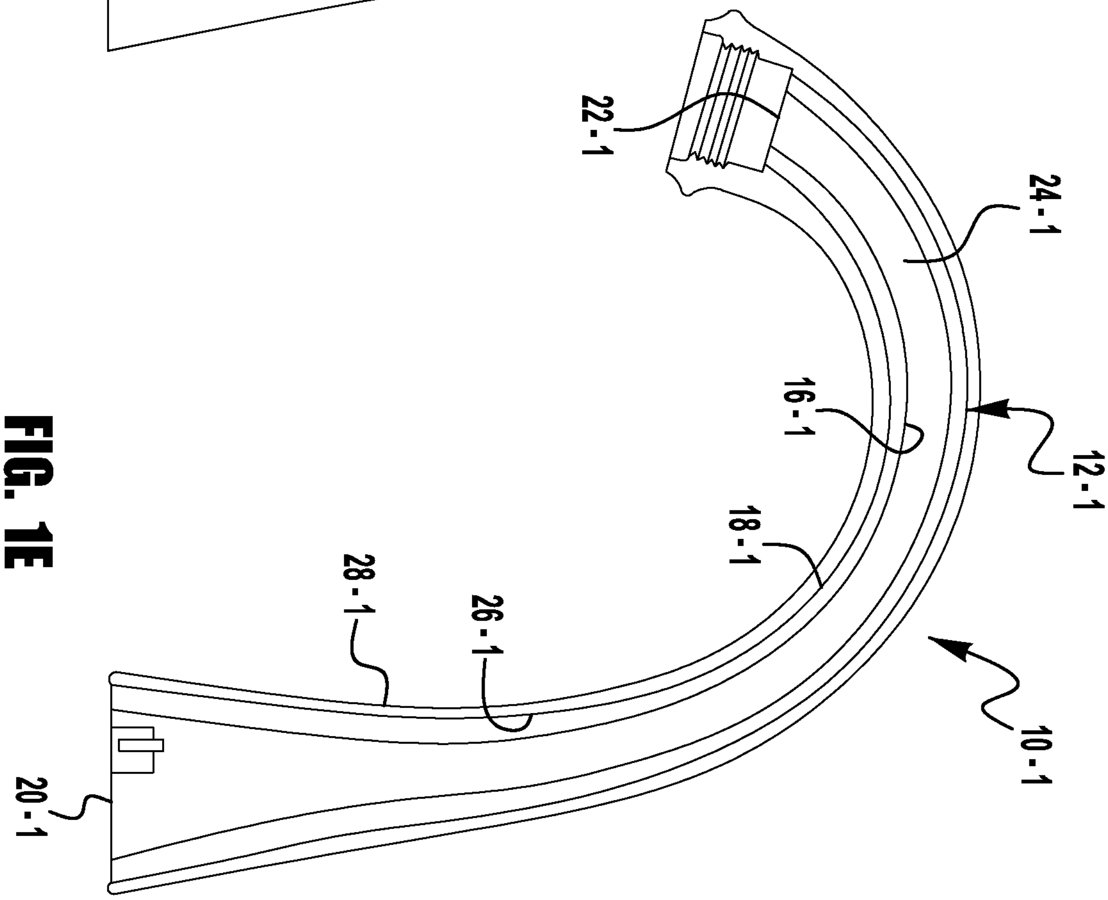


FIG. 1E

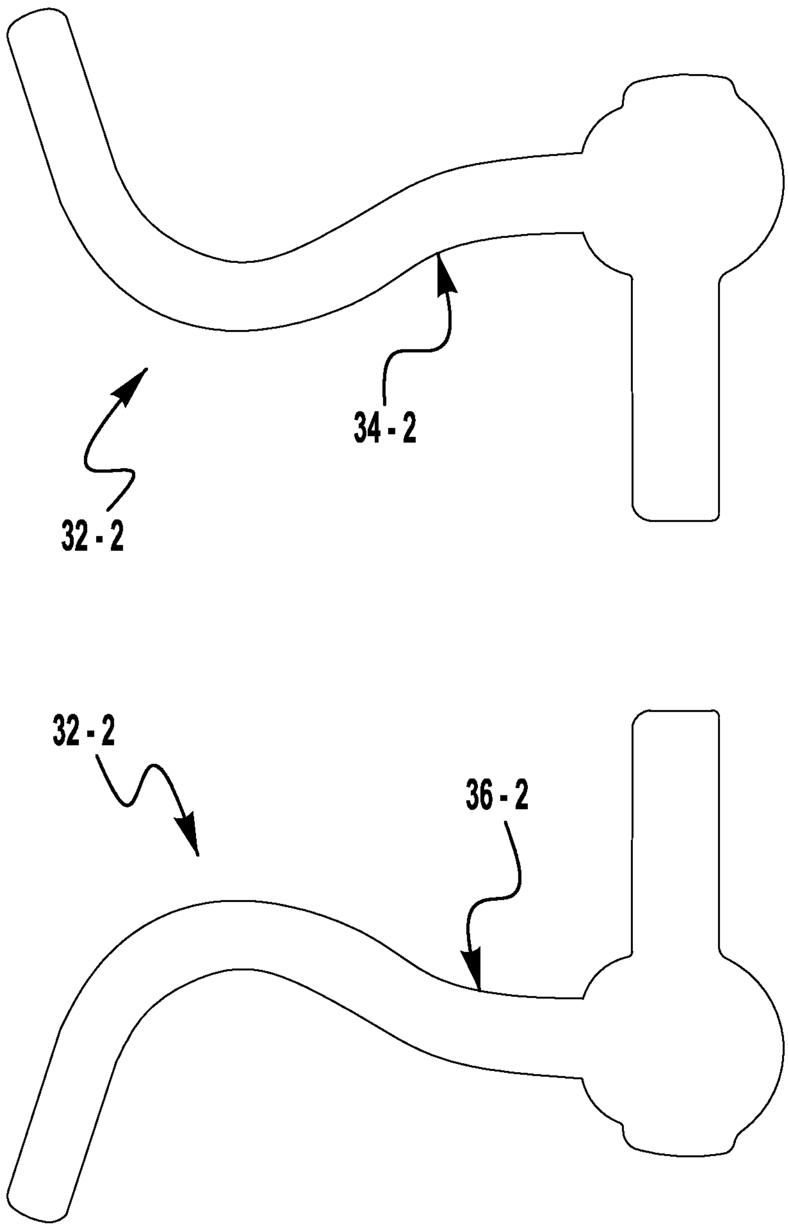


FIG. 2A

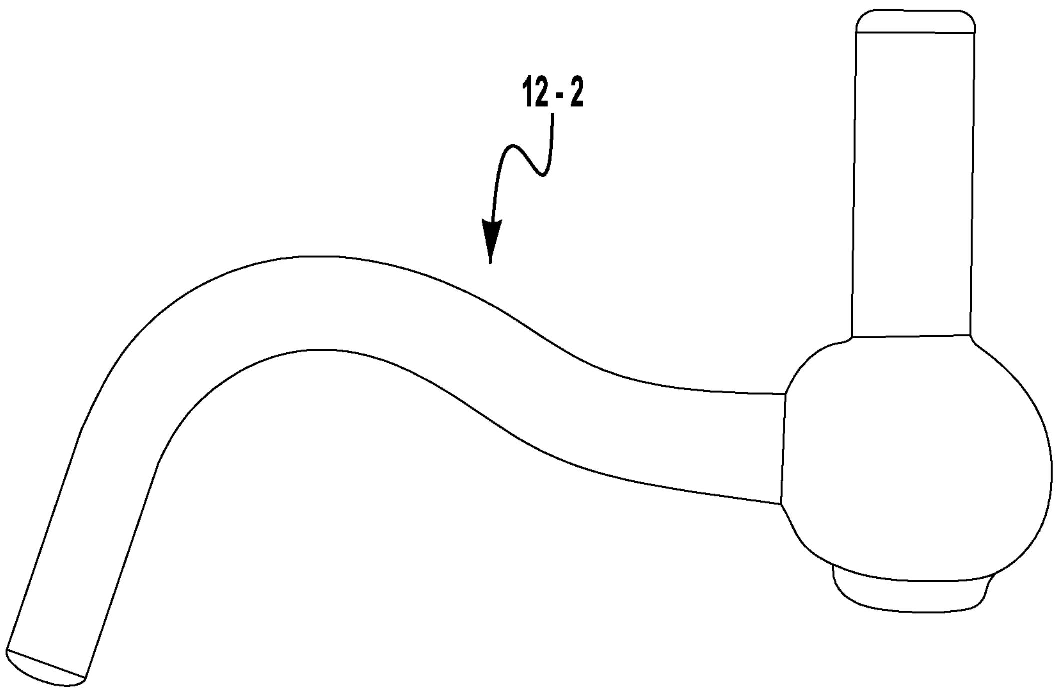


