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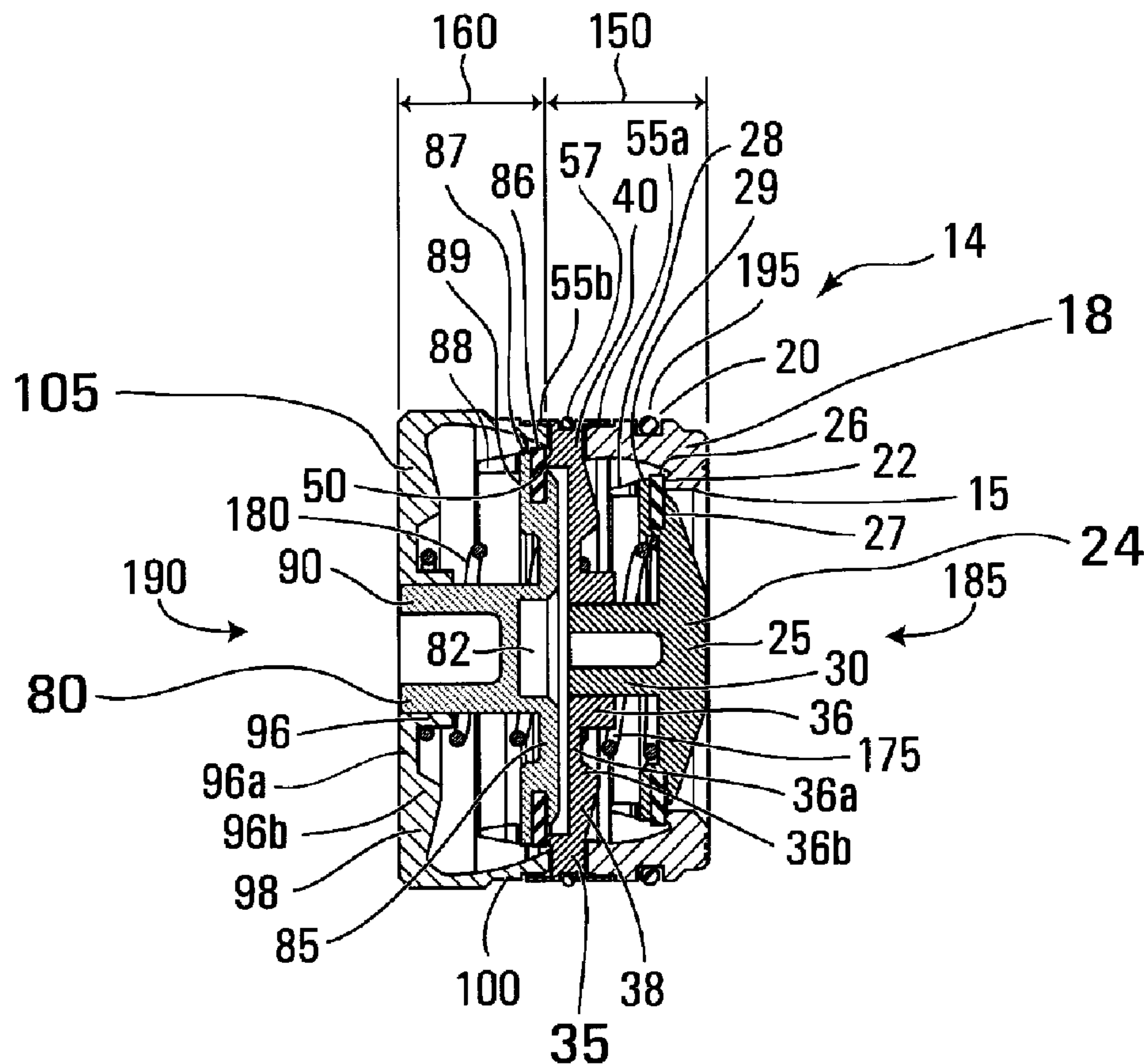
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(57) Abrégé/Abstract:

A compact dual-check poppet-style valve cartridge is provided. The valve cartridge is compact so as to be usable in a variety of applications. Compactness of the valve cartridge is achieved by having a poppet support of a first valve integral with a valve seat of

(57) **Abrégé(suite)/Abstract(continued):**

a second valve, by having the poppet stems nesting, and by having other features nest within each other. The valve cartridge is also self-contained so as to facilitate handling thereof and reduce the time required to insert or remove the valve cartridge from a valve body. A check valve is also provided wherein the valve cartridge is retained in an inlet bore using an open-latticed cage. Both the check valve and cage are adapted so as to be insertable into a valve body in one direction only so as to avoid improper installation.

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ABSTRACT

A compact dual-check poppet-style valve cartridge is provided. The valve cartridge is compact so as to be usable in a variety of applications. Compactness of the valve cartridge is achieved by having a poppet support of a first valve integral with a valve seat of a second valve, by having the poppet stems nesting, and by having other features nest within each other. The valve cartridge is also self-contained so as to facilitate handling thereof and reduce the time required to insert or remove the valve cartridge from a valve body. A check valve is also provided wherein the valve cartridge is retained in an inlet bore using an open-latticed cage. Both the check valve and cage are adapted so as to be insertable into a valve body in one direction only so as to avoid improper installation.

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CHECK VALVE**FIELD OF THE INVENTION**

The invention relates to check valves, and in particular to valves used to prevent backflow through fluid-
5 conducting passages.

BACKGROUND OF THE INVENTION

Particularly in the plumbing and waterworks industries, situations frequently arise where it is important to ensure that fluid flows through a conduit in only one
10 direction. Such a result is often achieved by introducing a check valve into the conduit. Check valves utilize any of a variety of valve mechanisms including balls, flaps, swing doors, and poppets to allow fluid to flow through the valve in one direction, but not the other.

15 Poppet-style valves are frequently used for such applications because they tend to be simple, durable, reliable and compact. Such valves comprise a valve seat defining a bore therethrough, a poppet having a poppet face parallel to the valve seat and having a front side adapted to cover the valve
20 seat bore when the valve is in its closed position as well as a poppet stem extending perpendicularly from said poppet face, and a poppet support adapted to receive the poppet stem for reciprocal movement therein between a closed position in which the poppet face is held against the valve seat and an open
25 position in which the poppet face is spaced from the valve seat permitting fluid flow around the periphery of the poppet face. Typically, the poppet is biased towards its closed position such that its face seats against the valve seat when no flow exists through the valve. When the fluid pressure against a
30 back side of the poppet face is greater than that on its front

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side, this pressure differential tends to hold the poppet tightly against the valve seat thereby increasing the sealing force. When the fluid pressure on the front side of the poppet face exceeds the fluid pressure on its back side by an amount
5 sufficient to overcome the biasing of the poppet towards the valve seat, the poppet moves away from the valve seat allowing for fluid flow through the valve.

One exemplary situation in which such unidirectional flow is desirable is in a residential or commercial water
10 supply application. In such an application, it is often desirable to allow water to flow from the municipal water supply (water main) into the building water system but not vice versa. This is because should water flow from the building to the water main (which can occur when there is a pressure drop
15 in the water main caused by, for example, a broken water main or burst fire hydrant), the municipal water supply can be contaminated with water from the building. One manner in which unidirectional flow in such an application can be achieved is through the introduction of a check valve between the municipal
20 water supply and the building water system.

Many existing check valves however are found to be inadequate for use in such applications because they are not sufficiently compact, or have too many parts resulting in difficulties during installation, inspection and servicing.

25 Further, most existing check valves are single-check valves in that they possess only a single set of valve components, such that should one or more of these components fail, there is no backup feature to prevent backflow. One solution to this problem is to use multiple sets of valve
30 components in series, see for example United States Patent No. 5,148,828. However, the use of such multiple sets of valve

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components increases the number of parts to be handled and also increases the required length of the check valve.

Additionally, as municipal standards for backflow prevention become more stringent, there arises a need to retrofit existing plumbing in order to introduce a check valve between the municipal water supply and the building water system. The most convenient location in which to introduce such a check valve is to replace a conventional elbow joint with one containing check valve components. In many applications, the elbow joint replaced is one which directs water from a horizontal pipe connected to the municipal water supply, down through a vertical pipe connected to the building water system. However, existing elbow check valve devices are often too bulky to fit within the existing piping to be retrofitted. Most often, valve components are contained within the bottom of the vertical bore of the elbow check valve, thereby necessitating a longer vertical bore. The existing piping may not accommodate such a lengthy vertical bore, necessitating additional retrofitting steps. Of course compactness of a check valve is a desirable trait regardless of whether it is used in such a specific retrofitting example, other retrofitting situations, or indeed non-retrofitting applications.

Finally, when used within a valve body (a hollow body intended to house the valve components) valve components can be held in place by a variety of means. For example, the valve components may have an external feature that locks into place on an inner surface of the valve body. However, these methods of retaining the valve components in place in a valve body are not satisfactory as they require special features to be machined into the interior of the valve body, and also do not allow for the easy removal and insertion of the valve

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components. One solution to this problem is demonstrated by United States Patent No. 5,148,828, wherein a cage is used for retaining check valve components in place in the valve body. However, the cage disclosed in this patent is only adapted to
5 maintain valve components in the bottom of the vertical bore of the elbow valve. Additionally, there is no easy means of ensuring that the cage is oriented in a direction which maximizes flow through the valve.

SUMMARY OF THE INVENTION

10 This invention provides an improved valve cartridge and check valve, which seeks to address one or more of the problems noted above.

 In accordance with a broad aspect, the present invention provides a valve cartridge for use in a valve body
15 having a redundant dual-check feature, the valve cartridge being a single unit containing all components necessary for the valve cartridge to function as a valve when placed in the valve body, and wherein all of these components are either integral with, attached to, contained within one another, or are
20 otherwise connected such that the cartridge remains unitary during handling prior to insertion into the valve body.

 In other aspects, the valve cartridge has two independently-operating valves offering redundant protection, each of the two valves being poppet-style with a valve seat, poppet (having a poppet face and a poppet stem) and poppet
25 support. Compactness of the valve cartridge is enhanced by integrating the poppet support of the first valve and the valve seat of the second valve, and by allowing the two poppets to nest within one another when one of the valves is open and the
30 other is closed. Further, the major components of the valve cartridge (the first valve seat, the first poppet support /

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second valve seat, and the second poppet support) are locked together, resisting both separation as well as relative rotation therebetween.

In accordance with another broad aspect, the invention provides a check valve comprising a valve body having an inlet passage adapted to be fluidly coupled to a fluid source, an outlet passage adapted to be fluidly coupled to a fluid outlet, and a main body chamber positioned therebetween and in fluid connection with both the inlet passage and the outlet passage, a valve cartridge seated substantially within the inlet passage, the valve cartridge having an upstream end and a downstream end and being adapted to permit fluid flow from the fluid source to the main body chamber but to resist fluid flow from the main body chamber to the fluid source, and valve cartridge retaining means for retaining the valve cartridge within the inlet passage, wherein the valve cartridge retaining means comprises a retaining cage in the main body chamber.

In other aspects, the retaining cage has an open-lattice structure to provide structural support to a cartridge-retaining face which abuts a downstream end of the valve cartridge and to allow flow of fluid therethrough, and both the valve cartridge and the retaining cage have features which allow them only to be inserted into the valve body in their correct orientations.

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In accordance with another broad aspect, the invention provides a self-contained dual-check valve cartridge for use in a valve body.

Other features of the invention will be understood from the detailed description of preferred embodiments of the invention below and from the
5 drawings attached hereto.

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BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described with reference to the attached drawings in which:

Figures 1A and 1B are, respectively, perspective and perspective exploded views of a valve cartridge in accordance with a preferred embodiment of the present invention;

Figures 2A and 2B are, respectively, perspective and cross-sectional side views of a first valve seat of the valve cartridge of Figure 1A;

Figures 3A and 3B are, respectively, cross-sectional side and downstream views of a first poppet of the valve cartridge of Figure 1A;

Figures 4A and 4B are, respectively, perspective and cross-sectional side views of a first poppet support of the valve cartridge of Figure 1A;

Figures 5A and 5B are, respectively, a cross-sectional side and downstream views of a second poppet of the valve cartridge of Figure 1A;

Figures 6A and 6B are, respectively, perspective and cross-sectional side views of a second poppet support of the valve cartridge of Figure 1A;

Figures 7A and 7B are cross-sectional side views of the valve cartridge of Figure 1A in its closed and open positions, respectively;

Figure 8 is a perspective exploded view of the valve cartridge of Figure 1A in the context of a check valve in accordance with a second aspect of the present invention;

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Figure 9 is a cross-sectional side view of a valve body of the check valve of Figure 8;

Figure 10 is a perspective view of a retaining cage of the check valve of Figure 8; and

5 Figure 11 is a cross-sectional side view of the check valve of Figure 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of a valve cartridge of the present invention will now be described in a very specific
10 exemplary context, namely its use in an elbow-style check valve to permit flow from a horizontal pipe connected to a municipal water supply to a vertical pipe connected to a building water system, but not vice versa.

In this description and in the claims, the term
15 "valve cartridge" is used to describe a collection of valve components which together function as a valve when placed within a valve body. The term "self-contained" when used to describe a valve cartridge refers to the valve cartridge being a single unit containing all components necessary for the valve
20 cartridge to function as a valve when placed in a valve body, and wherein all of these components are either integral with, attached to, contained within one another, or are otherwise connected such that the cartridge remains unitary during handling prior to insertion into the valve body.

25 The terms "axial" and "axially" are used to describe a direction parallel to a centerline of the valve cartridge, and the terms "radial" and "radially" are used to describe a direction perpendicular to and extending from the centerline of the valve cartridge. Further, "upstream" is used to describe
30 features which are located nearer an end of the valve cartridge

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from which fluid is intended to flow through the valve cartridge whereas "downstream" is used to describe features located nearer an end of the valve cartridge to which fluid is intended to flow through the valve cartridge. "Locked" refers to two or more components which are attached and resist separation. Finally, "integral" refers to a single continuous piece of material.

As shown in Figures 1A and 1B, the preferred embodiment self-contained dual-check valve cartridge 14 has an upstream end 185 and a downstream end 190, and broadly comprises a first valve 150 upstream of a second valve 160. The first and second valves 150, 160 provide the valve cartridge 14 with a dual-check feature by functioning independently of one another and thereby providing redundant protection against backflow through the valve cartridge 14.

The major components of the first valve 150 are a first valve seat 18, a first poppet 24, a first poppet support 35 and a first spring 175 interposed between the first poppet 24 and the first poppet support 35. The second valve 160 largely consists of a second valve seat 50 formed on a downstream surface of the first poppet support 35, a second poppet 80, a second poppet support 105 and a second spring 180 interposed between the second poppet 80 and the second poppet support 105. Each of these broad elements of the first and second valves 150, 160 will now be discussed in turn.

The first valve seat 18 of the preferred embodiment, illustrated in detail in Figures 2A and 2B, is an annular ring defining a bore 19 therethrough, and having a valve seat portion 18a and a connection sleeve portion 18b.

The valve seat portion 18a has an annular radially-inward projection 15 which slants downstream. A downstream

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surface of this projection 15 defines a first valve seat surface 22 against which a poppet seal 26 of the first poppet 24 presses when the first valve 150 is in its closed position.

