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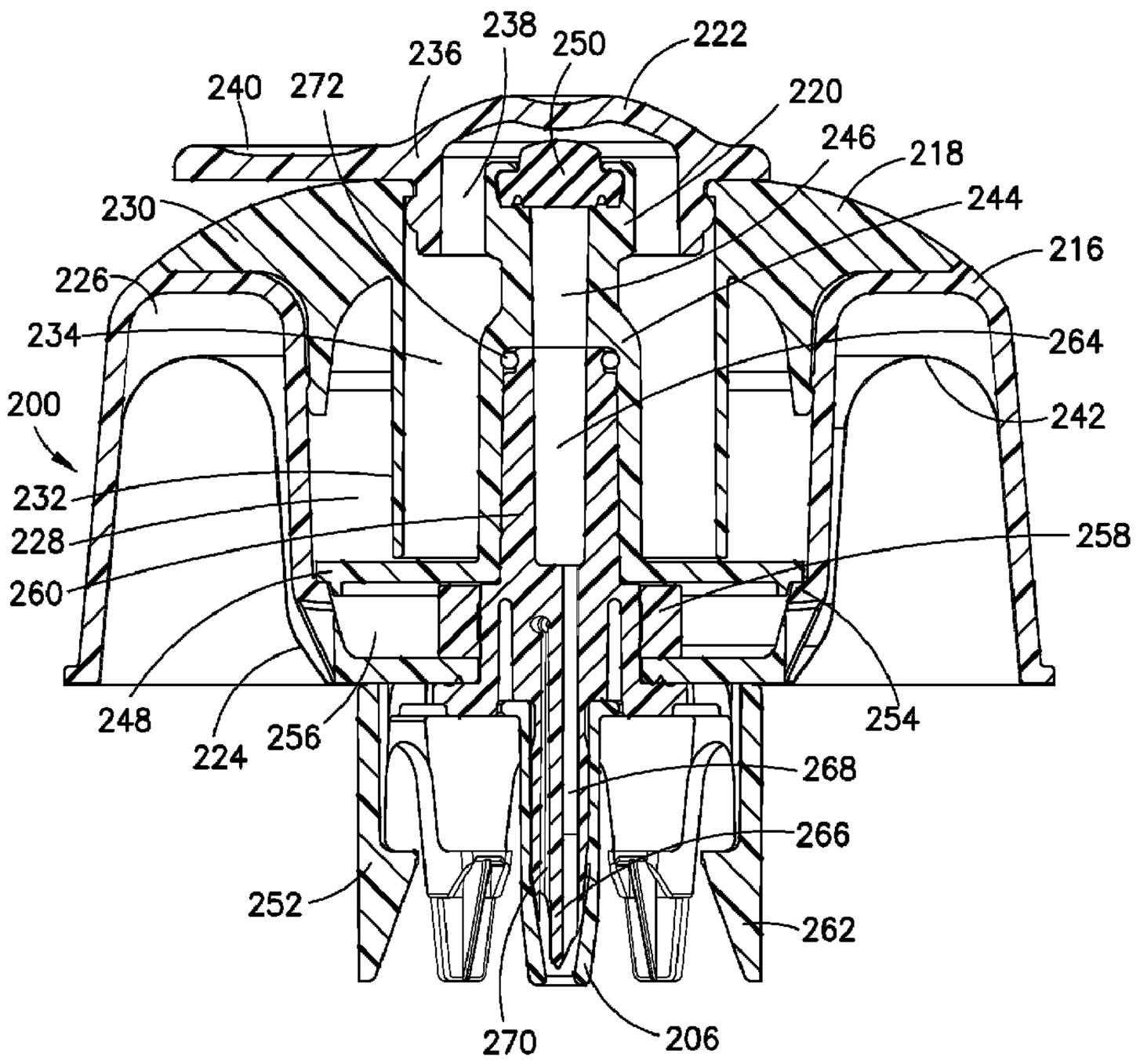
(72) **Inventeurs/Inventors:**
MARICI, PAUL PAIA, US;
YEMANE-TEKESTE, GIRUM, US

(73) **Propriétaire/Owner:**
BECTON DICKINSON AND COMPANY LIMITED, IE

(74) **Agent:** PIASETZKI NENNIGER KVAS LLP

(54) **Titre : SYSTEME AVEC ADAPTATEUR POUR TRANSFERT DE FLUIDES EN CIRCUIT FERME**
(54) **Title: SYSTEM WITH ADAPTER FOR CLOSED TRANSFER OF FLUIDS**




(57) **Abrégé/Abstract:**
A vial access device includes an outer housing defining an annular space and an inner space, an inner housing, and a connector configured to engage a mating connector with the connector having a body defining a central passageway and a flange that

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(57) **Abrégé(suite)/Abstract(continued):**
extends radially outward from the body. The flange and the housing defining a filter space that is in fluid communication with the annular space. A pressure equalization system is positioned within the annular space of the outer housing. The device also includes a vial connection element configured to be secured to a vial and having a body and a spike member extending from the body. The spike member defining a fluid passageway and a vent passageway with the fluid passageway in fluid communication with the central passageway of the connector and the vent passageway in fluid communication with the filter space and the annular space.

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(71) Applicant: **BECTON DICKINSON AND COMPANY LIMITED** [IE/IE]; Pottery Road, Kill O'The Grange, Dun Laoghaire (IE).

(72) Inventor; and
(71) Applicant *(for VC only)*: **MARICI, Paul, Paia** [US/US]; 38 Hedgerow Street, Piscataway, New Jersey 08854 (US).

(72) Inventor: **YEMANE-TEKESTE, Girum**; 240 Prospect Avenue, Apt. 404, Hackensack, New Jersey 07601 (US).

(74) Agents: **MILES, Kirk, M.** et al.; The Webb Law Firm, One Gateway Center, 420 Ft. Duquesne Blvd., Suite 1200, Pittsburgh, Pennsylvania 15222 (US).

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

*[Continued on next page]*

(54) **Title**: SYSTEM WITH ADAPTER FOR CLOSED TRANSFER OF FLUIDS

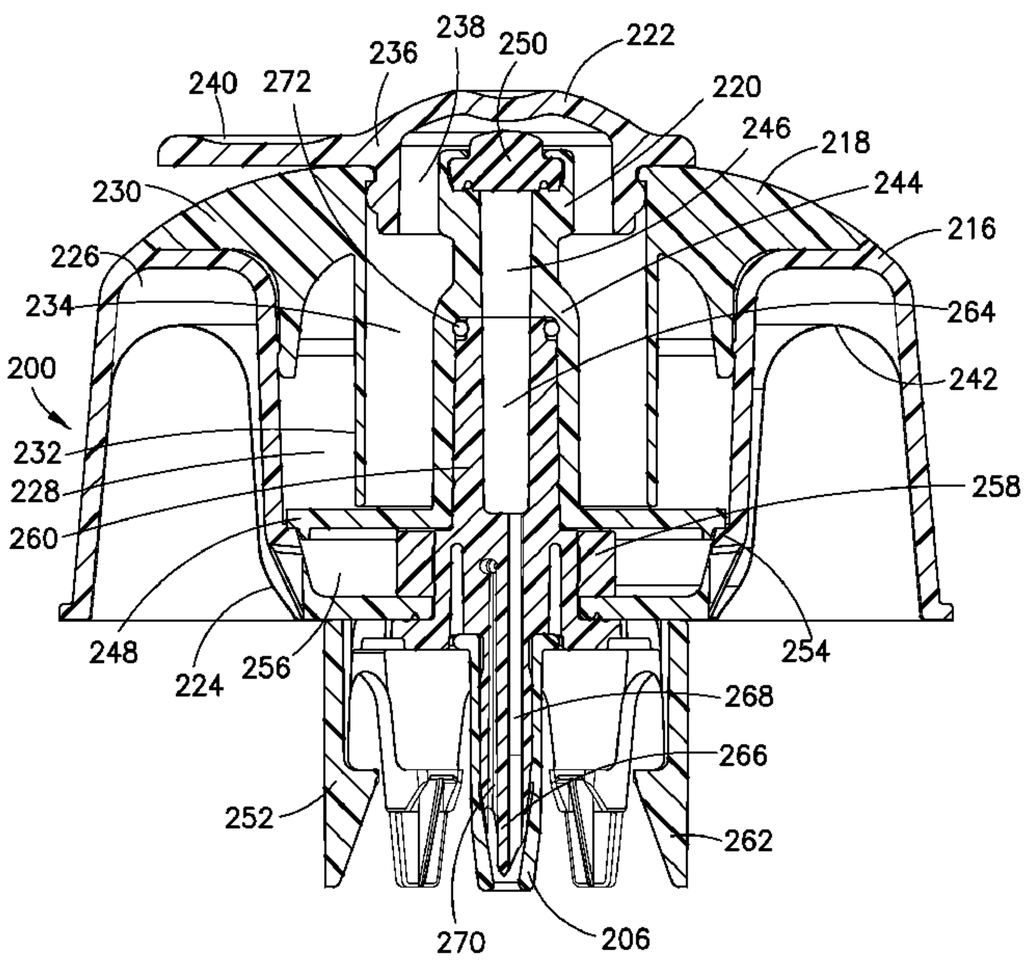


FIG.27

(57) **Abstract**: A vial access device includes an outer housing defining an annular space and an inner space, an inner housing, and a connector configured to engage a mating connector with the connector having a body defining a central passageway and a flange that extends radially outward from the body. The flange and the housing defining a filter space that is in fluid communication with the annular space. A pressure equalization system is positioned within the annular space of the outer housing. The device also includes a vial connection element configured to be secured to a vial and having a body and a spike member extending from the body. The spike member defining a fluid passageway and a vent passageway with the fluid passageway in fluid communication with the central passageway of the connector and the vent passageway in fluid communication with the filter space and the annular space.

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# SYSTEM WITH ADAPTER FOR CLOSED TRANSFER OF FLUIDS

## BACKGROUND OF THE INVENTION

1. Field of the Disclosure

**[0001]** The present disclosure relates generally to a system for the closed transfer of fluids. More particularly, the present disclosure relates to a system that accommodates vials having different sizes and provides leak-proof sealing and pressure equalization during engagement of a cannula with a vial, during transfer of a substance from a vial chamber to a barrel chamber via the cannula, and during disengagement of the cannula from the vial.

2. Description of the Related Art

**[0002]** Health care providers reconstituting, transporting, and administering hazardous drugs, such as cancer treatments, can put themselves at risk of exposure to these medications and present a major hazard in the health care environment. For example, nurses treating cancer patients risk being exposed to chemotherapy drugs and their toxic effects. Unintentional chemotherapy exposure can affect the nervous system, impair the reproductive system, and bring an increased risk of developing blood cancers in the future. In order to reduce the risk of health care providers being exposed to toxic drugs, the closed transfer of these drugs becomes important.

**[0003]** Some drugs must be dissolved or diluted before they are administered, which involves transferring a solvent from one container to a sealed vial containing the drug in powder or liquid form, by means of a needle. Drugs may be inadvertently released into the atmosphere in gas form or by way of aerosolization, during the withdrawal of the needle from the vial, and while the needle is inside the vial if any differential pressure exists between the interior of the vial and the surrounding atmosphere.

## SUMMARY OF THE INVENTION

**[0004]** In one aspect of the present invention, a vial access device includes an outer housing defining an annular space and an inner space, an inner housing having a body defining a central opening with at least a portion of the inner housing positioned within the inner space of the outer housing, and a connector configured to engage a mating connector with the connector having a body defining a central passageway and a flange that extends radially outward from the body. The flange and the housing define a filter space that is in fluid communication with the annular space. A pressure equalization system is positioned within the annular space of the outer housing with the pressure equalization system configured to change a volume of space

defined by the annular space and the pressure equalization system. The device also includes a vial connection element configured to be secured to a vial with the vial connection element having a body and a spike member extending from the body. The spike member defines a fluid passageway and a vent passageway with the fluid passageway in fluid communication with the central passageway of the connector and the vent passageway in fluid communication with the filter space and the annular space. A filter is positioned in the filter space.

**[0005]** The vial access device may further include a top cap having a body secured to the inner housing with the body of the top cap defining a recessed portion that receives a portion of the connector. The top cap may include a gripping surface configured to allow a user to remove the top cap from the inner housing.

**[0006]** The body of the vial connection element may define a central passageway, with the body of the vial connection element received within the central passageway of the connector with the central passageway of the vial connection element aligned with the central passageway of the connector. An O-ring may be positioned between the vial connection element and the connector.

**[0007]** The flange of the connector may abut a ledge defined by the outer housing, with the ledge extending radially inward into the inner space of the outer housing.

**[0008]** The inner housing may have a top surface having a shape that conforms to an outer surface of the outer housing. The body of the inner housing may have a cylindrical portion extending axially into the inner space of the outer housing. A membrane may be positioned on the connector adjacent to the central passageway of the connector.

**[0009]** The pressure equalization system may include a toroidal balloon configured to expand axially outer of the annular space of the outer housing. The filter may be annular and may be a hydrophobic filter.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** The above-mentioned and other features and advantages of this disclosure, and the manner of attaining them, will become more apparent and the disclosure itself will be better understood by reference to the following descriptions of aspects of the disclosure taken in conjunction with the accompanying drawings, wherein:

**[0011]** **Fig. 1** is an exploded, perspective view of a system in accordance with an aspect of the present invention.

**[0012]** **Fig. 2** is an assembled, perspective view of a system in accordance with an aspect of the present invention.

**[0013]** **Fig. 3** is a bottom, assembled view of a system in accordance with an aspect of the present invention.

**[0014]** **Fig. 4A** is a top, assembled view of a system in accordance with an aspect of the present invention.

**[0015]** **Fig. 4B** is a cross-sectional view of the system taken along line **4B-4B** of **Fig. 4A** in accordance with an aspect of the present invention.

**[0016]** **Fig. 4C** is a cross-sectional view of the system taken along line **4C-4C** of **Fig. 4A** in accordance with an aspect of the present invention.

**[0017]** **Fig. 4D** is a perspective view of an adapter within an elongate aperture of an outer housing of a system in accordance with an aspect of the present invention.

**[0018]** **Fig. 5A** is a perspective view of an outer housing in accordance with an aspect of the present invention.

**[0019]** **Fig. 5B** is a cross-sectional view of the outer housing of **Fig. 5A** in accordance with an aspect of the present invention.

**[0020]** **Fig. 6A** is a perspective view of an inner housing in accordance with an aspect of the present invention.

**[0021]** **Fig. 6B** is a side elevation view of an inner housing in accordance with an aspect of the present invention.

**[0022]** **Fig. 6C** is a cross-sectional view of the inner housing of **Fig. 6A** in accordance with an aspect of the present invention.

**[0023]** **Fig. 6D** is a top view of an inner housing in accordance with an aspect of the present invention.

**[0024]** **Fig. 7** is a cross-sectional view of a system in accordance with an aspect of the present invention.

**[0025]** **Fig. 8A** is a perspective view of a connector in accordance with an aspect of the present invention.

**[0026]** **Fig. 8B** is a side elevation view of a connector in accordance with an aspect of the present invention.

**[0027]** **Fig. 8C** is another perspective view of a connector in accordance with an aspect of the present invention.

**[0028]** **Fig. 8D** is another side elevation view of a connector in accordance with an aspect of the present invention.

**[0029]** **Fig. 8E** is a partial-sectional view of the connector of **Fig. 8A** in accordance with an aspect of the present invention.

**[0030]** **Fig. 8F** is a bottom view of a connector in accordance with an aspect of the present invention.

**[0031]** **Fig. 8G** is a top view of a connector in accordance with an aspect of the present invention.

**[0032]** **Fig. 9A** is a side elevation view of a connector in accordance with another aspect of the present invention.

**[0033]** **Fig. 9B** is a perspective view of a connector in accordance with another aspect of the present invention.

**[0034]** **Fig. 10** is a perspective view of a top cap housing in accordance with an aspect of the present invention.

**[0035]** **Fig. 11** is a cross-sectional view of a system in accordance with an aspect of the present invention.

**[0036]** **Fig. 12A** is a perspective view of an adapter in accordance with an aspect of the present invention.

**[0037]** **Fig. 12B** is another perspective view of an adapter in accordance with an aspect of the present invention.

**[0038]** **Fig. 12C** is a top view of an adapter in accordance with an aspect of the present invention.

**[0039]** **Fig. 12D** is a side elevation view of an adapter in accordance with an aspect of the present invention.

**[0040]** **Fig. 12E** is a bottom view of an adapter in accordance with an aspect of the present invention.

**[0041]** **Fig. 12F** is another side elevation view of an adapter in accordance with an aspect of the present invention.

**[0042]** **Fig. 12G** is another side elevation view of an adapter in accordance with an aspect of the present invention.

**[0043]** **Fig. 12H** is another side elevation view of an adapter in accordance with an aspect of the present invention.

**[0044]** **Fig. 13** is a perspective view of a system of the present disclosure connected to a first vial in accordance with an aspect of the present invention.

**[0045]** **Fig. 14** is a side elevation view of a system of the present disclosure connected to a first vial in accordance with an aspect of the present invention.

**[0046]** **Fig. 15** is a cross-sectional view of the system connected to a first vial taken along line **15-15** of **Fig. 14** in accordance with an aspect of the present invention.

**[0047]** **Fig. 16** is a perspective view of a system of the present disclosure connected to a second vial in accordance with an aspect of the present invention.

**[0048]** **Fig. 17** is a side elevation view of a system of the present disclosure connected to a second vial in accordance with an aspect of the present invention.

**[0049]** **Fig. 18** is a cross-sectional view of the system connected to a second vial taken along line **18-18** of **Fig. 17** in accordance with an aspect of the present invention.

**[0050]** **Fig. 19** is a side elevation view of a system having a pressure equalization system connected to a vial in accordance with an aspect of the present invention.

**[0051]** **Fig. 20** is an exploded, perspective view of a system in accordance with an aspect of the present invention.

**[0052]** **Fig. 21** is an assembled, perspective view of a system in accordance with an aspect of the present invention.

**[0053]** **Fig. 22** is a perspective view of a barrel assembly in accordance with an aspect of the present invention.

**[0054]** **Fig. 23** is a cross-sectional view of the barrel assembly of **Fig. 22** in accordance with an aspect of the present invention.

**[0055]** **Fig. 24** is a perspective view of a system in accordance with a further aspect of the present invention.

**[0056]** **Fig. 25** is an exploded perspective view of the system of **Fig. 24** in accordance with an aspect of the present invention.

**[0057]** **Fig. 26** is a front view of the system of **Fig. 24** in accordance with an aspect of the present invention.

**[0058]** **Fig. 27** is a cross-sectional view taken along line **27-27** in **Fig. 26** in accordance with an aspect of the present invention.

**[0059]** **Fig. 28** is a perspective view of the system of **Fig. 24** provided with a packaging member in accordance with an aspect of the present invention.

**[0060]** **Fig. 29** is an exploded perspective view of the system of **Fig. 24** provided with a packaging member in accordance with an aspect of the present invention.

**[0061]** **Fig. 30** is a front view of the system of **Fig. 24** provided with a packaging member in accordance with an aspect of the present invention.

**[0062]** **Fig. 31** is a cross-sectional view taken along line **31-31** in **Fig. 30** in accordance with an aspect of the present invention.

**[0063]** **Fig. 32** is a perspective view of the system of **Fig. 24** showing the system connected to a vial and a syringe adapter in accordance with an aspect of the present invention.

**[0064]** **Fig. 33** is an exploded perspective view of the system of **Fig. 24** showing the system along with a vial and a syringe adapter in accordance with an aspect of the present invention.

**[0065]** **Fig. 34** is a front view of the system of **Fig. 24** showing the system connected to a vial and a syringe adapter in accordance with an aspect of the present invention.

**[0066]** **Fig. 35** is a cross-sectional view taken along line **35-35** in **Fig. 34** showing the system connected to a vial and a syringe adapter in accordance with an aspect of the present invention.

**[0067]** **Fig. 36** is a perspective view of a vial adapter in accordance with a further aspect of the present invention, showing the vial adapter secured to a vial in an expanded state.

**[0068]** **Fig. 37** is a perspective view of the vial adapter of **Fig. 36** showing the vial adapter in an expanded state in accordance with an aspect of the present invention.

**[0069]** **Fig. 38** is a perspective view of the vial adapter of **Fig. 36** showing the vial adapter in an unexpanded state in accordance with an aspect of the present invention.

**[0070]** **Fig. 39** is a perspective view of a vial adapter in accordance with an aspect of the present invention, showing the vial adapter in an expanded state.

**[0071]** **Fig. 40** is a perspective view of the vial adapter of **Fig. 39** showing the vial adapter in an unexpanded state in accordance with an aspect of the present invention.

**[0072]** Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate exemplary aspects of the disclosure, and such exemplifications are not to be construed as limiting the scope of the disclosure in any manner.

## DETAILED DESCRIPTION

**[0073]** The following description is provided to enable those skilled in the art to make and use the described aspects contemplated for carrying out the invention. Various modifications, equivalents, variations, and alternatives, however, will remain readily apparent to those skilled in the art. Any and all such modifications, variations, equivalents, and alternatives are intended to fall within the spirit and scope of the present invention.

**[0074]** For purposes of the description hereinafter, the terms “upper”, “lower”, “right”, “left”, “vertical”, “horizontal”, “top”, “bottom”, “lateral”, “longitudinal”, and derivatives thereof shall relate to the invention as it is oriented in the drawing figures. However, it is to be understood that the invention may assume various alternative variations, except where expressly specified to the contrary. It is also to be understood that the specific devices illustrated in the attached drawings, and described in the following specification, are simply

exemplary aspects of the invention. Hence, specific dimensions and other physical characteristics related to the aspects disclosed herein are not to be considered as limiting.

**[0075]** In the following discussion, "distal" refers to a direction generally toward an end of a vial access device adapted for contact with a container, such as a vial, and "proximal" refers to the opposite direction of distal, i.e., away from the end of a vial access device adapted for engagement with the container. For purposes of this disclosure, the above-mentioned references are used in the description of the components of a vial access device in accordance with the present disclosure.

**[0076]** **Figs. 1-23** illustrate an exemplary aspect of the present disclosure. Referring to **Figs. 1** and **2**, a system **10** for the closed transfer of fluids includes a vial access device **12** and an adapter **14** sized for movement within the vial access device **12** as described in more detail below. In one aspect, vial access device **12** includes outer housing **16**, inner housing **18**, connector **20**, top cap housing **22**, and pressure equalization system **24**. System **10** provides a device capable of accommodating a plurality of vials having different sizes. System **10** also provides substantially leak-proof sealing and pressure equalization during engagement of a cannula with a vial, during transfer of a substance from a vial chamber to a barrel chamber via the cannula, and during disengagement of the cannula from the vial. The leak-proof sealing of the system **10** substantially prevents leakage of both air and liquid during use of the system **10**. System **10** is compatible with a needle and syringe assembly for accessing a medication contained within a vial for administering the medication to a patient. System **10** is also compatible to be used with a drug reconstitution system.

**[0077]** Referring to **Figs. 1-4C**, vial access device **12** includes a vial access housing **26** having outer housing **16** and inner housing **18**. System **10** provides a device capable of accommodating a plurality of vials having different sizes. Vial access device **12** is configured to establish fluid communication between a first container, e.g., a first vial having a first vial size, and a second container, e.g., an injector and/or syringe assembly. For example, vial access device **12** is attachable to a first vial **80** as described in more detail below. Referring to **Figs. 16-19**, first vial **80** defining a first vial size **81** may be a standard drug vial of any type having an open head portion **83** covered by a pierceable septum **84** of an elastomeric material. Walls **85** of first vial **80** define a vial chamber **86** for containing a first substance **88**. First vial **80** includes a flange **87** located adjacent open head portion **83**. Vial septum **84** is engaged with head portion **83** of first vial **80** to seal the first substance **88** within vial chamber **86**. Furthermore, adapter **14** of system **10** is configured to establish fluid communication between a first container, e.g., a second vial having a second vial size, and a second container, e.g., an

injector and/or syringe assembly. For example, adapter **14** of system **10** is attachable to a second vial **90** as described in more detail below. Referring to **Figs. 13-15**, second vial **90** defining a second vial size **91** may be a standard drug vial of any type having an open head portion **93** covered by a pierceable septum **94** of an elastomeric material. Walls **95** of second vial **90** define a vial chamber **96** for containing a second substance **98**. Second vial **90** includes a flange **97** located adjacent open head portion **93**. Vial septum **94** is engaged with head portion **93** of second vial **90** to seal the second substance **98** within vial chamber **96**.

**[0078]** Referring to **Figs. 5A** and **5B**, outer housing **16** generally includes a first or proximal end **30**; an opposing second or distal end **32**; an outer annular ring portion **34**; an inner neck portion **36** having a first region **38**, a second region **40**, and a third region **42**; a first shoulder **44** disposed between first region **38** and second region **40**; a second shoulder **46** disposed between second region **40** and third region **42**; a wall **48** defining an elongate aperture **50**; and a vial connection element **52** comprising vial grip members **54**, hook protrusions **56**, and angled walls **58**.

**[0079]** Referring to **Fig. 5B**, inner neck portion **36** of outer housing **16** includes first region **38**, second region **40**, and third region **42**. Outer annular ring portion **34** extends from first region **38** as shown in **Fig. 5B**. First shoulder **44** is disposed between first region **38** and second region **40** and is configured to provide an engagement surface with a flange portion **166** of a pressure equalization housing **160** as shown in **Fig. 7**. Second shoulder **46** is disposed between second region **40** and third region **42** and is configured to provide an engagement surface with a horizontal wall **110** of inner housing **18** as shown in **Fig. 6C**. Vertical wall **48** of third region **42** defines elongate aperture **50**. Referring to **Fig. 7**, in one aspect, vertical wall **48** defines elongate aperture **50** between an aperture proximal end **64** and an aperture distal end **66**.

**[0080]** Referring to **Fig. 5B**, a vial connection element **52** is disposed at second end **32** of outer housing **16**. In one aspect, vial connection element **52** includes a plurality of vial grip members **54** having hook protrusions **56** and angled walls **58**. In one aspect, vial grip members **54** are elastically deformable. Vial grip members **54** are attachable to a first vial **80** to secure vial access device **12** to the first vial **80**. Each vial grip member **54** includes a hook protrusion **56** arranged to engage a corresponding flange **87** on a container such as first vial **80** as shown in **Fig. 18**. Vial connection element **52** of vial access device **12** may be dimensioned to be attached to containers of any size and volume. In other aspects, vial connection element **52** of vial access device **12** may include other connection mechanisms for securing vial access device **12** to first vial **80** such as a threaded portion, a snap fit mechanism, locking tabs, or other similar

mechanism. Each vial grip member **54** includes an angled wall **58** arranged to provide a lead-in surface to center and align vial access device **12** on a vial.

**[0081]** Referring to **Fig. 5B**, a locking member or adapter engagement portion **68** is disposed on an interior surface **70** of wall **48** at second end **32** of outer housing **16**. Adapter engagement portion **68** acts as a physical barrier to prevent adapter **14** from being removed from within elongate aperture **50**. Adapter **14** is sized for movement within elongate aperture **50** of vial access housing **26** and adapter engagement portion **68** prevents adapter **14** from being removed from elongate aperture **50**. In one aspect, adapter engagement portion **68** comprises a protrusion.

**[0082]** Referring to **Fig. 5B**, outer annular ring portion **34** of outer housing **16** includes an annular groove **60** for receiving an annular protrusion **112** of inner housing **18**, as described in more detail below. Outer annular ring portion **34** also includes a pressure equalization receiving area **62** for receiving pressure equalization system **24** as described in more detail below.

**[0083]** Referring to **Figs. 6A-6D**, inner housing **18** generally includes a first or proximal end **100**; an opposing second or distal end **102**; a first region **104** and a second region **106**; a first shoulder **108** disposed between first region **104** and second region **106**; horizontal wall **110** disposed between first region **104** and second region **106**; annular protrusion **112** disposed at first end **100**; a first region wall **113** defining a cavity **114**; a first groove cavity **116** and a second groove cavity **118** within an adapter receiving portion **120**; a second region wall **121**; a spike member **122** including a piercing tip **124**; and a fluid transfer channel **126**.

**[0084]** Referring to **Fig. 6C**, inner housing **18** includes first region **104** and second region **106**. First shoulder **108** is disposed between first region **104** and second region **106** and is configured to engage second shoulder **46** of outer housing **16** as shown in **Fig. 7**. In this manner, second shoulder **46** of outer housing **16** acts as a physical barrier to prevent inner housing **18** from significant relative movement relative to outer housing **16** as shown in **Fig. 7**.

**[0085]** Referring to **Fig. 6C**, annular protrusion **112** extends downward from first end **100** of inner housing **18**. Referring to **Fig. 7**, annular protrusion **112** of inner housing **18** is received within annular groove **60** of annular ring portion **34** of outer housing **16**. In this manner, the engagement of annular protrusion **112** of inner housing **18** within annular groove **60** of outer housing **16** secures inner housing **18** to outer housing **16** and prevents inner housing **18** from significant relative movement relative to outer housing **16** as shown in **Fig. 7**.

**[0086]** Referring to **Fig. 6C**, horizontal wall **110** is disposed between first region **104** and second region **106**. Referring to **Fig. 7**, horizontal wall **110** together with vertical wall **48** of

outer housing **16** defines elongate aperture **50** between an aperture proximal end **64** and an aperture distal end **66**.

**[0087]** Referring to **Fig. 6C**, protruding out from second region wall **121** at second end **102** of inner housing **18** is a piercing member or spike member **122** which includes piercing tip **124**. Referring to **Fig. 6C**, a fluid transfer channel **126** extends through spike member **122** and adapter receiving portion **120** such that piercing tip **124** is in fluid communication with cavity **114** of inner housing **18**. The purpose of fluid transfer channel **126** is to permit a needle cannula to extend through vial access device **12** and to thereby permit fluid to be transferred through vial access device **12**. In other aspects, fluid transfer channel **126** may be embodied as any other suitable fluid transfer channel arrangement.

**[0088]** Referring to **Fig. 6C**, first region wall **113** defines cavity **114**. Cavity **114** receives connector **20** and top cap housing **22** as shown in **Fig. 4B**. In one aspect, cavity **114** receives top cap housing **22** by an interference fit between the exterior wall surface of a sidewall **154** of top cap housing **22** and the interior wall surface of first region wall **113** as shown in **Figs. 4B** and **4C**. First groove cavity **116** and second groove cavity **118** also receive respective bottom protrusions **136** of connector **20** as shown in **Figs. 4C** and **11**. In this manner, the engagement of bottom protrusions **136** of connector **20** within respective first groove cavity **116** and second groove cavity **118** secures connector **20** to inner housing **18** and prevents connector **20** from significant relative movement relative to inner housing **18** as shown in **Figs. 4B** and **4C**.

**[0089]** Referring to **Figs. 4B**, **4C**, and **7**, as described above, inner housing **18** is attachable to outer housing **16** by first shoulder **108** of inner housing **18** engaging second shoulder **46** of outer housing **16** and by annular protrusion **112** of inner housing **18** being received within annular groove **60** of outer housing **16**. In this manner, inner housing **18** is secured to outer housing **16** and inner housing **18** is prevented from significant relative movement relative to outer housing **16**.

**[0090]** In one aspect, outer housing **16** and inner housing **18** may form a single integral component. In another aspect, outer housing **16** and inner housing **18** are separate components and inner housing **18** is attachable to outer housing **16** such that significant relative movement between outer housing **16** and inner housing **18** is prevented.

**[0091]** Referring to **Fig. 7**, with inner housing **18** secured to outer housing **16**, spike member **122** extends in a direction substantially parallel with the plurality of vial grip members **54**. Spike member **122** serves the purpose of piercing a fluid container such as first vial **80** during assembly of vial access device **12** to first vial **80** as shown in **Fig. 18** and also serves the

purpose of piercing a fluid container such as second vial **90** during assembly of vial access device **12** to second vial **90** as shown in **Fig. 15**.

**[0092]** Referring to **Figs. 8A-8G**, in one aspect, connector **20** generally includes a first or proximal end **130**; an opposing second or distal end **132**; a membrane cavity **134** located at first end **130**; a bottom protrusion **136** located at second end **132**; and a locking groove **138**. In other aspects, connector **20** comprises other connectors which are compatible with a closed system drug transfer device.

**[0093]** Referring to **Figs. 4B** and **4C**, as described above, connector **20** is attachable to inner housing **18** by cavity **114** of inner housing **18** receiving connector **20** and first groove cavity **116** and second groove cavity **118** also receiving respective bottom protrusions **136** of connector **20**. In this manner, the engagement of bottom protrusions **136** of connector **20** within respective first groove cavity **116** and second groove cavity **118** secures connector **20** to inner housing **18** and prevents connector **20** from significant relative movement relative to inner housing **18** as shown in **Figs. 4B** and **4C**.

**[0094]** Referring to **Fig. 8A**, connector **20** includes a connection element or connection system **140**. In one aspect, connection system **140** comprises locking groove **138**. Locking groove **138** of connector **20** is engageable with a portion of an injector or injector adapter, e.g., injector **27** (**Figs. 20** and **21**), to secure the injector **27** to connector **20** and vial access device **12**. Connection system **140** of connector **20** provides a secured attachment between vial access device **12** and an injector such that significant relative movement between the injector and vial access device **12** is prevented and such that a cannula of the injector is maintained in a leak-proof sealing system throughout the process of engaging the cannula with a vial. Although a specific arrangement for the connector **20** is shown, the connector **20** may be embodied as any other suitable connection arrangement.

**[0095]** Referring to **Figs. 4B** and **4C**, in one aspect, membrane cavity **134** of connector **20** may contain a pierceable barrier member. In other aspects, other suitable barrier members may be utilized. The pierceable barrier member provides for a liquid and gas tight seal between a piercing member and the pierceable barrier member during fluid transfer to minimize leakage and thereby prevent exposure of hazardous medicaments to a user. The pierceable barrier member provides a self-sealing seal that, with vial access device **12** attached to a vial, provides a leak-proof seal preventing any substance contained within the vial chamber from being exposed to a health care provider reconstituting, transporting, or administering a drug using system **10**. In one aspect, the pierceable barrier member comprises a resilient material. For example, the pierceable barrier member is preferably a unitary device molded of any flexible,

elastomeric material conventionally used for fabricating gas-proof closures. The pierceable barrier member may be formed of a natural rubber material, polyurethane elastomers, butyl rubbers, or similar materials. It is contemplated that the pierceable barrier member is formed of a material having a Shore A hardness of approximately 10 to 50. It is also envisioned that the pierceable barrier member can have other material hardness values that would provide an appropriate self-sealing material to provide a leak-proof seal with a vial septum of a vial and an injector, thereby preventing any liquid or medication residue from being exposed to a health care provider reconstituting, transporting, or administering a drug using system **10**.

**[0096]** **Figs. 9A** and **9B** illustrate another exemplary aspect of a connector of the present disclosure. The aspect illustrated in **Figs. 9A** and **9B** includes similar components to the aspect illustrated in **Figs. 8A–8G**, and the similar components are denoted by a reference number followed by the letter **A**. For the sake of brevity, these similar components and the similar steps of using connector **20A** (**Figs. 9A** and **9B**) will not all be discussed in conjunction with the aspect illustrated in **Figs. 9A** and **9B**.

**[0097]** Referring to **Figs. 9A** and **9B**, in one aspect, connector **20A** includes a bottom aperture **142**. Connector **20A** is attachable to inner housing **18** by cavity **114** of inner housing **18** receiving connector **20A** and bottom aperture **142** of connector **20A** being locked over a protrusion on inner housing **18** to secure connector **20A** to inner housing **18** and prevent connector **20A** from significant relative movement relative to inner housing **18**.