FIG. 2B

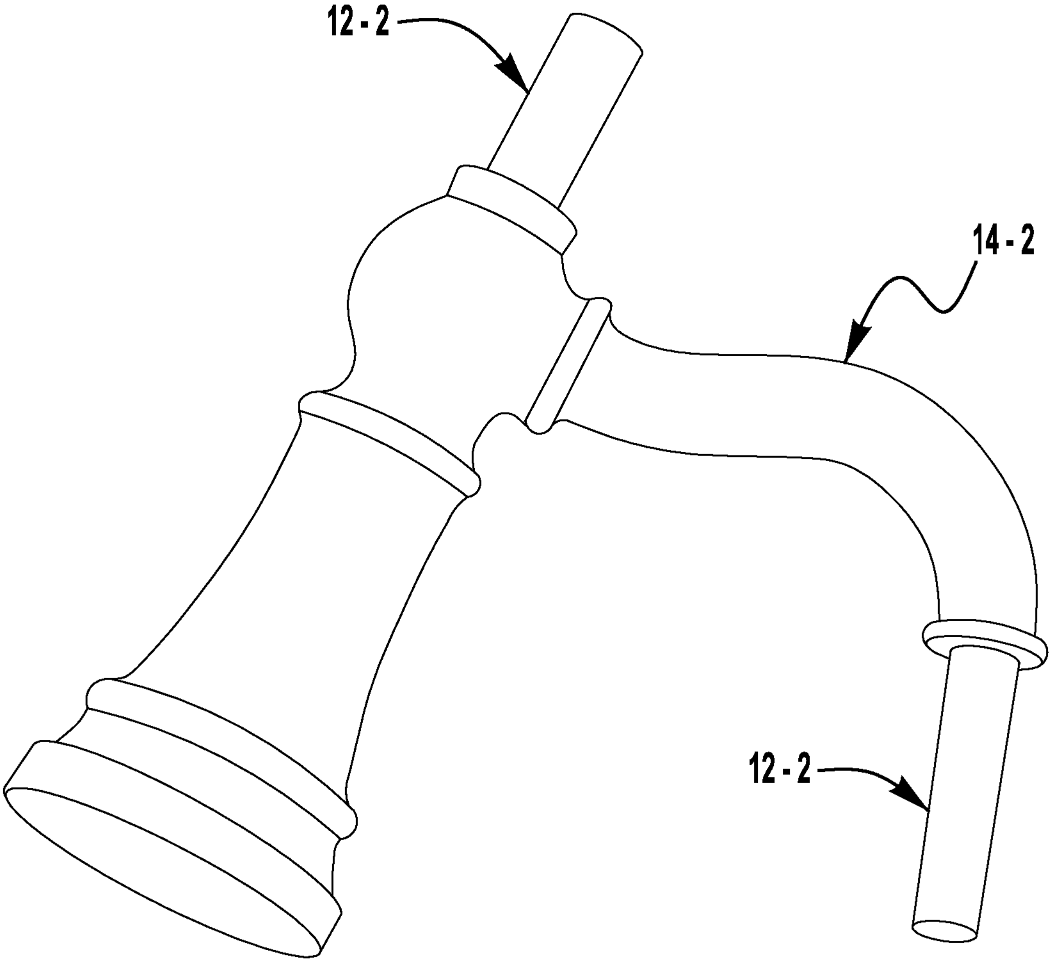


FIG. 2C

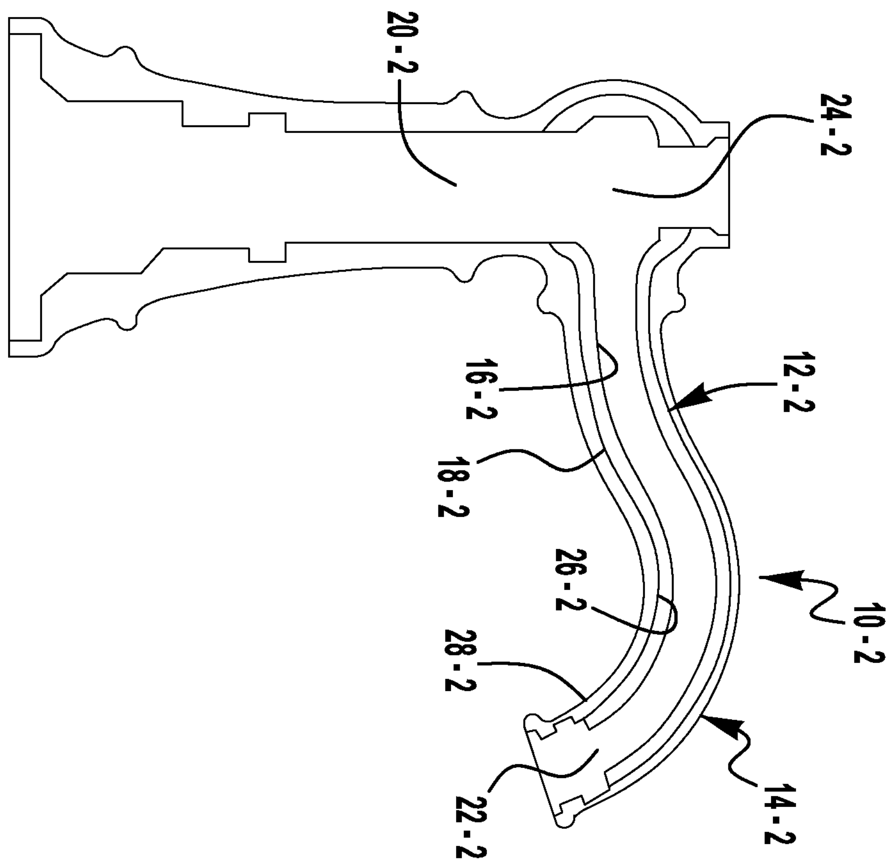