An internal diameter of the connection sleeve portion 18b of the first valve seat 18 is greater than that of the first valve seat surface 22, such that when the first poppet 24 is in its open position, a flow passage is created between a periphery of the first poppet 24 and an interior surface of the connection sleeve portion 18b of the first valve seat 18.

The connection sleeve portion 18b of the first valve seat 18 has two annular grooves defined on its outer surface. The first is a first valve seat O-ring groove 20 adapted to accept a first valve seat O-ring 195 which forms a seal between the first valve seat 18 and a valve body wall when the valve cartridge 14 is inserted within a valve body 16 as discussed further below. Downstream of the first valve seat O-ring groove 20 is a first valve seat connecting groove 23 adapted to accept in locking relationship, an inwardly-projecting connection ridge 42 of an upstream connection flange 55a of the first poppet support 35. Spaced circumferentially within the first valve seat connecting groove 23 are four first valve seat alignment tabs 21. As discussed further below, the first valve seat connecting groove 23 and first valve seat alignment tabs 21 function to connect the first valve seat 18 to the first poppet support 35, to align it therewith, and to resist separation and relative rotation therebetween once locked together.

The first poppet 24, as shown in detail in Figures 3A and 3B, comprises a poppet face 25 with a poppet stem 30 extending downstream from the center thereof, an annular spring-retention flange 34 extending downstream near a

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periphery of the poppet face 25, an annular seal-retention web 29 extending radially outwardly from a downstream end of the spring-retention flange 34, and an annular flow-direction flange 28 extending downstream from a periphery of the spring-
5 retention web 29.

The poppet face 25 of the first poppet 24 has a slightly conical upstream surface to direct fluid towards the periphery of the poppet face 25. An outer diameter of the poppet face 25 is sized so as to fit within the first valve
10 seat surface 22.

The poppet stem 30 of the first poppet 24 extends downstream from the centre of the poppet face 25 and has four longitudinal large splines 31 spaced circumferentially on its outside surface. Spaced between the large splines 31 are four
15 small splines 32 each of which extend radially from the poppet stem 30 to a lesser extent than the large splines 31. As discussed in greater detail below, the large splines 31 serve to prevent relative rotation between the first poppet 24 and the first poppet support 35 while the small splines 32 reduce
20 the contact surface area between the poppet stem 30 of the first poppet 24 and the first poppet support 35 thereby reducing friction therebetween.

Extending downstream near the periphery of the poppet face 25 of the first poppet 24, coaxial with and surrounding a
25 portion of the poppet stem 30, is the spring-retention flange 34. The spring-retention flange 34 is spaced from the poppet stem 30 so as to accommodate the first spring 175 therebetween.

The seal-retention web 29 of the first poppet 24 is spaced downstream from the poppet face 25 so as to accommodate
30 the annular poppet seal 26 in a seal recess 27 therebetween. The outer diameter of the poppet face 25 is less than an outer

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diameter of the seal-retention web 29 so as to allow, during assembly of the valve cartridge 14, the poppet seal 26 to be slipped over the poppet face 25 and into the seal recess 27. Additionally, the outer diameter of the poppet face 25 being
5 smaller than the diameter of the first valve seat surface 22, and the outer diameter of the seal-retention web 29 being greater than the diameter of the first valve seat surface 22 allows the poppet seal 26 to contact the first valve seat surface 22, and also allows the seal-retention web 29 to
10 support the poppet seal 26 against the first valve seat surface 22.

The flow-direction flange 28 of the first poppet 24 has compression notches 33 spaced circumferentially therearound which accommodate support spokes 38 of the first poppet support
15 35, when the first valve 150 is in its open position, thereby reducing the necessary overall length of the valve cartridge 14.

The first poppet support 35, as seen in detail in Figures 4A and 4B, broadly consists of a guide sleeve 36,
20 support spokes 38, a support rim 40, an upstream connection flange 55a and a downstream connection flange 55b.

The guide sleeve 36 of the first poppet support 35 defines a longitudinal bore 39 therethrough which receives the poppet stem 30 of the first poppet 24 during assembly of the
25 valve cartridge 14. The guide sleeve 36 guides reciprocal axial movement of the first poppet 24 relative to the first poppet support 35. The guide sleeve bore 39 is sized so as to accommodate the poppet stem 30 of the first poppet 24 and the small splines 32 thereon. The longitudinal bore 39 of the
30 guide sleeve 36 also has defined therein four longitudinal alignment slots 41, circumferentially spaced so as to

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accommodate the four large splines 31 of the poppet stem 30 of the first poppet 24. When the poppet stem 30 is inserted into the bore 39 of the guide sleeve 36, the large splines 31 cooperate with the alignment slots 41 to prevent relative rotation between the first poppet 24 and the first poppet support 35. Further, the small splines 32 provide a reduced contact area between the poppet stem 30 and the poppet guide sleeve 36, reducing friction during axial movement of the first poppet 24.

Extending radially outwardly from a downstream end of the guide sleeve 36 of the first poppet support 35 is an annular spring support web 36a and extending upstream from a periphery of the spring support web 36a is a spring retention flange 36b. When the valve cartridge 14 is assembled, the first spring 175 is compressed between the downstream surface of the poppet face 25 of the first poppet 24 and the spring support web 36a of the first poppet support 35. The first spring 175 is held in place by the poppet stem 30 and the spring retention flange 34 of the first poppet 24 at one end, and the guide sleeve 36 and spring retention flange 36b of the first poppet support 35 at the other.

Support spokes 38 extend radially outwardly from the spring retention flange 36b of the first poppet support 35 and connect the guide sleeve 36 with the support rim 40. The support spokes 38 ensure that the guide sleeve 36 is positioned and maintained centrally within the support rim 40, and that the longitudinal bore 39 through the guide sleeve 36 is coaxial with the remainder of the valve cartridge 14. The support spokes 38 are spaced circumferentially so as to engage the compression notches 33 of the flow-direction flange 28 of the first poppet 24 to maximize the amount of compression of the first spring 175 when the first valve 150 is in its open

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position. Spaces between the support spokes 38 define flow passages 37 through the first poppet support 35.

Extending downstream from a radially inward downstream portion of the support rim 40 of the first poppet support 35 is an annular protrusion which forms the second valve seat 50 against which the poppet seal 86 of the second poppet 80 presses when the second valve 160 is in its closed position.

The upstream connection flange 55a extends upstream from, and the downstream connection flange 55b extends downstream from, a peripheral surface of the support rim 40.

The upstream connection flange 55a has an inwardly-projecting connection ridge 42 at an upstream end thereof for engaging the connecting groove 23 of the first valve seat 18 when the valve cartridge 14 is assembled. The connection ridge 42 of the upstream connection flange 55a also has defined therein, upstream connecting groove notches 44 sized and spaced circumferentially to accommodate the first valve seat alignment tabs 21 of the first valve seat connecting groove 23.

Similarly, the downstream connection flange 55b has an inwardly-projecting connection ridge 43 at a downstream end thereof for engaging a connecting groove 107 of the second poppet support 105 when the valve cartridge 14 is assembled. The connection ridge 43 of the downstream connection flange 55b also has defined therein, downstream connecting groove notches 45, sized and spaced circumferentially to accommodate second poppet support alignment tabs 108 of the second poppet support connecting groove 107, as further discussed below.

Between the upstream and downstream connection flanges 55a, 55b of the first poppet support 35 is defined an

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annular O-ring groove 56 adapted to accommodate an O-ring 57. The O-ring 57 forms a seal between the first poppet support 35 and the valve body wall when the valve cartridge 14 is inserted within the valve body 16 as discussed further below.

5 Turning now to the second valve 160, as discussed above the second valve seat 50 is formed on a downstream surface of the first poppet support 35.

 The second poppet 80, as shown in detail in Figures 5A and 5B, comprises a poppet face 85 with a poppet stem 90
10 extending downstream from the center thereof, an annular spring-retention flange 81 extending downstream near a periphery of the poppet face 85, an annular seal-retention web 89 extending radially outwardly from a downstream end of the spring-retention flange 81, and an annular flow-direction
15 flange 88 extending downstream from a periphery of the spring-retention web 89.

 An upstream surface of the poppet face 85 of the second poppet 80 has an indent 82 defined therein to accommodate the poppet stem 30 of the first poppet 24 when the
20 first valve 150 is open and the second valve 160 is closed. This feature assists in allowing the valve cartridge 14 to be compact in length. An outer diameter of the poppet face 85 is sized so as to fit within the second valve seat 50.

 The poppet stem 90 of the second poppet 80 extends
25 downstream from the centre of the poppet face 85 and has four longitudinal large splines 92 spaced circumferentially on its outside surface. Spaced between the large splines 92 are four small splines 91 each of which extend radially from the poppet stem 85 to a lesser extent than the large splines 92. As
30 discussed in detail below, the large splines 92 serve to prevent relative rotation between the second poppet 80 and the

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second poppet support 105 while the small splines 91 reduce the contact surface area between the second poppet poppet stem 90 and the second poppet support 105 thereby reducing friction therebetween.

5 Extending downstream near the periphery of the poppet face 85 of the second poppet 80, coaxial with and surrounding a portion of the poppet stem 90, is the spring-retention flange 81. The spring-retention flange 81 is spaced from the poppet stem 90 so as to accommodate the second spring 180
10 therebetween.

 The seal-retention web 89 of the second poppet 80 is spaced downstream from the poppet face 85 so as to accommodate the annular second poppet poppet seal 86 in a seal recess 87 therebetween. The outer diameter of the poppet face 85 is
15 smaller than the outer diameter of the seal-retention web 89 so as to allow, during assembly of the valve cartridge 14, the poppet seal 86 to be slipped over the poppet face 85 and into the seal recess 87. Additionally, the outer diameter of the poppet face 85 being smaller than the diameter of the second
20 valve seat 50, and the outer diameter of the seal retention web 89 being greater than the diameter of the second valve seat 50 allows the poppet seal 86 to contact the second valve seat 50, and also allows the seal-retention web 89 to support the poppet seal 86 against the second valve seat 50.

25 The flow-direction flange 88 of the second poppet 80 has compression notches 93 spaced circumferentially therearound which accommodate support spokes 98 of the second poppet support 35, when the second valve 160 is in its open position, thereby reducing the necessary overall length of the valve
30 cartridge 14.

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The second poppet support 105, as seen in detail in Figures 6A and 6B, broadly consists of a guide sleeve 96, support spokes 98, and a support rim 100.

The guide sleeve 96 defines a longitudinal bore 95 therethrough which receives the poppet stem 90 of the second poppet 80 during assembly of the valve cartridge 14. The guide sleeve 96 guides reciprocal axial movement of the second poppet 80 relative to the second poppet support 105. The guide sleeve bore 95 is sized so as to accommodate the poppet stem 90 of the second poppet 80 and the small splines 91 thereon. The longitudinal bore 95 of the guide sleeve 96 also has defined therein four longitudinal alignment slots 99, circumferentially spaced so as to accommodate the four large splines 92 of the second poppet poppet stem 90. When the poppet stem 90 is inserted into the bore 95 of the guide sleeve 96, the large splines 92 co-operate with the alignment slots 99 to prevent relative rotation between the second poppet 80 and the second poppet support 105. Further, the small splines 91 of the poppet stem 90 provide a reduced contact area between the poppet stem 90 and the guide sleeve 96 of the second poppet support 105, reducing friction during axial movement of the second poppet 80.

Extending radially outwardly from a downstream end of the guide sleeve 96 of the second poppet support 105 is a spring support web 96a, and extending upstream from a periphery of the spring support web 96a is a spring retention flange 96b. When the valve cartridge 14 is assembled, the second spring 180 is compressed between the downstream surface of the poppet face 85 of the second poppet 80 and the spring support web 96a of the second poppet support 105. The second spring 180 is held in place by the stem 90 and the spring-retention flange 81 of the second poppet 80 at one end, and the guide sleeve 96 and

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the spring retention flange 96b of the second poppet support 105 at the other.

Support spokes 98 extend radially outwardly and upstream from the spring retention flange 96b of the second poppet support 105 and connect the guide sleeve 96 with the support rim 100. The support spokes 98 further ensure that the guide sleeve 96 is positioned and maintained centrally within the support rim 100, and that the longitudinal bore 95 through the guide sleeve 96 is coaxial with the remainder of the valve cartridge 14. The support spokes 98 are spaced circumferentially so as to engage the compression notches 93 of the flow-direction flange 88 of the second poppet 80 to maximize the amount of compression of the second spring 180 when the second valve 160 is in its open position. Spaces between the support spokes 98 define flow passages 97 through the second poppet support 105.

An exterior surface of an upstream portion of the support rim 100 of the second poppet support 105 has an annular connecting groove 107 defined therein. This connecting groove 107 is adapted to accept in locking relationship, the inwardly-projecting connection ridge 43 of the downstream connection flange 55b of the first poppet support 35. Spaced circumferentially within this connecting groove 107 are four alignment tabs 108. This connecting groove 107 and these alignment tabs 108 function to connect the second poppet support 105 to the first poppet support 35, to align it therewith, and to resist separation and relative rotation therebetween once locked together.

When the valve cartridge 14 is in its assembled form, the support spokes 98 of the second poppet support 105 form a flat downstream surface 115 at the downstream end 190 of the

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cartridge 14 that is capable of co-operating with a cartridge-retaining face 141 on a retaining cage 130, as discussed in greater detail below.

Further, the support spokes 98 of the second poppet support 105 have an outer diameter that is larger than the outer diameter of other valve components of the valve cartridge 14 such that when the valve cartridge 14 is assembled, the downstream end 190 of the valve cartridge 14 has an outer diameter greater than that of the remainder of the valve cartridge 14 to facilitate proper insertion and removal of the valve cartridge 14 from the valve body 16 as described in greater detail below.

The first valve seat alignment tabs 21, the second poppet support alignment tabs 108, and the connecting groove notches 44, 45 of the upstream and downstream connection flanges 55a, 55b of the first poppet support 35 are circumferentially positioned such that when the valve cartridge 14 is assembled, the support spokes 38, 98 of the first and second poppet supports 35, 105 align so as to maximize flow through the valve cartridge 14 when the first and second valves 150, 160 are in their open positions.

An exemplary manner in which the preferred embodiment valve cartridge 14 may be assembled will now be described.

First, the various seals are inserted into their respective seats. The poppet seal 26 of the first poppet 24 is pushed over the poppet face 25 and into the seal recess 27 of the first poppet. Next, the poppet seal 86 of the second poppet 80 is pushed over the poppet face 85 and into the seal recess 87 of the second poppet 80. The first valve seat O-ring 195 is then pushed onto the first valve seat 18 to seat within the first valve seat O-ring groove 20 thereon, and the first

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poppet support O-ring 57 is pushed onto the first poppet support 35 to seat within the first poppet support O-ring groove 56 thereon.

Next, the first valve 150 is assembled. The first
5 spring 175 is placed over the guide sleeve 36 of the first poppet support 35 and the poppet stem 30 of the first poppet 24 is inserted into an upstream end of the guide sleeve 36. The first valve seat 18 is placed over the first poppet 24 and pushed towards the first poppet support 35 causing the first
10 spring 175 to compress. Once the first valve seat 18 contacts the first poppet support 35, these two components are twisted relative to one another until the first valve seat alignment tabs 21 of the first valve seat 18 align with the connecting groove notches 44 of the upstream connection flange 55a of the
15 first poppet support 35. Further compression between the two components allows the connection ridge 42 of the upstream connection flange 55a to engage the first valve seat connecting groove 23. Once engaged, the interaction between the connection ridge 42 of the upstream connection flange 55a of
20 the first poppet support 35 and the connecting groove 23 of the first valve seat 18 resists separation of the two valve components, while interaction between the first valve seat alignment tabs 21 and the upstream connecting groove notches 44 of the first poppet support 35 prevents relative rotation
25 between the two valve components during operation.