**[0098]** Referring to **Fig. 10**, in one aspect, top cap housing **22** generally includes a first or proximal end **150**; an opposing second or distal end **152**; a sidewall **154** extending between first end **150** and second end **152** and defining a connector receiving portion **156**; and a handle portion **158**. In other aspects, top cap housing **22** comprises other covers which are compatible with a closed system drug transfer device. For example, top cap housing **22** may be embodied as any other suitable cover arrangement.

**[0099]** Referring to **Figs. 4B** and **4C**, as described above, top cap housing **22** is attachable to first end **100** of inner housing **18** by cavity **114** of inner housing **18** receiving top cap housing **22** by an interference fit between the exterior wall surface of sidewall **154** of top cap housing **22** and the interior wall surface of first region wall **113** as shown in **Figs. 4B** and **4C**. With connector **20** and top cap housing **22** properly positioned within inner housing **18**, first end **130** of connector **20** is received within connector receiving portion **156** of top cap housing **22** as shown in **Figs. 4B** and **4C**.

**[00100]** With top cap housing **22** properly secured to inner housing **18** as described above, the top cap housing seals vial access device **12**, i.e., top cap housing **22** provides a substantially

impermeable enclosure with respect to vial access device **12**, provides a leak prevention and protection enclosure, protects the contents of vial access device **12**, and/or maintains a sealed, sterilized environment within vial access device **12**. Top cap housing **22** provides a sufficient seal at a range of temperatures, pressures, and humidity levels.

**[00101]** Referring to **Figs. 1**, **4B**, **4C**, **7**, and **19**, pressure equalization system **24** includes a pressure equalization housing **160** and an expandable balloon **162** which includes an expansion chamber **164**. Pressure equalization housing **160** also includes a flange portion **166**. Expandable balloon **162** includes a variable volume. Pressure equalization housing **160** comprises a relatively rigid material and expandable balloon **162** comprises a relatively flexible material. In one aspect, expandable balloon **162** comprises a thin, transparent plastic film that is attached to pressure equalization housing **160** in a gastight manner. In one aspect, expandable balloon **162** is designed as a bellow which is compressible and extendable and thus the volume of the expansion chamber **164** of expandable balloon **162** can thereby be increased and decreased. In one aspect, pressure equalization housing **160** extends radially around inner housing **18** and expandable balloon **162** extends radially around inner housing **18**. In one aspect, expandable balloon **162** comprises a toroidal shape. In other aspects, pressure equalization system **24** comprises other pressure equalization systems which are compatible with a closed system drug transfer device.

**[00102]** Pressure equalization housing **160** provides a barrier wall member that protects expandable balloon **162** from being torn during engagement of a cannula with a vial, during transfer of a substance from a vial chamber to a barrel chamber, e.g., a barrel assembly **28** (**Figs. 20-23**), via the cannula, and during disengagement of the cannula from the vial. In one aspect, by having expandable balloon **162** extending radially around the entirety of inner housing **18** of vial access device **12**, the vial access device **12** is balanced such that a center of mass is positioned at about a longitudinal axis of vial access device **12**. In one aspect, expandable balloon **162** extends three-hundred sixty degrees (360°) radially around inner housing **18** of vial access device **12**. In one aspect, a portion of expandable balloon **162** is not covered by pressure equalization housing **160**. In this manner, expandable balloon **162** is capable of expanding in an axial direction.

**[00103]** As discussed above, pressure equalization housing **160** is received within outer housing **16** such that first shoulder **44** of outer housing **16** provides an engagement surface with flange portion **166** of pressure equalization housing **160** as shown in **Figs. 4B** and **4C**. In one aspect, pressure equalization housing **160** and outer housing **16** are a single integral component. In another aspect, pressure equalization housing **160** and outer housing **16** are separate

components and pressure equalization housing **160** is attachable to outer housing **16** such that significant relative movement between pressure equalization housing **160** and outer housing **16** is prevented.

**[00104]** In one aspect, a pressure normalization channel extends from piercing tip **124** to expandable balloon **162**. In this manner, the pressure normalization channel is arranged to provide gas communication between the expandable balloon **162** and the interior of a vial when vial access device **12** is connected to a vial. The pressure normalization channel may be embodied as any suitable pressure normalization channel arrangement. With vial access device **12** connected to a vial, a syringe, cannula assembly, or injector, e.g., injector **27** (**Figs. 20** and **21**), may be used to inject fluid into the vial or to withdraw fluid therefrom.

**[00105]** Although a specific arrangement for the pressure equalization system **24** is shown, the pressure equalization system **24** may be embodied as any other suitable pressure equalization system arrangement.

**[00106]** The function and advantages of pressure equalization system **24**, according to the present disclosure, will be described in greater detail. When preparing and administering drugs, care has to be taken to minimize, or preferably eliminate, the risk of exposing people, such as medical and pharmacological personnel, to toxic substances. Some drugs must be dissolved or diluted before they are administered, which involves transferring a solvent from one container to a sealed vial containing the drug in powder or liquid form, by means of a needle, for example. Drugs may be inadvertently released into the atmosphere in gas form or by way of aerosolization during the withdrawal of the needle from the vial and while the needle is inside the vial if any differential pressure exists between the interior of the vial and surrounding atmosphere. Vial access device **12** of the present disclosure eliminates this problem by using pressure equalization system **24** of vial access device **12** that may be attached to a vial during the preparation of drugs. The pressure equalization system **24** includes an expandable balloon **162** which is in communication with the interior of a vial which ensures that neither an increased pressure nor a vacuum can occur inside the vial, e.g., first vial **80** (**Figs. 16-19**) or second vial **90** (**Figs. 13-15**), when gas or liquid is injected into or withdrawn from the vial. In one aspect, the expandable balloon **162** may be filled with cleaned or sterilized air prior to its use to ensure that the contents of the vial do not become contaminated with air-borne particles such as dust, pollen, mold, bacteria, or other undesirable substances.

**[00107]** Referring to **Figs. 16-19**, **20**, and **21**, the vial access device **12** may be secured to a cannula of injector **27** which in turn can be connected to a fluid container, such as barrel assembly **28**, and the vial access device **12** can also be assembled via its vial connection

elements **52** with a second fluid container, such as a first vial **80**. As vial access device **12** is assembled with the first vial **80**, the piercing tip **124** of the spike member **122** is pierced through a septum **84** of the first vial **80**. First vial **80** may be a standard drug vial of any type having an open head portion covered by a pierceable septum of an elastomeric material. As discussed above, the plurality of vial grip members **54** fixedly connect vial access device **12** to the first vial **80** as the hook protrusions **56** of vial grip members **54** engage the corresponding flange **87** on first vial **80** as shown in **Fig. 18**. After assembly, a user is able to insert fluid into the first vial **80**, or optionally, to retract fluid from the first vial **80**.

**[00108]** As a fluid is inserted into the first vial **80**, using the cannula of injector **27** and barrel assembly **28** (**Figs. 20-23**), an overpressure is created inside the first vial **80**. The pressure equalization system **24** of vial access device **12** permits pressure equalization between the first vial **80** and the expandable balloon **162**. The pressure normalization channel of the pressure equalization system **24** normalizes the pressure inside the first vial **80** by relieving the pressure inside the first vial **80** to the expansion chamber **164** of the expandable balloon **162** as shown in **Fig. 19**.

**[00109]** Referring to **Figs. 12A-12H**, **15**, and **18**, adapter **14** generally includes a first or proximal end **170**; an opposing second or distal end **172**; guide channels **174**; a vial connection element **176** comprising adapter vial grip members **178**, hook protrusions **180**, and angled walls **182**; and locking members or outer housing engagement portions **184**. Adapter **14** is sized and shaped for movement within the elongate aperture **50** of vial access housing **26** and the adapter **14** is transitionable between a first position (**Figs. 13-15**) in which the adapter **14** is adjacent the aperture distal end **66** of the vial access housing **26** and the adapter **14** is attachable to a second vial **90** defining a second vial size **91**, the second vial size **91** different than the first vial size **81** of first vial **80**, and a second position (**Figs. 16-18**) in which the adapter **14** is adjacent the aperture proximal end **64** of the vial access housing **26** and the vial connection element **52** of the vial access device **12** is attachable to the first vial **80**.

**[00110]** Referring to **Figs. 12B** and **15**, a vial connection element **176** is disposed at second end **172** of adapter **14**. In one aspect, vial connection element **176** includes a plurality of adapter vial grip members **178** having hook protrusions **180** and angled walls **182**. In one aspect, adapter vial grip members **178** are elastically deformable. Adapter vial grip members **178** are attachable to a second vial **90** to secure vial access device **12** to the second vial **90** via adapter **14**. In this manner, vial access device **12** and adapter **14** provide a system **10** that is capable of accommodating a plurality of vials having different sizes, e.g., first vial **80** having first vial size **81** and second vial **90** having second vial size **91**. Each adapter vial grip member

**178** includes a hook protrusion **180** arranged to engage a corresponding flange **97** on a container such as second vial **90** as shown in **Fig. 15**. Vial connection element **176** of adapter **14** may be dimensioned to be attached to containers of any size and volume. In other aspects, vial connection element **176** of adapter **14** may include other connection mechanisms for securing adapter **14** and vial access device **12** to second vial **90** such as a threaded portion, a snap fit mechanism, locking tabs, or other similar mechanism. Each adapter vial grip member **178** includes an angled wall **182** arranged to provide a lead-in surface to center and align vial access device **12** on a vial.

**[00111]** As discussed above, vial access device **12** and adapter **14** provide a system **10** that is capable of accommodating a plurality of vials having different sizes, e.g., first vial **80** having first vial size **81** and second vial **90** having second vial size **91**. In one aspect, it is envisioned that vial access device **12** and adapter **14** are compatible with a first vial **80** comprising a 20 mm vial and a second vial **90** comprising a 13 mm vial. In another aspect, it is envisioned that vial access device **12** and adapter **14** are compatible with a first vial **80** comprising a 28 mm vial and a second vial **90** comprising a 20 mm vial. In another aspect, it is envisioned that vial access device **12** and adapter **14** are compatible with a first vial **80** comprising a 32 mm vial and a second vial **90** comprising a 28 mm vial. In other aspects, it is envisioned that vial access device **12** and adapter **14** are compatible with a first vial **80** comprising other vial sizes and a second vial **90** comprising other vial sizes, wherein the second vial size is less than the first vial size.

**[00112]** Referring to **Fig. 4D**, in one aspect, guide channels **174** of adapter **14** are configured to engage corresponding guiding protrusions **71** within elongate aperture **50** of outer housing **16**. In this manner, the corresponding guiding surfaces of adapter **14** and outer housing **16** provide a guided, controlled movement of adapter **14** between the first position (**Figs. 13-15**) and the second position (**Figs. 16-18**) and establish a secure attachment between the adapter **14** and the outer housing **16** as shown in **Figs. 15** and **18**.

**[00113]** Referring to **Figs. 4D** and **15**, locking members or outer housing engagement portions **184** of adapter **14** engage adapter engagement portions **68** which act as a physical barrier to prevent adapter **14** from being removed from within elongate aperture **50**. Adapter **14** is sized for movement within elongate aperture **50** of vial access housing **26** and engagement of adapter engagement portions **68** with locking members **184** of adapter **14** prevents adapter **14** from being removed from elongate aperture **50**.

**[00114]** Referring to **Figs. 15** and **18**, the use of vial access device **12** and adapter **14** to provide a system **10** that is capable of accommodating a plurality of vials having different sizes,

e.g., first vial **80** having first vial size **81** and second vial **90** having second vial size **91**, will now be described.

**[00115]** Referring to **Fig. 15**, with the adapter **14** in the first position, the adapter **14** is adjacent the aperture distal end **66** of the vial access housing **26** and the adapter **14** is attachable to the second vial **90** defining the second vial size **91** as described above. With the vial access device **12** attachable to the second vial **90** via the adapter **14**, the spike member **122** is in fluid communication with vial chamber **96** of the second vial **90** as shown in **Fig. 15**. With the vial access device **12** attached to the second vial **90** via the adapter **14**, system **10** provides substantially leak-proof sealing and pressure equalization during engagement of a cannula of injector **27** with second vial **90** during transfer of a substance from vial chamber **96** to a barrel chamber of barrel assembly **28** via the cannula, and during disengagement of the cannula from the second vial **90**. The leak-proof sealing of the system **10** substantially prevents leakage of both air and liquid during use of the system **10**. System **10** is compatible with a needle and syringe assembly for accessing a medication contained within a vial for administering the medication to a patient. System **10** is also compatible to be used with a drug reconstitution system. Furthermore, as a fluid is inserted into the second vial **90**, using the cannula of injector **27** and barrel assembly **28** (**Figs. 20-23**), an overpressure is created inside the second vial **90**. The pressure equalization system **24** of vial access device **12** permits pressure equalization between the second vial **90** and the expandable balloon **162**. The pressure normalization channel of the pressure equalization system **24** normalizes the pressure inside the second vial **90** by relieving the pressure inside the second vial **90** to the expansion chamber **164** of the expandable balloon **162** as shown in **Fig. 19**.

**[00116]** As discussed above, adapter **14** is sized and shaped for movement within the elongate aperture **50** of vial access housing **26** and the adapter **14** is transitionable between the first position (**Figs. 13-15**) and the second position (**Figs. 16-18**).

**[00117]** Referring to **Fig. 18**, with the adapter **14** in the second position, the adapter **14** is adjacent the aperture proximal end **64** of the vial access housing **26** and the vial connection element **52** of the vial access device **12** is attachable to the first vial **80** as described above. With the adapter **14** in the second position, the adapter **14** is disposed above the vial connection element **52** of the vial access device **12**. In this manner, the adapter **14** is out of the way of the vial connection element **52** and the vial connection element **52** is attachable to the first vial **80**. With the vial access device **12** attachable to the first vial **80**, the spike member **122** is in fluid communication with vial chamber **86** of the first vial **80** as shown in **Fig. 18**. With the vial access device **12** attached to the first vial **80**, system **10** provides substantially leak-proof

sealing and pressure equalization during engagement of a cannula of injector **27** with first vial **80**, during transfer of a substance from vial chamber **86** to a barrel chamber of barrel assembly **28** via the cannula, and during disengagement of the cannula from the first vial **80**. The leak-proof sealing of the system **10** substantially prevents leakage of both air and liquid during use of the system **10**. System **10** is compatible with a needle and syringe assembly for accessing a medication contained within a vial for administering the medication to a patient. System **10** is also compatible to be used with a drug reconstitution system. Furthermore, as a fluid is inserted into the first vial **80**, using the cannula of injector **27** and barrel assembly **28** (**Figs. 20-23**), an overpressure is created inside the first vial **80**. The pressure equalization system **24** of vial access device **12** permits pressure equalization between the first vial **80** and the expandable balloon **162**. The pressure normalization channel of the pressure equalization system **24** normalizes the pressure inside the first vial **80** by relieving the pressure inside the first vial **80** to the expansion chamber **164** of the expandable balloon **162** as shown in **Fig. 19**.

**[00118]** Referring to **Figs. 24-27**, a further aspect of a vial access device **200** is shown. The vial access device **200** is similar to the vial access device **12** described above and will operate in the same manner. The vial access device **200** also includes an outer housing **216**, inner housing **218**, connector **220**, top cap **222**, a pressure equalization system **224**, and a vial connection element **252**.

**[00119]** The outer housing **216** defines an annular space **226** that receives the pressure equalization system **224**. The outer housing **216** also defines an inner space **228** that receives at least a portion of the inner housing **218** and the connector **220**. The inner housing **218** includes a body **230** having a curved top surface and a cylindrical portion **232** extending in a longitudinal direction. The body **230** defines a central opening **234** that receives at least a portion of the top cap **222**, the connector **220**, and the vial connection element **252**. The inner housing **218** is secured to the outer housing **216** by a snap-fit connection, although any other suitable securing arrangement may be utilized, such as adhesive, welding, etc. The top cap **222** includes a body **236** that defines a recessed portion **238** that receives a portion of the connector **220**. The body **236** also includes an extension portion that defines a gripping surface **240** that is configured to facilitate grasping of the top cap **222** to remove the top cap **222** from the inner housing **218**. The gripping surface **240** is shown as a recessed area of the body **230**, although any other suitable arrangement may be utilized, such as a textured surface, a protrusion, dimples, etc. The top cap **222** is secured to the inner housing **218** via a snap-fit connection, although any other suitable securing arrangement may be utilized. The pressure equalization system **224** includes a toroidal balloon **242** positioned within annular space **226** of the outer

housing **216**. As discussed above in connection with the pressure equalization system **24**, the balloon **242** is configured to expand and contract to change the volume defined by the balloon **242** and the outer housing **216**. In particular, the balloon **242** is configured to expand axially outward from the annular space **226**.

**[00120]** The connector **220** is positioned within inner space **228** of the outer housing **216** and the central opening **234** of the inner housing **218**. As discussed above in connection with connector **20**, the connector **220** is configured to mate with a mating connector or component. The connector **220** includes a body **244** defining a central passageway **246**. A flange **248** extends radially outward from the body **244** of the connector **220**. A membrane or septum **250** is positioned and secured at a proximal end of the connector **220** and closes the central passageway **246**. The flange **248** abuts a ledge **254** defined by the outer housing **216** and defines an annular filter space **256** that receives an annular filter **258**. The flange **248** may be secured to the outer housing **216** via snap-fit connection, although any other suitable securing arrangement may be utilized. The filter **258** is hydrophobic filter that prevents liquid flow, but allows air to flow through during operations of the pressure equalization system **224**.

**[00121]** Referring again **Figs. 24-27**, the vial connection element **252** is similar to the vial connection element **52** described above. The vial connection element **252** includes a body **260** having vial grip members **262** extending from the **260**. The vial connection element **252** is configured to be secured to a vial thereby securing the vial access device **200** to the vial. The body **260** of the vial connection element **252** is cylindrical and received within the central passageway **246** of the connector **220**. The body **260** defines a central passageway **264** that is aligned with the central passageway **246** of the connector **220**. The vial connection element **252** includes a spike member **266** that is configured to puncture a septum of vial as discussed above in connection with system **10**. The spike member **262** defines a fluid passageway **268** in fluid communication with the central passageways **246, 264** of the connector **220** and the vial connection element **252**. The spike member **262** also defines a vent passageway **270** in fluid communication with the filter space **256** and the annular space **226** of the outer housing **216**. The fluid passageway **268** is configured to facilitate the transfer of fluids to and from a vial to a mating device connected to the connector **220**. The vent passageway **270** is configured to cooperate with the pressure equalization system **224**, as discussed above in connection with system **10**, to prevent a vial from being pressurized or depressurized during the transfer of contents to and from the vial. The filter **258** prevents the passage of liquids into the filter space **256** and into the annular space **226**.

**[00122]** Referring to **Figs. 25** and **27**, an O-ring **272** may be positioned between the connector **220** and the vial connection element **252** where the connector **220** and the vial connection element **252** are joined and where the central passageways **246**, **264** come into alignment. The vial access device **200** also includes a sleeve member **274** positioned over the spike member **266**, which prevents leakage during fluid transfer when longer openings are used for the spike member **266** to optimize evacuation of the vial.

**[00123]** Although a specific arrangement for the connector **220** is shown, the connector **220** may be embodied as any other suitable connection arrangement.

**[00124]** Referring to **Figs. 28-31**, the vial access device **200** may be provided with a packaging arrangement **208**. The packaging arrangement **208** holds the vial access device **200** and maintains sterility prior to use, but can also be used to hold the vial access device **200** while connecting the vial access device **200** onto a container, such as a vial. **Fig. 31** shows a configuration without the top cap **222** and where a portion of the packaging arrangement **208** engages the inner housing **218**.

**[00125]** Referring to **Figs. 32-35**, the vial access device **200** is shown in use with a syringe adapter **210** and the vial **80**. The syringe adapter **210** may be the syringe adapter and system noted above in connection with connector **20**. The syringe adapter **210** cooperates with the connector **220** to facilitate the sealed transfer of substances between the vial **80** and a syringe (not shown) connected to the syringe adapter **210**.

**[00126]** Referring to **Figs. 36-38**, another aspect of a vial access device **300** is shown. The vial access device **300** is similar to the vial access device **12** described above and will operate in the same manner. The vial access device **300** includes a connector **20**, a pressure equalization system **24**, a connection element **52**, and a spike member **122**. The vial access device **300** also includes the sleeve member **274** discussed above in connection with the vial access device **200**. The pressure equalization system **24** shown in **Figs. 36-38** is generally rectangular.

**[00127]** Referring to **Figs. 39** and **40**, another aspect of a vial access device **400** is shown. The vial access device **400** is similar to the vial access device **300** described above and will operate in the same manner as described in connection with vial access device **12**. The vial access device **400** has a pressure equalization system that is substantially spherical.

**[00128]** While this disclosure has been described as having exemplary designs, the present disclosure can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the disclosure using its general principles. Further, this application is intended to cover such departures from

the present disclosure as come within known or customary practice in the art to which this disclosure pertains and which fall within the limits of the appended claims.

**WHAT IS CLAIMED IS:**

1. A vial access device comprising:

an outer housing defining an annular space and an inner space;

an inner housing having a body defining a central opening, at least a portion of the inner housing positioned within the inner space of the outer housing;

a connector configured to engage a mating connector, the connector having a body defining a central passageway and a flange that extends radially outward from the body, the flange and the outer housing defining a filter space, the filter space in fluid communication with the annular space;

a pressure equalization system positioned within the annular space of the outer housing, the pressure equalization system configured to change a volume of space defined by the annular space and the pressure equalization system;

a vial connection element configured to be secured to a vial, the vial connection element having a body and a spike member extending from the body, the spike member defining a fluid passageway and a vent passageway, the fluid passageway in fluid communication with the central passageway of the connector, the vent passageway in fluid communication with the filter space and the annular space; and

a filter positioned in the filter space.

2. The vial access device of claim 1, further comprising a top cap having a body secured to the inner housing, the body of the top cap defining a recessed portion that receives a portion of the connector.

3. The vial access device of claim 2, wherein the top cap includes a gripping surface configured to allow a user to remove the top cap from the inner housing.

4. The vial access device of claim 1, wherein the body of the vial connection element defines a central passageway, the body of the vial connection element received within the central passageway of the connector with the central passageway of the vial connection element aligned with the central passageway of the connector.

5. The vial access device of claim 4, further comprising an O-ring positioned between the vial connection element and the connector.

6. The vial access device of claim 1, wherein the flange of the connector abuts a ledge defined by the outer housing, the ledge extending radially inward into the inner space of the outer housing.

7. The vial access device of claim 1, wherein the inner housing has a top surface having a shape that conforms to an outer surface of the outer housing.

8. The vial access device of claim 1, wherein the body of the inner housing has a cylindrical portion extending axially into the inner space of the outer housing.

9. The vial access device of claim 1, further comprising a membrane positioned on the connector adjacent to the central passageway of the connector.

10. The vial access device of claim 1, wherein the pressure equalization system comprises a toroidal balloon configured to expand axially outward from the annular space of the outer housing.