FIG. 2E

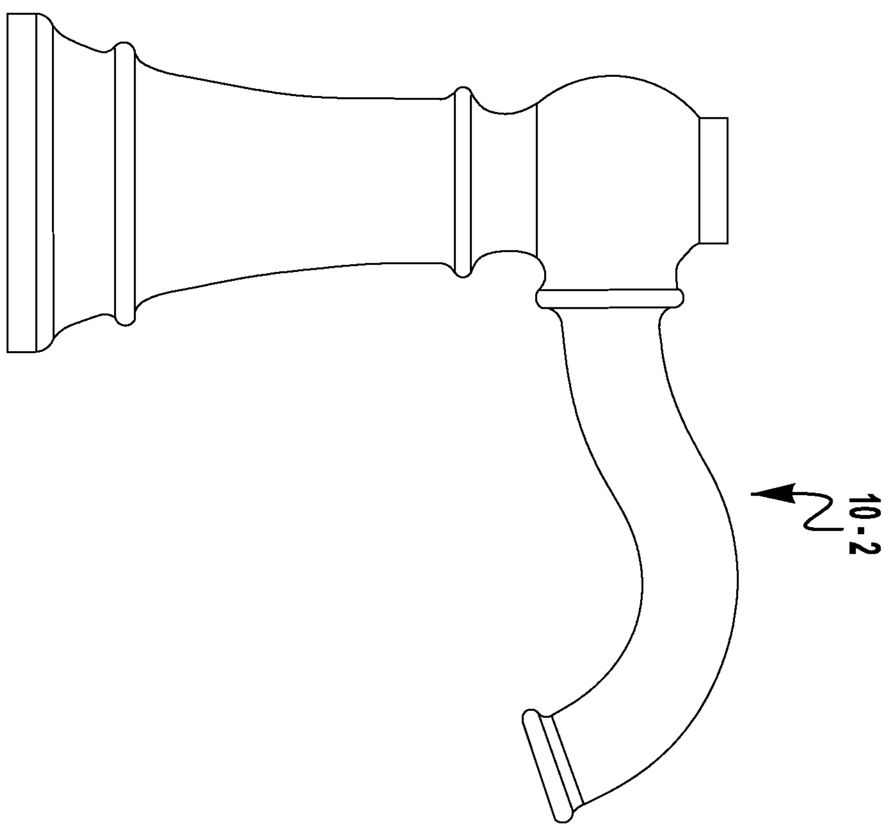


FIG. 2D

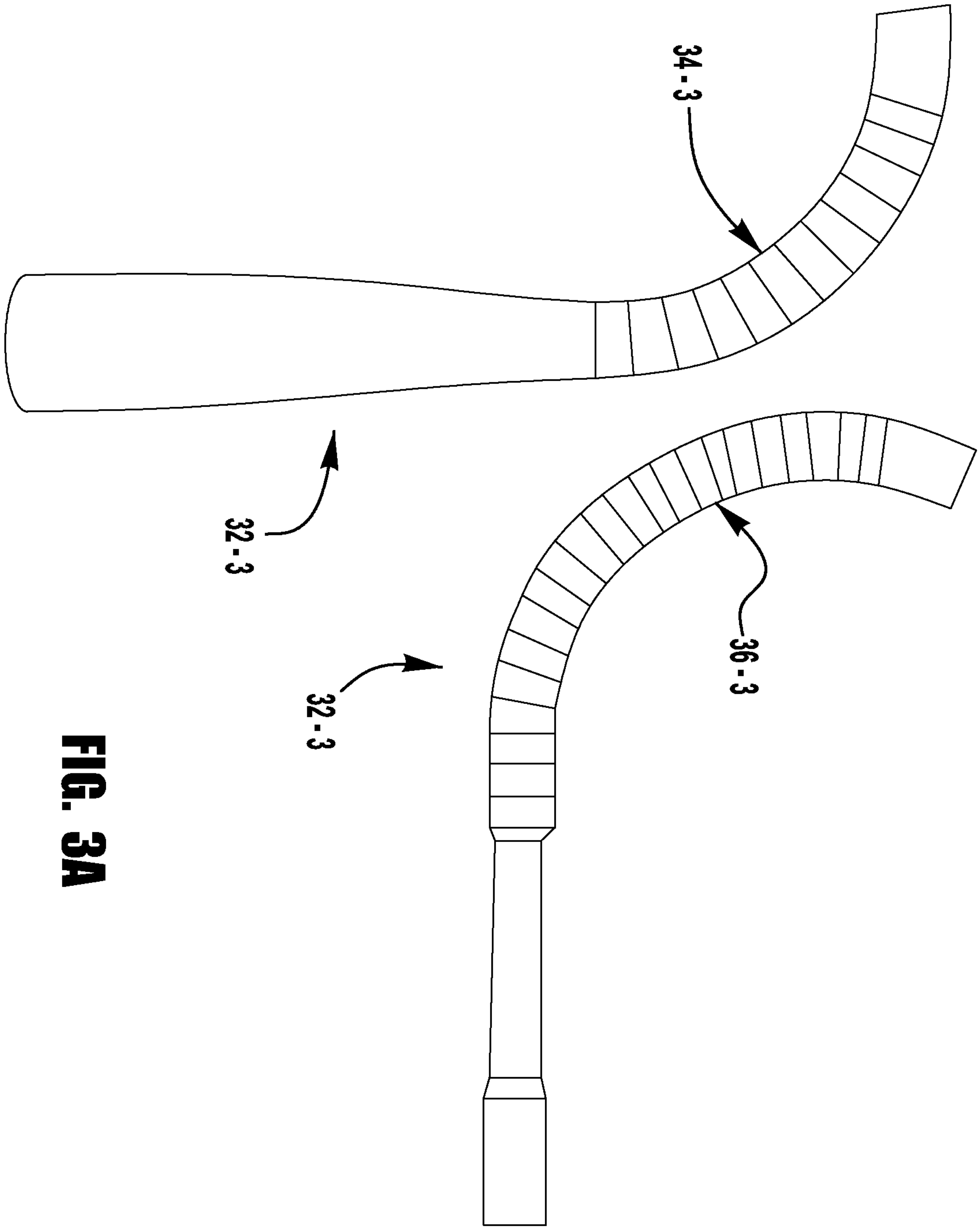


FIG. 3A