The second valve 160 is then assembled. The second spring 180 is placed over the second poppet support guide sleeve 96 and the stem 90 of the second poppet 80 is inserted into the second poppet support guide sleeve 96. A downstream
30 side of the first poppet support 35 is placed over the second poppet 80 and pushed towards the second poppet support 105 causing the second spring 180 to compress. Once the first

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poppet support 35 contacts the second poppet support 105, these two components are twisted relative to one another until the second poppet support alignment tabs 108 of the second poppet support 105 align with the connecting groove notches 45 of the downstream connection flange 55b of the first poppet support 35. Further compression between the two components allows the connection ridge 43 of the downstream connection flange 55b to engage the second poppet support connecting groove 107. Once engaged, the interaction between the connection ridge 43 of the second poppet support 105 and the connecting groove 107 of the second poppet support 105 resists separation of the two valve components, while interaction between the second poppet support alignment tabs 108 and the connecting groove notches 45 of the first poppet support 35 prevents relative rotation between the two valve components during operation.

Although an exemplary manner of assembling the valve cartridge 14 has been described, it is to be understood that the cartridge may be assembled using other methods and in other sequences, as will be understood by those skilled in the art.

Once assembled, the valve cartridge 14 is self-contained insofar as the valve cartridge 14 is a single unit containing all components necessary for the valve cartridge 14 to function as a valve when placed in a valve body, and wherein all of these components are either integral with, attached to, contained within one another, or are otherwise connected such that the cartridge remains unitary during handling. Further, the major components of the valve cartridge 14 resist relative rotation by the means described above to avoid causing unwanted wear and/or flow turbulence.

The operation of the preferred embodiment valve cartridge 14 will now be described. Figures 7A and 7B

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illustrate, respectively, the closed and open positions for the fully assembled valve cartridge 14.

When the valve cartridge 14 is installed in a valve body and the pressure difference between the upstream and downstream ends 185, 190 of the valve cartridge 14 is small or is zero, the first and second valves 150, 160 are closed as shown in Figure 7A. The first spring 175 pushes the first poppet 24 upstream such that the seal 26 of the first poppet 24 is pressed against the first valve seat surface 22. Similarly, the second spring 180 pushes the second poppet 80 upstream such that the seal 86 of the second poppet 80 is pressed against the second valve seat 50. In this state, two independent seals are created to restrict flow through the valve cartridge 14. The upstream seal is formed by the first poppet poppet face 25, the first poppet poppet seal 26, the first valve seat surface 22, the first valve seat 18 and the first valve seat O-ring 195. The downstream seal is formed by the second poppet poppet face 85, the second poppet poppet seal 86, the second valve seat 50, the first poppet support 35, and the first poppet support O-ring 57.

If the water pressure at the downstream end 190 of the valve cartridge 14 exceeds the pressure at the upstream end 185, this pressure differential tends to increase the force with which the second poppet 80 is pressed against the second valve seat 50, thereby improving the seal between the second poppet poppet seal 86 and the second valve seat 50. In such circumstances, the second valve 160 will be closed and no additional pressure is exerted on the downstream surface of the first valve 150, though the first valve 150 will remain closed due to the force exerted by the first spring 175 on the first poppet 24, as explained above.

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Should the second valve 160 fail, the first valve 150 will still restrict backflow (flow from the downstream end 190 to the upstream end 185) of water through the cartridge. Indeed, if the second valve 160 fails when the water pressure at the downstream end 190 of the valve cartridge 14 exceeds the pressure at the upstream end 185, the force with which the first poppet 24 is pressed against the first valve seat surface 22 is increased, thereby improving the seal between the first poppet poppet seal 26 and the first valve seat surface 22.

As can be seen, so long as at least one of the first and second valves 150, 160 do not fail, backflow through the valve cartridge 14 will be restricted. Accordingly, the two valves 150, 160 provide the valve cartridge 14 with its dual-check feature. The valves provide redundant protection, such that if one of the valves fails, backflow through the valve cartridge 14 will still be checked.

If the water pressure at the upstream end 185 of the valve cartridge 14 exceeds the pressure at the downstream end 190 by a degree sufficient to overcome the spring force exerted by the first and second springs 175, 180, then the pressure against the poppet faces 25, 85 moves the first and second poppets 24, 80 downstream away from the first and second valve seats 22, 50 respectively, opening both valves as shown in Figure 7B and allowing water to flow from the upstream end 185 of the valve cartridge 14 to the downstream end 190. When both valves 150, 160 are open, water from the upstream end 185 of the valve cartridge 14 is directed to the periphery of the first poppet poppet face 25, flows in an annular passage between the periphery of the first poppet 24 and the interior surface of the connection sleeve 18b of the first valve seat 18, through the gaps between the support spokes 38 of the first poppet support 35, around the periphery of the second poppet 80

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and past the gaps between the support spokes 98 of the second poppet support 105.

Having described the features of the preferred embodiment valve cartridge 14, its assembly as well as its operation, an exemplary valve application incorporating the valve cartridge 14 will now be described. In this case, the valve application is the preferred embodiment check valve 200 of a second aspect of the present invention, illustrated in Figures 8 and 11.

Figure 8 shows an exploded view of the major elements of the preferred embodiment check valve 200. As noted previously, the very specific exemplary context described for the check valve 200 is one used to permit flow from a horizontal pipe connected to a municipal water supply down to a vertical pipe connected to a building water system, but not vice versa. The major elements of the check valve 200 are the valve body 16, valve cartridge 14, retaining cage 130 and service cap 17.

The valve body 16, shown in detail in Figure 9, has a vertical main body bore 202, a horizontal inlet bore 204 communicating with the main body bore 202 from the side, and a vertical outlet bore 206 extending down from the main body bore 202.

The inlet bore 204 is sized to accommodate the valve cartridge 14 in a close fit and has a lip 207 near its outside end to retain the valve cartridge 14 within the inlet bore 204. An outside surface 208 of the valve body 16 adjacent the inlet bore 204 is provided with suitable attachment features to allow the sealed connection of the horizontal pipe connected to the municipal water supply. As illustrated in Figure 8, the attachment features of the check valve 200 are of the meter

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flange type. Of course, other attachment features may be used, female iron pipe for example.

The outlet bore 206 is sized to accommodate the vertical pipe connected to the building water system. In the
5 illustrated valve body 16, a lower end of the outlet bore 206 is provided with internal threading 210 as shown in Figure 11 to facilitate a sealed connection with the vertical pipe. Of course, other attachment means may be implemented.

The main body bore 202 is sized to accommodate the
10 insertion of the valve cartridge 14 therein, manipulation of the valve cartridge 14 such that it can be inserted into the inlet bore 204, as well as insertion of the retaining cage 130. An upper end of the main body bore 202 is provided with internal threading 212 to engage external threading 214 of the
15 service cap 17. In conjunction with a service cap O-ring 216, the service cap 17 seals the upper end of the main body bore 202.

The retaining cage 130 has an open-lattice structure consisting of struts, spokes, rings, and partial rings that
20 provide structural support for a substantially flat cartridge-retaining face 141 adapted to retain the valve cartridge 14 within the inlet bore 204 once the check valve 200 is assembled, while allowing water to easily flow through the retaining cage 130. The cartridge-retaining face 141 has at
25 its center, a ring 142 adapted to permit the second poppet poppet stem 90 of the preferred embodiment valve cartridge 14 to extend therethrough when the second valve 160 of the valve cartridge 14 is in its open position. The retaining cage 130 further has a tab 135 at its top to facilitate insertion,
30 rotation and extraction of the retaining cage 130 from the valve body 16.

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To assemble the check valve 200, the valve cartridge 14 is first inserted into the main body bore 202 through the top and slid into the inlet bore 204 upstream-end 185 first. As explained above, the second poppet support support spokes 98 have an outer diameter that is larger than the remainder of the valve cartridge 14, and indeed larger than the internal diameter of the inlet bore 204. As a result of this feature, the valve cartridge 14 can only be inserted into the inlet bore 204 upstream end 185 first, namely in the correct orientation.

Following insertion of the valve cartridge 14, the retaining cage 130 is slid into the main body bore 202. To facilitate this task, the tab 135 may be grasped and the retaining cage 130 rotated about its longitudinal axis such that cartridge-retaining face 141 is oriented towards the inlet bore 204, before the retaining cage 130 is lowered into the main body bore 202. As the retaining cage 130 is substantially round in horizontal cross-section with the exception of the substantially flat cartridge-retaining face 141, the retaining cage 130 can only be inserted into the main body bore 202 in its correct orientation, namely with the cartridge-retaining face 141 abutting the downstream end 190 of the valve cartridge 14 and retaining it in place within the inlet bore 204.

With the retaining cage 130 in place, the service cap 17 is screwed onto the top of the main body bore 202 with the service cap O-ring 216 therebetween to seal the top of the main body bore 202.

In use, the check valve 200 is screwed onto the vertical pipe connected to the building water system such that the internal threading of the outlet bore 206 engages external threading on the vertical pipe. The horizontal pipe is then fluidly connected to the inlet bore 204 using the above-

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mentioned attachment features. Connected in this manner, the valve cartridge 14 which is retained in place by the retaining cage 130, allows water to flow from the horizontal pipe to the vertical pipe, but not vice versa.

5 To service the check valve 200, the service cap 17 is removed, and the retaining cage 130 extracted using the tab 135. The valve cartridge 14 is then removed through the main body bore 202 and inspected, serviced or replaced as necessary. Notably, the valve body 16 need not be disconnected from either
10 the horizontal or vertical pipe for this procedure. The check valve 200 may then be reassembled as described above.

 In the above description, the valve cartridge of the present invention has been described in the context of a very specific application, namely its use in an elbow-style check
15 valve in allowing flow from a horizontal pipe connected to a municipal water supply to a vertical pipe connected to a building watery system but not vice versa. It is to be understood that the valve cartridge of the present invention can be used in a wide variety of applications as will be
20 understood by those skilled in the art. For example, the valve cartridge 14 can be used in many plumbing or waterworks application to ensure unidirectional flow through a conduit. It can also be used to ensure unidirectional flow of other fluids, sewage or gasses for example. Additionally, its use is
25 of course, not limited to insertion within the preferred embodiment elbow-style check valve of the present invention, but could be used in other elbow valves, in straight-pipe valves, etc..

 The check valve of a second aspect of the present
30 invention has also been described in a very specific application, namely its use in allowing flow from a horizontal

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pipe connected to a municipal water supply to a vertical pipe connected to a building watery system but not vice versa. However, the check valve can of course be used in a variety of other applications, in chemical production plant applications,
5 plumbing applications, etc..

While both the valve cartridge and the check valve can be used in retrofit applications, they can also be used in new installations.

Very specific geometries, orientations,
10 configurations and relative positions of the various elements have also been provided for both the valve cartridge and check valve. However, it is to be understood that other suitable geometries, orientations, configurations and relative positions may be used by persons skilled in the art without necessarily
15 departing from the scope of the invention. For example, the components of the valve cartridge need not necessarily be round in cross-section - a square valve cartridge for use within a square valve body or conduit is also contemplated. As another example, although the preferred embodiment valve cartridge has
20 been provided with four sets of alignment tabs and notches to align the first valve seat, the first poppet support and the second poppet support, a greater or lesser number of such tabs and notches may be used, 3 or 6 for example. A similar comment applies in respect of, for example, the number of spokes for
25 each of the first and second poppet supports and the corresponding number of compression notches on each of the first and second poppet flow-direction flanges, the number of large splines on the first and second poppet stems and corresponding number of alignment slots in the first and second
30 poppet guide sleeves, the number of small splines on the first and second poppet stems, etc.

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The poppet stems of the valve cartridge have been described as having small splines thereon to reduce the contact surface between the poppet stems and the poppet guides. However, the present invention also contemplates the absence of
5 such splines.

In the preferred embodiment valve cartridge and check valve, the valve body and the service cap are made of brass alloy, the various seals and O-rings are made of rubber, the springs are made of steel, and the remaining valve components
10 are made of plastic. However, it is to be understood that other suitable materials may be used without necessarily departing from the scope of the invention, as will be appreciated by persons skilled in the art.

While the check valve has been described and
15 illustrated as used with the preferred embodiment valve cartridge, it is to be understood that the check valve can also be used with other valve cartridges, a single-check valve cartridge for example.

Although the check valve of the present invention has
20 been described as an elbow-style check valve, it is to be understood that the check valve need not be elbow-style. For example, the check valve may be a straight valve where the outlet bore would be colinear with the inlet bore.

While the interior features of the check valve of the
25 present invention have been described as being bores, it is to be understood that these features need not necessarily be cylindrical. These features could for example be cuboid.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is
30 therefore to be understood that within the scope of the

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appended claims, the invention may be practised otherwise than as specifically described herein.

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CLAIMS:

1. A self-contained dual-check valve cartridge for use in a valve body.
2. The valve cartridge of claim 1, wherein the cartridge
5 comprises a first valve and a second valve, each of said first and second valves being capable of switching between closed and open positions independent of the other.
3. The valve cartridge of claim 2, wherein the first and second valves are poppet-style valves and the first valve is
10 upstream of the second valve.
4. The valve cartridge of claim 3, wherein the first valve comprises:
 - a first valve seat defining a bore therethrough;
 - a first poppet having a first poppet face parallel to
15 the first valve seat and adapted to cover the first valve seat bore when the first valve is in the closed position, and a first poppet stem extending perpendicularly from said first poppet face; and
 - a first poppet support adapted to receive said first
20 poppet stem for reciprocal movement therein between the closed position in which the first poppet face is held against the first valve set to cover the first valve seat bore and the open position in which the first poppet face is spaced from the first valve seat permitting fluid flow
25 around the periphery of the first poppet face,
- and the second valve comprises:
 - a second valve seat defining a bore therethrough;

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a second poppet having a second poppet face parallel to the second valve seat and adapted to cover the second valve seat bore when the second valve is in the closed position, and a second poppet stem extending perpendicularly from said second poppet face; and

a second poppet support adapted to receive said second poppet stem for reciprocal movement therein between the closed position in which the second poppet face is held against the second valve seat to cover the second valve seat bore and the open position in which the second poppet face is spaced from the second valve seat permitting fluid flow around the periphery of the second poppet face.

5. The valve cartridge of claim 4, wherein the first poppet support and the second valve seat are integral.

15 6. The valve cartridge of either one of claims 4 and 5 wherein the first valve seat, the first poppet support and the second poppet support are locked together.

7. The valve cartridge of any one of claims 4 to 6 wherein one of the first and second poppet faces has a central indent adapted to accept an end of the stem of the other of the first and second poppets therein.

8. The valve cartridge of claim 7 wherein the second poppet face has the central indent adapted to accept the end of the first poppet stem therein when the first valve it is in its open position and the second valve is in its closed position.

9. The valve cartridge of any one of claims 4 to 8 wherein:

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the first poppet face is located intermediate the first valve seat and the first poppet support and the first poppet stem extends downstream from the first poppet face;

the second poppet face is located intermediate the second valve seat and the second poppet support, and the second poppet stem extends downstream from the second poppet face.

