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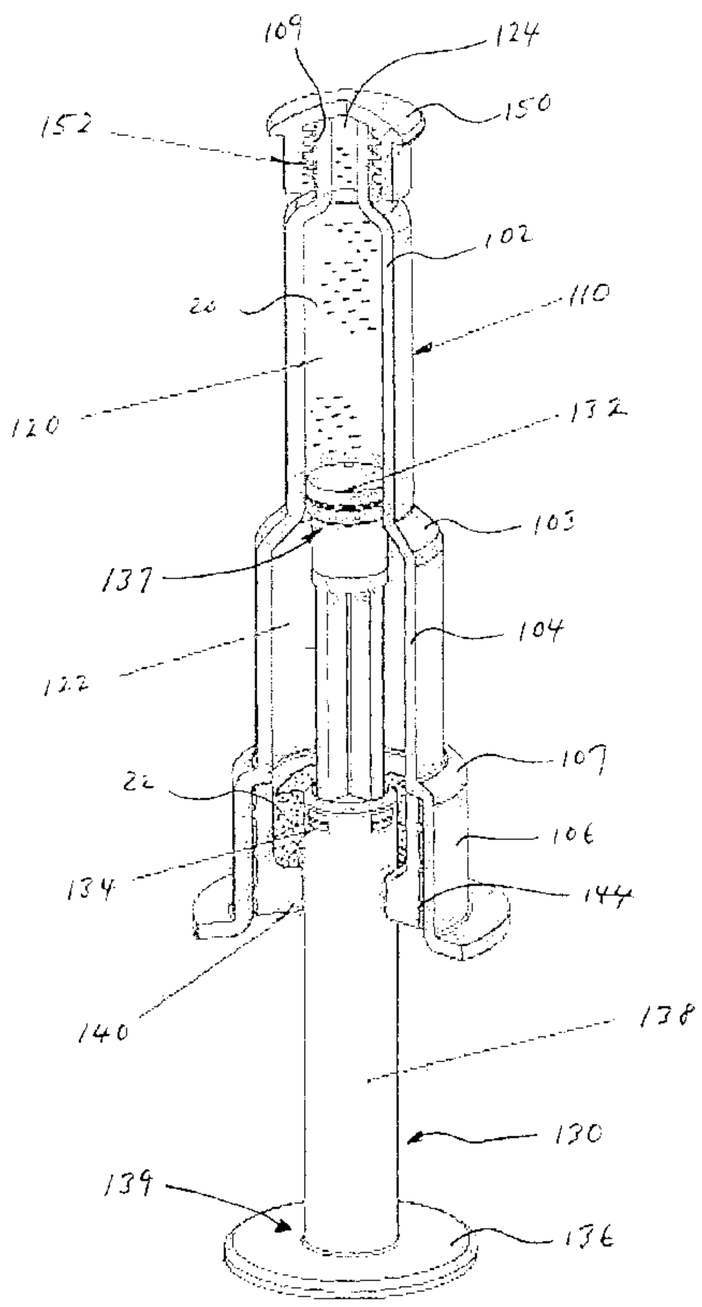
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(54) Title: A MULTI-COMPARTMENT SYRINGE




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A multi-compartment syringe (100) for storing two or more substances in separate compartments comprises a tubular body having an opening at each end and a plunger (130). The body has two or more compartments defined along its length, where each compartment has a successively larger diameter. The plunger has a plunger head (132) at one end that partitions the first and second compartments (102,104) and one or more bungs (140), slidable along the plunger's shaft, for partitioning each of the other compartments. The plunger head and the bungs can be unsealed to establish a flow communication between the compartments.

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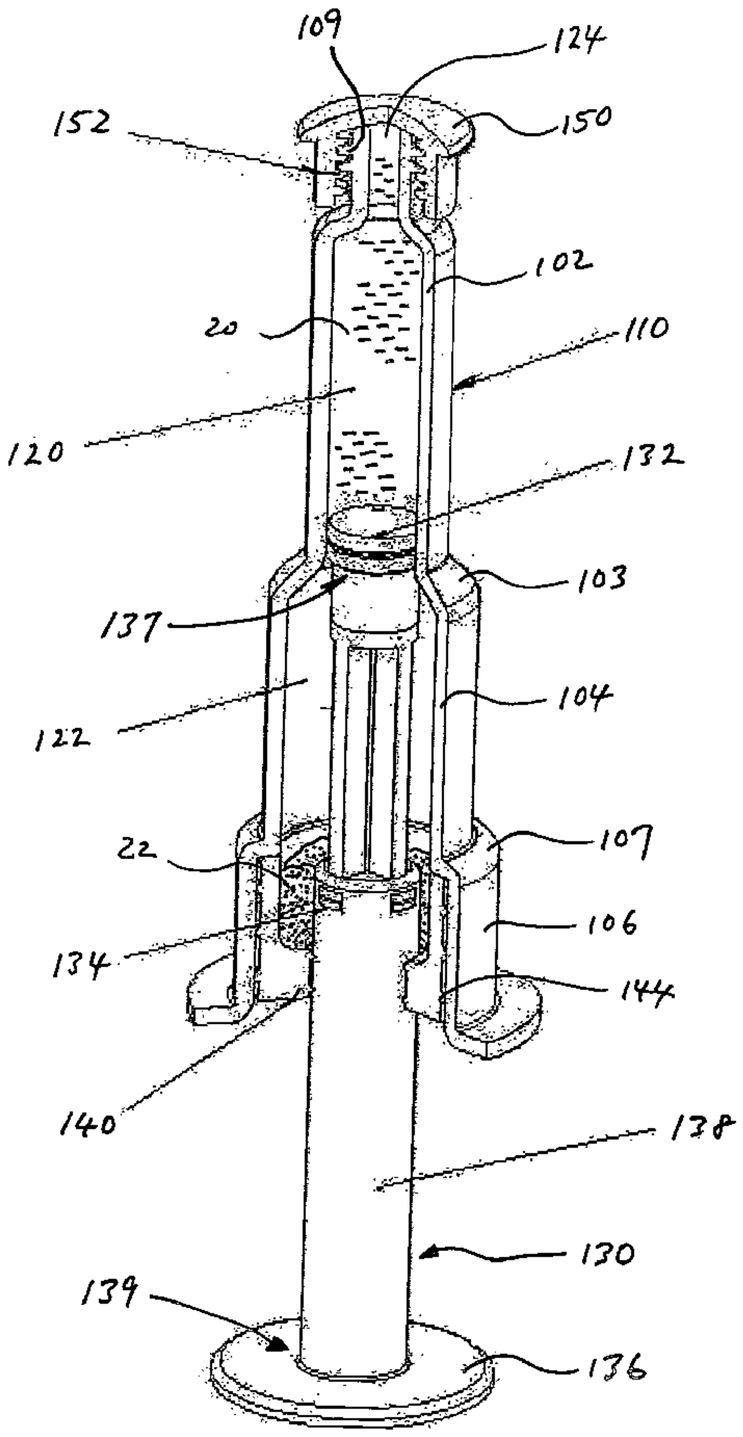
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(54) Title: A MULTI-COMPARTMENT SYRINGE




(57) Abstract: A multi-compartment syringe (100) for storing two or more substances in separate compartments comprises a tubular body having an opening at each end and a plunger (130). The body has two or more compartments defined along its length, where each compartment has a successively larger diameter. The plunger has a plunger head (132) at one end that partitions the first and second compartments (102,104) and one or more bungs (140), slidable along the plunger's shaft, for partitioning each of the other compartments. The plunger head and the bungs can be unsealed to establish a flow communication between the compartments.

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# A MULTI-COMPARTMENT SYRINGE

## FIELD OF THE INVENTION

The present invention relates to a multi-compartment syringe and more particularly to a pre-filled single barreled multi-compartment syringe that stores at least two substances in separate compartments until ready to be mixed just prior to use.

## SUMMARY OF THE INVENTION

The multi-compartment syringe according to the present invention is a single barreled syringe that may be configured to store two or more components of a medicament or other formulation separately in hermetically sealed compartments until just prior to use.

When ready to mix the contents of the pre-filled syringe, the seal(s) partitioning the compartments can be easily unsealed, establishing flow communication between the compartments so that the contents of each compartment can be mixed to form the medicament.

A two-compartment syringe device according to one embodiment of the present invention includes a syringe body having an opening at each of its top and bottom ends and a shoulder located between the top and the bottom ends. The shoulder delineates the syringe body into a top compartment and a bottom compartment.

A base ridge located between the shoulder and the bottom end of the syringe body further defines the syringe body into a bottom-compartment sidewall portion and a base-skirt portion. The bottom-compartment sidewall portion is between the shoulder and the base ridge and the base-skirt portion is between the base ridge and the bottom end of the syringe body. The bottom-compartment sidewall portion has a larger diameter than the top-compartment sidewall portion and the base-skirt portion has a larger diameter than the bottom-compartment sidewall portion.

A plunger having a shaft, a distal end, a proximal end, and a plunger at the distal end is provided within the syringe body. The plunger head is configured and adapted to form a slidable hermetic seal when it engages the top-compartment sidewall. The plunger is axially translatable between a first position where the plunger head is slidably sealingly engaged within the top-compartment sidewall, dividing the syringe body into a top compartment and a bottom compartment, and a second position where the plunger head is disengaged from the top-compartment sidewall portion establishing a flow communication between the top and bottom compartments.

A bung having an aperture is also provided. The plunger shaft is slidably disposed within the aperture of the bung so that the bung is slidable along the plunger shaft between a sealed position, hermetically sealing the bottom-end opening, and an unsealed position where the bottom-end opening is not sealed. When the bung is in its sealed position, it is substantially positioned within the base-skirt portion of the syringe body and the plunger can be axially translated between its first position and the second position without dislodging the bung from the base-skirt portion. To enable the translation of the plunger without dislodging the bung, the bung may be configured and adapted so that the friction between the bung and the syringe body is greater than the friction between the bung and the plunger shaft.

The syringe is assembled and filled, according to one method, by first orienting the body with the two-compartment embodiment of the syringe in an upright position with its top-end opening pointing upwardly. The plunger is then inserted into the syringe body, plunger-head portion first, until the plunger head engages the top-compartment sidewall. This forms a hermetic seal at the bottom of the top compartment near the shoulder portion. The top compartment is then filled with a first component of a medicament, preferably a liquid, through the top-end opening and sealed with a suitable top sealing member or assembly. To prevent any degradation of the first component from prolonged exposure to air during storage, the top compartment may be sized to fill completely with the first component liquid, minimizing or eliminating any air pockets inside the top compartment. Alternatively, any unfilled space in the top compartment may be filled with a material, such as nitrogen gas for example, which is inert with the first component.

Where the first component of a medicament is a liquid, the top compartment may be filled by inserting the plunger completely to the end of the top compartment, immersing the open top end in the liquid, then drawing the liquid into the top compartment by pulling the plunger back to its sealed position between the compartments.

Next, the syringe device may be turned 180 degrees, with the sealed top end oriented downwardly, so that the bottom-end opening is facing up. The bottom compartment is filled with a second component of the medicament through the bottom-end opening and sealed with the bung. The second component may be a liquid or a powdered solid substance. In this embodiment where a bung seals the bottom opening, the second component may be placed in the bottom compartment in a hydrated form and dried using a lyophilization process. Before the lyophilization process begins, the bung is brought close to the base-skirt portion so that it almost fits into the base-skirt portion and the substantial

portion of the bung remains outside the base-skirt portion. The vacuum created in the bottom compartment during the lyophilization process pulls the bung completely into the base-skirt portion sealing the bottom-end opening.

Alternatively, the bottom opening of the syringe body may be configured and adapted to be sealed using a bottom closure member that can be screwed onto the syringe body's bottom-end opening.

A syringe device having three compartments may also be provided for separately storing three components of a medicament for storage until ready for use. In this embodiment the syringe device has an additional compartment situated between the top and bottom compartments. As with the two-compartment embodiment, each compartment section has progressively larger diameter where the top compartment closest to the top-end opening has the smallest diameter and the bottom compartment has the largest diameter. The hermetic seal between the top and the middle compartment is formed by the plunger head and the top-compartment sidewall. The hermetic seal between the middle compartment and the bottom compartment is formed by an additional bung that sealingly engages the portion of the syringe body between the middle compartment and the bottom compartment where the diameter of the syringe body changes. The present invention also includes the method of assembling and filling such a syringe device.

The invention will now be described in more detail with references to two and three-compartment embodiments of the syringe device of the invention. It would be appreciated by those skilled in the art that the same principle is also applicable to syringe devices having more than three compartments.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the present invention will become more readily apparent from the following detailed description of the invention in which like elements are labeled similarly and in which:

**Figure 1** is a perspective view of an embodiment of the syringe device of the invention having two compartments where the syringe body is illustrated as being translucent in order to show the internal structures of the syringe;

**Figure 2** is a sectional view of the bung from the syringe device of **Figure 1**;

**Figure 3** is a sectional view of the syringe device of **Figure 1**, illustrating the syringe device in an interim stage in the process of filling and assembling the syringe device where its top compartment has been filled with a desired substance and sealed;

**Figure 4** is a sectional view of the syringe device of **Figure 3**, illustrating the syringe device in a next interim stage in the process of filling and assembling the syringe device where its bottom compartment has been filled and sealed, ready for use;

**Figure 5** is a sectional view of the syringe device of **Figure 4**, illustrating the plunger retracted into the bottom compartment so that the two compartments are in communication with one another allowing the contents of the two compartments to mix;

**Figure 6** is a sectional view of the syringe device of **Figure 5**, where the plunger has been pushed into the top compartment for dispensing the mixed medicament, which is now in the top compartment, and the cap has been removed from the top-end opening;

**Figure 7** is a sectional view of the syringe device of **Figure 6**, where the plunger is in a fully depressed position after the medicament in the top compartment has been completely dispensed;

**Figure 8** is a sectional view of another two-compartment embodiment of the invention;

**Figure 9** is a sectional view of the bottom closure member from the syringe device of **Figure 8**;

**Figure 10** is a sectional view of the syringe device of **Figure 8** before it is filled with its contents;

**Figure 11** is a sectional view of the syringe device of **Figure 8** in an interim stage in the process of filling and assembling the syringe where the top compartment is being filled a first component of a formulation;

**Figure 12** is a sectional view of the syringe device of **Figure 11** in a next interim stage in the process of filling and assembling the syringe device where the bottom compartment is being filled with a second component of the formulation;

**Figure 13** is a sectional view of the syringe device of **Figure 12** in a next stage in the process of filling and assembling the syringe device where the two compartments have been filled and sealed;

**Figure 14** is a sectional view of the syringe device of **Figure 13** where the partition between the two compartments has been unsealed and the first and second components are being mixed;

**Figure 15** is a sectional view of the syringe device of **Figure 14** in a next stage in the process of mixing and dispensing the contents of the syringe device;

**Figure 16** is a sectional view of the syringe device of **Figure 15** in a next stage in the process of mixing and dispensing the contents of the syringe device ready for dispensing;

**Figure 17** is a sectional view of the syringe device of **Figure 16** in a different orientation;

**Figure 18** is a perspective view of another embodiment of the invention in the form of a three-compartment syringe where the syringe body is illustrated as being translucent in order to show the internal structures of the syringe;

**Figure 19** is a sectional view of the first bung of the syringe device of **Figure 18**;

**Figure 20** is a sectional view of the second bung of the syringe device of **Figure 18**;

**Figure 21** is a sectional view of the syringe device of **Figure 18**, illustrating the syringe device in an interim stage in the process of filling and assembling the syringe device where the plunger is inserted into the syringe body so that the plunger head is sealingly engaged with the top-compartment sidewall;

**Figure 22** is a sectional view of the syringe device of **Figure 21**, illustrating the syringe device in an interim stage in the process of filling and assembling the syringe device where its top and middle compartment has been filled and sealed;

**Figure 23** is a sectional view of the syringe device of **Figure 22**, illustrating the syringe device in a next interim stage in the process of filling and assembling the syringe device where the bottom compartment has been filled and sealed;

**Figure 24** is a sectional view of the syringe device of **Figure 23**, where the plunger has been retracted so that the plunger head is in the middle compartment and the first bung is in the bottom compartment so that the three compartments are in communication with one another allowing the contents of the three compartments to mix;

**Figure 25** is a sectional view of the syringe device of **Figure 24**, where the plunger has been pushed into the top compartment for dispensing the mixed medicament, which is now in the top compartment, and the cap has been removed from the top-end opening; and

**Figure 26** is a sectional view of the syringe device of **Figure 25**, where the plunger is in a fully depressed position after the medicament in the top compartment has been completely dispensed.

## DETAILED DESCRIPTION OF THE INVENTION

**Figures 1-7** disclose a syringe device **100** according to one embodiment having two-compartments. **Figure 1** illustrates the syringe device comprising a syringe body **110** having two open ends: a top-end opening **124** (see **Figure 3**) and a bottom-end opening **126.** The syringe body **110** has three main sections, a top-compartment sidewall

**102**, a bottom-compartment sidewall **104**, and a base-skirt portion **106**, with the diameter of the syringe body increasing progressively with each section. In other words, the diameter of the base-skirt portion **106** is larger than the diameter of the bottom-compartment sidewall **104**, which in turn, is larger than the diameter of the top-compartment sidewall **102.**

Between the top-compartment sidewall **102** and the bottom-compartment sidewall **104** is a shoulder **103** where the diameter of the syringe body **110** changes from the top-compartment sidewall **102** to the bottom-compartment sidewall **104.** Between the bottom-compartment sidewall **104** and the base-skirt portion **106** is a base ridge **107** where the diameter of the syringe body **110** increases from the diameter of the bottom-compartment sidewall **104** to the larger diameter of the base-skirt portion **106.**

The syringe device **100** also includes a plunger **130.** The plunger **130** consists of a plunger shaft **138**, a distal end **137**, and a proximal end **139** and is provided with a plunger head **132** at distal end **137.** The plunger head **132** sealingly engages the inside wall surface of the top-compartment sidewall **102** to form a hermetic seal that forms a partition between the top compartment **120** and the bottom compartment **122.** The plunger head **132** is preferably made of an elastomer having characteristics (e.g. hardness, elasticity, etc.) that is suitable to provide the desired sealing quality. The particular elastomer selected for the plunger head **132** should also be chemically inert with respect to the particular medicament or components with which the plunger head **132** may come in contact. A thumb rest **136** may be provided on proximal end **139** of the plunger **130** with which a user may urge the plunger **130** into the syringe body **110** to dispense the contents of the syringe device **100**.

The syringe device **100** also includes a bung **140** for sealing the bottom-end opening **126. Figure 2** illustrates a detailed cross-section of the bung **140.** The bung **140** has a central aperture **146** through its axial center so that the plunger **130** is received through the central aperture and the bung **140** can be moved up and down the plunger shaft **138.** The outer surface of the bung **140** is provided with a plurality of outer sealing ribs **144** for sealingly engaging the inside surface of the base-skirt portion **106** and sealing the bottom-end opening **126.** The side wall of the central aperture **146** is provided with a plurality of inner sealing ribs **142** for sealingly engaging the plunger shaft **138.** These sealing ribs may be configured to form hermetic seals with the mating surface through compression. When assembled, the bung **140** is positioned on the plunger shaft **138** between the thumb rest **136** and stopper tab **134.**

When the bung **140** is positioned in its sealed position, preferably the plunger **130** can be withdrawn partially from the syringe body **110** without dislodging the

bung **140** from its sealed position within the base-skirt portion **106.** This allows the plunger head **132** to be disengaged from the top-compartment sidewall **102** to establish communication between the top and the bottom compartments without unsealing the bottom-end opening.