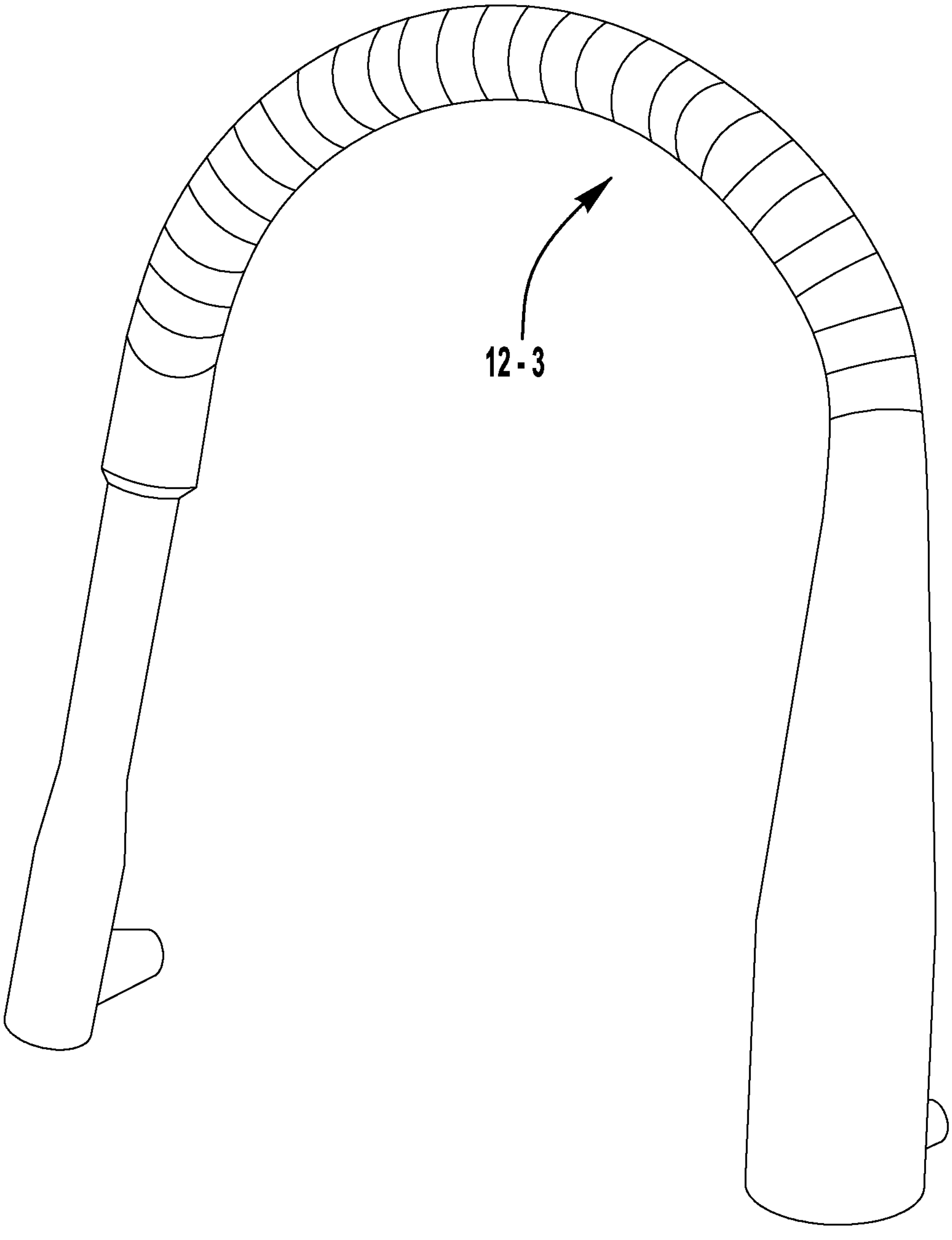


FIG. 3B

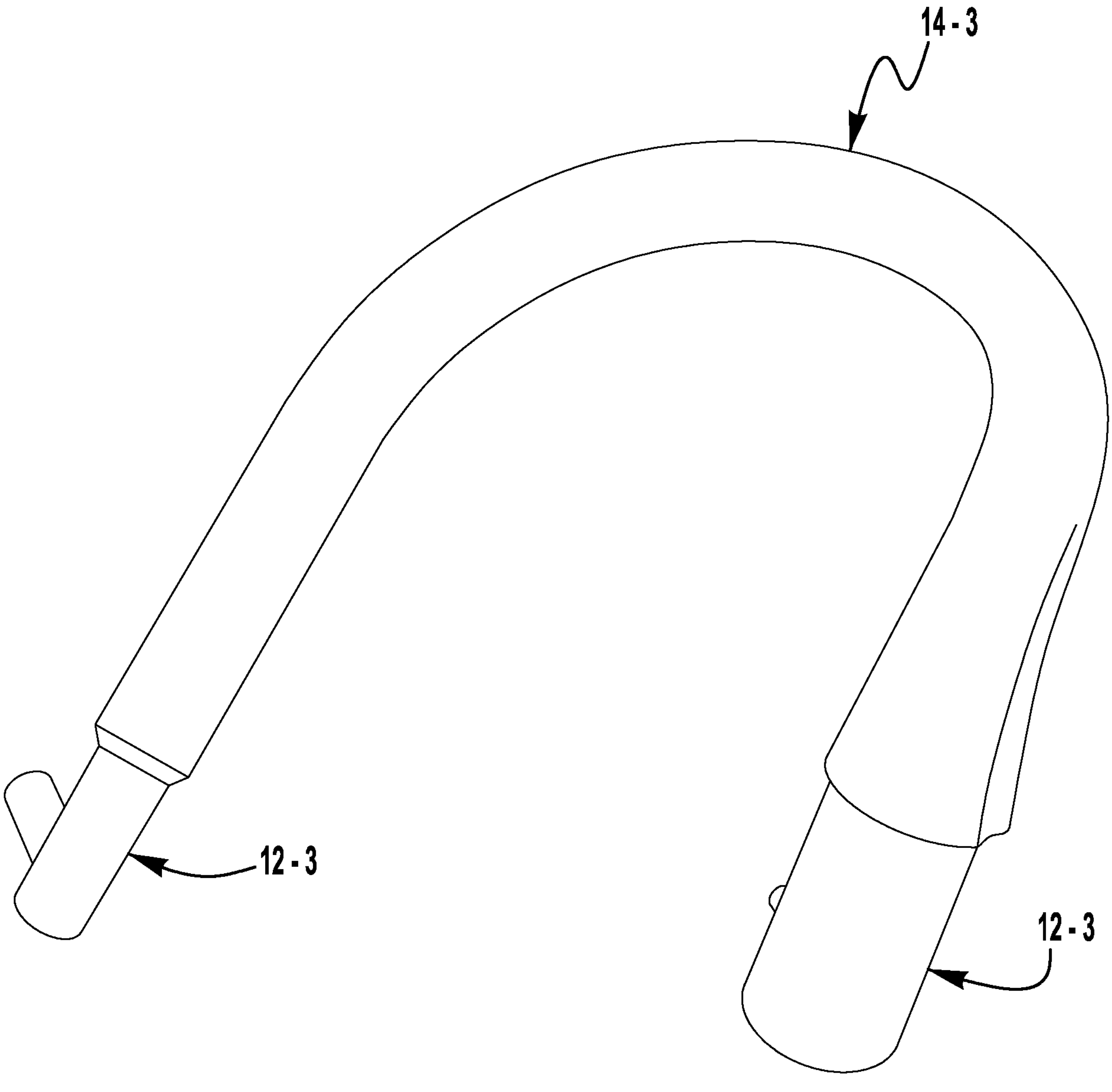


FIG. 3C

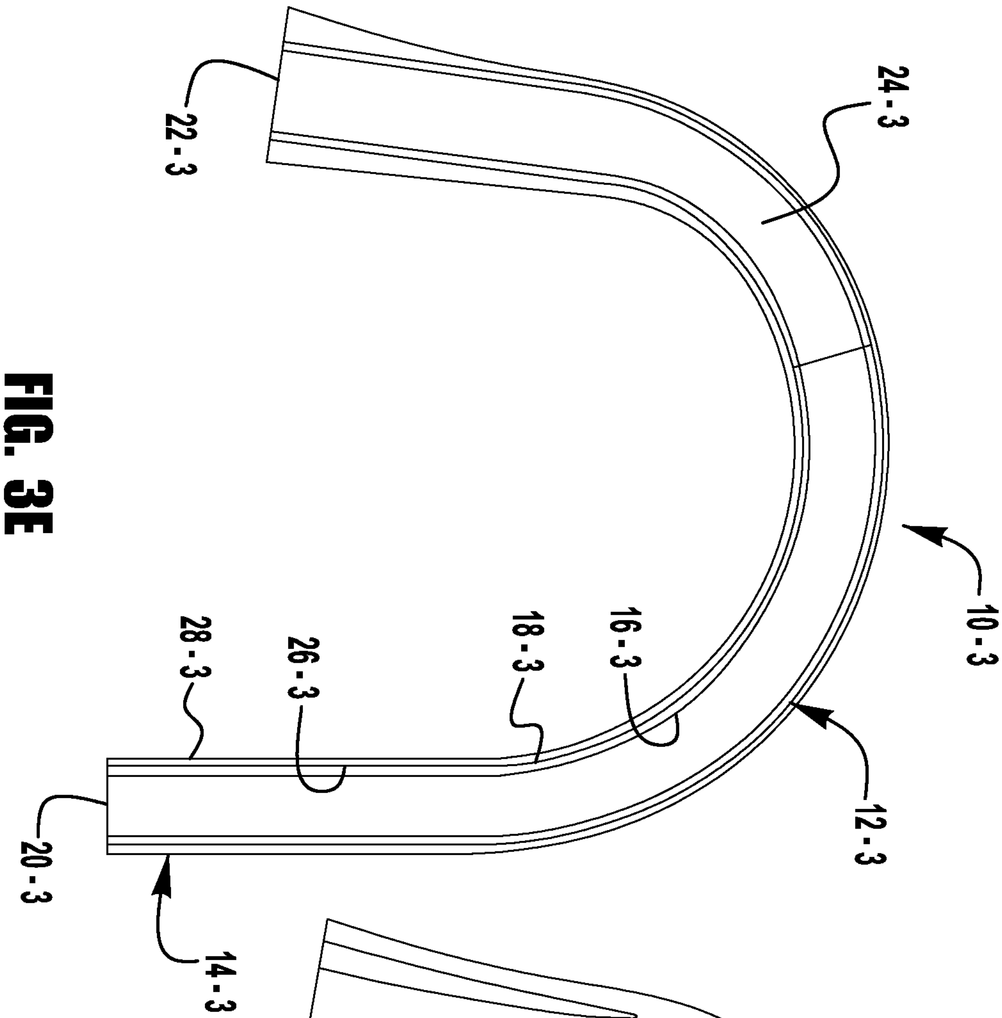