10. The valve cartridge of any one of claims 4 to 9, further comprising:

first sealing means for preventing flow through the first valve when the first poppet is in its closed position;

first flow means for permitting flow through the first valve when the first poppet is in its open position;

first poppet control means for moving the first poppet between its closed position and its open position in response to changes in a differential between fluid pressure on the upstream side and the downstream side of the first poppet face;

wherein said first flow means for permitting flow through the first valve when the first poppet is in its open position comprises the first valve seat bore, at least one flow passage around the first poppet face, and at least one flow passage through the first poppet support.

11. The valve cartridge of claim 10 wherein the first poppet includes a first poppet seal, and the first sealing means for preventing flow through the first flow passage when the first poppet is in its closed position comprises a seal created by the first poppet seal between the first poppet and the first valve seat when the first poppet is in its closed position.

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12. The valve cartridge of either one of claims 10 and 11 further comprising first biasing means for biasing the first poppet towards its closed position.

13. The valve cartridge of claim 12 wherein the first
5 poppet control means for moving the first poppet between its open position and its closed position in response to changes in the differential between fluid pressure on the upstream side and the downstream side of the first poppet face comprises the first biasing means, as well as upstream and downstream
10 surfaces of the first poppet face being substantially perpendicular to a direction of flow through the valve cartridge which causes a force to be exerted on the first poppet when a pressure differential exists between the upstream and downstream sides of the first poppet face, said first
15 poppet moving from its closed position to its open position when the force exerted on the upstream surface of the first poppet face by a higher fluid pressure on the upstream side of the first poppet is sufficient to overcome a force exerted by the first biasing means, and the first poppet moving from its
20 open position to its closed position otherwise.

14. The valve cartridge of either one of claims 12 and 13 wherein said first biasing means is a spring located between the first poppet and the first poppet support.

15. The valve cartridge of any one of claims 4 to 14,
25 further comprising,

second sealing means for preventing flow through the second valve when the second poppet is in its closed position;

second flow means for permitting flow through the second valve when the second poppet is in its open position;

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second poppet control means for moving the second poppet between its closed position and its open position in response to changes in a differential between fluid pressure on the upstream side and the downstream side of the second poppet face;

wherein said second flow means for permitting flow through the second valve when the second poppet is in its open position comprises the second valve seat bore, at least one flow passage around the second poppet face, and at least one flow passage through the second poppet support.

16. The valve cartridge of claim 15 wherein the second poppet includes a second poppet seal, and the second sealing means for preventing flow through the second flow passage when the second poppet is in its closed position comprises a seal created by the second poppet seal between the second poppet and the second valve seat when the second poppet is in its closed position.

17. The valve cartridge of either one of claims 15 and 16 further comprising second biasing means for biasing the second poppet towards its closed position.

18. The valve cartridge of claim 17 wherein the second poppet control means for moving the second poppet between its open position and its closed position in response to changes in a differential between fluid pressure on the upstream side and the downstream side of the second poppet face comprises the second biasing means, as well as upstream and downstream surfaces of the second poppet face being substantially perpendicular to a direction of flow through the valve cartridge which causes a force to be exerted on the second poppet when a pressure differential exists between the upstream and downstream sides of the second poppet face, said second

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poppet moving from its closed position to its open position when the force exerted on the upstream surface of the second poppet face by a higher fluid pressure on the upstream side of the second poppet is sufficient to overcome a force exerted by the second biasing means, and the second poppet moving from its open position to its closed position otherwise.

19. The valve cartridge of either one of claims 17 and 18 wherein said second biasing means is a spring located between the second poppet and the second poppet support.

10 20. The valve cartridge of any one of claims 10 to 19 wherein the first poppet support comprises a central guide sleeve for receiving the first poppet stem, a peripheral rim, and a plurality of support spokes extending radially between the guide sleeve and the rim, and the at least one flow passage through the first poppet support comprises gaps between the spokes of the first poppet support.

21. The valve cartridge of claim 20 wherein said first poppet stem has a plurality of longitudinal splines on an exterior surface thereof which engage corresponding longitudinal slots on an interior surface of the first poppet support guide sleeve to permit relative longitudinal reciprocal motion therebetween while resisting relative rotational motion therebetween.

22. The valve cartridge of claim 21 wherein said first poppet stem additionally has a plurality of smaller longitudinal splines on the exterior surface thereof which contact the interior surface of the first poppet support guide sleeve to reduce contact area and therefore friction therebetween.

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23. The valve cartridge of any one of claims 15 to 19 wherein the second poppet support comprises a central guide sleeve for receiving the second poppet stem, a peripheral rim, and a plurality of support spokes extending radially between
5 the guide sleeve and the rim, and the at least one flow passage through the second poppet support comprises gaps between the spokes of the second poppet support.

24. The valve cartridge of claim 23 wherein said second poppet stem has a plurality of longitudinal splines on an
10 exterior surface thereof which engage corresponding longitudinal slots on an interior surface of the second poppet support guide sleeve to permit relative longitudinal reciprocal motion therebetween while resisting relative rotational motion therebetween.

15 25. The valve cartridge of claim 24 wherein said second poppet stem additionally has a plurality of smaller longitudinal splines on the exterior surface thereof which contact the interior surface of the second poppet support guide sleeve to reduce contact area and therefore friction
20 therebetween.

26. The valve cartridge of any one of claims 4 to 19 wherein each of the first and second poppet supports comprises a central guide sleeve for receiving its respective associated poppet stem, a peripheral support rim, and a plurality of
25 support spokes extending radially between the guide sleeve and the rim.

27. The valve cartridge of claim 26 wherein the second valve seat is defined on a downstream side of the first poppet support rim.

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28. The valve cartridge of either one of claims 26 and 27 wherein the first valve seat comprises a downstream first valve seat surface radially interior and upstream of a connection sleeve, said connection sleeve having an inner diameter greater
5 than an outer diameter of the first poppet face.

29. The valve cartridge of claim 28 wherein the first valve seat is locked to the first poppet support by means of an inwardly-projecting connection ridge on an upstream connection flange extending upstream from the first poppet support rim
10 engaging an external connecting groove on the first valve seat connection sleeve.

30. The valve cartridge of claim 29 wherein the first valve seat and the first poppet support are aligned and prevented from rotating relative to one another by engagement
15 of alignment tabs in the first valve seat connecting groove in notches defined in the connection ridge of the upstream connection flange of the first poppet support rim.

31. The valve cartridge of any one of claims 26 to 30 wherein the second poppet support is locked to the first poppet
20 support by means of an inwardly-projecting connection ridge on a downstream connection flange extending downstream from the first poppet support rim engaging an external connecting groove on the second poppet support rim.

32. The valve cartridge of claim 31 wherein the second
25 poppet support and the first poppet support are aligned and prevented from rotating relative to one another by engagement of alignment tabs in the second poppet support connecting groove in notches defined in the connection ridge of the downstream connection flange of the first poppet support rim.

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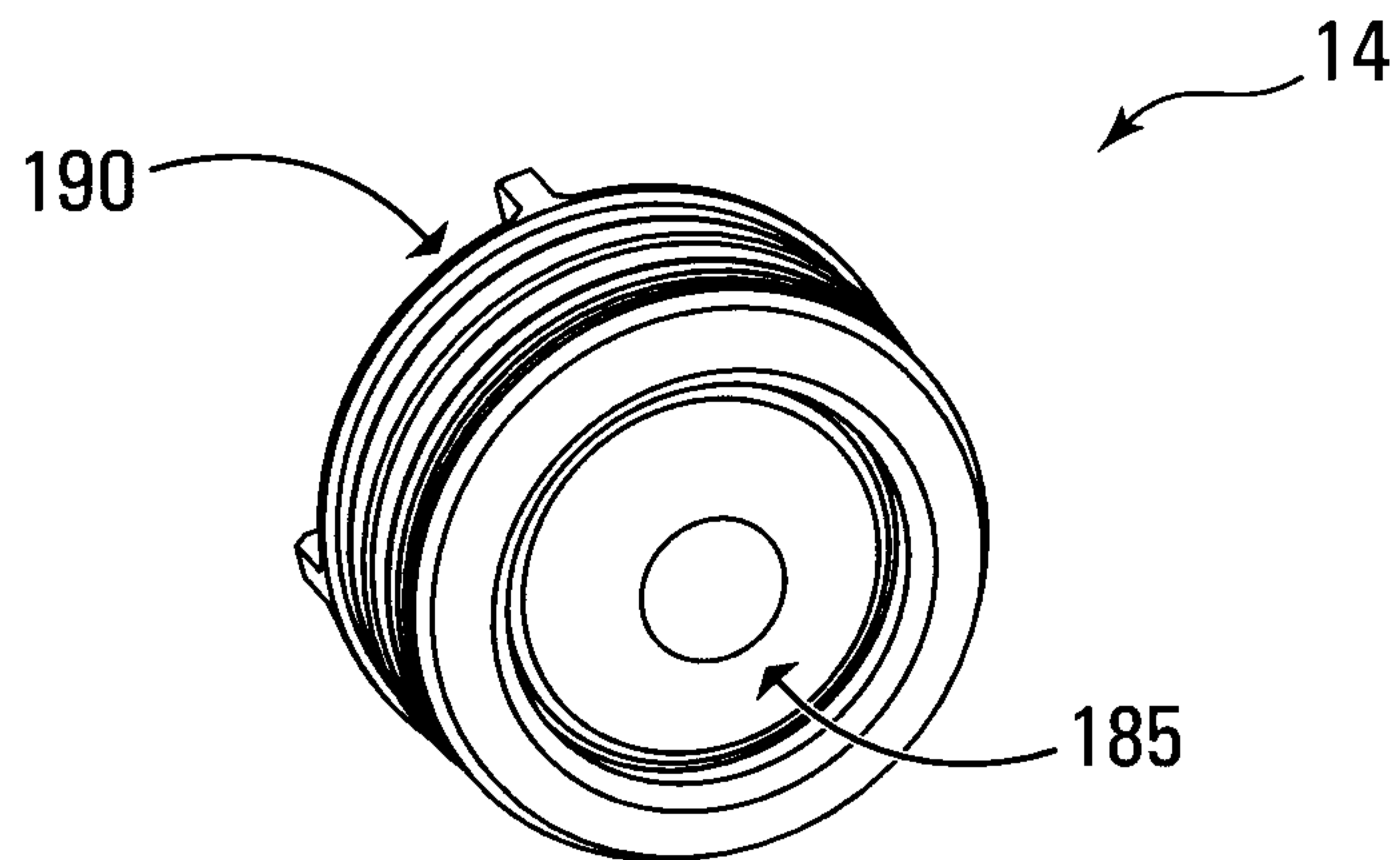
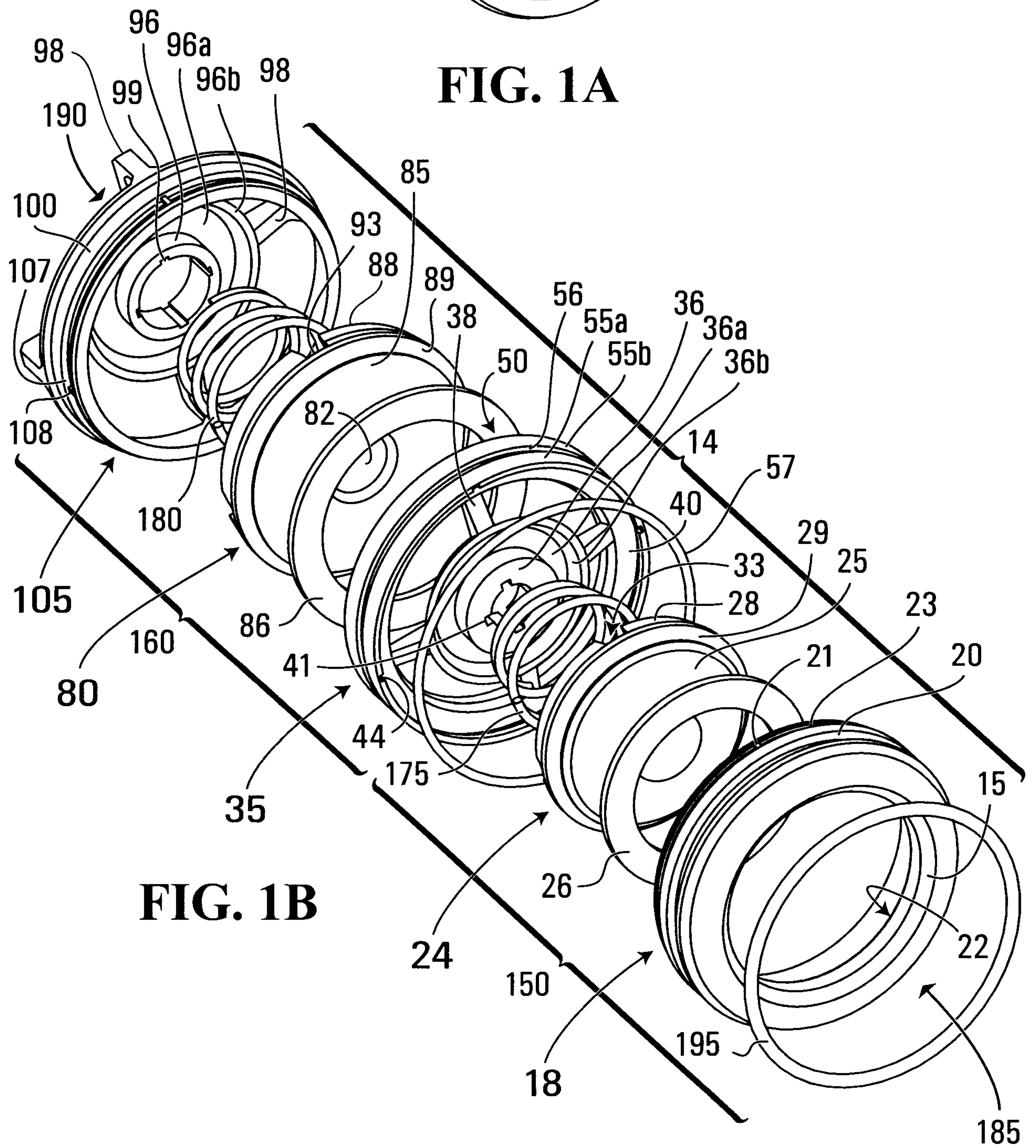
33. The valve cartridge of any one of claims 26 to 32 wherein the first poppet face further has a flow-direction flange extending downstream from a periphery thereof, said flow-direction flange having compression notches defined
5 therein to engage the support spokes of the first valve support when the first valve is in its open position.

34. The valve cartridge of any one of claims 26 to 33 wherein the second poppet face further has a flow-direction flange extending downstream from a periphery thereof, said
10 flow-direction flange having compression notches defined therein to engage the support spokes of the second valve support when the second valve is in its open position.