To enable the translation of the plunger **130** without dislodging the bung **140** from the bung's sealed position within the base-skirt portion **106**, the bung **140** may be configured and adapted so that the friction between the bung **140** and the base-skirt portion **106** is greater than the friction between the bung **140** and the plunger shaft **138.**

The bung **140** is provided with a well **148** so that the inner sealing ribs **142** are confined to the limited surface of lower portion **147** of the bung **140.** In this embodiment, a greater number of outer sealing ribs **144** are provided compared to the inner sealing ribs **142.** Where the dimensions of the outer and inner sealing ribs are such that the static friction between each sealing rib and its mating surface, the base-skirt portion or the plunger shaft, are substantially equal, this configuration provides greater friction between the bung **140** and the base-skirt portion **106** than the friction between the bung **140** and the plunger shaft **138.**

Although in the particular example of the bung **140** illustrated in **Figure 2**, the frictional forces between the bung and the syringe body **110** and the plunger shaft **138** may be controlled by varying the number of the sealing ribs at each sealing surfaces, it will be obvious to one of ordinary skill in the art that the same result could be achieved by many other methods. For example, the dimensions of the sealing ribs, such as their widths and thicknesses, may be varied to achieve the desired frictional forces at each sealing interface without necessarily varying the number of the sealing ribs.

**Figure 1** illustrates a fully assembled syringe device **100** in a storage configuration. The plunger **130** is positioned inside the syringe body **110** so that the plunger head **132** sealingly engages the top-compartment sidewall **102**, in proximity to the shoulder **103**. Thus, the plunger head **132** partitions the syringe body **110** into a top compartment **120** and a bottom compartment **122.** The seal formed by the plunger head **132** and the top-compartment sidewall **102** may be hermetic so that two components of a medicament or other formulation may be stored separate in each compartment until ready to be mixed.

In this fully assembled and ready-for-storage configuration, the bung **140** resides substantially within the base-skirt portion **106** so that the plurality of outer sealing ribs **144** sealingly engage the inside wall of the base-skirt portion **106** hermetically sealing the bottom-end opening **126.** The base ridge **107** functions as a stopper preventing the bung **140** from traveling too far into the syringe body **110.**

The top-end opening **124** is removably sealed with a top sealing member or assembly which is configured to be removable when desired; for example, when the contents of the syringe device **100** have been mixed and are ready to be dispensed. The top sealing member **150** may be a cap as shown in **Figure 3**. In this embodiment, the top sealing member **150** is a screw cap. The cap **150** is provided with screw threads **152** and the top-end opening **124** of the syringe body **110** is also provided with screw threads **109** so that the cap **150** can be screwed onto the syringe body **110** to seal the top end opening **124.**

It will be apparent to those skilled in the art that a top sealing member **150** and the top-end opening **124** may be configured to sealingly engage each other in a variety of ways that may be appropriate and suitable for a particular application. For example, the top sealing member **150** may be a foil or a membrane made of a suitable material that may be heat sealed along the rim **125** of the top-end opening **124**. The heat sealed membrane may be peeled away to unseal the top-end opening **124** when the syringe device **100** is ready to be used.

The process of assembling and filling the syringe device **100** will now be described with the aid of **Figures 3** and **4**. A syringe body **110** is oriented in an upright position with its top-end opening **124** pointing upwardly. A plunger **130** is then inserted through bottom opening **126** into the syringe body **110** plunger head **132** first, until the plunger head **132** engages the top-compartment sidewall **102.** The engagement of the plunger head **132** with the top-compartment sidewall **102** forms a hermetic seal at the bottom of the top compartment **120** in proximity to the shoulder **103.**

The top compartment **120** is then filled with a first component of a medicament through the top-end opening **124** and sealed with the cap **150.** In this embodiment of the invention, the first component is preferably the liquid component of the medicament. To prevent any degradation of the first component from prolonged exposure to air during storage, the top compartment **120** may be filled completely with the first component liquid, minimizing or eliminating any air pockets inside the top compartment **120** when sealed with the cap **150.** In the alternative, the filling process may be conducted under a vacuum or an inert gas environment so that even if the top compartment is not completely filled with the first component liquid, there would not be any air trapped inside the top compartment after being sealed with the cap **150.**

The top compartment may also be filled by inserting the plunger completely to the end of the top compartment, immersing the open top end in the first component liquid, then drawing the liquid into the top compartment by pulling the plunger back to the sealed position between the compartments. The syringe body **110** may be dimensioned so

that when the plunger is withdrawn back to its sealed position, the top compartment **120** will be filled with a predetermined desired amount of the first component **20.**

The cap **150** is preferably configured and adapted to form a hermetic seal along the rim **125** of the top-end opening **124.** But, it would be apparent to one of ordinary skill in the art that the particular requirement for the quality of the seal formed by the cap **150** would be dictated by the particular application for which the syringe device is intended. This would be true for the seal formed by the bung **140** at the bottom-end opening **126** also and for the seal formed by the plunger head **132** between the top compartment **120** and the bottom compartment **122.**

**Figure 3** is a sectional illustration of the syringe device **100** at this stage of the assembly. The top compartment **120** has been filled with the first component of a medicament and the top-end opening has been sealed with the cap **150** and at the opposite end by the plunger head **132.**

At this stage of the assembly, the syringe device **100** may be turned 180 degrees, with the capped end oriented down, so that the bottom compartment **122** may be filled. At this stage of the assembly, the bung **140** is not yet in its sealed position and it is positioned near the thumb rest **136** of the plunger **130** so that the bottom-end opening **126** is free of any encumbrances. The static frictional force between the plunger shaft **138** and inner sealing ribs **142** on the bung **140** will keep the bung **140** from sliding down the plunger shaft **138.**

The bottom compartment **122** is then filled with a second component of the medicament through the bottom-end opening **126.** The bottom compartment **122** may then be sealed by sliding the bung **140** along the plunger shaft **138** and into the base-skirt portion **106.** However, this sealing operation is preferably carried out in a vacuum so that air pressure inside the bottom compartment does not prevent the bung **140** from sliding into the base-skirt portion **106.** The second component may be a liquid or a powder substance.

Alternatively, the bottom compartment **122** may be filled using a lyophilization process (also known as freeze drying). After the second component of the medicament in a hydrated form is placed inside the bottom compartment **122,** the bung **140** is positioned on the plunger shaft **138** so that it is almost fitted into the base-skirt portion **106** so that substantial portion of the bung **140** is still outside the base-skirt portion **106.** And during the lyophilization process, the vacuum created in the bottom compartment **122** pulls the bung **140** completely into the base-skirt portion **106** forming a hermetic seal at the bottom-end opening **126.**

**Figure 4** illustrates the fully assembled syringe device **100** in the storage configuration. The syringe device **100** now consists of two completely sealed compartments – the top compartment **120** and the bottom compartment **122** – where each compartment is holding a component of a medicament for storage until ready to be mixed just prior to use.

The quality of the seal formed between the bung's inner sealing ribs **142** and the plunger shaft **138** and the quality of the seal formed between the bung's outer sealing ribs **144** and the base-skirt portion **106** should be configured so that the two seals combined can provide the quality of the sealing desired for the bottom compartment **122.** The quality of the seals may be controlled by the appropriate selection of the elastomer materials for the bung **140** and other parameters such as the surface finish of the plunger shaft **138** and the inside surface of the base-skirt portion **106.** The material selection criteria are also equally applicable to the plunger head **132.**

The process involved in preparing and dispensing the medicament from the two components stored in the syringe device **100** will now be described with references to **Figures 5-7**. In order to mix the two components of a medicament stored in the syringe device **100**, the plunger **130** is first withdrawn towards the proximal end **139** of the plunger **130** so that the plunger head **132** disengages from the top-compartment sidewall **102** as illustrated in **Figure 5**. During this procedure, the bung **140** remains in place within the base-skirt portion **106** in its sealed position. This is possible because the bung **140** is configured such that the static frictional force present at the bung to base-skirt-portion interface is greater than the static frictional force present at the bung to the plunger-shaft interface, allowing the plunger **130** to be withdrawn without displacing the bung **140** from its sealed position within the base-skirt portion **106.** By withdrawing the plunger head **132** from the top-compartment sidewall **102**, the two compartments are now in communication with one another so that the contents of the two compartments can mix.

During this operation, the withdrawal of the plunger **130** is limited by stopper tab **134** on the plunger shaft **138**. As the plunger **130** is withdrawn further, the stopper tab **134** will touch the bung **140** and limit the travel of the plunger **130** so that a substantial portion of the plunger shaft **138** remains within the bottom compartment **122.** Typically, the syringe device **100** would be shaken vigorously to mix the contents of the syringe device **100**. And the presence of the substantial portion of the plunger shaft **138** inside the bottom compartment **122** enhances the mixing of the contents by functioning as an agitator during the shaking. This agitating function of the plunger shaft **138** may be further enhanced by providing vanes **131** in the portion of the plunger shaft that is positioned within the bottom compartment **122.**

In the embodiment of the syringe where the bottom compartment is pre-filled using the lyophilization process, the disengaging the plunger head **132** from the top-compartment sidewall **102** may be accomplished by an alternative method. In this alternative method, the user simply unseals the top-end opening **124** of the syringe device **100** by unscrewing the cap **150.** In this embodiment, the lyophilization process creates a vacuum condition in the bottom compartment **122** and the vacuum in the bottom compartment **122** pulls on the plunger head **132.** But because the top compartment **120** is filled with liquid and sealed air-tight the plunger head **132** is prevented from being sucked into the bottom compartment **122.**

Then, when the cap **150** is unscrewed from the top-end opening **124**, the pressure inside the top compartment **120** will equalize with the atmospheric pressure and cause the plunger head **132** to be abruptly sucked into the bottom compartment **122** breaking the seal separating the two compartments. This abrupt breaking of the seal causes the liquid from the top compartment **120** to gush into the bottom compartment **122** enhancing the mixing of the liquid and the dry contents of the bottom compartment **122.**

Once the contents of the syringe device **100** are completely mixed and the medicament is ready for dispensing, the syringe device **100** is oriented so that the top compartment is pointing downward. This will cause the medicament to drain into the top compartment **120.** The volume of the two components of the medicament preferably is controlled so that the mixed medicament would fit completely inside the top compartment **120** without overflowing into the bottom compartment **122**. This minimizes any portion of the medicament from being wasted.

Next, while maintaining the top compartment-down orientation of the syringe device **100**, the plunger **130** is pushed down until the plunger head **132** sealingly engages the top-compartment sidewall **102.** The syringe device **100** then may be turned so that the top end of the syringe device **100** points upwardly. Then, as shown in **Figure 6**, the cap **150** may be removed and a syringe needle (not shown) may be attached to the top-end opening **124.** Depending on the application, other dispensing apparatus may be attached to the top-end opening to dispense the medicament. In this configuration, the syringe device **100** operates like a standard syringe. To completely dispense the medicament contained in the top compartment **120**, the plunger **130** is fully depressed into the syringe device **100** as illustrated in **Figure** 7.

**Figure 8** illustrates another embodiment of a two-compartment syringe device where the bottom opening of the syringe body is sealed with a screw-type closure member. A two-compartment syringe device **200** comprises a syringe body **210** having a circular cross-section and openings at top and bottom ends. The syringe body **210**

comprises a top-compartment sidewall **202** having one diameter and a bottom-compartment sidewall **204** having a larger diameter.

The syringe device **200** further comprises a plunger **230** having a plunger head **232** at its distal end **237.** When the plunger **230** is inserted inside the syringe body **210**, the plunger head **232** sealingly engages the top-compartment sidewall **202** and divides the inside of the syringe body **210** into a top compartment **220** and a bottom compartment **222.**

A bottom closure member **240** is also provided that is slidably mounted on the plunger **230** and is movable along plunger shaft **238** between the plunger's proximal end **239** and stopper tabs **234.** The bottom closure member **240** is illustrated in detail in **Figure 9**. The bottom closure member **240** further comprises a base portion **247** and a well portion **248.**

The base portion **247** has a central aperture **246** for slidably receiving the plunger shaft **238.** The sidewall of the central aperture **246** is configured with at least one sealing ribs **242** so that an appropriate seal is maintained at the interface between the plunger shaft **238** and the bottom closure member **240.**

The well portion **248** is sized to receive the bottom end of the syringe body **210** and is provided with screw threads **245** along its inside wall. The syringe body **210** is provided with mating screw threads **207** near its bottom end so that the bottom closure member **240** can be screwed onto the syringe body **210** and seal the bottom opening of the syringe body **210** as illustrated in **Figure 8**. The bottom closure member **240** may be made of a single material or formed as a composite, but preferably at least the sealing ribs **242** and the inside surface of the base portion **247** that sealingly engages the syringe body **210** are made from an elastomer.

Top-end opening **224** of the syringe body **210** is preferably sealed with a removable closure. In this embodiment, the top-end opening **224** is sealed with a screw cap **250**. The screw cap is provided with screw threads **252** and the syringe body **210** is provided with mating threads **209** so that the screw cap **250** can be screwed onto the syringe body **210.**

The desired quality of the seals produced by the screw cap **250** and the bottom closure member **240** will be dictated by the particular application for the syringe device such as the particular substance stored in each compartment of the syringe. For example, the seals may be hermetic or non-hermetic but liquid tight.

Alternatively, the top-end opening **224** may be sealed with any other appropriate sealing methods. For example, the top-end opening **224** may be heat sealed

along the rim **225** with a foil membrane made of an appropriate material that can be peeled away to dispense the contents of the syringe.

**Figure 10** illustrates the syringe device **210** in a state before each of its two compartments are filled with components of a medicament. The plunger **230** is fully inserted into the syringe body **210.** The bottom closure member **240** is fully screwed into position closing the bottom end of the syringe body **210.** The screw cap **250** is screwed on to the top end of the syringe body **210** sealing the top-end opening **224** to prevent any contaminants from entering the syringe. In fact, all components of the syringe device **200** are preferably provided in sterile condition to prevent any contamination of the medicament or formulation to be stored in the syringe device **200.** Of course, if required, the filling and assembly operation itself may be conducted in a sterile environment.

Next, **Figures 11-17** will be utilized to illustrate the process involved in filling the syringe device **200** for storage and also mixing the contents of the syringe device **200** and preparing to dispense the mixed formulation. In this example, the top compartment **220** will be filled before the bottom compartment **222.** In **Figure 11**, the first component **20** being introduced into the top compartment **220** is a liquid. The screw cap **250** is removed from the syringe body **210.** While the top opening **224** of the syringe device is submerged in the liquid substance **20**, plunger **230** is withdrawn from a fully inserted position in the direction of the arrow **290.** The vacuum created in the top compartment **220** by this motion will draw the liquid substance **20** into the top compartment **220.**

The plunger **230** may be provided with a thumb rest **236** near the proximal end **239** of the plunger shaft **238** that can also be used to withdraw the plunger **230** from the syringe body **210.** Such thumb rest **236** will be useful also when pressing the plunger **230** into the syringe body **210.** If desired, the plunger **230** may be positioned at its sealed position at the bottom end of the top-compartment sidewall portion **202** and then filled through the top opening. The top compartment **220** maybe filled with either a liquid or a powder substance.

In **Figure 11**, the bottom closure member **240** is illustrated as being in its sealed position sealingly engaged to the syringe body **210** while the top compartment **220** is being filled. However, the bottom closure member **240** may just as easily be unscrewed from the syringe body **210** during this process.

**Figure 12** illustrates the next stage in the filling process. After the top-compartment **220** is filled with a desired amount of the first component **20** of a medicament, the top opening **224** is sealed with a screw cap **250.** The bottom closure member **240** is then unscrewed from the syringe body **210** to its unsealed position (if not

already in its unsealed position) removed. Next, the bottom compartment **222** is filled with a second component **22** of a medicament through the bottom opening **226.** During this process, the plunger **230** is maintained in its position so that the plunger head **232** remains engaged with the top-compartment sidewall **202** confining the first component **20** within the top compartment **220** and the bottom closure member **240** is positioned near the proximal end **239** of the plunger **230** to facilitate the filling of the bottom compartment **222.**

After a desired amount of the second component **22** is introduced into the bottom compartment **222**, the bottom opening **226** is sealed by sliding the bottom closure member **240** along the plunger shaft **238** towards its distal end **237** and screwing the bottom closure member **240** onto the syringe body **210. Figure 13** illustrates the syringe device **200** after the bottom closure member **240** has been screwed into its sealed position. The two components **20, 22** are kept separate in their respective compartments **220, 222** within the syringe device **200** and they may be stored until ready to be mixed and dispensed.

**Figure 14** illustrates the syringe device **200** in a configuration where the two components **20, 22** are being mixed into a medicament or a formulation. The plunger **230** has been withdrawn so that the plunger head **232** is no longer sealingly engaging the top-compartment sidewall **202** but lies within the bottom-compartment **220.** The plunger **230** may be provided with stopper tabs **234** that limit the travel of the plunger **230** when it is being withdrawn to prevent any compromise of the seal between the plunger shaft **238** and the bottom closure member **240.** Because the bottom-compartment sidewall **204** has a larger diameter than the plunger head **232**, the top and bottom compartments **220, 222** are in flow communication with one another. So that the two components **20, 22** may mix. The user may shake the syringe device **200** to properly combine the two components **20, 22**. The presence of the plunger **230** inside the bottom compartment **222** acts as an agitator during the shaking operation and facilitate the mixing of the components. The portion of the plunger **230** that lies within the bottom compartment **222** may be configured with vanes **231** that enhances the agitating function of the plunger **230.**

To dispense the medicament, the syringe device **200** is placed in an orientation illustrated in **Figure 15** with its top end pointing down and the plunger end pointing up. This causes the medicament **26** to drain into the top compartment **220.** The plunger head **232** is then pushed back into the top compartment **220**, as illustrated in **Figure 16**, and the syringe device **200** may be used like a standard syringe. The user would place the syringe device **200** in a top end up orientation as illustrated in **Figure 17.** Any air trapped in the top compartment **220** would then rise to form the head space **227.**

The screw cap **250** may then be removed to attach an appropriate dispensing device to the top end of the syringe device **200.** For example, a hypodermic needle may be attached to the syringe device **200** at the top end.

Once an appropriate dispensing device is attached, the plunger **230** is pressed further into the syringe body. But as the plunger head **232** advances further into the top compartment **220**, the increase in the volume of the bottom compartment **222** will create a low pressure condition in the bottom compartment **222** and may interfere with the dispensing process. To alleviate this concern, an air vent channel **270** may be provided on the plunger shaft **238.** As the plunger advances further into the syringe body **210** the air vent channel **270** will break the seal between the bottom closure member **240** and the plunger shaft **238** and allow outside air to vent into the bottom compartment **222.** Similarly, in the illustration of **Figure 11**, the air vent channel **270** will prevent any excessive air pressure build up in the bottom compartment **222** as the plunger **230** is being withdrawn to fill the top compartment **220.**

In an alternate embodiment, the bung **140** and the syringe body **110** of the syringe device **100** illustrated in **Figure 1** may be configured and adapted so that the bung **140** may be screwed into the syringe body **110.** The bung **140** may be provided with screw threads on its outer surface and the inside wall of the syringe's base-skirt portion **106** may be provided with mating screw threads.

**Figures 18-26** illustrate another embodiment of the invention, a syringe device **300** having three compartments for storing three different components of a medicament or a formulation, each in separate compartments until ready for use, wherein the three components may be mixed to form the medicament. **Figure 18** is an illustration of the fully assembled syringe device **300** in a ready-for-storage configuration. Plunger **330** is positioned inside a syringe body **310** so that plunger head **332** sealingly engages top-compartment sidewall **302**, in proximity to shoulder **303**, and a first bung **360** is sealingly engaged with middle ridge **305.** In this storage configuration, the plunger head **332** forms the partition between top compartment **320** and middle compartment **321.** The first bung **360** forms the partition between middle compartment **321** and bottom compartment **322.** The seal formed by the plunger head **332** and the top-compartment sidewall **302** is hermetic so that components stored in the top compartment **320** and the middle compartment **321** may be kept separate until ready to be mixed. The seal formed by the first bung **360** and the middle ridge **305** serves the same function between the middle compartment **321** and bottom compartment **322.**

**Figure 19** illustrates a cross-sectional view of the first bung **360.** The first bung **360** is provided with a central aperture **366** through its center so that the plunger **330**

is received through the central aperture and the first bung **360** can be moved up and down the plunger shaft **338.** The sidewall of the central aperture **366** may be provided with a plurality of inner sealing ribs **362** for sealingly engaging the plunger shaft **338.** Top portion **368** of the first bung **360** has a smaller outer diameter than the bung's bottom portion **369.** The outer diameter of the top portion **368** is such that the top portion **368** fits within the middle-compartment sidewall **308** and sealingly engages the middle-compartment sidewall **308.** Otherwise the outer surface **367** fits snugly to form a seal.