11. The vial access device of claim 1, wherein the filter is annular.

12. The vial access device of claim 1, wherein the filter comprises a hydrophobic filter.

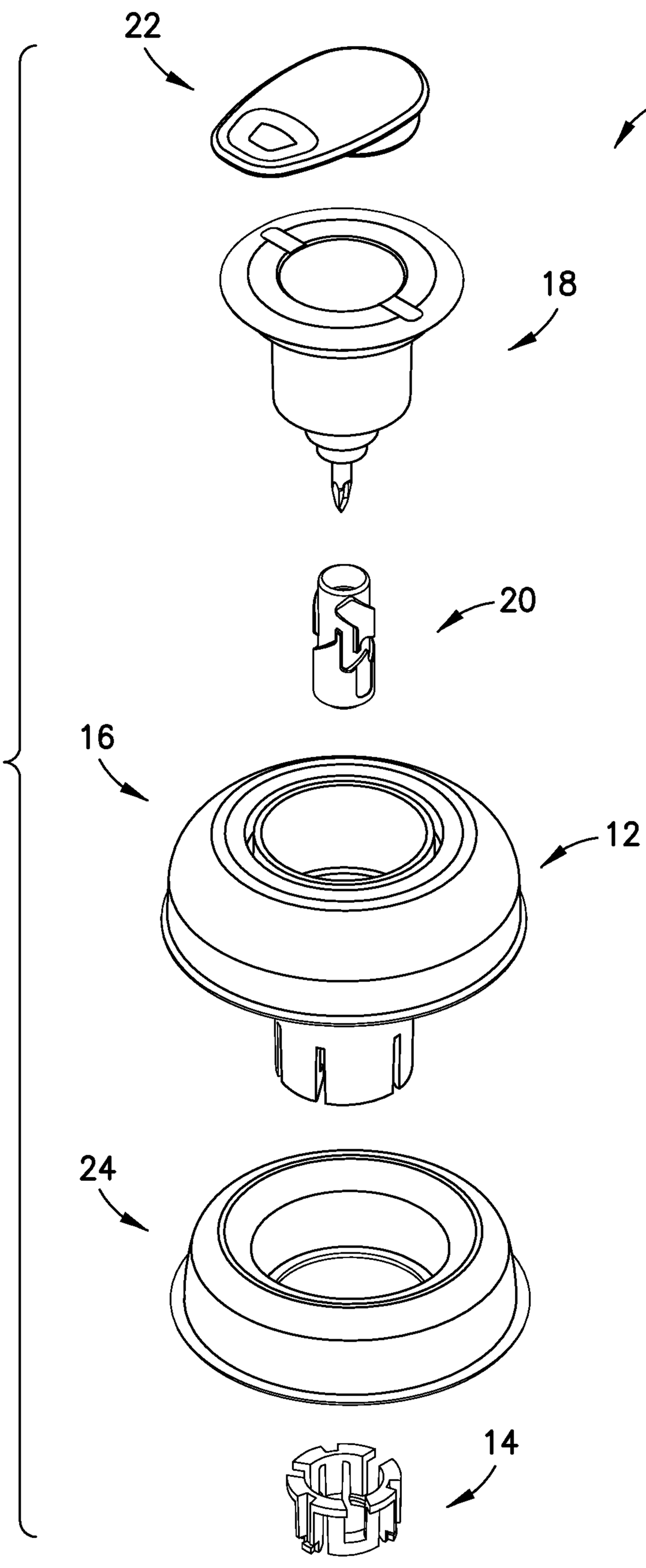


FIG. 1

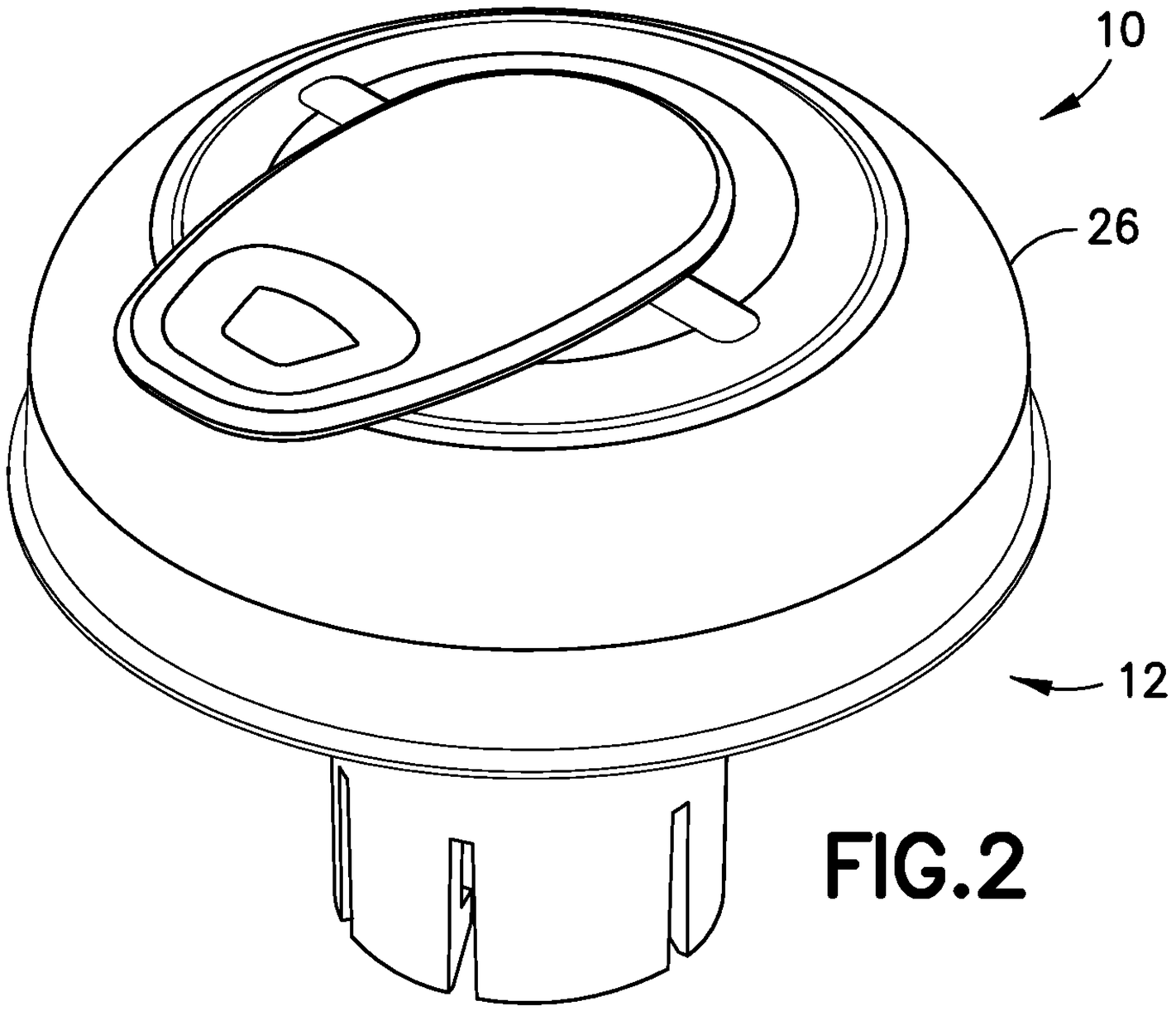


FIG.2

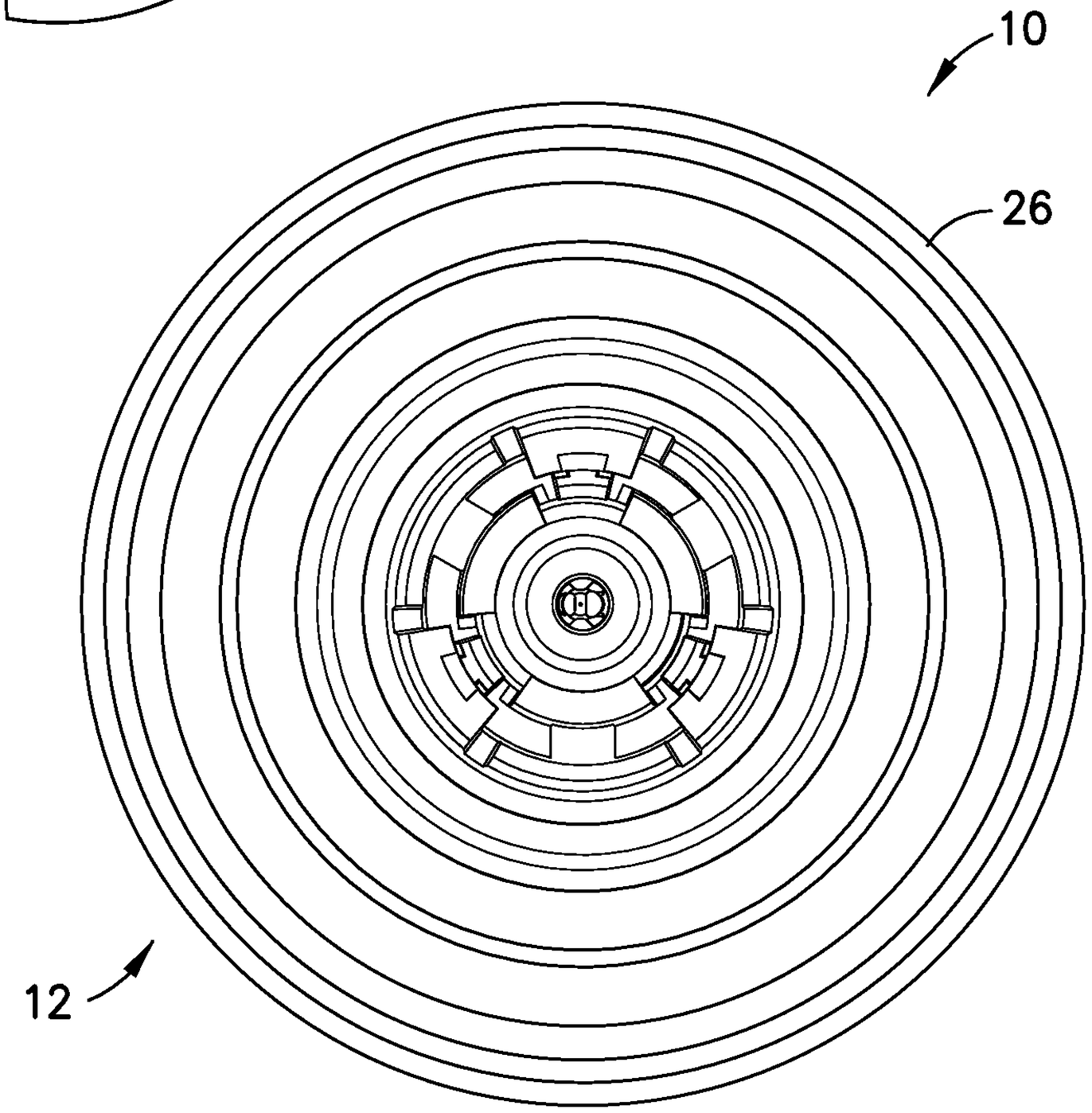


FIG.3

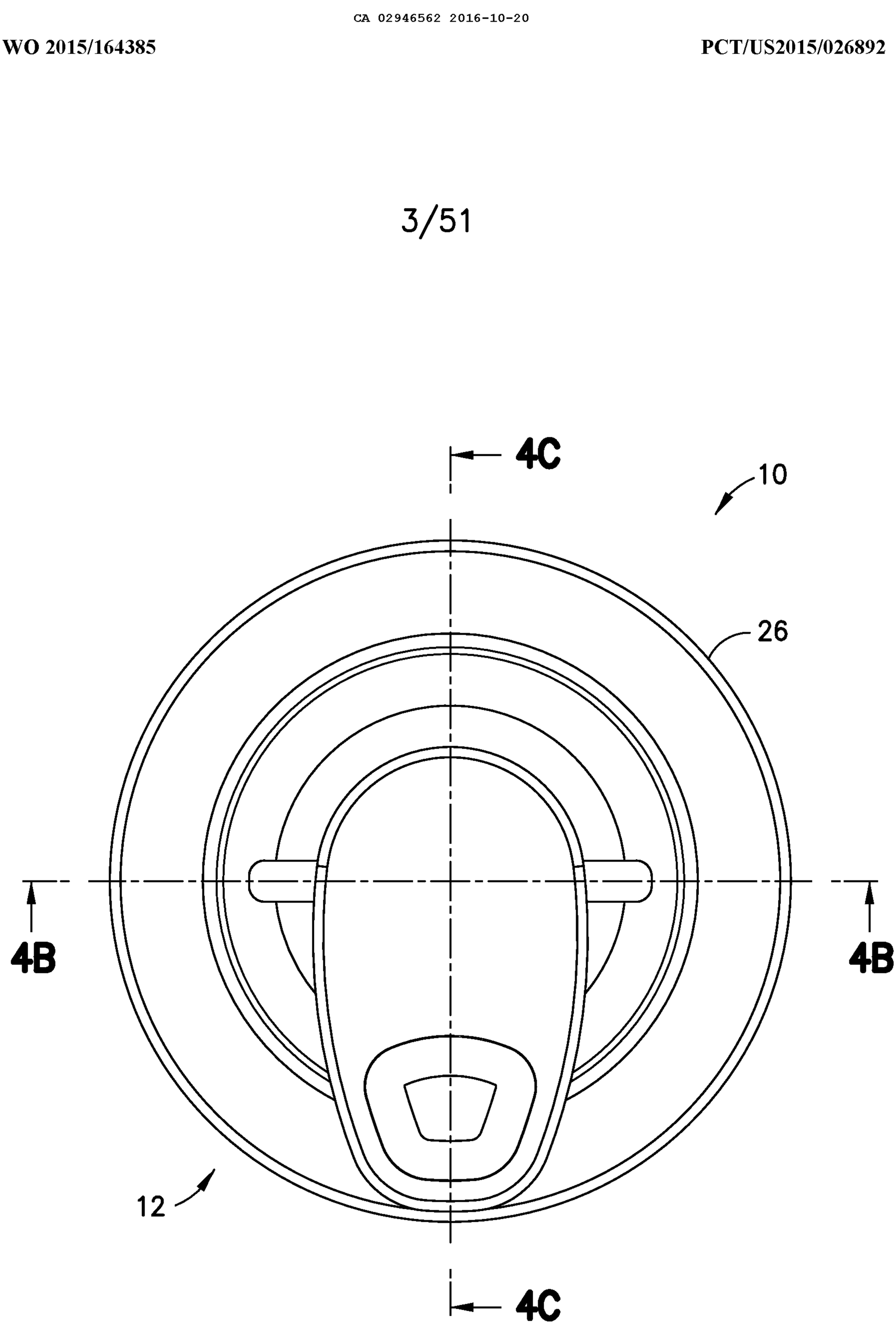


FIG.4A

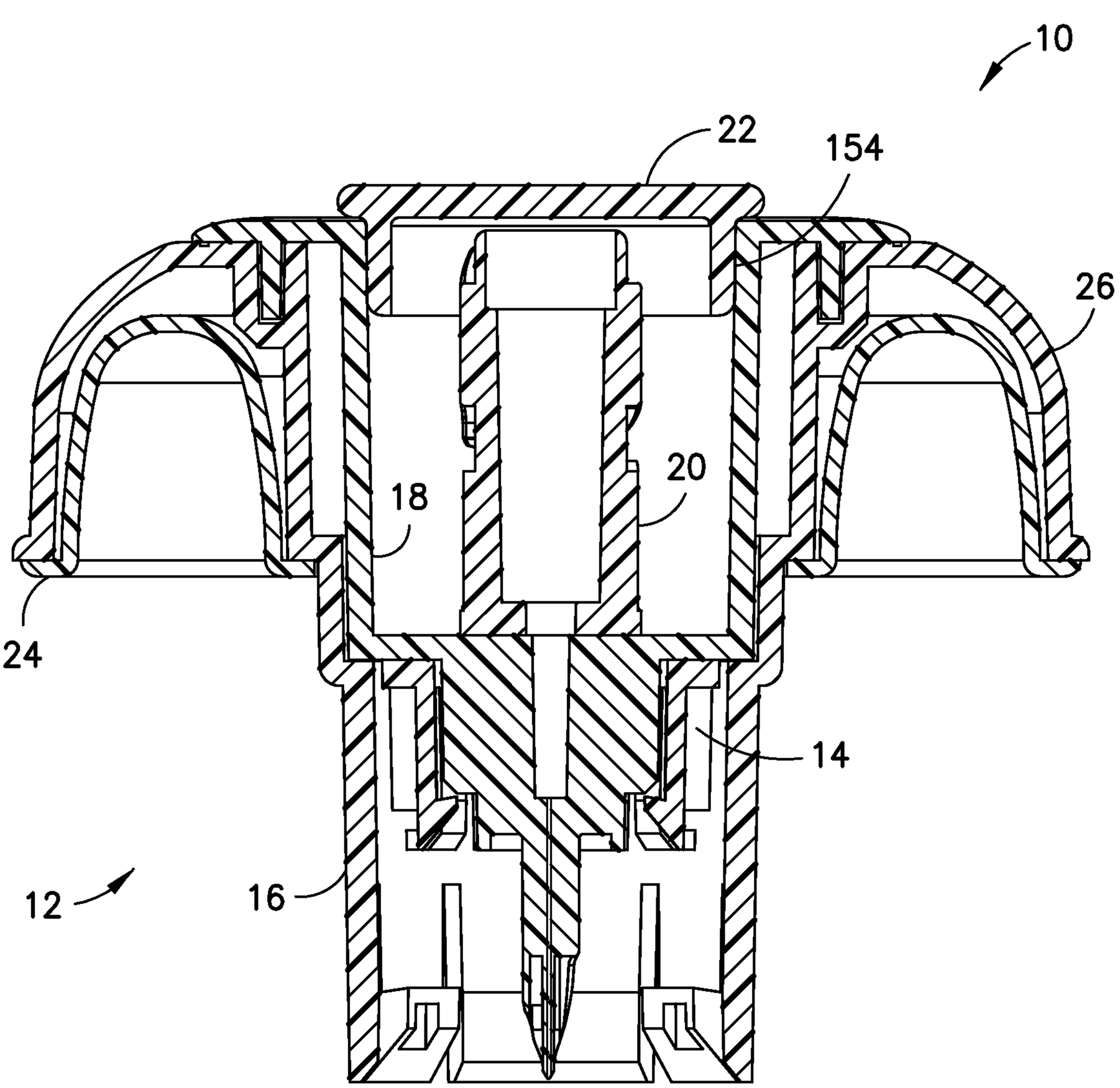


FIG.4B

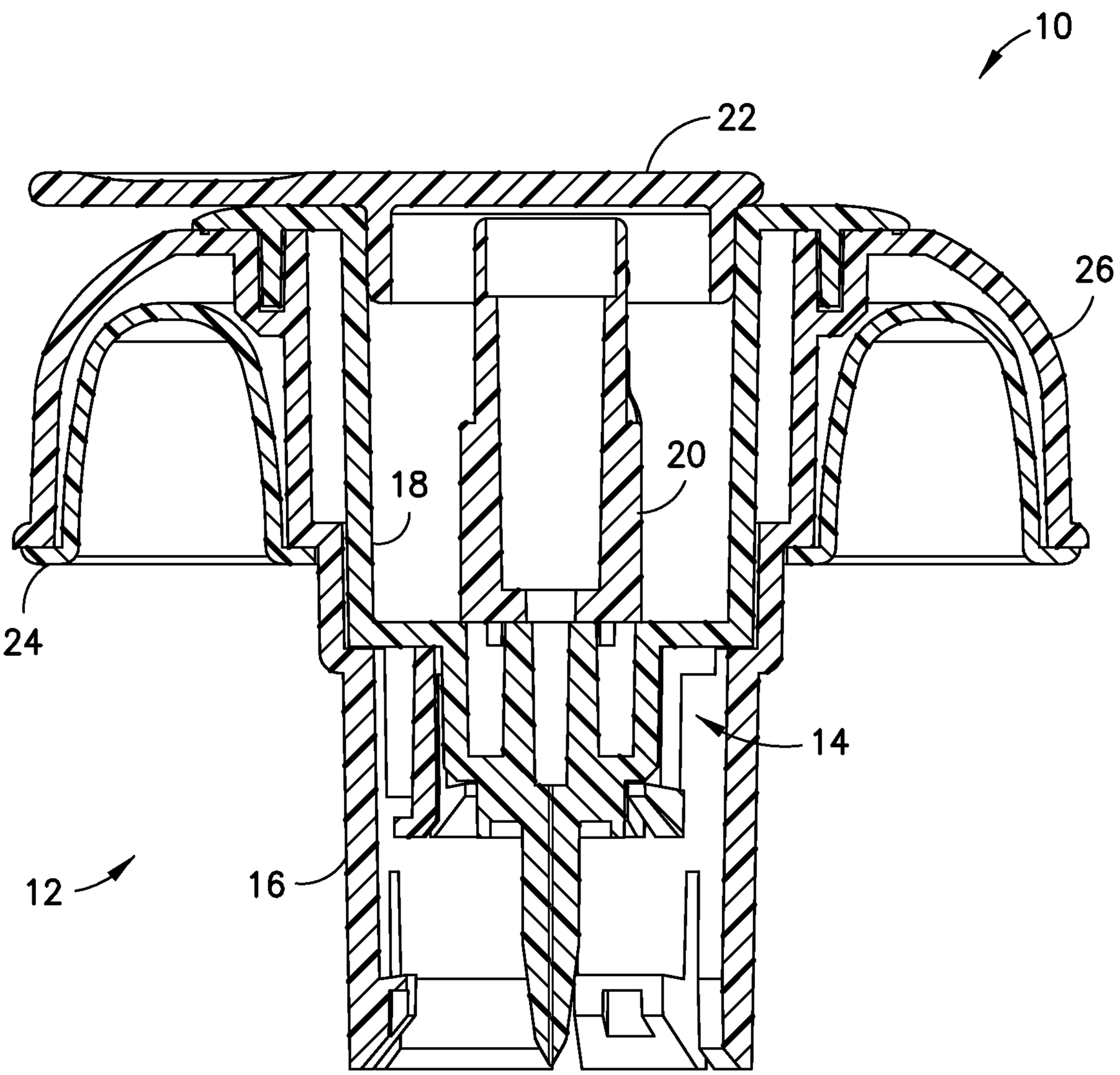


FIG.4C

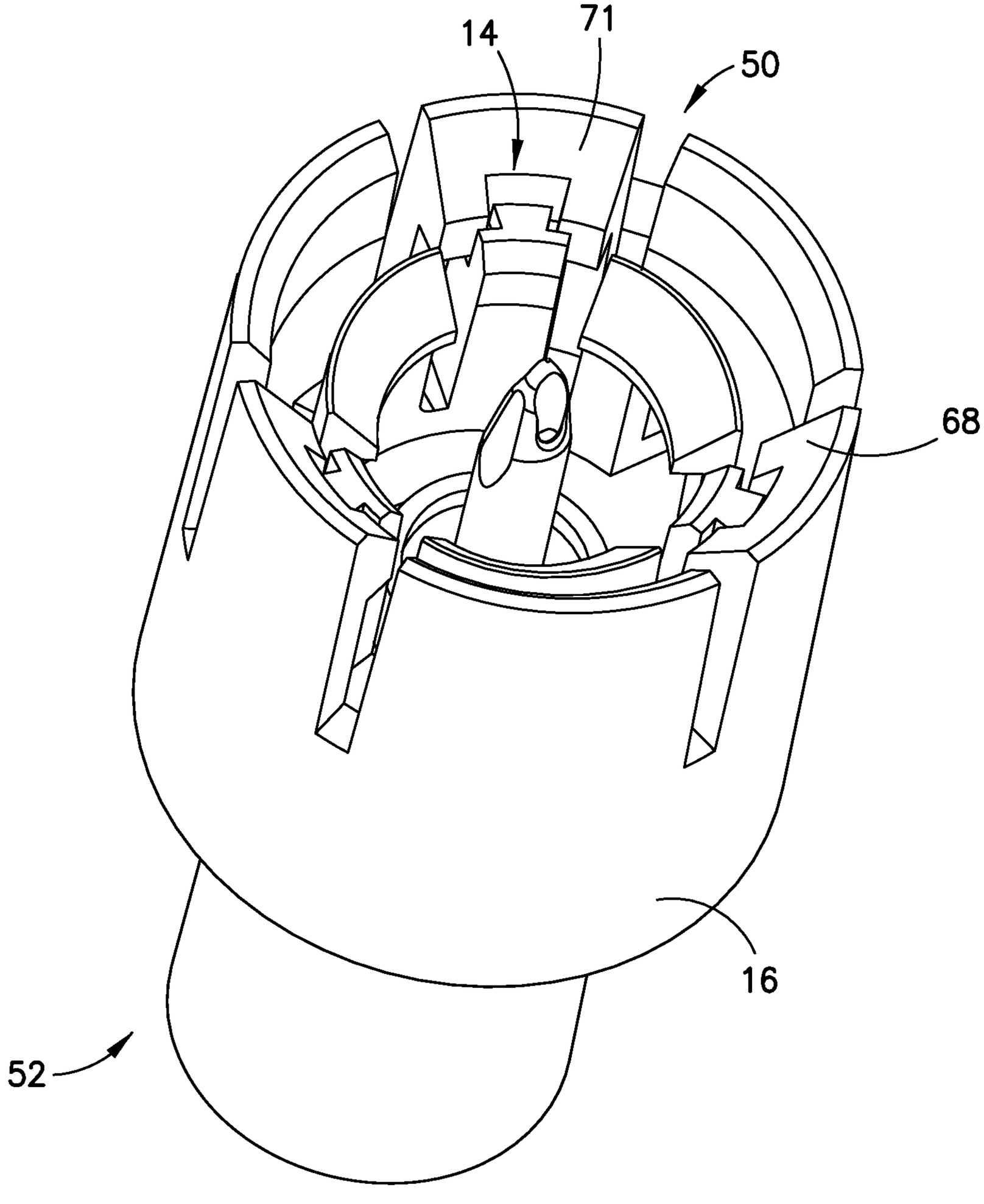


FIG.4D

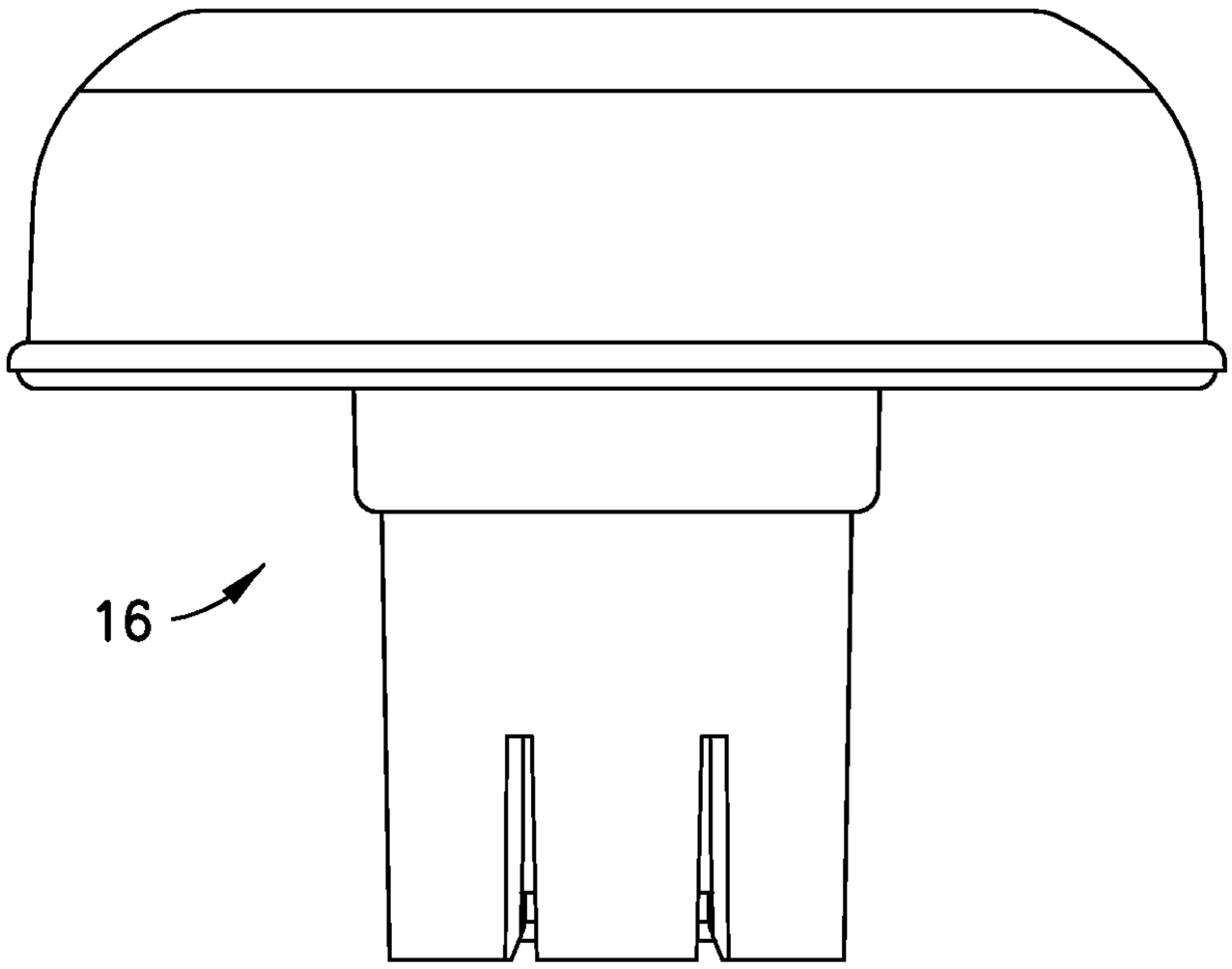
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FIG.5A

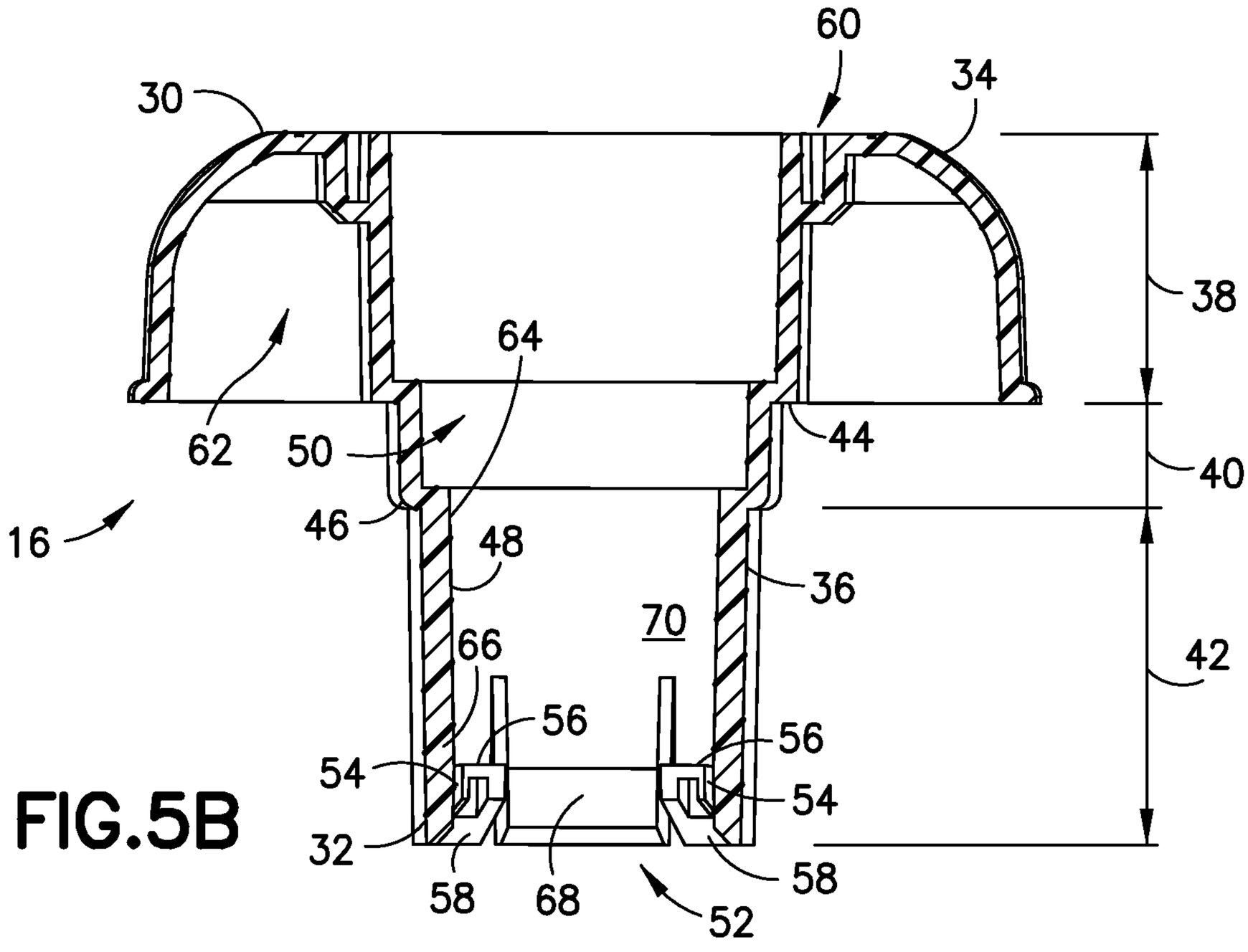
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FIG.5B

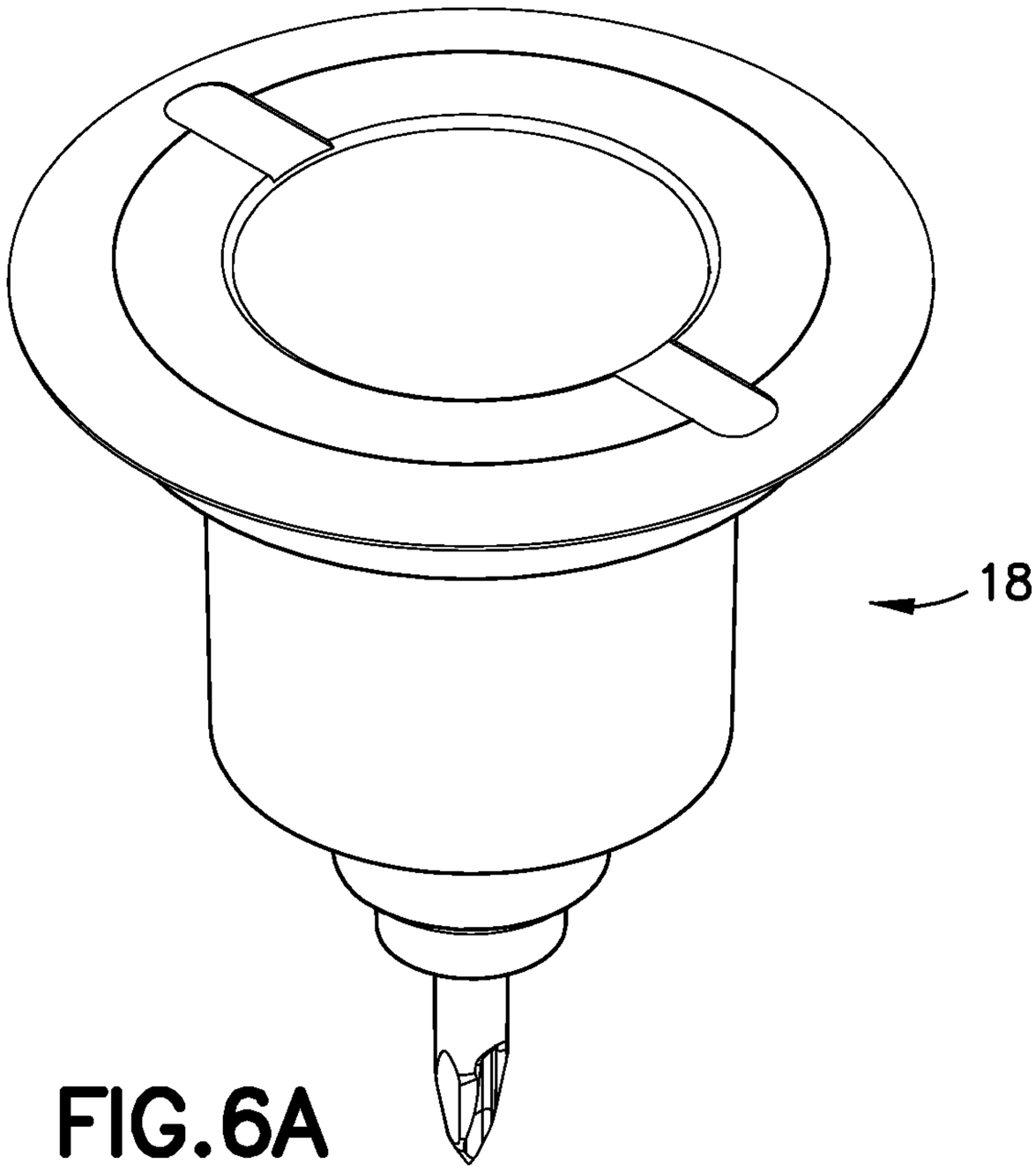


FIG.6A

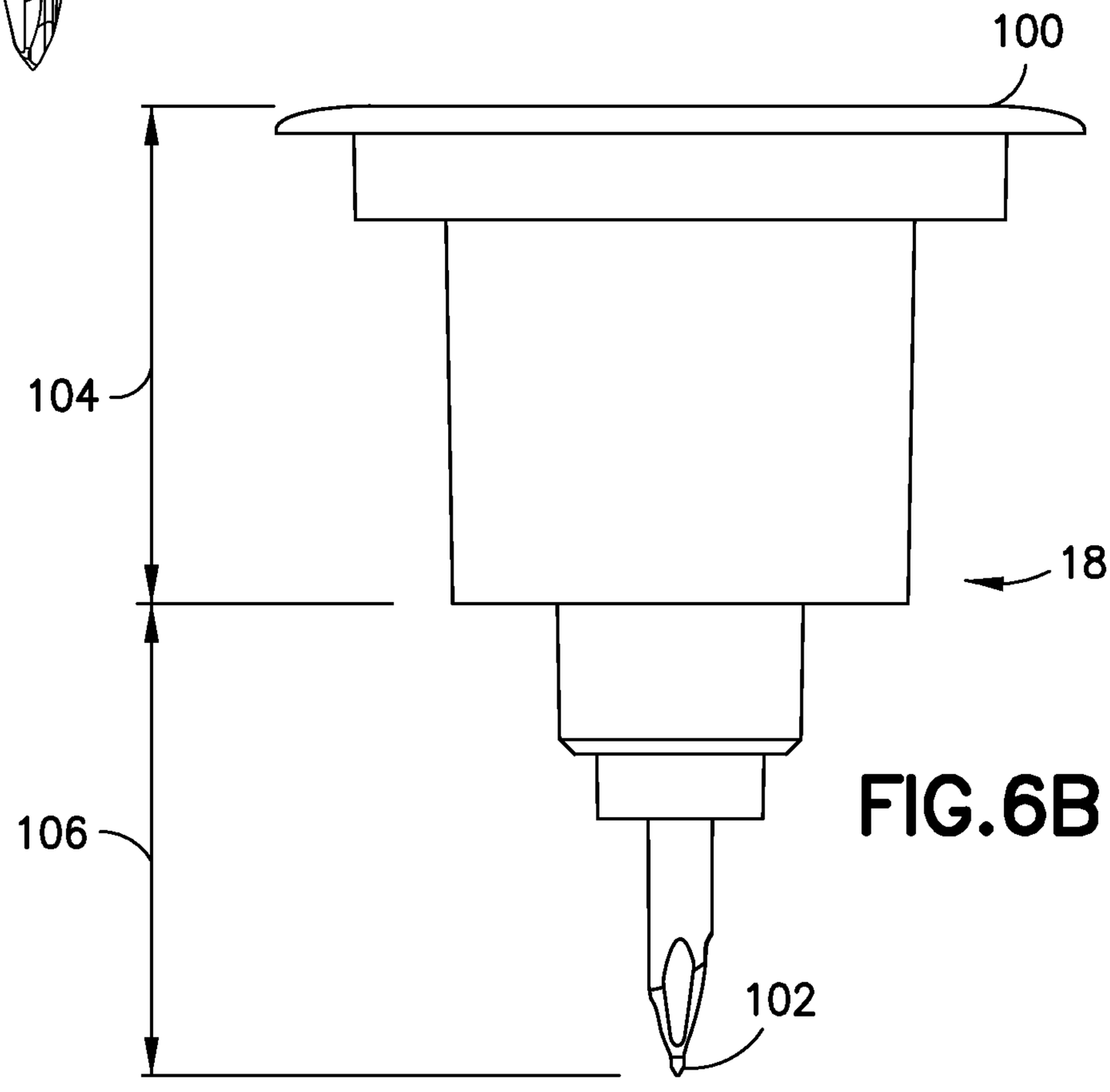


FIG.6B

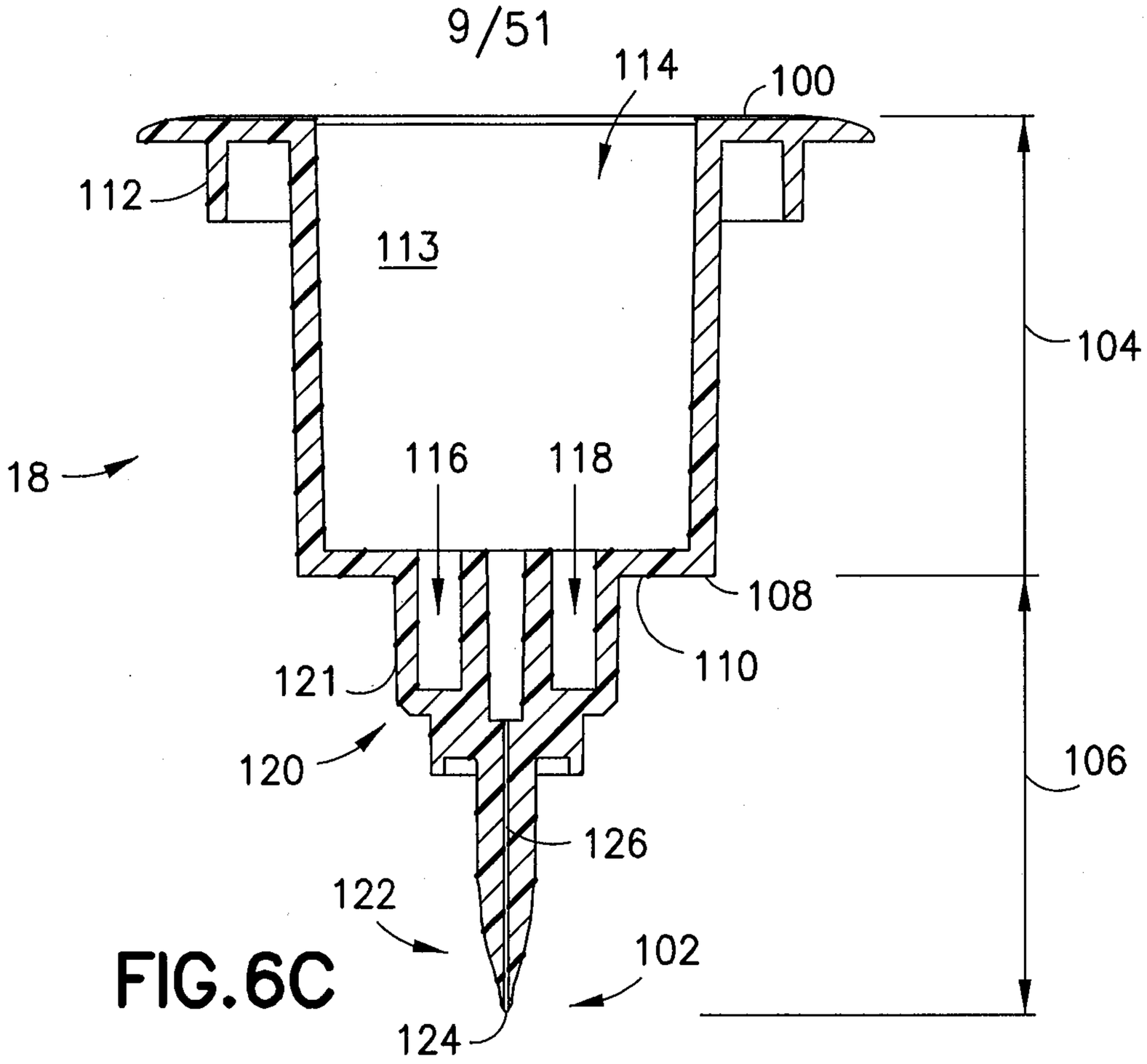
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FIG.6C

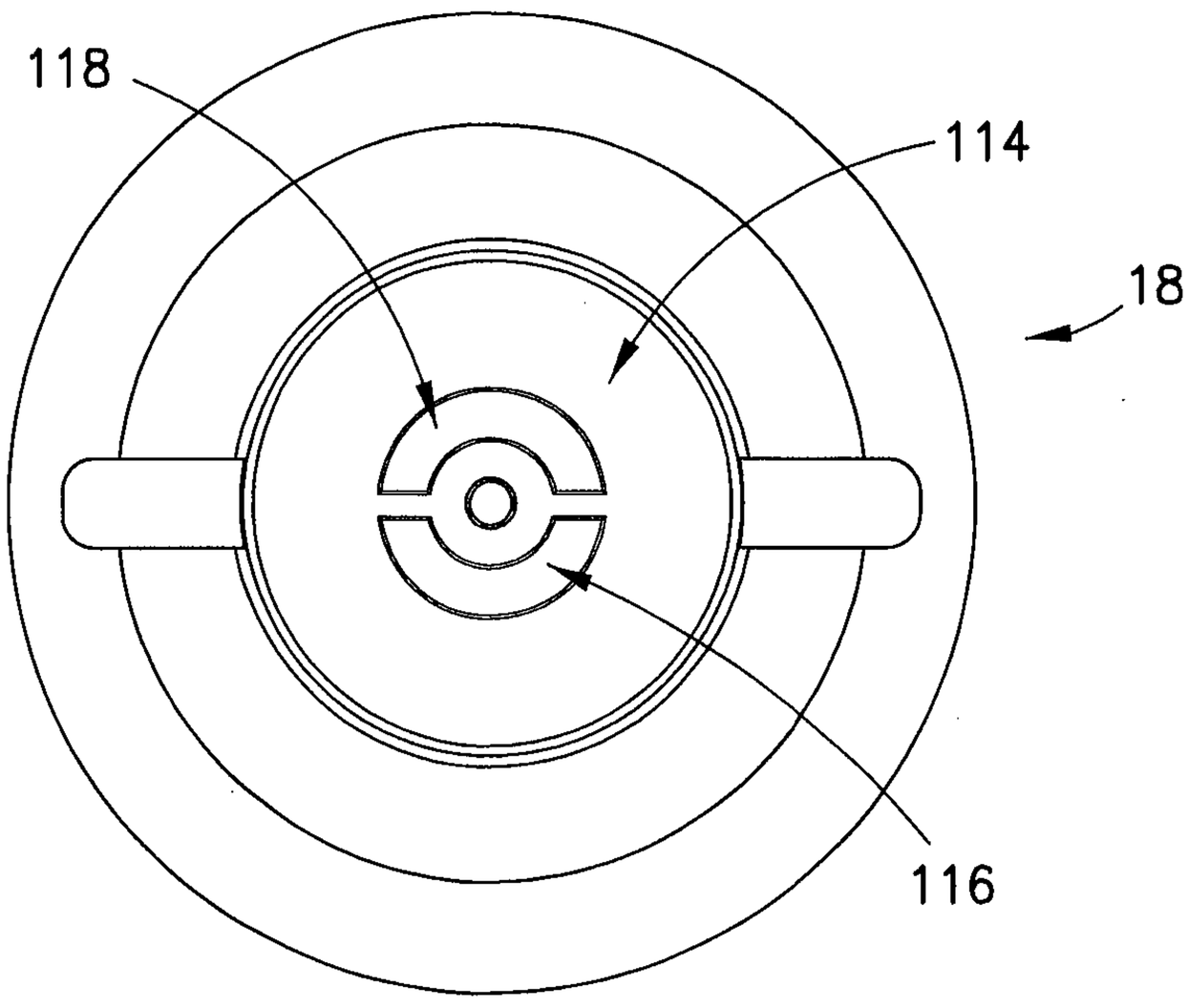
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FIG.6D