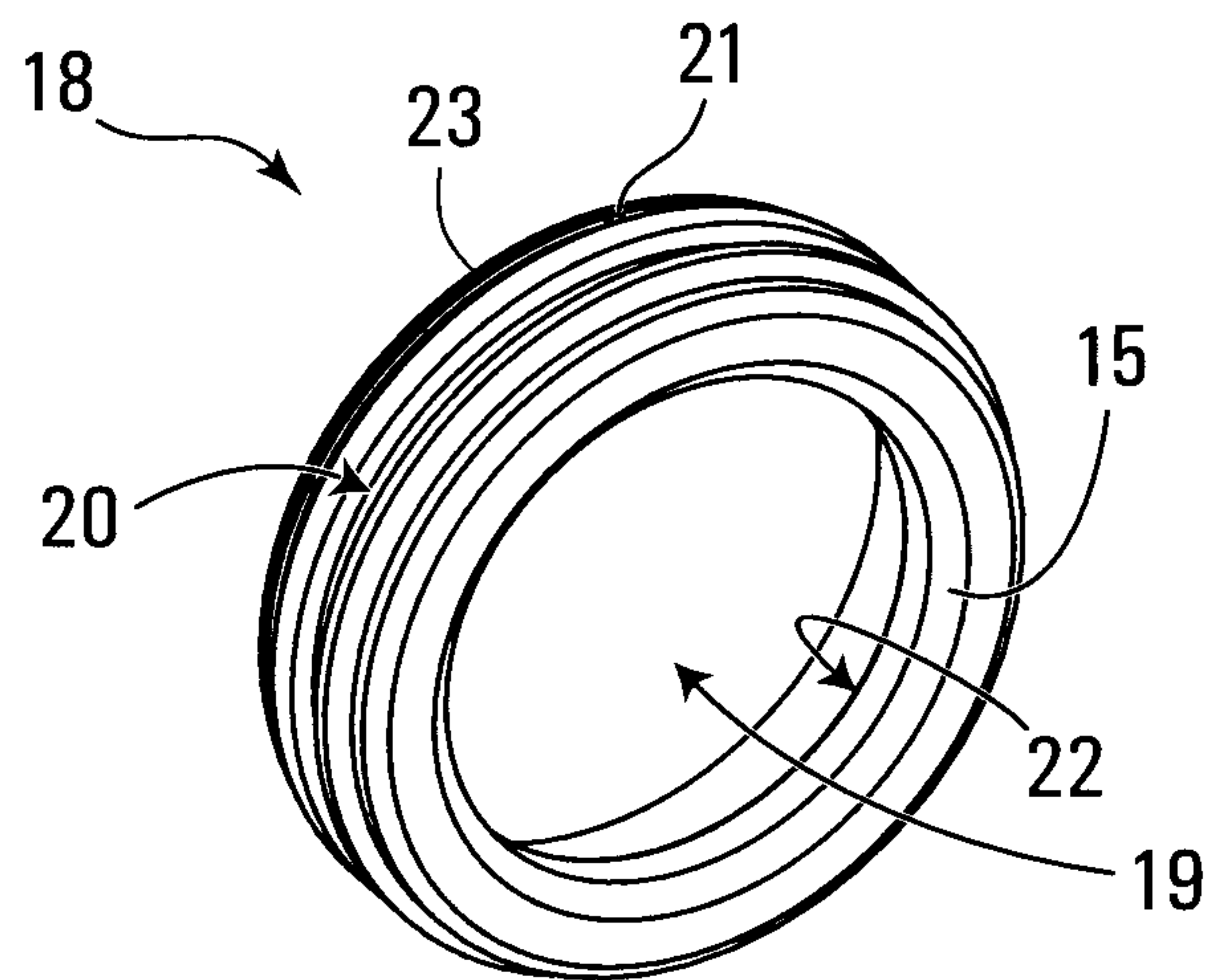
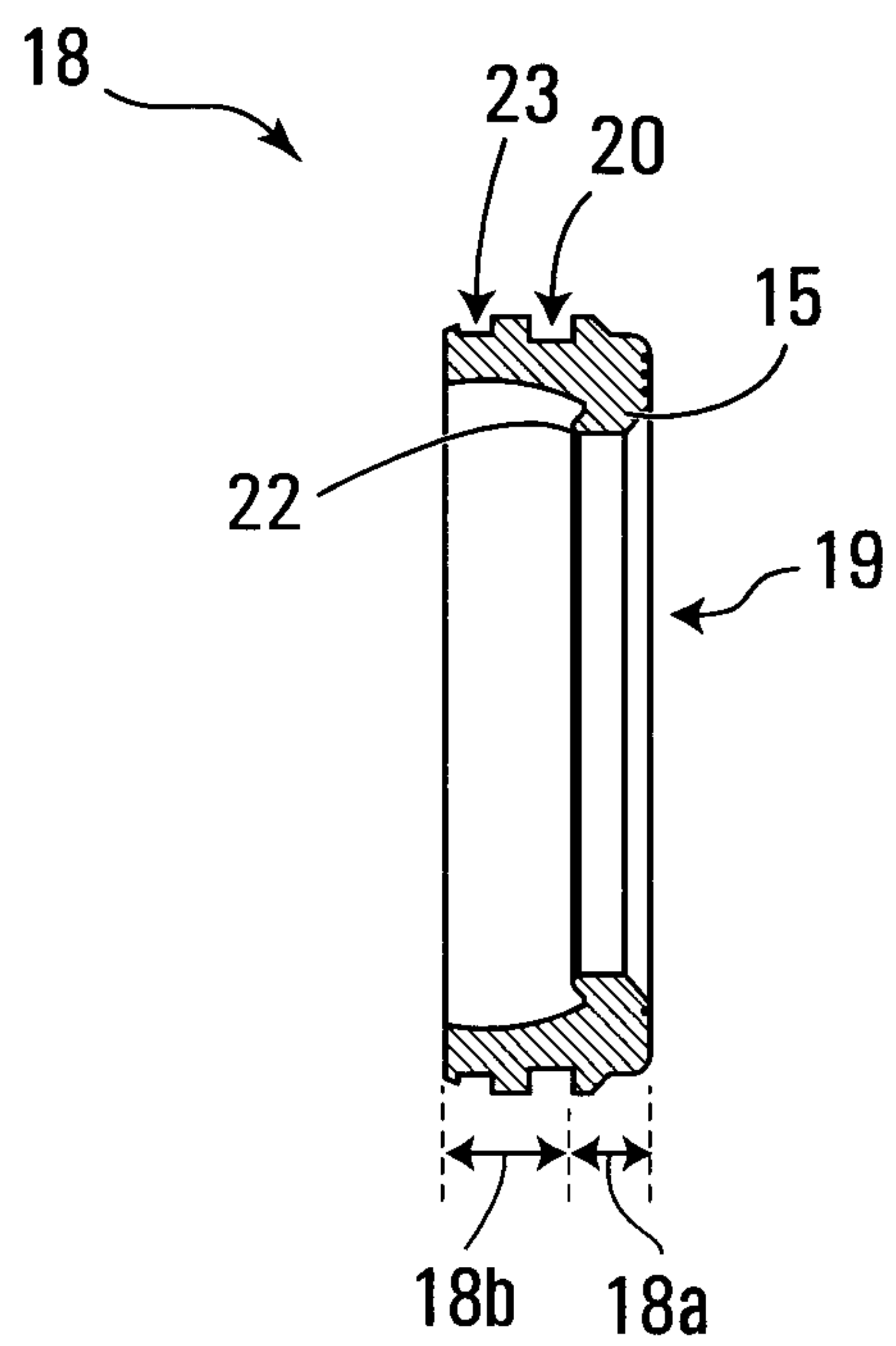
35. The valve cartridge of any one of claims 4 to 34 wherein the first valve seat has a seal groove on its outside
15 surface, said seal groove having seated therein an O-ring to seal the first valve seat against an interior surface of the valve body when the valve cartridge is inserted within said valve body.

36. The valve cartridge of any one of claims 4 to 35
20 wherein the first poppet support has a seal groove on its outside surface, said seal groove having seated therein an O-ring to seal the first poppet support against an interior surface of a valve body when the valve cartridge is inserted within said valve body.

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**FIG. 1A****FIG. 1B**

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**FIG. 2A****FIG. 2B**

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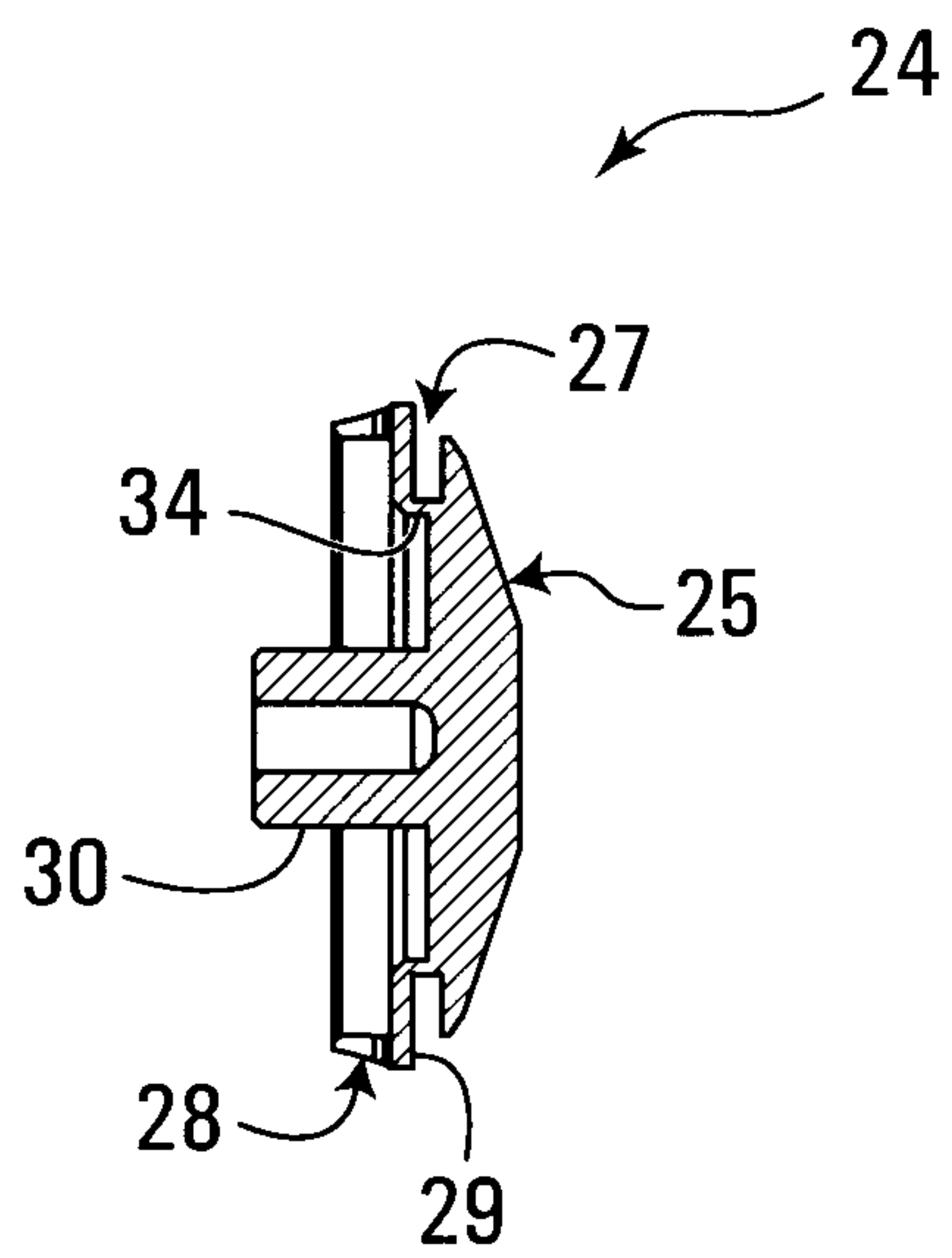