The bottom portion **369** has a larger diameter than the top portion **368** so that a stopper ridge **364**, separating the top portion from the bottom portion **369**, interferes with the middle ridge **305** of the syringe body **310**, preventing the first bung **360** from traveling too far into the middle compartment **321.** But the diameter of the bottom portion **369** is sufficiently small that it does not contact the bottom-compartment sidewall **304** and leaves a sufficient clearance space between the bottom-compartment sidewall **304** and the bottom portion **369** for the contents of the syringe device **300** to pass through the space when the first bung **360** is dislodged to its unsealed position.

The first bung **360** is preferably made from an elastomer and the diameter of the top portion **368** of the first bung **360** is such that when the first bung **360** is in its sealed position, the top portion **368** compressively seals against the inside surface of middle-compartment sidewall **308.** If desired, a plurality of outer sealing ribs (not shown) may be provided along the outer surface **367** of the top portion **368** to facilitate the sealing. Alternatively, the first bung **360** may have a composite structure where at least the seal forming portions, i.e., the sealing ribs **362** and the top portion **368**, are made from one or more elastomers. The rest of the first bung **360** may be made from any material suitable to maintain the structural shape of the first bung **360** and chemically compatible with the elastomer portions. Bottom portion **369** of the first bung **360** has a smaller diameter than the bottom-compartment sidewall **304** so that the first bung can be moved through the bottom compartment **322** to form a seal with the inside surface of the middle-compartment sidewall **308.**

A second bung **340** is positioned within the base-skirt portion **306**, of the syringe housing **310** sealing the bottom-end opening **326.** The second bung **340** presses up against base ridge **307** which functions as a stopper preventing the bung **340** from traveling too far into the syringe body **310.**

A detailed cross-sectional view of the second bung **340** is illustrated in **Figure 20**. The second bung **340** is similar in structure as the bung **340** of the syringe device **100**, illustrated in **Figure 2**. The second bung **340** has a central aperture **346** through its axial center so that the plunger **330** can be received through the central aperture

and the second bung **140** can slide up and down the plunger shaft **338.** The outer surface of the second bung **340** is provided with a plurality of outer sealing ribs **344** for sealingly engaging the inside surface of the base-skirt portion **306** and forming a hermetic seal at the bottom-end opening **326.** The side wall of the central aperture **346** is provided with a plurality of inner sealing ribs **342** for sealingly engaging the plunger shaft **338.** The diameters of the outer surface and the central aperture **346** of the second bung **340** is sized so that the sealing ribs may form hermetic seals with the mating surfaces through compression.

The second bung **340** also may be provided with a well **348** so that only the lower portion **347** of the bung **340** forms the seal with the plunger shaft **338.** As discussed with reference to the bung **140**, illustrated in **Figure 2** above, the inner sealing ribs **342** and the outer sealing ribs **344** of the second bung **340** are preferably configured so that the plunger **330** can be partially withdrawn form the syringe body **310** without dislodging the second bung **340** from its sealed position within the base-skirt portion **306.** The top-end opening **324** (see **Figure 18**) is sealed with a cap **350** which is configured to be removed when the contents of the syringe device **300** has been mixed and is ready to be dispensed.

The process of assembling and filling the syringe device **300** according to the invention will now be described with references to **Figures 21-23**. A syringe body **310** is oriented in an upright position with its top-end opening **324** pointing upwardly. A plunger **330** is first inserted through bottom-end opening **326** and into the syringe body **310** plunger head **332** first until the plunger head **332** engages the top-compartment sidewall **302.** The engagement of the plunger head **332** with the top-compartment sidewall **302** forms a hermetic seal at the bottom of the top compartment **320** in proximity to the shoulder **303.** The first bung **360**, in this assembly configuration, is positioned between the middle compartment **321** and the bottom compartment **322.**

The top compartment **320** is then filled with a first component of a medicament through the top-end opening **324** and sealed with a cap **350.** In this embodiment of the invention, the first component is preferably the liquid component of the medicament. To prevent any degradation of the first component from prolonged exposure to air during storage, the top compartment **320** is filled completely with the first component liquid, minimizing or eliminating any air pockets inside the top compartment **320** when it is sealed with the cap **350.** In the alternative, the filling process may be conducted under a vacuum or an inert gas environment so that even if the top compartment is not filled completely with the first component liquid, there would not be any air trapped inside the top compartment after being sealed with the cap **350.**

The top compartment may also be filled by inserting the plunger completely to the end of the top compartment, immersing the open top end in the first component liquid, then sucking the liquid into the top compartment by pulling the plunger back to the sealed position between the compartments.

As discussed above in reference to the cap **150** of the syringe device **100**, the cap **350** is preferably configured and adapted to form a hermetic seal around the top-end opening **324.** And the particular requirement for the quality of the seal formed by the cap at the top-end opening and the seals formed between the compartments throughout the syringe device **300** would be dictated by the particular application for which the syringe device is intended.

**Figure 21** is a sectional illustration of the syringe device **300** at this stage of the assembly. The top compartment **320** has been filled with the component of a medicament and the top-end opening **324** is about to be sealed by the cap **350.** After the cap **350** is in place, the syringe device **300** may be turned 180 degrees, with the capped end oriented downward, so that the middle compartment **321** and the bottom compartment **322** may be filled. At this stage of the assembly, the first bung **360** and the second bung **340** are positioned near the thumb rest **336** of the plunger **330**, as illustrated in **Figure 21**, so that bottom-end opening **326** is free of any encumbrances. The bungs are kept from sliding down the plunger shaft **338** by the static frictional forces between the bungs and the plunger shaft **338.**

The middle compartment **321** is then filled with a second component of the medicament through the bottom-end opening **326.** The second component may be a liquid or a powder substance but as discussed above, in reference to the filling process of the bottom compartment **122** of the syringe device **100** illustrated in **Figures 1-3**, the configuration of the syringe device **300** is particularly well suited for filling the middle compartment **321** using the lyophilization process. The second component of the medicament in a hydrated form would be placed inside the middle compartment **321.** Then, the first bung **360** is moved down the plunger shaft **338** until it snugly fits into the middle compartment sidewall **308** so that the first bung **360** is not fully engaged into its sealed position. As illustrated in **Figure 22**, during the lyophilization process, the vacuum created in the middle compartment **321** pulls the first bung **360** completely into the middle compartment **321** until the stopper ridge **364** of the first bung **360** comes in contact with middle ridge **305** of the syringe body **310.** The first bung **360** thus forms a hermetic seal between the middle compartment **321** and the bottom compartment **322.**

Next, the bottom compartment **322** is filled with a third component of the medicament through the bottom-end opening **326** and sealed with the second bung **340**

also using the lyophilization process. Alternatively, the bottom compartment may not be filled using the lyophilization process, in which case, the second bung **340** and the syringe body **310** are configured and adapted to form a seal at the bottom opening **326** by mechanically pushing or screwing the second bung **340** into the sealed position. In these alternative embodiments, the plunger shaft **338** is provided with a venting channel, similar to the venting channel **370** of the device **300** illustrated in **Figures 10 - 17**, to relieve the pressure built inside the bottom compartment **322** during the sealing process.

**Figure 23** illustrates the fully assembled syringe device **300** in the storage configuration. The syringe device **300** now consists of three completely sealed compartments – the top compartment **320**, the middle compartment **321**, and the bottom compartment **322** – where each compartment is holding a component of a medicament for storage until ready to be mixed just prior to use.

The process involved in preparing and dispensing the medicament stored in the syringe device **300** will now be described with references to **Figures 24-26**. In order to mix the three components stored in the syringe device **300**, the plunger **330** is first pulled back towards the proximal end **339** of the plunger **330** so that the plunger head **332** disengages from the top-compartment sidewall **302** as illustrated in **Figure 24**. The motion of disengaging the plunger head **332** from the top-compartment sidewall **302** simultaneously disengages the first bung **360** from its sealed position. As illustrated in **Figure 24**, this is enabled by stopper flange **333** which is an outwardly protruding portion of the plunger shaft **338** positioned above the first bung (as shown in **Figure 23)**. When the plunger shaft **338** is pulled back towards its proximal end **339**, the stopper flange **333** catches the first bung **360** and dislodges the bung from its sealed position. The top compartment **320**, the middle compartment **321**, and the bottom compartment **322** are now in communication with one another so that the contents of the three compartments can mix.

During this operation, the plunger's **330** travel is limited by a second stopper tab **334** so that a substantial portion of the plunger shaft **338** remains within the middle compartment **321** when the plunger head **332** disengages from the top-compartment sidewall **302** and the three compartments are in communication with one another. When the syringe device **300** is shaken vigorously to mix the contents, the presence of a substantial portion of the plunger shaft **338** facilitates the mixing of the contents by functioning as an agitator. As discussed above in reference to the syringe device **100** of **Figure 4**, this agitating function of the plunger shaft **338** may be further enhanced by providing vanes **331** in the portion of the plunger shaft that is positioned within the middle compartment **321.**

In an embodiment of the three-compartment syringe that is pre-filled by lyophilization, the disengaging of the plunger head **332** from the top-compartment sidewall **302** may be accomplished by an alternative method. In this alternative method, the user simply unseals the top-end opening **324** of the syringe device **300** by unscrewing the cap **350.** In this embodiment, the lyophilization process creates a vacuum condition in the bottom compartment **322** and the vacuum in the bottom compartment **322** pulls on the plunger head **332.** But because the top compartment **320** is filled with liquid and sealed air-tight, the plunger head **332** is prevented from being sucked into the bottom compartment **322.**

Then, when the cap **350** is unscrewed from the top-end opening **324**, the pressure inside the top compartment **320** will equalize with the atmospheric pressure and cause the plunger head **332** to be abruptly sucked into the bottom compartment **322** breaking the seal separating the two compartments. This abrupt breaking of the seal causes the liquid from the top compartment **320** to gush into the bottom compartment **322** enhancing the mixing of the liquid and the dry contents of the bottom compartment **322.**

Once the contents of the syringe device **300** is completely mixed and the medicament is ready for dispensing, the syringe device **300** is oriented so that the top compartment is pointing downward. This will cause the medicament to drain into the top compartment **320.** The volume of the three components of the medicament preferably is controlled so that the mixed medicament would fit completely inside the top compartment **320** without overflowing. This minimizes any portion of the medicament from being wasted.

Next, while maintaining the top-compartment oriented down, the plunger **330** is pushed down until the plunger head **332** sealingly engages the top-compartment sidewall **302.** The syringe device **300** then may be turned into the orientation with the top end of the syringe device **300** pointing upwardly. Then, as shown in **Figure 25**, the cap **350** may be removed and a syringe needle **380** may be attached to the top-end opening **324.** In this configuration, the syringe device **300** operates similar to a standard syringe. To completely dispense the medicament contained in the top compartment **320**, the plunger **330** is fully depressed into the syringe device **300** as illustrated in **Figure 26**. It would be apparent to one of ordinary skill in the art that the syringe device **300** may be provided with a dispensing apparatus other than a syringe needle for dispensing the medicament.

As described above with reference to the two-compartment syringe device, one or both of the bungs **340** and **360** in the three-compartment syringe device **300** also may be configured with screw threads so that they may sealingly engage the syringe body

**310** by being screwed into their sealed positions. Of course, in this alternate embodiment, the corresponding portions of the syringe body **310** should be provided with screw threads for receiving the bungs **340** and **360.**

Most of the seals discussed herein in reference to the various embodiments of the multi-compartment syringe device are described as hermetic seals. However, the quality of the seals may be hermetic or non-hermetic as necessitated by the particular application for the syringe device. The quality of the particular seal in the syringe device can be controlled by selecting appropriate materials for the components that form the seal. The particular physical arrangement or configuration of the components selected will also affect the quality of the seal. For example, in the embodiment of the syringe device where the top-end opening is sealed with a heat sealed membrane, the membrane may be selected from a variety of materials of having varying permeability with respect to air or the particular substance placed inside the top compartment to achieve the desired seal quality at the top-end opening.

It should be emphasized that the above described embodiments of the present invention are merely specific examples. In addition, components and formulations other than medicaments may be administered with the syringe. Various modifications may be made by those skilled in the art which will embody the principles of the invention and fall within the spirit and the scope thereof.

We claim:

1. A syringe device comprising:
a syringe body having an opening at each of its top and bottom ends;
a shoulder provided between the top and the bottom ends defining a top-compartment sidewall portion between the top end and the shoulder;
the shoulder further defining a bottom-compartment sidewall portion between the shoulder and the bottom end;
the bottom-compartment sidewall portion having a larger cross-section than the top-compartment sidewall portion;
a plunger having a shaft, a distal end, a proximal end, and a plunger head provided at the distal end;
the plunger inserted into the syringe body plunger head first through the bottom-end opening;
the plunger head configured and adapted to form a seal when the plunger head engages the top-compartment sidewall, wherein the plunger is axially translatable between a first position where the plunger head is sealingly engaged with the top-compartment sidewall dividing the syringe body into a top compartment and a bottom compartment, and a second position where the plunger head disengages from the top-compartment sidewall establishing a flow communication between the top and bottom compartments; and
a bottom closure member having a central aperture in which the plunger shaft is slidably disposed, wherein the bottom closure member is slidable along the plunger shaft between an unsealed position where the bottom-end opening is not sealed and a sealed position sealing the bottom-end opening of the syringe body.

2. A syringe device according to claim 1, wherein the syringe body's internal shape is tubular.

3. A syringe device according to claim 1, wherein the plunger head forms a hermetic seal with the top-compartment sidewall.

4. A syringe device according to claim 1, wherein the bottom closure member, when in its sealed position, hermetically seals the bottom-end opening of the syringe body.

5. A syringe device according to claim 1, wherein the bottom closure member seals the bottom-end opening of the syringe body by being screwed onto the syringe body.

6. A syringe device according to claim 1, wherein the bottom closure member is a bung having at least one sealing ribs on its outer surface that forms a seal with the bottom-compartment sidewall when the bung is inserted into the bottom-end opening of the syringe body.

7. A syringe device according to claim 1, further comprising a base ridge provided between the shoulder and the bottom end further defining a base-skirt portion, having a larger diameter than the bottom-compartment sidewall portion, between the base ridge and the bottom end of the syringe body, wherein the bottom closure member is a bung having at least one sealing ribs on its outer surface that forms a seal with the base-skirt portion when the bung is inserted into the bottom-end opening of the syringe body.

8. A syringe device according to claim 1, further comprising a top sealing member for sealing the top-end opening of the syringe body that is readily removable to dispense the contents of the syringe device.

9. A syringe device according to claim 8, wherein the top sealing member is a screw cap having screw threads and seals the top-end opening by being screwed onto the top-end opening.

10. A syringe device according to claim 8, wherein the top sealing member is a membrane that is heat-sealed to the top-end opening.

11. A syringe device according to claim 1, wherein at least a portion of the plunger shaft, located within the bottom compartment when the plunger is in its second position, is provided with a plurality of vanes oriented axially along the shaft.

12. A syringe device according to claim 1, wherein the plunger is provided with a thumb rest at its proximal end.

13. A syringe device according to claim 1, wherein the bottom closure member is a bung provided with screw threads on its outer surface and the inside surface of the syringe body near the bottom-end opening is provided with mating screw threads so that the bung screws into the bottom-end opening of the syringe body to seal the bottom-end opening.

14. A syringe device according to claim 1, wherein the bottom closure member is made of an elastomer.

15. A syringe device according to claim 5, wherein the bung has a plurality of outer sealing ribs on its outer surface that sealingly engage the base-skirt portion and a plurality of sealing ribs on the central aperture that sealingly engage the plunger shaft.

16. A syringe device according to claim 1, wherein the plunger head is made of an elastomer.

17. A syringe device according to claim 8, wherein a liquid substance is stored in the top compartment and a dry substance is stored in the bottom compartment.

18. A method of filling a syringe device of claim 1 comprising:
inserting the plunger into the syringe body plunger head first from the bottom-end opening of the syringe body until the plunger head sealingly engages the top-compartment sidewall portion;

introducing a first component of a medicament through the top-end opening;

sealing the top-end opening with a removable top sealing member;

orienting the syringe body so that the bottom-end opening is directed upwardly;

introducing a second component of a medicament into the bottom compartment through the bottom-end opening; and

sealing the bottom-end opening with a bottom closure member.

19. A method of filling a syringe device according to claim 18, wherein the bottom closure member screws onto the bottom-end opening to seal the bottom-end opening.

20. A method of filling a syringe device according to claim 18, wherein the bottom closure member is a bung and the bottom-end opening is sealed by screwing the bung into the bottom-end opening.

21. A method of filling a syringe device according to claim 18, wherein the removable top sealing member is a screw cap.

22. A method of filling a syringe device according to claim 18, wherein sealing the top-end opening includes heat sealing the top-end opening with a membrane, that can be peeled away to unseal the top-end opening.

23. A syringe device comprising:
a syringe body having an opening at each of its top and bottom ends;

a shoulder provided between the top and the bottom ends defining a top-compartment sidewall portion between the top end and the shoulder;

at least one middle ridge located between the shoulder and the bottom end defining a middle-compartment sidewall portion between the shoulder and the middle ridge, and a bottom-compartment sidewall portion between the middle ridge and the bottom end;

the top-compartment sidewall portion, the middle-compartment sidewall portion and the bottom-compartment sidewall portion having successively larger diameters;

a plunger having a shaft, a distal end, a proximal end, and a plunger head provided at the distal end;

the plunger inserted into the syringe body plunger head first through the bottom end opening;

the plunger head configured and adapted to form a slidable hermetic seal when the plunger head engages the top-compartment sidewall,

wherein the plunger is axially translatable between a first position where the plunger head is sealingly engaged with the top-compartment sidewall defining a top compartment between the top end and the plunger head, and a second position where the plunger head is disengaged from the top-compartment sidewall;

at least two bungs, each having a central aperture in which the plunger shaft is slidably disposed, wherein one of the at least two bungs is a terminal bung positioned on the plunger shaft between the plunger head and the proximal end for sealingly engaging the bottom end opening of the syringe body, and the other of the at least two bungs is an intermediate bung positioned on the plunger shaft between the plunger head and the terminal bung;

the intermediate bung slidable along the plunger shaft between a sealed position sealingly engaging the at least one middle ridge, providing a partition between the middle compartment and the bottom compartment, and an unsealed position where the middle compartment and the bottom compartment is in flow communication;

the terminal bung slidable along the plunger shaft between a sealed position sealing the bottom-end opening, and an unsealed position; and

the plunger axially translatable between the first position and the second position without dislodging the terminal bung from its sealed position, and a flow communication is established among the compartments when the plunger is in the second position.

24. A syringe device according to claim 23, further comprising a base ridge provided between the middle ridge and the bottom end defining a base-skirt portion between the base ridge and the bottom end wherein the terminal bung forms a seal with the base-skirt portion when the terminal bung is inserted into the bottom-end opening.

25. A syringe device according to claim 23, wherein the syringe body's internal shape is tubular.

26. A syringe device according to claim 23, wherein at least one of the bungs is made of an elastomer.

27. A syringe device according to claim 23, wherein at least one of the bungs has a plurality of outer sealing ribs on its outer surface that sealingly engage the base-skirt portion and a plurality of sealing ribs on central aperture to seal against the plunger shaft.

28. A syringe device according to claim 23, wherein at least one of the bungs is provided with screw threads on its outer surface the inside surface of the syringe body is provided with mating screw threads on its inside surface so that the bung screws into the syringe body to the bung's sealed position.