FIG. 3E

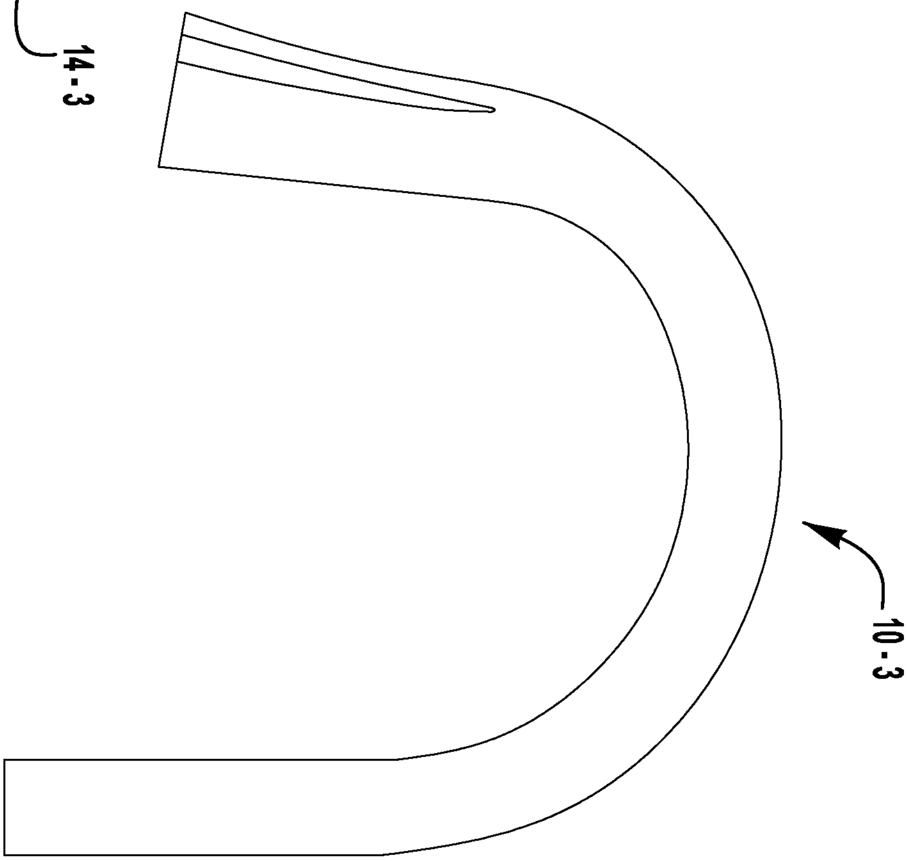


FIG. 3D

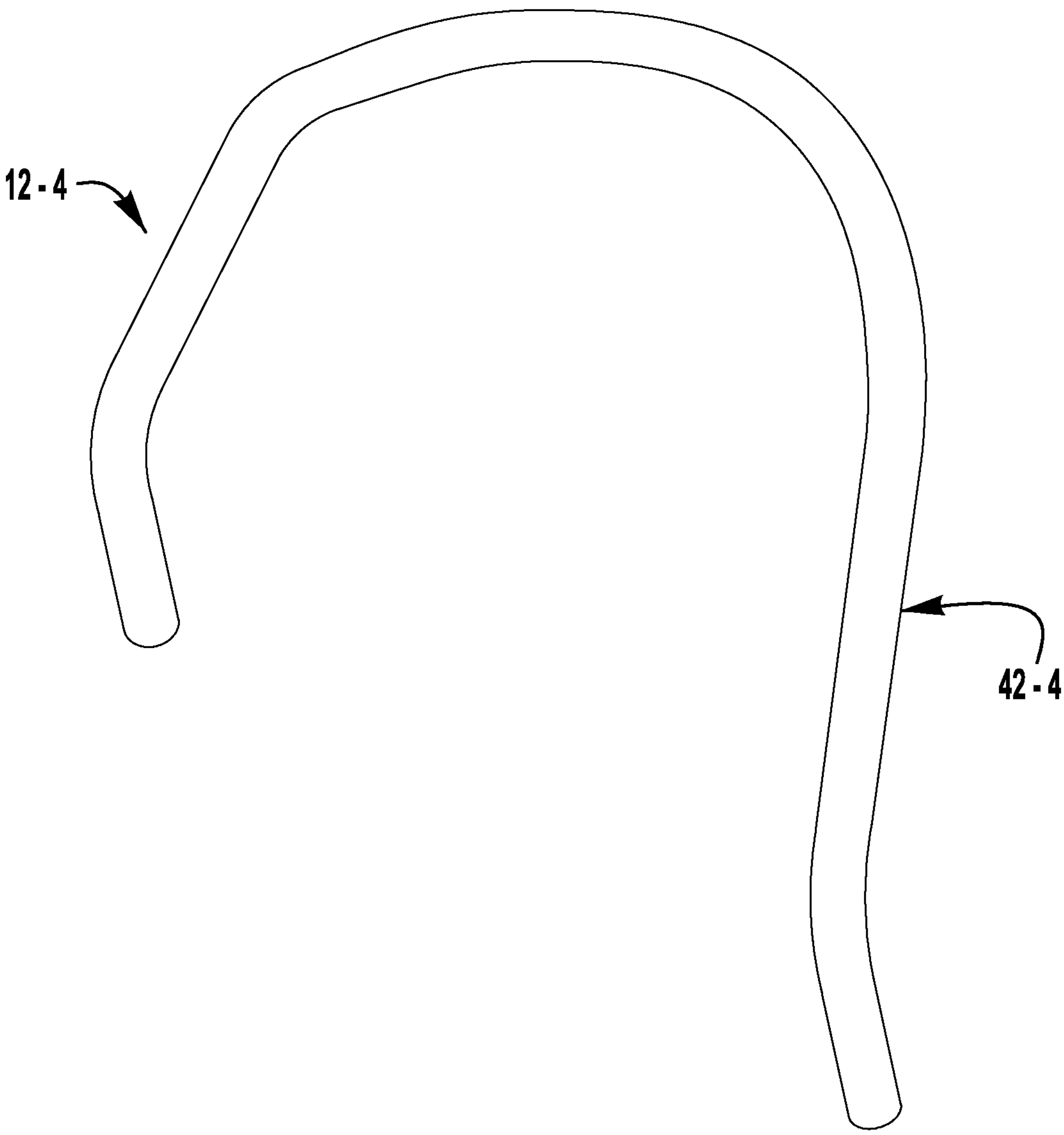


FIG. 4A