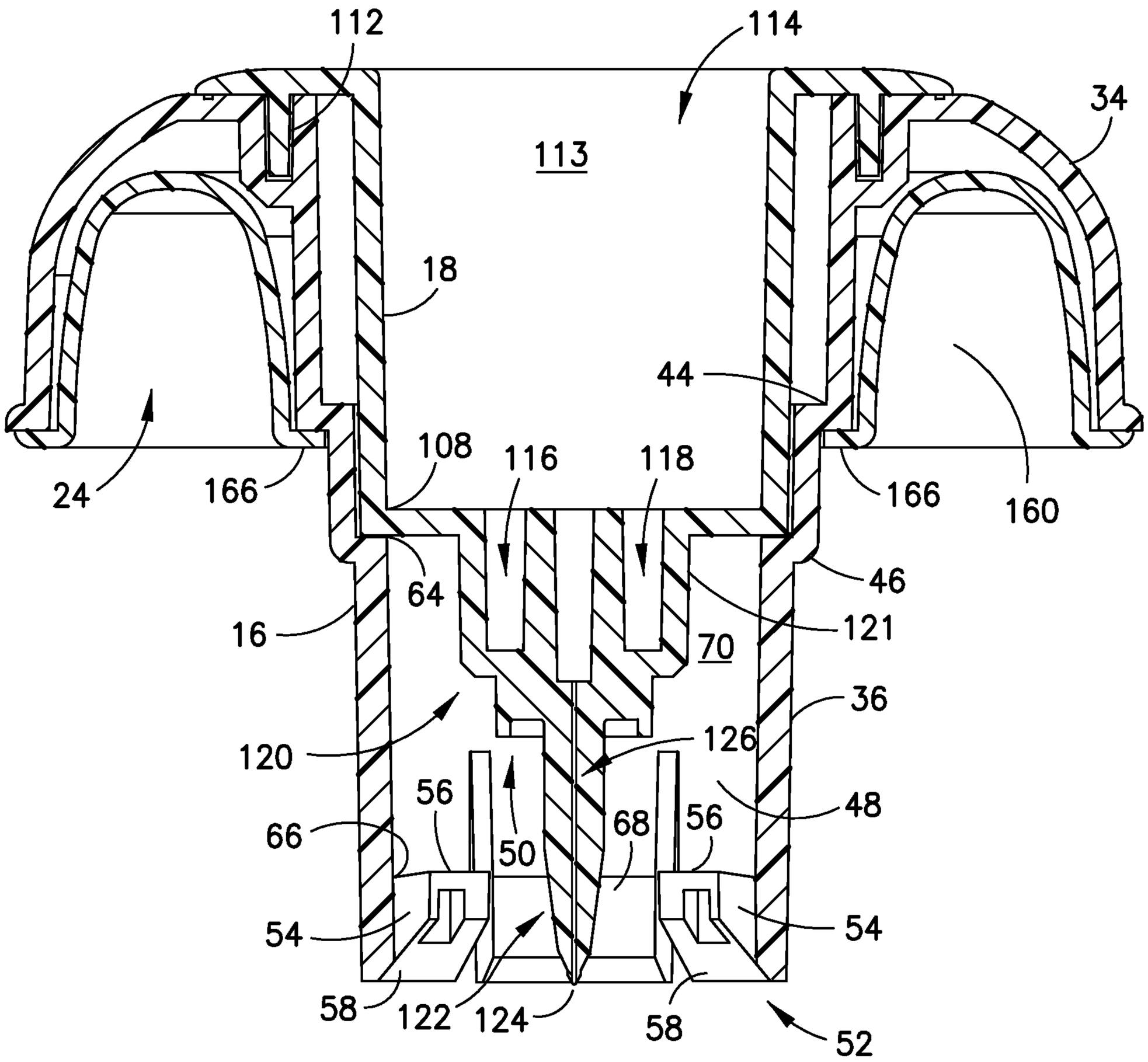
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FIG.7