29. A syringe device according to claim 23, wherein the plunger head is made of an elastomer.

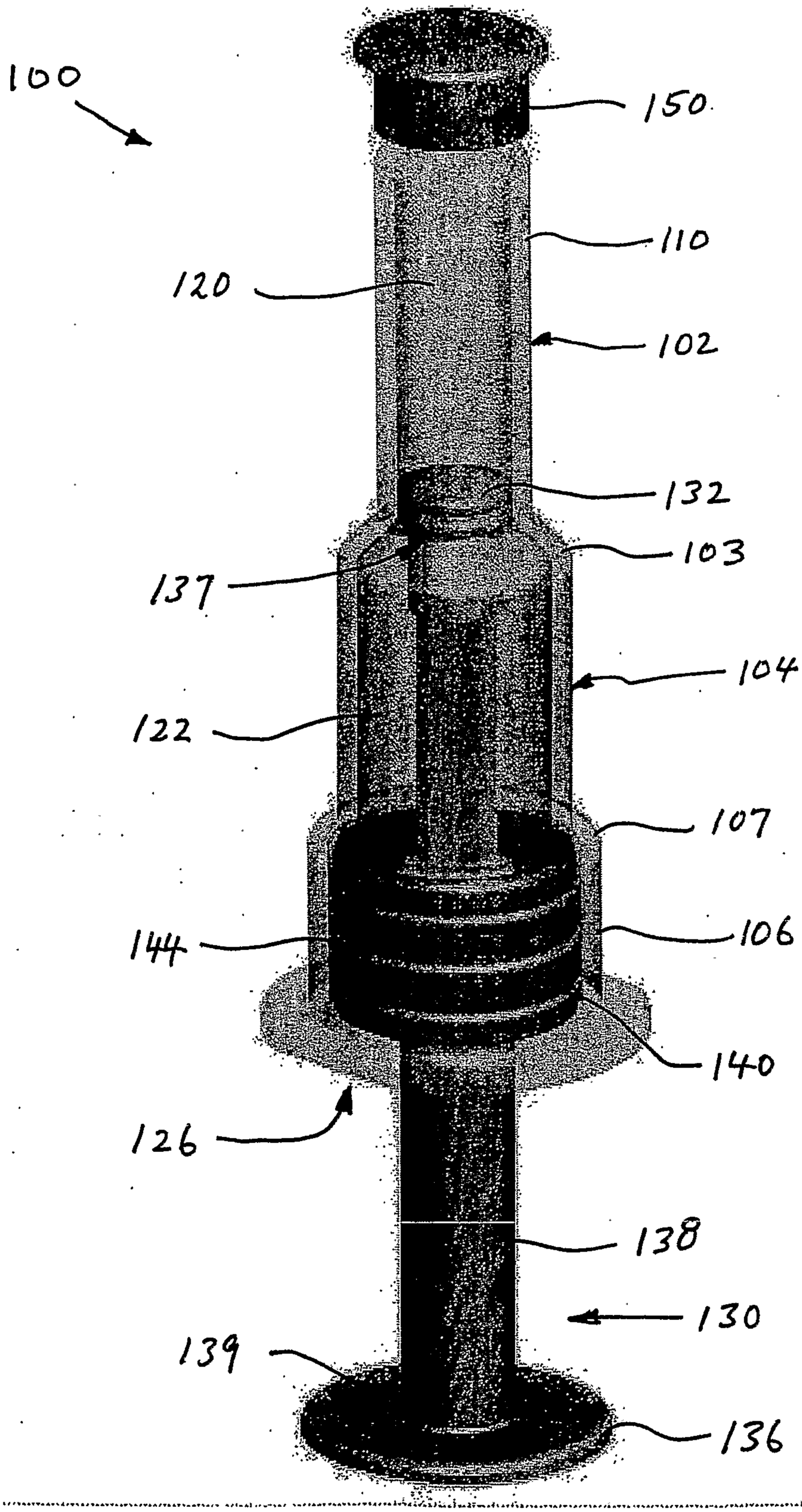

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Fig. 1

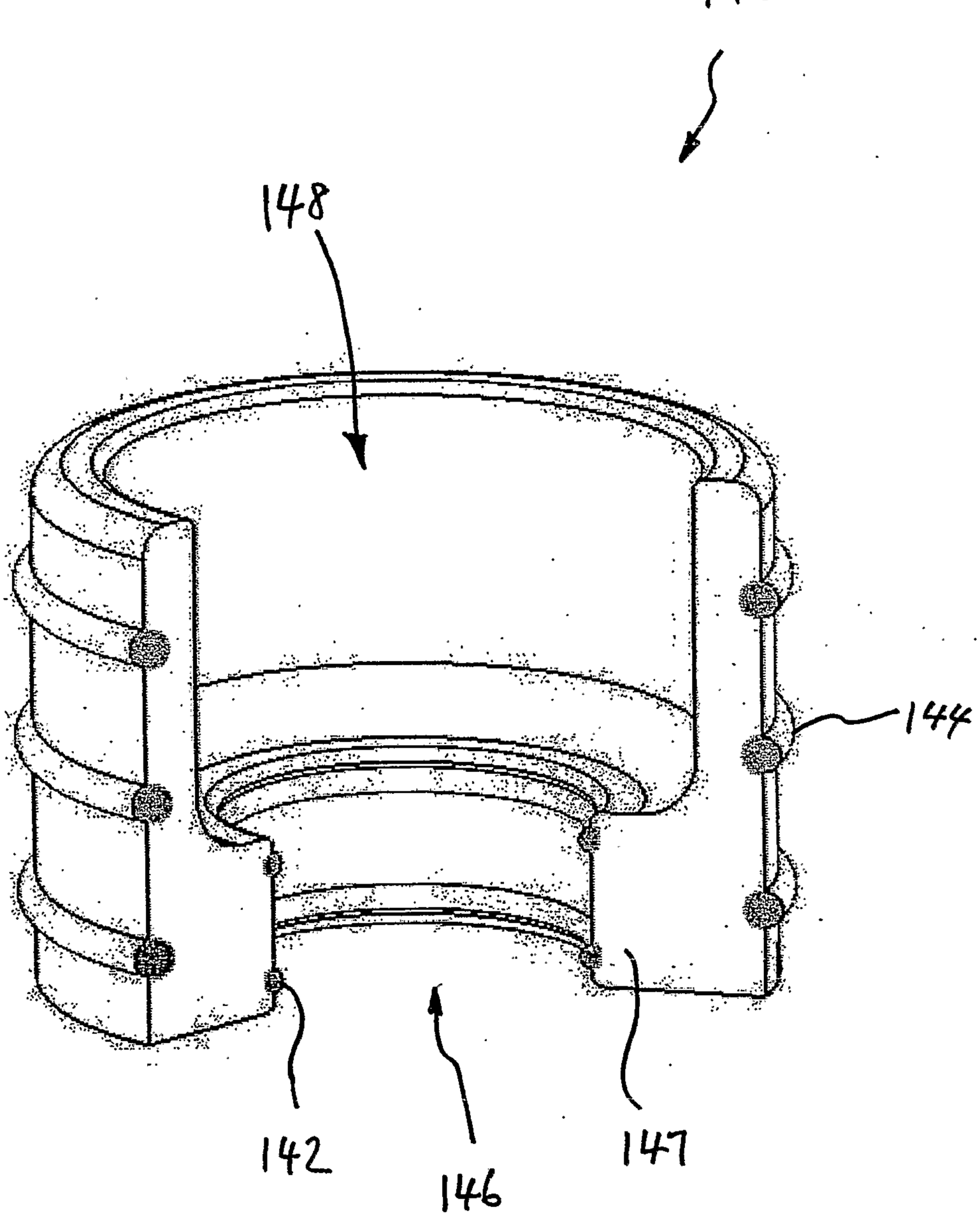



Fig. 2

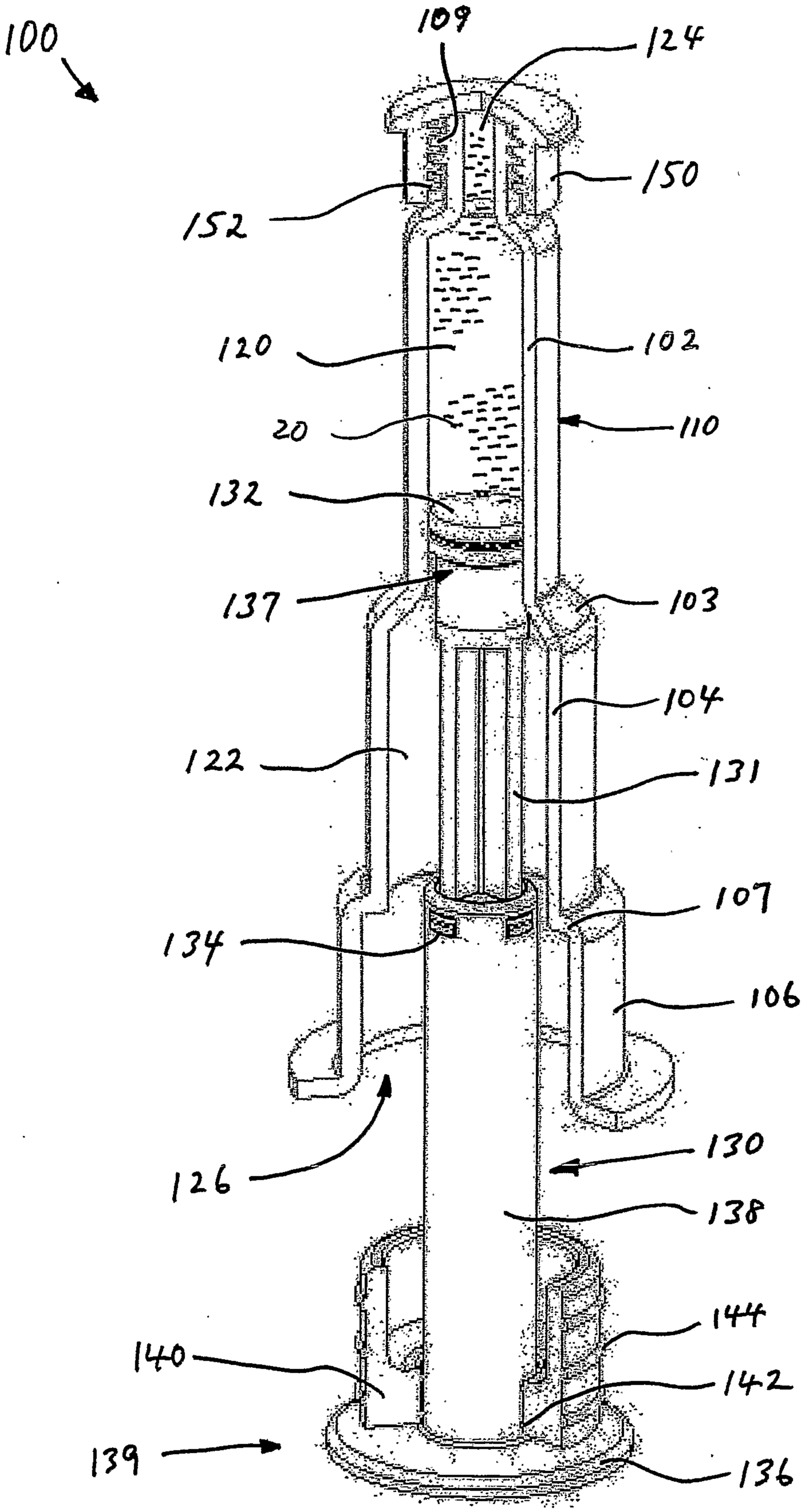

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Fig. 2

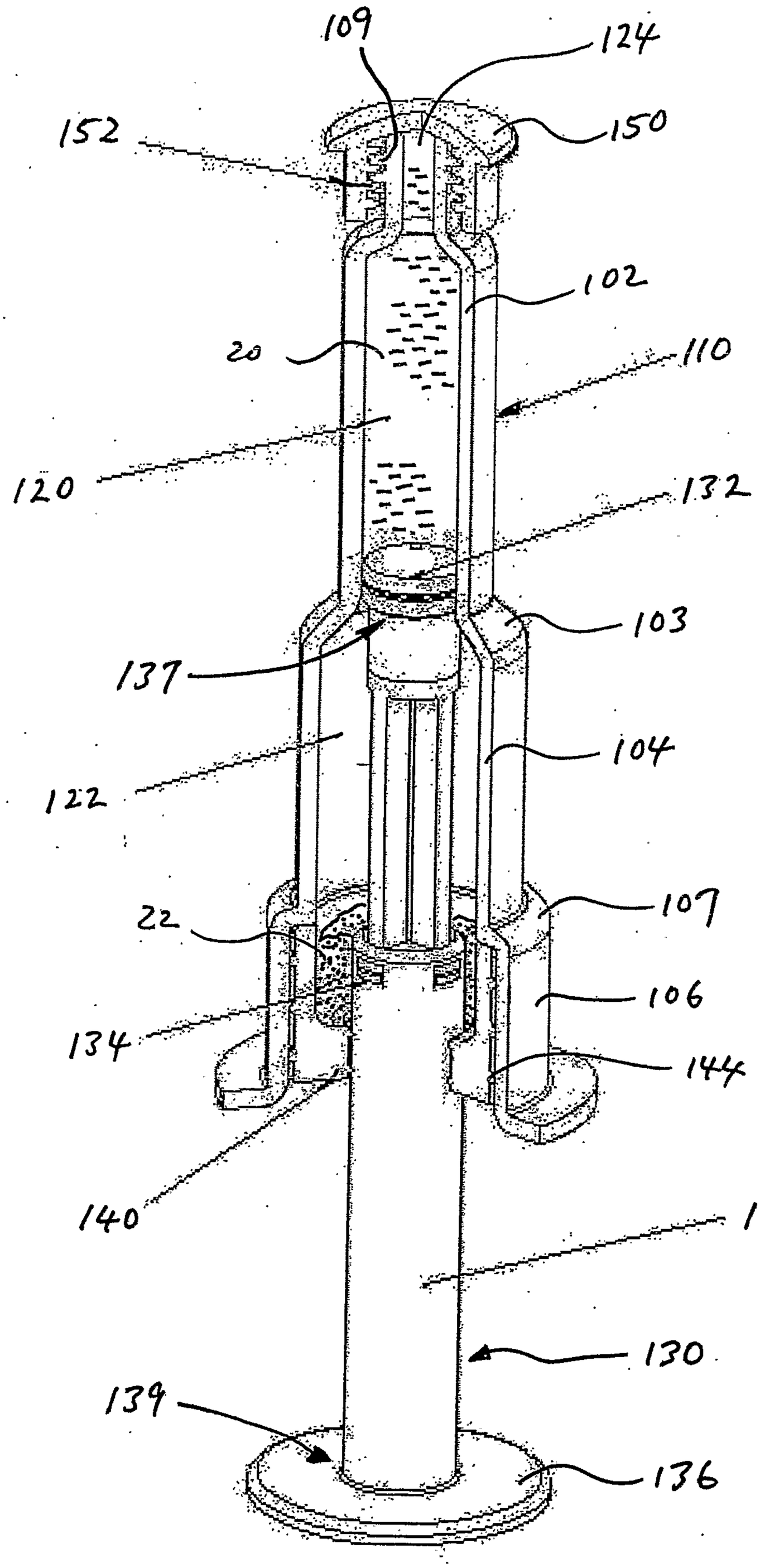

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Fig. 4

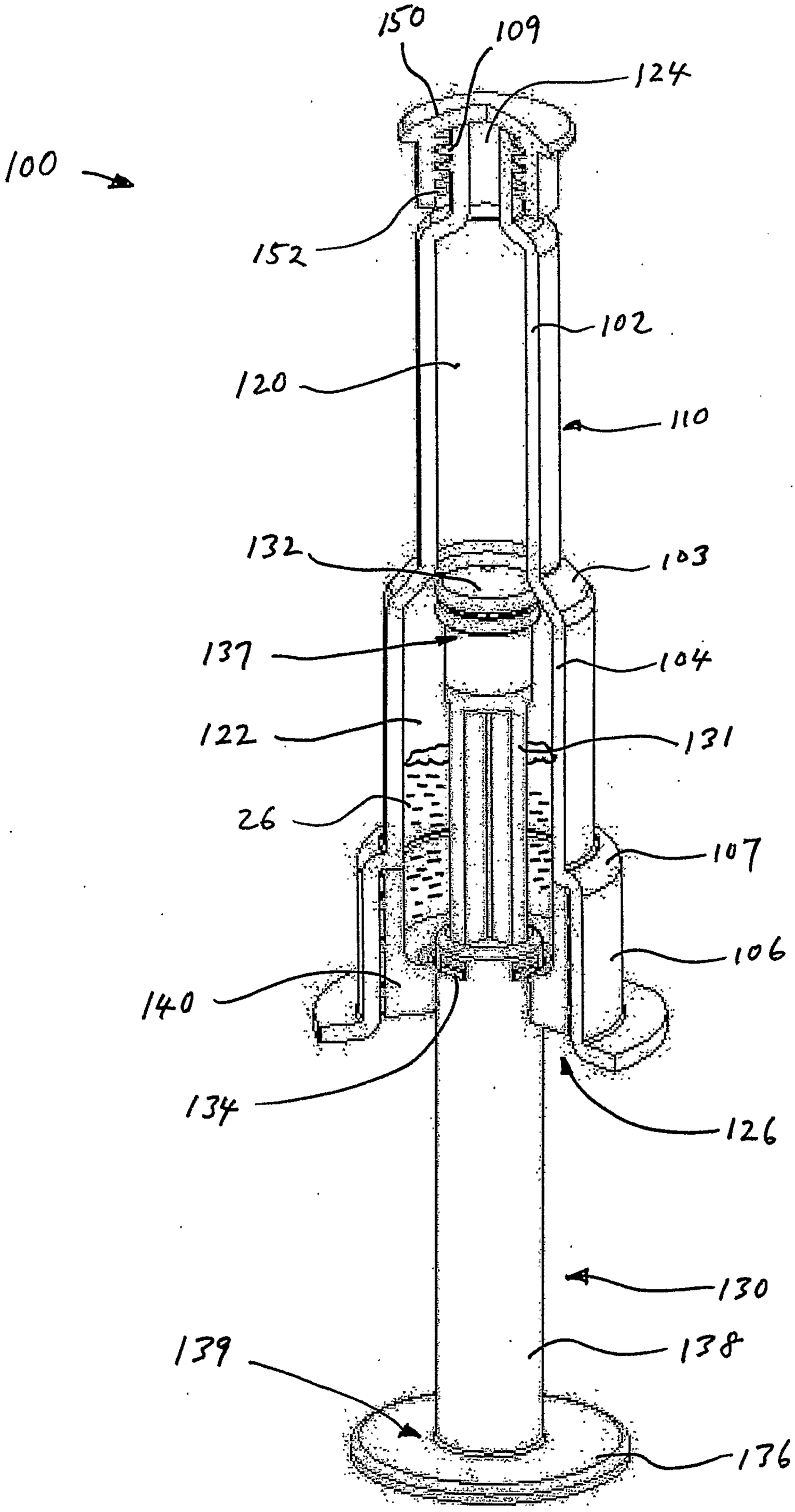