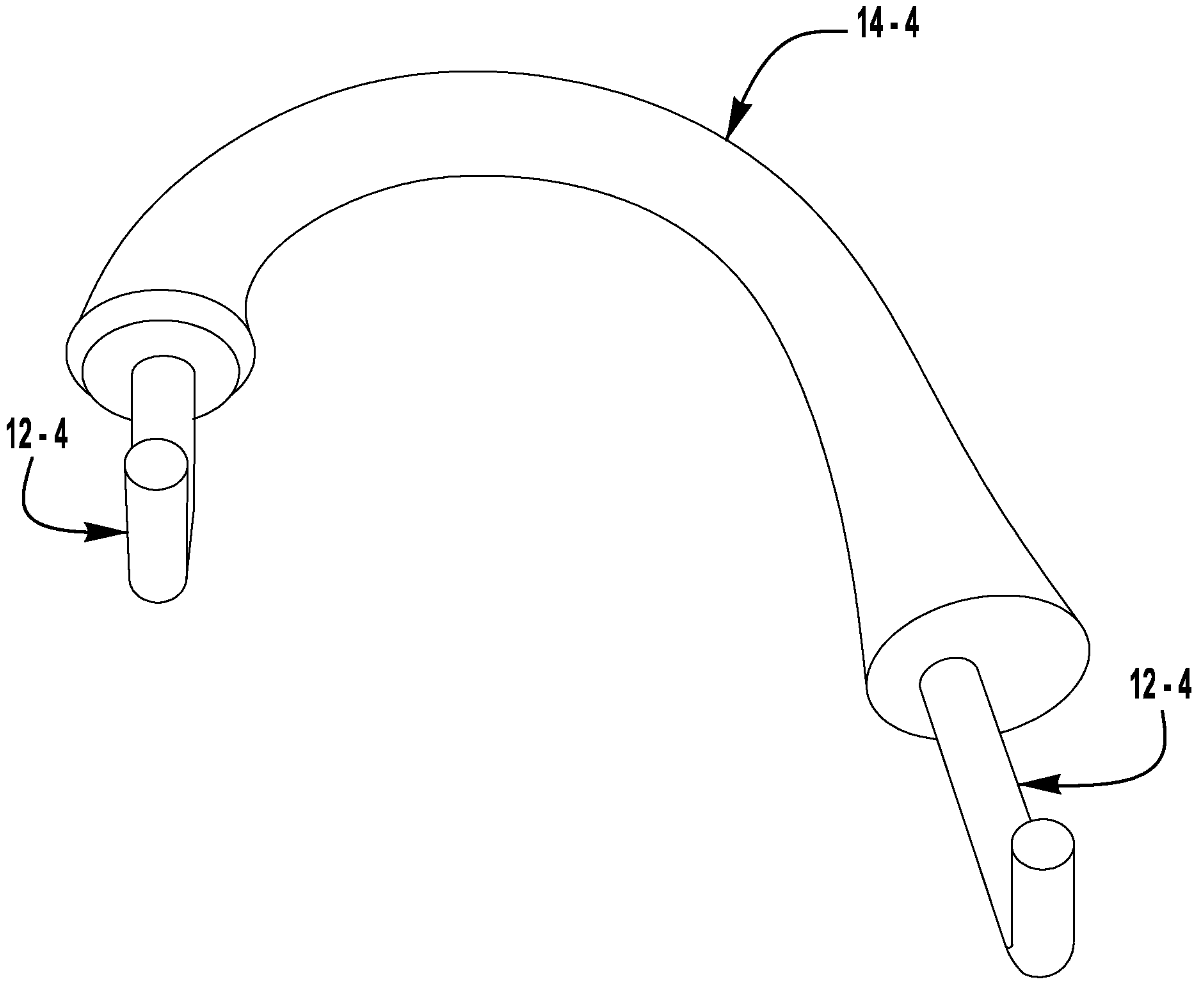


FIG. 4B

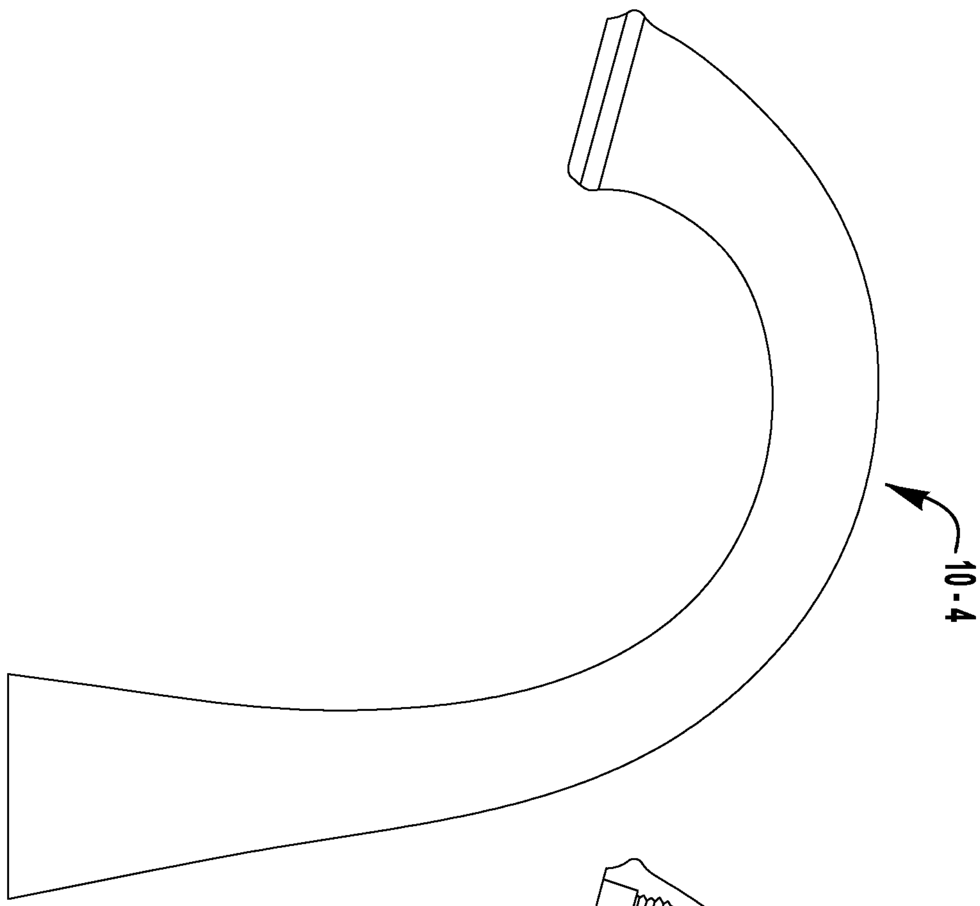


FIG. 4C