FIG. 3A

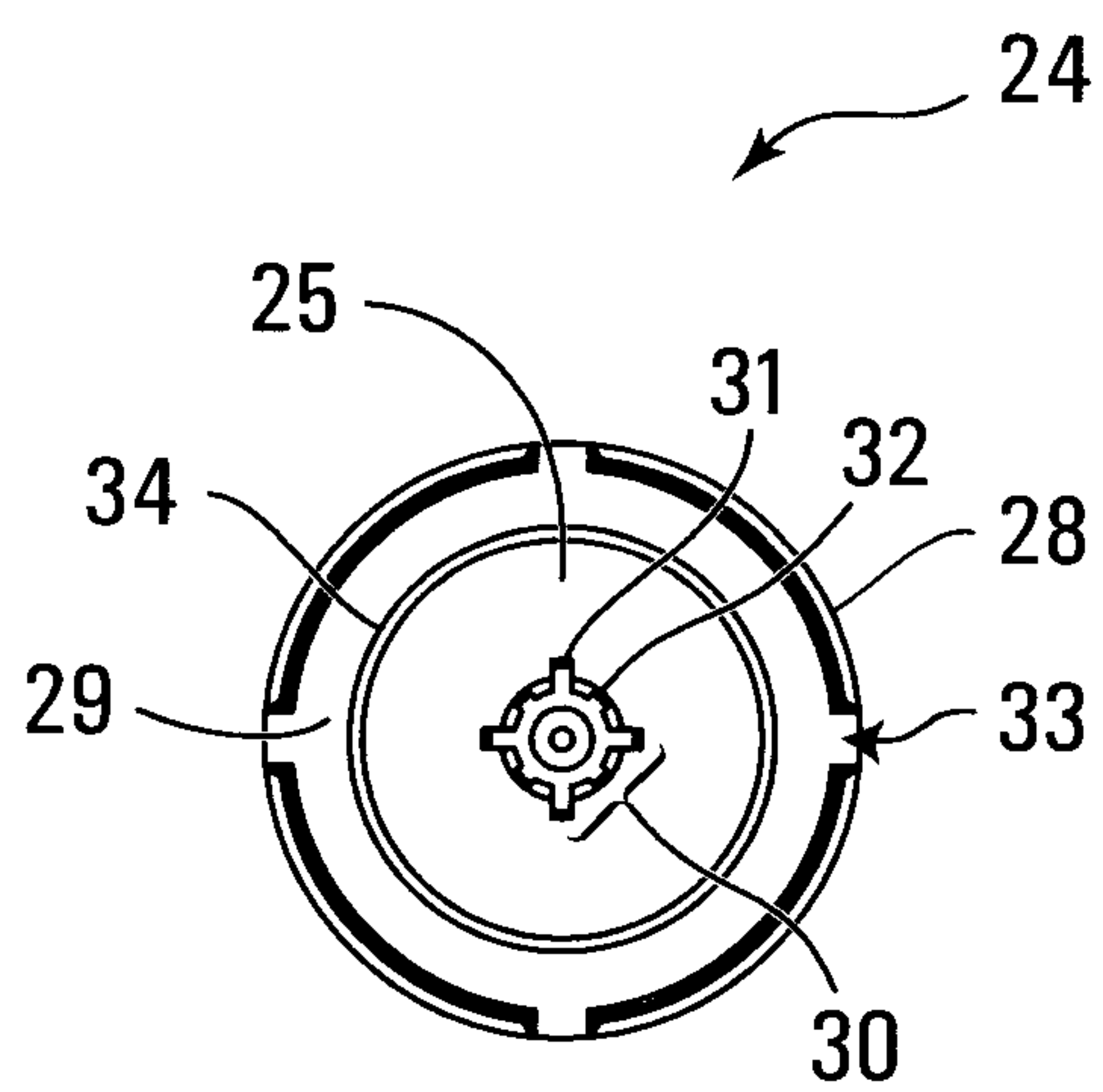
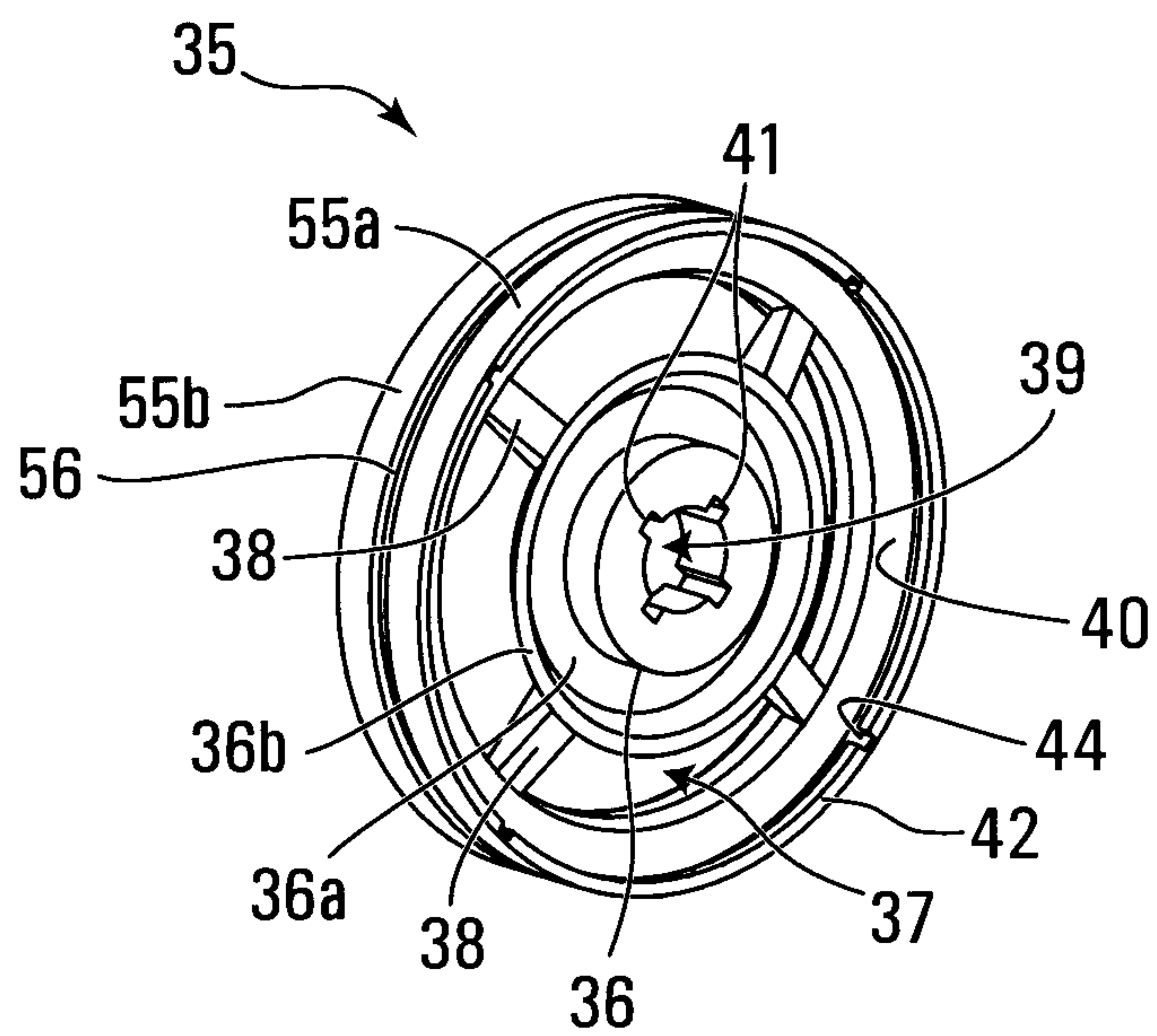
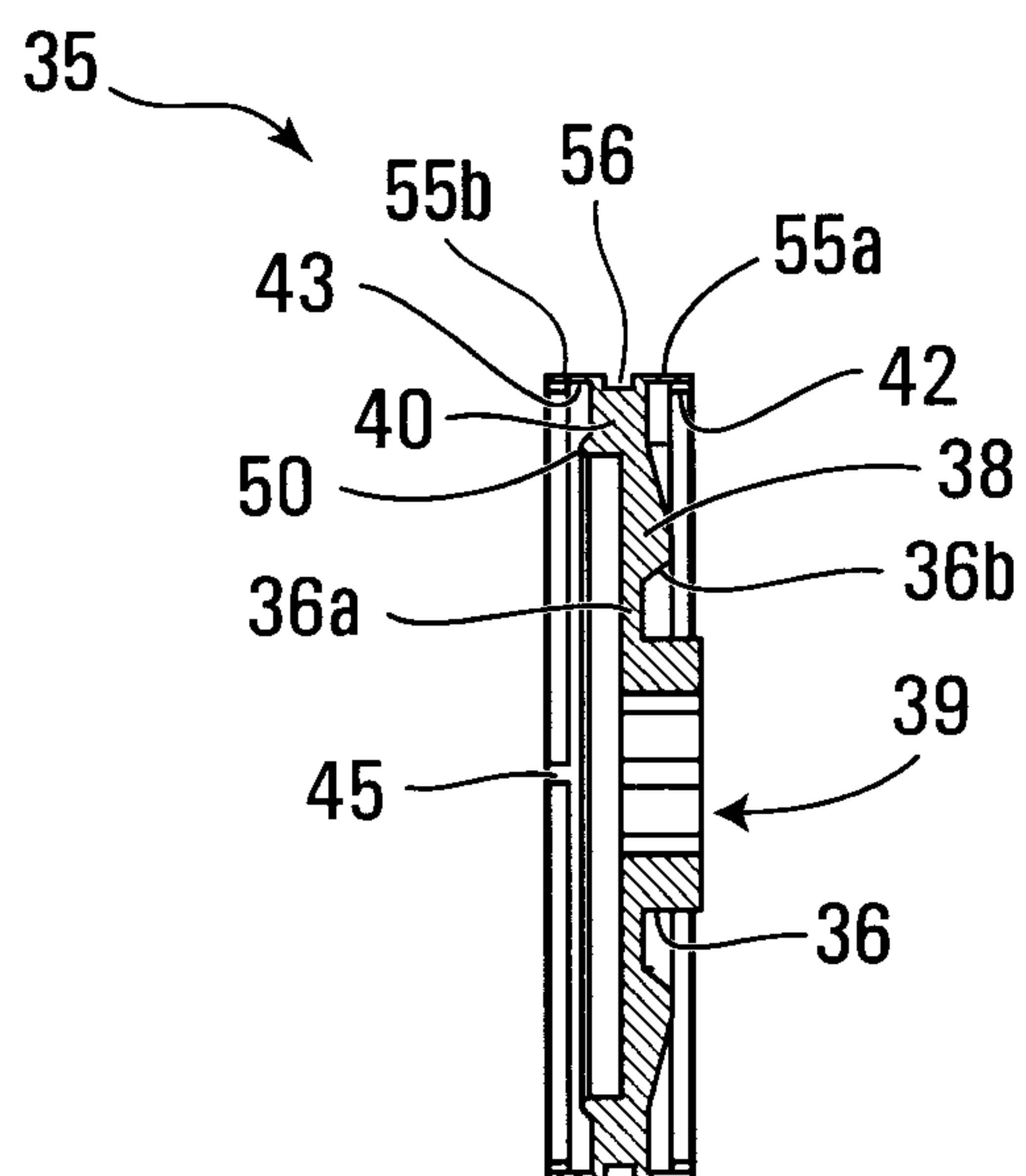


FIG. 3B

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**FIG. 4A****FIG. 4B**

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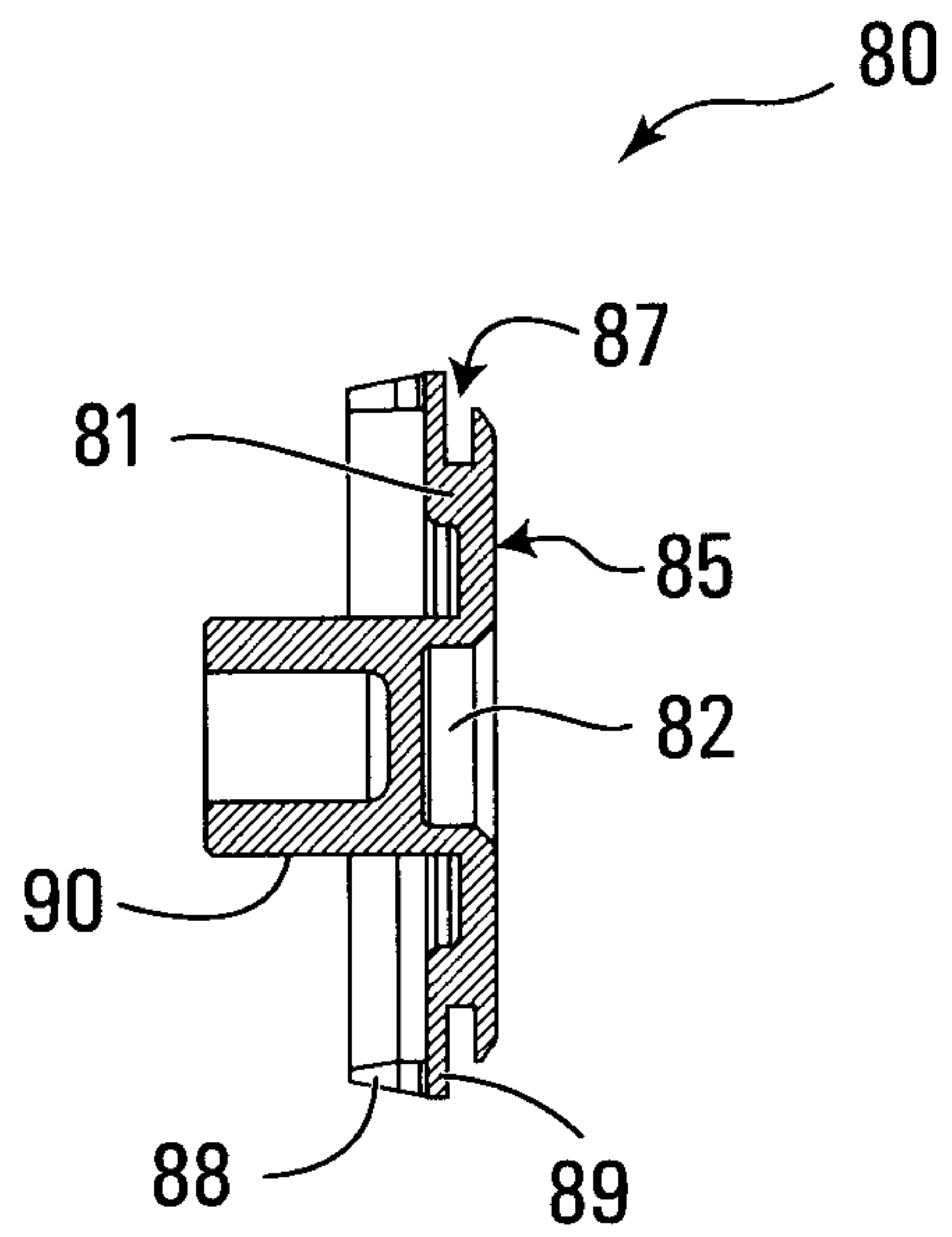