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Fig. 5

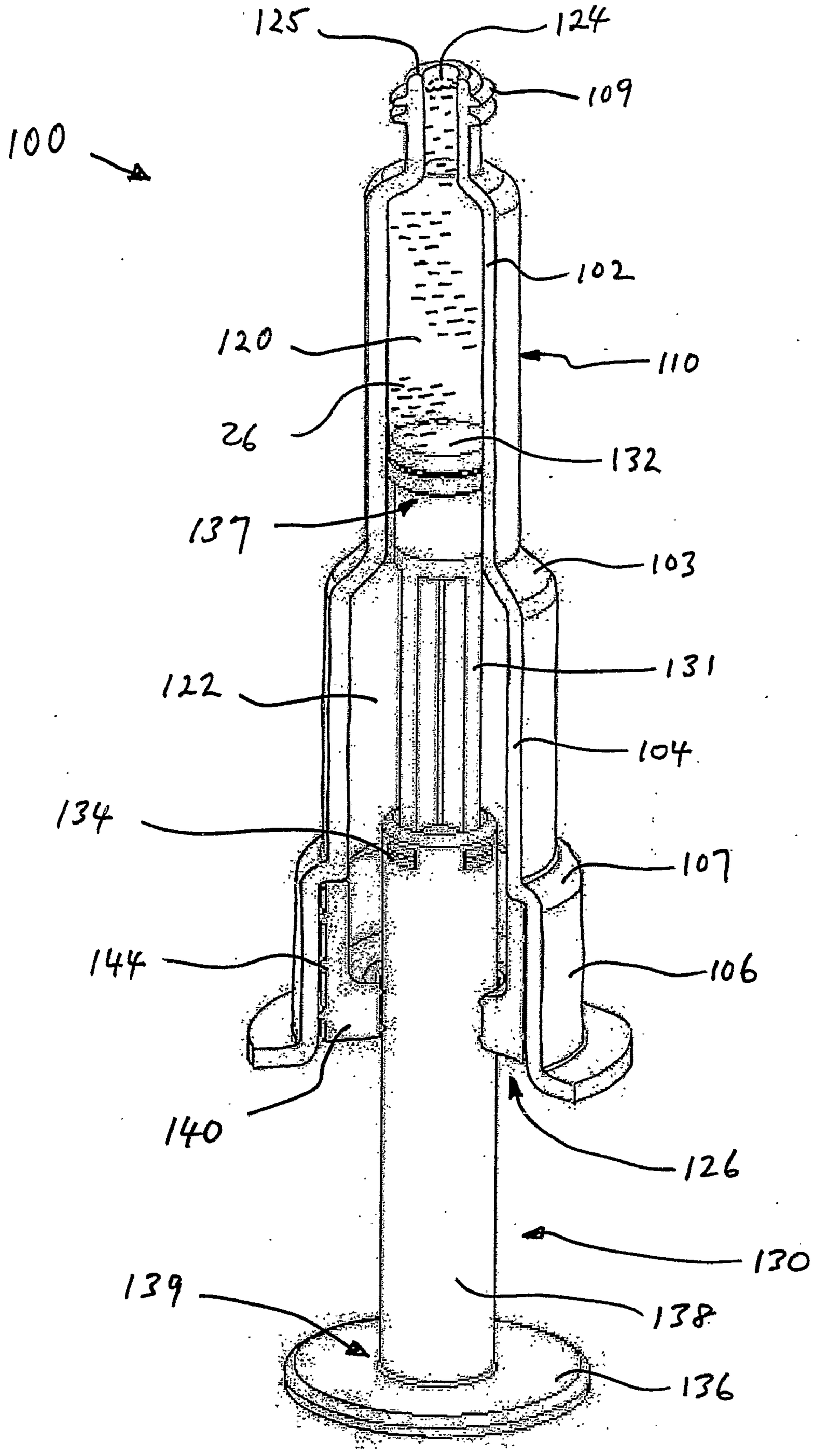

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Fig. 6

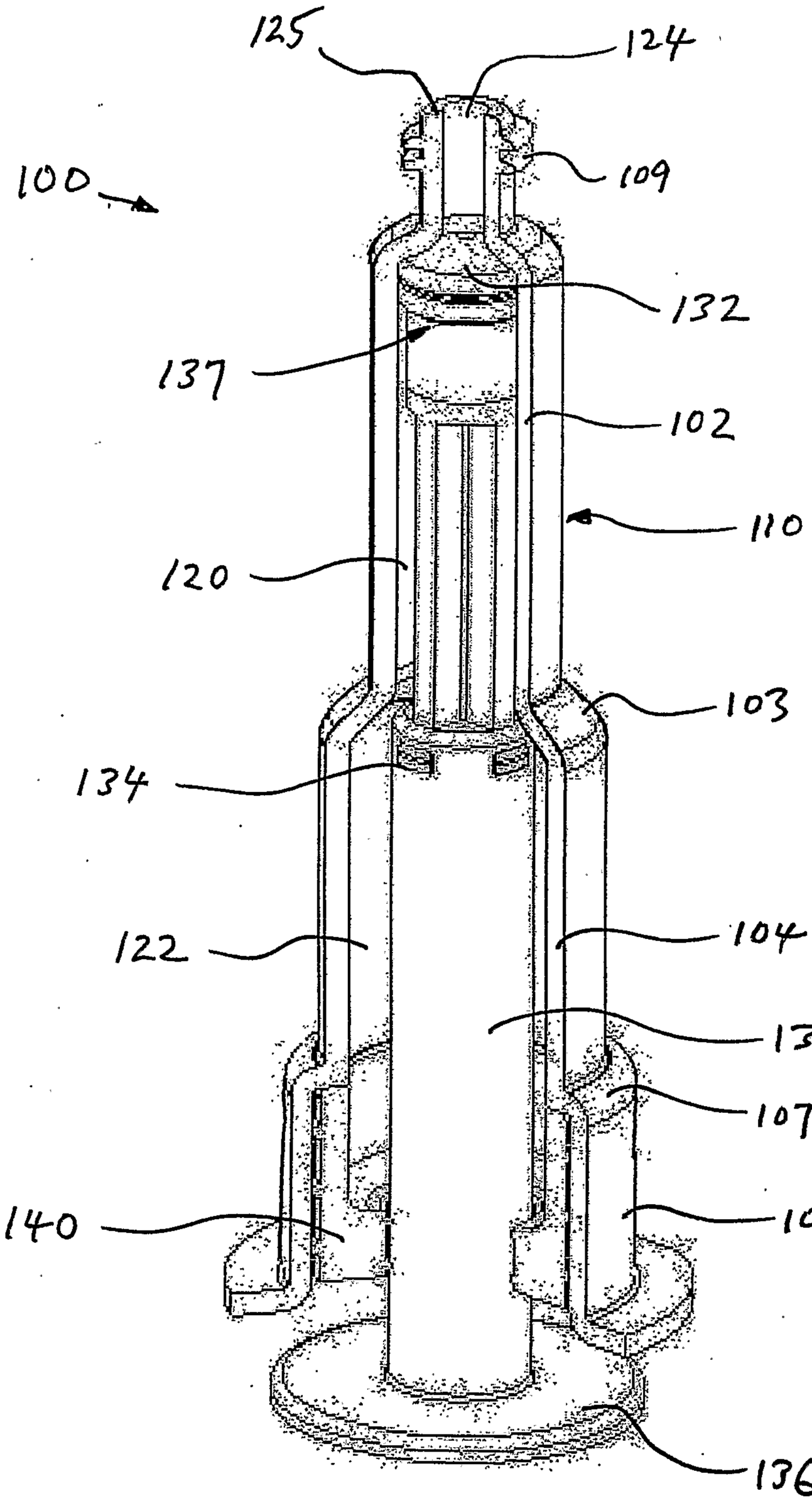

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Fig. 7

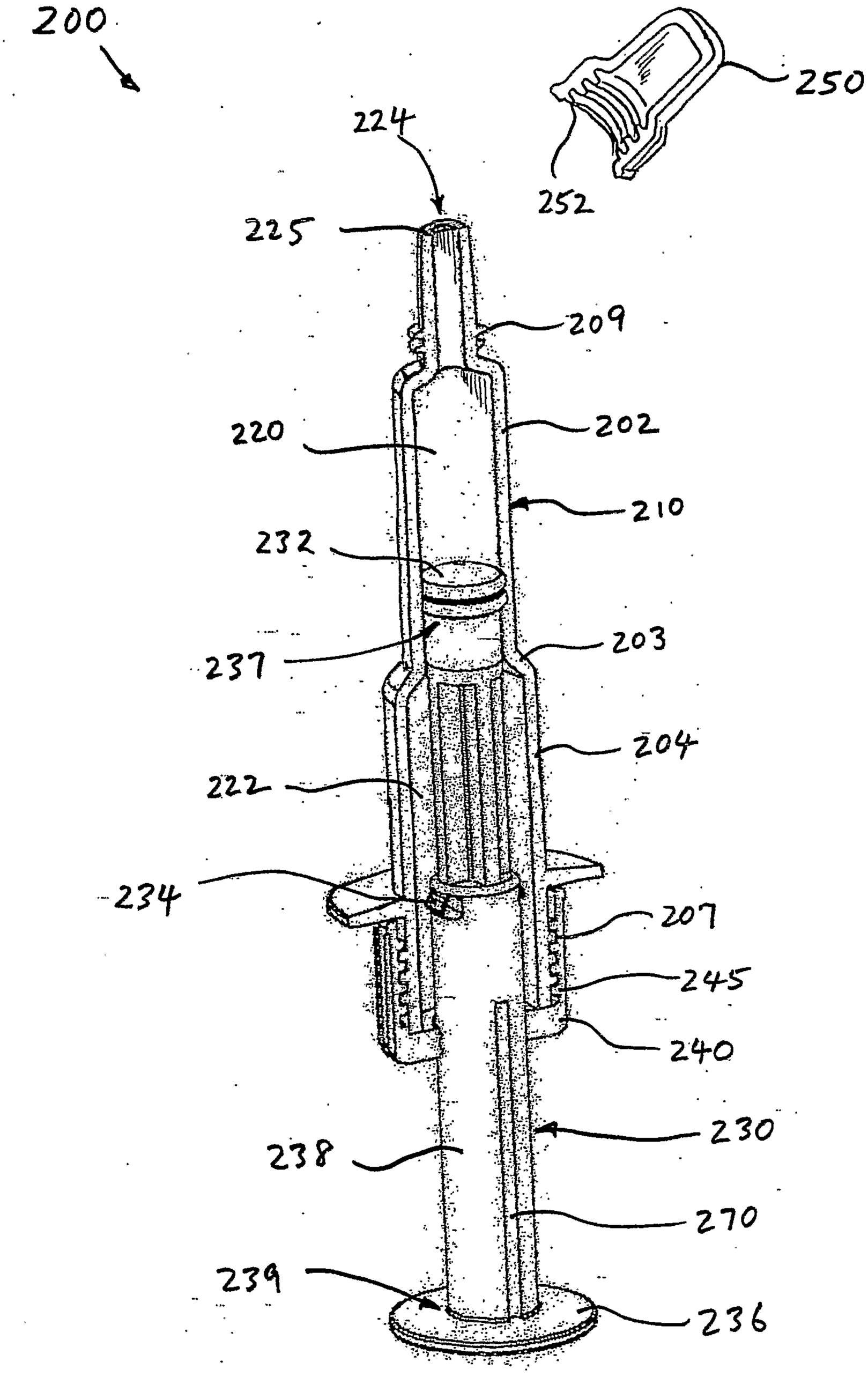

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Fig. 8

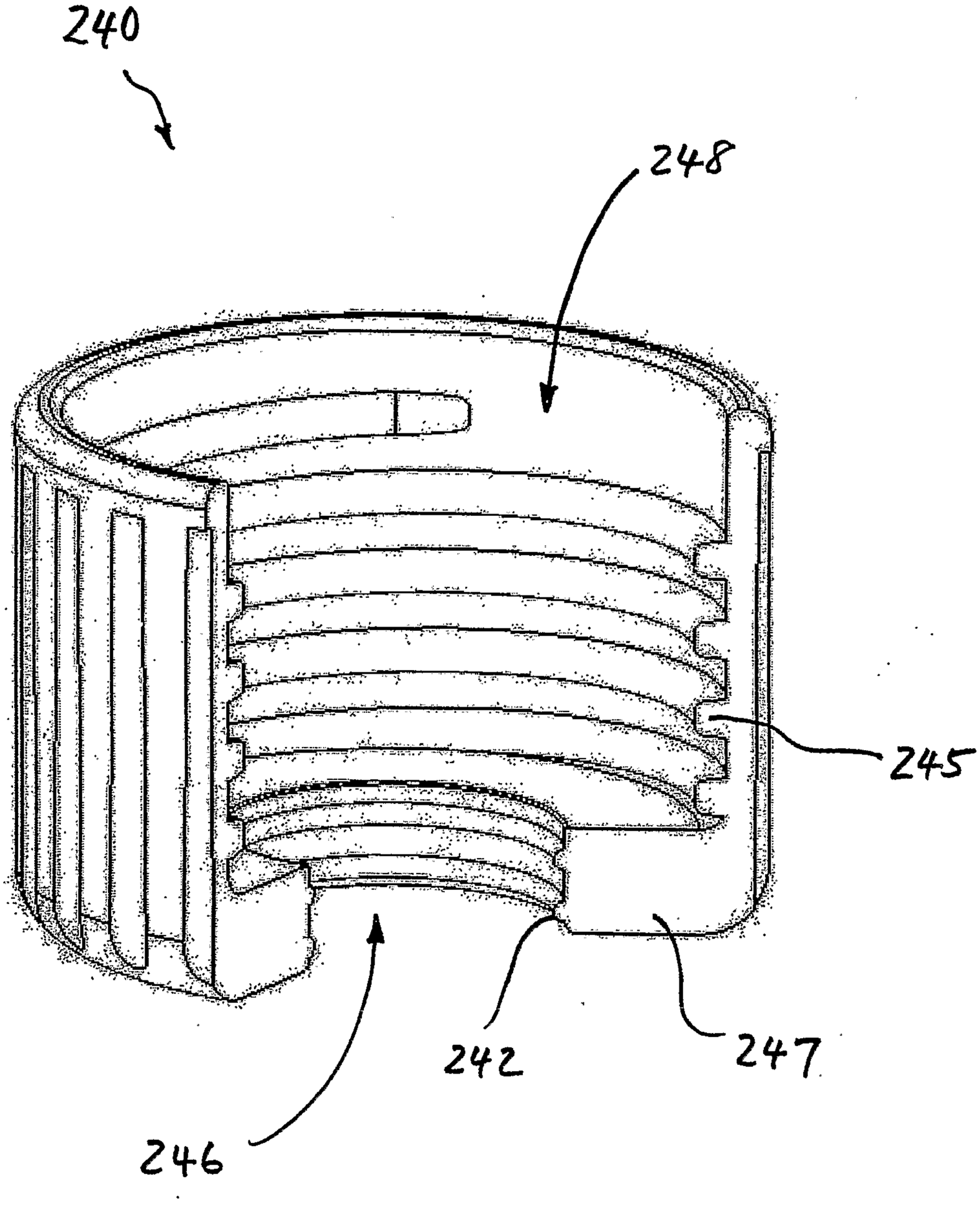



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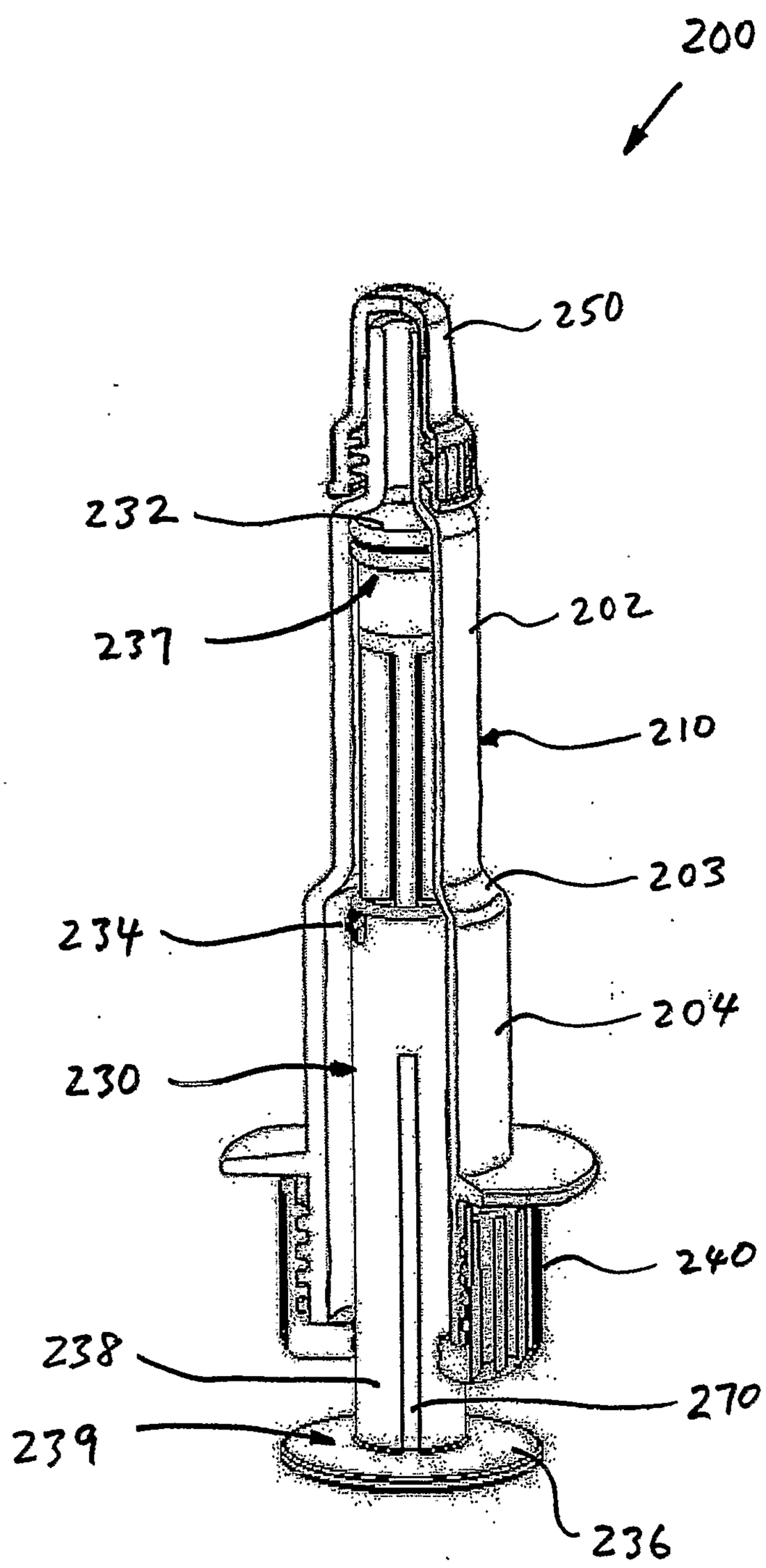