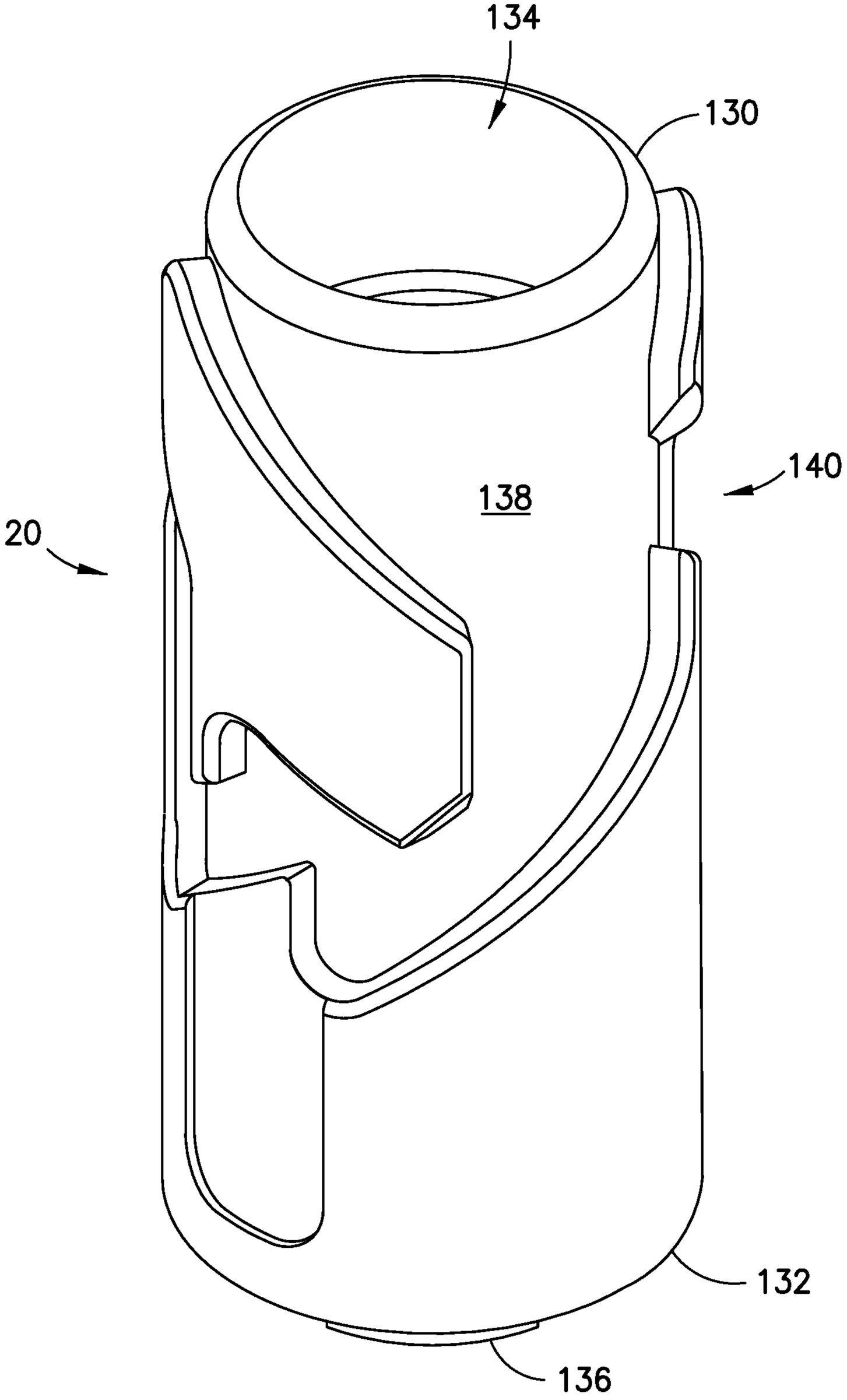


FIG.8A

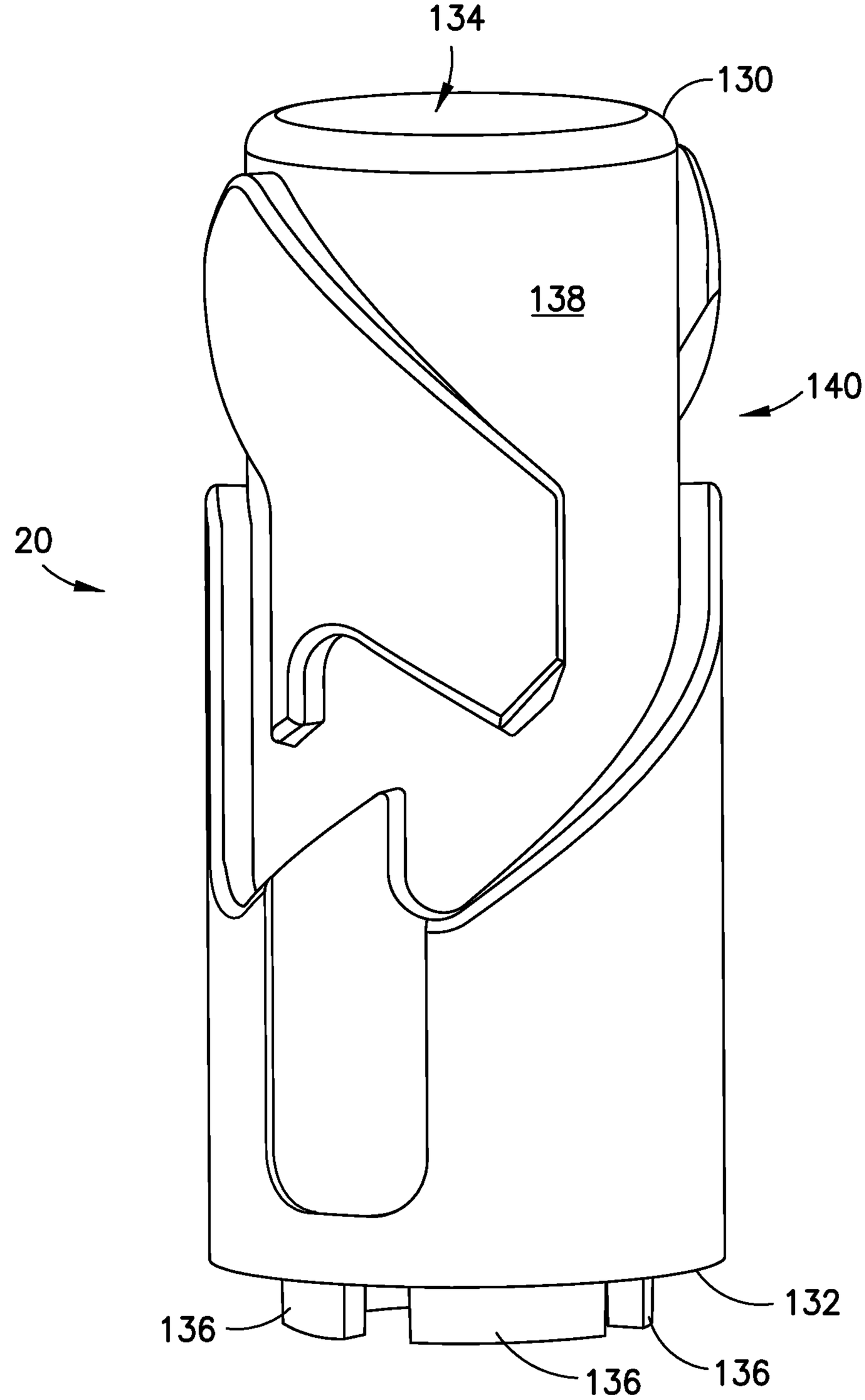


FIG.8B

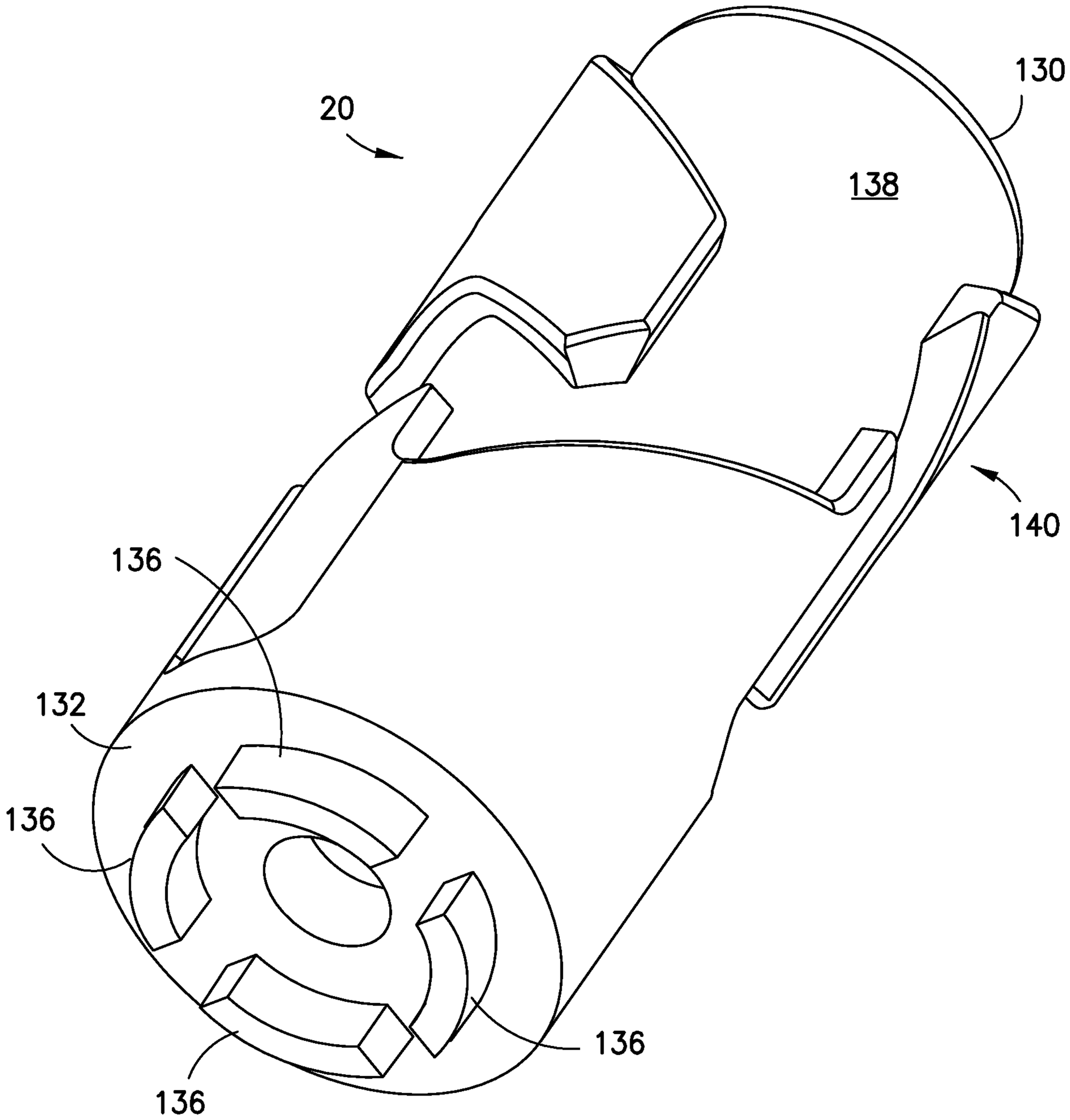


FIG.8C

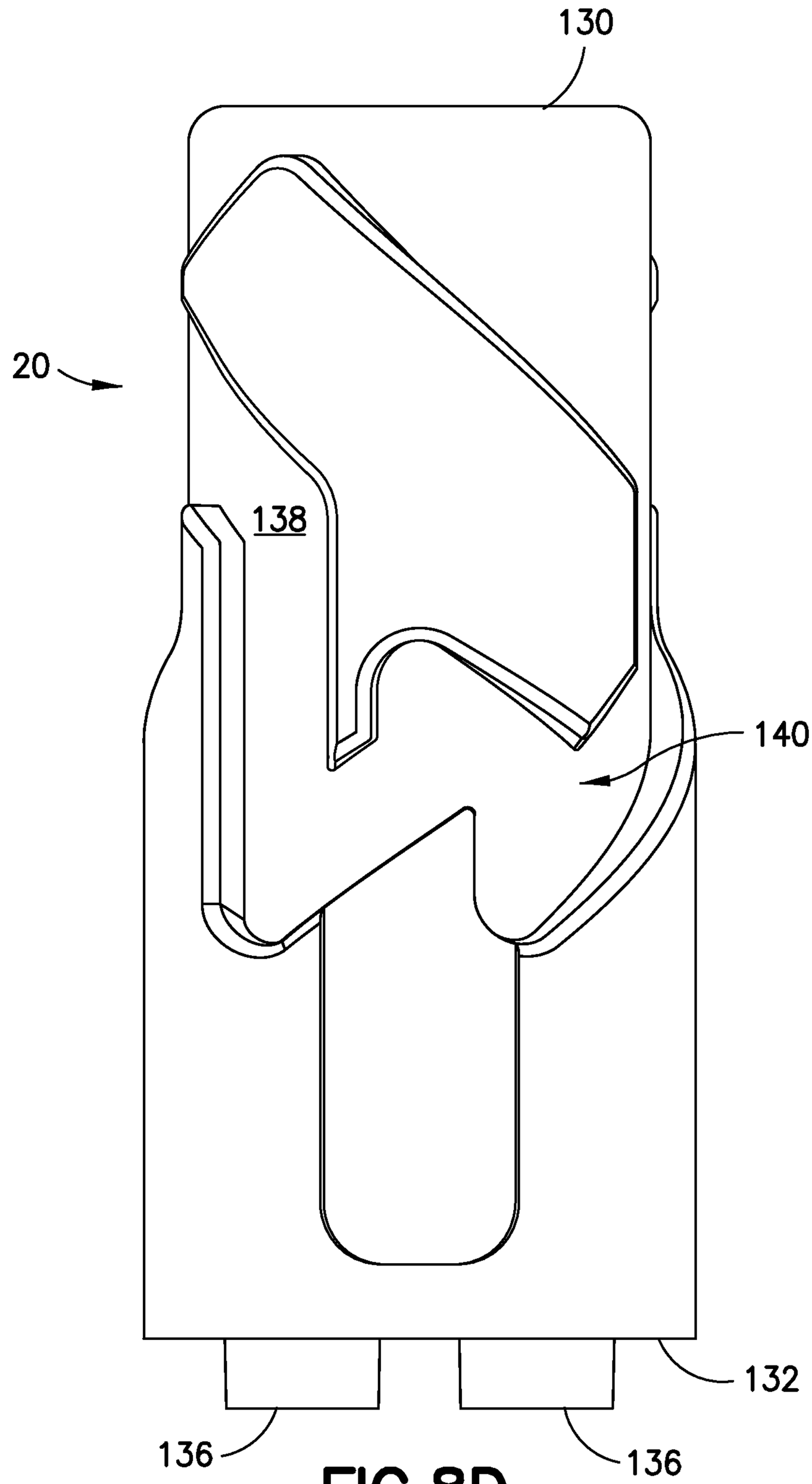


FIG.8D

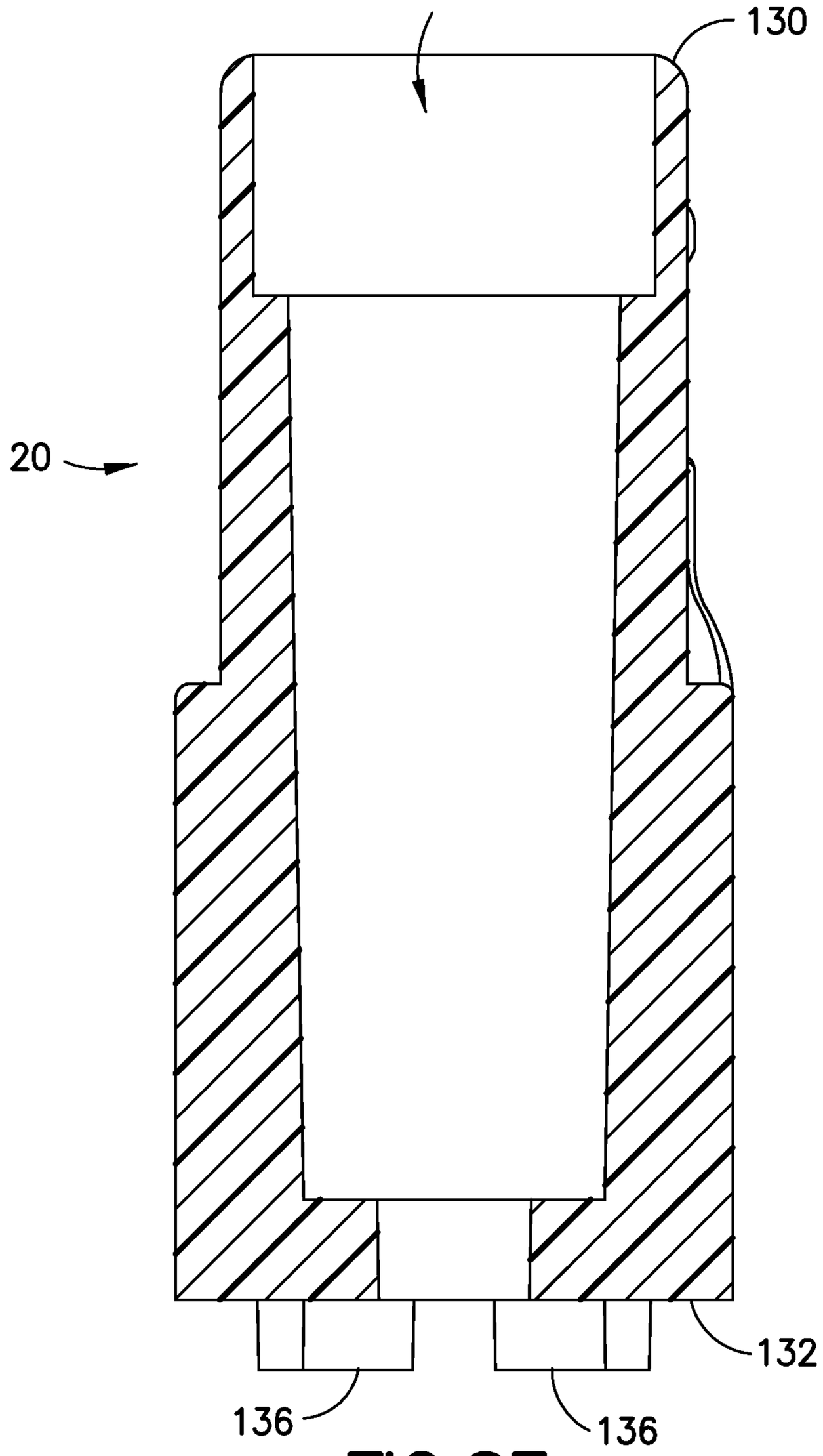


FIG.8E

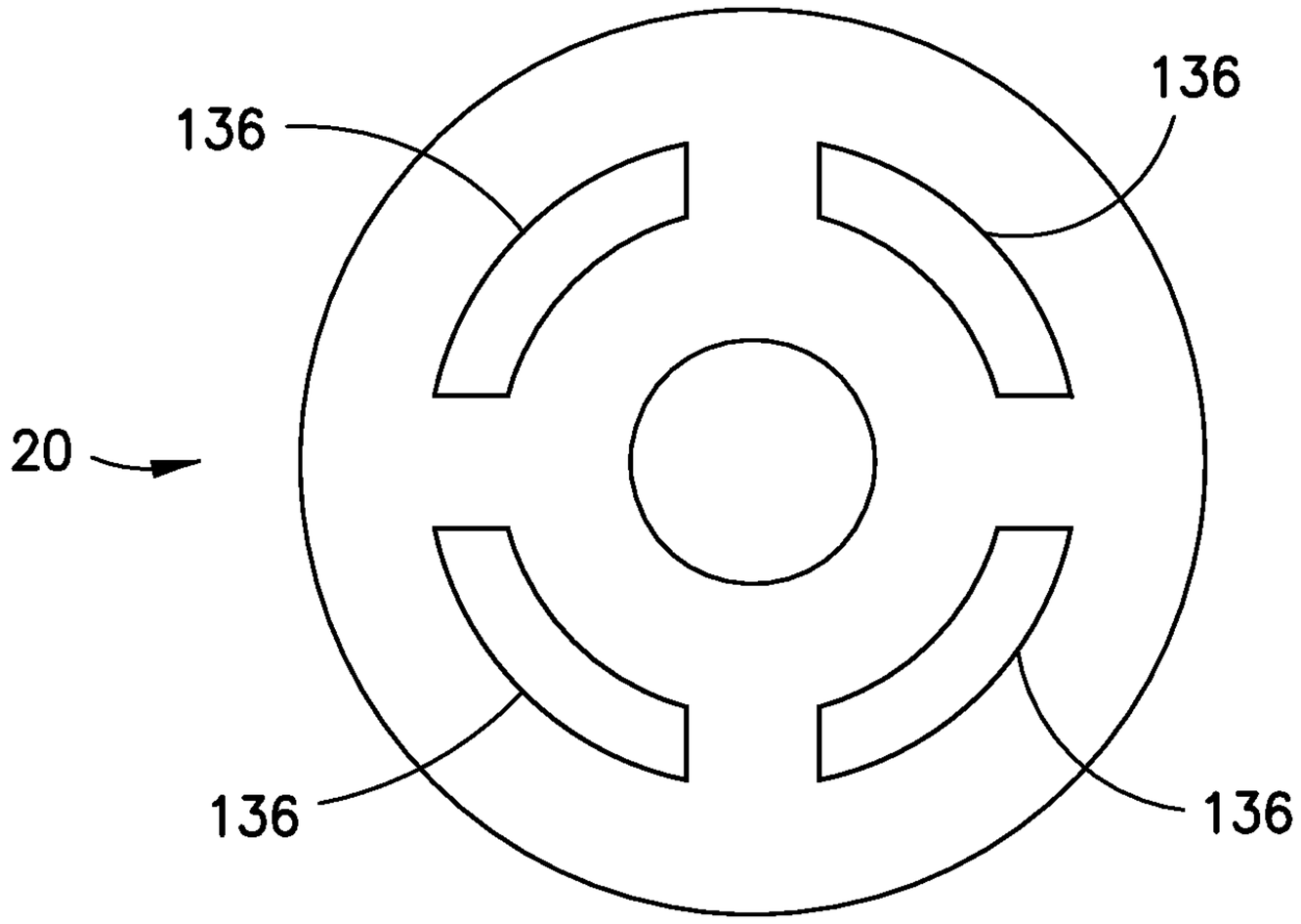


FIG.8F

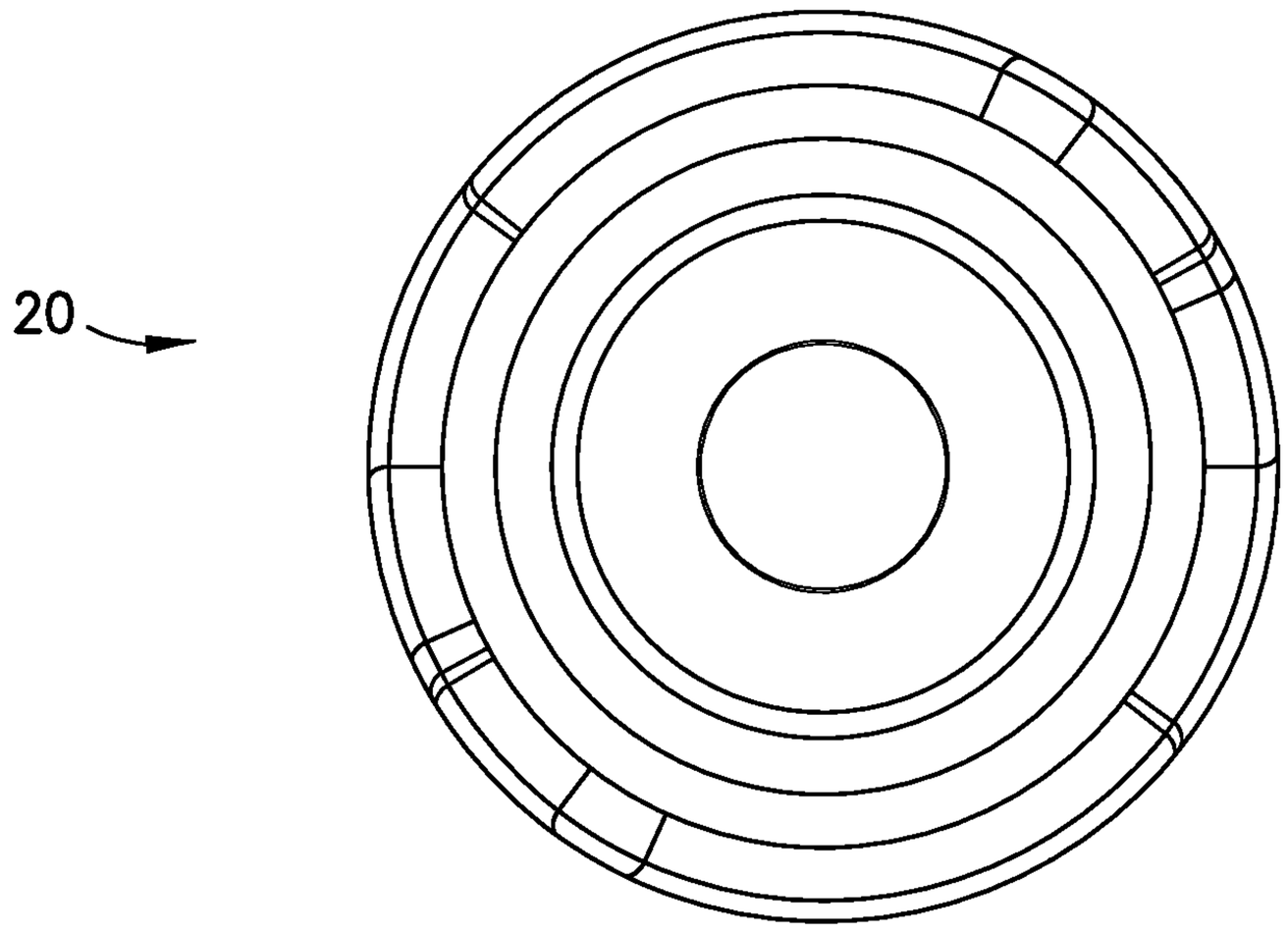


FIG.8G

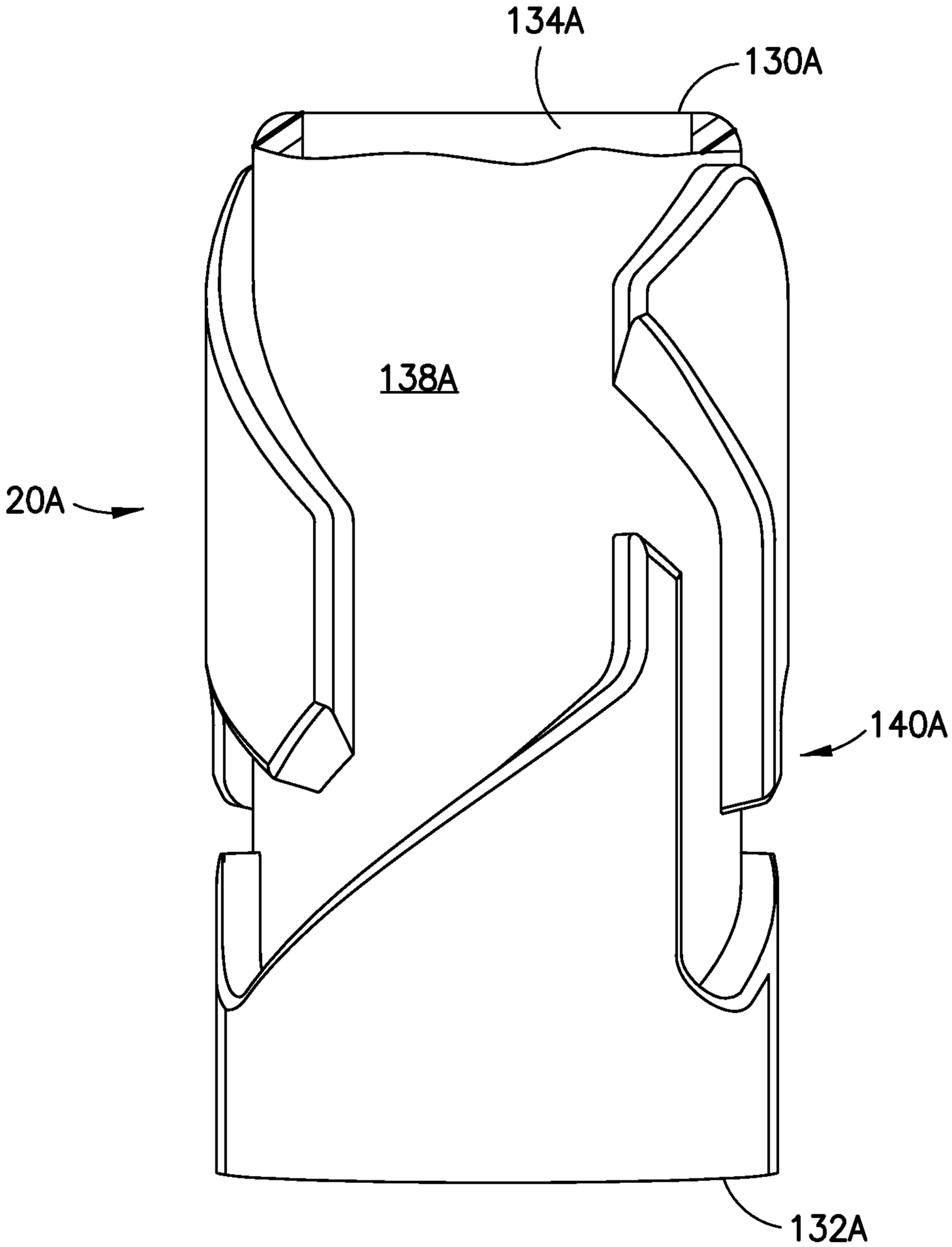


FIG.9A

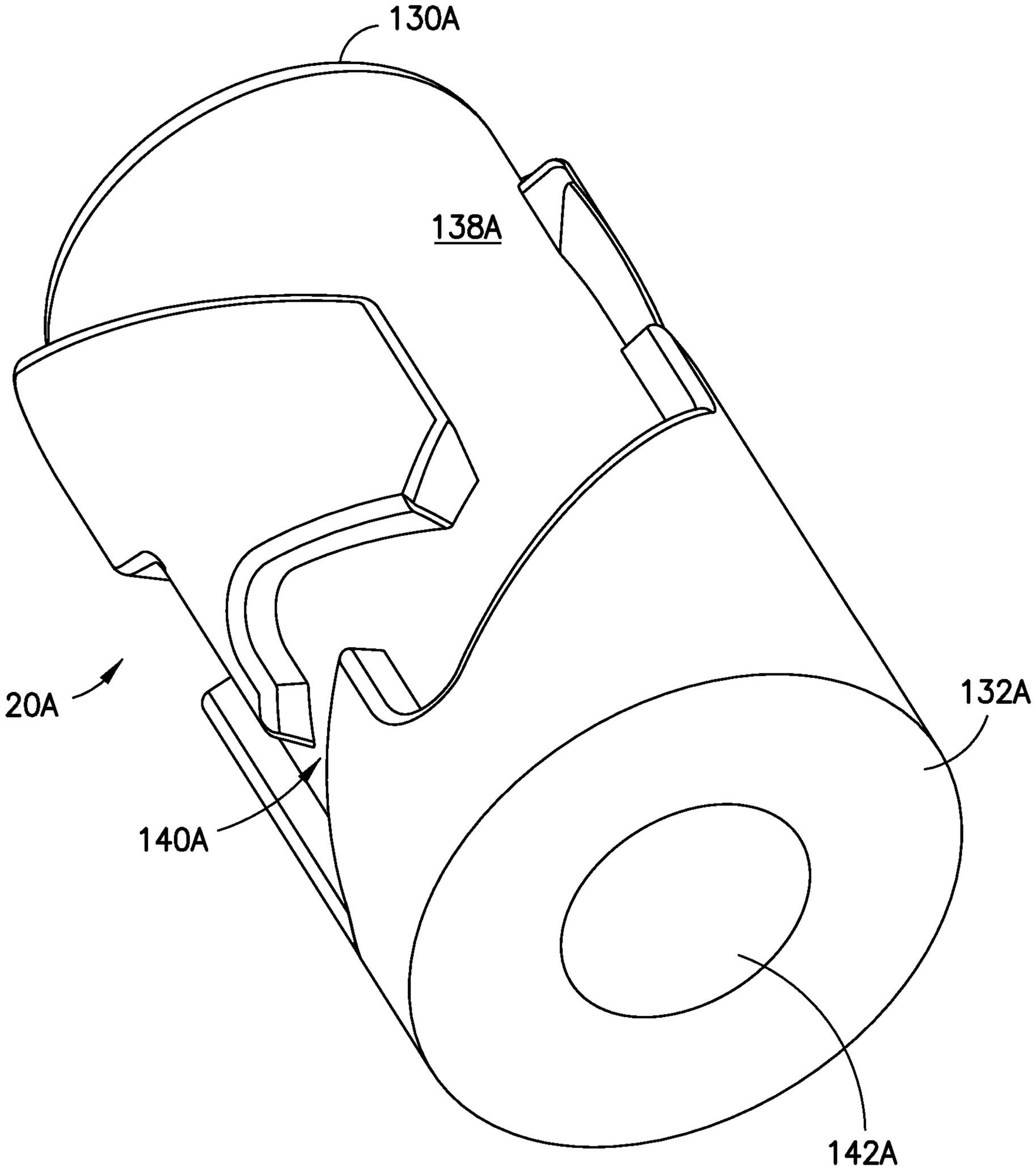


FIG.9B

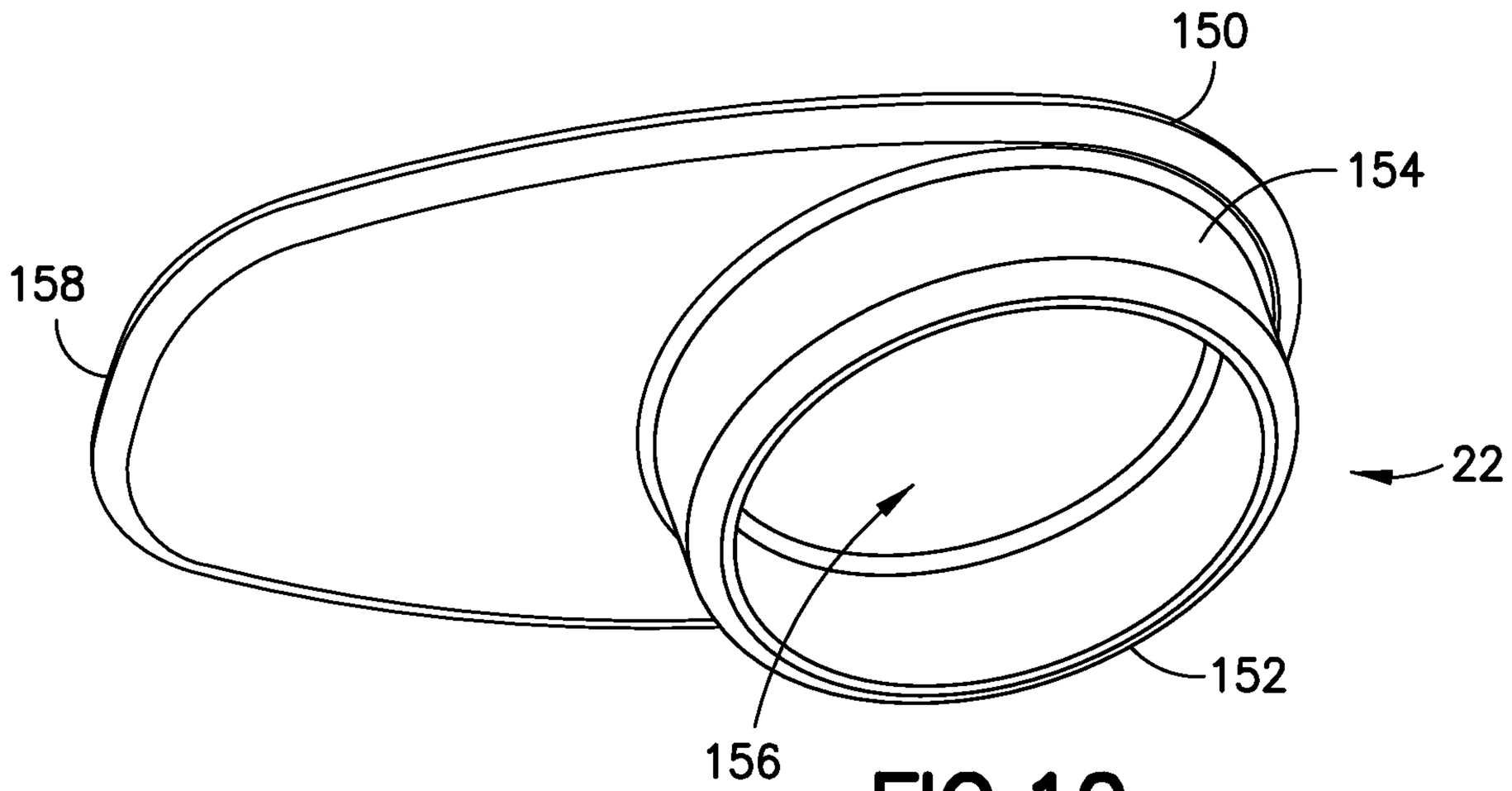


FIG.10

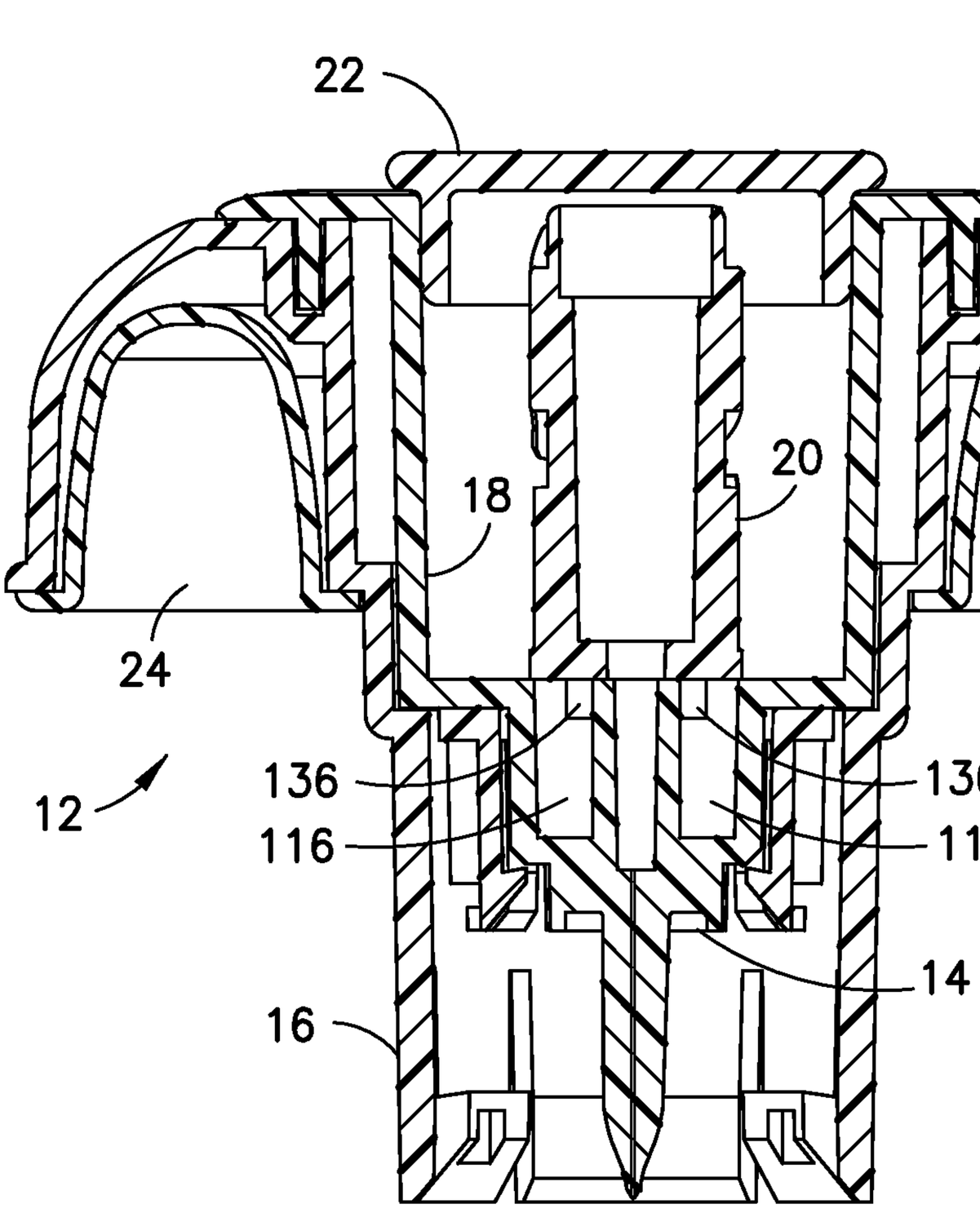


FIG.11

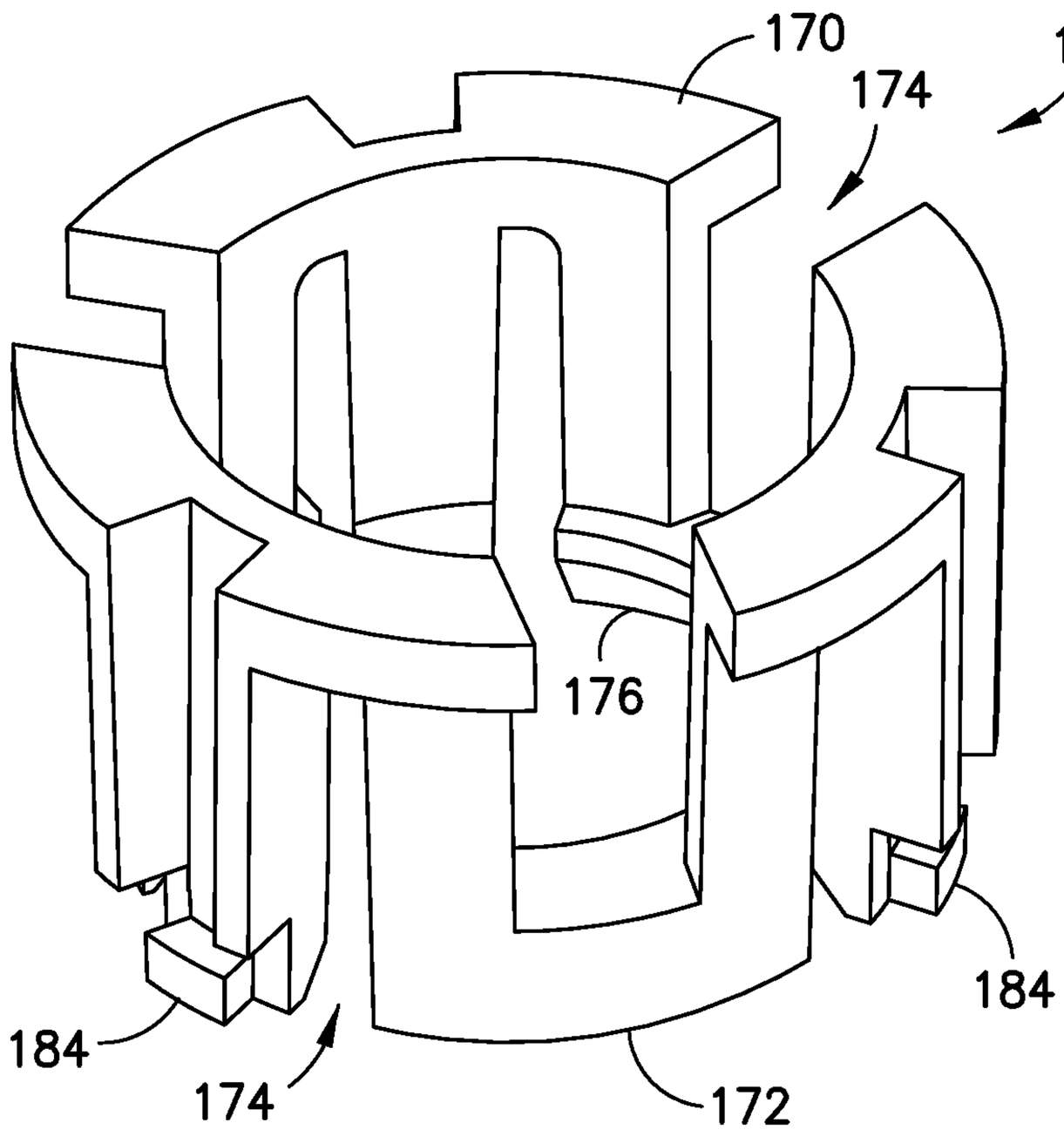