FIG. 5A

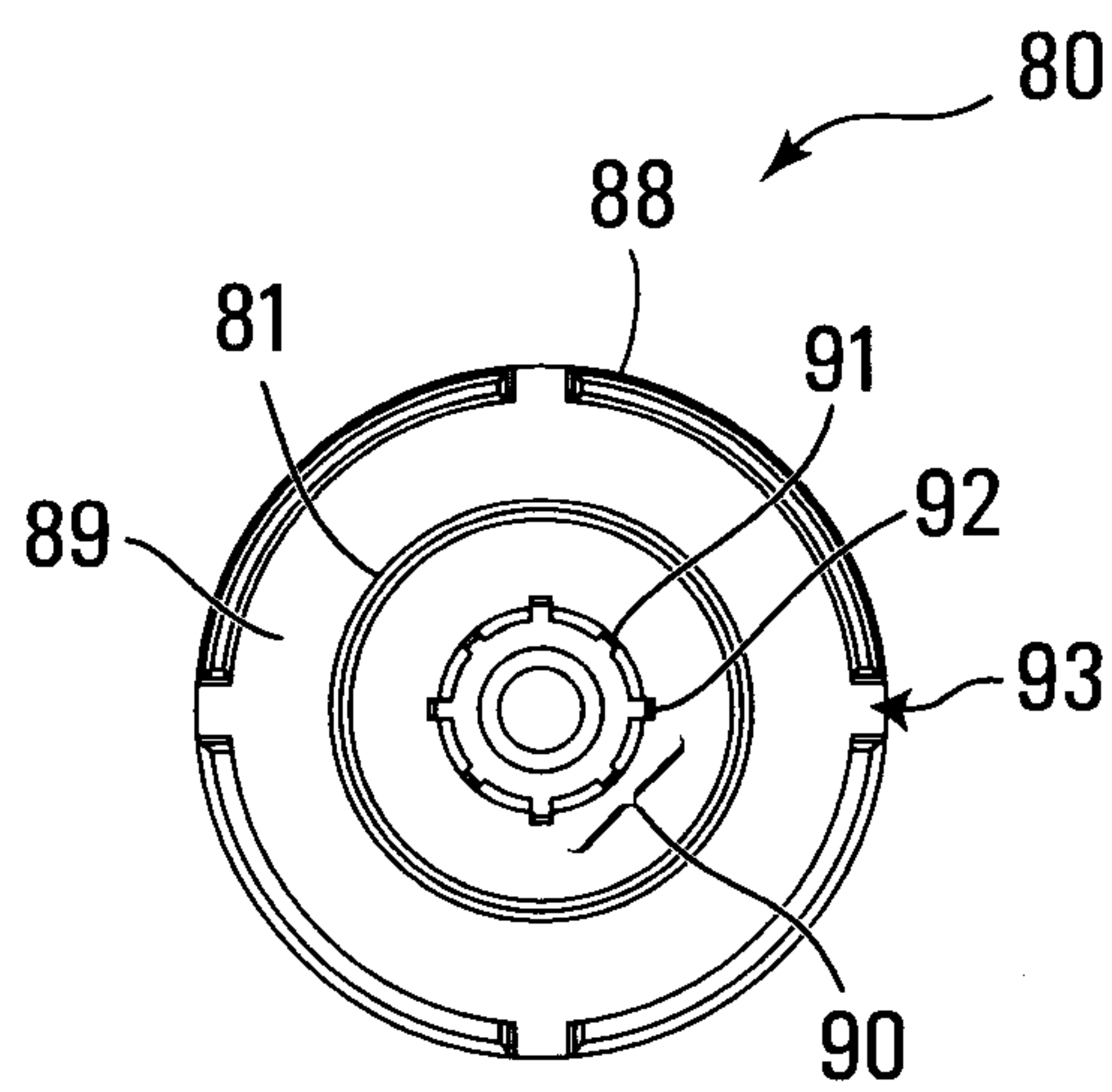
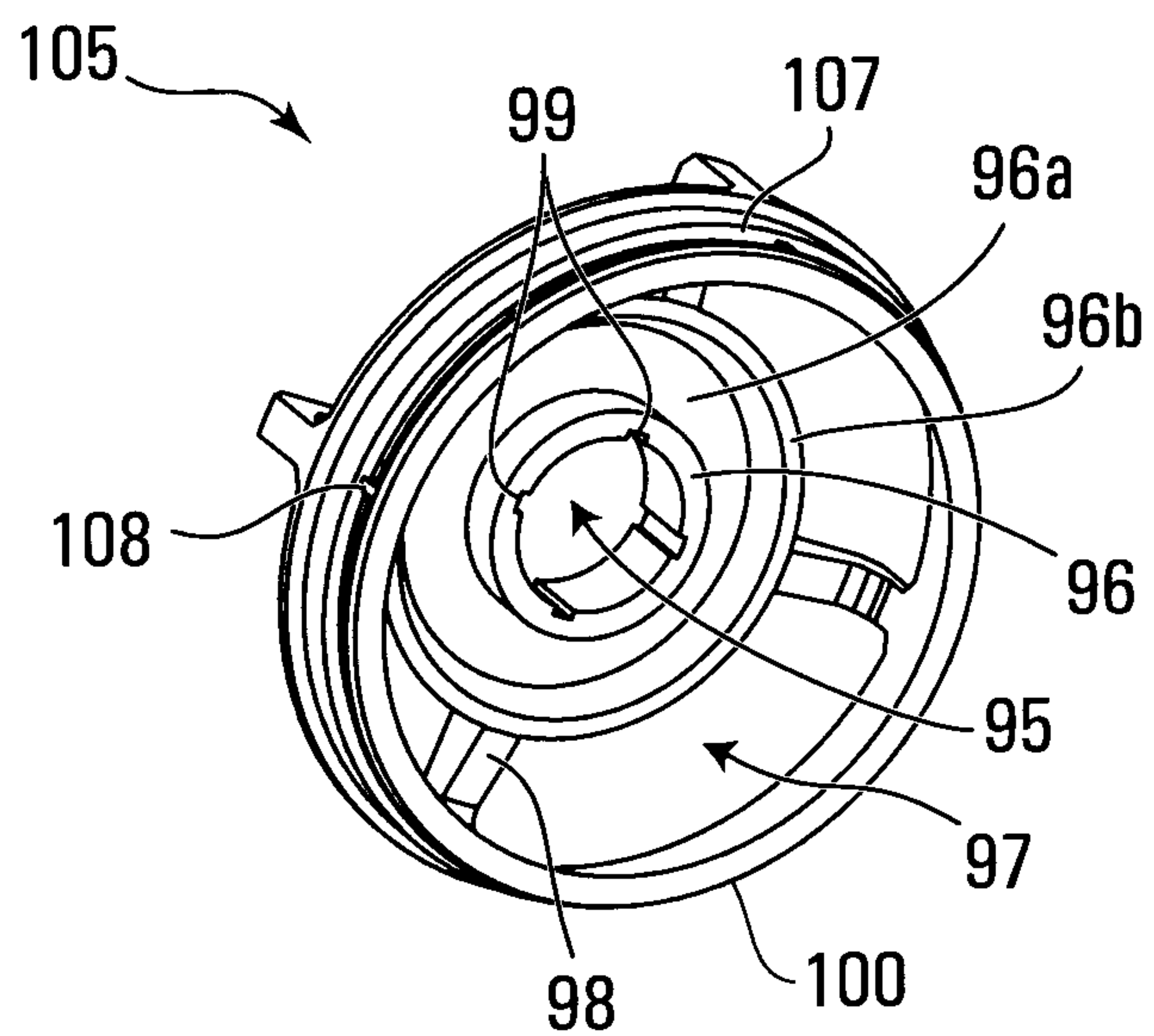
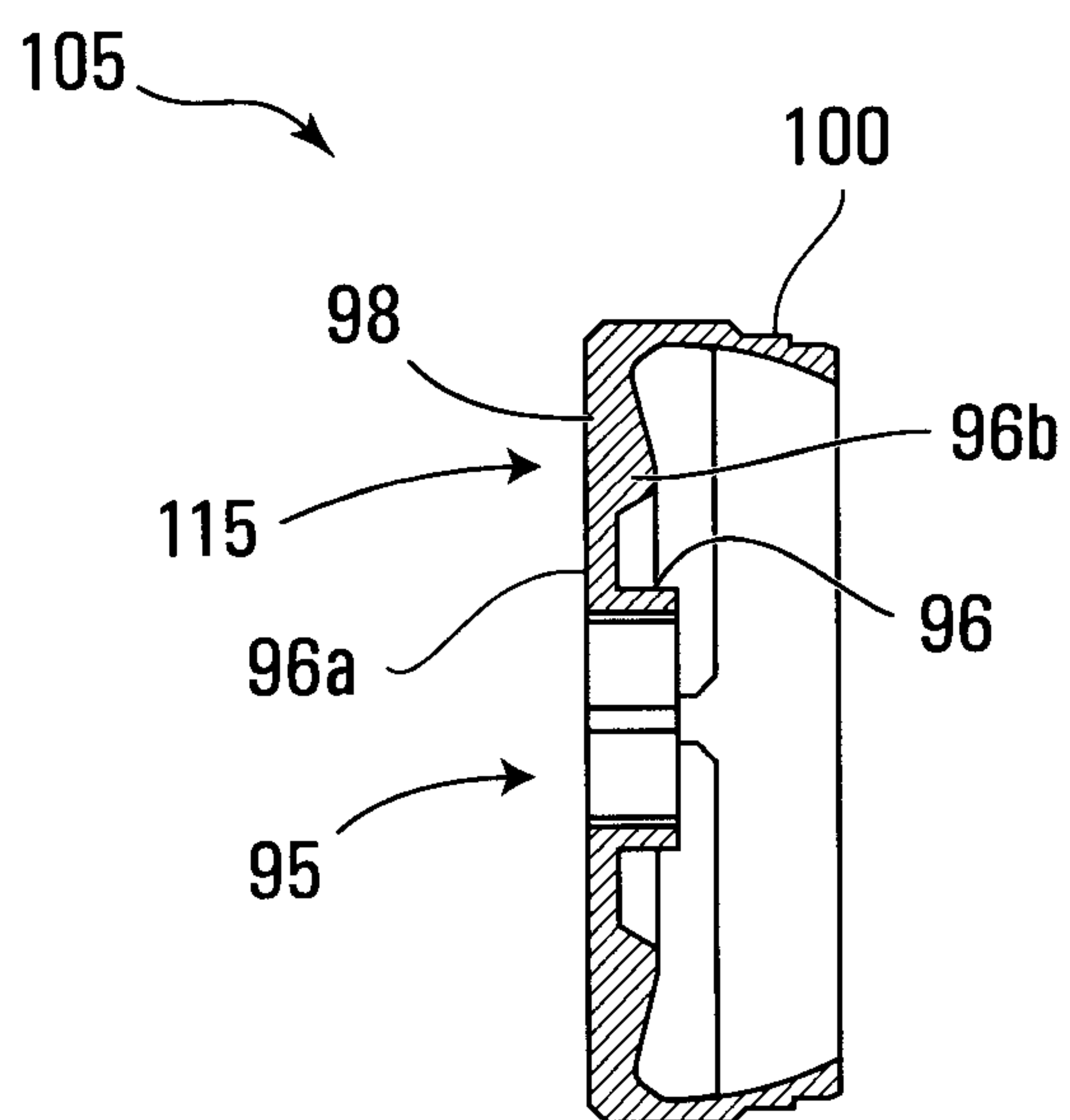
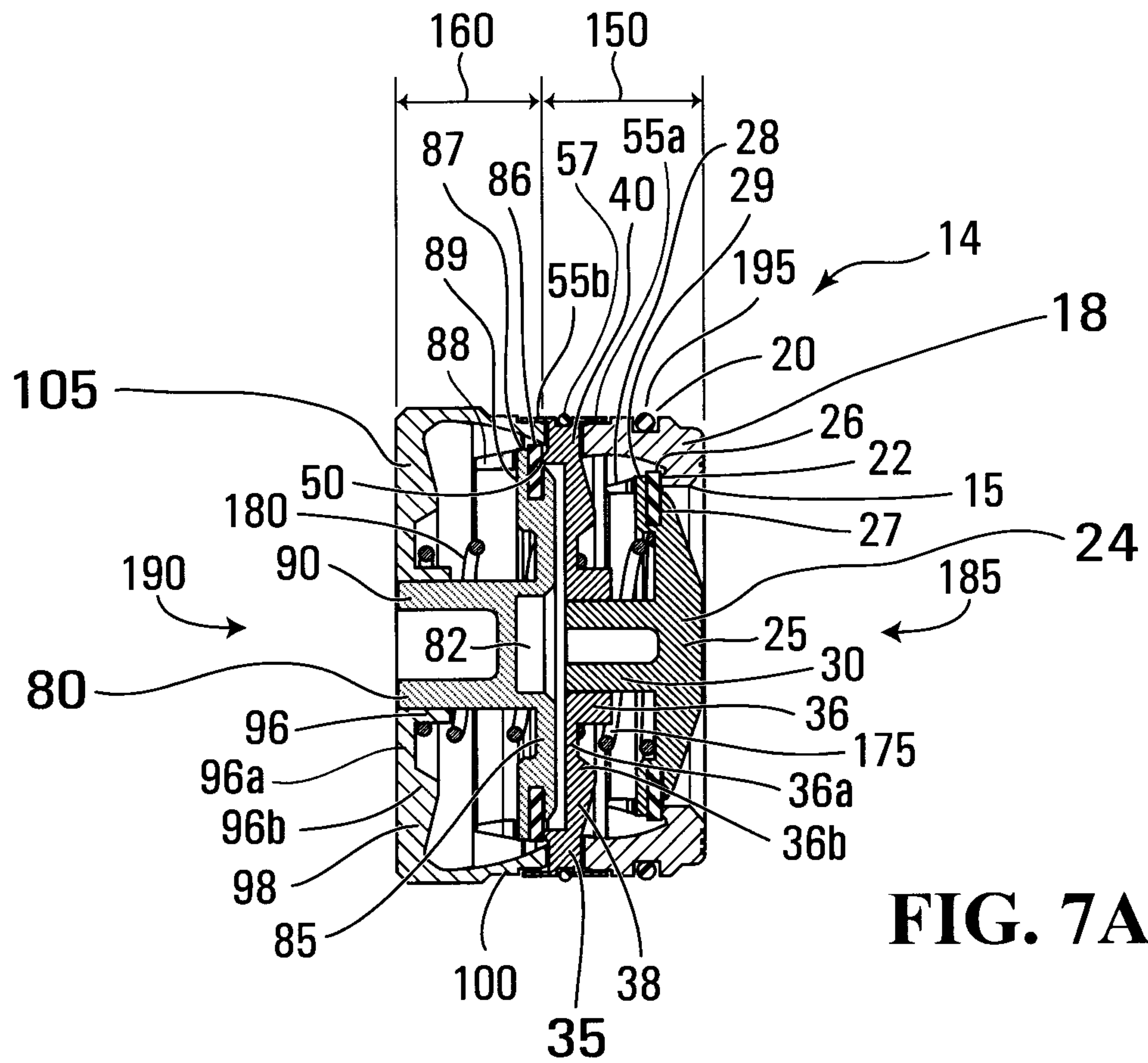
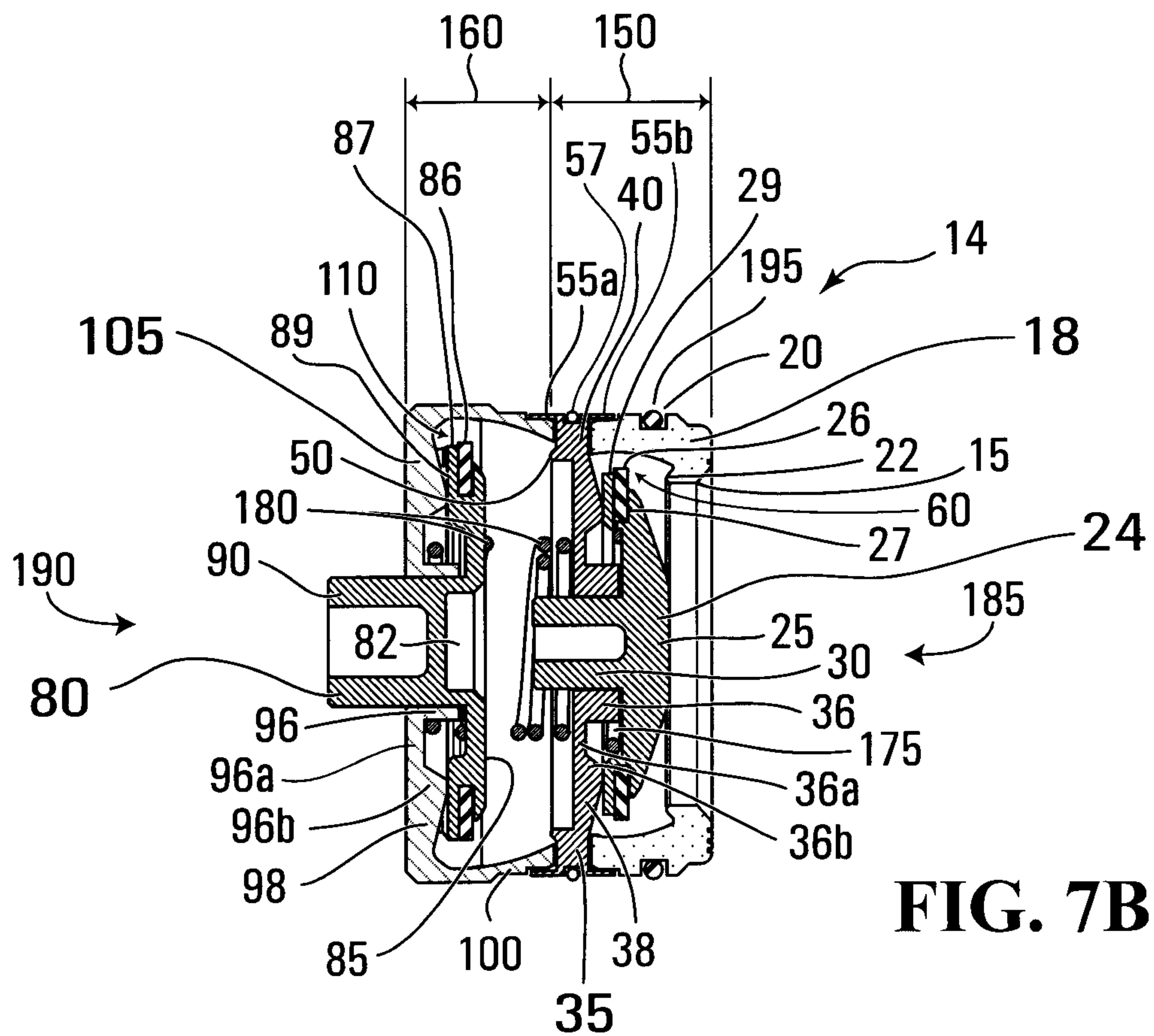