Fig. 10

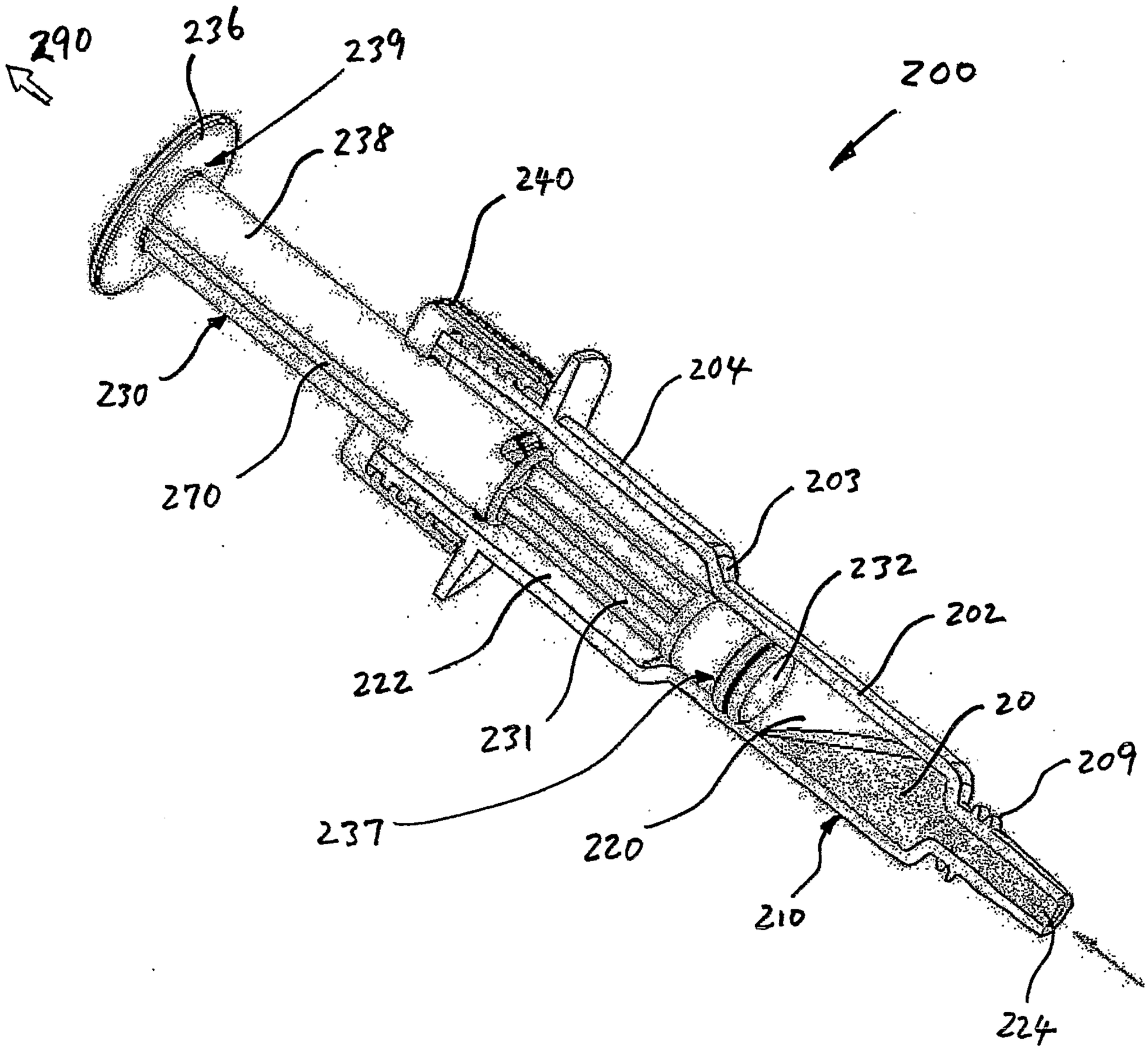

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Fig. 11

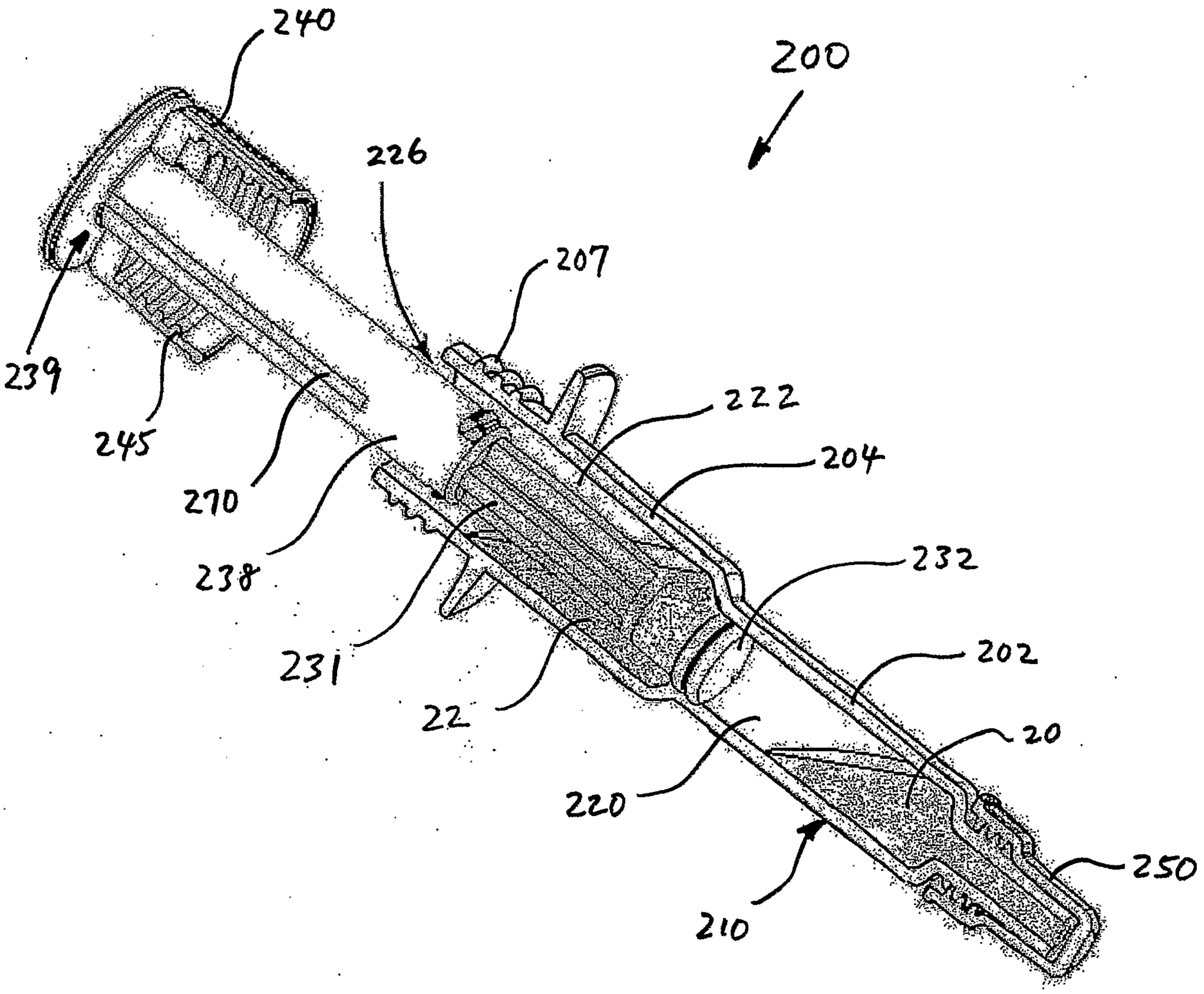

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Fig. 12

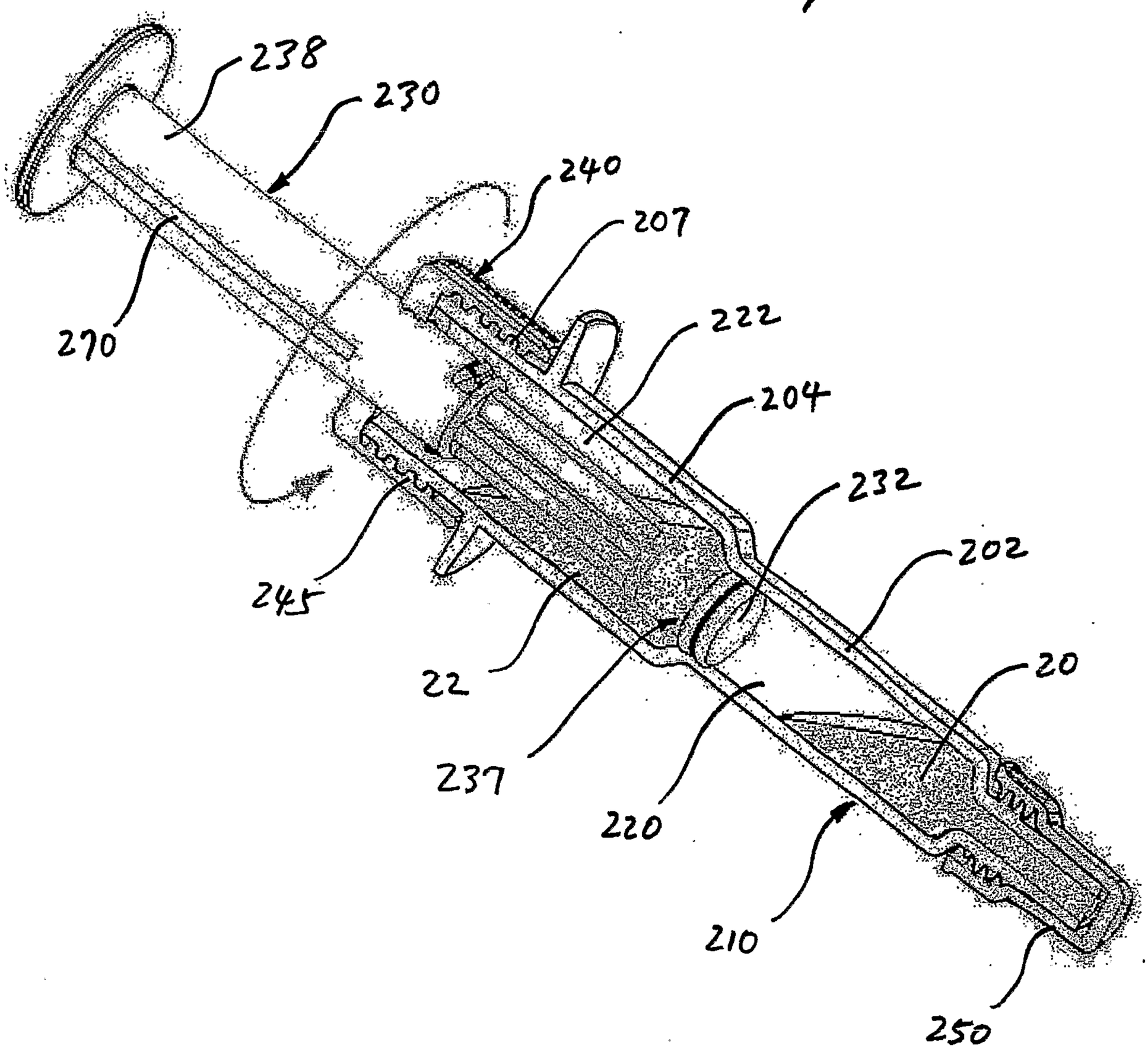



Fig. 13

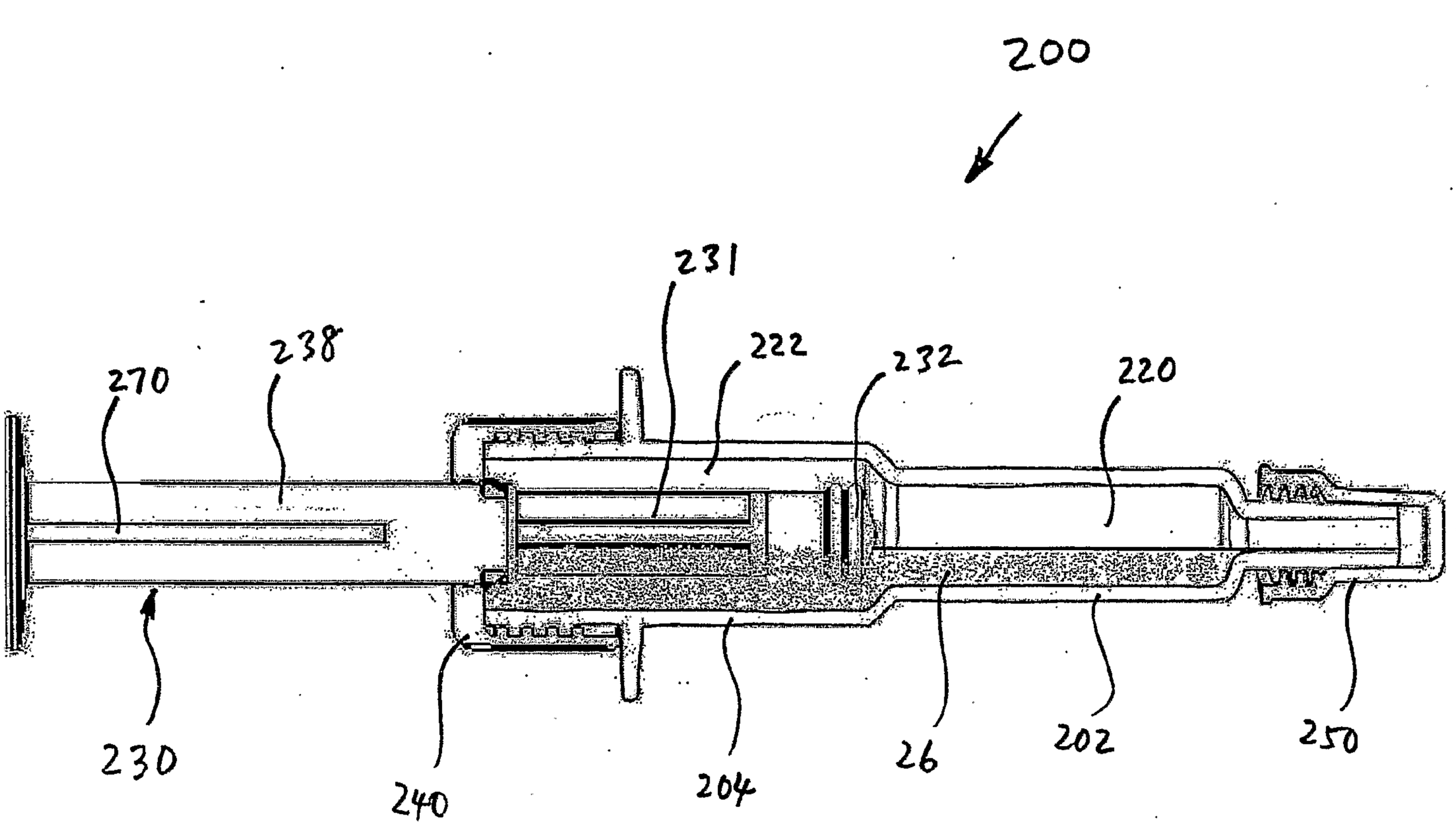



Fig. 14

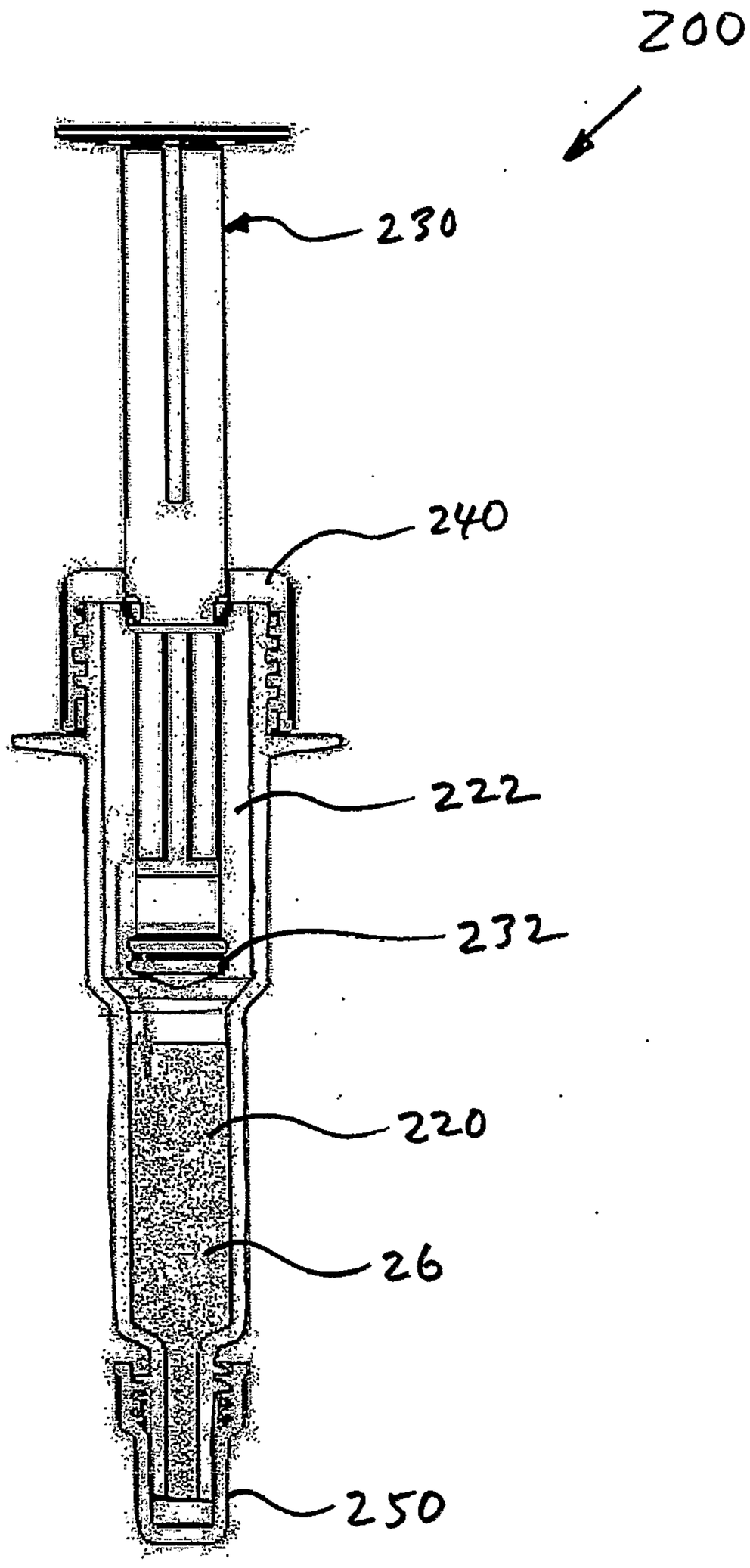



Fig. 15

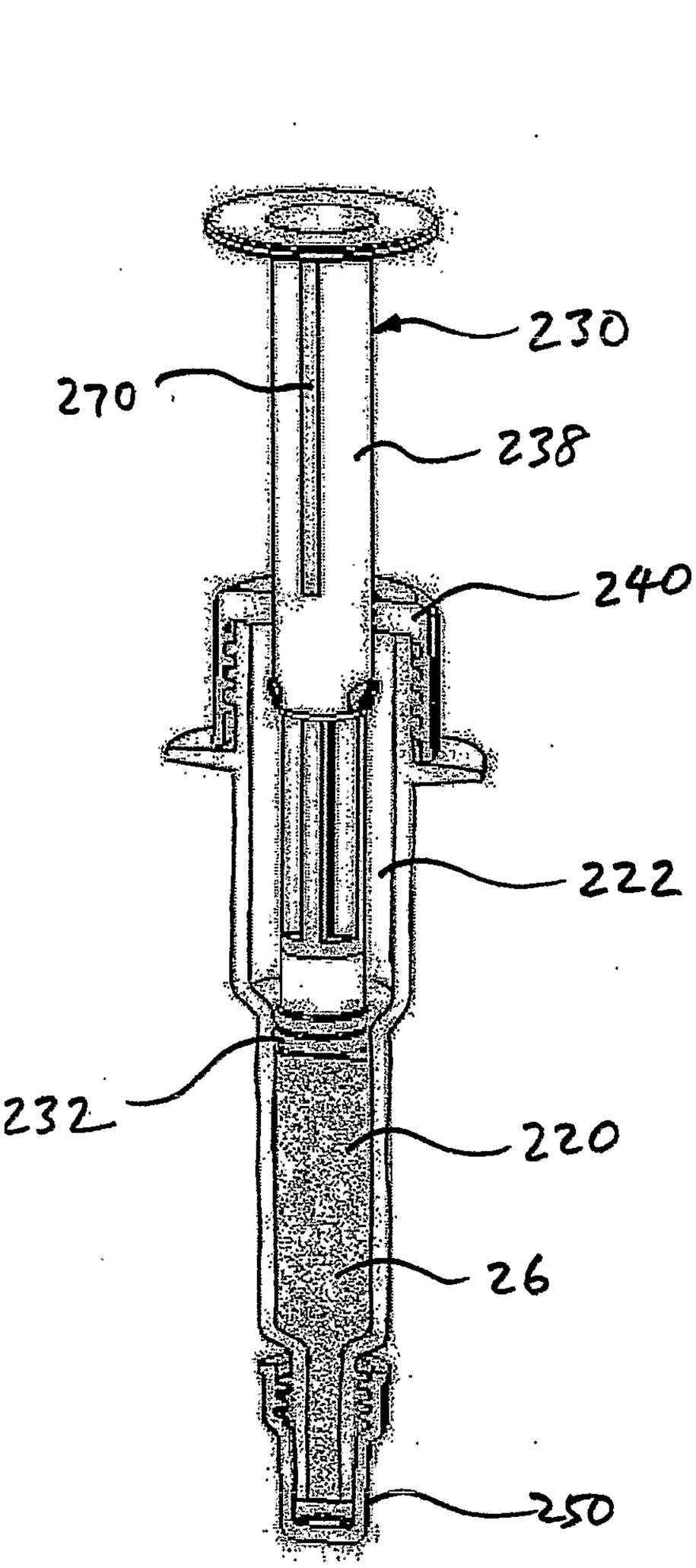



Fig. 16

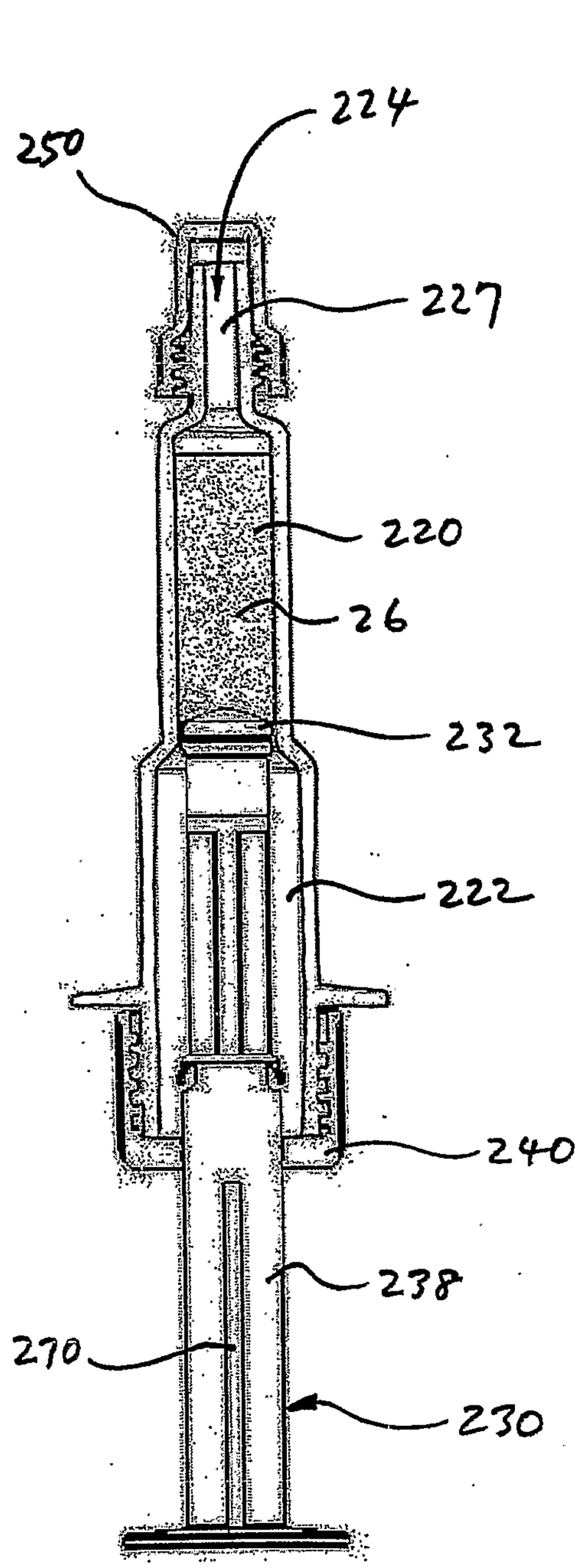