FIG.12A

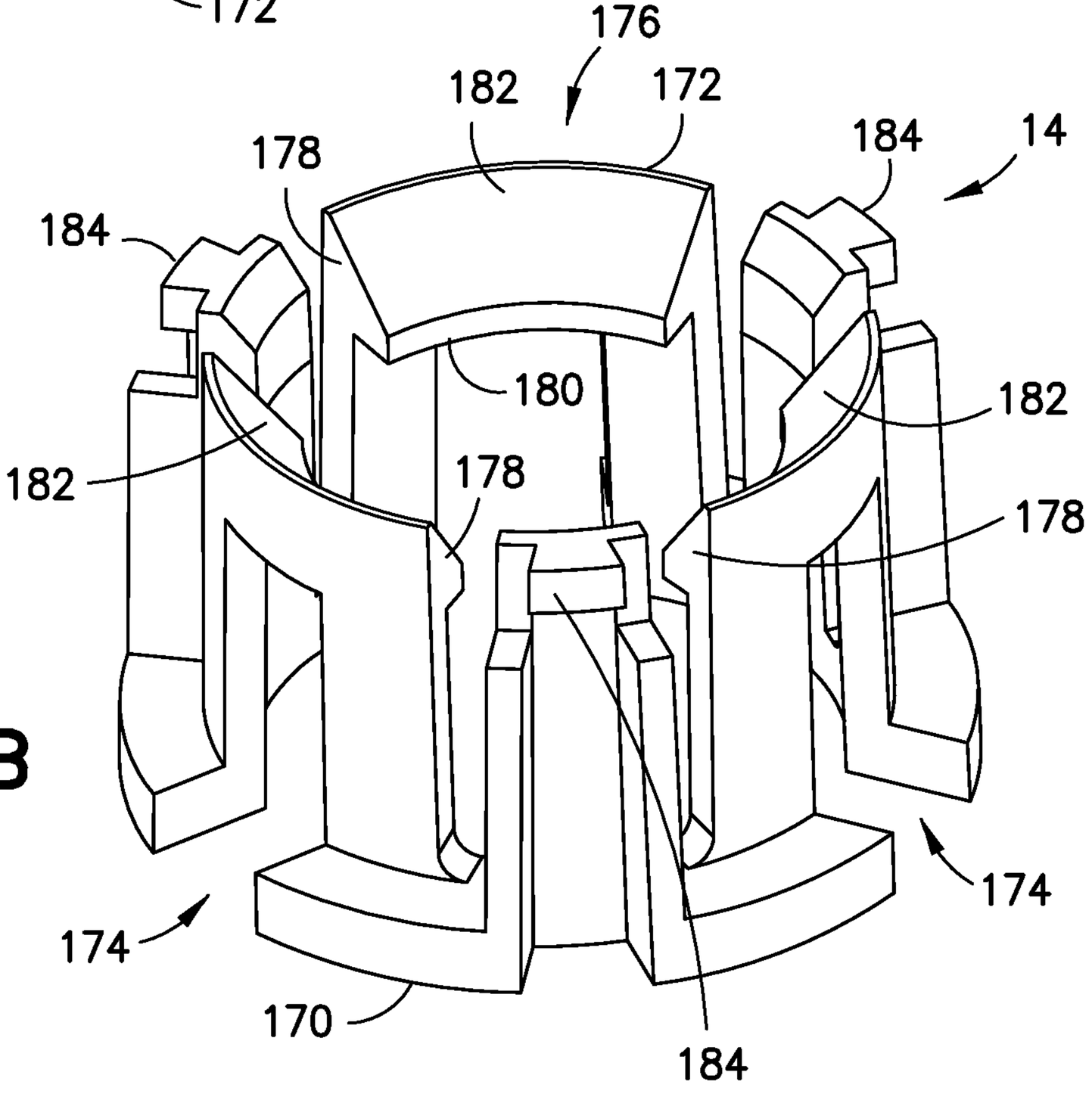


FIG.12B

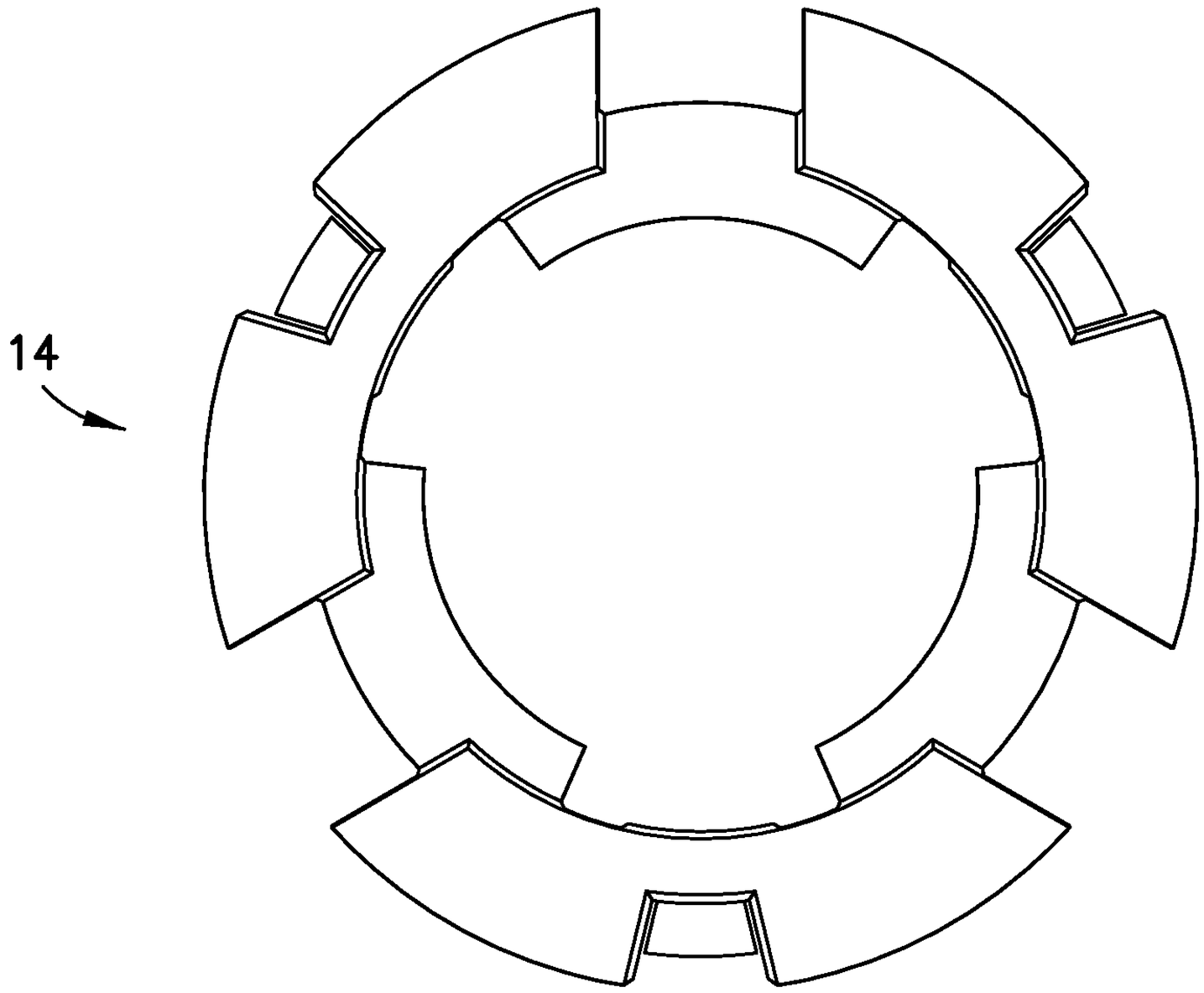


FIG.12C

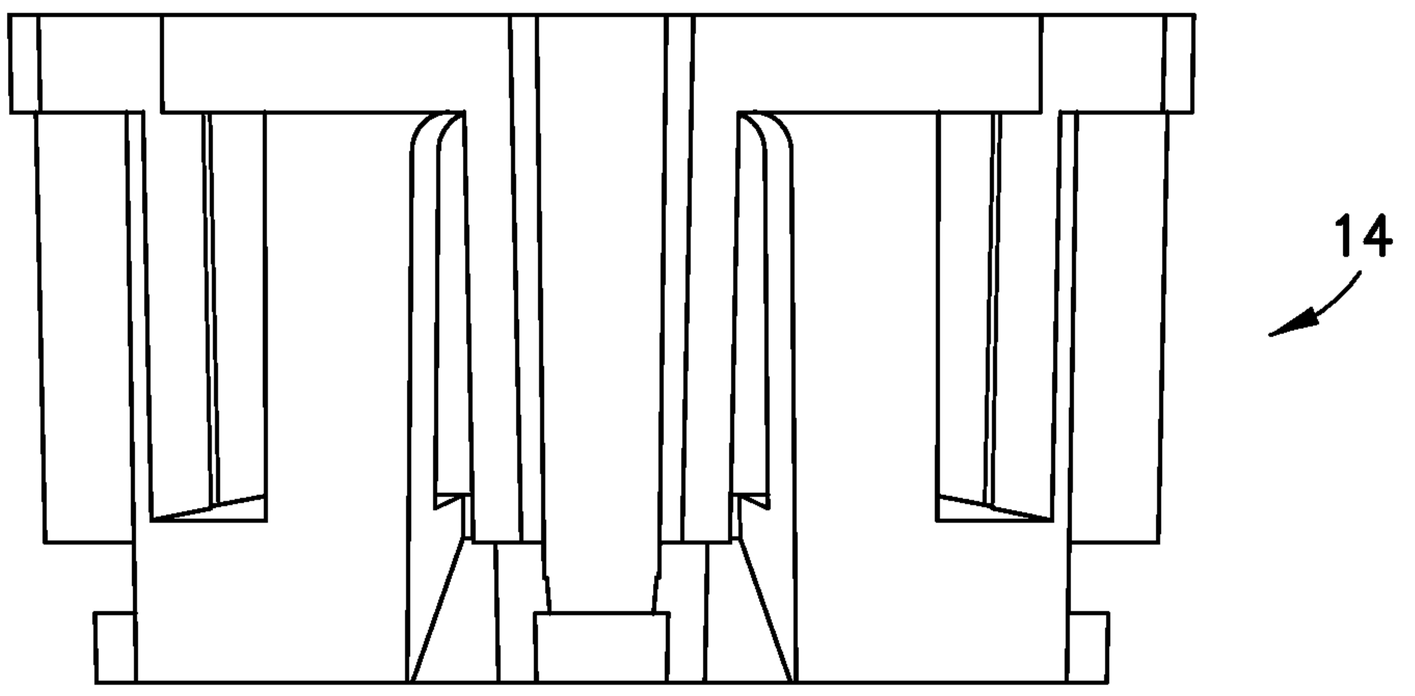


FIG.12D

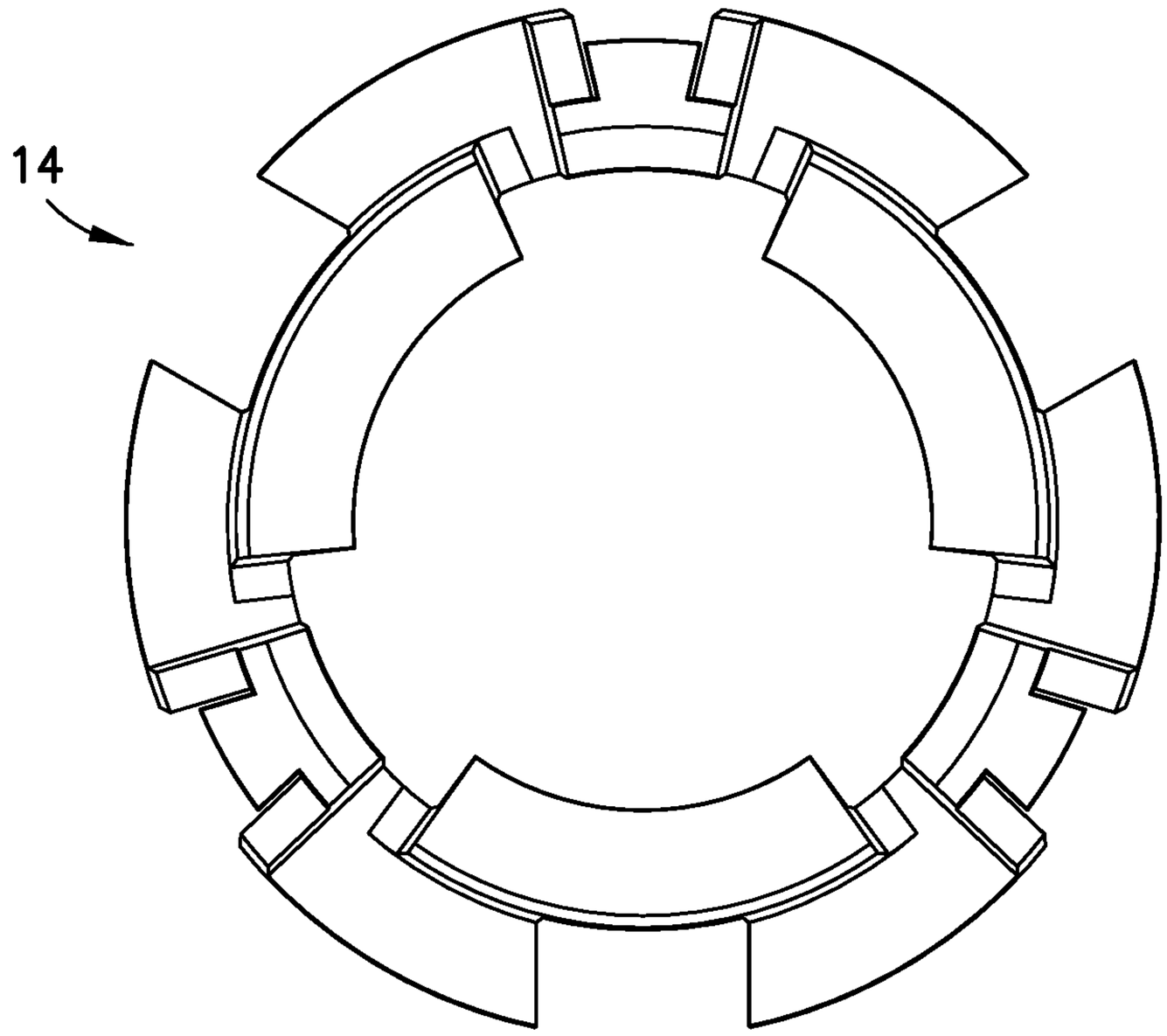


FIG.12E

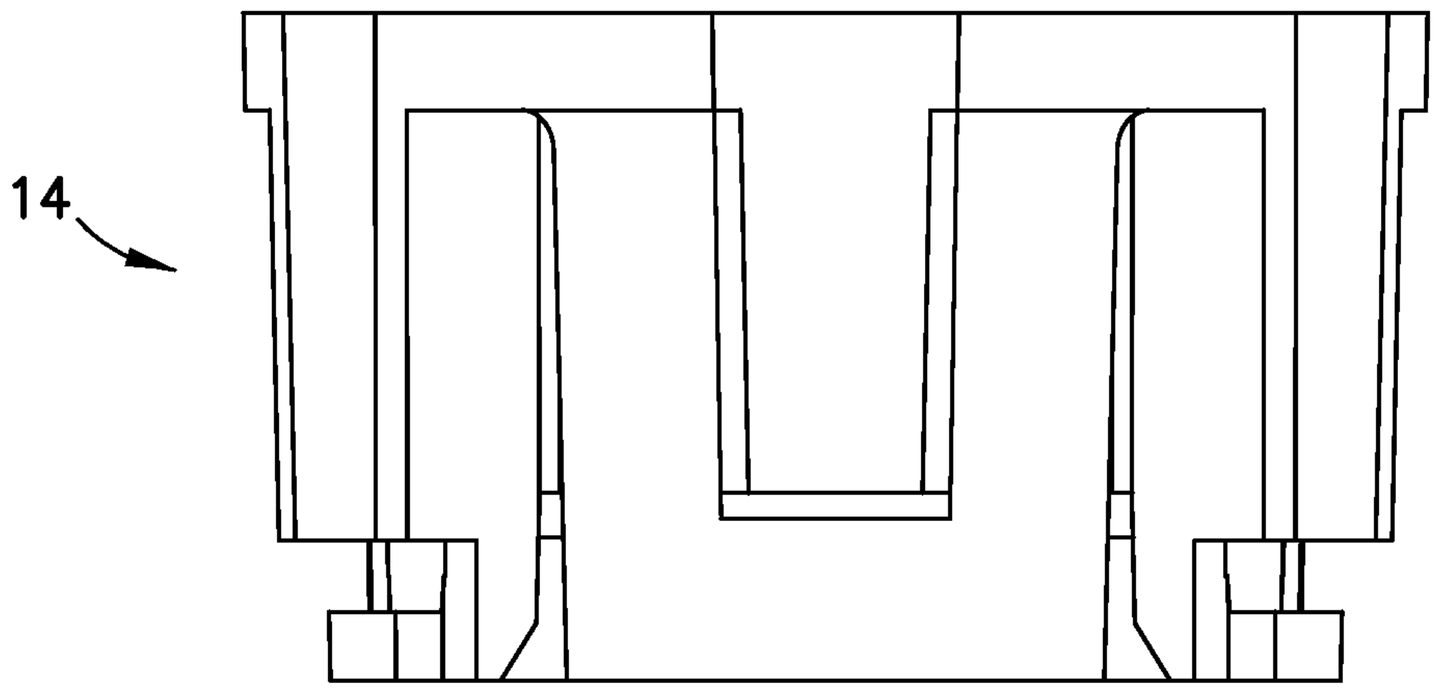


FIG.12F

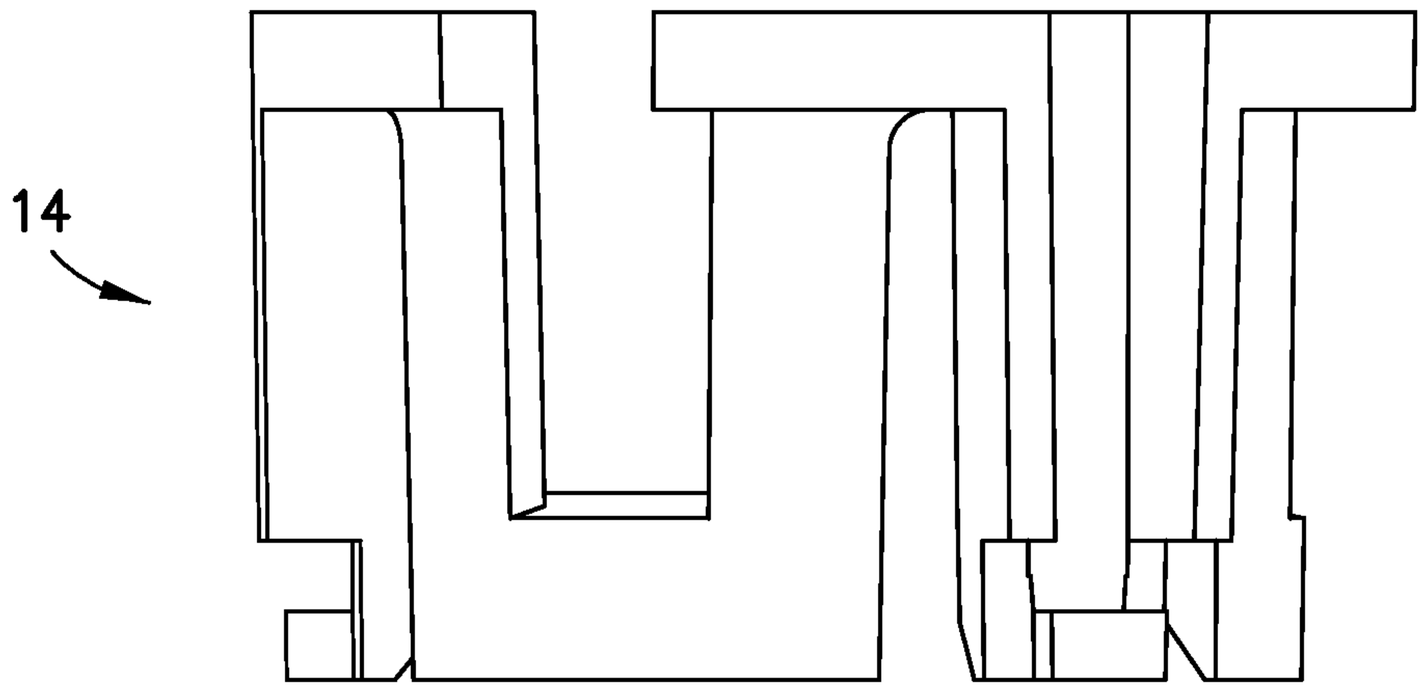


FIG.12G

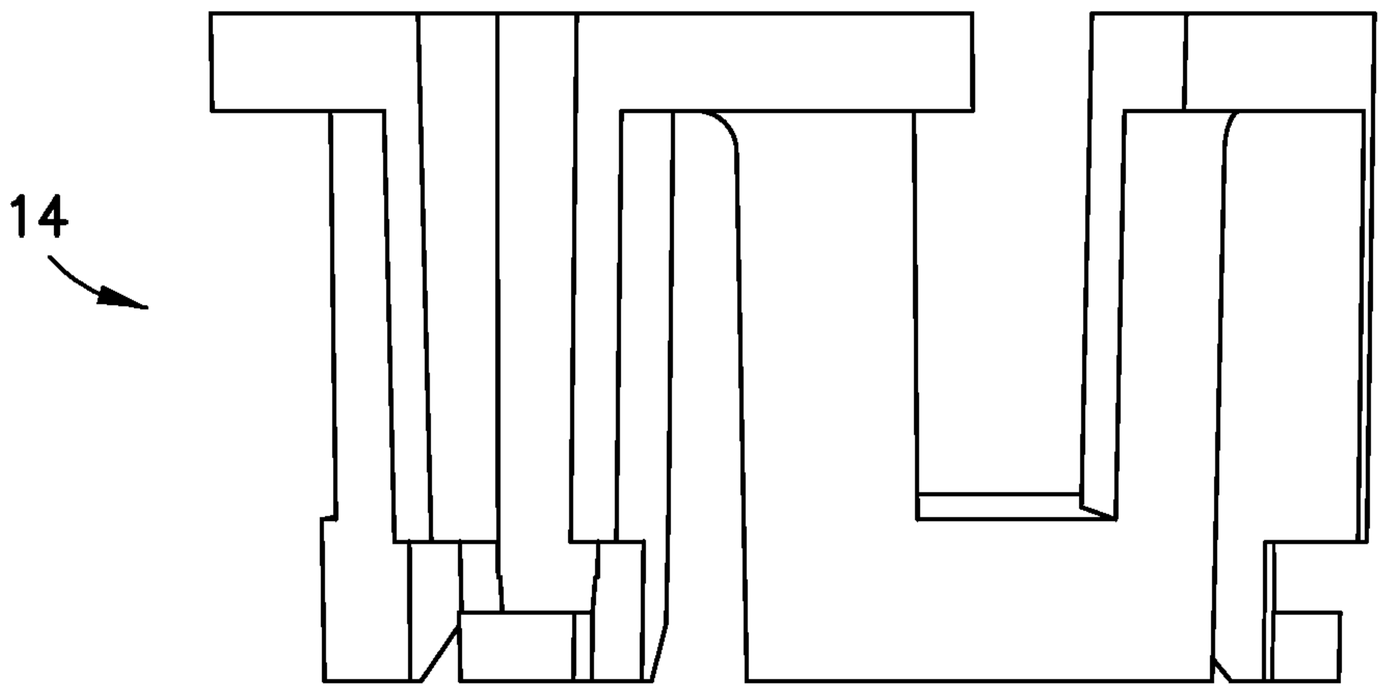


FIG.12H

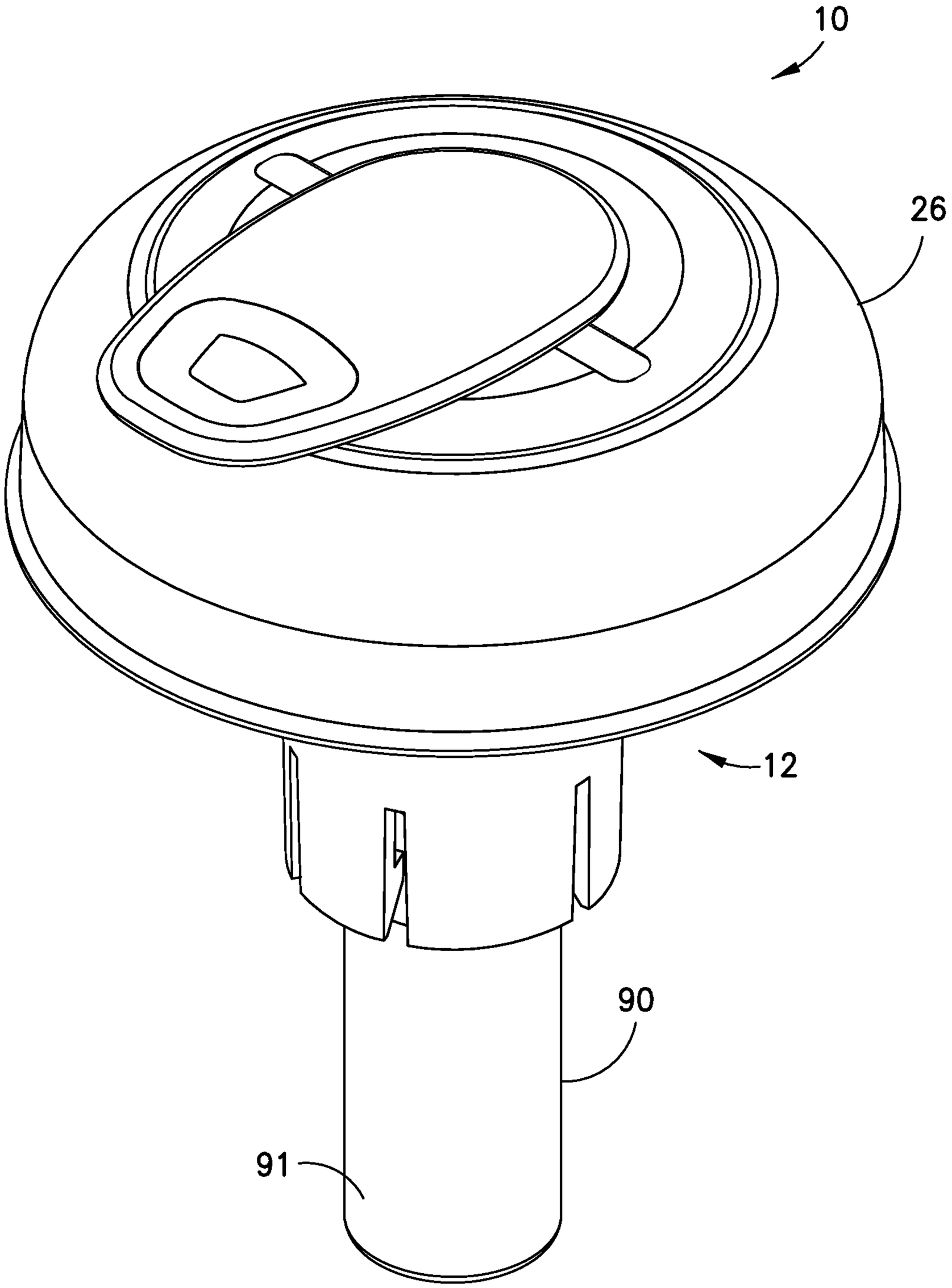


FIG.13

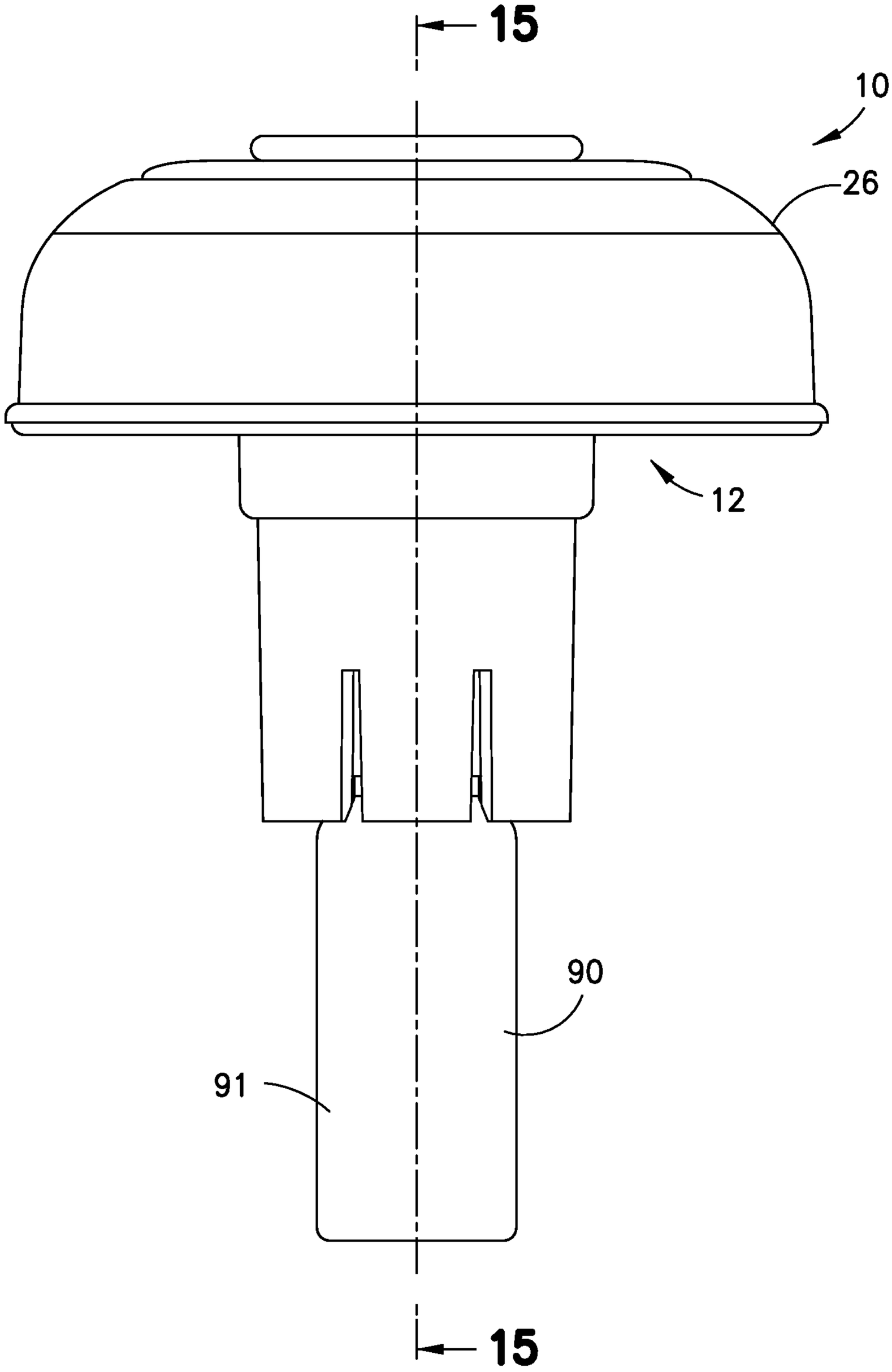


FIG.14

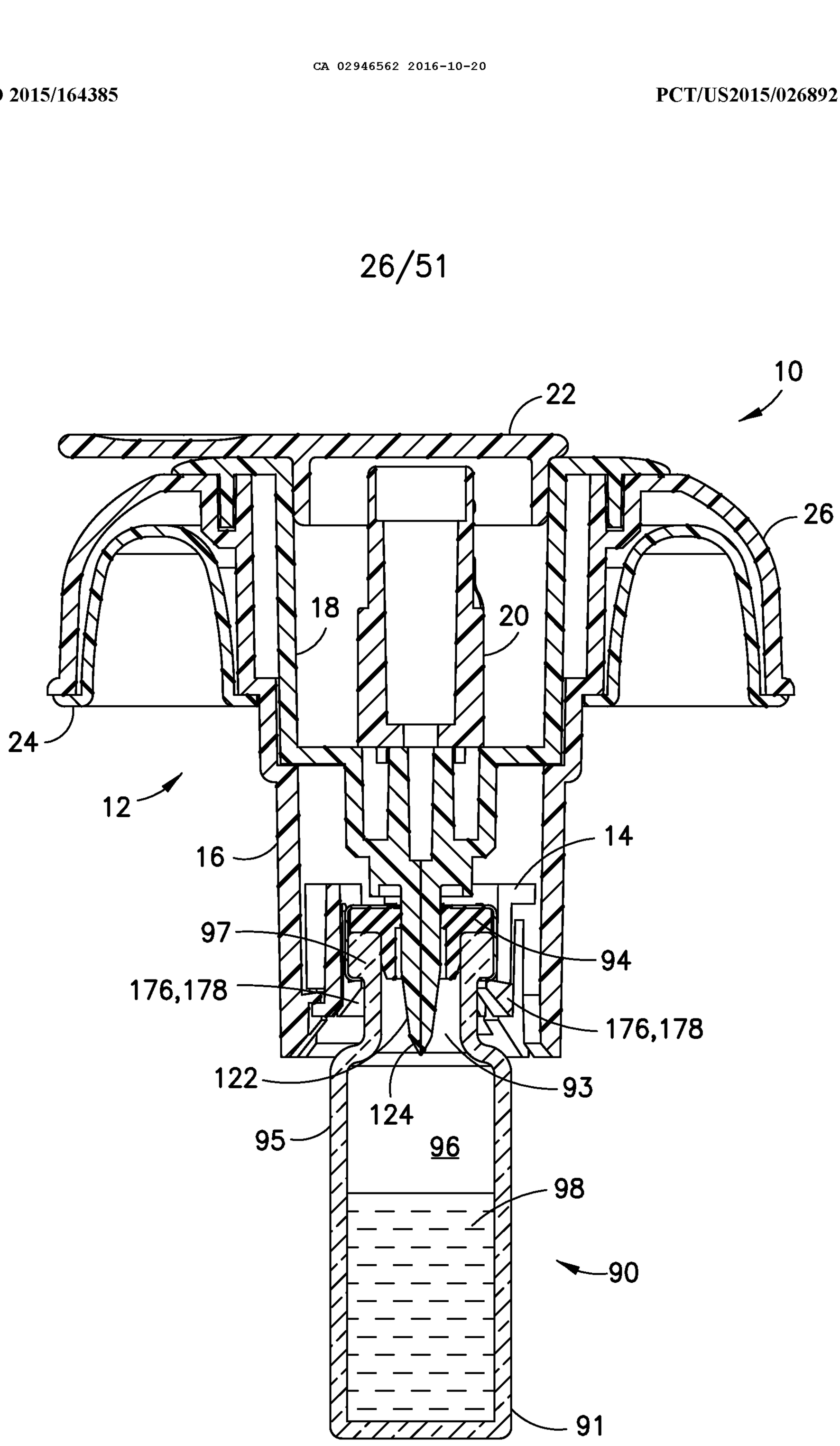
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FIG.15