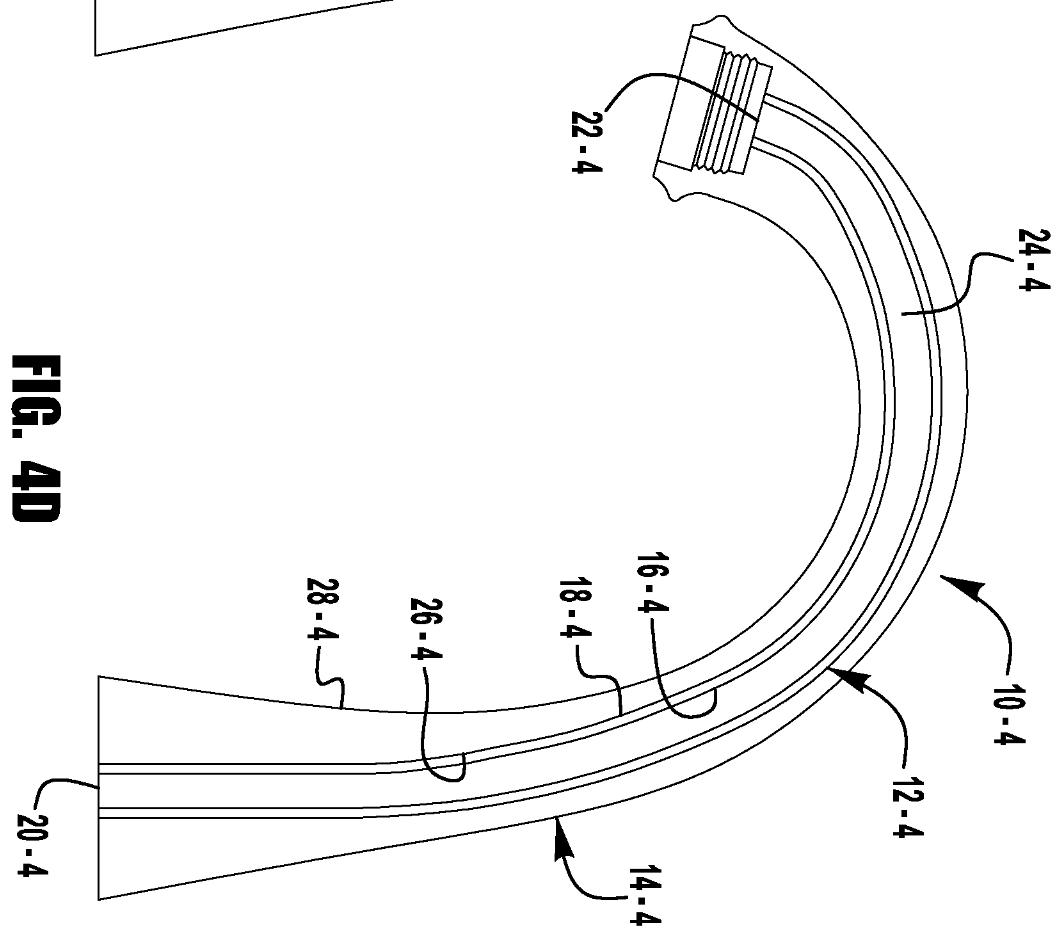


FIG. 4D

FIG. 5A

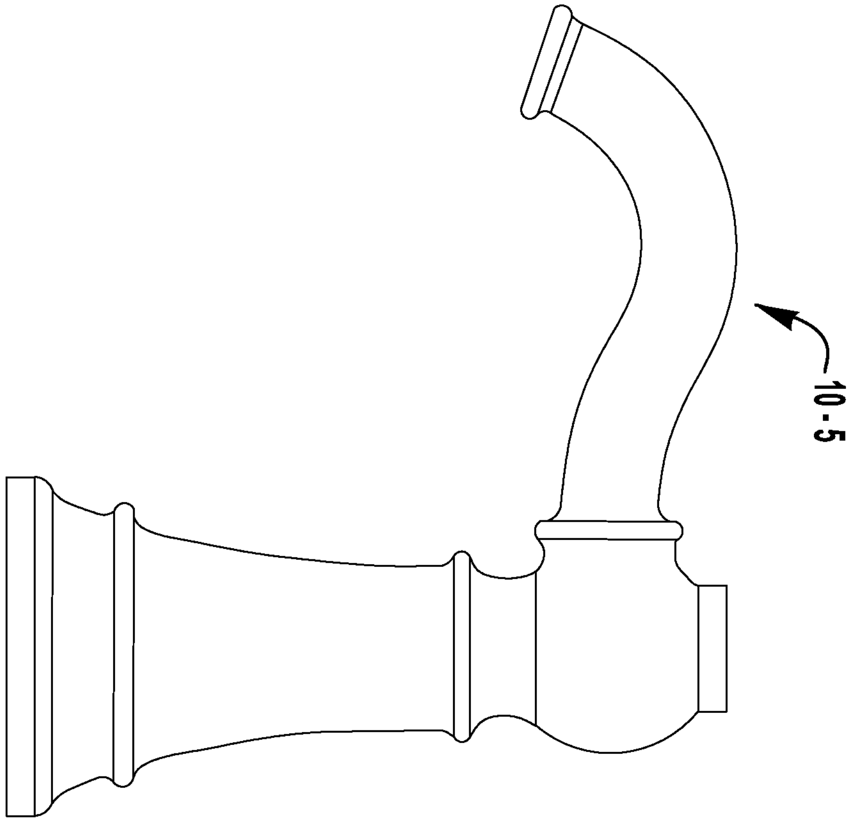
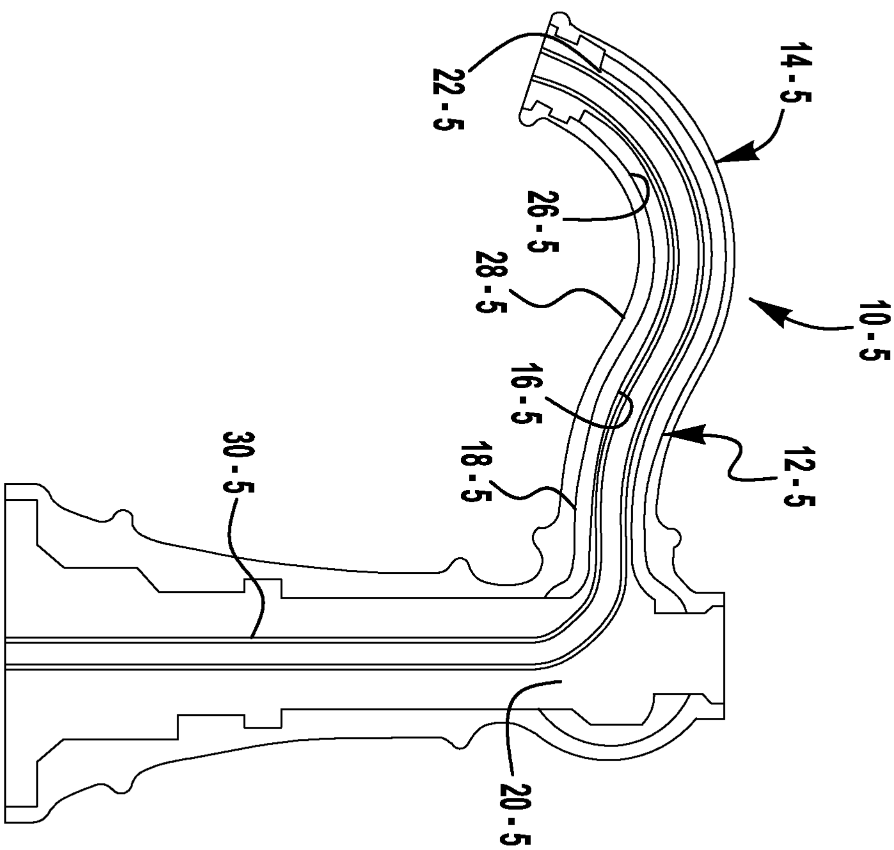