Fig. 17

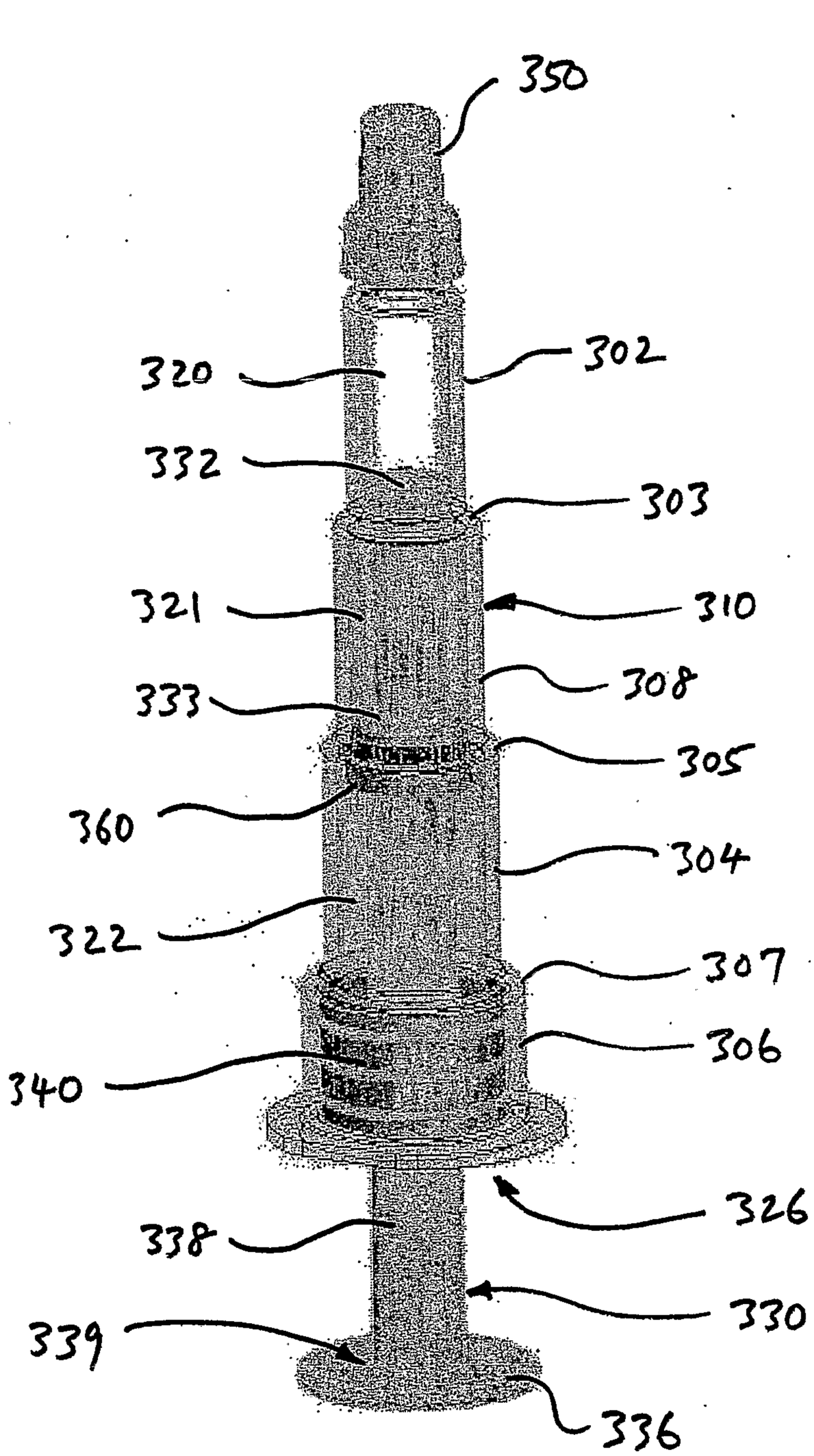

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Fig. 18

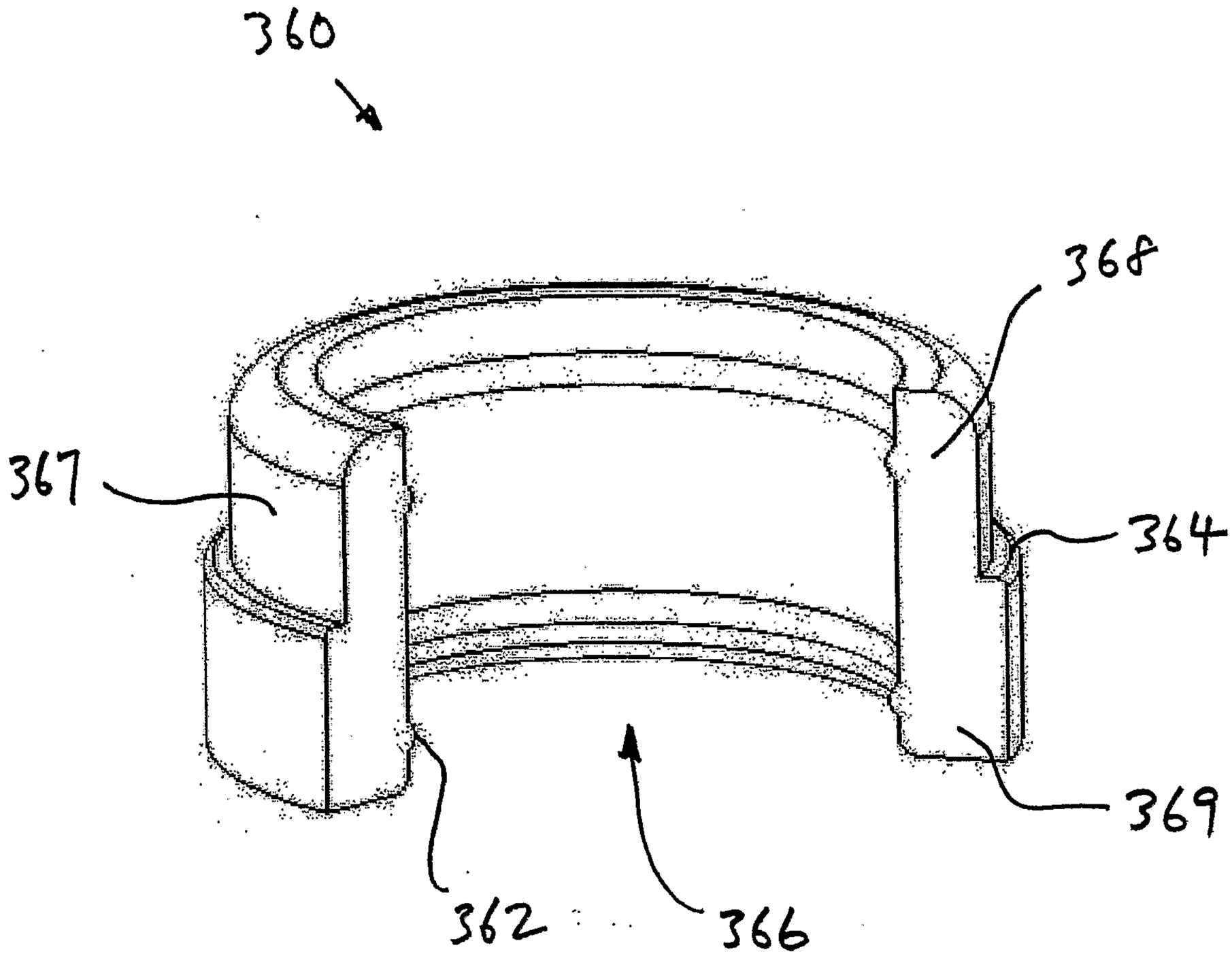



Fig. 19

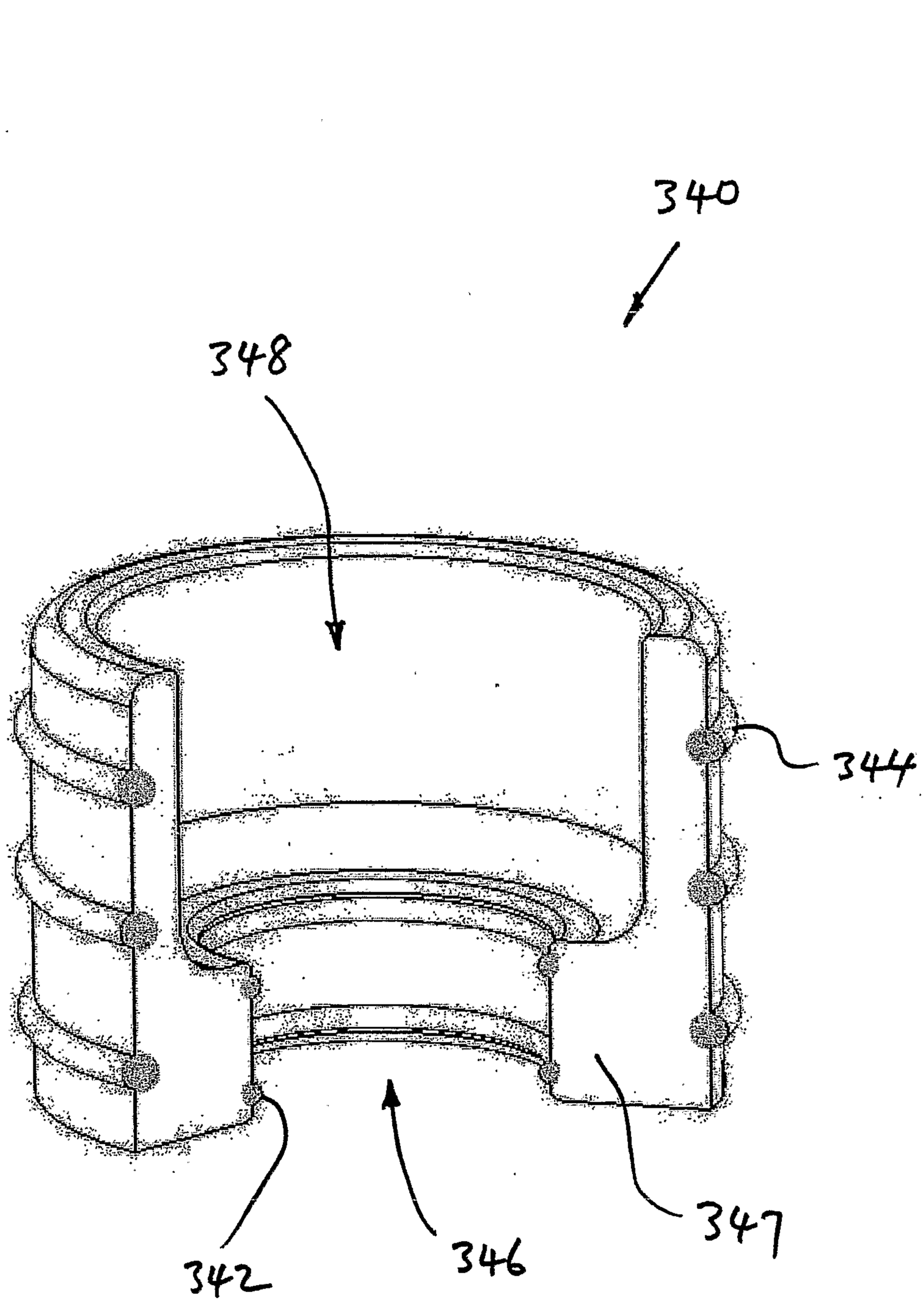



Fig. 20

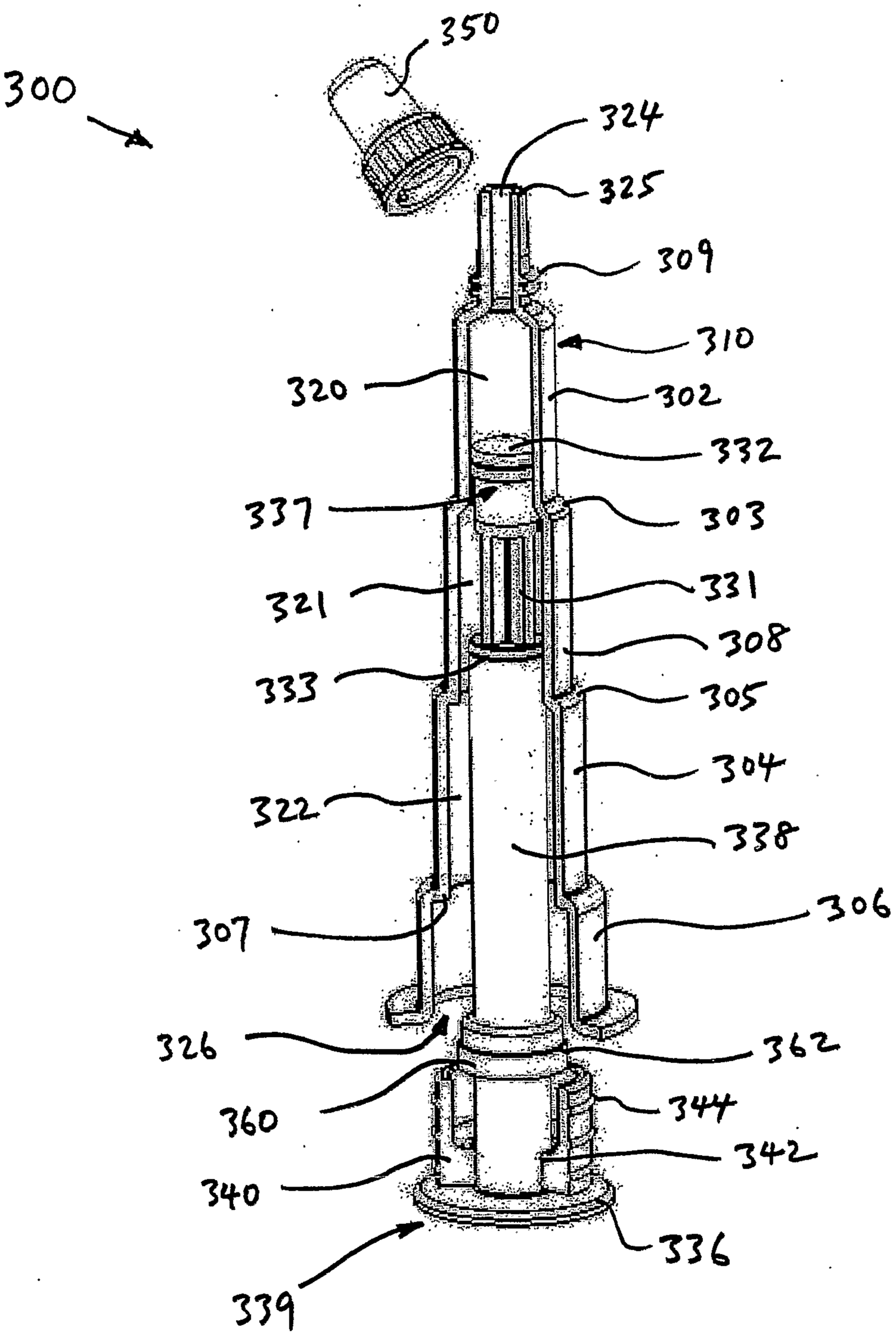

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Fig. 21

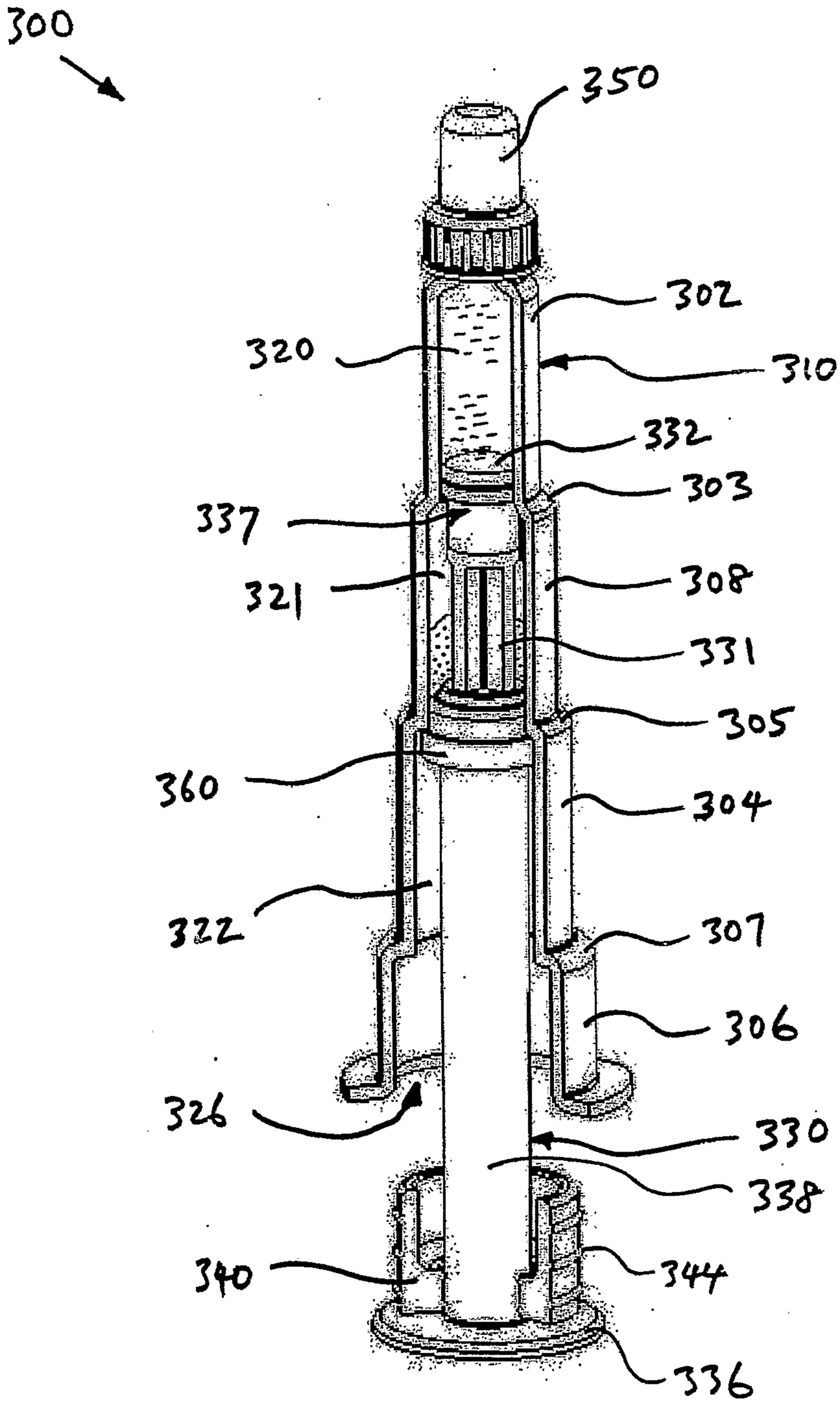

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Fig. 22

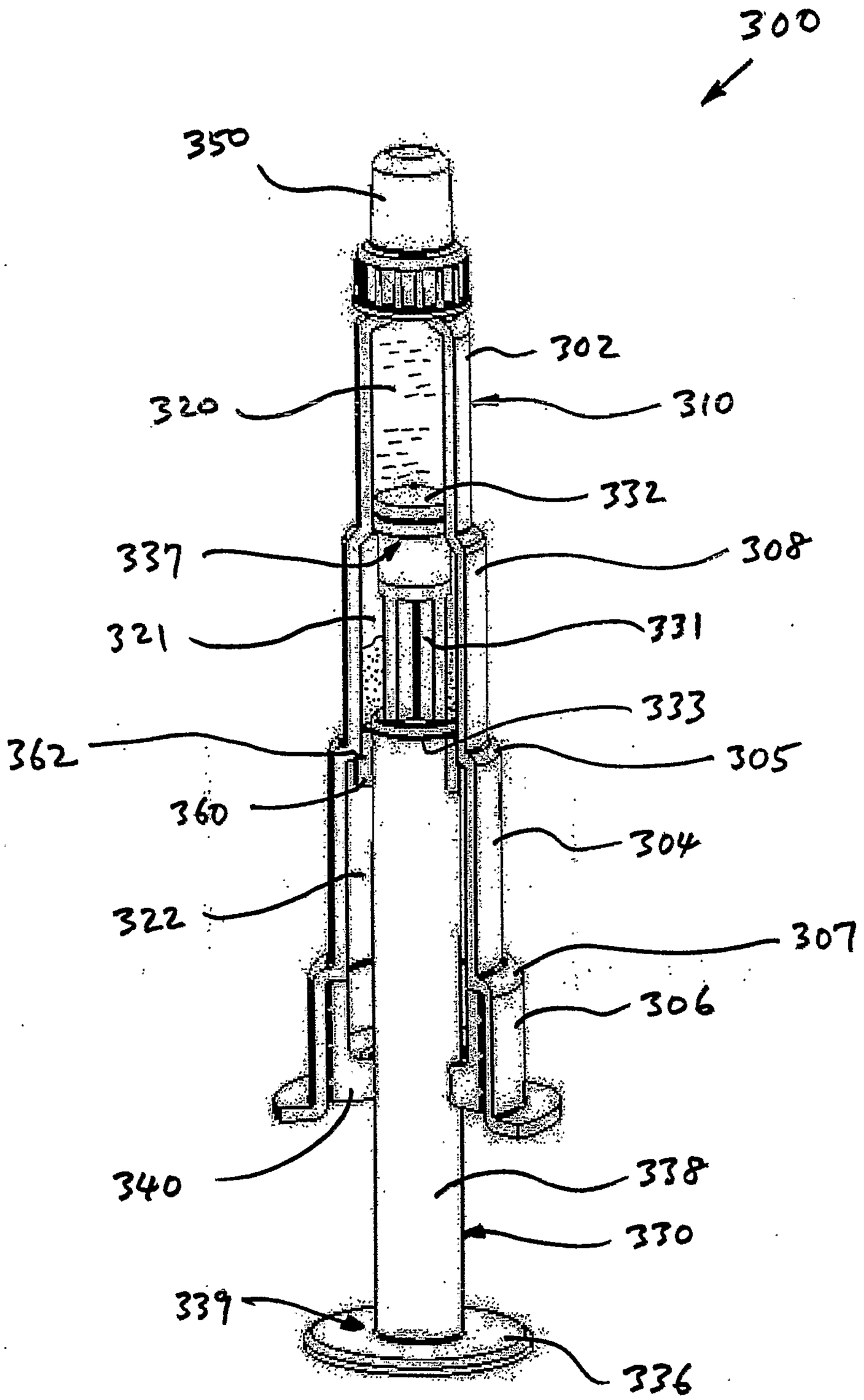