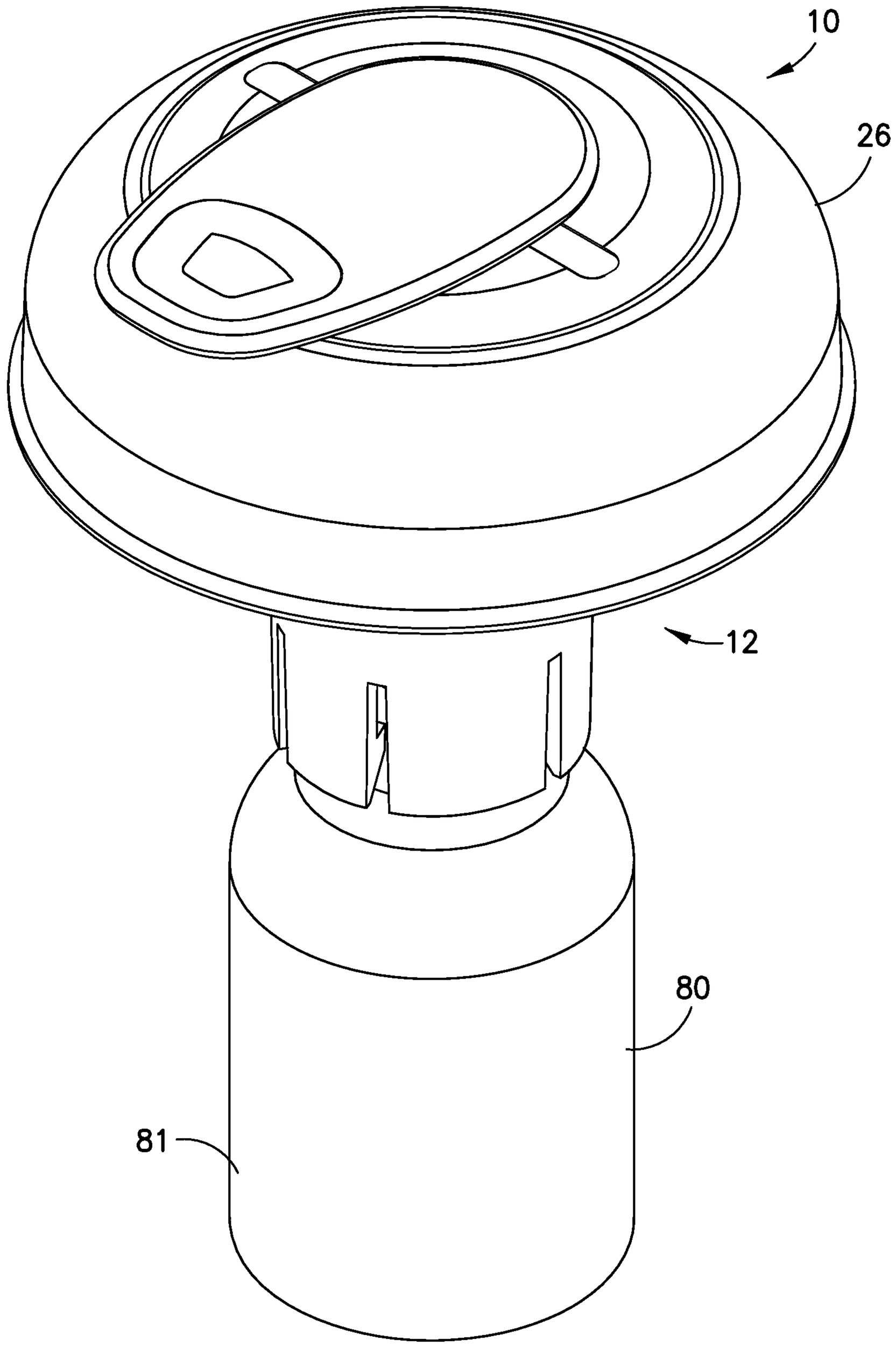


FIG.16

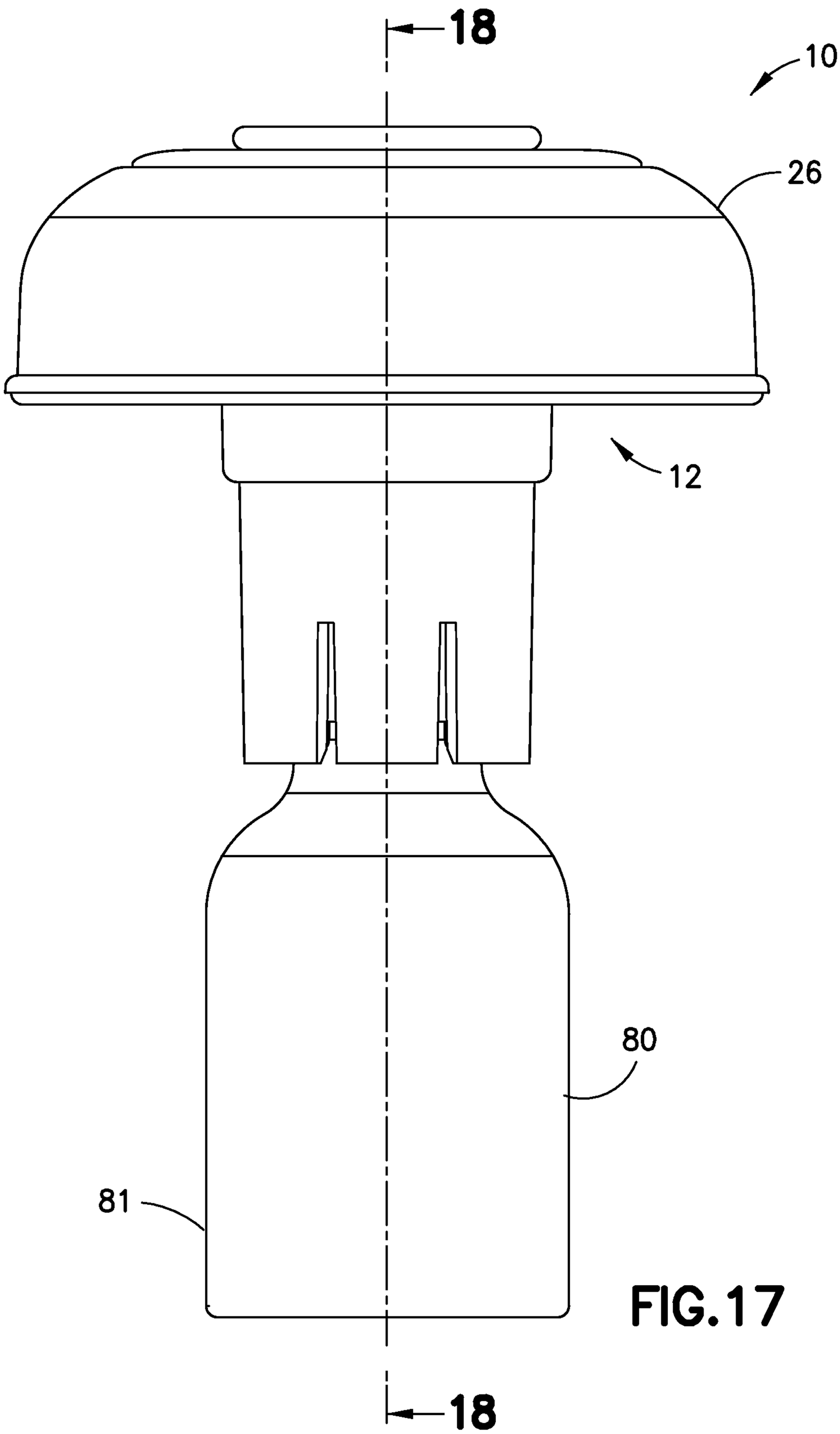


FIG.17

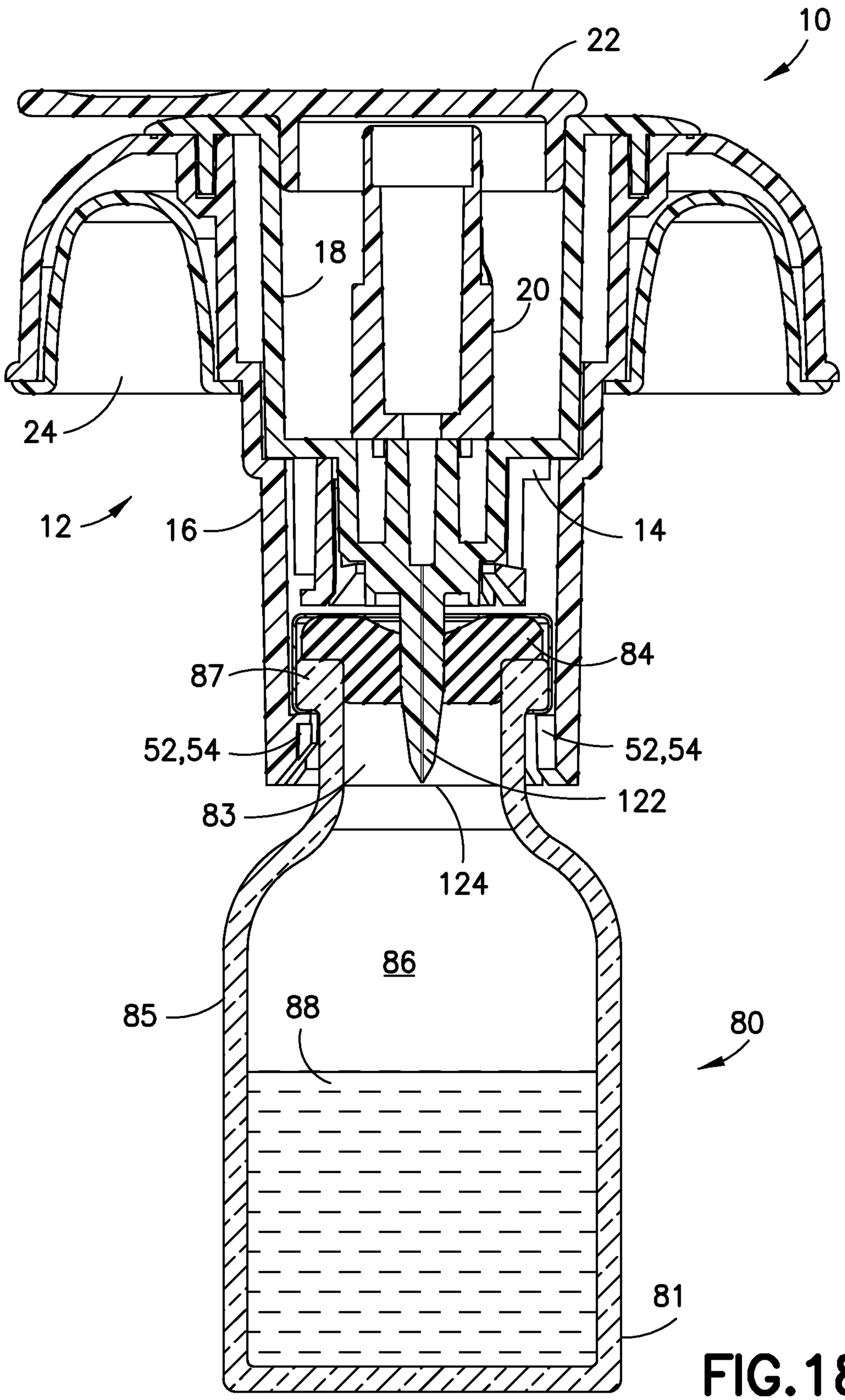


FIG.18

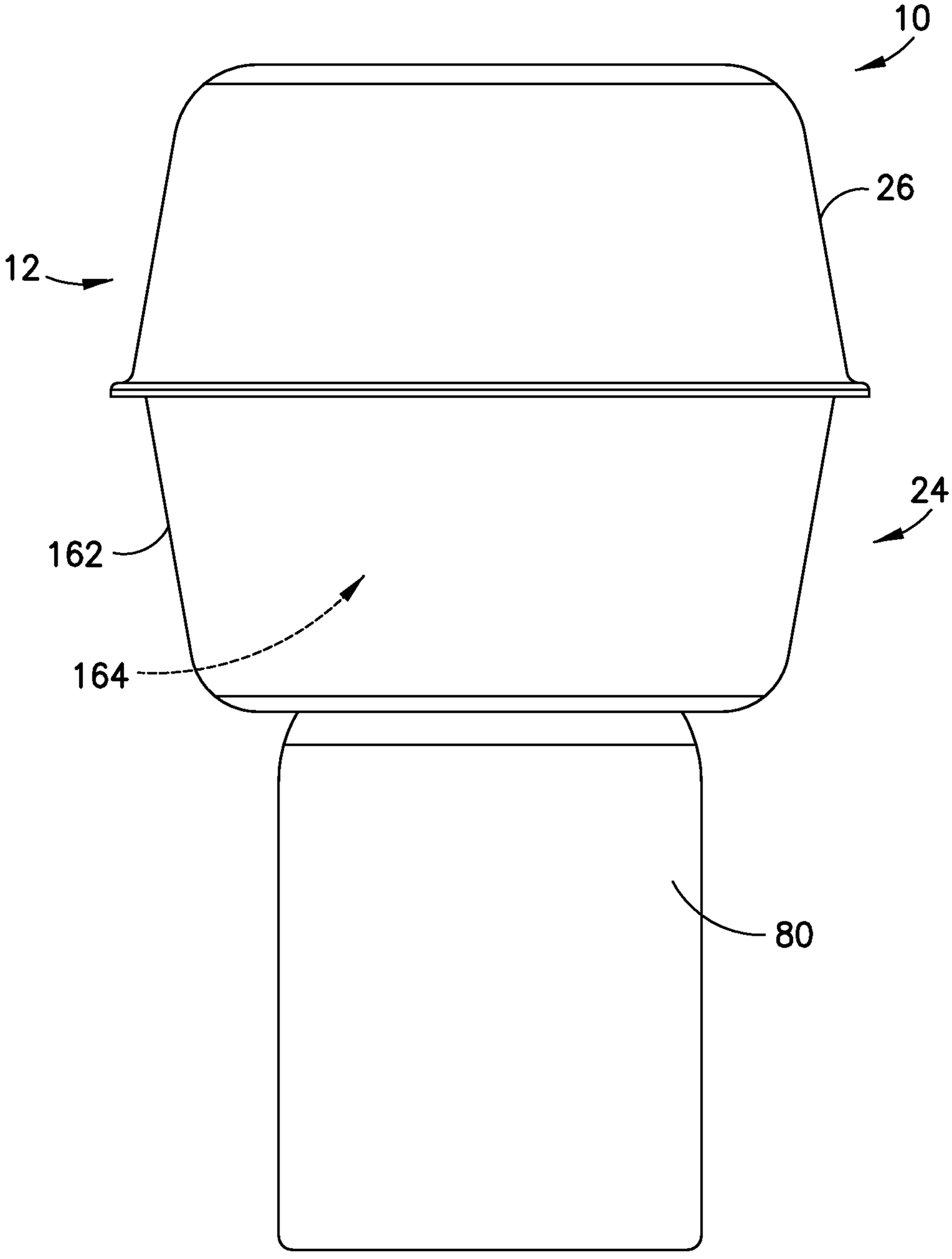


FIG.19

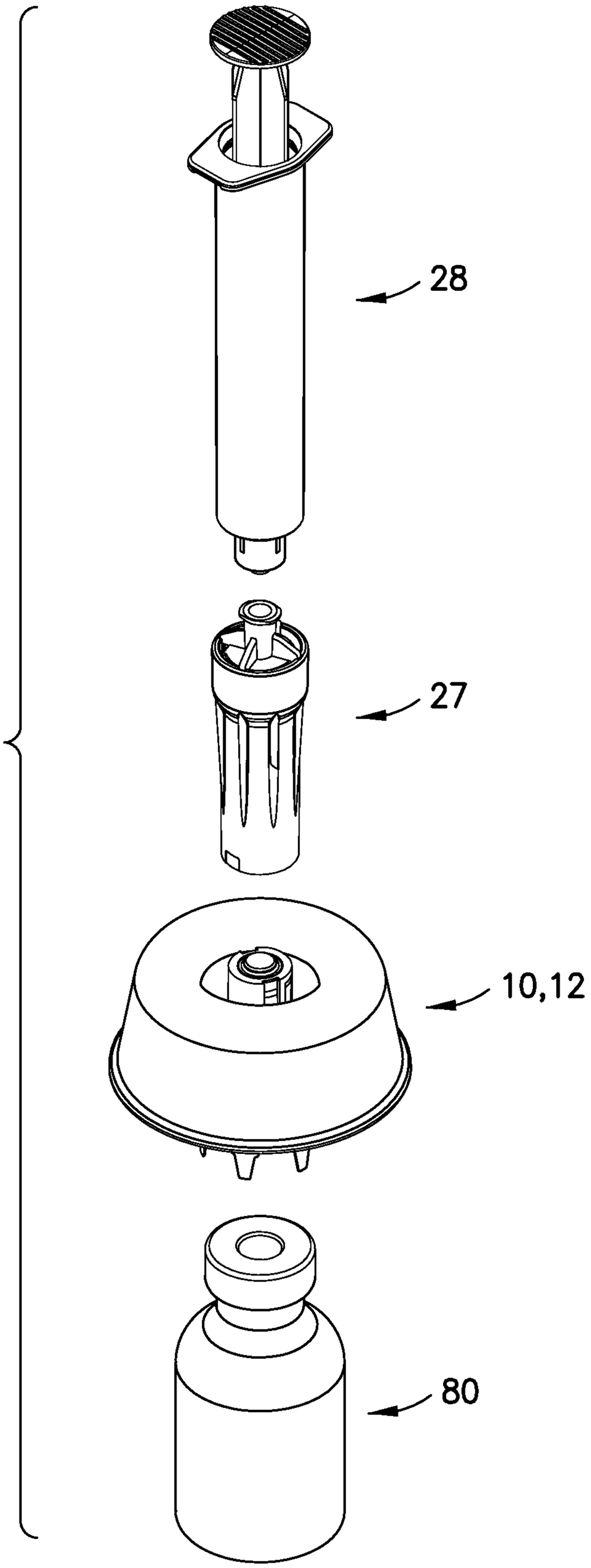


FIG.20

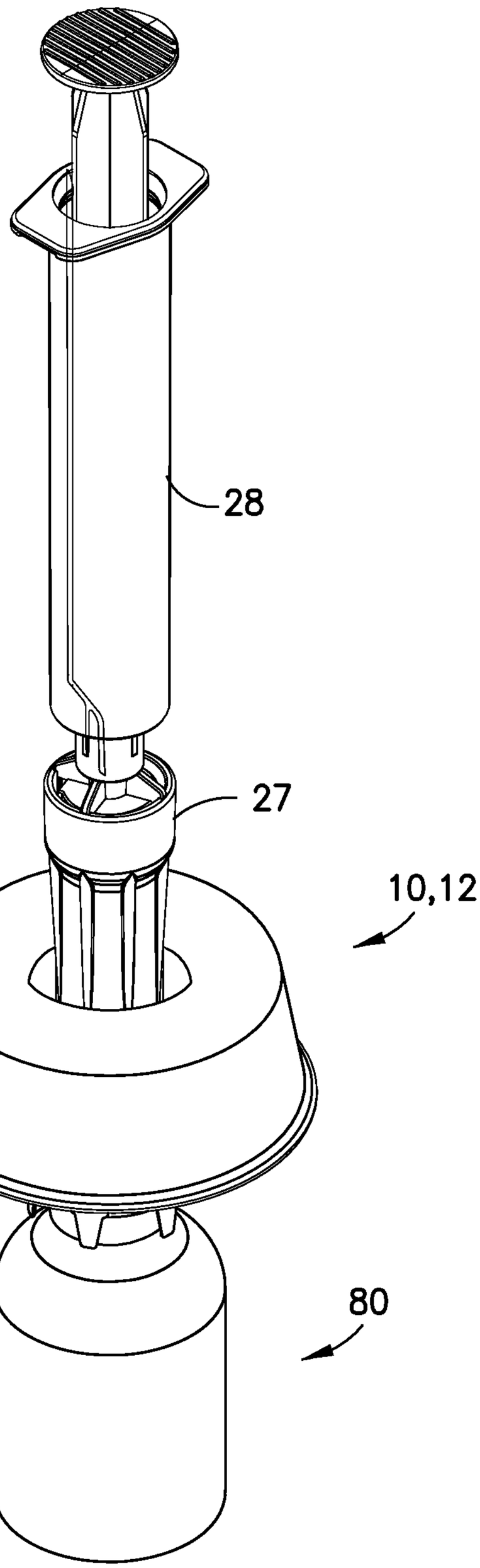


FIG.21

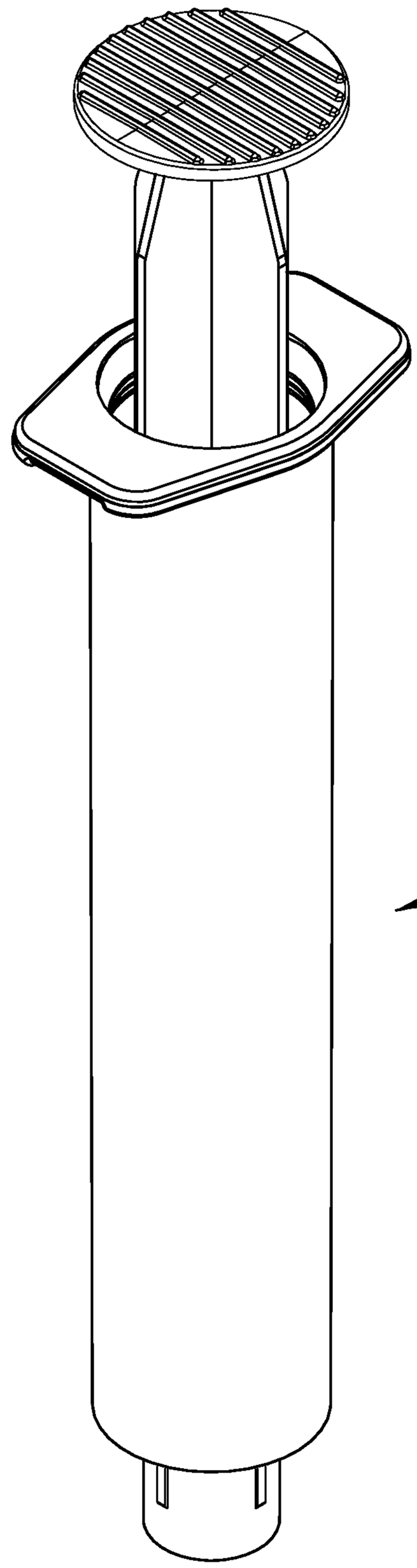


FIG.22

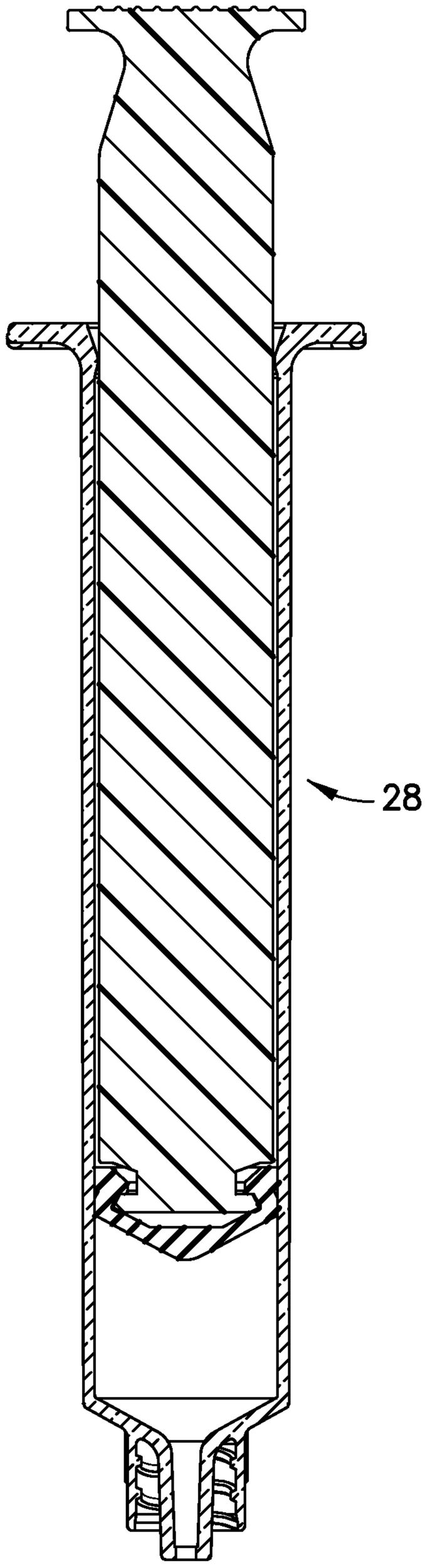


FIG.23

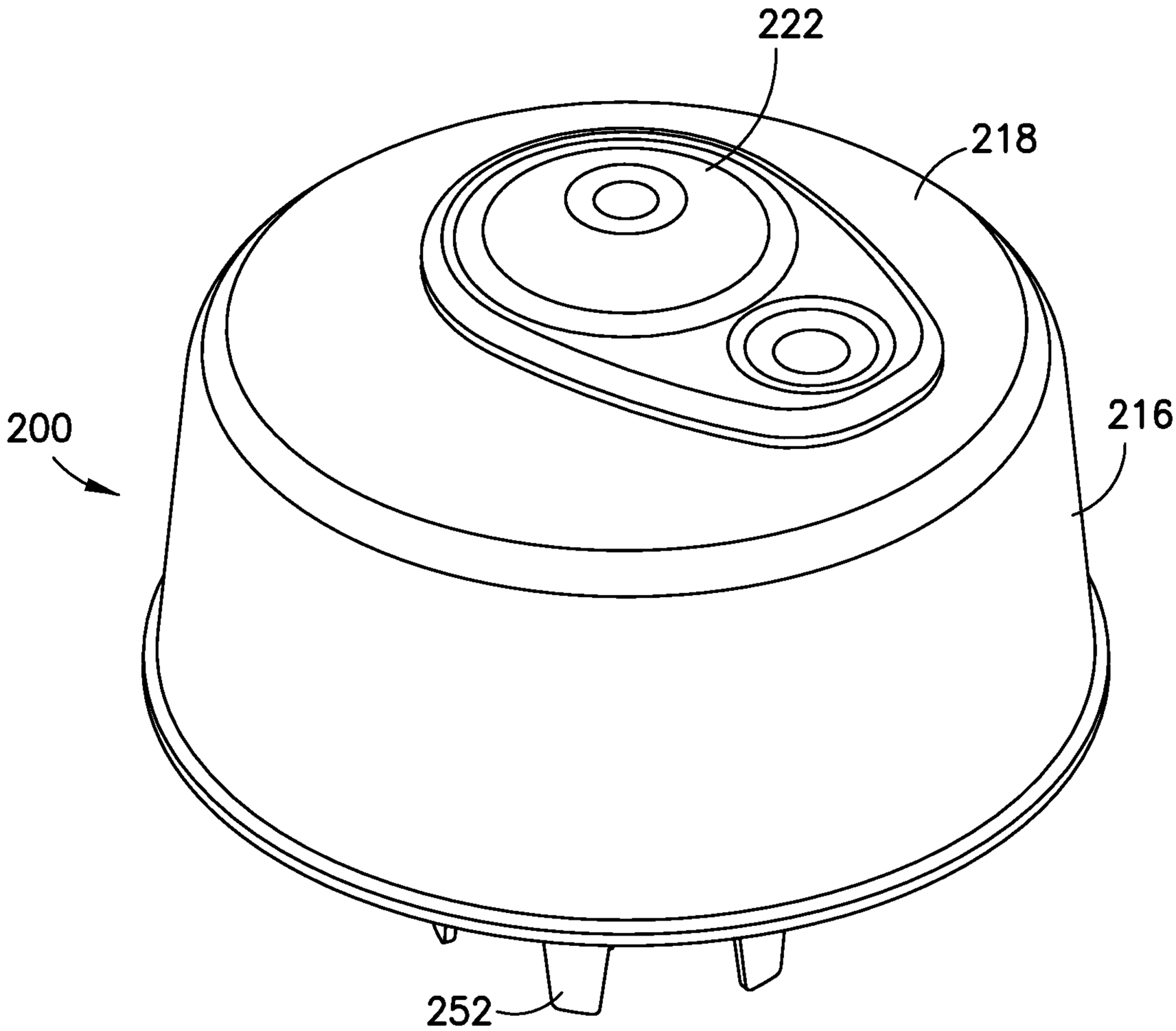


FIG.24

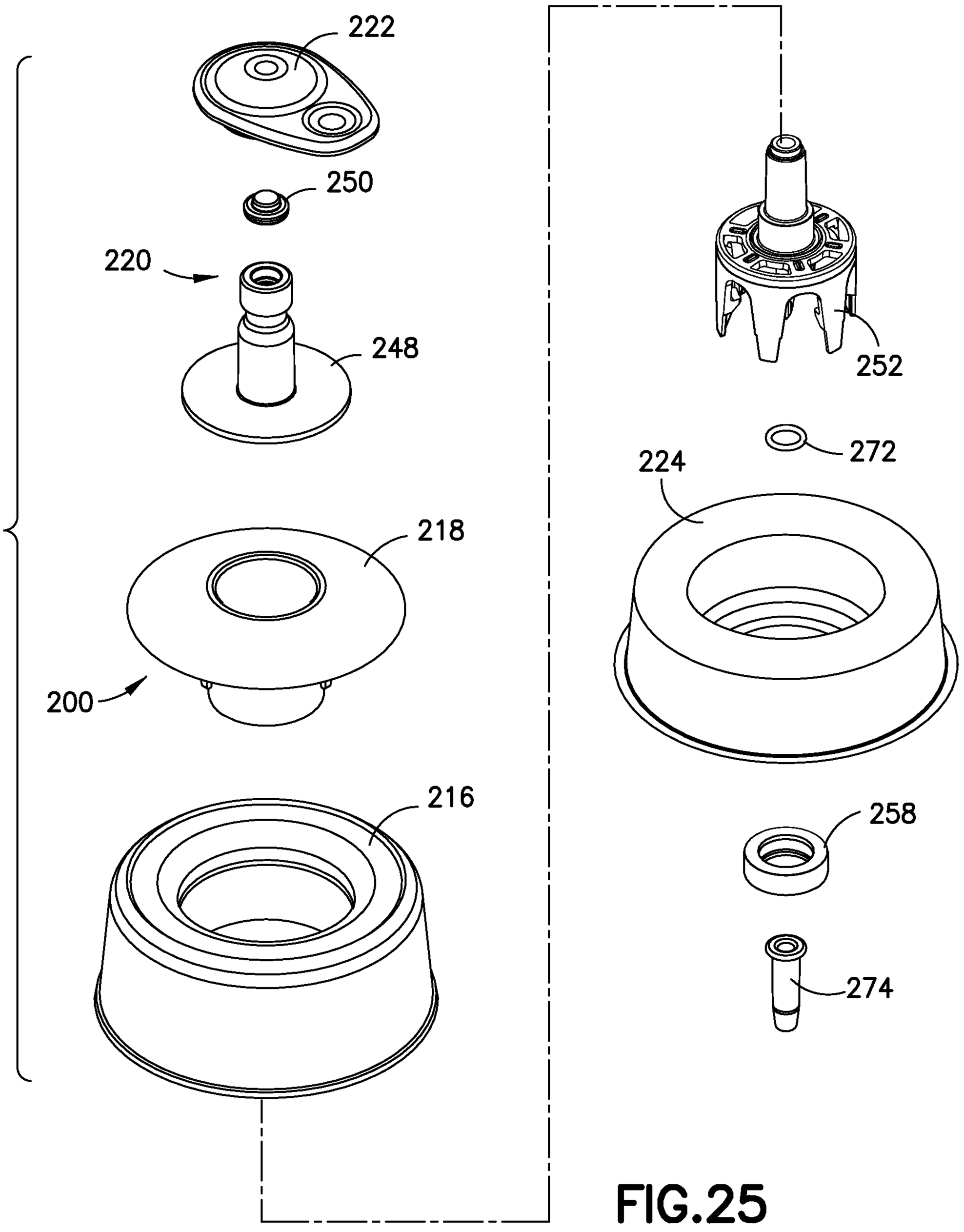


FIG.25

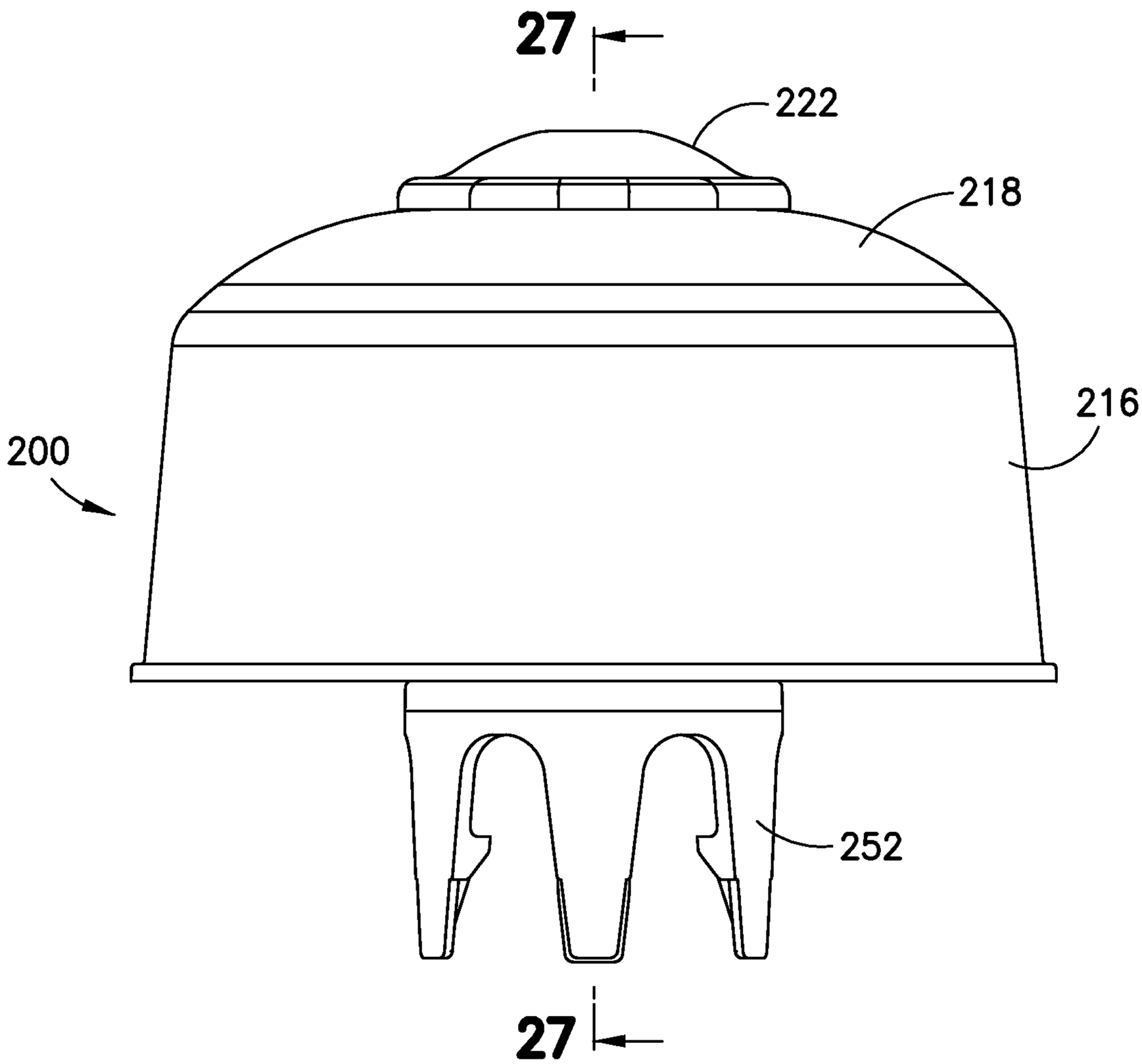


FIG.26

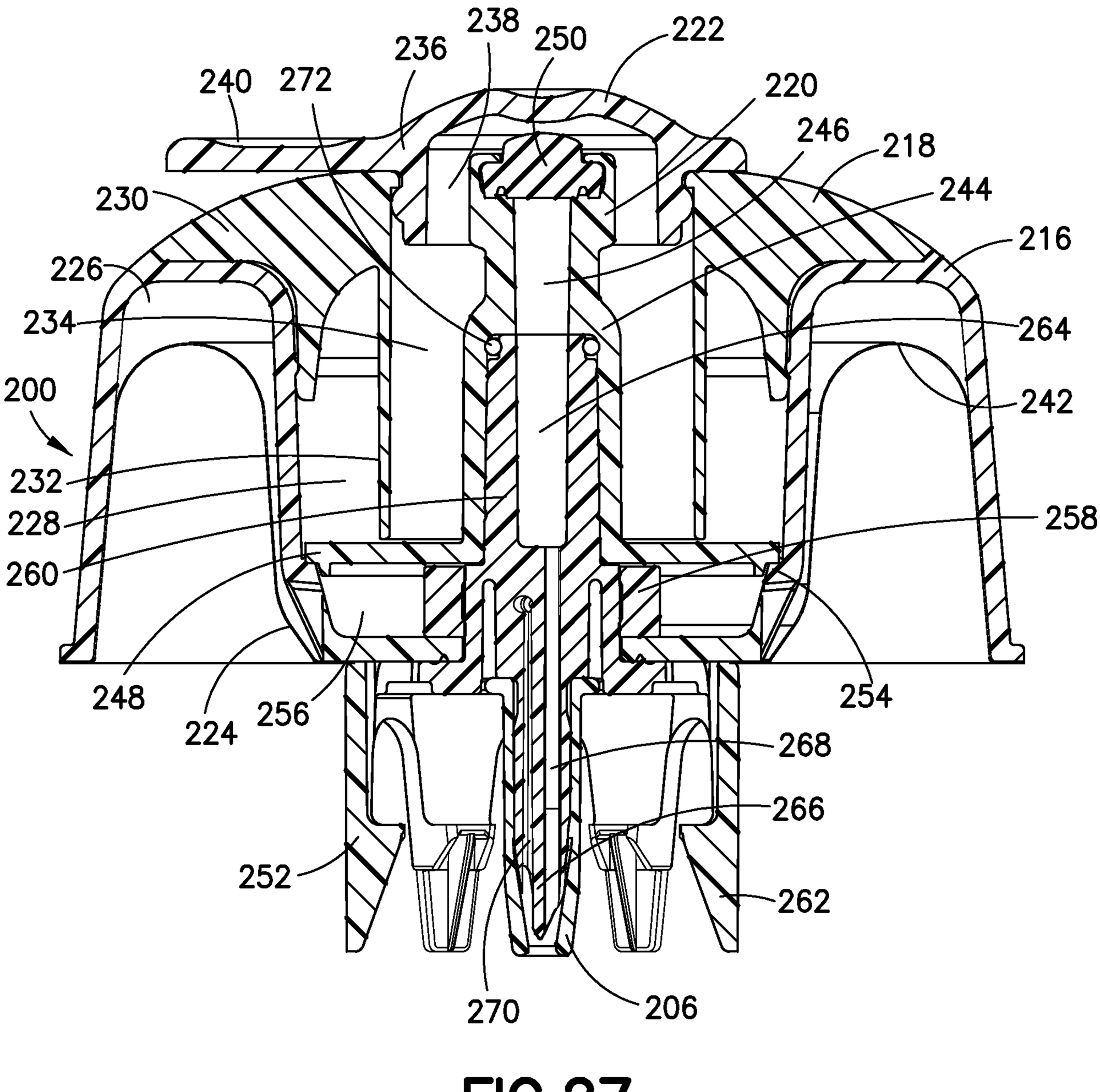
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FIG.27