FIG. 5B

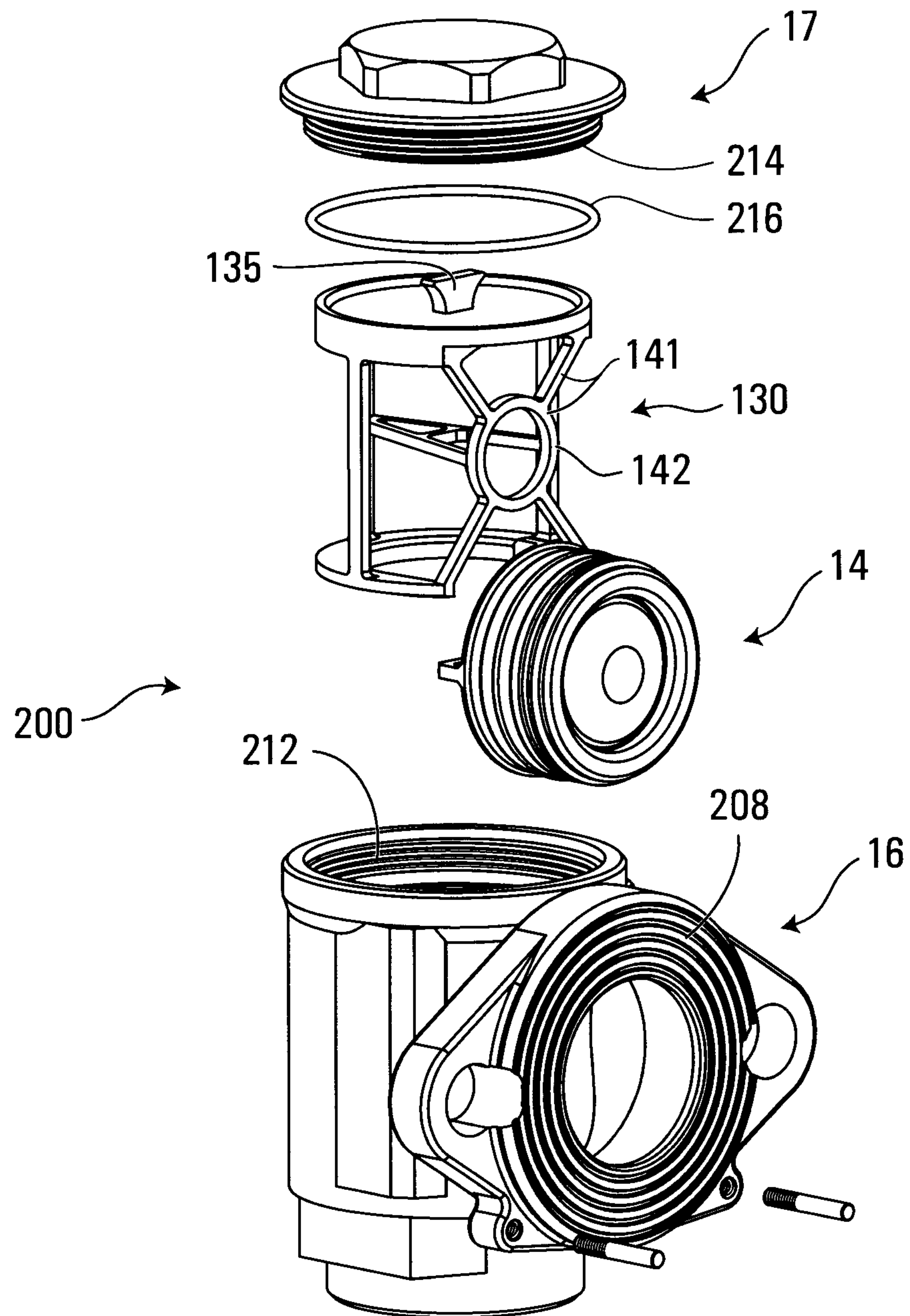
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**FIG. 6A****FIG. 6B**

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**FIG. 7A****FIG. 7B**

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**FIG. 8**

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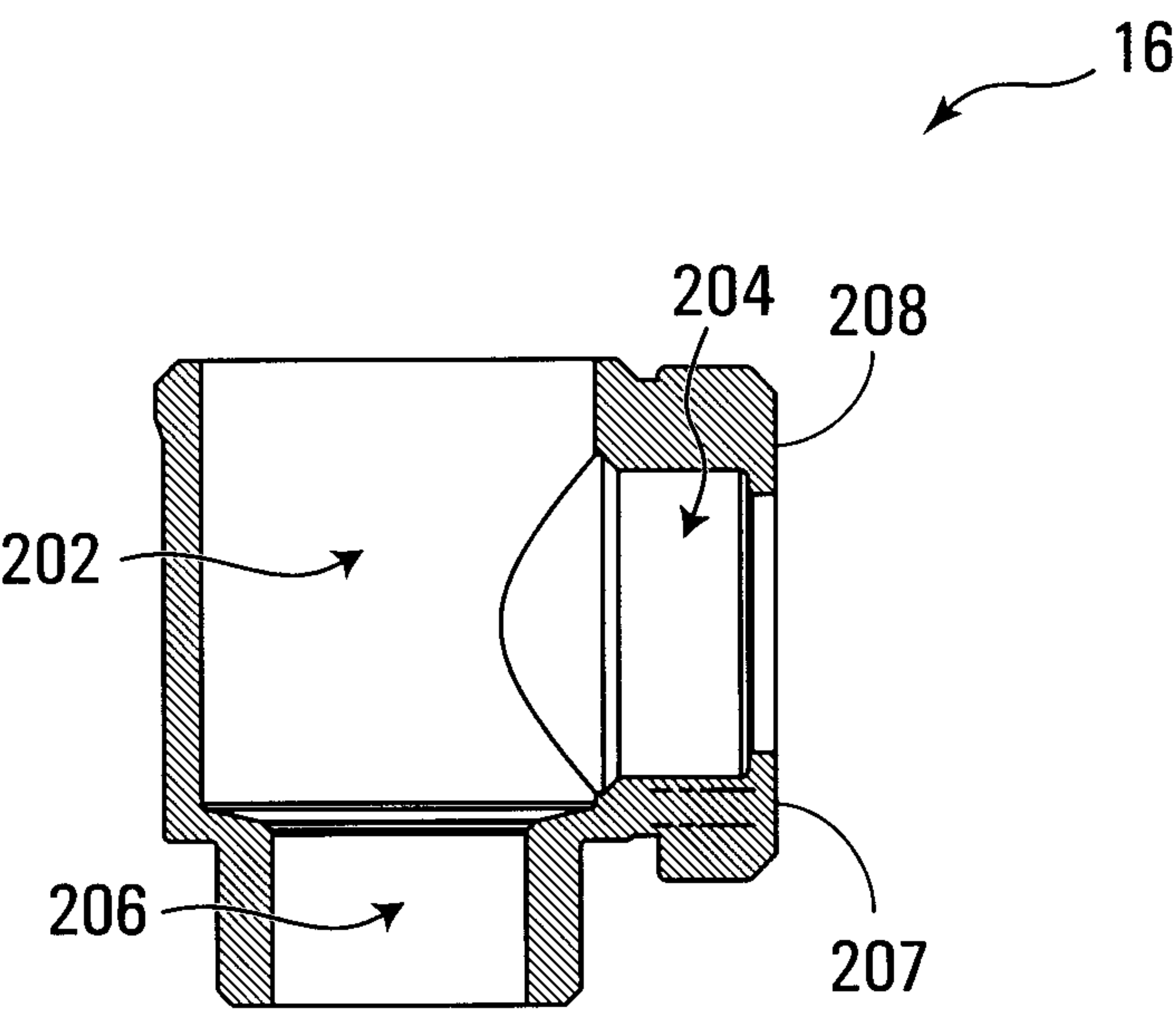


FIG. 9

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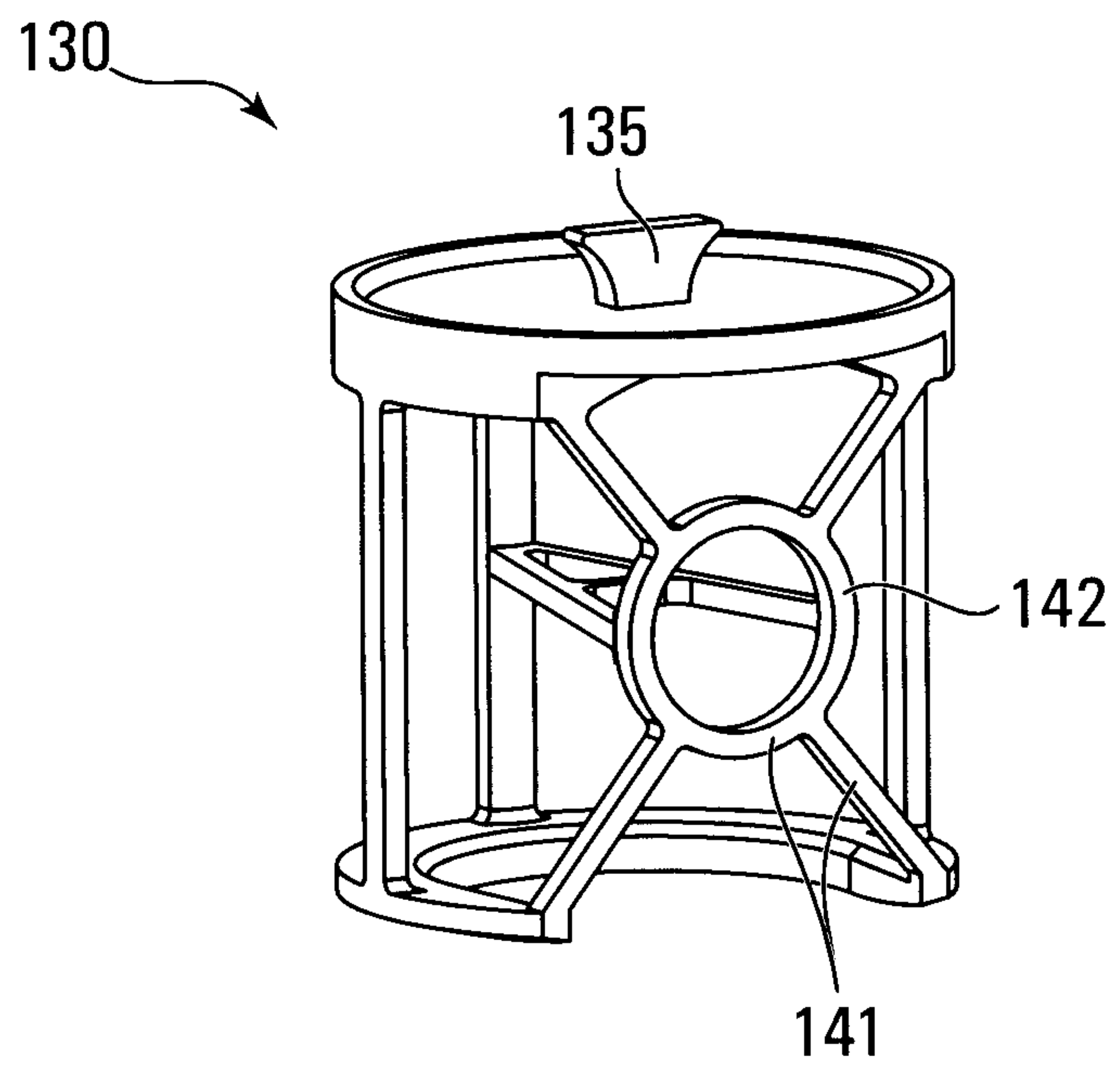


FIG. 10

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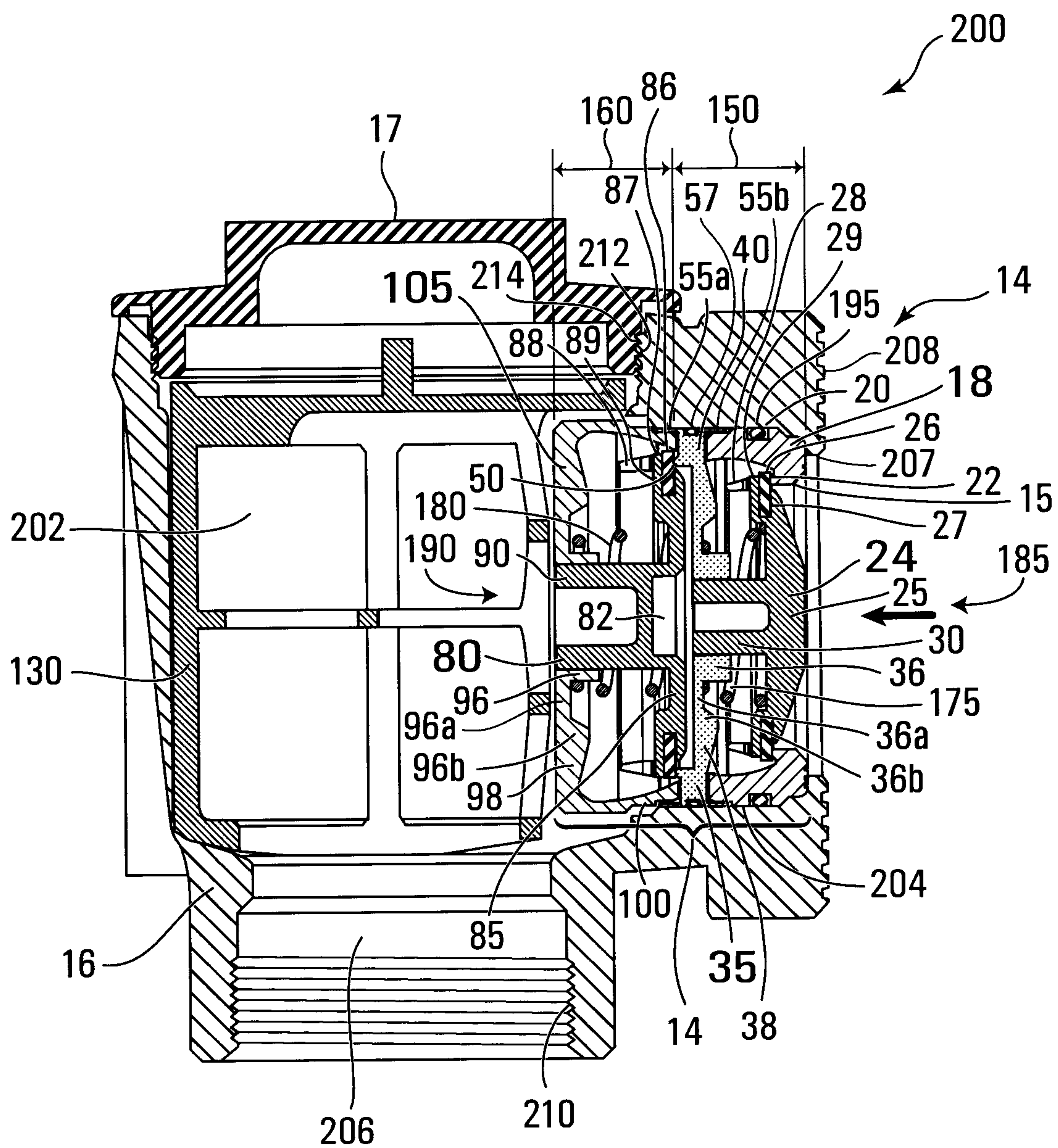


FIG. 11