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Fig. 23

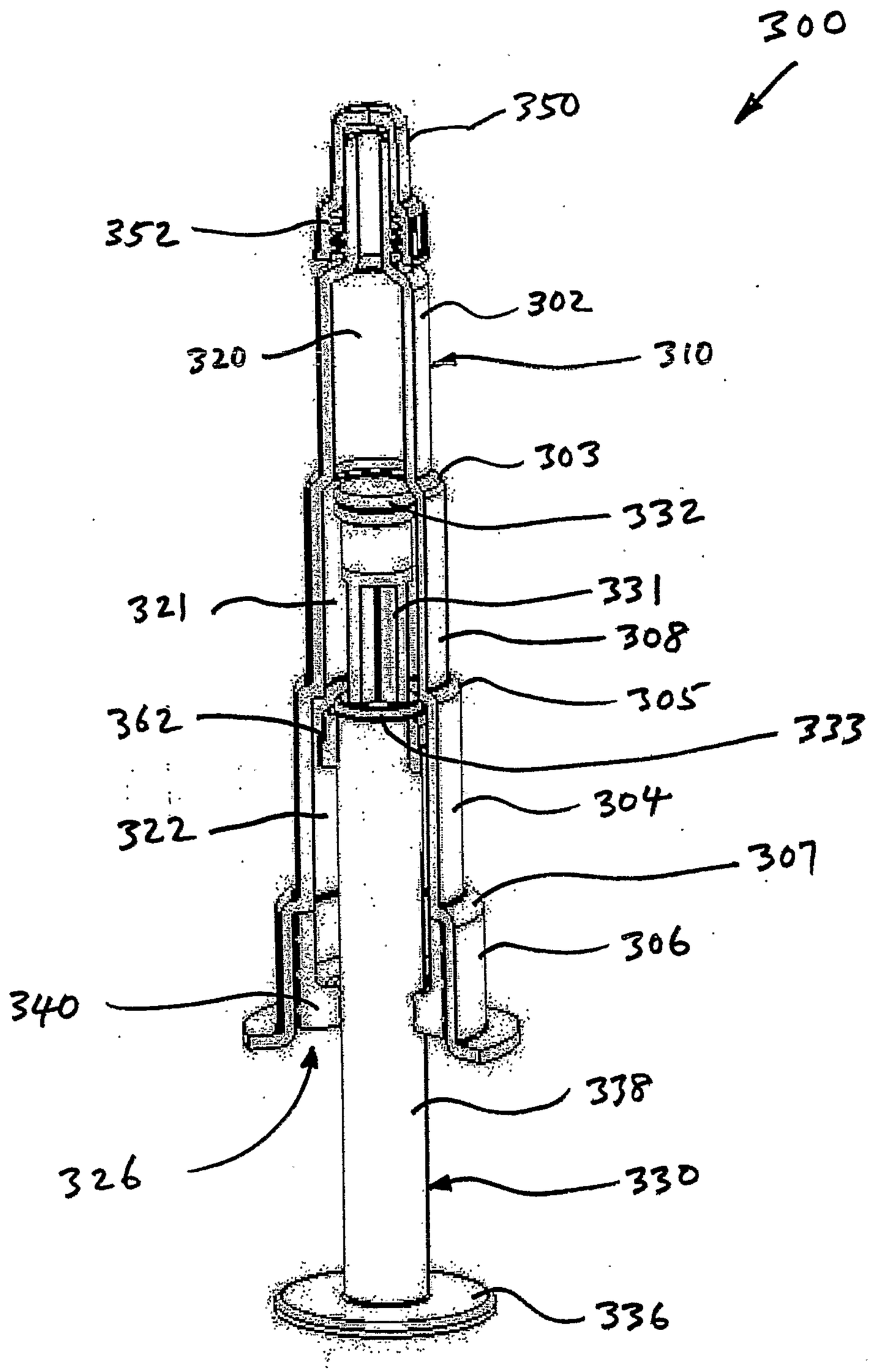

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Fig. 24

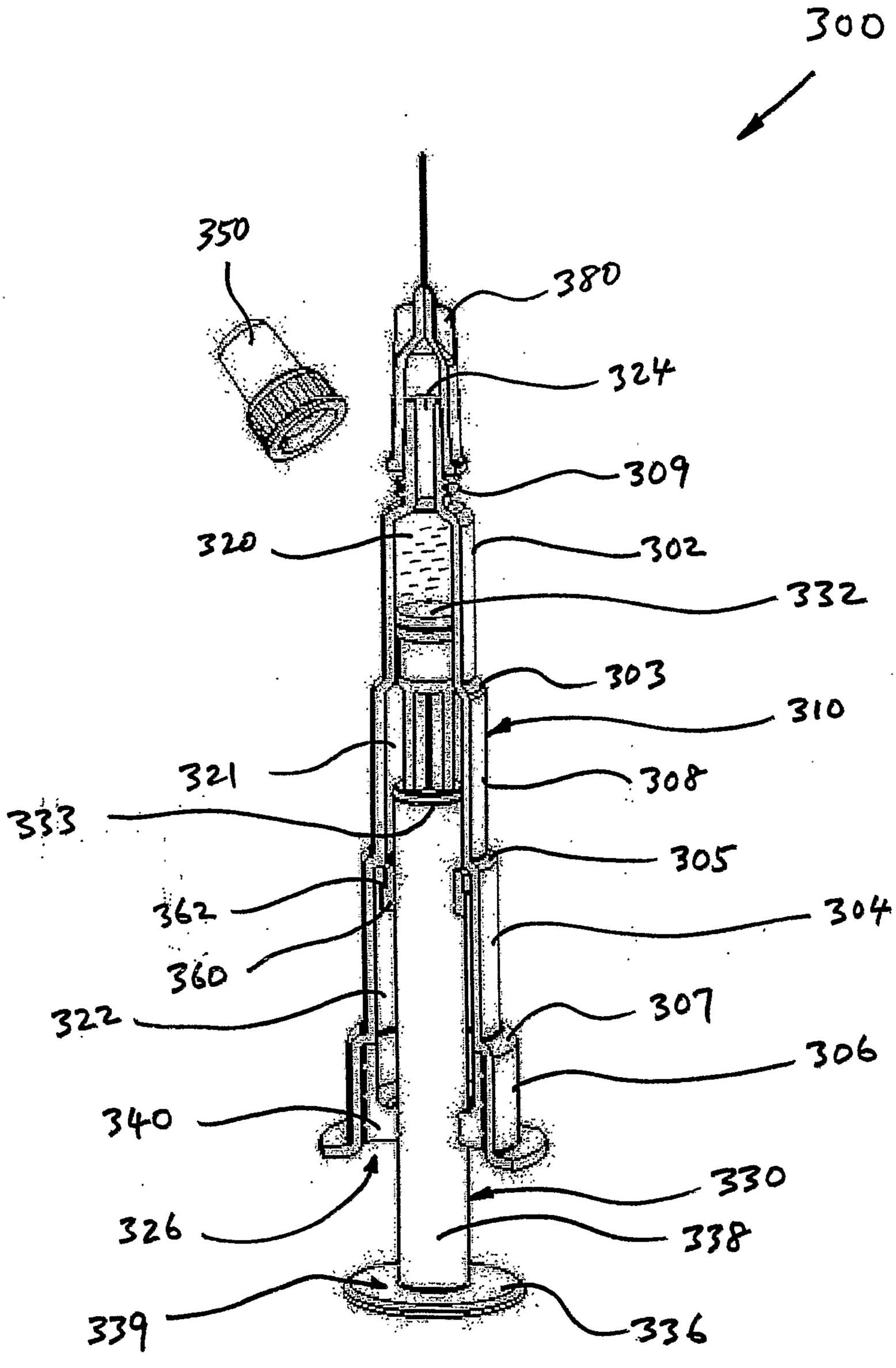

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Fig. 2.5

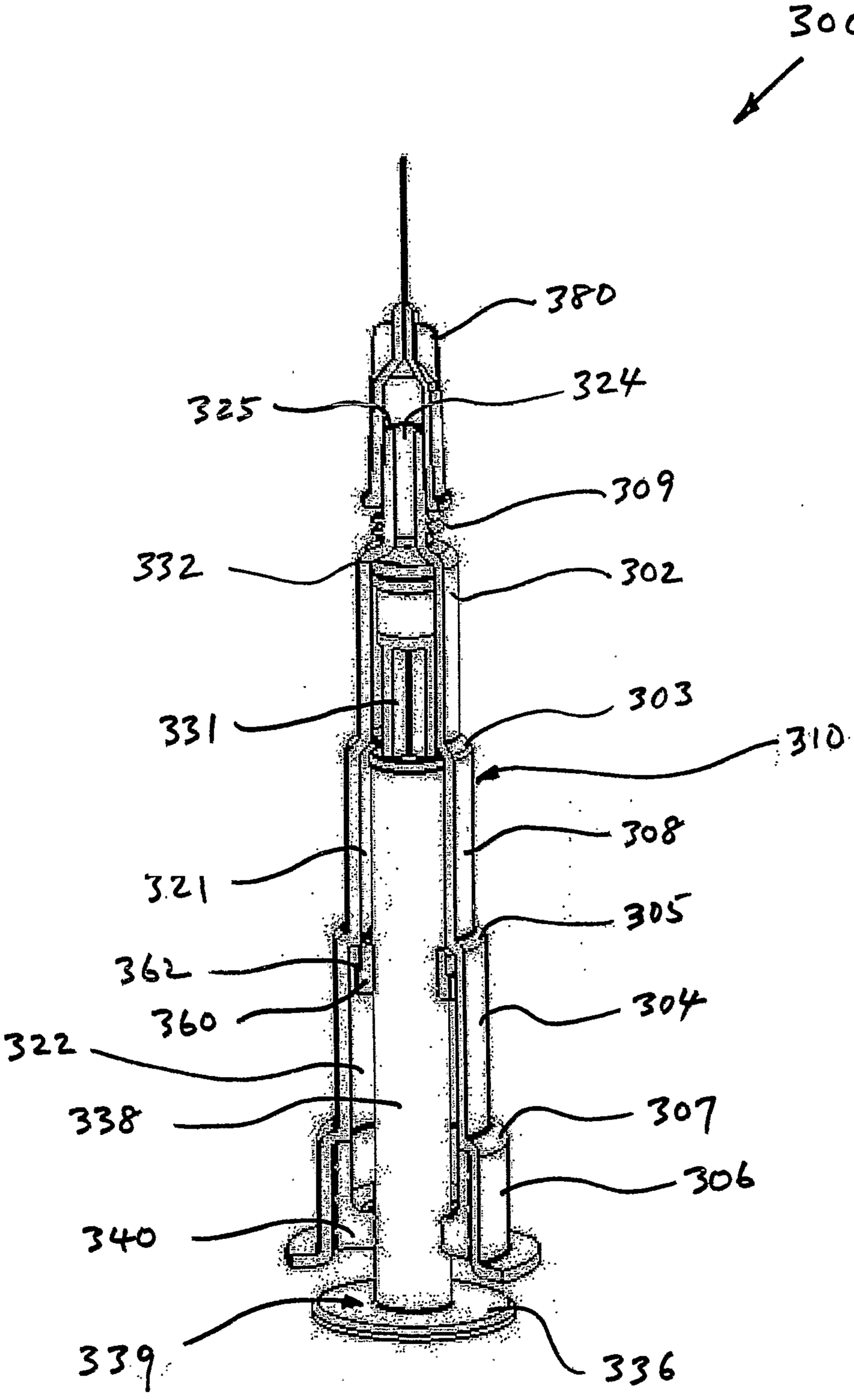
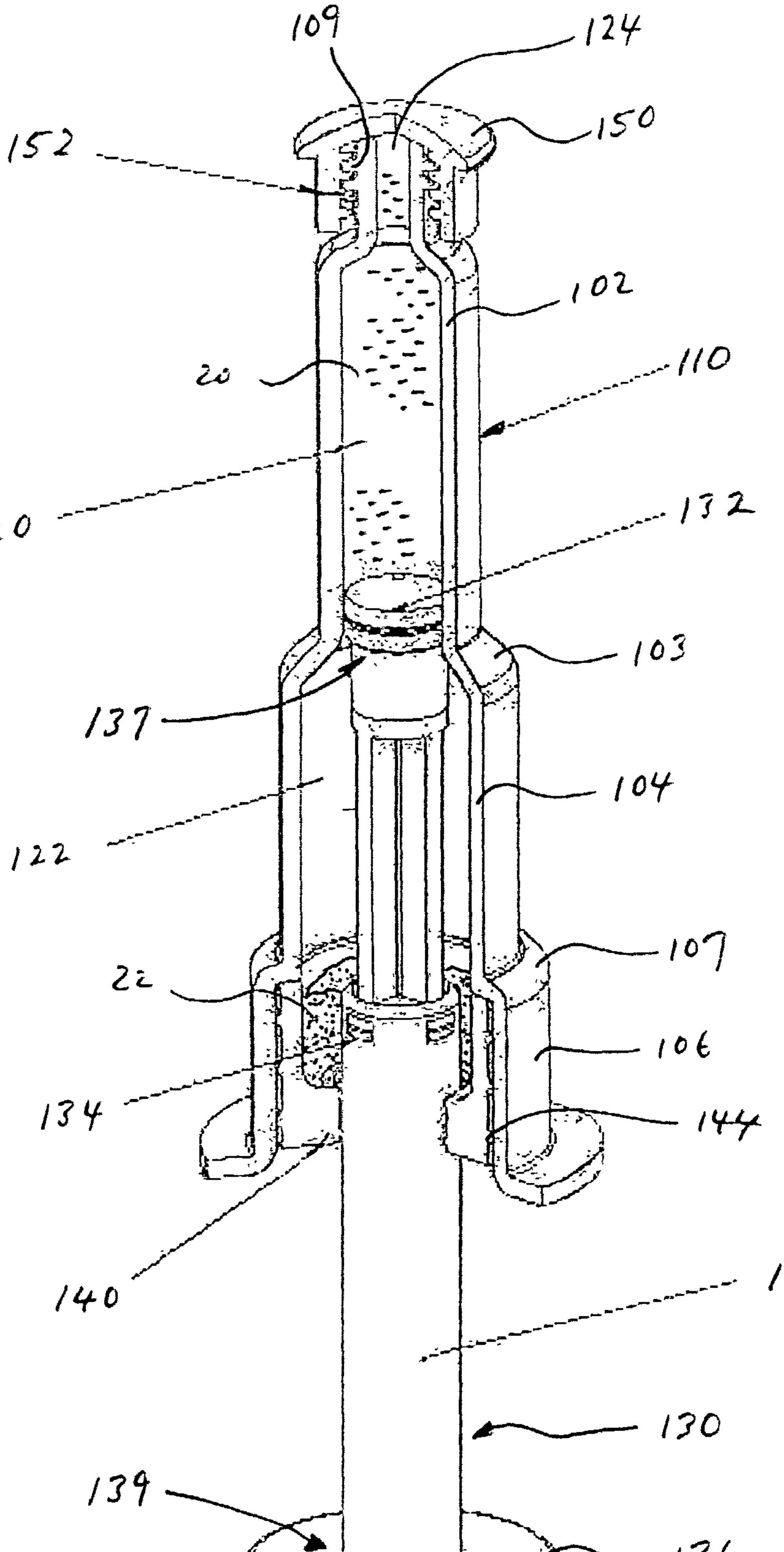

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Fig. 26


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