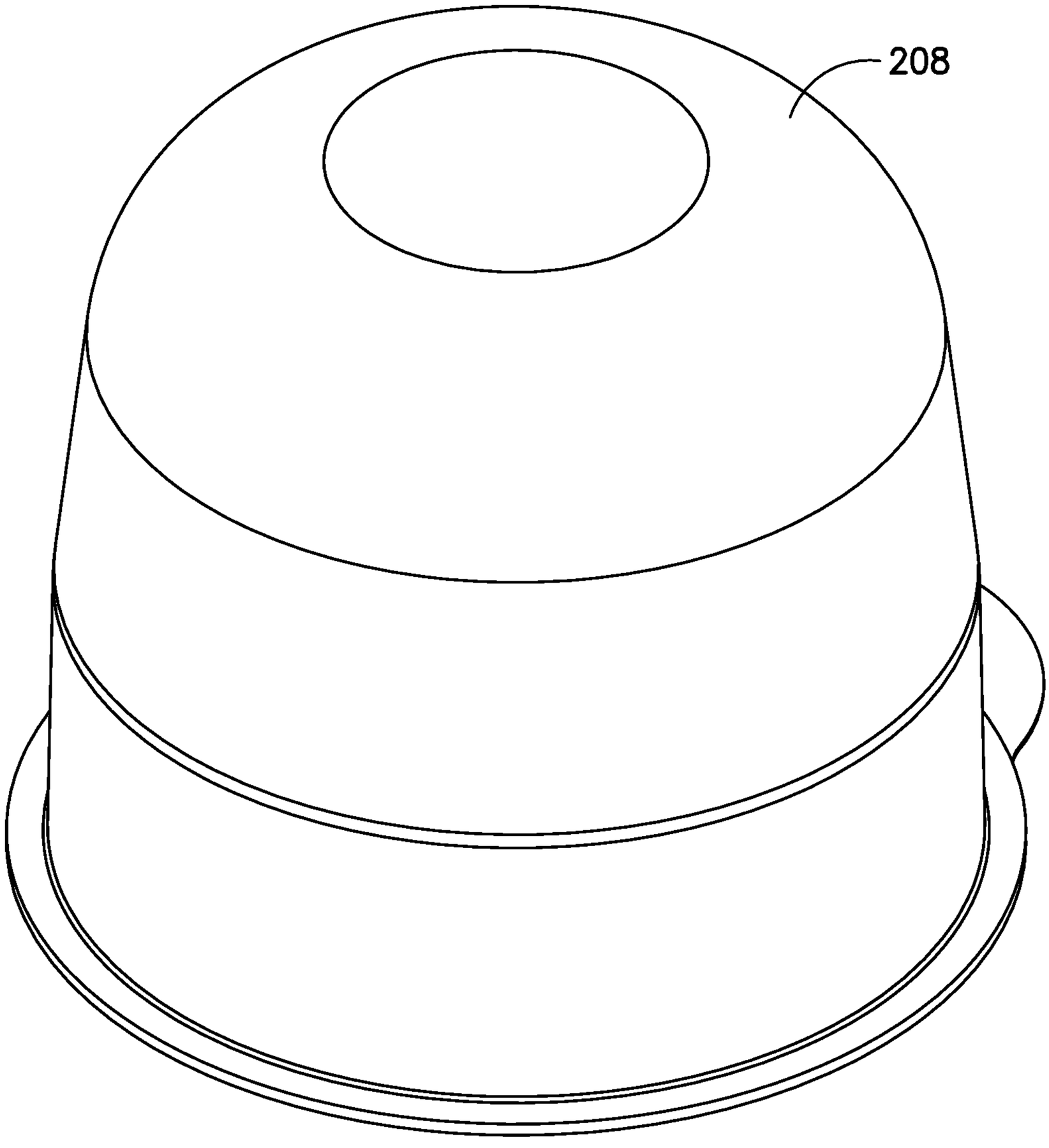



FIG.28

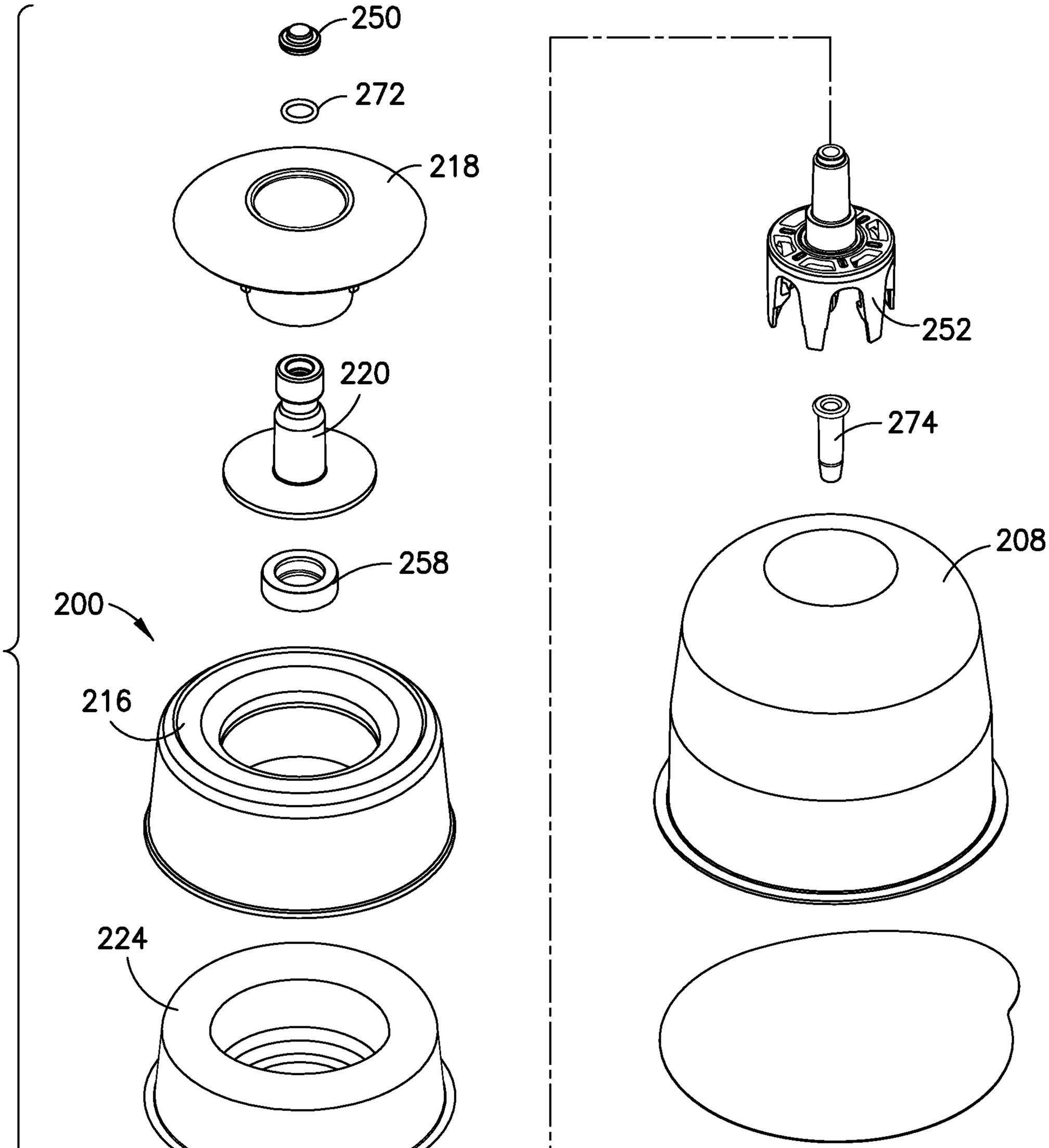



FIG.29

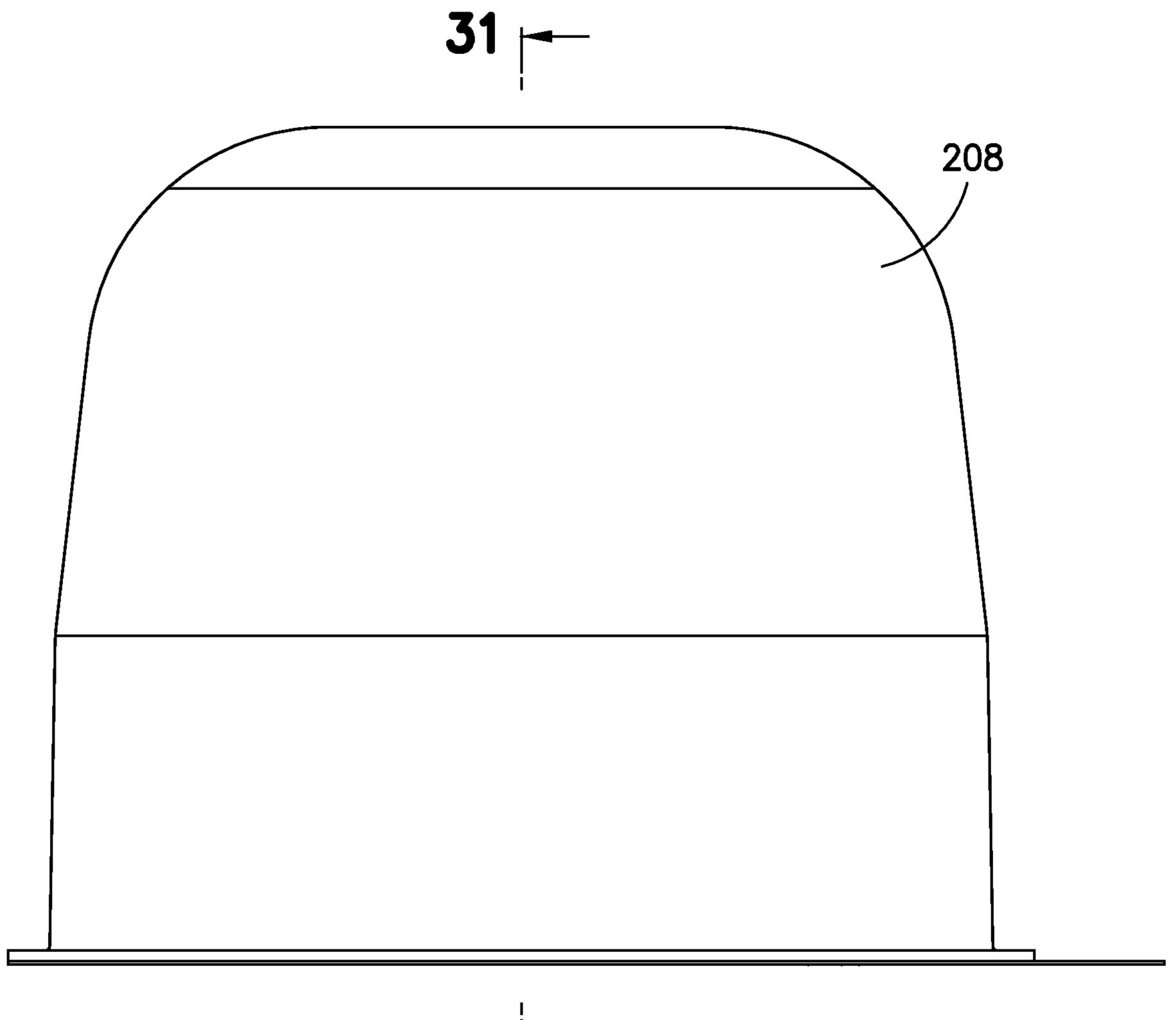



FIG.30

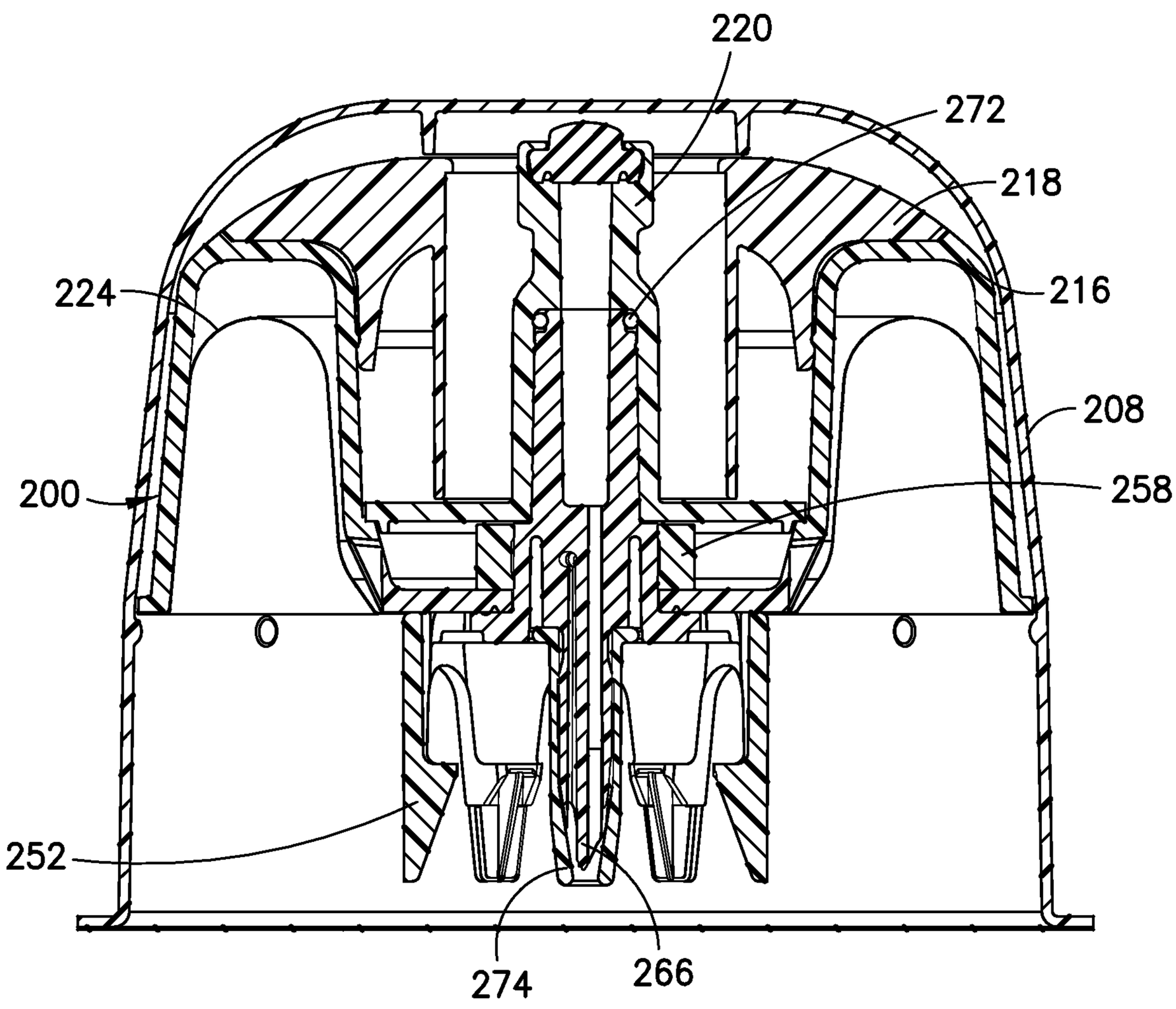



FIG.31

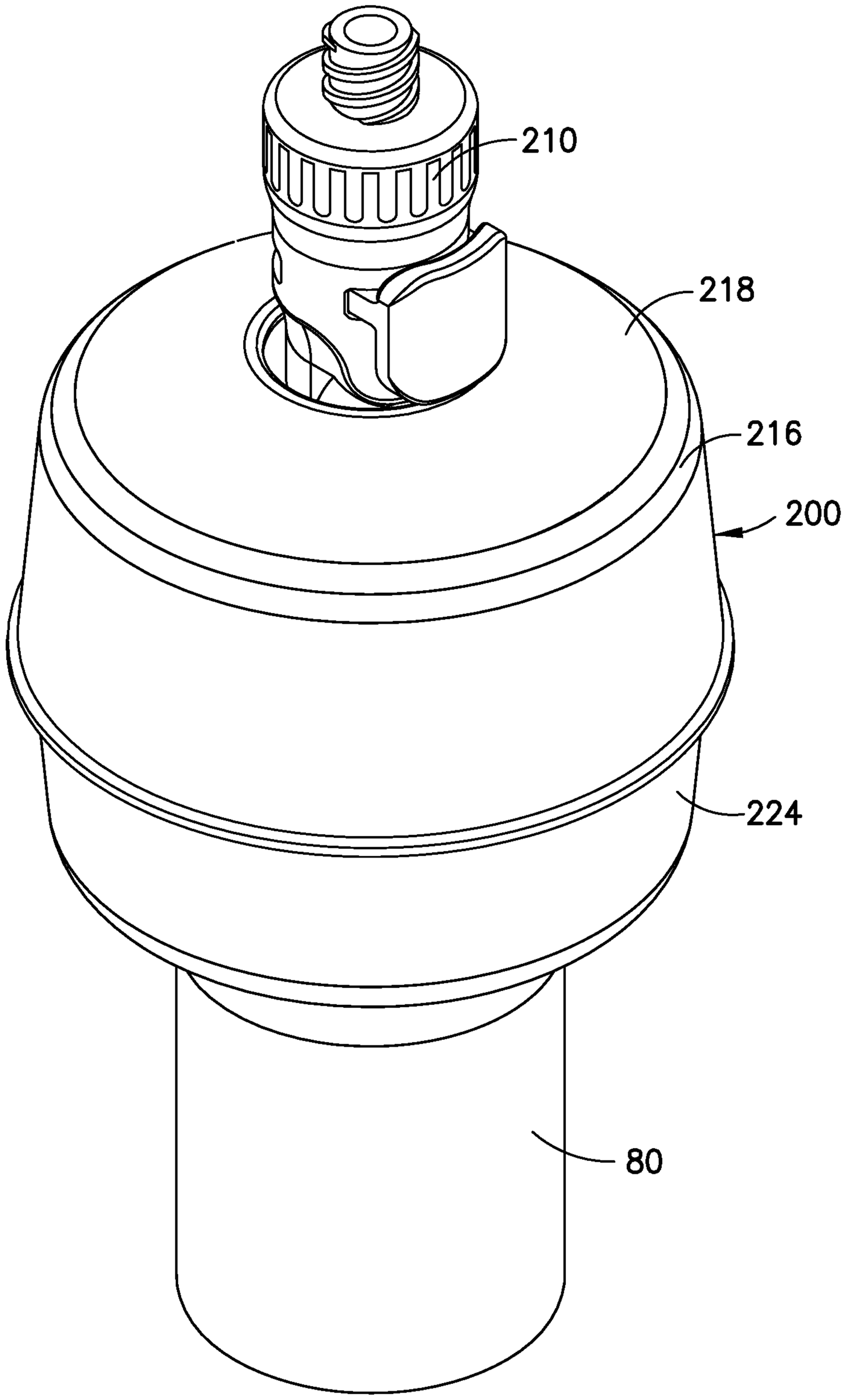



FIG.32

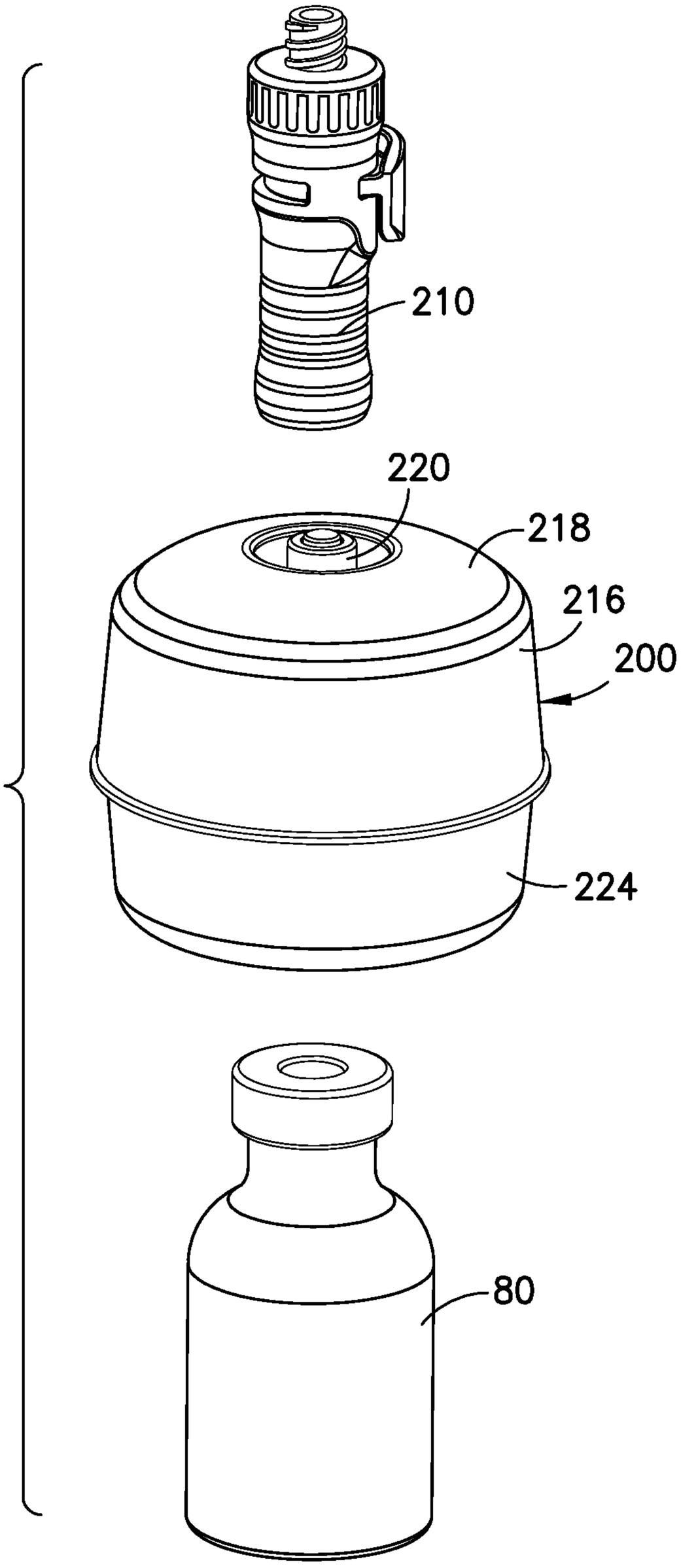



FIG.33

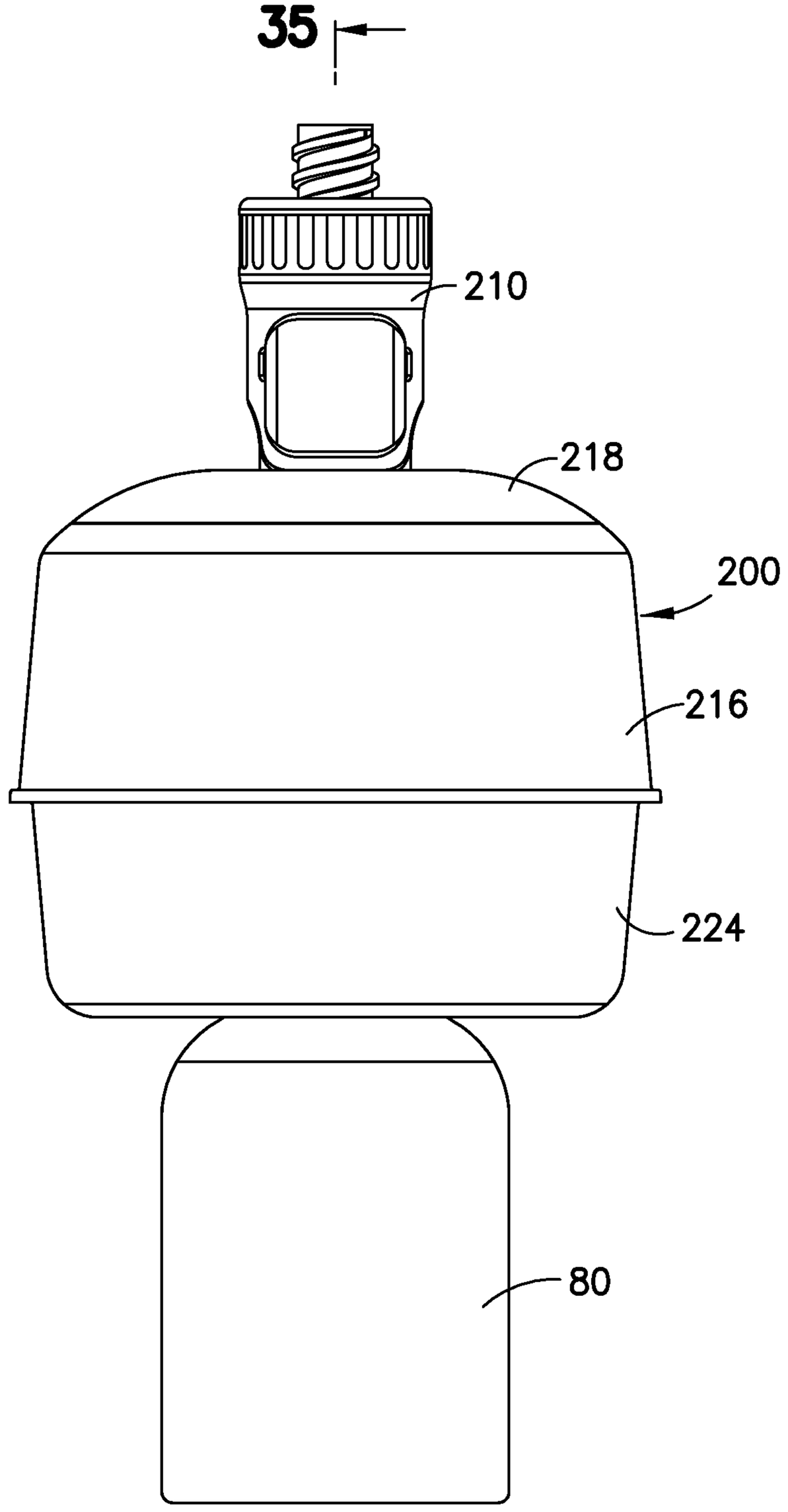



FIG.34

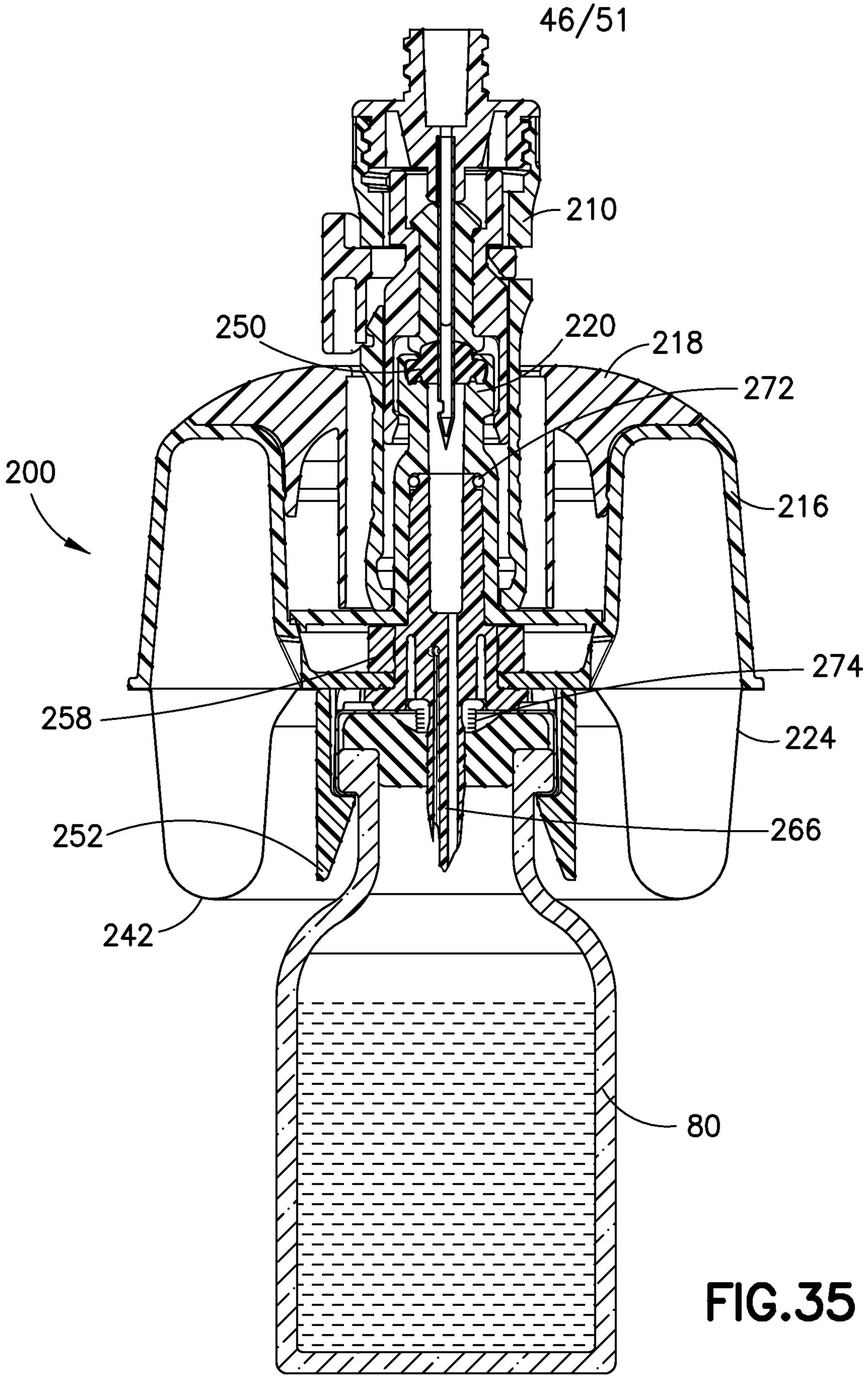



FIG.35

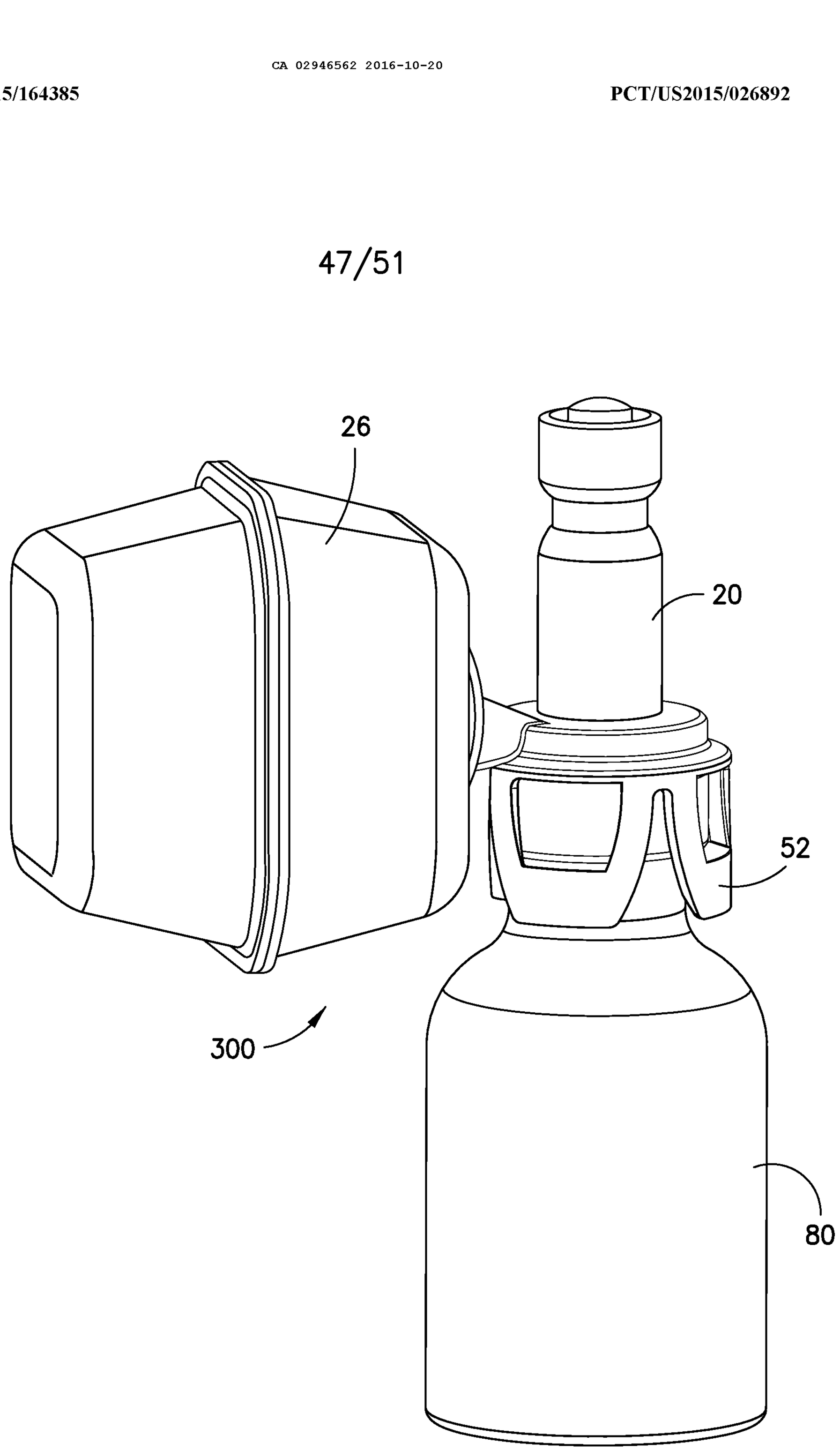



FIG.36

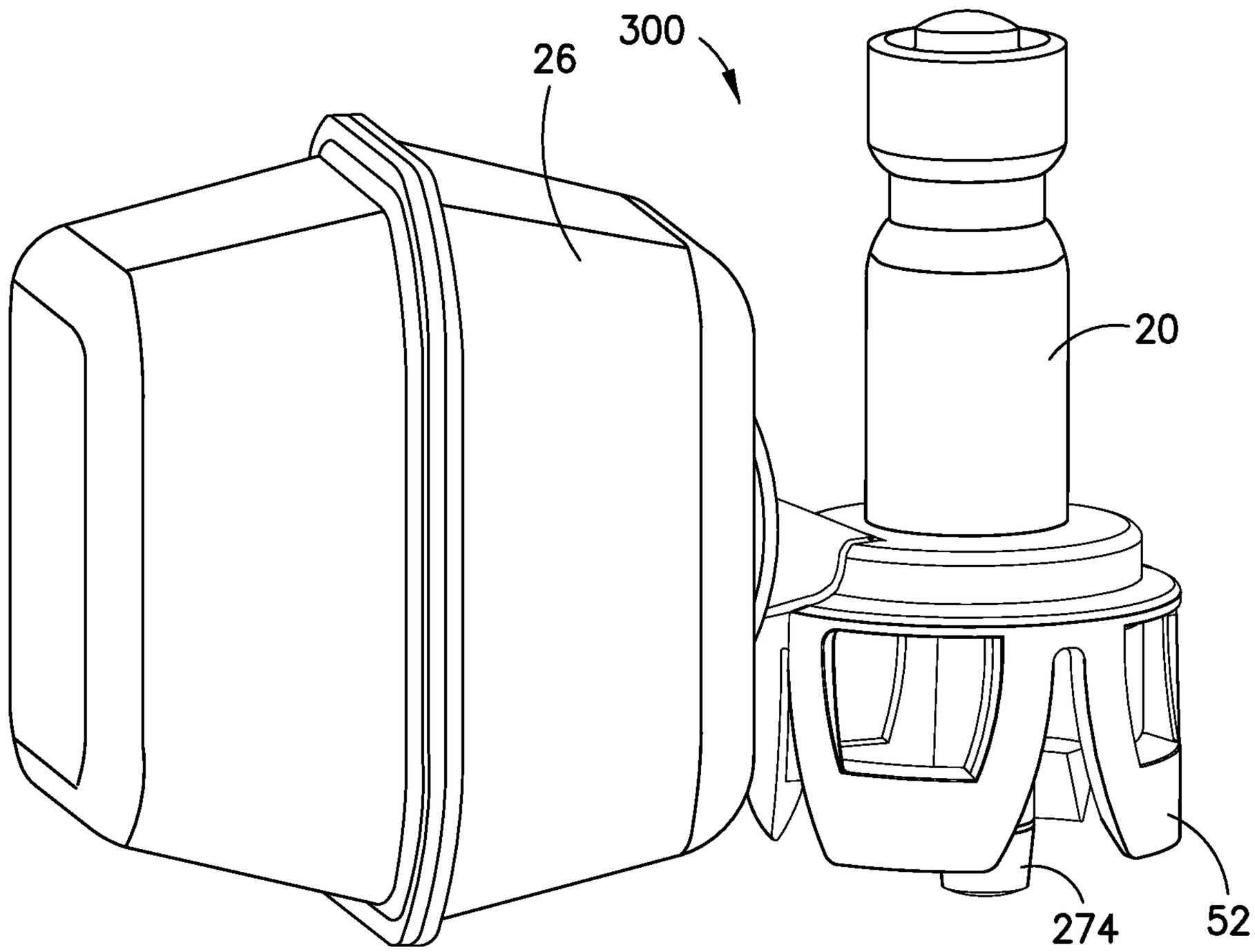



FIG.37

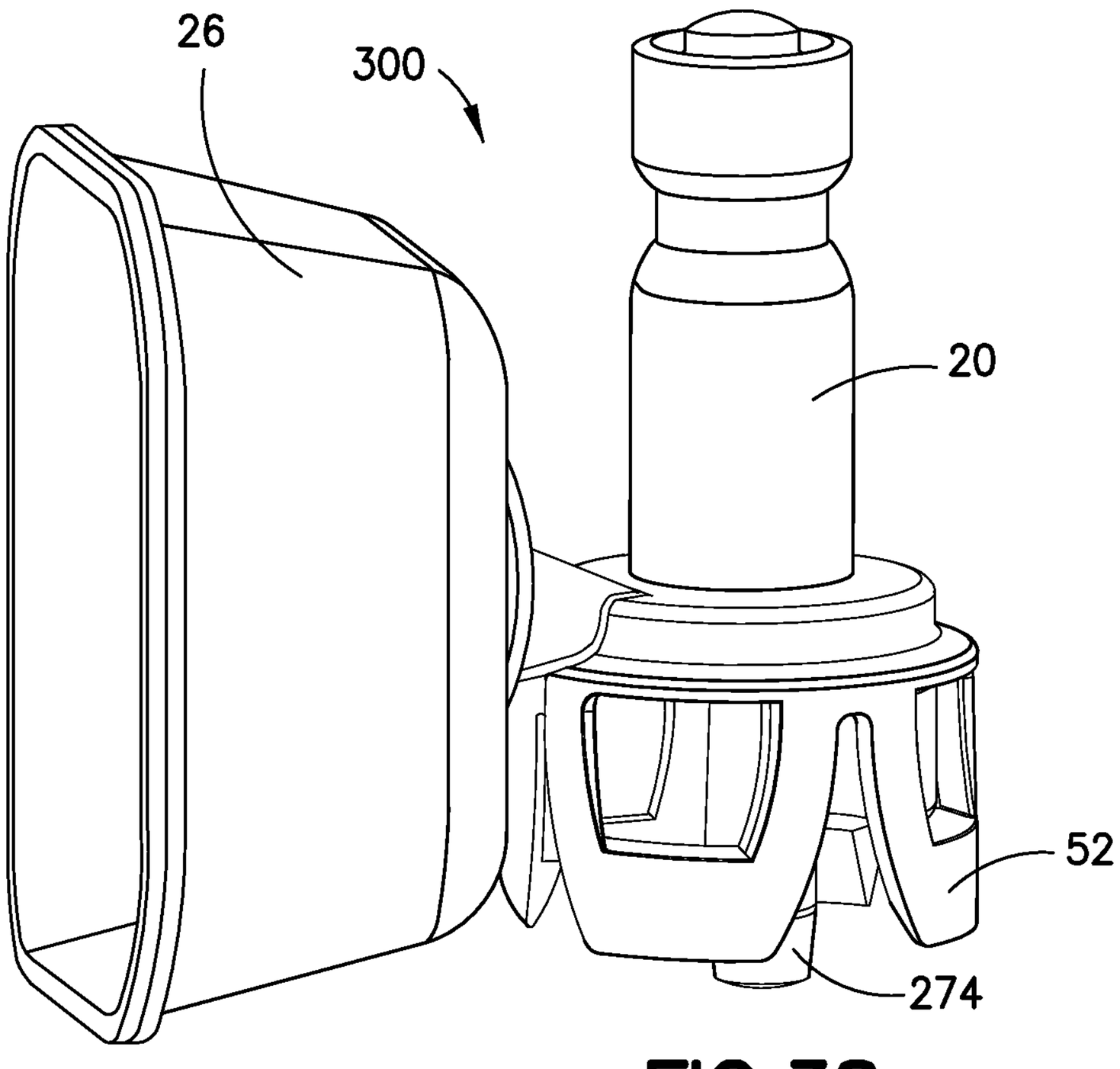



FIG.38

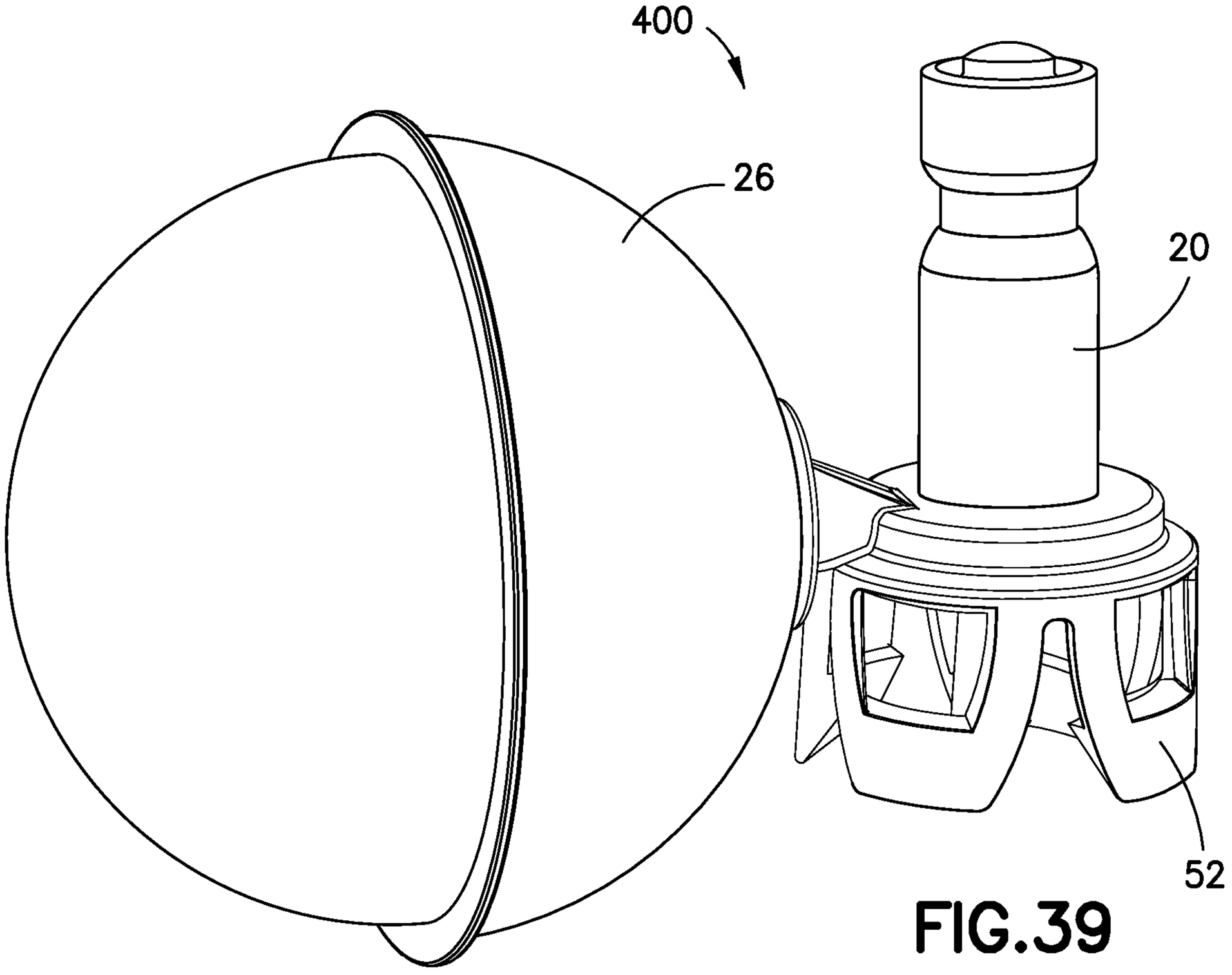



FIG.39

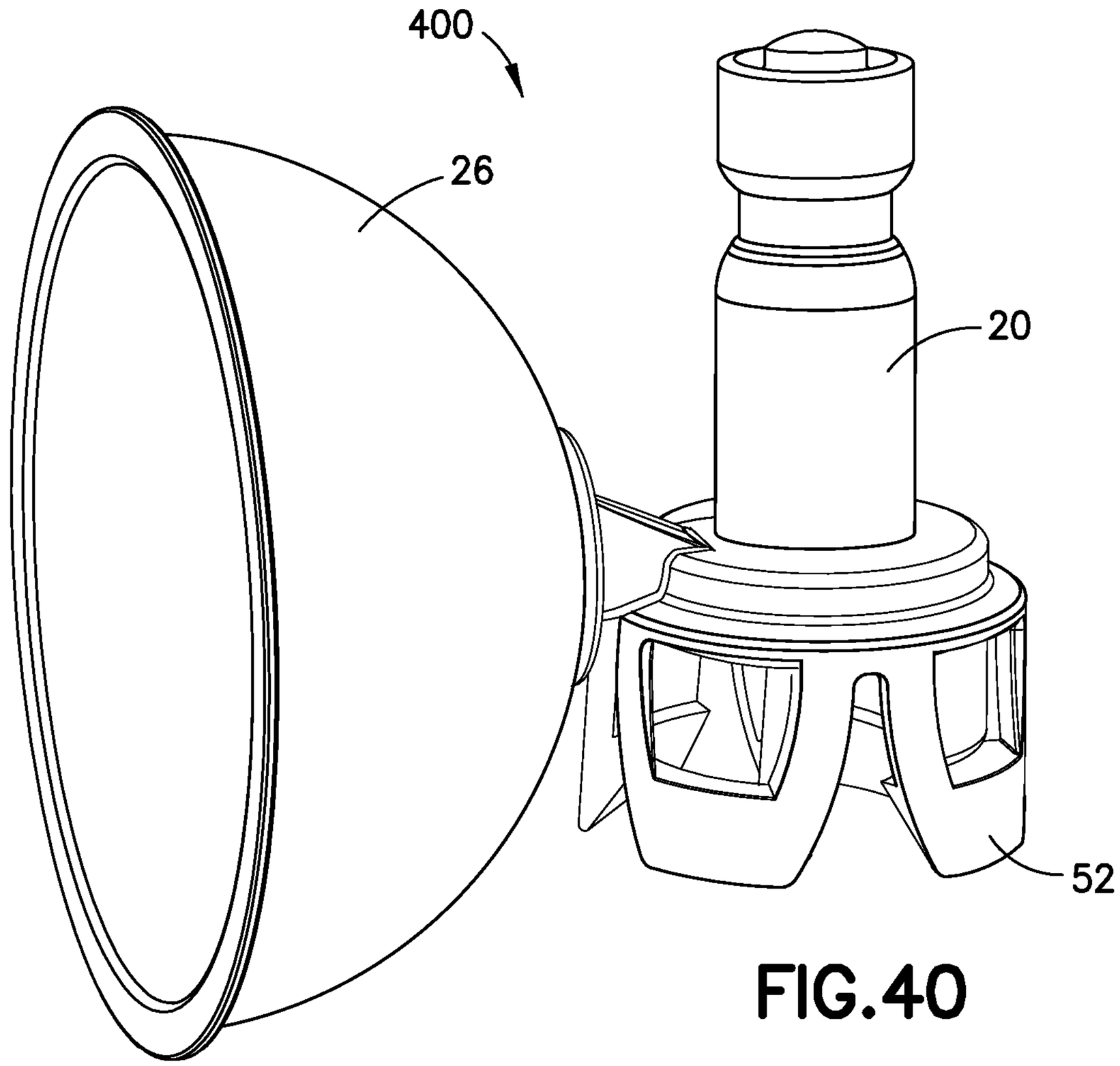
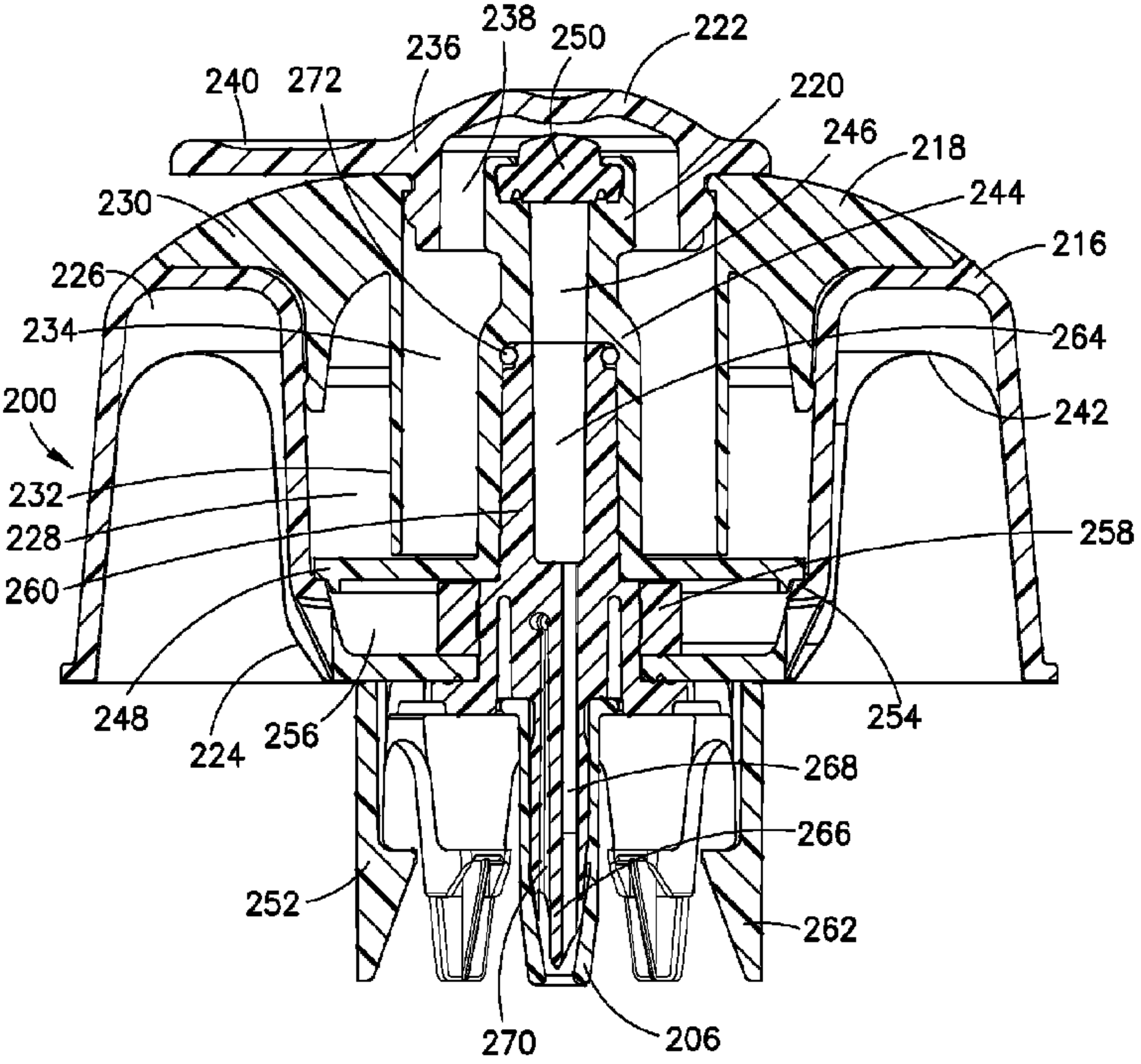



FIG.40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