FIG. 5B



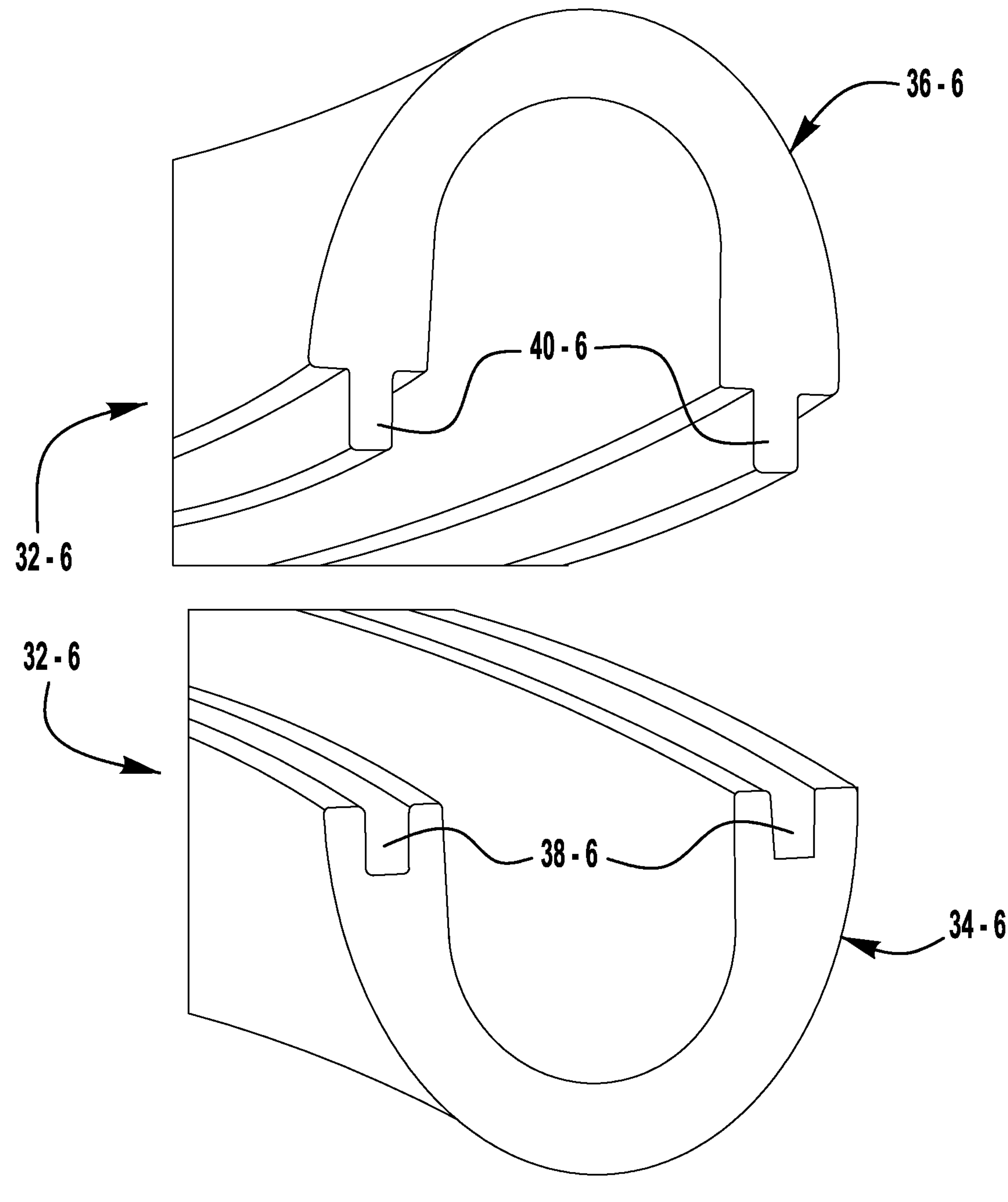


FIG. 6

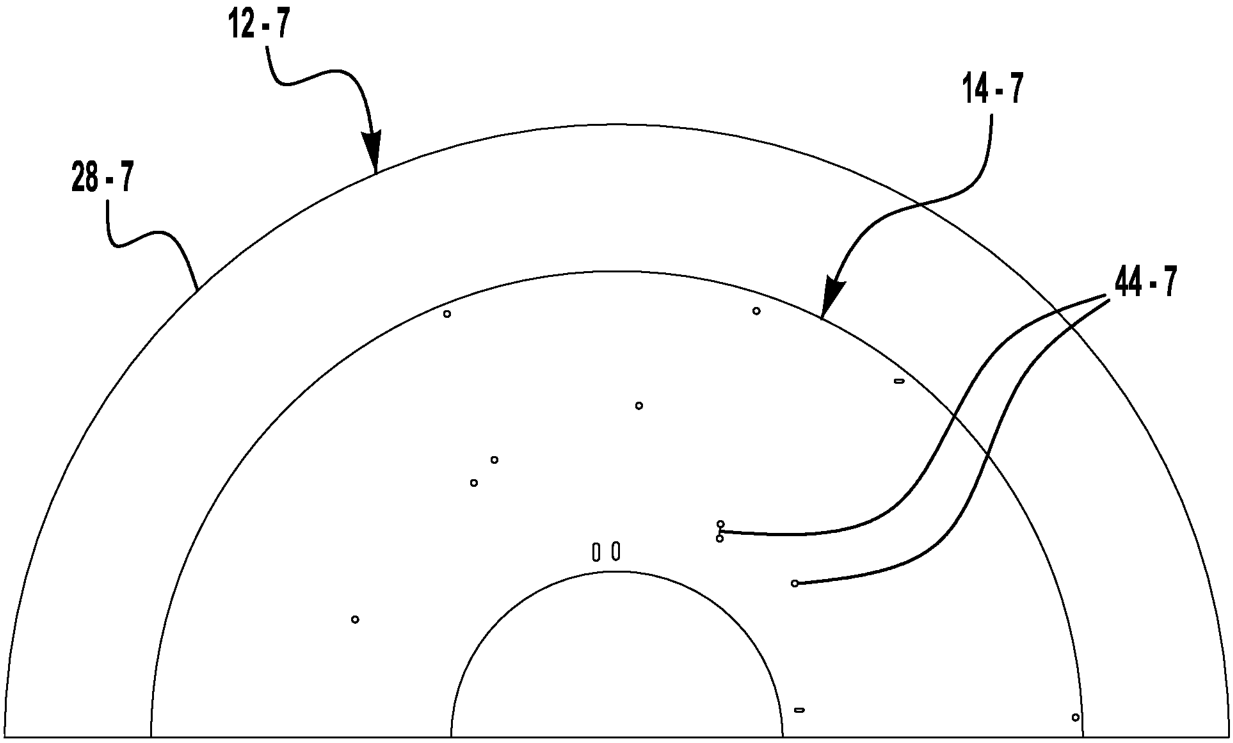


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/038352

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E03C 1/04 (2014.01)
CPC - E03C 1/0404 (2014.07)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - E03C 1/04 (2014.01)
CPC - E03C 1/0404 (2014.07)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 4/675, 678; 29/890.14, 890.141; 137/375, 801; 138/114; 164/47, 91, 98

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,579,808 A (MIKOL et al) 03 December 1996 (03.12.1996) entire document	1-26
Y	EP 0 632 220 A2 (ORLANDI) 04 January 1995 (04.01.1995) entire document	1-10, 14-23
Y	US 2003/0062088 A1 (PERLA) 03 April 2003 (03.04.2003) entire document	11-13, 24-26
Y	US 5,348,778 A (KNIPP et al) 20 September 1994 (20.09.1994) entire document	4, 9, 17, 22

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 September 2014	08 OCT 2014

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774